Hysteresis and path dependence in economic analysis: formalizations, causes and implications

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This paper argues that history, path dependence and hysteresis should have a much greater role in economic analysis than they do at present. To do so, it first reviews several meanings of hysteresis and path dependence using different abstract formulations and discusses applications of these approaches to economic analysis to examine the aspects of the economy to which they have been applied, and the causes and effects of these applications. It then suggests a taxonomy of the broad causes of path dependence. It concludes by summarizing the argument for giving these phenomena a much greater role in models and analyses, and makes some additional comments about these phenomena and their incorporation into economic analysis.

Keywords: Path dependence, hysteresis, equilibrium, economic methodology, history and economics

JEL codes: B50, B41, C60, E12

1 INTRODUCTION

It is often asserted that ‘history matters’ and that there is ‘path dependence’.¹ However, these assertions raise a number of questions. First, what do the expressions mean? Second, are these assertions valid and, if so, why, that is, are there plausible causes or explanations for these phenomena? Third, why does it matter whether the assertions are valid, that is, what are their implications or consequences, and why should one care about them?

The purpose of this paper is to take a stab at answering these questions for the economy and economic analysis using, to start with, some mathematical formulations. The focus on the economy narrows down our field of inquiry, and mathematical formulations are intended to make the meanings, causes and consequences of these phenomena precise and, it is hoped, clear. Both these limiting methods, however, need qualification. It is not quite clear what the ‘economy’ and its analysis actually mean. Are there clear boundaries between what aspects of society are economic and what are not? Can it be justifiably argued that what are often considered to be ‘economic’ actually do not go beyond the economy? Regarding the use of mathematical formulations, they are only taken as a starting point. All too often such an approach provides only formal definitions of phenomena,

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1. Although these expressions are not equivalent, we will use them more or less interchangeably except when otherwise noted.
and their causes and consequences remain abstract and, perhaps, too sterile. So, we will go beyond mathematical abstractions and relate them to concrete real-world issues.

The need for precision using formal methods requires a little more explanation. It arises from fact that all three questions posed at the outset are rather vague. The problems start with the first question. For the phrase ‘history matters’, while it is obvious that history refers to the past, several things are unclear. What aspect of the past is being referred to since, obviously, not everything in the past matters? Since some historical events or changes are being considered, what form should they take? Does it refer to a single event or change that occurred in the past which continues to occur, or has stopped or been reversed, or to a series of events along a path? Presumably, by ‘matters’ we refer to the effects of past changes, but on what, to what and when? The effect is presumably on something significant, but in what sense? ‘On what’ may refer to a unit, like a person or firm, or to a system as a whole or to some part of it. ‘When’ may refer to a time path after that event or change, to any later point, or to some end-point of a path or process. And what does end point mean? The term ‘path dependence’ is perhaps a little less vague, because it refers to what happens on a time path in the past, but the other questions still remain. After we have answered these questions regarding meaning, perhaps in a number of different ways, we can turn to the second question, since the fact that something in the past affects what happens later does not necessarily imply causation or dependence. We need to examine whether what happens in the past actually causes what happens later, which requires an analysis of how it does so. More specifically, to understand why history matters, or why later events depend on the events in the past path, we have to take into account the fact that there are many explanations for why something happens, perhaps several in the past and several contemporaneously. This makes it difficult to isolate causes, and difficulty exists a fortiori in exploring and classifying the kinds of general explanations. Finally, why does it matter whether path dependence or history matter? The analyses of specific instances and phenomena may tell us about the consequences of these phenomena in those instances, and it would be more interesting to understand their general implications and how and why they matter. To make some sense of how to answer these questions, especially the first and second, and to narrow them down to manageable proportions, we start with abstract mathematical formulations and see how they are applied to specific aspects of the economy.

To ‘path dependence’ and ‘history matters’, we add a third concept, ‘hysteresis’, which appears as the first word in this paper’s title. We do so because in its ‘pure’ form it is arguably one of the more interesting and precise formalizations of path dependance and is sometimes claimed to be superior to other formulations. Moreover, the term has been used more generally to refer to some, though not all, formulations, which makes it almost synonymous with path dependence, though not for its pure form.

This paper will address the three questions by drawing largely on the existing literature on hysteresis and other forms of path dependance. The first set of questions will involve using some abstract mathematical formulations and selectively reviewing the applications of each abstract formulation to concrete issues, which enable us

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2. The literature on these issues is large and growing and cannot be reviewed comprehensively in a single paper. There are some general surveys, such as Franz (1990), Göcke (2002) and Setterfield (2009), and surveys on specific topics, such Røed (1997) and Arestis and Sawyer (2009). The discussion here will focus on a sample of theoretical contributions and exclude empirical contributions.
to also examine the causes and consequences of path dependence in the different applications. On the second, we distinguish between different, though related, reasons; and on the third, we analyze the implications, but in general terms, since in answering the first set of questions, as mentioned, we will address specific cases. The first two questions are addressed in Sections 2 and 3. Section 4 will summarize and make some concluding comments regarding prevalence, the modeling and general implication of path dependence and speculate on the persistence of the relative neglect of path dependence for the economy and society.

2 FORMALIZATIONS AND APPLICATIONS

We start with a simple abstract system, in which it is often alleged that history does not matter. It then uses it as a basis for examining different ways in which it has been modified or interpreted to allow history to matter in a more significant way. The abstract mathematical formulations, in addition to making the ideas precise, also sidesteps some questions raised earlier. What ‘happens’ can be used to simply refer to the positions and changes of variables and parameters and the ‘end point’ can refer to the concept of equilibrium in economics and other quantitative social sciences, but there are problems with these interpretations, since they narrow down events mostly to changes in quantitative indicators. The abstract systems will be made more concrete by referring to specific applications, and brief comments will be made on the relative strengths of the different formulations.

2.1 An equilibrium model

We start with a simple formalization in which (allegedly) history does not matter. We consider a model with two variables, \( x \) and \( y \), which are related to each other by two implicit functions, \( F \) and \( G \), with corresponding equations

\[
F(x, y, \alpha) = 0, \\
G(x, y, \beta) = 0,
\]

where \( \alpha \) and \( \beta \) are exogenously given, or parameters, and the partial derivatives are assumed, as examples and without loss of generality, to be \( F_x < 0, F_y < 0, G_x > 0 \) and \( G_y < 0 \). We can write these equations in explicit form as \( y = f(x, \alpha) \) and \( y = g(x, \beta) \), where the sign pattern of the partial derivatives of the implicit functions implies \( f' = -F_x/F_y < 0 \) and \( g' = -G_x/G_y > 0 \). These equations are shown graphically in Figure 1. Their intersection point, \( E \), satisfies both equations, and can be called the equilibrium point, defined as the solution to the two equations; we assume that the curves intersect at positive values of both variables. If some exogenous change, for instance, a change in \( \alpha \) or \( \beta \), moves one curve then, in general, the system immediately moves to a new equilibrium. But there is no role for history: what happens (to an exogenous variable) now affects the system (that is, its equilibrium values) now; there is no movement over time and, hence, no time path or history.

Dynamics can be introduced into this model using two equations,

\[
\dot{x} = \Omega F(x, y, \alpha), \\
\dot{y} = \Psi G(x, y, \beta),
\]
where $\Omega$ and $\psi$ are positive (and finite) constants (for simplicity), and the over-dot denotes a time derivative. The lines $F$ and $G$ show combinations of $x$ and $y$ for which $\dot{x} = 0$ and $\dot{y} = 0$. The dynamics of $x$ and $y$ are shown by the horizontal and vertical arrows, respectively. Now we have time paths for the two variables: starting from any point, the time path of the system can be inferred from the horizontal and vertical arrows. This implies the following. One, from any starting point, the system moves along a specific time path; implying that as long as it does not reach $E$, what happens in the past affects what happens later, so history matters. Two, at $E$, we have $\dot{x} = \dot{y} = 0$, and the system is in equilibrium. Irrespective of the starting point, the system moves over time to $E$, the unique and stable equilibrium. The equilibrium (or end point) is not affected by the path and the levels of the two variables on it (even if the system somehow jumps to another path); history does not matter. Three, if a parameter is changed, for instance $\alpha$ is increased, if $F_\alpha > 0$, the $F$ line moves to the right and the equilibrium values of both variables increase. So, history matters: what happens in the past (a parametric change) affects the equilibrium, and it also has an effect on the path. Four, if after the shift, $\alpha$ is reduced back its original level, that is, the change is temporary, the system returns to its original equilibrium and history does not matter. However, if $F$ is non-linear in $x$, what happens along the path before equilibrium is reached changes, so that history matters. Five, if we interpret the (original) variables as growth rates or ratios of some other level variables, a temporary shift, despite leaving the equilibrium values of the original variables unchanged, will affect the level variables at any point in time, including at equilibrium, at which the level variables will not become constant but will be changing at the same rate.

The main problem of models of this kind is that history plays a very small role in them, for which they (especially the Neoclassical market-clearing one considered below) were strongly criticized by Kaldor (1972) and Robinson (1974), among others. The latter suggests that history has no role in these models: history and equilibrium are antithetical, they involve changes in space and not in time, and if we must refer to time, it is logical and not historical time. As we saw, however, while this statement has some validity, a more nuanced view is necessary.

There are numerous examples of such models in economics (probably the vast majority of them), of which the most familiar one, and the first that students see, is the demand/supply model for a perfectly competitive market for a single product. It is usually presented as a static model. It has two variables, $p$, price, and $q$, quantity,
related by demand and supply equations \( q = D(p) \) and \( q = S(p) \), with \( D' < 0 \) and \( S' > 0 \), with the income of consumers as an example of a parameter. All the observations regarding the abstract model apply to this one except for the last, since the variables are levels, not growth rates.\(^3\)

### 2.2 Reinterpreting the equilibrium model

One specific interpretation of the equilibrium model is that it depicts the main features of a part or all of the actual world, implying that: all the variables and parameters in it relate to clearly defined analogues of real-world concepts; it is possible to distinguish clearly between variables and parameters in a specific model; the variables and parameters are interdependent, involving specific deterministic or objectively probabilistic functional relations; and there are only a ‘few’ variables, parameters and functional relations that make tractable mathematical formulations possible. Arguably no modeler believes that all these claims are literally true, but this is often forgotten, and the models are interpreted as theoretical representations of the main features of the real world and are subjected to econometric ‘testing’ with real-world data. All of these are treated as assumptions or axioms used for building models and are examples of what Dow (1985) calls the Cartesian/Euclidean mode of thought. Some modelers go further to add that the relations in the model have to be derived from the optimizing behavior of individuals, an approach usually called rational choice methodological individualism, and in economics, the Neoclassical approach.

An alternative interpretation jettisons at least some of these assumptions and adopts the Babylonian approach and argues that this approach can be viewed as using an open systems approach rather than a closed one (Dow 1996). This distinction is further clarified by Chick and Dow (2005), who define a system as a connected or correlated group of objects, ‘principles, ideas or statements belonging to some department of knowledge or belief’ (p. 364), which can be an open one or a closed one. Only roughly using their definitions, the former is not complete in the sense of not containing all possible objects, ideas and relationships; the relations are uncertain (in the Keynes–Knight sense) and can change in an uncertain manner; the precise meaning of ideas and objects is unclear; and the distinction between what is held constant (parameters) and what is to be ‘determined’ within the system (variables) is fluid. The closed system is complete, and exhibits all the features of the so-called Cartesian/Euclidean approach described earlier. It is still possible to build and use models, so long as the properties of an open system are kept in mind. They view a mathematical model as a closed system that is embedded in an open system, but it seems better for us to interpret the mathematical model as representing an open system rather than a closed one.

There are at least two senses in which history matters when an equilibrium model is interpreted in this way. First, a change in a parameter generally changes the values of the variables, and if the parameters are assumed to be determined by historical forces, history does matter, but this is no different from the sense in which history matters in any equilibrium model. Second, and this is specifically the result of the model being

\(^3\) A dynamic version usually adds one equation, \( \dot{p} = \Omega[D(p) - S(p)] \), which does not specify what happens to \( q \), implicitly assuming that it adjusts immediately to some point of the horizontal price line. Another dynamic equation \( \dot{q} = \Theta[\min(D(p), S(p)) - q] \), which uses the short-side principle, solves this problem, but is problematic for other reasons which we need not discuss here.
interpreted in an open systems manner, any path or equilibrium position in it cannot be considered to be a precise one, but as a rough depiction of what happens. Thus, a change in an exogenous variable or parameter does not have a precise effect as suggested by the model, but only an approximate one, and there is no reason why a reversal of that change (which also has an approximate effect) will return the system exactly to its original position.

It has been suggested that an example of this type of reinterpretation is Sraffa’s formulation of the Classical–Marxian model. Eatwell (1997) argues that this model’s equilibrium is historically determined. The equilibrium values of the variables, the relative prices for the products and one distributional variable (the real wage or the rate of profit), are determined by the model, with the parameters, the input–output ratios in production, sectoral output levels and the other distributional ‘variable’ given as data. These data, in turn, are historically determined. He appears to justify this procedure by arguing that this model abstracts from the myriad of circumstances and facts and relationships that are believed to be the most important and relevant to the matter in hand. The problem with this argument is that, by treating the data as constants and examining how they are related to the variables only in a unidirectional way, they are not seen as important or relevant enough for examining how they move over time. The open systems interpretation of Sraffa’s formulation is less problematic, since it does not claim that the parameters and their mutual relations with the variables are ignored because these relations are unimportant, but because they are less law-like and systematic than the relation among the variables that are included.

While there is in principle nothing wrong with this interpretation, and it provides, arguably, the only reasonable way for models of social systems to be interpreted, it raises some questions. First, if some models can be interpreted as open systems models, it is not clear why all models in the social sciences cannot be interpreted in this way. For instance, if a Neoclassical general equilibrium model takes as data consumer preferences, technology and initial endowments of consumers, there is no reason why these data cannot be explained by endogenizing them informally or even formally (which has already been done). It can be argued that these data are qualitatively different from those of Classical and Sraffian models, but this claim needs justification. Second, it seems that this approach incorporates history in a very limited way, with history determining only the parameters, after which the model takes over. However, dynamic models for which adjustment variables in the equations of motion may be historically determined, thereby giving a greater role to history in the sense that the time path of the system, but not its equilibrium, may be affected by historical factors. Moreover, these models may have multiple equilibria, and the time path and, hence, history will determine which equilibrium will be the end state, an issue to which we will turn to in Section 2.4. Finally, this interpretation may tell us that history matters, but nothing about the mechanism by which it does so, relying only on some unspecified ‘approximate’ effects of changes.

### 2.3 Parametric changes

Sections 2.1 and 2.2 examined the role of parametric changes in equilibrium models holding other things constant and found that, in general, equilibrium values of some variables are affected, but if the parametric change is reversed later by the same magnitude, that is, the change is temporary, the equilibrium values are not affected. However, in both cases, the time paths of the variables may be affected. We now consider
the effects of a change in a parameter when some other parameters are exogenously
time-dependent, thereby violating the ceteris paribus clause. Models with this property
are presented in discrete time to allow parameters and functions to change from one
period to the next. For these models, if the values of these other parameters happen
to be different when the initial shock to the parameter of interest occurs, from their
values when the shock is reversed, there is remanence, which Setterfield (1997,
2009) calls hysteresis, since the model’s equilibrium position does not ‘forget’ tempo-
ardy shocks. Katzner (1999) provides a dynamic model of what he calls historical time
in which the value of a variable in one period is a function of its value in the previous
period plus a parameter, in which both the function and the parameter are time-dependent.
In such a model, there is no equilibrium because of the time dependence of the parameter
and functions, but the value of the variable for each time period depends on all history, that
is, all past parameter values and functions, and the starting level of the variable. Not all
of history needs to be relevant, since the functions can change over time to allow some
history to have a greater role than others, which may even be forgotten. This model,
not having an equilibrium, cannot be used to examine whether there is hysteresis in the
sense in which a temporary shock affects the equilibrium or not. However, Setterfield
(2009) proposes a definition in which changes in the time-varying parameter sum up
to zero, while the sum of the changes in the values of the variable does not, to define
the meaning of hysteresis.

While there is no reason to rule out time-dependent values for exogenous para-
eters (or functions) and, indeed, they may have a useful role in defining or charac-
terizing a particular form of remanence, this approach does not tell us what real-world
mechanisms explain this phenomenon and whether they are plausible. Setterfield
(1997) examines Kaldor’s (1970) model of regional growth for which the Verdoorn
effect (according to which the rate of growth of labor productivity depends positively
on the rate of growth of output in the manufacturing sector due to increasing returns
and learning by doing) results in cumulative causation involving productivity growth,
export-led aggregate demand and output growth, making some regions grow fast and
others falter, and argues that it leads to hysteresis, but it seems to do so by making
other parameters in the model change exogenously in unexplained ways. Modifications
of this model have been suggested, but the extent to which Kaldor’s analysis
and Setterfield’s formalizations provide a plausible explanation of hysteresis remains
unclear (see Dutt 2005).

2.4 Instability and multiple equilibria

A more fundamental modification of the model departs from the assumptions that pro-
duced a unique and stable equilibrium and instead, examines the possibility of multiple
equilibria and/or instability.

Starting with a single-variable case, where $x$ is the variable (with another variable,
y, hidden behind the scenes, with $x + y = 1$, implying that these variables represent
shares) which affects $x$. Figure 2 (adapted from Arthur 1989), shows two examples
of how $x$ depends on $x$. In the one shown by $\phi_1$, the system has one stable equilibrium
at $E$, where both $x$ and $y$ are positive, which corresponds to the dynamic model of
Section 2.1. In the second, shown by $\phi_2$, there are three equilibria: an unstable one
at $U$, and two stable ones, at $x = 0$ and 1. If $x$ starts to the right of $U$, it goes to the
equilibrium at $x = 1$, while if it starts to the left of $U$, it goes to $x = 0$. History matters
in the sense that the initial value of $x$ and its subsequent path, or its history, determines
the final outcome. Such models with unstable equilibria result in what is called a 'lock-in' such that, given the assumptions of the dynamic system, the equilibrium cannot be dislodged from it. Models of this type also have the additional implication that if stochastic elements are introduced to represent chance events, the system becomes non-ergodic (in which the average statistical properties of a stochastic process change over time). Non-ergodicity also occurs in Post-Keynesian analyses of uncertainty, but here it arises in a situation of risk rather than uncertainty in the Keynes–Knight sense. Non-ergodicity also creates problems for statistical testing of econometric models.

Several examples of this type of model analyze technology choice. Arthur (1989), who examines the relative fortunes of competing technologies that perform similar functions, states that a technology that, by chance, gains an early lead may eventually 'corner the market', locking out other technologies and that this is the result of increasing returns in a broad and dynamic sense, which also includes learning by doing, information cascades, network externalities and herding behavior (Arthur 1994), in contrast to diminishing returns or constant returns, as usually assumed in Neoclassical models. These ideas show that history can explain how one technology gets ahead, after which the cumulative causation process takes over. David (1985) examined the case of typewriter keyboards to show how QWERTY ended up dominating the market, beating out its eventually more efficient rival, Dvorak, possibly because of its initial advantage in that it reduced the incidence of jamming typewriter hammers. QWERTY remains locked in despite technological changes that stopped the use of hammers, because typists are used to it, training schools teach it and technicians know how to repair typewriters using it. There are many other examples of models of multiple equilibria and instability, including those explaining vicious cycles of poverty and development, and divergent growth and uneven development on a global scale, in which the gap between high-income and low-income countries increases, as emphasized by Myrdal (1957) and later modeled by Krugman (1981), involving increasing returns and the learning effect.

Although this way of formalizing path dependence seems quite appealing and plausible, it has also been criticized for several reasons. First, because of its knife-edge feature that allows small changes in initial conditions to have huge effects, history plays a small role in determining outcomes, providing only the initial conditions (due to some small chance event) after which the internal dynamics of the model take over. The knife-edge, however, can be blunted by following Arthur (1994) and adding a stochastic term to represent chance events, which creates a band within which positive feedback
effects can be reversed by stochastic shocks. In models of uneven development in which one region forges ahead because of its initially larger stock of capital than the other region, it is not because of small accidents in the past, but as a consequence of a long period of colonization with forced capital transfers and policies and practices of the colonial government. Moreover, the colonial government used its power to prevent the colony from adopting policies such as imposing tariffs that could weaken the role of positive feedback. Second, it has been argued that the approach gives too much weight to the initial condition of the model, and the outcome of the system becomes determinate in the sense that it can be defined and reached in terms of the data of the system if we include the initial conditions in that data. However, a modification of the model to include stochastic shocks and political economy as just mentioned can make the outcome less deterministic. Finally, Leibowitz and Margolis (1995) argue that if there is perfect knowledge of the future, decision-makers will know the longer-run profitability of their decisions and choose correctly, even if currently one path seems to be more profitable. But the assumption of perfect knowledge in the context of externalities, where the behavior of others changes the profit stream of the decision-maker, and the presence of uncertainty, is highly questionable, to say the least (see also David 2007).

A different set of issues regarding path dependence arises in models with two variables and non-monotonicity, which consequently have three equilibria, one a saddle-point and the two others, stable. A model was developed in Assous and Dutt (2013) with two state variables: the growth rate of capital and the profit share in income. The model assumes that growth is wage-led so that the relation between the growth rate and the profit share that keeps the growth rate constant is negatively sloped, and that the curve that keeps the profit share constant is non-monotonic, explained by the fact that although an increase in the profit share has a negative effect on the change in the profit share which provides a stabilizing effect, at intermediate levels of the profit share, a rise in the profit share and fall in the wage share reduces aggregate demand and slackens the labor market, increasing the profit share. Depending on which side of the saddle-point’s separatrix the economy starts, it will go to a high-growth, low-profit share equilibrium or a low-growth, high-profit share equilibrium, implying path dependency, as in the one-variable model. However, a fall in autonomous aggregate demand which shifts the growth curve down can take the economy from a high-growth to a low-growth equilibrium that crosses the separatrix, but a reverse increase in autonomous demand may not make the economy return to its original high-growth equilibrium but go to a new equilibrium with a lower growth rate than the original one, but higher one than the one with only a reduction of autonomous aggregate demand. The model therefore provides an example of what will in Section 2.6 be called ‘pure’ hysteresis, in which a temporary reduction in the autonomous aggregate demand has a permanent impact on growth and the profit share, and the equilibrium levels of variables depends not just on the current autonomous aggregate demand parameter, but also on its earlier time path. This model suggests that instability and ‘pure’ hysteresis may not be too far apart.

### 2.5 Zero-root and unit-root systems

An extreme case of a model with multiple equilibria is one with a continuum of equilibria. Suppose, in a two-variable system, the two dynamic equations take the form

\[
\dot{x} = F(x, y),
\]

\[
\dot{y} = H(F(x, y)),
\]
where $H(0) = 0$ and $H'$ can take either sign. This dynamic system is a zero-root system because the characteristic roots of the Jacobian matrix of the system are zero and the conditions for $\dot{x} = 0$ and $\dot{y} = 0$ are the same. The phase portrait of the system is shown in Figure 3, where system has a continuum of equilibria. The figure assumes $F_x < 0$, $F_y < 0$ and $H' > 0$. This figure implies that a change in the starting point of the system will result in a change in the path of taken by the variables, as well as in equilibrium value of the system, assuming that the equilibria are stable (the case shown in Figure 3). The starting point determines the later path and the equilibrium so that history has a role. However, if the system is shocked, which is later reversed, in general the system will return to its old path and equilibrium, unless there is an irreversible (or less than fully reversible) change in some other parameter in one of the above equations (this could even be a change in the speed of adjustment parameter or function $H$).

There are several examples of zero-root systems. One takes the NAIRU (the non-accelerating inflation rate of unemployment), $u_n$, to be an attractor for the actual unemployment rate $u$ for the usual reasons like wage flexibility, and for $u$ to be an attractor for $u_n$ for reasons to be discussed later for unit-root models. The model implies convergence to an equilibrium with $u = u_n$, without there being a unique NAIRU. Another examines the role of uncertainty by introducing the interaction between changes in what Keynes (1936) referred to as short- and long-period expectations (Dutt 1997), which results in path dependence and problems with ascertaining the precise effects if policy changes. van de Klundert and van Schak (1990) examine the effect of an adverse aggregate demand shock which makes firms reduce their capital stock and their price. Output and employment fall as a result, resulting in persisting unemployment. Neoclassical Synthesis Keynesian models assume that investment demand falls when unemployment is low, which implies that aggregate supply considerations rule the roost and aggregate demand adjusts to it. Dutt (2006) presents a model in which the change in the ‘autonomous’ aggregate demand reacts negatively to the gap between the growth of labor demand and labor supply, which increasingly tightens the labor market, but by also introducing endogenous technological change, the change in the growth rate of labor productivity adjusts to changes in labor market tightness, or the differences between labor demand and labor supply growth. The result is a zero-root model in which the growth rates of aggregate demand and aggregate supply interact and aggregate demand has a long-run effect on the so-called natural rate of growth by allowing productivity growth to adjust.

![Figure 3 A zero-root model](https://www.elgaronline.com/)

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It may be thought that zero-root models require very special conditions unlikely to be fulfilled in the real world. However, it should be noted that there are different explanations of zero-root dynamics: one in which two variables attract each other (as in the first model), another when changes in two variables, rather than their levels, are related (as in the second model) and when two variables adjust to the same gap that depends on the two variables (as in the last two models). Moreover, it is argued that the models allow too much endogeneity and a strong role for history since any change in the initial conditions of the system leads to a different equilibrium.

The analogue of these models in discrete time is a model with unit roots. Consider the first-order linear difference equation

$$x_t = A + B x_{t-1},$$

where $t$ refers to time, and $A$ and $B$ are constants with $A$ and $B \neq 1$. The equilibrium value for $x_t$ is

$$\bar{x} = \frac{A}{1-B}.$$ 

Whatever value of $x_t$ the system starts from, say $x_0$, the system will always have the same equilibrium, as in the models of Section 2.1. Now assume that $A$ changes over time, and takes the value $A_t$, which may be interpreted as a random shock or a deterministic parameter that changes exogenously over time and $B = 1$, we have

$$x_t = A_t + x_{t-1},$$

which has the solution

$$\bar{x}_t = x_0 + \sum_{i=1}^{t} A_i,$$

for all $t = 1, 2, \ldots$. There is no single equilibrium value, and the ‘equilibrium’ value of $\bar{x}_t$ changes over time, depending on the initial value, $x_0$, and the sum of all past shocks and the current one. So, the system is path-dependent, since $\bar{x}_t$ depends on the starting point and every past (and current) ‘event’. Such a unit-root system is sometimes called a system with hysteresis.

An example of this is provided by Blanchard and Summers (1987), who show that if some workers are insiders who have input into the determination of the wage, and are interested only in their own wage and not the wage of outsiders who are currently unemployed, a negative demand shock makes output and employment fall, but since insiders have no incentive to reduce the wage to induce firms to increase employment, the result is a random walk with no equilibrium unemployment rate and no fixed NAIRU. Other similar stories have been told, such as the loss of skills and employability when people are unemployed; workers discouraged from looking for jobs because they have been looking and not finding any; and the adverse psychological effects on the unemployed, including those on cognitive performance, motivation, perceptions and emotional well-being and increases in the feeling of helplessness, which reduce their employability, their ability to seek employment and to keep their jobs if they find one (see Darity and Goldsmith 1993).

Although these models give history a role, they have been criticized because they require $B = 1$ to have hysteresis. If $B < 1$ but very close to 1, the system has an equilibrium, but takes a long time to reach it. Many equations for many countries have
been estimated, and the results in support of hysteresis are mixed. It has been argued, however (Amable et al. 1994; Lang 2009), that this approach does not provide an appropriate definition of hysteresis, as does the ‘pure’ hysteresis approach, which we consider in Section 2.6, so that results that do not support the hypothesis that \( B = 1 \) do not imply that there is no hysteresis. This implies that while the unit-root condition is sufficient for hysteresis, it is not necessary. While this is true, it is not clear why something is not good because it is not something else, just because the latter is ‘pure’ in the sense that it corresponds to the original definition, unless there are other reasons for preferring the second. Lang (2009) also argues that although this approach gives history a role, it does in an implausibly strong manner: like an elephant, the system remembers everything. However, this problem can be overcome by assuming that \( A_t \) has a time-varying coefficient, say \( \eta_t \), which can be zero for any \( t \) for which there is complete forgetting, and even allow \( \eta_t \) at any particular \( t \) to change with the passage of time.

### 2.6 ‘Pure’ Hysteresis

The concept of what has or can be called ‘pure’, strong or genuine hysteresis (we chose to place the first within quotes because impurity need not be a bad thing) refers to the property of systems which retain a memory of their time paths because different levels of the dependent variable can result from a particular level of the independent variable, because the former depends on previous levels of the independent variable and not just on its current level. It has also been defined as the phenomenon in which the effect persists after the changes that caused it have been removed. It was first used in print by Alfred Ewing, a Scottish physicist and engineer in 1881 to describe the behavior of electromagnetic fields in ferric metals that were exposed to magnetizing cycles. He showed that the former was lower when the magnetizing force was increased, compared to when it was reduced after attaining a high level, and the effect remained after the magnetizing force was removed (Cross and Allan 1988; Cross 1993).

A model with a single unit (a firm or an individual) that has different ‘switch off’ and ‘switch on’ points for a binary dependent variable in response to changes in an independent variable provides a simple example of a model with hysteresis or remanence. As shown in Figure 4, let \( x_1 \) be the independent variable, the value of which determines the level of a binary dependent variable \( x_2 \), in say a behavioral equation (which states whether a specific action is taken or not). As the value of \( x_1 \) increases from 0 to \( x_1^F \) and beyond, \( x_2 \) stays at the level 0 till \( x_1^N \) is reached. As \( x_1 \) takes the value \( x_1^N \) or higher, the system switches on and \( x_2 \) takes the value 1. If \( x_1 \) then decreases below \( x_1^N \), but stays above \( x_1^F \), \( x_2 \) remains at 1. It switches off when \( x_1 \) goes below \( x_1^F \). Thus, for \( x_1 \in [x_1^F, x_1^N] \), \( x_2 \) can take the value 0 or 1 depending on the prior value of \( x_1 \). Moreover, if the system starts from any point in the interval \([x_1^F, x_1^N] \), with unit switched on (off) and is then shocked to take it to some lower (higher) level outside interval, and then brought back to the initial level by a reverse shock, the value of \( x_2 \) will be different. Amable et al. (1994) refer to this form of ‘pure’ hysteresis as weak hysteresis, since it implies path dependence with only two states, on or off.

With a number of such units with different values of \([x_1^F, x_1^N]\) and aggregate over them to get the total value of the dependent variable, given by \( X_2 = \sum x_2 \), history will matter in a more complicated way. In this case, which Amable et al. (1994) call strong hysteresis, the precise time path of \( x_1 \) determines exactly how many units are in or out,
and hence, the value of $x_2$ (which is equal to the number switched on) at any time. The history stored by the system actually consists of the past dominant maxima and minima of the independent variable for the system (which determine how many units are in or out at any given time), rather than all past values as in zero- and unit-root systems. More general models do not need to feature binary dependent variables but can have segments in which the level of the dependent variable depends on the level of the action taken when the independent changes.

There are several models with ‘pure’ hysteresis. Georgescu-Roegen (1967, 1971) examined the effects of a change in price or income on the bundle chosen by the consumer, and argued that the experience of consuming the new bundle changed the preferences of the consumer – the return to the original price or income does not imply that the consumer returns to the original bundle; he also mentions that a similar effect can follow from the introduction of a new product that changes consumer preferences. After a gap of several years, the hysteresis effect again began to attract attention, this time to examine the effects of a change in the exchange rate on international trade. Baldwin (1986) recognized that the entry of foreign firms into a country’s home market requires a high level of sunk costs upfront for investing in marketing, reputation building and distribution channels. Costs are also incurred in running its operations later, but are small in comparison to the sunk costs. The firm’s strategy will depend, among other things, on the behavior of the exchange rate. A sufficiently large increase in the exchange rate, or foreign currency price of the home currency, even if it is known that it will fall later, may make the firm find it profitable to incur the sunk cost and begin to export. When the exchange rate falls, however, the exporter will continue to export even when it falls to a lower level than when it entered, because it has incurred sunk costs. Since the exchange rate is higher for entry than for exit, we have ‘pure’ hysteresis. Modifications of this have been made by Baldwin and Krugman (1989), Dixit (1989) and Amable et al. (1994), among others. Dixit (1992) examined hysteresis in investment, and explained it in terms of three properties of the investment decision: first, it entails sunk costs involving expenses that cannot be recouped if the decision is reversed; second, the economic environment involves uncertainty (actually risk in the Keynes–Knight sense); and third, the investment opportunity does not vanish, so that the act can be postponed. If there were no sunk costs the decision could be reversed costlessly. If there is no risk, it would be clear – at any given time – whether investment is profitable or not. If it cannot be postponed, the decision-maker does not have the luxury of waiting. Cross et al. (1998) use the sunk cost mechanism to obtain hysteresis in the labor market. With different firms having different switch-on and

![Figure 4](https://www.elgaronline.com/hhtp://www.elgaronline.com/)

Figure 4 A model of ‘pure’ hysteresis
switch-off points for production and employment, a range of natural rates of unem-
ployment is found, so that there is no unique natural rate.

Sunk costs play a major role in almost all these models, and many of them use an
optimizing framework. Not all decisions, however, involve high sunk costs, and we
can ask whether they can result in hysteresis. To do so, it may be noted that the
role of sunk costs is to cause a low degree of reversibility, that is, once it is incurred,
it cannot, at least easily, be recouped. The main factor behind hysteresis is not sunk
cost, but low reversibility, which can have other causes. To examine how this can hap-
pen, we consider the most common of all decisions, consumption, which does not
usually have high sunk costs except, perhaps for some high-ticket items. We follow
Duesenberry (1949) by relying on habits and social interactions as reasons for low
reversibility, and drop the optimizing approach. To start with habit, we assume that
consumers form consumption habits when they consume at some level and find it dif-
cult, even painful, to reduce their consumption levels when something happens to
reduce it. In Figure 5, if an individual consumer’s real income increases from \( Y_1 \) to
\( Y_2 \), consumption increases along the solid consumption line, which shows how con-
sumption increases when income increases steadily. Most people do not find it painful,
or even difficult, to increase their consumption level from the level to which they have
become habituated, but for a variety of reasons, including the difficulty of departing
from what they have become used to, mild cases of addiction, loss-aversion and
loss of self-esteem, they find it difficult to consume less than what they are habituated
to. Having reached \( Y_2 \), if income falls back to \( Y_1 \), the consumer reduces consump-
tion (though some may not), but along the dashed line, since it is difficult to break habits.
Hence, at income \( Y_1 \) the consumption level is higher than it was initially. Duesenberry
called this the ‘ratchet effect’ rather than hysteresis. They can maintain this higher
level of consumption by drawing on past saving or by borrowing, but cannot do so
indefinitely, so they will switch back to a lower level of consumption, but by that
time, income may rise again.

Duesenberry also examines how consumer spending is affected by the consumption
of others. When the consumer sees someone else in what is called her reference group
with more consumer goods or more expensive ones than she possesses, she may

![Figure 5 Consumption and habit formation](https://www.elgaronline.com/)

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increase her own spending according to what Duesenberry (1949) calls the ‘demonstration effect’. This can happen because of various reasons, including fear of losing status and the need to not be ashamed for deviating from social norms. These considerations imply that when the consumer’s income falls (usually in comparison to that of others) she may not reduce consumption as much as what is shown by the solid consumption function line. Different consumers may have different switch-off and switch-on points even if they have the same income because, for instance, of differences in the degree of habit formation and different degrees of pain from departing from their habits.

This version of hysteresis, while very interesting and plausible, gives a limited role to history. A property of this model is that although it has a memory of past shocks, that memory is selective in the sense that it remembers only the non-dominated sequence of extremum values of shocks to \( x \), and not everything that happened in the past. While it is implausible to expect a system to remember everything that happens in the past, it is not clear that it should remember only such non-dominated extremum values.

3 CAUSES

It is difficult to identify the precise causes and determinants of path dependence. Outcomes in models in the social sciences, including economics, do not usually depend on one cause, or even a single major cause. Hence it is no simple matter to distinguish between, and provide a classification of, causes and determinants. We have examined various types of path dependence, on several specific aspects of the economy, and in so doing, examined the main mechanisms through which path dependence occurs in specific instances. Here we attempt to classify causes and determinants in terms of some general categories, which are to some extent interdependent and arbitrary, including physical/material and human irreversibility, technological issues in a broad sense, psychological issues, uncertainty, institutions and power.

First, there are several types of complete or partial irreversibility, for which sunk costs provides just one cause. Some are physical/material in nature. Humpty Dumpty, broken by a great fall from atop a wall, could not be put back together again (even) by all the king’s horses and men. This is an example of a physically irreversible event, but it need not be so considered unless our interest lies in that unfortunate egg, but on egg production as a whole, since there is no irreversibility in its flow. A clearer example of physical irreversibility or partial reversibility is the installation of a machine which, once installed, cannot usually be converted into something else, or disposed of at no cost except, slowly, through the process of depreciation. A much more important type of material irreversibility, one that has attracted a great deal of attention, is the depletion of exhaustible natural resources and irreversible damage to, and insufficient conservation of, renewable resources, which are likely to have enormous adverse path dependencies. This issue has been examined by ecological and environmental economists, but has not attracted attention in the path dependence literature, perhaps because of its complexity and specialized nature. Other irreversibilities affect humans. In addition to death and severe physical and mental disability, there are other irreversible changes in human beings. Some may have favorable consequences, such as the accumulation of knowledge by humans, which does not normally disappear but, in fact, new knowledge can build on existing knowledge, unless the knowledge is forgotten after years of neglect, if it is clearly false or because knowledge, especially tacit, is
embodied in people who may die without passing it on to others. Others have unfavorable consequences such as deskill, and deterioration of mental health caused by long periods of unemployment and, for other reasons, may result in the persistence of unemployment and other social consequences.

Second, there are technological factors, broadly defined. Some are mainly matters of engineering. Sunk costs may be high for technical reasons, such as the costs of building factories, installing machinery and developing information systems, and has been found to be an important cause of path dependence including ‘pure’ hysteresis. Technological knowledge, as one type of knowledge, can also be somewhat irreversible and can build on itself. The presence of scale economies in a technical sense has been seen to lead to path dependance and lock-in, and the same can be said for technological change due to learning-by-doing. Many of these mechanisms, however, are not strictly engineering in nature. As we have seen, sunk costs can relate to initial marketing efforts and establishing distribution networks, and scale economies and learning-by-doing involve social factors, such as the organization of work and management, and trust and cooperation between firms and political economy factors that affect the scope and nature of government activities to foster technological learning (by establishing technological education institutions, research centers, improving physical infrastructure and subsidizing appropriate research and development activities). However, the term ‘increasing returns’ has been overused to refer to network externalities that may have social components, consumer choices based on what others consume (due to the lack of information on products) and trust and cooperation among firms. While these considerations require a broad perspective of technology, in some cases the concept of increasing returns has been extended too far to include many forms of positive feedback efforts that have little or nothing to do with technological issues (see, for instance, Pierson 2000).

Third, there are psychological factors that affect individual decision-making and mental health, which are related to several forms of path dependence. Mental health issues can result in the persistence of unemployment and poverty. Decision-making can be based on habits, emulation and various type of heuristics, all of which can result in path dependence. The importance of habit formation, psychological factors causing emulation and status seeking can result in path dependence in consumption, as discussed earlier. Moreover, the use of heuristics in making decisions in uncertain environments (see Kahneman et al. 1982) provide additional explanations for path dependence. An example is the availability heuristic, according to which the probability of an event is assessed by the ease with which instances of the events come to mind, through retrieval or visual simulation. Which events come to mind, of course, depends on the decision-maker’s past experiences, especially those in the recent past, and this can result in the path dependence of decisions and behavior. Behavioral patterns can also be caused by the prevalence of loss aversion among many people, that is, the tendency of people to be much more affected by losses than by gains. This leads to conservatism in decision-making regarding consumption choices, asset holding, investment and social interactions, and can lead to the persistence of behaviors, although this tendency can sometimes be used by others, including those involved in sales promotion and political propaganda, to affect and change peoples’ behavior. It should be noted that many of these mechanisms are not just related to individuals’ tendencies and characteristics, but have social dimensions, which are examined by social psychologists and sociologists.

Next, we turn to a broader group of factors and the mechanisms arising from them – institution, uncertainty and power – that, while analytically distinct, are closely
interrelated (see Dutt 2015), each of which have implications for path dependence and for each other. Discussing them also provides a useful way for examining how the interdependence of economic, social and political factors contributes to path dependence.

Institutions may be defined broadly to include formal laws, rules and constitutions, whether codified or not; habits, social norms or conventions; and more or less formal organizations of people or groups, including courts, the police, clubs and families. The need for including these three aspects of institutions into one concept arises from the fact that most of them are so closely interrelated, that the nature and role of one cannot be fully grasped without an understanding of the others.

It is often argued that institutions change slowly and this leads to their persistence (see, for instance, David 1994). For instance, legislatures take time to change laws, including those that favor incumbents and their political allies, and result in persistence of laws; constitutions require super-majorities to amend; and judges rely on precedents. Habits, social norms and conventions exhibit rigidity, because of individual inertia due to ingrained behavior patterns and status quo biases, group reinforcement due to emulation and sanctions, and their roots in religion and other aspects of culture and ethics which often resist change. North (1990) also points to sunk costs, risk and other features associated with ‘pure’ hysteresis, thereby drawing directly on the path dependence literature, and the complementarity and interconnectedness of different institutions make each one of them resistant to change. Mahoney (2000), writing on path dependency in historical sociology and focusing mainly on systemic and long-term changes, distinguishes between self-reinforcing sequences with positive feedbacks that reinforce institutional patterns (like the ones just mentioned), and reactive sequences or chains of temporally ordered events where each step in the chain is influenced by prior steps, each step reacting to, and sometimes reversing earlier events. While the first sequence leads to the persistence and the reinforcement of institutions, the second also results in path dependence but not necessarily persistence. He recognizes different frameworks for understanding institutional changes or persistence, including the power approach in which elites try to gain from institutions at the expense of others, and the legitimation approach in which institutional reproduction depends on perspectives of what is moral. Pierson (1990) explains many causes of path dependence in politics by focusing mostly on institutions, such as the collective nature of its institutions and policies, where exit possibilities are limited when individuals disagree with something decided collectively and enforced by coercion; the persistence and the complementary of political institutions; and the role of power, in which elites use their power to shape institutions according to their perceived interests, which reinforces their power.

Uncertainty, defined in the Keynes–Knight sense in which the future is unknown even in an objectively probabilistic manner, contributes to path dependence and hysteresis in several ways, as already been mentioned. In models with instability and lock-in properties, uncertainty provides an important reason why producers adopt technologies that have been adopted by a higher share of producers compared to similar competing technologies, relying on available information, rather than by attempting to choosing among technologies through the estimation of their profit stream over all future periods, about which they have no reliable knowledge. Uncertainty, with the interaction of short- and long-period expectations in zero-root systems, and with investment in ‘pure’ hysteresis models, also results in path dependence. Moreover, with uncertainty, most decision-makers try to avert losses by avoiding financial assets with volatile prices, try to enter into agreements with employers to keep their wages
relatively stable and use relatively stable rules of thumb. These behaviors can serve to stabilize the economy. But stability and tranquility often excite the animal spirits of firms and banks, leading to high levels of lending and borrowing, and financial speculation. This results in financial turbulence and possibly financial crisis, which increases uncertainty, and to a decline in investment, production and employment, which may persist.

Since power is a complex concept with many faces, it has eluded a precise and general definition; we will avoid definitions and, instead, briefly mention different faces and sources of power. The first face, which refers to the ability of some individuals or groups to make others act in ways that they would otherwise not do and which is against their perceived interests, is the most common perception of power. However, it does not take into account other faces, such as the ability of some to shut off and veto the options of others and set the agenda for negotiations; influence and change preferences and values of others to their perceived disadvantage; induce the dominated to acquiesce to their domination; and devise ways in which individuals’ values and identities are socially constructed, not through the active manipulation of individual preferences, but in social and cultural terms where values are shared through social interactions, and through the education system and the media. To the social construction of values and norms, if we add other institutions, such as laws and organizations, and other aspects of society and the economy that change slowly, such as technological systems, the social relations of production and the organization of industry and finance, we come to what are often referred to as structures. Structural power is embodied in the structures of the economy and society in the context of which individuals and groups act, without the need for actually exercising power or revealing the ability to do so, and can be taken to refer to the last two faces of power, as compared to relational power, which is the power relevant for the relationships between people and groups, related to the first three faces; we may refer to them as types of power. The sources of power, relevant both for structural power and relational power, are: control over production, finance, violence and knowledge and culture and the strength derived from organizations, numbers and the characteristics of leaders of groups.

This discussion of the different faces, types and sources of power suggest that there are interactions both within each of the three, and between the three (see also Pierson 2015). It can be argued that most of these interactions – though not all – result in positive feedbacks. Regarding positive feedbacks, having more money because of production and financial power results in the ability to influence the preferences of others and create a culture through the educational system and the media, that is, knowledge power. High levels of relational power for the powerful can result in the ability to change structures in a direction favoring them. Regarding negative feedbacks, although an increase in numbers can increase the chances of influencing election results, in many cases the strength in numbers is better described as weakness in numbers, because of collective action problems stressed by Olson (1965), and money can neutralize the advantage of strength in numbers. It should be noted, however, that the sources of power, for instance, do not depend only on each other but also on other influences, including elements exogenous to the system being considered, which can be chance events, changes in socioeconomic conditions that can arise from other (exogenous) factors, chance events and the failure to exercise power, which is usually contested more or less strongly, because of divisions among different sections of the elites or other groups, and the perception of interests not being the same as actual interests, for instance, because of misperceptions about how society works and fallacies of composition.
The three aspects of society – that is, institutions, uncertainty and power – interact in various ways, many of them, though not all, producing positive feedback effects. For instance, the power of elites can influence the nature of institutions, uncertainty about the real world allows the powerful to influence the expectations and world-views of others, the presence of uncertainty can be an important motivation for the institutional innovation of change and, can sometimes, though not always, reduce uncertainty, and power can allow elites to shift the adverse consequences of uncertainty to the non-elites, making them more vulnerable. Reactive sequences can also occur. For instance, a high level of inequality can lead to excessive increases in it due to positive feedbacks, which may, but need not, reverse this trajectory. The reversal may be due to the widespread recognition of the unfairness of extreme inequality, and the adverse macroeconomic consequences due to a decline in aggregate demand. Moreover, there can be a change in the animal spirits of the non-elite to take action spontaneously or in an organized manner to confront the elites and political parties representing them both inside and outside the polling booth. None of these forces may lead to a major reversal.

The positive feedback effects of increasing inequality and power of the elites can also influence government policies, which are distinct from institutions. These elites, through campaign contributions, lobbying activities and personal relations with politicians and other influential people, perhaps lubricated by money flows, influence a range of policies – such as fiscal, monetary, labor, anti-trust, welfare and trade policies, among others – in a manner that promotes their perceived interests. As Palley (2017) argues, the resulting changes in the distribution of income and wealth will increase the power of the rich and change the economic and social conditions in a manner that influence political conditions and sentiments that make a pro-rich policy stand more likely. This results in a positive feedback loop that leads to lock-in of this policy stance along the lines of the path-dependent models of Section 2.4. He also applies the ‘pure’ hysteresis approach discussed in Section 2.6 by considering political conditions and sentiments to be an independent variable and the policy stance, for simplicity, a binary dependent variable. As political sentiment moves to the right (pun intended) at some point, the pro-rich policy regime is switched on. But if, for some reason political sentiment moves to the left, the pro-right policy switch-off point will be at a lower level of political sentiment than at switch-on point perhaps because of institutional and ideological rigidity, resulting in a policy regime hysteresis. In fact, there may be no switch point, and the policy regime gets locked in. This analysis focuses mainly on the effect of political sentiment on policy regimes, and (except in figure 2 of that paper and a few remarks) does not examine the feedback from policy regimes to socioeconomic conditions and political conditions and sentiments. These may be reactive, as discussed earlier, and shift political sentiment to the left which, due to hysteresis effects, would take a greater shift in political sentiment to switch off pro-rich policies.

4 CONCLUSION

This paper has examined how path dependence has been addressed in economic (and related) analysis. It has done so by reviewing different types of abstract methods that try to define and understand path dependence and hysteresis and examine how they have been applied to different aspects of the real world. Based on this review, it has tried to examine some general causes and mechanisms that bring about path
dependence in models and other analyses closely related to these models, with the objective of increasing our understanding of how these phenomena come about in the real world. In this final section, we briefly discuss some general conclusions that can be drawn from our analysis, either directly or by implication, as follows.

(1) There are many aspects of the economy and society for which path dependence plausibly exists, including technology choice, international trade, investment, consumption, unemployment and labor markets, institutions and institutional change, political economy and public policy. The variety of such aspects suggests that almost anywhere we care to look we are likely to find path dependence. It seems that Georgescu-Roegen (1971) was right to claim that in the social sciences path dependence is more the rule than the exception and that ‘no search for a complete description of social phenomena can avoid them’ (p. 126). It should be noted that these instances have been uncovered using both mainstream (Neoclassical) and heterodox analyses, distinguished according to whether they use (and insist on using) individual optimization as a way of understanding behavior, or not. Heterodox approaches rely, instead, on the use of groups as well as individuals, rules of thumb that depend on contexts, and differences between groups and people in terms of their position and role in society as ways of examining behavior, and the structures of systems as a whole for examining how individuals, groups and the economy and society as a whole behave and what these behaviors imply. This, as noted earlier, can examine the interaction between the ‘input’ or independent variable and the ‘output’ or dependent variable in the ‘pure’ hysteresis approach.

(2) The review of different applications suggests that two broad types of approaches have been examined, that is: microeconomic, ‘microfounded’, and addressing ‘narrow’ questions; and macroeconomic and systemic, and addressing ‘broader’ questions. Examples of microeconomic and narrower approaches include effects of exchange rates of international trade, path dependence in investment spending and why some technologies get locked in, such as the QWERTY keyboard. While these issues are of some interest and importance, they are microeconomic in nature and examine narrower questions. Some of them, such as those using the ‘pure’ hysteresis formulation, deal with single units which are then aggregated, mainly to find more complicated patterns of path dependence, but models that start in this way do not examine systemic issues, for instance by examining how the ‘independent’ variable in the microeconomic model can be endogenized by introducing systemic features, as noted in Section 3. Further, taking into account ‘pure’ hysteresis or other types of path dependence simultaneously in different aspects of the system, such as consumption, investment and labor markets may yield complicated models, but without doing so in a relatively simple matter it is not possible to examine whether the system as a whole exhibits path dependence. It can be conjectured that all aspects of the system need not be path dependent for the system to be path dependent. Of course, there are models that deal with macroeconomic outcomes starting from micro behaviors, such as Blanchard and Summers (1987), but they typically deal with simple approaches to determining employment, isolating, for instance, the insider–outsider approach to the labor market. There is no reason why ‘pure’ hysteresis models and other approaches – apart from their complicating features, which may be possibly be simplified – cannot be extended to deal with systemic issues. In fact,
some models of the system as a whole, such as those of Krugman (1981) and Assous and Dutt (2013) have taken some steps in doing so, and can be further extended by endogenizing trade and fiscal policies.

(3) There are many general mechanisms for understanding why path dependence can occur, including physical and human (at least partial) irreversibilities, technological factors (broadly defined), including increasing returns and sunk costs, psychological aspects of human behavior, institutions, uncertainty and power (and the interaction of the last three) in different aspects of society and for society as a whole. This range of mechanisms yet again suggests the ubiquity of path dependence in economies and societies. It can be noted that there is a larger range of mechanisms that can be and have been found in heterodox approaches than in mainstream ones, since the latter has not sufficiently appreciated the role of increasing returns, psychological aspects of behavior (apart from its emphasis in behavioral economics, which has perhaps drawn attention away from other mechanisms), uncertainty and power and had an arguably narrow perspective on institutions.

(4) The variety of abstract approaches to examining the phenomenon of path dependence and hysteresis has perhaps reinforced the appreciation of its ubiquity in the economy and society and a greater appreciation of major differences or the shades of difference between definitions, mechanisms and effects of this phenomena. While it is fine to explore the strengths and weaknesses of different abstract formulations for understanding of the meanings, mechanisms and implications of these phenomena, these differences seem to have had the unfortunate result of promoting unnecessary and unproductive rivalries between the proponents of different abstract approaches, and the tendency to apply one approach, with minimal modifications, to different aspects of the real world. This is particularly evident among the advocates of what we have referred to as ‘pure’ hysteresis, which they have described as the strong form, richer, more faithful to its original meaning, genuine and true, so as to suggest or even use derogatory antonyms for other forms, with one group of authors suggesting that the zero- or unit-root approach is not hysteresis at all (see Amable et al. 1994; Lang 2009). The problems with this view are first, that path-independent models are no more than simple heuristic devices which should be used only as a basis for understanding the phenomenon of path dependence, and second, that it has proved to be relatively simple to translate similar ideas from one to another abstract formulations including, for instance Dutt (1997) translating zero root to ‘pure’ hysteresis models to examine the interactions between short- and long-period expectations, and Palley (2017) for translating the analysis of positive feedbacks to ‘pure’ hysteresis to examine changes and lock-in in policy regimes.

(5) The models and verbal analysis using different abstract approaches have a variety of general implications for what the real world is like and how it changes. First, these models examine the phenomenon of cumulative causation, divergence and inequality, in line with the models of Section 2.4 rather than implying stable equilibrium models of negative feedback, convergence and changes in inequality that can be reversed. Second, they are more likely to allow aggregate demand to have a greater role, even in the longer run, than models that do not admit to path dependence. This result does not imply that expanding the role of aggregate demand requires path dependence, but is likely to be present in a larger set of models than those without it. Third, there is nothing ‘natural’ about economic and social outcomes, such as equilibria that results from impersonal market
forces of demand and supply, or the natural rate of unemployment. The appropriate way to examine the properties of equilibrium outcomes and endpoints is not use some *a priori* characterizations of these outcomes (for instance, there cannot be unemployment in equilibrium, because if it does, the wage will fall), but the dynamic path of systems that allows the possibility of path dependence. Fourth, many of the outcomes for systems, either in the sense of paths along which the system moves or its endpoint, do not result in desirable outcomes in a variety of senses. The standard mainstream approach to desirable outcomes involves the notions of efficiency or Pareto optimality, which involves the reliance on individual preferences. The endogeneity and hysteresis found for preferences in the analysis of Georgescu-Roegen (1971) call into question this approach (although for this, the endogeneity of preferences is the key issue, and not hysteresis). But even if we use the mainstream criteria of efficiency, several of our models imply that path dependence can result in inefficient outcomes, as suggested by the role of cumulative causation getting the system possibly locked into endpoints that are inefficient, or in models with an endogeneity of the ‘natural rate’ in which involuntary unemployment can persist. Multiple equilibria and instability that result in poverty traps and growing inequality, as examined in Section 2.5, and the possible irreversibility of environmental damage with feedback effects on the rest of society make a strong case for focusing directly on poverty, inequality and the environment concerns (in addition to their ethical importance) rather than (or at least in addition to) efficiency. Finally, while these implications focus on how the economy actually works, that is, ontological implications, this analysis also has methodological, normative and prescriptive implications which are left for future discussion, except to note that in terms of the first of these, organizing frameworks in which path dependence is taken seriously, for instance by questioning the use of single-valued functions involving relevant variables, and by being more cautious about the use of equilibrium analysis and mathematical methods, without going to the extreme of jettisoning them. Moreover, our analysis implies that greater attention needs to be paid to overcoming disciplinary boundaries and using transdisciplinary approaches that examine economic, sociological, political and psychological issues and, of course, history, although the case for going in this direction does not rest on path dependence alone.

(6) We end with some remarks on why – despite the proliferation of models and analyses of path dependence in economic and related issues, which suggest the ubiquity of the phenomenon – the economic analysis using it is limited, and often narrow. The analysis of path dependence provides a number of insights. The initial conditions need not be explained. But its characteristic that marginalist and mainstream analyses were beginning to show signs of domination over other approaches, such as Marxian and institution approaches, can be explained in terms of a reaction to subversive ideas, to the often intentional borrowing of ‘scientific’ ideas and approaches, mainly from classical physics, and perhaps to the change in focus from economic growth to resource allocation that may have been caused by the economic maturing of higher-income countries. Starting from this initial position, the dynamic positive feedback effects can be explained by the propensity of very well-known economists to continue with their chosen methods of inquiry because of the high sunk costs they incurred in achieving their dominant position; their desire to maintain this position by supporting students by
training, hiring, tenuring and promoting them and getting them jobs in prestigious departments (who, in turn, gladly accept these gifts not least because of their career interests), through their control of major journals and influence on funding sources; the importance of academic groups and departments at more prestigious universities as organizations; the psychological tendencies towards preferring approaches that are familiar; and the tendency of scholars outside the supposed bastions of excellence and prestige to follow their approach. The lock-in of mainstream approaches, with its proclivity for equilibrium methods and tractable mathematical formulations, and an ideological bent towards methodological individualism with optimizing agents, and support of the role of market forces in producing desirable outcomes, tend to draw effort away from path dependence. To the power of the academic establishment, we may add the money power of rich elites, who endow universities and research organizations and provide grants to scholars, preventing many (other than the foolish) scholars from rocking the boat by becoming subversive, and the knowledge power of rich and powerful countries to dominate knowledge (through education, incentives for publishing in leading journals and the possibility of visiting and living in rich countries to increase their income) over much of the rest of the world which, in the eyes of scholars and elites of the rich countries as centers, is relegated to the subordinate periphery.

REFERENCES


