Claudius Gräbner-Radkowitsch
Jakob Kapeller

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Claudius Gräbner-Radkowitsch
Europa-Universität Flensburg, Department of Pluralist Economics
Johannes Kepler University Linz, Institute for Comprehensive Analysis of the Economy (ICAE)
claudius.graebner-radkowitsch@uni-flensburg.de

Jakob Kapeller
University of Duisburg-Essen, Institute for Socio-Economics
Johannes Kepler University Linz, Institute for Comprehensive Analysis of the Economy (ICAE)
jakob.kapeller@uni-due.de

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Abstract

This short paper explains the theory of path dependence and clarifies its relation to concepts such as positive feedback or lock-in, arguing that path dependence is a core theoretical element of political economy in general, and institutional and evolutionary economics in particular. We first clarify the core conceptual elements of path dependence, show how it is relevant in a wide variety of problems and approaches, and situate these diverse applications in a common theoretical understanding that can be synthesized as a general mechanism. We then discuss the different ways in which path dependence has been theorized in evolutionary-institutional economics and related schools of thought. Finally, we present some archetypical models of path dependent processes.

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Correspondence: claudius.graebner-radkowitsch@uni-flensburg.de (CGR), jakob.kapeller@uni-due.de (JK).

1. What is path dependence?

‚Path dependence' is a core concept in institutional and evolutionary economics (IEE) and related social science disciplines, such as history, political science or management studies. In essence, path dependence characterizes situations or processes in which *history matters*: past developments have led to current configurations that in turn constrain the space for future developments and thereby reduce contingencies. In practical use, it refers either to (1) a certain property or state of some (socio-economic) system, or to (2) theoretical arguments about how such stable configurations emerge. Hence, it can be used in a *descriptive* as well as in an *explanatory* way.

Arguments on the presence and relevance of path-dependent constellations can be found in a wide variety of different contexts, ranging from central questions of economic history (e.g. on the ‚Great Divergence' or the persistence of social stratification) to issues of technological and social standards (e.g. related to the stability of social norms or the dominance of potentially inferior technological standards) or individual behavior (to explain the persistence of organizational routines, groupthink or self-reinforcing expectations). This diversity of applications suggests that path-dependence is a very general concept in the sense that it is applicable to a broad variety of socio-economic systems. As a consequence, path dependence is considered a key concept in heterodox economics. It is often presented as a prime example for an emergent phenomenon and bears strong implications for other key themes of IEE, such as time & historicity, ergodicity, power & stratification or development & change.

As diverse as the applications of path dependence may seem, there are some common features across all of these cases. First, most, if not all, concise arguments about path dependence incorporate some notion of *positive feedback* (Dobusch and Kapeller, 2013), that is "effects that are able to act as a catalyst for regenerating that very same effect" (Heinrich 2013, p. 166). This notion of self-reinforcement associated with positive feedback is related to several more specific terms, such as cumulative advantage (e.g., Merton 1942, Kaldor 1955), preferential attachment (Albert & Barabási 2002), network effects (Sydow et al. 2009) or Matthew effects[1] (Merton 1968), all of which reflect this core notion in different contexts. In practice, this may be due to dominant actors, standards or behavioral patterns, which have attained a dominant position, making structural changes, such as a shift in social hierarchies or the replacement of some technological standard, less likely. Whenever the positive feedback mechanisms have operated long enough to stabilise the state of the system substantially, the state is often described by the term ‚lock-in', which is usually considered as the final stage of a path-dependent process (Sydow et al. 2009; see below).

A generic formulation of the key mechanism underlying path dependent phenomena that is based on these commonalities can, therefore, be formulated as follows:

> *For all systems (x) holds ceteris paribus: If "positive feedback" (PF) is a characterizing force within a system and a series of competing and*

[1] The latter refers to a phrase in the bible, Matthew 25:29, that captures the underlying logic of self-reinforcement: "For whosoever hath, to him shall be given, and he shall have more abundance: but whosoever hath not, from him shall be taken away even that he hath."

> *incommensurable social standards are available, then one or few of these standards will tend to dominate.*

Here, the term standard is to be interpreted broadly and can refer to some social standard (such as a norm or routine), technological blueprints (such as the QWERTY keyboard), a distributional setup (such as the distribution of income or market power), an organizational rigidity, or a prevailing expectation.

A second common feature of path dependent phenomena is that they can usually be separated into three distinct phases. The *first phase* is one of contingency or 'path-creation'. Here, randomness in the form of "historically small events" (Arthur, 1983) plays a decisive role in determining the dynamics of the system. After this initiation, positive feedback mechanisms become visible and the system enters the *second phase* of 'path determination', in which the self-reinforcing processes narrow down the potential for future development and dominant standards emerge. The *third phase* represents a lock-in to a dominant standard with little chance of endogenous change. It is particularly the second and third phases – which are often difficult to separate in practice – in which the above mechanism of positive feedback reducing contingency tends to be most relevant, as it renders the development of the system more predictable. In the first phase of path creation, the system dynamics are mostly perceived as contingent (Garud et al, 2010).

Such an understanding of path dependence allows for illustrating different concrete cases of path-dependent states or developments, while providing the necessary degrees of freedom to conceptually incorporate different contexts. For example, classical arguments on path dependency in business history often refer to technological standards and, relatedly, dominant players in specific industries (archetypical cases include QWERTY, VHS vs. betamax or Intel and Microsoft; see Dobusch & Schüssler 2013 for more examples). They typically refer to direct and indirect network effects as well as learning effects to make a case for positive feedback as a dominant force.

In contrast, in the context of social hierarchies and stratification we can understand path-dependence as the inverse of social mobility, since it would imply that the relative social positions of a given individual tend to remain constant over time. While this is obviously not true for any single individual, it is certainly true on average for most historical periods. It is for this reason that many IEE scholars have a long-standing interest in institutions such as property rights, class or inheritance, which consolidate social stratification over time by facilitating positive feedback effects (e.g., Mulder et al. 2009, Pistor 2019). Also, the notion of path-dependence is also present in conventional understandings of wealth dynamics, which are typically based on a combination of cumulative advantage and multiplicative random growth (both of which show path-dependent properties to varying degrees).

Finally, it should be noted that we can also observe path-dependent phenomena in systems located outside of the classical scope of the social sciences, such as natural systems. An example of this is the emphasis of Ecological Economics on tipping points in the context of the climate crisis since such tipping points effectively create additional positive feedback loops that foster climate heating. This example shows how the underlying logic of path dependence may in principle also transcend disciplinary boundaries.

2. The diverse notions of path dependence in IEE

Close to the conceptualization of path dependency presented in the previous section, scholars in IEE have often described the notion of path dependency in terms of ‚cumulative change' (Veblen 1904) or ‚cumulative causation' (e.g., Kaldor 1985). The broader term 'circular cumulative causation' (e.g., Myrdal 1944) also builds on path dependency and positive feedback in a temporal sense, but adds spatial and functional dimensions that emphasize the interdependency between different sub-systems in contemporary society.

William Kapp (1976) even considered the concept of circular cumulative causation aka path dependence to be "*the* key concept of institutional economics" (Berger 2009, p. 7). In retrospect, this statement appears to be valid, although there is some heterogeneity in the focus of different authors: Veblen's use of the term, for example, was more methodological, emphasizing the need for a non-equilibrium analysis of causes and effects, Myrdal's work stressed the circular and self-reinforcing nature of poverty and underdevelopment cycles and the relevance of non-economic factors, while Kaldor focused more on such economic factors to emphasize the importance of increasing returns and technological change for economic growth (see, for example, Berger 2009, O'Hara 2008).

The extent to which these original elaborations on path dependence are compatible with more recent proposals to open up institutional analysis to new formal modelling approaches, also in order to better understand the mechanisms underlying path dependence, has been subject to some debate in IEE so far. Clearly, scholars such as Kaldor, Myrdal or Kapp used the concept of path dependence to strongly criticise the equilibrium models that dominated the economic mainstream of their time, and at least Kapp and Myrdal were also skeptical against formal models in general (see Kapp 1961; Myrdal 1968). At the same time, many formal innovations have taken place since then and several constructive proposals on how to incorporate certain types of formal models into institutionalist analysis have been made, often using path dependence as a central example for why these models can be useful (e.g., Elsner, 2012, Gräbner 2016, Heinrich 2017). Therefore, in Section 3 we try to follow up on these arguments and try to reconcile more classical takes on path dependence from the IEE with models that seek to formalise the mechanisms underlying the positive feedback that gives rise to path dependence.

Economic development and the question of international convergence constitutes a major area of theoretical and political controversy, in which path dependence plays a crucial role. Path dependence in economic development is classically suggested by Verdoorn's Law, which posits that a current output positively influences productivity growth (Verdoorn 2002[1949]), thereby suggesting that economic development is governed by a positive feedback loop, i.e. cumulative causation. In the context of international competition the same core intuition of cumulative causation has been expressed as „success breeds further success and failure begets more failure" (Kaldor 1980, p. 88), implying that the current levels of development in some respect – be it health, education, economic prosperity or cultural achievements – depend on past states. Building on this basic intuition, economic development and economic history are a core area of application for path dependence, with the ‚Great Divergence' – that is the bifurcation of living standards between the Global North

and the Global South following colonialism and related processes of industrialization in the Global North – as a prime example. This process is said to have created path dependencies and associated power asymmetries in myriad ways, including technological leadership, strategic ownership and standard-setting power, all concentrated in the economies of the Global North, which have led to the persistence and maintenance of differences in living standards for much of economic history since the Great Divergence (see, e.g., Dosi et al 2019 for a related model). At the theoretical level, arguments about cumulative causation and path dependency in economic development have influenced seminal contributions such as the Prebisch-Singer hypothesis (Prebisch 1959, Singer 1950), the Lewis model of development and structural change (Lewis 1954), or the Thirwall model of balance of payment-constrained growth (Thirwall 1979).

Similar to power relations in international trade and economic development, path-dependency can also be used to better understand the stability of power structures in markets, such as stable monopolies and oligopolies, or the overall highly skewed distribution of firm size. The latter typically follows a power law distribution, meaning that inter-firm relationship are characterised by a high degree of persistent inequality (e.g. Axtell 2001, Heinrich & Day 2016). Again, the general principle of „success breeds success“ a.k.a. positive feedback can be used to formally explain why dominant firms typically maintain their relatively privileged position over long periods of time or why such a highly skewed distribution of firm size and associated market power emerges in the first place. Models with increasing returns to scale in production (and corresponding restrictions on market entry, interfirm competition based on notions of evolutionary fitness or positive network effects, or firm popularity based on preferential attachment would all be able to derive such stylized results; they also share the basic intuition of cumulative causation encapsulated in this chapter (for a more general review of possible mechanisms leading to such skewed distributions see, e.g., Heinrich & Day 2016).

Given that path dependency is a suitable concept to describe and explain stable hierarchies within markets and across firms, it might not come as a surprise that also the evolution of (the distribution of) private wealth is considered to follow path-dependent patterns. The conjecture here is that greater wealth provides greater means to exert power and/or generate income and, at the same time, increases one’s reservation options. Conversely, the absence of private wealth comes close to a poverty trap as some basic endowment can prove necessary to achieve personal advancement (Balboni et al. 2021). Arguments along these lines can be read as using the intuition of cumulative causation as a core factor in the emergence and persistence of social classes. In a narrower sense, cumulative causation can be understood and modeled as cumulative advantage, which classically refers to the higher saving rates and higher rates of return enjoyed by those that are already wealthy (Kaldor 1955, Pasinetti 1962). Such an assumption is not only compatible with the notion of positive feedback, but also allows to reproduce the power law properties of the upper segment of the wealth (and income) distribution, that are typically found in empirical research. It should be added, that the main alternative modeling strategy present in IEE to describe the emergence of power laws in wealth is based on multiplicative random growth (classically: Gibrat 1931). Such models also exhibit path-dependent characteristics, which, however, unfold in a stochastic instead of deterministic way.

Similar to the understanding of firm and household stratification presented in the preceding paragraphs, also network dynamics and, relatedly, dynamics of attention and visibility, often follow dynamics that reproduce similar characteristics of differential growth as introduced above. Such dynamics have been classically described by Merton (1968) for the case of scientific contributions, whereas Albert & Barabási (2002) developed a general model of this mechanism.

A further main strand of research on path dependency in IEE relates more indirectly to notions of power and is concerned with standards in the broadest sense, including technological standards, social standards, organizational routines and norms, as well as political or institutional standards. Technological standards are thus a classic topic in IEE, as well as in related research fields such as innovation studies or economic history, and relate to a wide diversity of topics ranging from questions of basic infrastructure design (such as railway gauges, e.g., Veblen 1915) over issues of industry-wide standard-setting (e.g. paper sizes, keyboard layouts, charging devices, operating systems…, e.g., Heinrich 2018) to novel fields of application concerning platform dynamics (e.g. the adoption of messenger apps and social media, e.g., Heinrich & Gräbner 2019). Research on social and organizational norms and routines, which are in turn related to cultural heterogeneity (Smith 1761[1759]) and firm performance (Nelson & Winter 1982) documents how such norms become inscribed in specific cultural contexts through their successive repetition, imitation and expectation. These patterns create positive feedback loops that stabilize practices over time in a manner similar to the mechanisms underlying other cases of path dependency (see also Hodgson & Knutson 2004).

Finally, these dynamics also apply to dominant political institutions, the latter are also said to actively contribute to their entrenchment as they manage political decisions and junctures in a way that ensures their own survival, which provides an additional feedback loop ensuring the stability of once dominant political institutions (e.g. Page 2006).

In conclusion, it should also be emphasised that path dependency plays an important role not only in IEE but also in many heterodox schools of thought. Structuralists and dependency theorists are a case in point, as for them the concept is essential to grasp the contemporary relevance of historical events, such as the continuing importance of imperialism and colonialism (e.g., Kvangraven 2020). Post-Keynesians, with their concept of hysteresis – the potentially permanent effects of temporary macroeconomic shocks – are another important example. Thus, path dependence is also a concept that could help facilitate a productive convergence of heterodox schools in the sense of Elsner (2017).

3. Modeling path dependency

This final section now focuses on an example of modeling of path dependent systems. For this purpose it will first introduce what is often considered the most generic model of path dependency, the so-called (Eggenberger-)Polya urn model. In a second step, we explain shortly how this simple model relates to the core intuition of path dependence as described above and provide a glimpse on how contributions in the field of IEE implicitly or explicitly build on this core intuition.

The original version of the Polya urn model of Eggenberger & Polya (1923) describes a scenario with an urn containing two balls of different colors (say, orange and purple). In each round one ball is chosen randomly from the urn and two balls of the same color are added back into the urn in turn. In this setup, both colors have an equal probability to eventually dominate. Figure 1 below shows six typical runs from such a model that starts with two balls, one of each color, and lasts 200 steps (left panel), as well as typical outcomes of 500 iterations of such model runs (right panel). To illustrate the results, the left panel of Figure 1 plots the median (where the share of each color is about 50%) and maximum outcome as well as the 25%-quantiles for all cases where orange dominates (and, correspondingly, purple is subordinated). In this plot we can observe a qualitative difference between a path-creation phase dominated by randomness in the first rounds, a path-formation phase, where things slowly stabilize, and the path-dependent phase, where constellations are stable and rigid. Hence, the simple Polya urn model mirrors the different phases of path dependent processes introduced in the first section. Moreover, given that we use quantiles for plotting outcomes, we also see that these outcomes are close to uniformly distributed in the simple Polya urn scheme. The latter property implies that the Polya urn model also reproduces a weak form of the second major idea present in the key mechanism discussed in the first section, namely dominance as the mean share of the dominant color across runs is around 75%.

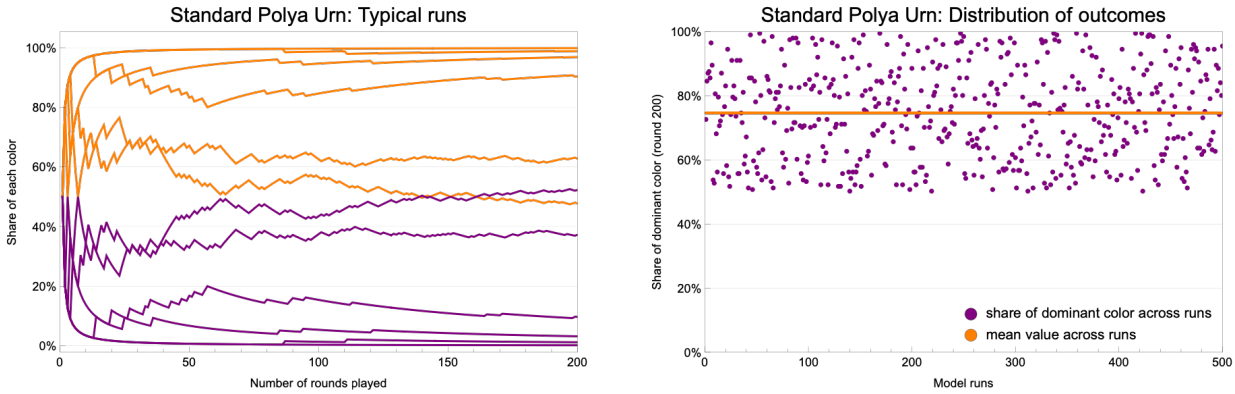

Figure 1: Outcomes of the standard Polya urn model.

There exist several variations of this standard model. Two basic variations concern variants with a higher number of colors or a higher number of initial balls per color. The second modification will lead to a similar result as shown in Figure 1, but without a clear-cut path-creation phase: if one starts with many balls, the initial shares of the colors will simply be preserved forever.[2] The first modification, however, creates stronger results for (relative) dominance as single colors will take over comparably large relative shares in the phases of path creation and formation, which is, in turn, preserved in the final lock-in of the system. After the phase creation, however, the system preserves the contemporaneous shares (Arthur et al. 1983) as in the standard Polya urn model.

However, the most influential variations of the basic Polya urn model concern variations of the replacement mechanism. The simple model has a very basic mechanism – drawing one ball and adding another of the same color. Of course, other mechanisms are conceivable and

[2] This intuition also resonates with the mathematical proofs that show that the expected value for the share of each color is equivalent to its share in the first round.

may be more appropriate to understand the case at hand. For example, Figure 2 shows an example of a mechanism that is very close to the simple model, but adds three balls of the drawn color instead of one. This modification causes the dynamics to diverge earlier, making balanced outcomes less likely (see the distribution of runs in the left panel), and, accordingly, increases the share of the eventually dominant color across all runs (see right panel). Heuristically, we can argue that the simple Polya urn model features the mildest form of Matthew effects, where growth is, on average proportional to endowments, whereas the modified scheme with higher growth per round introduces standard Matthew effects, where growth is disproportionate to endowments.[3]

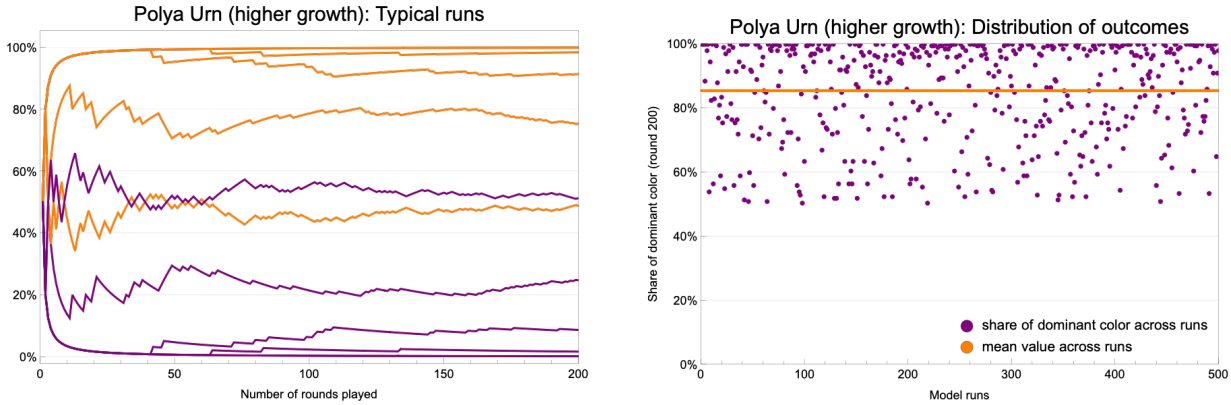

Figure 2: Outcomes of a modified Polya urn model with higher growth per round.

By moving to more general replacement mechanisms one enters the realm of *generalised* urn schemes, which were studied by Arthur et al. (1983) and the work that followed this seminal contribution. In their paper, Arthur et al. (1983) show that for many replacement mechanisms, the initial shares are not preserved, even when there are already many balls per color, but that the system evolves towards certain fixed points determined by the initial conditions and the concrete replacement mechanisms. For instance, if the process of adding a new ball to the urn is probabilistic, and the probability of adding a particular color is an increasing function of the current share of ball of that color in the urn, the resulting system will evolve towards the strong dominance of a single color, thus exhibiting the second key idea of path dependence, dominance, in a very pronounced way.

In all, the class of (generalized) urn models is able to capture the central elements of path dependence theory - positive feedback, the different phases of path dependent development, potential dominance and lock-ins - within a formal framework. The fact that the precise degree of persistence and dominance depends on the particular setting - initial conditions, number of competing standards, or the replacement mechanism - is not a weakness of these models, but only a proof that to fully understand path dependent systems in reality, a meticulous investigation of the concrete system under investigation is necessary. Maybe its because of this that not only has path dependence played such a central role in IEE, but also that IEE has been particularly successful in studying path dependent systems.

[3] The mechanism in the simple model would amount to a constant relative Gini-coefficient and an increasing absolute Gini, while in the modified version both, relative as well as absolute Gini, will increase over time.

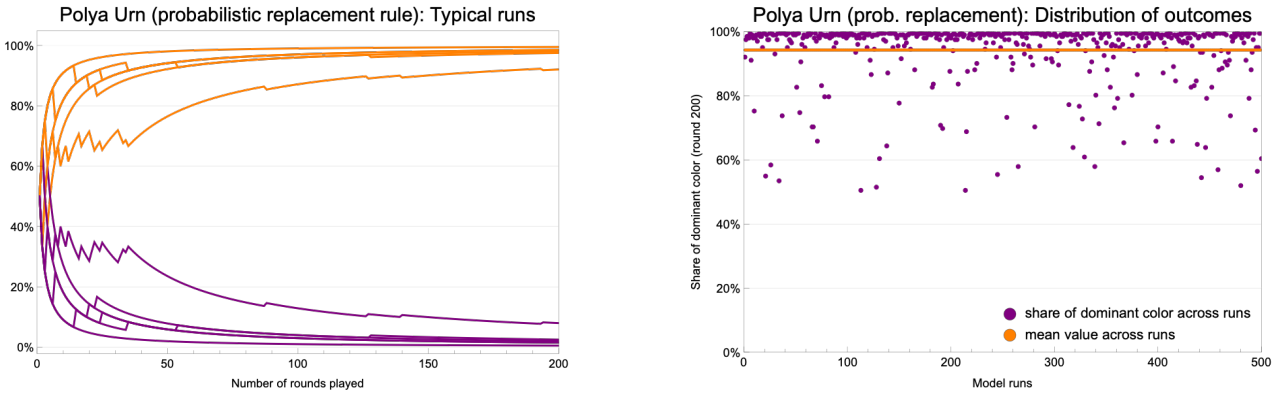

Figure 3: Outcome for a modified Polya urn where the probability for the new ball to have color x is proportional to the current share of balls that are of color x.

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Institute for Socio-Economics
University of Duisburg-Essen

Lotharstr. 65
47057 Duisburg
Germany

uni-due.de/soziooekonomie
wp.ifso@uni-due.de