

The Same or Not the Same - On the Variety of Mechanisms of Path Dependence

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Abstract—In association with path dependence, researchers often talk of institutional “lock-in”, thereby indicating that far-reaching path deviation or path departure are to be regarded as exceptional cases. This article submits the alleged general inclination for stability of path-dependent processes to a critical review. The different reasons for path dependence found in the literature indicate that different continuity-ensuring mechanisms are at work when people talk about path dependence (“increasing returns”, complementarity, sequences etc.). As these mechanisms are susceptible to fundamental change in different ways and to different degrees, the path dependence concept alone is of only limited explanatory value. It is therefore indispensable to identify the underlying continuity-ensuring mechanism as well if a statement’s empirical value is to go beyond the trivial, always true “history matters”.

Keywords—path dependence, increasing returns, historical institutionalism, lock-in.

I. INTRODUCTION

THE path dependence concept has developed into one of the most frequently used explanatory approaches of the social sciences [1]-[4]. It stresses the historicity of institutions, assuming that decisions taken in the past, established ways of thinking and routines have a decisive impact on the present. Path dependence confines potential action alternatives and thus crucially impacts the course of future developments. In this context, the inclination for stability of path-dependent processes is usually rated extremely high. In many cases, researchers refer to institutional “lock-in”, thereby indicating that deviation from a path or change of paths are to be regarded as cases of absolute exception or even as impossible.

This article wishes to call the alleged *general* inclination for stability of path-dependent processes into question and address opportunities to counter the implicit conservatism of the path dependence theory. It deals with the different reasons for path dependence that can be found in the literature and represent different continuity-ensuring mechanisms [5]-[7] that can be at work when social scientists talk about path dependence. For this purpose, an overview of the discussion shall be given in part 1. In part 2, it shall be argued that basic theoretical assumptions on path dependence do not necessarily rule out fundamental change. If, however, the stability’s

susceptibility remains in the focus, the question comes up which mechanism is underlying institutional continuity. Identification of mechanisms means that options for action concerning the generation, the stabilisation and the termination of continuity come to the fore. As a result – as explained in the concluding part 3 – chances for intended shifts of direction come to the focus of attention. From that point of view, attempts at intervention by actors in the context of historical path dependence no longer seem hopeless or strongly restricted. Characterisation of fundamental change as “unforeseeable exception” becomes obsolete.

II. HISTORY OF THE PATH DEPENDENCE DISCUSSION

The path dependence concept is mostly attributed to economist and business mathematician W. Brian Arthur on the one hand and economic historian Paul A. David on the other. In their analyses, both authors criticise the efficiency assumptions of neo-classical economics. Based on non-linear stochastic models, Arthur [8][9] demonstrates that of two or several alternatives, the most efficient does not necessarily prevail. To accept this kind of inefficiency, Arthur argues, a specific condition is required, which he calls “increasing returns”. This condition is met if more comprehensive application of the technology (or, more generally: increased production or increased distribution of a product) raises the benefit in a self-reinforcing way. According to Arthur [8], this can be the case for various reasons including:

- 1) High initial costs or fixed costs that carry less weight in case of larger quantities,
- 2) Learning effects capable of contributing to the improvement of a product or the reduction of production costs,
- 3) Co-ordination effects resulting from opportunities for co-operation in a situation where various economic actors take similar decisions,
- 4) Adaptive expectations bringing about a situation where a product’s future use depends on its current distribution.

If the requirement of “increasing returns” is met, Arthur argues, anomalies of selection are to be expected that do not occur in case of stable or decreasing returns: among various alternatives, the most efficient will not necessarily prevail. Instead, it remains a relatively open question which of the available alternatives gets the upper hand. If, however, a point of equilibrium is reached, departure from this point is hardly

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possible anymore (lock-in). Small and accidental events can have a strong impact on the assertion of an alternative, as they reinforce a once chosen path of development.

Arthur, in whose opinion the condition of “increasing returns” is of crucial importance for path-dependent development, does not refer to any further, ancillary conditions. However, this condition significantly restricts the area of validity. In Arthur’s opinion, the rule of “diminishing returns” applies to the overwhelming majority of all economic activity. For example, a coffee-farmer who extends his utilisation of land will at some stage be forced to farm fields that are less suitable for coffee growing. This will reduce his returns per unit of area [10]. The condition of “increasing returns” is only met if there is no such limit. Arthur considers the condition to be fulfilled in the area of knowledge-based technology, but not in the resource-based area of the economy.

Owing to this significant restriction on the validity of path dependence, the scientific debate first focussed on finding individual examples of path-dependent development. The thesis was popularised in particular by the work of the second path dependence pioneer Paul A. David [11]-[13]. Using the example of the Qwerty keyboard, David illustrates that a technology is capable of long-term stabilisation even if the reason underlying its development has long lapsed and, in principle, other ways of optimisation are available. His inefficiency assumption concerning the Qwerty keyboard results from the original construction motive. In a “trial and error” procedure, the letters were arranged in such a way that mechanical blockage in type bar typewriters could be minimised. Some letters in the top row owe their positions to the circumstance that, for marketing reasons, users should be able to write the word “typewriter” as quickly and conveniently as possible. By contrast, ergonomic reasons played no more than a secondary role. In particular, David attributes the Qwerty keyboard’s development into the technological standard to two accidental events:

- 1) In historical rapid writing contests, the Qwerty keyboard emerged victorious. This, however, was primarily due to the circumstance that, at that time, the victorious typewriter operators were already proficient in the innovative ten-finger-system.
- 2) Typewriter training and instruction led to an increased dissemination of the Qwerty keyboard, as written learning aides were originally on offer in particular for this type of typewriter.

Owing to technological development (e.g. spherical head typewriters, computers), the main reason for the arrangement of keys later became insignificant. In principle, this would have opened up the opportunity to replace the Qwerty standard with other keyboards. But owing to path dependence, other key arrangements with optimised solutions in terms of writing ergonomics have hitherto been unable to assert themselves. In later articles and in an analogous manner, other authors have illustrated that computer programmes, video

systems technology, nuclear reactors, automobile drive technology and railway track gauges are also subject to technological path dependence [14][15].

In contrast to Arthur, who emphasises “increasing returns” as the sole factor of path-dependent stabilisation, David attributes the establishment of the Qwerty keyboard to a combination of three causation contexts [16]:

- 1) “*System scale economies*” – Rising economies of scale ensure that any market share gained has a positive effect on production costs.
- 2) “*Technical interrelatedness*” – the technology’s benefit rises significantly if the arrangement of keys complies with the user’s learning background.
- 3) “*Quasi-irreversibility of investment*” – once users have learned a certain arrangement of keys, change becomes comparatively costly (relearning time, typing errors).

David uses the concept of “system scale economies” instead of Arthur’s “increasing returns”, which, however, is likely to come down to the same thing. His additional condition of “technical interrelatedness” is an interaction effect that, in a general sense, may well be called “complementarity”. Complementarity can both constitute paths and favour the stabilisation of path-dependent development [17]. In David’s Qwerty example, coincidental interaction of the ten-finger-typing-method with the Qwerty keyboard brings about victory in the rapid writing contests that were of great importance to the path’s establishment. Complementarity can acquire a self-reinforcing character because actors take their bearings from already existing institutions and take the “logic” of institutional configurations into consideration when it comes to their strategic behaviour – which is why this configuration can be reinforced and continued [18][19].

Quasi-irreversibility, the third factor cited by David, is mainly based on the *sequence* of events. For people who have not made any previous experience with typewriter keyboards, learning keyboard arrangement X is likely to be similarly time-consuming as learning keyboard arrangement Y. If, however, a user has already learned keyboard arrangement X, a switch to Y is substantially more time-consuming. In the same way, learning X is hindered if the user in question has learned keyboard arrangement Y. Learning times and efforts for X or Y thus essentially depend on the sequence of events. If someone has already learned X, he will only learn Y in addition if potential returns justify the additional time and effort of relearning. The circumstance that a large number of people have already learned the Qwerty keyboard arrangement means that, for sequence reasons, this arrangement could only be replaced by distinctly superior keyboard arrangements. Among others, Pierson [20] and Rueschemeyer & Stephens [21] point out the importance that sequences have for path-dependent processes.

In conclusion, Arthur and David agree that “increasing returns” are a necessary condition of path dependence. David, however, complements it by additional factors.

Yet the assumption that “increasing returns” are required for path-dependent development is not shared by everybody.

Kenneth J. Arrow [22] for instance denies this, claiming that one of David's early analyses [23] shows that path dependence is possible even without "increasing returns". In the United States of America, mechanical harvesters were used at a much earlier stage than in England, although England initially had a technological advantage. In David's analysis, this fact is attributed to the ploughing method and the depth of furrows respectively. In the United States, it was possible to plough previously uncultivated soils in such a way that harvesters could be used without difficulty. By contrast, soils in England that had already been cultivated for centuries required deep furrows, which hindered the use of harvesters. According to Arrow [22], this example demonstrates that, at least in this case, path dependence is not related to "increasing returns", as the reason given for path dependence is independent of the size of fields or the harvesters' service life. In a concluding, generalised model, Arrow shows that path-dependent processes are possible even in case of complete competition and constant economies of scale. In his opinion, path dependence is not related to "increasing returns", but with quasi-irreversibility (of investment), which David states as an additional condition. The fact that cultivation of fields in England could not simply be reversed prevented the use of harvesters for a long time. Only much later did the further development of agricultural technology allow English farmers to use harvesters too. Arrow identifies similar irreversibility in all other empirical case examples for path-dependent development. In the majority of studies, he admits, there are "increasing returns"; the critical factor however, as demonstrated by the example of harvesters, was quasi-irreversibility.

An extension of the path dependence concept that was of great importance for further discussions and went beyond the concept's previous application to technology research was brought up by Douglass North [24]. North generalises path dependence by making it the basis of a theory of *institutional* change. His theory aims at explaining institutional differences between societies and economies, including an explanation as to why economic systems with a continuously poor performance record remain stable nevertheless. His institution approach breaks away from neoclassical approaches, in which inefficient conditions can only appear as transitional phenomena. Extending the path dependence theory into a theory of institutional change also means that the conditions of path dependence change. North considers "increasing returns" necessary, but not – as in Arthur's view – sufficient. He introduces imperfection of the market, transaction costs and the limited rationality of actors as further conditions.

As compared to the approaches presented above, accentuation of path dependence also underwent substantial change: North gives a different explanation as to why "increasing returns" occur: In his opinion, they primarily result from the mutual relationship of institutionalisation processes [25]. Specific path processes are now no longer caused by "historical coincidence" or "small events", but rather by the actors' continuously limited rationality on the

one hand and high transaction costs for changing institutional systems on the other. Consequently, a change of paths does not seem impossible, but only encumbered with high transaction costs [26]. The phenomenon that efficient alternatives are "locked out" is no longer the focal point of North's analysis, which rather gives room to several alternatives. In his model, simultaneous existence of institutional systems with different levels of efficiency is the normal case. This also has an impact on what he considers to be path-dependent development. From his point of view, path dependence is no longer about the reproduction of the identical (e.g. confirmation of the ever-identical Qwerty keyboard arrangement), but rather about gradual change. North considers institutional change a permanently ongoing incremental process initiated by individual actors and especially by organisations, with the impulse for change originating from the self-interest of actors and from competition among organisations. However, according to North, innovative learning always remains limited, as – when behaving innovatively – actors still take their bearings from the existing institutions, and their "mental models" are also shaped by the past [27].

North's translation of the path dependence thesis to institutional change associates historical continuity of all kinds with the path dependence conception. Like Arthur, he regards the condition of "increasing returns" as a limiting basic requirement. By adding transaction costs and limited rationality as necessary conditions, North loosens the "ceteris paribus" assumptions of neoclassical theory. His additional conditions do not limit the concept's area of application. Instead, North only revokes some unrealistic assumptions of neoclassicism that were introduced into this theoretical context essentially for the facilitation of economic modelling.

All previously discussed approaches to path dependence deal with the *efficiency* of either technologies or institutions. The path dependence thesis serves as an explanation for long-term stability of institutions with different degrees of success and for the predominance of technologies and products, the optimality of which is called into question. The arguments primarily turn against economic equilibrium models in which efficiency is achieved in a state of equilibrium. They are also directed against the notion that "perfect" markets ensure efficient institutions ("invisible hand"). Many of the conditions stated for path dependence such as incomplete rationality of actors, existence of transaction costs or the possibility of "increasing returns" thus result from a critical reference to hegemonic schools of economic thought.

Within the context of other social sciences (e.g. Sociology, Political Science), however, the question of efficiency plays no more than a secondary role. Owing to the impact of power, norms, values, traditions, incomplete rationality and functional logics, it is often assumed in Sociology and Political Science that actors do not take their bearings from (economic) efficiency [28]. The majority of sociological approaches are e.g. not based on an equilibrium model, so that for this reason alone, criticism of equilibrium conceptions voiced by

proponents of the path dependence thesis is partially misdirected. As a result, transfer of the path dependence conception into the context of Sociology and Political Science went hand in hand with further extensions and shifts of the conception.

The currently very intense discussion of the path dependence concept in the social sciences is particularly influenced by the work of political scientist Paul Pierson [3][20]. Pointing out that there is a danger of overstretching the concept by translating it to the non-economic context [3], Pierson holds that the approach has a substantial potential in all social sciences in case of its consistent application. He regards “increasing returns” and self-reinforcing processes as the basis of path dependence. For him, path dependence is of general significance, as – in his opinion – institutions generally meet the condition of “increasing returns”. Institutions create reliability of expectations, and ongoing applicability raises an interest in their perpetuation. Pierson takes the view that secondary conditions – high foundation costs and learning or co-ordination effects – also apply to all institutions. The trend towards perpetuation of existing institutions, he argues, is even higher without the market’s pressure for change, so that path dependence is of far greater relevance in non-economic environments. For the area of politics, he cites the high significance of collective action, the high density of institutions, asymmetric power relations and immanent complexity as additional factors that favour path dependence. Pierson thus extends the reasons stabilising path dependence, as the cited asymmetry of power and the particular logic of collective action do not play a role in the discussion on economic path dependence. However, this extension makes path dependence dependent on actor constellations. Asymmetries of power may change, actors may gain or lose influence. Paul Pierson [20] therefore emphasises that not any path is shaped by self-reinforcing event sequences, and that counter-reactions against stabilisation are possible as well. Paths can therefore come to an end if such counter-reactions occur or reinforcement of a chosen direction does not take place. In his opinion, path-dependent institutionalisation usually does not lead to a “freeze” of existing conditions. Instead, change is merely restricted. Change continues, but it is bounded change – until something erodes or swamps the mechanisms of reproduction that generate institutional continuity [20]. Pierson attributes the narrowness of path-dependent change primarily to the fact that certain options available in the past are no longer available in the present and the future. A chosen “path” is stabilised by the fact that actors keep referring to it in their actions because a cumulation of mutual commitments results. This implies that the initial condition from the beginning of the process is no longer applicable, and the options available at that point in time are no longer available either.

With respect to sociological adaptation of the path dependence concept, James Mahoney [2] takes up the extension by Pierson, describing power-based reproduction as one in several alternative reasons for path-dependent

development. All in all, he distinguishes between four different possibilities of institutional reproduction, thereby referring to various analyses of historical sociology:

- 1) *Utilitarian reasons* are applicable if an institution is reproduced because actors contribute to its stability by taking rational decisions. Co-ordination effects and adaptive expectations contribute to a situation where even inefficient institutions endure despite the rational behaviour of actors. Mahoney refers to Douglass North in particular and implicitly assigns the entire technology-related path dependence research to this reason of reproduction.
- 2) *Functional reasons* play a role if an institution is reproduced because of its function within an institutional system. Owing to path dependence, the stabilised institution may well be less functional than possible alternatives. In this context, Mahoney cites Emmanuel Wallerstein’s [29] world system theory, in which a European capitalism and a Chinese capitalism are envisioned as functional alternatives, with the European model having asserted itself largely by coincidence and seen as having a potentially detrimental effect in functional terms on the current world system.
- 3) *Reproduction on the grounds of power* is applicable if actors can resort to power in order to assert their interest in preserving an institution against other actors. Path dependence can favour certain actors who previously were not part of the power elite. Mahoney cites William G. Roy’s study on the development of America’s private sector [30] as an example. According to Roy, several coincidental events led to a situation where American state-owned enterprises were forced onto the defensive around 1830, and private companies received a boost. The new class of entrepreneurs benefited from this situation and used their new power to promote private enterprise. Hence an originally coincidental trend was consolidated on the basis of power.
- 4) *Legitimacy reasons* apply if institutions are reproduced because actors feel a moral commitment to do so or regard institutions as legitimate. Mahoney cites an analysis by Karen Orren [31] as an example of path dependence for legitimacy reasons. In the state-formation phase of the United States, traditional English labour law was simply transferred, although at that time it was no longer in line with the liberal attitudes of the political and economic elite. Following the transfer, American courts strictly adhered to the assumed labour law on the grounds of its legitimacy and undoubted legal effectiveness. It was not until the increased significance of collective agreements in the 1930s that the courts abandoned this labour law, based on a master-and-servant relationship, as they now considered it to be no longer up to date.

Mahoney thus comes up with a wide range of potential reasons for reproduction of path dependence. Alongside this differentiation, he also distinguishes between “self-reinforcing” path-dependent processes, in which the already

mentioned reproduction reasons take effect, and path dependence based on “reactive sequences”. Reactive sequences are applicable if early events trigger a chain of reactions, which then leads to further events. Whereas self-reinforcing sequences are characterized by processes of reproduction that reinforce early events, reactive sequences are marked by backlash processes that transform and perhaps reverse early events. In a reactive sequence, early events trigger subsequent development not by reproducing a given pattern, but by setting in motion a chain of tightly linked reactions and counter reactions [2]. In case of reactive sequences, the impulse for change features high stability, as it results in change upon change. There needs to be a strong causal link between individual events, so that, as a basic principle, the next event follows from the preceding one without an alternative. Mahoney illustrates this difference using a text by Goldstone [32] as an example. In this text, Goldstone explains the origin of the Industrial Revolution in England as follows: England had only few woods and, owing to the relatively cold climate, coal became the predominant source of heating (event A). Extensive use of coal led to a situation where surface mining reserves were soon exhausted (B), so that a switch to underground mining was required (C). In underground mining, however, groundwater poses a problem (D). To solve this problem, Thomas Newcomen invented a steam engine in 1712, which permitted to pump groundwater out of the gallery (E). The steam engine then triggered a number of follow-up inventions and marks the start of the industrial revolution (F). So it was an unlikely but still conclusive sequence of events (A-E) that led to the industrial revolution.

In all cases – the four self-reinforcing mechanisms of reproduction that he specifies as well as path dependence based on a reactive sequence – Mahoney stresses contingency at the beginning of the process – a contingency that he regards as the main criterion of path dependence. This, however, means there is a distinct shift of emphasis as compared to the institution-economic conception. The latter – as has already been pointed out – places the problem of lacking economic efficiency in the centre of argumentation. As, in Mahoney’s view, this aspect is of relevance only in a special sub-case, he elevates another aspect to become the core of his conception.

This is of relevance insofar as the broader line of argument within historical institutionalism, based on emphasising “initial conditions”, “founding moments” and “critical junctures”, can thus be assigned to the path dependence theory. A synopsis of these lines of argument has been compiled by Thelen [18].

In the context of historical institutionalism, institutions are usually seen as a “legacy” of preceding social conflicts that continue to affect the future. The path dependence concept was originally not used in the studies; instead, they refer to “routes” or, more recently, to “pathways”. Classics of this literature include Moore [33], Gerschenkron [34], Skocpol [35] and Collier & Collier [36]. Here, historical continuity is

not primarily attributed to reinforcing mechanisms, but to specifically formative historical events that rule out alternative development. From this point of view, institutional differences arise e.g. because the mode of social transition affects later institutionalisation [37], because comparable decisions were taken in different phases of social development in different countries [36] or because differing geopolitical competitive situations in a specific historical context had a long-term impact on the distribution of power within a society [38]. According to these approaches, the “window of opportunity” closes after the formative event or phase, and a “freeze” or “crystallization” of the generated institutional configuration results [39], or further institutional development following the formative event is considered to be dependent on this event [40]. Most analyses of historical institutionalism do without an explanation as to how the effects of “critical junctures” reproduce themselves in the future. Institutions are thus per se classified as permanent. This is clearly criticised for instance by Kathleen Thelen [18]. As an exception in this respect, Thelen cites the analysis by Ruth Berins Collier and David Collier [36]. In this analysis, the differences between Central and South American countries in terms of taking employee interests into consideration are not only attributed to path-forming “critical junctures”, but also to different stabilisation mechanisms (e.g. patronage vs. suppression). What the reasons cited by Collier and Collier have in common is that they are constellations of power distribution and power protection. This also applies to most other historical-institutional analyses even if, in most cases, specific mechanisms remain implicit.

By contrast, sociological *New Institutionalism* within organisation theory assigns the key role for the explanation of institutional continuity to uncertainty. Organisation-theoretical arguments were brought up as a variant of the path dependence theory by Pierson [3] and Thelen [41]. According to the proponents of organisation-sociological institutionalism, actors and organisations take their bearings predominantly from key conceptions that are applicable in their so-called “organisational field” [42]. In this context, institutionalisation of key conceptions is defined as the construction over time of a social definition of reality such that certain ways of action are taken for granted as the ‘right’ if not the only way to do things [43]. In the process of institutionalisation, a joint view on the efficiency or modernity of practises such as the organisational structure of corporations [44] is developed. These joint key conceptions or “scripts” need not necessarily be optimal for all actors or organisations within an organisational field. It is the high extent of uncertainty associated with deviation from the existing key conception that favours behaviour *in conformity* with key conceptions. Under this model, institutional change results from a change in the key conception initiated by an innovator (who is only a peripheral part of the organisational field). Subsequent diffusion processes eventually result in a new phase with high continuity until the then applicable key conception is replaced with another one [41].

To summarise it can be said that the discussion on path dependence has resulted in an extension of the conception's content. The range of reasons underlying path-dependent development is fairly comprehensive. Reference to "path dependence" of developments therefore tends to be ambiguous and can serve as an explanation only to a limited extent. Given this variety, specification of the stabilisation mechanism underlying the individual case seems to be required.

III. SUSCEPTIBILITY OF PATH DEPENDENCE TO FUNDAMENTAL CHANGE

The path dependence theory is *generally* associated with long-term stabilisation of technologies or institutions. The concept has been shaped in a sustainable way by the assumption of a "lock-in" of once found solutions, although this assumption is not included in all variants of path dependence. Nevertheless, path-dependent development is susceptible to fundamental change, the end of a path being within the realms of possibility. In some of the aforementioned conceptions, there is an explicit reference to this fact. All-too often, however, this circumstance remains implicit – a fact that has essentially fostered the association of path dependence with long-lasting stability.

Depending on the underlying reason or stabilisation mechanism, different extents of susceptibility to fundamental change can be assumed. Hence the question of which stabilisation mechanism underlies institutional continuity makes a substantial difference. Or in other words: not all path dependence is alike.

In case of path dependence based on "*increasing returns*", it seems obvious to expect permanent "lock-in" as postulated by W. Brian Arthur himself. However, Arthur may well be accused of using a strongly platonic model. This becomes evident if alternative models for "increasing returns" are taken into consideration. In an explanatory model for his path dependence thesis, Arthur [8] e.g. takes into account the benefit that actors enjoy because other actors take similar decisions, but neglects the potential benefit that deviating actors may enjoy (exclusivity, not being like others etc.). With a different kind of modelling, "lock-in" of one single solution would not necessarily result. How real this possibility can be is demonstrated e.g. by the relative success of Apple Computers.

An extension of model construction as undertaken by Katz & Shapiro [45], who take intentional optional choice and variable adaptive expectations into account, also turns the development process into an open matter. Owing to their alternative modelling, Katz & Shapiro do not refer to "increasing returns", but to "network externality". Network externality can be conceived as economies of scale originating from the demand side. Basically, however, the case of path-dependent stabilisation of an inefficient initial solution complies with Arthur's logic of "increasing returns", which is why "increasing returns" and "network externality" are often used as synonyms. Alongside the effect that, given a constant

network externality, a product becomes more attractive the more customers currently use it, Katz & Shapiro emphasise as a second effect that consumers of durable consumer goods are also interested in these products' future usability – i.e. they *ex ante* prefer marketable products, the future usability of which seems to be guaranteed. If actors form the expectation that an established standard will continue to be applicable in the future, adaptive expectations will produce stabilisation of the chosen path. If that is not the case, however, the result may well be the exact opposite, and an established standard may be given up. In reality, this happens comparatively often. Vinyl records for example were almost completely eliminated from the market by Compact Discs and these by mp3 downloads.

Another modification with similar consequences is undertaken by Ulrich Witt [46]. Deviating from Arthur, Witt does not assume an original situation in which different technologies simultaneously enter a not yet occupied market environment ("virgin market"). In his opinion, a modelling is more appropriate in which new technologies compete with already existing ones. "Increasing returns" then favour the technology that has the highest market share. Owing to this circumstance, new technologies according to Witt need to have a certain absolute advantage over the existing standard in order to prevail. If this advantage is not exorbitantly high, the focus will be on stochastic effects. It is important that a critical market threshold ("critical mass") is reached, from which onwards the development process is bound to favour the new technology. While this threshold can be reached coincidentally by a new technology with minor advantages, another technology with greater advantages may fail to achieve it because of unfortunate selection sequences [46]. Even in this modelling on the effect of "increasing returns", more efficient technologies do not necessarily assert themselves against less efficient ones; however, long-lasting stabilisation of an inefficient technology is seen as an exception. This demonstrates that "increasing returns" do not necessarily lead to long-lasting "lock-ins".

The finiteness of path-dependent development is impressively demonstrated by some of the much-cited examples that, in the meantime, have already become obsolete. The VHS video system did assert itself against the allegedly better Beta technology [47], but is now superseded by other technologies. MS-DOS was able to assert itself against the more convenient DR-DOS. Though today's market leader for standard operating systems is still Microsoft, the original technology has long been replaced. In these cases, a change in the competitive situation is typical of a change in technological standards. The video standard VHS was not replaced by a better video standard, but by a completely new image-recording technology. The programmable operating system MS-DOS was not replaced by other programmable operating systems, but by an object-oriented operating system technology. At present, the strongest technological competitor of the Qwerty keyboard is likely to be not a new "typewriter keyboard", but the multifunctional keyboard of mobile telephones or the language identification technology that is

generally attaining market maturity.

In areas beyond technology-related path dependence research, “increasing returns” were granted a significantly larger field of application. As already mentioned, Douglass North and Paul Pierson act on the assumption that this condition applies to institutions in general. In this context, it needs to be pointed out that wider interpretation of “increasing returns” is a matter of controversy. Using the example of democratic institutions, Gerard Alexander [48] e.g. shows that political actors very often benefit from institutional revisions, that allegedly self-perpetuating “vested interests” [36] are usually called into question by others, that – as a basic principle – the transaction cost of changing democratic rules is rather low and that the most frequently cited causes of “increasing returns” apply to such institutions at best to a limited extent. Accordingly, actors by no means consider institutions consolidated, but continuously press for change and demand review [48]. General reference to path dependence of institutions is therefore exaggerated, and it has to be precisely checked in each case whether the conditions are met for the institution under review.

Beside this criticism, the following seems to be relevant as well: As a result of translating the “increasing returns” logic to institutions, this logic has lost its original accuracy. Both North and Pierson do not act on the assumption of hyper-stable institutions and irreversible “lock-ins”. North for instance emphasises the transaction costs of path change. Provided that these are fairly low, a path may be terminated despite “increasing returns”. Beside the amount of costs, secondary aspects such as calculability of transaction costs are also likely to play a role, as collective actors will be more willing to cover easily assessable costs than costs that are difficult to assess and tend to be variable. In addition, the transaction costs of change can alter in the course of time, as it cannot be ruled out that intervening factors exert influence on their amount. As a basic principle, even North’s theory that places gradual change in the centre includes the possibility that dynamic upheaval follows a long period of historical continuity. Similarly, Pierson allows for the termination of path-dependent continuity on the grounds that self-reinforcement fails to take place or that counter-reactions occur as one plausible possibility.

The other reasons for stability or reproduction of path dependence are also susceptible to fundamental change. In case of institutional *complementarity*, an essential reason for change is related to the same logic that is responsible for stability. If advantages result from the combination of institutions, individual institutions can only be changed if actors are ready to give up this advantage. If change takes place nevertheless, all institutions linked by complementarity will come under pressure for adaptation. In the process of transition, “domino effects” may occur. Beside susceptibility in case of selective change, fundamental change is to be expected in particular if the absolute or relative advantage resulting from combination decreases or ceases to be of importance because of intervening factors. For example,

complementarity may lead to a situation where the settlement of certain industrial sectors at certain locations is favoured (e.g. shipbuilding in regions near the coast). If this branch of industry’s overall significance decreases, continuing interactive relationships may become irrelevant.

In another cause of path dependent development – sequencing of events – fundamental change seems to be unlikely at first sight. In case of events that took place in a certain chronological order, it is ruled out that this order of events is simply reversed. At times, the effects of events can be reversed, but the events themselves cannot be undone. In many cases, the effects are difficult to reverse as well. Irreversibility, however, does not allow the conclusion that such paths are not susceptible to fundamental change.

While it is true that already performed sequences cannot be reversed, the consequences of sequences may last for different periods of time. Sequencing does not include a reinforcement or reproduction mechanism, so that – though sequences have differentiating effects [49] – these differences need not continue. Basically, other factors and new sequences are able to annul, overlay or reverse the effects. The example of harvesters proposed by David [23] proves precisely this. From a certain point in time, the depth of furrows was no longer relevant, and harvesters were used both in the United States and Great Britain. So in the course of time, bifurcation of paths came to an end.

Another variant of path dependence based on sequences provides that certain sequences of events take place in the same chronological order several times. This can be exemplified by the Qwerty keyboard, where the repeated process of learning the keyboard arrangement produces the effect that, subsequently, other arrangements of keys are less easy to learn. If these sequences of events are not independent of each other – in this example, because supplementary network externalities suggest learning the standard arrangement of keys – a kind of path dependence results that, owing to the repetition of sequences, can less easily be overlaid by other effects. But even in this case, change of paths is not completely ruled out. In a subpopulation for instance, the same mechanism may reproduce a different sequence. An organisation deliberately opting against the Qwerty keyboard would be well advised to acquire exclusively such persons who had no previous typewriting experience with the Qwerty keyboard. For these persons, retroactive learning of the Qwerty keyboard would turn out to be difficult too. Fundamental change could then be initiated for instance through growth of the subpopulation.

“Reactive sequences”, in which events have a causal connection to subsequent events, represent another variant of sequence-based path dependence. As already mentioned, “reactive sequences” tend to be exceptional cases, as events usually do not result from preceding events without an alternative.

Power-, function- and legitimacy-based reasons for stability that have been introduced into the socio-scientific debate on path dependence are mostly understood by their authors in

such a way that fundamental change is not ruled out anyway. At new critical junctures, further bifurcation or termination of a path is deemed possible. In an overview of the many possible reasons for reproduction of path dependent development, James Mahoney [2] states typical reasons for deviation from a chosen path. In case of *power-based* path dependence, he refers to a potential change in the power elite's composition and to a situation where opposing groups that were less powerful at the start, later gain in power. Such changes can occur either abruptly (e.g. revolutions) or – as pointed out in particular by Kathleen Thelen [41] – by smooth transition. In many cases of path-dependent development, she argues, institutional transformation and remodelling is to be expected, resulting in a mixture of continuity and discontinuity. From this perspective, fundamental change can go ahead even with the preservation of partial or purely symbolic path continuity. In this context, Thelen refers to two mechanisms:

The “*institutional layering*” mechanism is at work if groups of actors do not possess sufficient power to do away with existing institutions, but are strong enough to introduce new, supplemental institutions. By implementing institutional innovations, actors can fundamentally change the institutional system without openly calling it into question. As a typical example, Thelen cites the change of state constitutions that are amended by new laws and thereby undergo partially fundamental change without a fundamental reversion of existing constitutional elements.

By contrast, the “*institutional conversion*” mechanism means that a change of actor constellations can also fundamentally change the character of an institution without calling the institution itself into question. As an example, she cites the German vocational education system: the trade unions who were originally of no significance for the emergence of the education system, later became its central supporters because, in the course of time, they managed to substantially reorganise the system.

All this gets us to the conclusion that, in the case of power-based path dependence, there are various variants of fundamental change, and the type of transition depends on the skills and strategies of potential counter-groups as well as on the strategies of established power elites.

In case of *legitimacy-based* path dependence, fundamental change is not ruled out either. The change of norms and values surely is a long-term process in most cases, but it is going on continuously. In terms of legitimacy, stability is likely to be most sustainable if legitimacy seems “objectively” predetermined. With reference to Berger & Luckmann [50], it is possible to link the transition of habitual patterns of action into “objective reality” with the alteration of generations. To individuals who did not immediately experience the emergence of patterns of action, their legitimacy seems to be predetermined and not socially constructed. In turn, this permits the conclusion that a change of paths is particularly likely if awareness of the institutionalisation process can be updated e.g. through reference to other traditions.

“Objectivity” can also be called into question by a situation where diverging interpretations are possible, because then social construction comes to light owing to the struggle for interpretative dominance. The example cited by Mahoney – the initial American labour law, based on a master-and-servant relationship – indicates that there is another possibility of terminating legitimacy-based continuity. In this case, transition to a new set of laws became possible because existing regulations were no longer considered to be purposeful.

What James Mahoney [2] rates highest is the stability of *function-based* path dependence. Mahoney considers external shocks to be the typical mechanism of path termination, as they change the functional requirements of the overall system and thus stimulate institutional change. Yet Mahoney seems to disregard the fact that functional compliance does not necessarily reproduce itself. As an example, wells in arid environments may be cited, the function of which (water supply) can be called into question by their own utilisation (potentially leading to a decrease in the ground water level). In most cases, function and dysfunction (which are called effect and side-effect in the case of medication) go hand in hand, so that functional compliance does not necessarily suggest a continuous path-dependent stability that can only be changed by external shocks. The typical reason for path change from a functionalist point of view is dysfunction that can have various exogenous and endogenous reasons.

Compliance with existing key conceptions and action scripts for reasons of uncertainty reduction and *conformity*, as discussed in neo-institutional organisation theory, is not immune against fundamental change either. The change of key conceptions within an “organisational field” is inherent from the outset in this theoretical context. Innovations or crises can lead to a situation where old key conceptions are called into question and replaced with new ones. A temporary change of key conceptions is even highly likely, as constructed ideas on efficiency, legitimacy or modernity of the practices underlying key conceptions are usually in no way optimal for all actors and organisations within the organisational field. For that reason, deviation from the key conception is associated with a high risk, but this risk may well be worth taking if the actors – despite the high extent of uncertainty – find a better solution for themselves. Successful deviations can thus become a starting-point for new key conceptions.

To summarise it can be stated that all paths are susceptible to fundamental change. Moreover, the discussion on the susceptibility of path-dependent processes to fundamental change has shown that the mechanism underlying historical continuity makes a difference because susceptibility has different reasons in each specified case (see table 1).

IV. SUSCEPTIBLE STABILITY AND CHANCES OF INTERVENTION

As shown by our review of explanations given for path dependence, the range of what can be understood as path dependence is pretty wide. This also refers to the assumed

TABLE I
OVERVIEW OF MECHANISMS CAPABLE OF PRODUCING PATH-DEPENDENT
CONTINUITY

Mechanism	Continuity-ensuring logic	Destabilization options
Increasing Returns	Self-reinforcing effect	Formation of adaptive expectations against established institutions; transaction costs of change are low and/or assessable; transgression of quantitative thresholds in combination with substantial efficiency gaps; transition to decreasing returns owing to change in the environment
Sequences	Irreversibility / Quasi-Irreversibility of event sequences	Overlay of effects; counter-sequences with annulling effect; termination of "reactive" sequences as soon as alternative options for action emerge
Functionality	Purposes, systemic requirements	Change of functional requirements caused by external circumstances; dysfunction as a result of functional compliance; emergence of significant "secondary effects", replacement by functional equivalents
Complementarity	Interaction effect	Domino effect following partial change; end of complementarity because of intervening factors; loss in the complementarity effect's relevance
Power	Power saving, power of veto	Formation of countervailing power; infiltration or "conversion"; influence or "layering" that suggest supplementation
Legitimacy	Belief in legitimacy, sanctions	Diverging interpretations and traditions; delegitimation because of contradictions, e.g. inexpedience
Conformity	Exoneration from decision, mimetic isomorphism	Assertion of a new key conception e.g. because an innovation or crisis calls the old key conception into question

reasons for high stability of developments. Precise analysis unveils that each and every continuity-ensuring mechanism offers opportunities for the termination of path-dependent development or abandonment of a chosen path. In each and every approach – no matter whether they refer to "increasing returns", complementarity, power constellations or other bases of path dependence – termination of a path is possible. If this is taken into account, all paths seem to be more or less susceptible to fundamental change. In addition, the fact is of significance that susceptibility to fundamental change differs depending on the assumed reason for path dependence and on the assumed mechanism of stabilisation.

As actors can systematically capitalise on their awareness of a path's specific susceptibility to fundamental change, path-dependent development is not protected against successful intervention. Strategic action in this sense was taken for instance by Nintendo when introducing its game console "Wii". In this case, awareness of the "increasing returns" effect in this market segment determined the corporation's

product and marketing strategy. While the product was designed to be attractive for new customer groups, the market was not entered until it was ensured that sufficient programmes were available; and the marketing strategy aimed at gaining a high market share as soon as possible. According to Arthur [10], this competitive strategy, consciously putting up with high "sunk costs" in order to realise a high market share, is typical of market segments that meet the "increasing returns" condition.

"Quasi-irreversibility" of path dependence based on *sequences* can likewise be thwarted by purposeful collective action, as a reinforcement mechanism is not inherent in the sequences. In addition, actors can influence the sequence of events and thus bring sequence effects to bear against existing sequences. Path dependence based on *functionality* can be changed by actors by means of functional equivalents or completely abandoned by calling the systemic correlation into question. In case of high *complementarity*, actors interested in change may be well advised to focus their resources on the change of one element, as the change of this element may be sufficient to bring about comprehensive change. With regard to purely *power-based* path dependence, one would also be completely mistaken to believe in deterministic non-changeability. In these cases, change-oriented action can aim e.g. at the establishment of countervailing power, infiltration or the implementation of supplemental institutions. It also seems evident that actors can systematically call *legitimacy* into question, and that *conformity-induced* path dependence can come under pressure for change if actors try to enforce new key conceptions.

As a matter of course, this does not imply that path dependence can be terminated easily or that its termination is more or less foreseeable provided that one chooses the right kind of strategy. Efforts for reform-oriented change are always associated with unintended effects – this becomes the more applicable, the more complex action situations are. Long-term stability tends to militate in favour of high hurdles for change. This resistance to change, however, essentially differs from "lock-in" determinism. Reforms are possible at any rate. Admittedly, the extent to which initiated reforms comply with original expectations always remains uncertain. In this respect, failure continues to be of relevance. As explained, however, failure owing to a situation where intervention is categorically impossible can be ruled out for all variants of path dependence.

An implicit conservatism of the path dependence theory can thus be countered if susceptibility of developments to change is taken into consideration. Then, institutional stability no longer appears to be consolidated in non-specific ways or highly determined, but remains dependent on the ongoing effectiveness of a stabilisation mechanism. Each of the mechanisms discussed indicates the kind of potential path change. Though the time of change remains an open question, there are concrete options concerning the method by which change can be achieved. These options can then be extended and specified by means of additional empirical research. It is

the specification of underlying mechanisms that permits to move susceptibility to fundamental change and chances of intervention into the focus. To talk of path-dependent development being "locked in" is no more than a metaphor for ongoing effectiveness of a stabilisation mechanism. What should be borne in mind is that actors are always capable of finding a key by which to reopen the lock.

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