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Capitalism as a complex adaptive system and its growth

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Abstract

Complex adaptive systems consist of a multitude of agents from whose individual adaptation efforts the adaptive behavior of the system as a whole emerges. In this paper it will be argued that capitalism is a complex adaptive system. Except for its particular mode of production many of its features are typical for such a system. A case in point is the way in which economic growth emerges as a collective outcome of individual adaptation strategies. The complex adaptive systems perspective offers a particular explanation for why the successive extension of the bounds of existing production possibilities is unsteady and rather wasteful in capitalism. Moreover, the strategies by which the agents try to adapt to crises – many of which imply some form of innovations – do not necessarily contribute to a re-emergence of new growth impulses. It is shown that the empirical record of economic growth in the most developed economies indeed reveals a trend of declining growth rates. This seems to suggest that successfully creating new economic growth through innovative strategies is the more difficult, the more prosperous an economy becomes. The paper discusses what can be conjectured to be the cause of this development and what to do about it.

Introduction

Complex adaptive systems consist of a multitude of agents from whose individual adaptation efforts the adaptive behavior of the system as a whole emerges. At both levels, the level of the individual agents and the level of the system as a whole, viability is contingent on a proper adaptation to the environment. The adaptation of the system as a whole is the collective outcome of the adaptation efforts of all its individual agents. This multi-level adaptation process is neither certain to be a smooth one nor to be necessarily successful in the sense of improvement, progress, or growth. To the contrary, there are cases in which complex adaptive systems mal-adapt as a whole (Wilson 2016).

In this paper it will be argued that capitalism is a complex adaptive system. Except for its particular mode of production many of its features are typical for complex adaptive systems. A case in point is the way in which economic growth emerges as a collective outcome of individual adaptation strategies. As will be discussed, a complex adaptive systems perspective suggests that the process by which the bounds of the existing production opportunities are successively expanded in capitalism is unsteady and rather wasteful. Taking such a perspective on economic growth therefore requires

turning away from the equilibrium theories of balanced growth (starting with Solow 1956) as well as the more recent endogenous growth theories à la Aghion and Howitt (1998). Once such a turn has been made, an important problem that appears on the screen is whether and how new economic growth can re-emerge after each crisis. Can a high-rate growth be resumed or is capitalist growth leveling off?

The unsteadiness of capitalist development is a longstanding theme of economic theorizing from Marx (1867) to Schumpeter (1934[1912]) to Keynes (1937). In contrast, the question of whether economic growth will prevail has only more recently gained increasing attention. It was raised as a consequence of observing secularly declining growth rates in the most developed economies since the 1970s (Durlauf et al. 2005, see also Maddison 2001, Chap. 3). From a complex adaptive systems point of view, an industry's contribution to national economic growth is the collective outcome of the efforts at the individual level to adapt to a critically changing environment. The interesting point therefore is how the results of individual adaptation efforts may have changed so that declining growth rates result at the national level. As will be discussed, an analysis of the typical individual adaptation strategies to capitalist crises can offer a clue for understanding what obstacles to growth have occurred and what can be done to extend possible limits of capitalist growth.

The argumentation in the paper proceeds as follows. Section 2 sets the frame by explaining why capitalism can be interpreted as a complex adaptive system. The vulnerability of the capitalist growth process to crises is then argued to be explicable as a typical feature of such systems. The key point is the role which mass production and its accumulation needs play for capitalism and its unsteadiness. Before starting a theoretical reflection on whether economic growth re-emerges as a result of the adaptive efforts undertaken during the crises, Section 3 briefly highlights the empirical growth record. The analysis suggests that some systematic change is going on as capitalist countries become more prosperous. Section 4 traces the cause(s) of that change. The specific adaptation strategies of industries facing a crisis are explored with respect to what they contribute to a re-emergence of economics growth. All discussed strategies involve some type of innovation, but these innovations differ substantially regarding their effect on economic growth. As will turn out, the differences between them also hint at what is changing when economies get more prosperous and what can be done when, as a consequence, their growth rates decline. Section 5 offers the conclusions.

Complex adaptive systems, capitalism, and the unsteadiness of the growth process

Before addressing the growth problems of capitalist economies from the perspective of complex adaptive systems it is useful to briefly outline the main features of such systems. A system is called complex if two conditions are met (Gell-Mann 1995). First, it is composed of a large number of parts or agents from whose individual behavior the behavior of the system as a whole emerges. Second, the interactions between the individual parts or agents are such that the emerging behavior of the system as a whole is difficult to predict on the basis of only observing the behavior at the individual level.

The distinctive feature of complex *adaptive* systems – a subclass of complex systems that consists of living systems – is that the individual agents create, and operate in, an evolving environment to which they must continually adapt under competitive

conditions (Wilson 2016). This means that failure to adapt carries the risk of being outcompeted. The adaptation of the system as a whole is the collective outcome of the adaptive efforts of all of its agents. The latter efforts are not necessarily conducive to a successful adaptation of the system as a whole. Some forms of individual adaptive behavior do contribute to a highly successful collective adaption. Other forms do not or do even harm to the collective adaptation (which may then result in causing damage to the adaptive success of all agents in the system). The individual adaptation efforts can thus result in an unintended and perhaps undesired collective adaption. This means, conversely, that the individually pursued intentions of the agents often do not materialize as envisioned.

The economy of a region or a country is obviously a complex adaptive system. It is made up of a multitude of agents. Their adaptive behavior is characterized by a competitive pursuit of their interests, be it in a cooperative or non-cooperative manner.[1] But not only individual agents have to adapt under competitive conditions. All economies are embedded in a changing global economy in which they compete with other economies and face adaptation pressure as a whole in order to catch up or not to fall behind.

Turning to capitalism as a complex adaptive system, its distinctive feature is a particular mode of production: mass production.[2] By decomposing and standardizing the various steps of the transformation of materials and information the task of carrying them out can, in part or in full, be transferred to automata. For setting up the corresponding equipment, investment into capital stock is required that gave capitalism its name. In this way, human production knowhow can be applied and reused over and again and in parallel without much further involvement of human labor. The transformation steps of production can be reiterated more often, faster, and more reliably. (The proviso is, of course, that the necessary materials and non-human energy resources can be made available for running the automata at a reasonable cost.) Production of standardized goods and services in very large numbers becomes feasible so that scale economies can be exploited. This means that labor requirements and production costs per unit of output decrease by orders of magnitude as compared to handicraft production methods or information processing by human labor. Labor productivity increases.

Capitalist mass production has first occurred in the beginning of the nineteenth century (Mokyr 1990, Chap. 5 and 6). Historically seen, there is no doubt that it has contributed since to the improved "standard of living of the masses" (as Schumpeter 1942, Chap. 7 put it). Capitalism being a complex adaptive system, a positive long run trend like this is the collective outcome of the agents' simultaneous adaption efforts over an extended period of time. Such a collective outcome can neither be taken for granted nor be extrapolated into the future. In fact, the expansion of capitalist mass production has never been a frictionless adaption process. The unsteady and rather wasteful episodes of booms and busts, of rapid growth and temporary decline, are but averaged out in the long run.[3] Moreover, in the present context particularly notable is the recent leveling off of the growth trend in the most prosperous economies.

A closer look at how capitalism works as a complex adaptive system reveals why the individual adaptation efforts result in an unsteady collective outcome in terms of growth rates. For every entrepreneur competing by-the-rules in free markets it is an

imperative to reduce costs, be it for obtaining an advantage over competitors or for keeping pace with them. Realizing scale economies through mass production of goods or services is a prime strategy to do so, particularly if competitors still rely on customized handicraft production or information processing techniques predominantly based on human labor. However, these attempts require investments in creating or expanding a capital stock. The more entrepreneurs in an industry try to realize the cost advantage, the more the industry's overall production capacity grows. The individual parallel expansion efforts are not coordinated *ex ante* by the price mechanism. Therefore, their collective outcome – the parallel multiplication of output – sharply increases competitive pressure at the industry level in an unanticipated way, if the demand for the industry's output is not, or not sufficiently rapidly, growing.

This is especially the case when ever more producers of customized goods or services have already been driven out of the market and mass producers remain as sole competitors. Prices tend to fall and so do the returns – often to an extent that losses have to be incurred. Sooner or later producers are then forced into wasteful adjustment processes of the production capacity. Capital is prematurely depreciated; labor is laid off; entire enterprises go out of business, net investment plunges. In free markets, the competitive behavior that appears most advantageous to the individual producer can thus result in an undesired outcome for the industry as a whole or even the entire economy.

As mentioned in the introduction, the unsteadiness of capitalism – explained here as a typical feature of a complex adaptive systems – has since long been recognized in economic theorizing. On the basis of his labor theory of value, Marx (1867) argued that, by necessity, the capitalist accumulation process leads to a falling profit rate. He saw a culminating sequence of crises ruining capitalists and causing an increasing pauperization of the working class. This, he believed, would ultimately provoke the transition to a communist economy. But how would such a non-capitalist economy then be run? The answer that was given later (see Lerner 1944) included the replacement of the multitude of independently planning capitalists by a central planning authority. From a complex systems perspective, such an institutional change on the production side (associated with a complete change of the ownership structure) can be seen as an attempt to reduce the complexity of the system. However, as the experience with actual socialist planning showed, the attempt failed. The lack of *ex ante* coordination in the capitalist accumulation process was just replaced by an equally wasteful lack of coordination. The centrally planned accumulation and mass production rarely met with the actual levels of labor supply and demand for goods and services to which the still independently deciding agents in the economy adapted.

Concerns about a secularly decreasing rate of return on investment were issued by Keynes as well. To explain the emergence of crises which he considered symptomatic of capitalism Keynes focused on effective demand failures. They occur when aggregate demand falls short of what is necessary to keep up full employment of all resources, in particular labor. Assuming that private consumption is a fixed share of income (and aggregate savings therefore not a function of the interest rate), Keynes attributed the cause of the demand failure to fluctuations of the rate of investment. His hypothesis was that these fluctuations do not automatically lead back to a rate restoring full employment (see Keynes 1937 for a summary). To resolve the crises, his followers suggested that the central bank should increase money supply to lower the interest rate

(monetary easing) and thus stimulate additional investment. Where this would not work because of unfavorable liquidity preference in the money market, the effective demand failure should be compensated by government expenditures raised beyond tax revenues (deficit spending).

From a complex systems point of view such a policy recommendation largely underrates the problem of predicting the behavior of complex systems as a whole. Both government and central bank are each but one agent among many (albeit more influential than the rest). Government and central bank actions are usually based on more or less refined linear extrapolations of the behavior of all other agents taken together. But this is an assumption that rarely suits complex systems. Not surprisingly, the experience with effective demand management policies, both monetary and fiscal ones, is therefore a rather mixed one.

The unsteadiness of capitalist economies is also center stage in Schumpeter's (1934 [1912]) path-breaking work on innovation-driven economic development. At the core of his theory is entrepreneurship capable of carrying out new combinations of resources, i.e. innovations. Only the most gifted entrepreneurs are assumed to have such a pioneering capacity. In a rather complex argumentation he submitted that these entrepreneurs appear "in swarms". A new swarm is supposed to enter the scene when the innovative boost brought to the economy by the previous swarm has ebbed away. Once the initial obstacles have been overcome, however, less entrepreneurial talent is required. Imitators get opportunities to participate in exploiting the innovation and massively invest and start producing in parallel. The result is a boom. It gets stuck once the unanticipated excess capacities bring down the profitability and a massive parallel repayment of credits induces an economic contraction.[4] Nonetheless, after each cycle, Schumpeter claims, the economy has been growing thanks to the innovation. Schumpeter's explanation is very much in line with the complex systems view. Yet, in the light of such a view, his growth optimism seems less well founded. It may be an ex post generalization of the growth that Schumpeter observed during the industrialization phase of his time. And it certainly rests on the hypothesis that (innovative) supply creates its own demand – which means that Schumpeter trusted Say's law.

Growth slowdown – the path capitalism is taking?

The wasteful unsteadiness of capital accumulation required for mass production is one cause for the observable ups and downs in aggregate output and employment described as alternating periods of booms and crises in various theories of the business cycle. Its unsteadiness notwithstanding, the accumulation process has resulted in an unprecedented growth of income and wealth over almost two centuries now. This was certainly not the balanced growth obeying "golden rules" as equilibrium growth models have it, but rather a process that successively expanded the bounds of the existing production opportunities in an unsteady and rather wasteful fashion. In the complex systems perspective, a collective outcome such as a long period of economic growth cannot simply be extrapolated to extend into the future. In complex adaptive systems, small changes in the agents' adaptation behavior and its success at the individual level can trigger a substantial change in the behavior of the system as a whole. The question is what the consequences may be for the growth performance of capitalism.

Most economic policy programs heavily rely on economic growth today and are supported by widespread growth optimism in economics. As a matter of fact, however, the

growth trend is leveling off in most highly developed economies. In the empirical macroeconomic literature dealing with the trend, attention has been detracted from this fact by a partly esoteric debate on whether the fluctuations in the aggregate economic variables are caused endogenously or by exogenous shocks and, in the latter case, of what kind of shocks.[5] Nonetheless, it is not subject to controversy in this literature that for the U.S. and other highly developed countries the empirical finding is a log-linear shape of the trend in real GDP per capita. Measured in growth rates, this implies a declining trend for the rate of economic growth. Unlike in the newly industrializing, less developed countries and in countries making the transition from socialism to capitalism in the 1990s, this trend can indeed be observed in most developed economies.

For demonstrating the rather obvious development a simple statistical exercise of fitting a linear trend for the times series of the GDP growth rates may do here. In order to obtain a timespan that is long enough for avoiding biases by shorter term fluctuations of GDP consider the economies of the 27 countries which were members of the OECD back in 1961. These countries belonged to the relatively most developed in the world at that time. They experienced no significant real structural breaks such as wars or massive natural disasters over the period of half a century from 1961 to 2011 (perhaps with the exception of Germany). When fitting a simple linear trend for the time series of the growth rates of real GDP per capita for each of the countries over this period, the finding is a statistically significant – and partly dramatic – downward slope in the trend of the growth rates of GDP per capita in 23 out of 27 OECD countries.[6]

Taking all 27 OECD countries together, the averages of their yearly growth rates displayed in Fig. 1 show the unsteadiness of the growth process in the entire developed economies. Moreover, using all the average values for fitting a simple linear trend results in the plain, downward sloping trend also displayed in Fig. 1 – a clear indication that economic growth is leveling off. Evidently, surging economic growth still happened during the last fifty years. Yet it took place elsewhere: in Asia, in several of the former socialist European countries, and most recently in some places in Africa (see Durlauf et al. 2005).[7]

Particularly impressive is the decrease of the growth rates for the 17 Western European countries in Table 1. They all belong to the most prosperous in the world, and they all have left their industrialization phase behind. For all of them, regressing their annual growth rates on the time variable results in a coefficient < 0 for the estimated linear trends which is significant at very low error levels, except

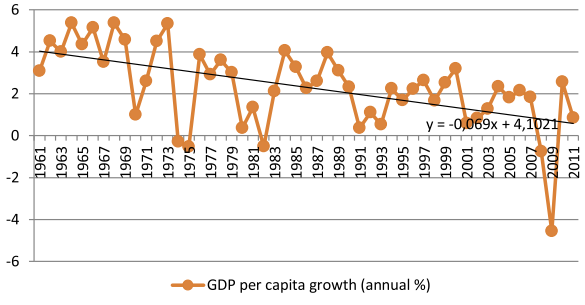

Fig. 1 Average Growth Rates of GDP per Capita 1961–2011 for all OECD countries of 1961 in % (deflated)

Table 1 Estimated Linear Trend Parameters for Real GDP per Capita Growth Rates in % 1961–2011 [a]

Country	Intercept			Regression Coefficients			R^2	DW	ADF	PP
	Value	t	*p*-value	Value	t	*p*-value				
Austria	4.25***	8.76	0.0000	−0.0636***	−3.91	0.0003	0.24	1.96	1%	1%
Belgium	4.36***	8.73	0.0000	−0.0756***	−4.51	0.0000	0.29	2.02	5%	1%
Denmark	3.75***	5.98	0.0000	−0.0674***	−3.21	0.0023	0.17	1.92	1%	1%
Finland	4.21***	4.82	0.0000	−0.0586*	−2.00	0.0508	0.08	1.27	1%	1%
France	4.50***	10.62	0.0000	−0.0870***	−6.13	0.0000	0.43	1.55	5%	1%
Germany	3.70***	6.64	0.0000	−0.0537***	−2.88	0.0059	0.14	1.79	1%	1%
Greece	6.42***	6.25	0.0000	−0.1437***	−4.19	0.0001	0.26	1.23	n.s.	1%
Iceland	4.57***	4.15	0.0001	−0.0787**	−2.13	0.0380	0.08	1.16	1%	1%
Ireland	6.90***	6.19	0.0000	−0.1032***	−2.77	0.0080	0.14	1.30	5%	1%
Italy	5.32***	9.60	0.0000	−0.1136***	−6.13	0.0000	0.43	1.92	5%	1%
Luxembourg	2.96***	2.99	0.0043	−0.0096	−0.29	0.7729	0.00	1.50	1%	1%
Netherlands	3.63***	6.35	0.0000	−0.0522***	−2.73	0.0088	0.13	1.52	1%	1%
Norway	4.46***	9.55	0.0000	−0.0702***	−4.49	0.0000	0.29	1.20	5%	1%
Portugal	6.66***	7.01	0.0000	−0.1320***	−4.15	0.0001	0.26	1.34	5%	1%
Spain	5.86***	8.73	0.0000	−0.1150***	−5.12	0.0000	0.35	0.76	5%	5%
Sweden	3.04***	4.74	0.0000	−0.0332	−1.55	0.1283	0.05	1.38	1%	1%
United Kingdom	2.76***	4.54	0.0000	−0.0262	−1.29	0.2034	0.03	1.44	1%	1%

Error Probability: *** 0.01, ** 0.05, * 0.1

[a] own calculation based on Worldbank WDI dataset: http://databank.worldbank.org/ddp/home.do

for Luxembourg and the U.K.[8] The intercept values are the lowest for Luxembourg, Sweden, and the U.K. The highest intercept values reflecting the initially highest growth rates are those for Ireland, Portugal, and Greece which have been catching-up countries for the first thirty years in the observation period. Portugal and Greece also show the steepest decline of the trend, perhaps not an unusual pattern for catching-up economies.[9]

The explanation of the secular trend of falling economic growth rates is far from being uncontroversial (see, e.g., Durlauf et al. 2005, Gordon 2012, Summers 2014). Very likely, in each country some individual particularities contribute to the phenomenon. On the other hand, the fact that the phenomenon is so wide-spread suggests that there is some systematic change going on when countries become more prosperous. The generic pattern of change seems to be that countries which grow rich travel down a path that converges to a lower bound of their economic growth rates. That bound may, or may not, have a value greater than zero. Corresponding to their respective levels of prosperity, some countries seem to have moved further ahead already on the convergence path, others are more behind.[10]

Adaptation by innovating, Say's law, and the problem of market saturation

What is the reason for the change that is obviously going on and that causes the observed leveling off of economic growth? A clue can be found by looking more closely into the adaptive efforts by which entrepreneurs try to cope with the increasing competitive pressure. As mentioned, this pressure builds up when, as collective outcome of the parallel expansion of mass production, output multiplies but demand does not keep pace with the growing supply. Since the latter condition implies that Say's law is

violated, a discussion of the micro foundations of that law is due here: What can be inferred from the analysis of the producers' adaptive efforts regarding the conditions under which Say's does, or does not, hold? Do their adaptive efforts enable the producers not only to escape from an individual profitability crisis but also to expand sales (reflecting a correspondingly growing demand) and thus to collectively contribute to new economic growth?

The main adaptive strategies producers can pursue all reach out beyond the ordinary daily business, i.e. they all require successfully carrying out innovations. By the logic of mass production, six types of innovative strategies can be distinguished.[11] In industries which are highly competitive due to excess mass production capacities, cutting costs and prices is a way of grabbing a larger share in the market and driving out competitors. To achieve this goal, a typical strategy that can often be observed to be chosen in such industries is *(i) realizing additional scale economies by mergers and acquisition*. Mergers and acquisition can help to concentrate production and marketing activities and thus to enlarge the scale of activities in order to reap the benefits of scale economies, i.e. to be able to move down a falling unit cost curve. Although not all mergers and acquisitions are motivated this way, in the typical mass production industries many are: in recent times, e.g., in parts of the chemical industry, in the steel industry, cement and construction materials industry, car manufacturing, consumer electronics, mobile phone service providers to mention just a few.

Another typical strategy is *(ii) reducing labor costs and costs of regulations by off-shoring production*. Off-shoring production to countries with significantly lower wages and/or less restrictive and, hence, less costly regulations on, e.g., environmental or safety standards helps bringing down the costs per unit of output as well. Off-shoring production usually goes hand in hand with outsourcing to, and subcontracting with, foreign producers in low cost countries. Good examples are the footwear industry (Donaghu and Barff 1990, Frenkel 2001) and the apparel industry (see, e.g., Gereffi 1999).

The major innovation implied by strategies (i) and (ii) is industrial (re-)organization. It typically occurs in the so-called "shake out" phase of the life cycle of a maturing mass producing industry (Klepper 2002). If the growth of the industry's sales is not already stagnating in this phase, growth rates are at least significantly declining. Put differently, the more mature the industry is, the less is its demand curve shifting outwards. The still not sufficiently reduced growth of production capacities puts strong competitive pressure on the producers. The likely result are cost and price cuts and a redistribution of market shares between surviving producers and those being driven out of the market. Extra demand, i.e. an outward shift of the industry's demand curve, is not induced in this way. (The cost and price reductions only activate additional demand along the given demand curve, depending on the price elasticity of demand.) For that reason it can be expected that, in reaction to an over-accumulation crises, an industry's adaptation efforts using (i) and (ii) makes a collective contribution to economic growth which is the smaller, the more mature an industry is.[12]

Something similar holds for a strategy consisting of *(iii) improving standardization, automation, and/or resource efficiency*. These activities can be subsumed under the label process innovations. However, a new standardization and new automation hardware can also lead to, or be associated with, the creation of new services particularly in the IT industry. Similarly, improved automation and rising resource efficiency may

affect the quality of goods and services and thus result in product innovations. There is thus a partial overlap with a product innovation strategy (strategy (iv) discussed next). Yet, a main effect of strategy (iii) is a reduction of the unit costs in mass production at any level of scale economies. If an industry faces an over-accumulation crisis, this effect, taken in isolation, can be expected to again translate into price reductions, but not necessarily in an expansion of the market by attracting new customers (i.e. an outward shift of the industry's demand curve). As before, the effect of price cuts on the sales volume of the industry hinges on the price elasticity of its demand. The prediction of the collective outcome of strategy (iii) in terms of economic growth thus depends on the particular circumstances of the industry.

A strategy that relies on product innovations is *(iv) differentiating and diversifying goods and services in innovative ways in order to outcompete similar existing offers*. In non-customized mass product markets for goods and services this type of innovations is particularly frequent in the mature, oligopolistic phases in which the market is quite saturated.[13] This means that the demand for the products of an industry is not growing much, if at all, while continued competitive increases of production capacity result in the familiar pattern of rising pressure on prices and earning. Successfully developing and launching a new vintage of differentiated and diversified goods or services therefore amounts to a large extent to outcompeting previous vintages of differentiations and diversifications. The same fate may of course happen at some future point in time to the vintage that is new today. Consequently, the collective outcome with respect to economic growth of pursuing strategy (iv) is likely to also be correlated with the degree of market saturation an industry is facing. The more mature and saturated the market for its products is, the less growth can be expected to follow from this adaptation strategy.

A further strategy by which producers try to evade an over-accumulation crisis in their traditional mass product markets is *(v) invading markets still dominated by customized handicraft production or human-based information processing*. This can be markets for complex means of production which, by modularization and standardization, are opened up for being produced in large series. Often the invasion activity also occurs in geographically separated markets, e.g., in countries less advanced in their development, or in markets for technologically "affine" goods and services that are not yet produced on large scale.

However, expanding into such markets is possible only once. As discussed, because of the strong unit cost and price reduction caused by mass production, such a step is likely to convert the markets irrevocably into a mass product markets (except, perhaps, for small remaining niches). The conversion can be expected to attract strongly increasing numbers of customers to the market. The demand curve is shifted outwards and, even if fairly price-inelastic in the short run, allows the industry to expand sales substantially. Yet, even when strategy (v) is successful this does not necessarily have a positive effect on economic growth as a collective outcome. The industry's increase of sales may come at the expense of the sale of other industries producing substitutes. The net effect on economic growth therefore hinges on the cross price elasticities of demand and possible income effects. It cannot be predicted without knowing the particular circumstances.

A strategy also relying on product innovations is *(vi) trying to open up ever new domains of life for commercial consumption offers* based on mass produced goods and

services. This can be done by developing not previously existing products designed to serve the needs that characterize the respective domains of life.[14] It is not difficult to find examples for a successful pursuit of that strategy. The "old" consumer goods industries of today once emerged in this way, e.g., that for automobiles. This innovation was originally developed by coach makers and producers of bicycles, sewing-machines, and the like mechanical devices. It opened up the human need for mobility for a commercial mass produced offer. Similarly, radio and television sets were originally launched by telegraphy producers. They opened up entertainment needs for mass produced goods. A more recent example is mobile telephony originally developed by producers of telecommunication equipment. Mobile phones opened up socializing and bonding needs for commercial consumption offers.

Strategy (vi) differs from the other strategies as it requires a longer term engagement in what usually involves the development of technological innovations. Moreover, in many cases the success of the strategy is contingent on parallel systemic investments in an infrastructure on the basis of which the new consumption offers can be used. This means that strategic investments have to be made that exceed the short run adaptations motivated by acute over-accumulation crises. Nonetheless, the mentioned examples show that the industries originally behind the creation of such new markets typically are industries already in a mature phase of their life cycle. They are therefore likely exposed to a tightening competitive pressure in their original mass product markets. They seek to evade the pressure by using their acquired technological expertise for affine applications by strategically building up new, less competitive markets.

Among the innovation waves that most successfully empowered the economic growth of modern capitalism many have originated from the pursuit of this strategy (see Rosenberg and Birdzell 1986, Gordon 2012). Once the new markets had been established and mass production started, the complementary systemic investments followed suit (e.g., building highways, establishing radio and television stations, setting up cellular networks). Moreover, when the market grew and matured, this paved the way for follow-up strategies such as (iii) and (iv) which may have had some growth potential of their own. From these historical observations it can be concluded that the collective outcome of strategy (vi) regarding the direct and indirect growth effects is substantial – if not immediately then as a result of its pacemaker and multiplier effects in the longer run.

The growth effects emerging as collective outcome from the adaptive efforts of the individual producers facing an over-accumulation crisis are summarized in Table 2. In the case of all discussed strategies, the producers develop an innovative response in order to cope with the unsteadiness of capitalist mass production. As can be seen, however, the resulting innovations are not equal with respect to their predicted effects on economic growth. At least in the highly developed economies with their mature industries and often rather saturated markets, the growth effects of the strategies are modest and contingent on the circumstances – except for strategy (vi) and, to a limited extent, for strategy (v).

Thus, the change that is going on when economies grow rich and that seems to force them on a path of secularly declining growth rates is the increasing market saturation. Say's law is not generally valid. Even innovative supply does not always create its own demand – contrary to Schumpeter's assumption. Say's law may be a good empirical generalization for industrializing economies with relatively low, but rising, per capita

Table 2 Individual Adaptation Strategies to Over-accumulation Crisis and Their Predicted Collective Effect on Economic Growth

Strategy	Predicted collective growth effect
(i) realizing additional scale economies by mergers & acquisitions	the smaller, the more mature industries are
(ii) reducing labor and/or regulation costs by off-shoring production	the smaller, the more mature industries are
(iii) improving standardization, automation, and/or resource efficiency	depending on the circumstances of the industries
(iv) diversifying goods and services which compete with existing offers	the smaller, the more saturated the markets
(v) invading markets still dominated by customized handicraft production	substantial, but not repeatable
(vi) opening up ever new domains of life for mass produced goods and services	substantial

income where there is still much room for expanding the standard of living of the masses. For the highly developed, high-income economies a more differentiated picture emerges. It may therefore be conjectured that in the latter economies growth rates are declining as a consequence of a sluggish consumption growth (Foellmi and Zweimüller 2008). In these economies, expansionary surges – and, hence, the major drivers of economic growth – are a matter of only a few innovative industries at a time, industries that are able to create entirely new markets.

What policy implications follow from this conjecture? Subsidizing private R&D directly or by tax privileges is now often recommended as a policy for stimulating economic growth (and has already become quite popular among policy makers). In the light of the preceding discussion this expensive policy would not appear to be very effective in stimulating economic growth as long as all innovations associated with any of the strategies (iii) to (vi) would qualify equally for such subsidies. As discussed, except for those related to strategy (vi) most of the innovations can be predicted not to trigger substantial growth effects. But concentrating R&D subsidies specifically on innovations related to strategy (vi) is difficult. For epistemological reasons, no innovation strategy leaves more room for speculation and uncertainty than the attempt to create entirely new markets. Hence it is difficult to decide what R&D projects are indeed part of a strategy that meets the corresponding criteria.

Given the uncertainty and the extraordinary risks associated with strategy (vi) it would perhaps be more promising, if the government were to set up a national industrial strategy for developing an entirely new market. The pertinent innovative efforts of all relevant producers could then be informally coordinated by the government, an exchange between them be organized, and complementary systemic investments be made where necessary. As with all national industrial strategies it may of course be asked whether the government can provide a less speculative and less uncertain answer to the question: what domain of life will be the next one yet to be successfully opened up for the innovative, mass produced commercial offers?

Conclusions

In this paper a look at capitalism has been taken through the lenses of the theory of complex adaptive systems. Such systems consist of a multitude of agents from

whose individual adaptation efforts the adaptive behavior of the system as a whole emerges. Starting from the assumption that capitalism is a complex adaptive system some fresh insights can be generated on how capitalism works and generates economic growth. The distinctive feature of capitalism is mass production. In a mass production regime, efforts of individual producers to realize scale economies by expanding the capital stock can gain them a competitive advantage. However, since the parallel expansion efforts in an industry are not coordinated *ex ante* by the price mechanism, they tend to generate industry-wide overaccumulation crises. These crises have since long been in the focus of economic theorizing on the business cycle. Unlike in these theories, the present approach suggests to explore the adaptation strategies by which producers try to evade the crises in order to understand the relationships between the unsteadiness of capitalism and its growth.

As has been discussed, the adaption strategies imply several forms of innovations. They have proved to substantially raise the standard of living of the masses in the presently most developed economies in the past and still do so in the now industrializing countries. Yet, in a complex systems perspective, a collective outcome of individual adaptation strategies such as high economic growth rates cannot simply be extrapolated to extend into the future. Indeed, in the most developed economies the growth trend has been shown to be declining over the past fifty years. The widespread and robust trend suggests that there is something going on in these economies when they grow rich that requires explanation.

A general insight from complex systems analysis is that perhaps only small changes in the success conditions of individual adaptation strategies can cause substantial change in the behavior of the system as a whole. This has been argued to be true also in the case of the innovative strategies by which the producers in an industry try to adapt to crises. The discussion of these strategies pointed at significant differences between them regarding the individual success conditions as well as the collective effect on economic growth. In both cases the effect of the innovations has been predicted to also vary with the level of prosperity an economy has already reached. In the highly developed economies with their mature industries the effects of many of the strategies on sales and economic growth decrease as a result of relative market saturation. Supply, even if innovative, does not any longer automatically create its own demand then. Although the consequence for the individual producers may not be dramatic, for the economy as a whole the consequence is a trend of secularly declining growth rates.

Economic policy making that aims at fostering economic growth can respond to this situation. At present many policies are advocated that support innovations *grosso modo*, i.e. without recognizing the differing impact they have on economic growth at different stages of economic development. Following the discussion in the present paper, the suggestion is, instead, that policy measures supporting innovativeness should discriminate the more between different innovative adaptation strategies, the further developed an economy is. For a growth-oriented policy to still be effective in the most advanced economies, measures like subsidies and tax privileges should be concentrated on only the few innovation strategies that have been identified here as promising continued positive growth effects.

Endnotes

[1]Weak institutions shift the balance of competitive adaptive strategies of the agents towards non-cooperative modes: defection, striving for privileges, dominating and exploiting others. By the same token they impede the chances of an economy to thrive (Acemoglu et al. 2002, North et al. 2009), i.e. to successfully adapt as a whole.

[2]Besides this technological characterization of capitalism by its principle production mode, classical economists since Ricardo (1817) have always emphasized the ownership structure of capital as a defining feature of capitalism. In Marx (1867), it is setting apart the antagonistic classes of capitalists and laborers. In the above outlined complex systems perspective, the configuration of property rights is, however, a socio-political, institutional feature of a society. Capitalism can be private or state capitalism depending on the ownership structure, while mass production is the principle production mode in any case. In the following a (mostly) private ownership is presumed.

[3]It should also be noted that the long run improvement of the standard of living has come about despite significant negative shorter term effects on individual welfare of some parts of the society. They result from the redistribution of income and wealth which the successive expansion of mass production and the corresponding automation causes, see Witt (2016) for a discussion. Such negative effect can again be observed, e.g. in the U.S., in the present information technology revolution driving digitalization, i.e. the automation of information processing, and the mass production of intangible goods, see Autor and Dorn (2013) and Acemoglu and Restrepo (2017).

[4]Schumpeter (1934[1912], 223–230). Later Schumpeter (1939) refined his analysis (see Andersen 2009) and, initiated by Schumpeter himself, his followers expanded the approach to a theory of long Kontratieff cycles, see Freeman (1984).

[5]If fluctuations around the trend are assumed to be the result of transitory shocks, gross domestic product (GDP) or GDP per capita, measured in real terms, would follow a deterministic trend (see, e.g., Fleissig and Strauss 1999). If the shocks are assumed to frequently develop more lasting effects so that the trend can randomly shift over time, this would be considered to result in a stochastic trend (Nelson and Plosser 1982, Murray and Nelson 2000). Yet another interpretation suggests that rare, but drastic shocks can induce structural breaks in what are otherwise piecewise deterministic trends (e.g. Perron 1989). The controversy was couched mostly in terms of a business cycle framework and, correspondingly, focused on partly contradictory implications for monetary and fiscal stabilization policies.

[6]The only exceptions are Turkey, Luxembourg, and the U.K. (in the latter two cases the decline is not statistically significant from no change at all), furthermore Chile which is the only country among the 27 for which the trend is upward sloping. The data used for the regression are from the Worldbank Development Index, http://databank.worldbank.org/ddp/home.do. For Germany and Ireland the data missing in the WDI for the period 1961–1970 have been completed by recourse to the corresponding publications of the respective national bureaus of statistics.

[7]These are countries which, after long periods of backwardness and/or political isolation, experienced institutional changes that opened up their markets and started to encourage entrepreneurial initiative in one way or other. By doing so they triggered a catching-up process. Per capita income started to grow and allowed a significant domestic demand to build up that supported in key sectors of their economies the transition to a rapidly growing mass production.

[8]For Sweden, the coefficient < 0 of the linear trend is not statistically significant. In the non-linear specification $w_t = a + b/t$ with w_t for the growth rate and t for the time variable, however, $a = 1.78$ and $b = 4.4791$ are significant at 0.01 and 0.1 error level respectively.

[9]The low R^2 values are not surprising, given that the time index t as trend variable is not expected to have much explanatory power. The low values of the Durbin-Watson statistic (DW) express the autocorrelation of the residuals over the business cycle and are therefore not surprising either. The Augmented Dickey Fuller unit root test (ADF) rejects the null hypothesis of a unit root at high levels of significance in all cases except for Greece, the Phillips-Perron unit root test (PP) in all cases. The growth rate time series can therefore be inferred to follow a deterministic rather than stochastic trend. This conclusion supports the assumption that the countries suffered no major lasting shocks or structural breaks during the observation period.

[10]Table 1 provides some evidence for this conjecture. The countries which in 1961 were more advanced already, are the U.K., Luxembourg, Sweden, the Netherlands, Germany, and Denmark. As would be expected if a common convergence path exists, these Northern European countries have moved further ahead on the path (implying that they have a smaller intercept and a flatter shape of the falling trend). For the countries most behind in their development (Ireland, Portugal, Greece, Spain, Italy) the opposite is true. In line with this conjecture the size of the regression coefficient in Table 1, is highly inversely correlated with the size of the intercepts (Bravais-Pearson correlation coefficient $R_{BP} = -.9312$).

[11]Due to the focus on mass production, the following catalogue of innovative strategies differs from Schumpeter's (1934[1912], p.66). He distinguishes product and process innovations, opening up of new outlet markets, tapping new input sources, and industrial reorganizations.

[12]The growth effect can be inferred in the case of consumer goods and services from an industry's income elasticity of demand (or sales) and, in the case of primary and intermediary products, from the elasticity with which sales respond to GDP changes.

[13]In durable goods markets this case is often characterized by a situation in which replacement demand is the major motive on the demand side. A typical example are household appliances, see Woersdorfer (2017) for a study of the industry's product differentiation efforts after market saturation had been reached. It may be noted that this type of innovations can also be observed in early phases of an industry's life cycle (before a dominant design for the industry's products has emerged, see Abernathy and Utterback 1978) where it is not associated with over-accumulation crises.

[14]Strategy (vi) has some similarity with strategy (v). It also means expanding into new markets, albeit not by means of substitutes for customized products in already existing markets. This strategy rather means to create the new markets in the first place.

Competing interests
The author declares that he has no competing interests.

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