Global Economic Change: A Schumpeterian Perspective

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by

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Abstract

My research focuses on global economic change, its driving forces, and what individual countries can do to cope with the challenges and opportunities that arise. In this paper I discusses the influence of Schumpeter's theorizing on my work. Three themes, central to my research, and for which Schumpeter's works have provided inspiration and guidance, are considered. The first concerns the international competitiveness of a country, what it means, how it is shaped, and the implications for policy. A second theme has to do with the large differences in the levels of economic development across countries, and what poor countries can do to exploit the potential for catching up. The third theme concerns the ongoing global green shift. The chapter concludes with some thoughts on the relevance of a Schumpeterian perspective for the study of future economic development.

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Introduction

My research has focused on global economic change, its driving forces, and what individual countries can do to cope with the challenges (and opportunities) that arise. When I have published about these issues, I have several times added a "Schumpeterian"(or evolutionary) perspective" to the title (or subtitle), often in response to editorial advice (of being more specific). In this paper I discuss why I came to adopt a Schumpeterian perspective on global economic change, what it means to me, and how it has influenced my research.

With respect to the latter, I will particularly focus on three themes, which have been central to my research over the years, and for which Schumpeter's works have provided inspiration and guidance. The first theme concerns the international competitiveness of a country, what it means, how it is shaped, and the implications for policy. In this case it is particularly Schumpeter's theory about technological – or quality - competition (rather than price competition) as the dominant form of competition under capitalism that guided my work. A second theme has to do with the large differences in the levels of economic development across countries, and what poor countries can do to exploit the potential for catching up technologically and economically with the rich part of the world. Schumpeter's emphasis on innovation as a powerful force of change in all kinds of economic environments arguably provides an appropriate starting point for addressing this issue. Finally, the third theme considered here concerns the ongoing green shift in response to the urgent climate challenge. Many will probably think that Schumpeter's work cannot be very relevant for an issue that only got serious attention long after his death but I am going to argue that the opposite is indeed the case. I conclude with some thoughts on the relevance of a Schumpeterian perspective for the contemporary setting.

However, first to how I came to adopt a Schumpeterian perspective, and what this means to me.

A Schumpeterian Perspective: What It Means and How I Got There

The evolutionary scholar Georgescu-Roegen once wrote: "Schumpeter turned me into an economist – the only true Schumpeterian, I believe. My only degree in economics is from Universitas Schumpeteriana." (Georgescu-Roegen 1992, p. 130). I cannot claim the same. In fact, during my time as a student in the Norwegian university system, I was hardly exposed to Schumpeterian economics at all.

I originally wanted to become a journalist, and had some stints at it at a major Norwegian newspaper before going to university. The main editor of the newspaper advised me to take some subjects at the university in preparation for a future career as a

journalist, so I studied three subjects, political science, history and economics, in succession, at three different Norwegian institutions. Among these subjects I was most drawn to history, although I ended up graduating in economics. At the outset I expected economics to be very important for understanding what was going on in the world. However, I found the version of it that I encountered during my economics studies overly static, formalistic, and based on questionable assumptions about e.g., human behaviour. While at university I also followed an extracurricular course (at the university's philosophy department) in Marx' economics, which appeared to me as more dynamic, and, in some respects, more appealing, than the standard neoclassical economics I had to learn to pass my final economics exam. I also familiarized myself with the post-Keynesian strand in economics,[1] which traditionally has had a great following among Norwegian economists, and wrote a master thesis aiming at synthesizing post-Keynesian and Marxian perspectives on long-run economic growth.

After graduation, I found myself working as a bureaucrat in the Norwegian Ministry of Finance, in the department for medium- and long-term forecasting and planning. When I joined, it actually was a separate (although very small) ministry headed by the social democrat Per Kleppe, a legendary figure in Norwegian politics, who previously had been chief economist in the (main) labour union. However, when the social democrats lost the general election shortly afterwards, and a new, conservative government took over, the ministry was relegated to a department in the Ministry of Finance (which it also had been prior to becoming a ministry). While there I worked mostly on international trade, particularly Norwegian exports and imports, and the inclusion of these in the department's forecasting exercises. At the time, a very popular view among economists associated with the government was that wages were to blame for the loss of market shares for Norwegian producers domestically or abroad, that is, the country's loss of international competitiveness. I found this perspective puzzling, because I felt that the wage level was only one of several factors that influenced competitiveness, and perhaps not the most important one. The more I dug into the issue, the more sceptical I became about the establishment's position on it, to the dismay of my bosses. Nevertheless, I was allowed by the head of the department to publish a working-paper[2] on the topic at a newly created think-thank (supported by the labour unions), in which I among other things reproduced the earlier finding of Nicholas Kaldor (1978) of a perverse relationship between wages and export performance, i.e., the opposite of what was commonly assumed. The paper eventually created a lot of furore, because an opposition newspaper used the paper (on its front page) as evidence against the government's policy stance. As a result, my position in the ministry became quite uncomfortable, and I started to look for other options. To my great relief, I was awarded

[1] Two contributions in this tradition that I read at the time, and which influenced me a lot, are Pasinetti (1974) and Cornwall (1977).
[2] Fagerberg, J. 1982. Konkurranseevne og næringsstruktur, Arbeidsnotat, No. 1, FAFO, Oslo.

a three-year scholarship from one of the country's research councils to do research on competitiveness.

During the first year of the scholarship, I searched rather widely for theoretical perspectives, literature and research environments of relevance for my topic, and it was at this time that I started to seriously engage with Schumpeter's works. Although I was aware of Schumpeter before that, it was mostly as an historian of economic thought (Schumpeter 1954), not as theoretician of capitalist dynamics. Motivation for engaging more actively with Schumpeter's own theories came among other things from interaction with members of the IKE-group (literally "the international competitiveness group") at Aalborg University in Denmark,[3] who repeatedly emphasized the relevance of Schumpeter's theory for competitiveness research. Through IKE I also came in contact with Christoper Freeman and others from SPRU in the UK,[4] who likewise applied Schumpeterian ideas to the analysis of contemporary phenomena, see for example Freeman, Clark, and Soete (1982), which impressed me a lot.

As a result, I read Schumpeter's main works (The Theory of Economic Development, Capitalism, Socialism and Democracy, Business Cycles) in rapid succession, as well as a number of his articles and other relevant literature. What primarily struck me was how different his take on economics was from anything I had encountered hitherto. Rather than seen through the lenses of static equilibria, with any technological progress that might occur as "manna from heaven", the focus in Schumpeter's works was on qualitative changes in historical time, driven by innovations and their spread in the economic and social system. Given my interest for history, it is perhaps not surprising that I found this perspective appealing. I also liked Schumpeter's notion of innovations as attempts to try out new ways to do things – introducing novelty in the economic sphere - rather than simply as new ideas (or inventions) as was (and still is) common in economics. This occurred to me as a very important distinction since, as Schumpeter explained, "As long as they are not carried out into practice, inventions are economically irrelevant" (Schumpeter, 1934, p. 88). Hence, the study of the social and economic processes that determine to what extent inventions are tried out in practice, retained and eventually become widely adopted – selection processes to use an evolutionary term - necessarily becomes an important part of the analysis. Another central feature of Schumpeter's analysis of innovation that I found attractive is that it isn't limited to "things" (new products) but extends to processes, logistics, organization, and the creation of new markets. Nor, as is (still) common in many settings, is it

[3] Particularly Bengt-Åke Lundvall, Esben Sloth Andersen and Bent Dalum, who I had met through the Nordic Summer University, an association for young academics in the social sciences and humanities in the Nordic area, with study groups, seminars and a large, annual summer-session, which I started to attend during my final years at university.

[4] My first encounter with Freeman (and SPRU) was at seminar in the spring of 1983, organized by myself under the auspices of the Nordic Summer University, in which Freeman and Carlota Perez gave a joint presentation. I was struck by the vigour, relevance and fruitfulness of their approach. Their presentation at the seminar was later published in a special issue that I edited (Freeman and Perez 1984).

confined to scientific breakthroughs or "high-tech" environments. An innovation can also be – as Schumpeter pointed out – a new version of sausage (Schumpeter 1947, p. 151). Thus, following Schumpeter, innovation is a vital element in all kinds of economic activities, and the essential driving force behind economic development and what economists call economic growth.[5]

So, this is, in very broad terms, what I mean with a Schumpeterian perspective, which I have tried to adopt, in various ways, in my own research over the years.

The Competitiveness Puzzle

While most of the post-Second World War period was characterized by high and stable economic growth in the Western world, and even faster trade growth, this changed markedly for the worse in the 1970s. Many developed countries, and Norway was no exception, experienced a slowdown in the demand for its exports, low economic growth, high inflation, and increasing unemployment. In the beginning, this was commonly interpreted as a (transitory) shock, caused by a coincidence of unfortunate events, which could be handled quite easily by counter-cyclical Keynesian policies. However, as the problems endured, the attention among mainstream economists, and a leading think tank such as the OECD, shifted to more long-run "structural" problems, e.g., rigidities in the labour market, leading to, it was commonly assumed, excess wage-growth, high inflation, and, hence, deteriorating international competitiveness.

This also was the consensus view among my bosses in the ministry. The logic[6] may be summarized as follows: Assume that prices of goods and services are determined by unit labour costs. If wages grow more in, say Norway, than elsewhere, prices on Norwegian goods and services will grow more than prices on competing products from other countries. As a consequence, Norwegian producers would lose market shares both at home and abroad, hurting production and employment. The policy implication was that wage growth needs to be kept in check, so that unit labour costs relative to trading partners - the preferred measure of international competitiveness in the ministry (and elsewhere) at the time – remain stable.

This logic may appear convincing at first but I noticed some possible flaws. In my view it failed to distinguish between competitiveness as an outcome – for which changes in market share may be a good candidate – and factors influencing it of which costs would be one (but not the only one). Moreover, I wondered why increasing quality – which

[5] In Schumpeter's own words: "... the historical increase in output of commodities and services is not only or even primarily due to the increase of capital or the working population, still less to increased skill or effort of the individual operative, but principally to improvements in technology and organization" (Schumpeter 1946, p. 193)

[6] This way of thinking was common in empirical macro-economic models at the time, see for example OECD's INTERLINK model (Samuelson 1973),

perhaps could support higher prices and wages without eroding profits – wasn't taken into account at all. It was at this point that Schumpeter came to my rescue. In Capitalism, Socialism, and Democracy he described competition under capitalist conditions as follows:

"Economists are at long last emerging from the stage in which price competition was all they saw. (…) But in capitalist reality, as distinguished from its textbook picture, it is not that kind of competition which counts, but the competition from the new commodity, the new technology, the new source of supply, the new type of organization (…), competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives." (Schumpeter, 1943, p. 84)

Thus, according to Schumpeter, the dominant form competition under capitalist conditions is not price competition but technological competition.[7] Following this suggestion my inclination was to extend the explanatory framework by including technological competition. Kaldor (1978) had as mentioned shown that the empirical support for the cost- or price- based model of competitiveness was shaky at best. In fact, according to his calculations, superior export performance appeared to go together with increasing relative unit labour costs, not the other way around. Perhaps a broader framework, incorporating the Schumpeterian perspective, could provide an explanation for these paradoxical findings?[8]

Hence, I introduced two new explanatory variables related to technological competition, reflecting how advanced a country is technologically, and its capacity to exploit technological opportunities. I measured the first (technological competitiveness) through R&D and patent statistics, while the second (capacity competitiveness) was measured by the country's investment intensity and its scope for imitation (reflecting the distance to the technological frontier)[9]. The introduction of these two new explanatory variables into the framework significantly improved the explanatory power, and was shown to provide a reasonable explanation for the seemingly paradoxical findings of Kaldor.[10] For example, during the period considered by

[7] This idea had, as Schumpeter readily admitted (Schumpeter, 1937, p. 166), been advanced earlier by Karl Marx in Capital, Volume 3 (Marx 1959) , in support of his theory of a falling rate of profit. In an earlier paper (Fagerberg 2003) I therefore use the notion "Marx-Schumpeter model" for this suggestion. However, while the form of technological progress considered by Marx was mechanization (by introducing ever-more capital-intensive techniques), Schumpeter took into account a much broader range of phenomena (i.e., new commodities; new technologies; new sources of supply; new types of organization).

[8] Another approach on this issue from this period disregarded costs and prices altogether and explained differences in economic performance through estimates of the "income elasticities of demand" for a country's exports and imports (Thirlwall1979). While empirically this worked quite well, as pointed out by Kaldor, such elasticities are not really exogenous but reflect "the innovative ability and adaptive capacity of its manufacturers" (Kaldor, 1981, p, 603). Following this, a better research strategy, which I hence tried to adopt, would be to try to measure "innovative ability and adaptive capacity" and include these into the explanatory framework.

[9] Countries that are far from the technological frontier have a larger scope for imitation than countries closer to the frontier (simply because there is much more to imitate). See also the next section.

[10] See Fagerberg (1988a), Tables 3-4.

Kaldor (60s and early 70s), relative unit labour costs in Japan increased by around one third, which – according to the logic presented above – should have been expected to lead a large decline in its market share for exports. However, the opposite happened, its market share more than doubled during these years. The reason for this increase, however, had little to do with changes in cost-competitiveness, the effects of which were found to be small (though "correctly" signed). Rather the explanation was that any negative effects of increasing relative costs were completely dwarfed by the increase in Japan's technological competitiveness, which according the calculations explained about two thirds of the increase in its market share during this period. An article reporting these findings was published in Economic Journal in 1988 (Fagerberg 1988a). A major update, including a larger set of countries and a broader range of indicators, appeared about two decades later (Fagerberg, Knell and Srholec 2007). The qualitative findings remained the same, however.

Thus, technology – innovation – matters for competitiveness. Supporting competitiveness cannot be reduced to concerns about cost-competitiveness, which is not the main factor anyway. Rather what policy-makers should do is to focus on innovation and the capacity to exploit technological opportunities.[11]

Why growth differs

Why do some countries prosper, and others not? This is one of the classic themes in economic research. In fact, already Adam Smith discussed this intensively. When I started to think about this question in the early 1980s, there was already a sizeable literature on it. The dominant framework among economists at the time for understanding this issue was the neoclassical model of economic growth developed by Robert Solow (1956), for which he later got the Nobel prize in economics. According to this model, based on the usual neoclassical assumptions about agents and markets, poor countries weren't poor because they were technologically or socially backward but because they had little capital (per head of population). However, per assumption this also meant that returns to investment would be particularly high there. The conclusion, therefore, was that as long as market forces were allowed to do their job, poor countries should be expected to have higher rates of investment and economic growth than elsewhere, and eventually catch up economically with the rich part of the world. At that point, GDP per capita would be the same everywhere,[12] and there would be no further growth in GDP per capita, except for possible exogenous increases in technology, so-called "manna from heaven", which would benefit everyone all over the globe equally.

[11] For treatments of innovation policy, see Fagerberg (2017) and Edler and Fagerberg(2017).
[12] This holds as long as population growth is the same everywhere. If not, the long run GDP per capita levels that countries will converge towards will differ. But growth of GDP per capita will still tend towards zero everywhere (in the absence of exogenous technological progress).

A convenient feature of Solow's neoclassical model was that it was possible to calculate the contribution to economic growth from capital accumulation and growth of the labour force, so-called "growth accounting". What remained when the contributions from factor growth were deducted would then be classified as exogenous technological progress or other unknown factors. When Solow and others attempted to do this what they found was that factor growth explained very little and that the residual therefore became surprisingly large. Moses Abramovitz aptly characterised the residual as a "measure of our ignorance about the causes of economic growth" (Abramovitz, 1956, p. 11). To improve on this embarrassing result researchers set out to reduce the size of the residual by taking into account other explanatory factors, such as structural change (from low-productivity to high-productivity industries), economies of scale and so on (Dennison 1967; Kendrick 1981; Maddison 1982).[13] This arguably made the growth accounts more "realistic" but at the expense of theoretical consistency, since many of these additional factors, economies of scale for instance, were ruled out by assumption by the neoclassical theory on which the accounting was based.

I felt the trajectory pursued by the growth accountants, that is, adding ever more additional factors with the purpose of "squeezing down the size of the residual" as Richard Nelson put it (Nelson 1981, p. 1032), was not the right one. The problem, in my view, was more basic, and had to do with a lack of understanding of the role of technology in economic growth in countries at different levels of development. To rectify this, I thought a dose of Schumpeterian thinking would be helpful. As explained above, according to Schumpeter technological progress does not come as "manna from heaven" but through innovation-activities in capitalist firms (fueled by technological competition). Moreover, from a Schumpeterian perspective innovation is not limited to advanced, "high-tech" firms, industries or countries but is relevant in all kinds of economic activities and environments. Thus, innovation should be expected to be a powerful force of change not only in the rich part of the world, but also in countries in the process of catching-up, and in poor countries more generally.

To further explore these ideas empirically, I created a simple model of capitalist dynamics in which the level of economic development in a country was assumed to reflect knowledge diffused to the country from abroad; knowledge created in the country; and the country's capacity for exploiting the benefits of knowledge independently of where these were created. With knowledge I meant "technological know-how", that is, knowledge and skills on how to produce goods and services.

Moreover, I assumed, as customary in the diffusion literature, that the diffusion of internationally available knowledge follows a logistic curve. This implies that the

[13] See Fagerberg 1994 for an overview and assessment.

contribution of diffusion of internationally available knowledge to economic growth is an increasing function of the distance between the total level of knowledge per capita appropriated in the country and that of the country on the technological frontier(for the frontier country, this contribution will be zero).

Thus, following this approach, the economic growth of a country will depend on three factors (Fagerberg 1987, 1988b):

- The diffusion of knowledge from abroad, the scope for which increases with the distance from the world innovation frontier.
- The growth in nationally produced knowledge (innovation)
- The growth in the country's capacity for exploiting the benefits offered by available knowledge, whether created within the country or elsewhere.

I dubbed this framework a “technology gap model of economic growth” (Fagerberg 1987, 1988b). The choice of terminology was inspired by previous attempts (see, e.g., Posner 1961, Gomulka 1971 and Cornwall 1976, 1977) to analyse economic development as the interplay of innovation, which tends to increase economic and technological gaps between countries, and imitation or diffusion which tends to reduce them. I regarded the framework as an extension of Schumpeter's dynamic theory of capitalist development, which was developed for a closed economy, to a world economy characterized by competing capitalist nation states. The main novelty with respect to existing applied work on the subject was of course the emphasis placed on innovation. As pointed out at the time by Keith Pavitt, the omission of the innovation variable makes it very difficult to analyse diverging trends, whether represented by laggards, or related to changes in technological leadership (Pavitt 1979/1980). I felt that the framework I had developed had a potential to make real progress in these respects.

Defining a relevant sample of countries, as well as finding the data for the variables highlighted above, became a challenge. At the outset, I understood that exploring capitalist dynamics based on information from OECD countries only would not be sufficient, since many of the most fast-growing nations worldwide were not members there. However, relevant statistical information from these countries were in scarce supply. After a quite extensive search, including corresponding with national and international statistical authorities (which in some cases furnished me with unpublished statistics), I managed to include data for six of the most important so-called “newly industrialized countries” at the time, half of which were in South America, and the remaining in Asia. The results of the subsequent test indicated that levels of economic and technological development, whether measured through R&D or patent statistics, were closely related (Fagerberg 1987). Moreover, the scope for imitation (approximated by the difference in GDP per capita vis-à-vis the frontier countries); growth in innovation (measured, following Soete (1981), by growth of patent

applications in foreign markets); and efforts related to exploitation of technology, proxied by investment-ratios, together explained around two thirds of the differences in growth across the countries included in the investigation. The innovation variable was shown to be particularly important for a group of fast-growing economies, including the newly industrialised countries in Asia (Fagerberg 1988b). Thus, as envisaged by Pavitt, the inclusion of the innovation variable, i.e., the Schumpeterian perspective, was important for understanding the dynamics of the global economy. This finding has also been corroborated by later research (see, e.g., Fagerberg, Srholec, and Knell 2007).

However, I was well aware of the limitations caused by the scarcity of relevant statistical information. For example, I didn't choose to measure innovation by patent statistics because it was the perfect indicator but because it was the only available indicator for a sufficiently large group of countries. Moreover, as I also noted at the time, there was probably more to countries' capacities for exploiting technology than their investment-ratios.[14] On this I became influenced by the works by the economic historians Alexander Gerschenkron and Moses Abramovitz, who also analysed technological catch-up as very challenging affair, requiring considerable effort and institution building in "backward" countries (Gerschenkron1952, Abramovitz 1986). Abramovitz, who I got the opportunity to interact with in the years that followed, used the term "social capability" for the "factors constituting a country's ability to import or engage in technological and organizational progress" (Ohkawa and Rosovsky 1973, p. 212). He particularly emphasized[15] managerial and technical competence (e.g., education); a stable and effective government capable of supporting economic growth; financial institutions and markets capable of mobilizing capital on a large scale; and the spread of honesty and trust in the population as important aspects of social capability. However, he expressed pessimism with respect to the possibilities for adequate measurement (Abramovitz 1994b).[16]

Nevertheless, during the years that followed, the availability of data on different aspects of development, being "technological" or "social", increased a lot, and in the mid-2000s I was approached by the UN organization UNIDO to take a fresh look at the measurement of the capabilities required for catching up technologically and economically, which resulted in a contribution to their Industrial Development Report for 2005 and, in revised form, in an article in the journal Research Policy a few years later (Fagerberg and Srholec 2008). At the time several partly overlapping concepts, such as technological capability,[17] absorptive capacity,[18] and social capability, were

[14] " This is, of course, a simplification since institutional factors obviously are very important" (Fagerberg 1987, p. 93)
[15] See Abramovitz (1986, pp. 387-390; 1994a, pp. 34-35; 1994b, p. 88) and the discussion in Fagerberg and Srholec (2008).
[16] In the applied growth literature, the social capability concept has often been treated as synonymous with educational attainment (see, e.g., Baumol et al., 1989) which obviously is a narrower perspective than what Abramovitz had in mind.
[17] Lall (1992) and Kim (1997).
[18] Cohen and Levinthal (1989)

used by different authors to analyse the capabilities required for succeeding in catch-up processes. Our take on this issue was to find indicators for the various aspects taken into account by these concepts, and analyse their interrelationships with the help of factor analysis. We ended up with a sample of more than a hundred countries and twenty-five indicators, ranging from typical "technological" aspects (patenting, standards, ICTs) via education and finance to the quality of governance and institutional characteristics, vastly superior to what I had been able to assemble two decades earlier. The results of the analysis pointed to two factors in particular as being important for economic development, one closely related to innovation, loading highly on patenting, standards, ICTs, education, and – to a lesser degree – finance, and another reflecting the quality of governance (loading highly on the working of courts, adherence to property rights, and lack of corruption). Other factors identified in the analysis, such as the character of its political system and the degree of openness to trade, were found to have much less impact. I saw these results as being broadly consistent with the "technology gap" framework to the analysis of why growth differs that I started out with two decades earlier.

Thus, innovation is a powerful source of economic change in all countries, irrespective of the level of development, and building capabilities for doing so is a must for countries that wish to catch up economically and technologically.

The green shift

The first decades of the new millennium witnessed the rise of yet another policy challenge which, although not entirely new, had been mostly ignored by policy-makers. That is global warming, caused by increasing concentration of greenhouse-gases in the atmosphere, mainly coming from burning of fossil fuels, and leading to a range of negative effects world-wide. In one sense the solution is simple, that is, stopping burning fossil fuels and replacing it with other energy sources that do not pollute the environment,[19] what has come to be known as a global green shift (Mathews 2017). However, in practice this is quite challenging, since the vast majority of energy used by humans comes from fossil sources. Although alternative energy technologies that do not emit greenhouse-gases exist, these were either in short supply or – at least until very recently - regarded as much too expensive to catch on (Pearson and Foxon 2012). Thus, how to get from here to there became a much-debated issue. Neoclassical economists argued that this should be left to the market, assuming that (an adequate) price on emissions would be introduced by policy-makers (Nordhaus 2013), which turned out to be easier said than done in most cases. It was obvious to me that the question of what

[19] This holds for about two thirds of GHG emissions, with the remaining third primarily coming from agriculture and land-changes (e.g., deforestation), which hence also needs to be addressed, see Fagerberg (2025, 2026a) for an extended account.

innovation – and policies supporting it – may contribute ought to be at the center of this debate, and that a Schumpeterian perspective potentially could be very relevant.

The global green shift denotes a process of change from a technological, economic and social system powered by fossil fuels, characterized by waste, pollution, global warming and ecological problems, towards a system where fossil fuels are replaced by renewables, resources are reused, and challenges related to climate and nature are catered for. Understanding the dynamics of such big techno-economic shifts, invariably labelled "industrial revolutions", "changes in techno-economic paradigms", or "long waves", has been a central theme in evolutionary economics for a long time. In fact, already Schumpeter studied this phenomenon intensively (Schumpeter 1939). He pointed out that a single innovation, however important, should not be expected to have a big economic impact. For this to happen, Schumpeter argued, a constellation of different, albeit related, radical innovations would be necessary. The question is what might lead radical innovations to cluster in this way.

Half a century later, two evolutionary economists, Christopher Freeman and Carlota Perez,[20] suggested that the "glue" in a large techno-economic shift is a "core factor" (or input) characterized by low and decreasing costs, almost unlimited availability, and very broad applicability (Freeman and Perez 1988). While the sector delivering the core factor should be expected to grow fast, of even greater importance would be the impetus that the introduction of the core factor in user sectors, so-called "carrier-branches", gives to innovation and growth there (and feedbacks from this on the growth of the system as a whole). An example of such dynamics, highlighted by Freeman and Perez, is the introduction of cheap and abundant oil around 1900, what may be dubbed "the global fossil shift", giving rise to numerous changes in energy using sectors; e.g., electricity production, transport (the internal combustion engine for example), textiles and clothing (e.g., synthetic fibres), and so on, and – via feedbacks – even greater demand for oil. However, as they pointed out, such broad systemic change is challenging, and may easily come into conflict with – and be hampered by - existing institutions, e.g., regulations. According to Freeman and Perez, a new technoeconomic shift therefore requires extensive economic, institutional and social change to deliver on its promise.[21]

What I have argued, following Mathews (2013), is that the global green shift is an example of the same type of dynamics (Fagerberg and Verspagen 2021, Fagerberg 2025). The core factor in this case is cheap renewable energy, primarily wind and solar. Until recently, these so-called "new renewables" were considered prohibitively

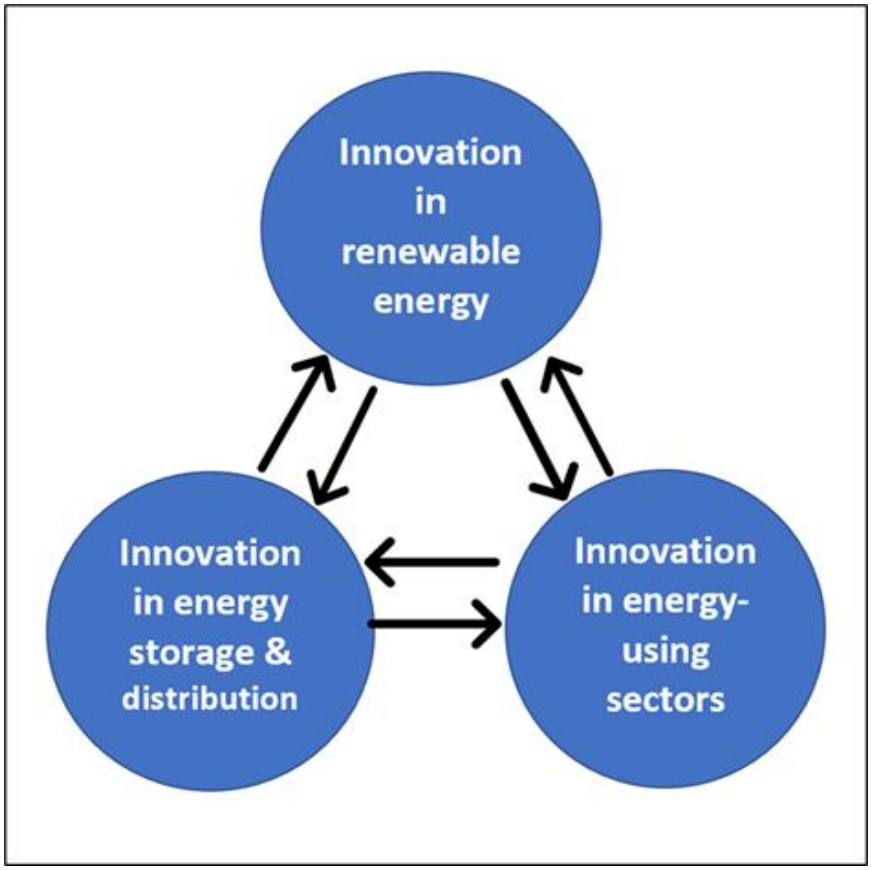
[20] For a more recent application of this perspective, with a focus on contemporary challenges, see Perez (2016).
[21] This is also an important point in the more recent social science literature science on sustainability transitions (Rip and Kemp 1998, Geels 2002, 2014). See Fagerberg (2018) for a comparison and discussion of different perspectives on how innovation - and policies affecting it - can contribute to sustainability transitions.

expensive compared to other ways to provide energy, e.g., from fossil fuels. However, during recent years the costs of renewable energy have come down considerably. The numbers are really eye-catching. Between 1984 and 2022 the cost of producing electricity from onshore wind declined with 90 per cent. The similar statistics for solar, PV module cost per watt, is even more impressive, 98 per cent (Fagerberg 2026a). As a result, in most contexts electricity from renewable energy is now the cheapest way to increase the supply of electricity. Consequently, the leading energy think-tank IEA, traditionally a close ally of the fossil fuels industry, now points to solar as "the new king of electricity supply" (IEA 2020).

As I see it, the global green shift is driven by interaction of radical innovations in three related areas, that is, renewable energy, energy use, and energy infrastructure, e.g., storage and distribution (Figure 1). These innovation processes arguably reinforce each other, as the two-way direction of the arrows in the figure indicates. Although the rate at which renewables have become competitive with fossil fuels is very impressive, perhaps the most important aspect is its impact on energy-using sectors, by allowing these to shift to new technologies using (green) electricity instead of polluting fossil fuels. Arguably, this will require – and lead to – a lot of innovation, large and small, technological, organizational as well as institutional. This also holds for the third part of the system, energy infrastructure, which needs to change in tandem with the other parts to avoid an outcome where the entire process gets stuck. For instance, electrification of energy-using sectors will necessitate a massive increase in the capacity of the grid. Moreover, the increasing role of wind and solar, combined with their intermittent character, will require radical changes in how the system is organized and governed. For example, robust and cost-effective mechanisms for electricity storage will be essential. Arguably, the rapid reduction in cost of batteries in recent years indicates that this process is already well underway.[22]

[22] The price of lithium-ion battery packs per kwh declined 82 % between 2013 and 2023 (Fagerberg 2026a).

Figure 1. The dynamics of the global green shift



Source: https://www.janfagerberg.org/the-global-green-shift/

In my view, electrification is a realistic and feasible strategy for achieving net-zero emissions in many cases. For example, green electricity can substitute for fossil fuels in power production, heating and cooling (in buildings for instance), and powering of various types of machinery. This may also lead to massive energy savings, as electrical applications generally are more energy efficient than devices powered by fossil fuels. Another important way to save energy is increased re-use of materials and artefacts, that is, circular economy. Energy saving[23] is an important element in the green shift, since it reduces the demand for renewables, and thereby frees up capacity and resources for the transition. Green electricity can also substitute for fossil fuels in many industrial processes. In fact, in several cases this implies a revival for electricity-based technological paths from the early part of the twentieth century, paths that were largely abandoned (or only survived in specialized niches) due to the competition from cheap and abundant fossil fuels (Fagerberg 2025). In other cases, electrification may be more

[23] Energy saving may be particularly important in buildings, which currently accounts for about one third of global energy consumption (and one half of global electricity production).

challenging and require extensive innovation, as well as public policies supporting it (Goodall 2024). I discuss policy-making in support of the green shift in more detail in Fagerberg (2022, 2026b).

Applying a Schumpeterian perspective on the green shift arguably leads to an improved understanding of what can be done about the climate challenge. Putting a price on pollution, or behavioural change, though essential, are not the only options. Unleashing innovation is just as (if not more) important.

Quo vadis?

Understanding the mechanisms behind economic growth has been a central theme in evolutionary economics. In fact, the most cited contribution within this field during the last half century, Nelson and Winter (1982), was exactly about that. Nevertheless, the benefits of economic growth are now questioned by a growing strand advocating the opposite, that is, "degrowth" (Latouche 2009, Kallis 2011, Hickel 2022), particularly in the rich part of the world. This is obviously an important question. Is economic growth simply passé? I am not going to try to resolve this here, just point out that I think that is issue for which a Schumpeterian approach may be very relevant.

Why do I think that? I started this paper with quoting Nicholas Georgescu-Roegen's statement about how much he had learned from Schumpeter. However, Georgescu-Roegen is also commonly regarded as the main source of inspiration for the degrowth strand. How can that be? That is because Georgescu-Roegen was one of the first to emphasize that there are planetary limits for human activities, e.g., for supply of minerals and disposal of waste. But Georgescu-Roegen was also careful to distinguish between growth, in the sense of doing more of the same, which may lead to increased resource depletion and pollution, and Schumpeterian development which in his view did not necessarily have the same implications (Georgescu-Roegen 1975). He therefore was at pains to stress that "true" environmentalists were not against development (ibid).[24] Another well-known ecological economist (and student of Georgescu-Roegen), Herman Daly, similarly points out that "There is no reason to limit the qualitative improvement in design of products, which can increase GDP without increasing the amount of resources used. The main idea behind sustainability is to shift the path of progress from growth, which is not sustainable, toward development, which presumably is" (Daly 2005, p. 103).

Thus, a Schumpeterian perspective, with development (innovation) at the center, is not necessarily passé at all. However, it is up to us to demonstrate its continuing relevance.

[24] See Fagerberg (2026a) for a more comprehensive presentation and discussion of Georgescu-Roegen's perspective and its relevance today.

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