“Railroadization” as Schumpeter’s Standard Example

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Schumpeter and the Analysis of Economic Evolution

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Comments are welcome

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By Esben Sloth Andersen

1. INTRODUCTION

In order to come to grips with Schumpeter's view of economic evolution, one can do no better than to consider the heroic age of railroad construction in the nineteenth century. This was the time when the horse-driven mail coaches and canal boats[1] were outcompeted, railroad towns mushroomed, financial schemes blossomed and failed, etc. More abstractly, it was an age of an irrevocable change of the routines of economic life, not least through the action of innovating entrepreneurs.

Schumpeter has declared this process of 'railroadization' to be the standard case of his evolutionary scheme[2] and there are good reasons to believe that Schumpeter considered the railroad case as being a paradigmatic link between his analytic scheme and different real-life processes. This is underlined in *Business Cycles* where he points out that

> ... the reader should not fail to work out ... step by step ... how railroad construction produces both prosperities and recessions ... and, in particular, simultaneous cycles of different span. ... For railroadization is our standard example by which to illustrate the working of our model. ... [Many factors] combine to make the essential features of our evolutionary process more obvious in this than they are in any other case. More easily that in any other can the usual objections to our analysis be silenced by a simple reference to obvious facts. (Schumpeter, 1939: 304, rearranged)

Such a conspicuous case may focus many discussions about Schumpeter's evolutionary scheme and it is clearly in his own spirit of 'family histories' and 'living pieces of reality' (Schumpeter, 1991a: 230). But it should from the very beginning be emphasised that this kind of

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1 Actually, many canal systems performed quite well. See later.

2 The major alternative as a paradigmatic example is what may be called 'automobilization'. Thus Schumpeter remarks: 'The automobile industry affords a good example of a purely entrepreneurial achievement turning to new uses not only existing resources but also existing technology ...' (Schumpeter, 1939: 415) 'The automobile industry led in every upswing and out of every downswing throughout the period [1919-1929], in fact far beyond it, and continued in the Kondratieff recession [after 1929] to qualify as well for the role of standard example for the processes embodied in our model as it had done in the upswing.' (Schumpeter, 1939: 772). Some developments of this case are found in *Business Cycles* (e.g., Schumpeter, 1939: 415-418, 772-777). Still, this is not the example of the young Schumpeter and it is probably not as close to his basic vision and scheme as the case of railroadization.

evidence is only supplying a 'scaffolding' by giving intuitive meaning to the theoretical argument. In the end the scaffolding most be removed and the theoretical building must be able to stand on its own and to be applied to other cases. One of the problems is pointed out by Schumpeter:

> There is, however, some danger in overstressing such obvious instances [like the railroad case], because this may easily lead to the familiar attitude of confining the phenomenon to this class and overlooking all the others—hence, to missing its true dimensions. (Schumpeter, 1939: 101)

Another problem which is remarked by Casson is the inability a many researchers to remove themselves from the folkloristic ideas of entrepreneurship (and economic evolution). He states that

> The existence of this stereotype [of the entrepreneur] has undoubtedly impeded the economic analysis of the entrepreneur. There is a tendency to evaluate theories solely on the basis of their ability to rationalize this preconceived view. This procedure is the very antithesis of proper research methodology. Many of the qualities with which the heroic stereotype is imbued are simply a reflection of contemporary cultural attitudes. Nevertheless the stereotype is useful in that it provides various hypothesis regarding the family background, personal qualities and the business methods of the entrepreneur. (Casson, 1991: 6)

Even if the present 'stereotype' of the heroic age of railroadization is much more complex that the one Casson refers to, his remarks provide an important warning against overestimating the role of the present case. Still, the case is quite rewarding and I wonder why Schumpeter did not develop it himself. Actually, we find scattered over some of the more than 1000 pages of *Business Cycles* (and elsewhere) the elements of a nice and handy book about railroadization considered as the paradigmatic example of Schumpeterian analysis.[3] In the following I try to give an impression of this material while at the same time preparing the way for a more

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[3] Schumpeter never made a systematic development of the paradigm of railroadization in relation to his basic evolutionary ideas. However, much material is presented in the section 'Railroadization' in *Business Cycles* (Schumpeter, 1939: 325-351) and in other parts of this book (e.g., 17, 73, 101, 113, 146, 158 f, 167 f, 277 f, 280, 291 f, 303 f, 314, 319 f, 352, 354, 357, 359, 361-363, 366, 368 f, 377, 385, 395 f, 402-408, 413 f, 488, 523, 569, 630, 632, 663, 686, 760, 878, 884). That this is not a particular interest of the elderly Schumpeter is revealed by many shorter references to the example in his first book, *Essence of Economics* (Schumpeter, 1908: 189 f, 245, 247, 250, 252 f, 451?, 512-514, 568, 584, 608-612). Further references are scattered throughout his works (e.g., Schumpeter, 1942: 68, 83, 99, 119, 132 and Schumpeter, 1912/34: 62, 66, 84, 215, cf. Schumpeter, 1912/26: 93-95, 123, 321). It may also be remarked that the central metaphor for routines are in German 'Bahnen' (Schumpeter, 1912/26: *passim*) while it is in the English translation 'channels'. The German word means tracks or even railways (abbreviation for 'Eisenbahnen') and has an active sound like in 'sich Bahn brechen', blaze one's trail, 'Bahnbrechend', epoch making. Finally, it should be remarked that the subdiscipline of railroad economics (cf. Schumpeter, 1954: 948 f) is neglecting economic evolution. Information should be searched elsewhere in the rich literature. In the present chapter I will mainly stick to the formulations of Schumpeter.

systematic reconstruction of Schumpeter's scheme of evolutionary analysis.[4]

2. RAILROAD ENTREPRENEURSHIP

In the process of railroadization innovative entrepreneurship played a clear and important role. Here we see that

> ... the function of entrepreneurs is to reform or revolutionize the pattern of production by exploiting an invention or, more generally, an untried technological possibility for producing a new commodity or producing an old one in a new way, by opening up a new source of supply of materials or a new outlet for products, by reorganizing an industry and so on. Railroad construction in its earlier stages ... afford spectacular instances of a large genus which comprises innumerable humbler ones—down to such things as making a success of a particular kind of sausage or toothbrush. (Schumpeter, 1942: 132)

As a first approximation we may consider the innovative entrepreneur to be the person who carried out a specific railroad project at the time when this was not a matter of routine. It is not primarily the 'judgmental decision' (Casson, 1991: 23 f) but first of all the ability to implement (carry out) the railroad project and thus to overcome a large set of personal and social resistances to change, an ability which characterises the Schumpeterian entrepreneur. Some of these resistances came from the owners of canals and horse transport systems who foresaw that they would be outcompeted. Thus Schumpeter points out:

> Comparative slowness of beginnings [of US railroad construction] is accounted for also by the fact that the entrepreneurial task of breaking down the resistance of the environment proved astonishingly difficult. Impediments, such as constraint to pay tolls to canal companies in cases of competition, local jealousies obstructing necessary [railroad] connections, and so on, were not overcome until much later [than 1835]. ... The "competing-down element" is thus obvious from the outset, and even absolute losses ... must have been felt almost immediately, not only by canal and highway companies, but in general by business in towns that lagged behind. (Schumpeter, 1939: 291 f)

But each of the thousands of railroad projects of the age of railroadization had also other kinds of problems: how to mobilize huge financial resources and how to persuade the potential customers to use the service of the railroad. We shall return to the problem of finance but here

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4 Schumpeter is only one of many who have dealt with the case of railroadization. Actually, the literature is overwhelming. But in the present context the interest is focused on Schumpeter and a few authors (like Kuznets) that he dealt with. Somewhat astonishingly we find no reference to Marshall's extended discussion of railroad problems and railroad history in *Industry and Trade* from 1919. But the reason is probably that any reference to this book with its mixture of facts and a gradualist theory of evolution would have demanded an extended explanation by Schumpeter. Marshall's book is well suited for studying the similarities and differences between two treatments of the railroad case. Marshall's major treatment of the case is found in 1919: 68-71, 89-91, 150-153, 322 f, 445-506, 785 f, 830-845.

we should remark that supply normally runs ahead of demand. This was, of course, most obvious in the early years. Here it was clear that:

> Railroads have not emerged because any consumers took the initiative in displaying an effective demand for their service in preference to the services of mail coaches. ... [They were] forced by producers on consumers who, more often than not, have resisted the change and have had to be educated ... (Schumpeter, 1939: 73)

But is was not only the consumers which were often forced to change. More generally we may say:

> A railroad through new country, *i.e.*, country not yet served by railroads, as soon as it gets into working order upsets all conditions of location, all cost calculations, all production functions within its radius of influence; and hardly any "ways of doing things" which have been optimal before remain so afterward. (Schumpeter, 1939: 101)

In other words, what started as entrepreneurial railroad projects ended by changing the fundamental 'data' of the whole economic system and thus the system of stocks and prices.

The entrepreneur's motivation for overcoming such difficulties came in the 'pure cases' from the expected profit which from his viewpoint was the residual after the deduction from the expected revenue of all the costs (including wages, rent, interest, risk premiums etc.). The reason for expecting such a profit was that the quality and the potential price of the transport service of the railroad was expected to be clearly better than the alternatives. The difference was normally so marked that the demand for the railroad service did not only come from substitution but also from a marked increase in the overall demand for transport services. This latter response to the railroad was often presupposing the activity of other innovating entrepreneurs in several sectors of the economy. Furthermore, much room was created for an arbitraging and equilibrium promoting type of 'entrepreneurs' (*à la* Kirzner, 1973).

Schumpeter does not do much to describe individual railroad entrepreneurs. But is it is clear that they are not only successful 'heroes' like the Stephensons who built railroads and locomotives and finally outcompeted horse power and other modes of traction (cf. Schumpeter, 1939: 277). On the scene is also the mixed performance of the utopian-socialist brothers Pereire who combined railroad building and banking but never transformed their *Crédit mobilier*, their engine of promotion and innovation, into a real success (cf. Schumpeter, 1939: 347). Furthermore, we have List, the German economist and proponent of Customs Unions and integrated railroad networks; he was a spokesman for entrepreneurs and wanted government to finance railroad construction like in the US (cf. Schumpeter, 1939: 113). Finally, we have the Austrian railroad entrepreneur and finance-raiser Strousberg who was arrested after the

economic crash of 1873 which actually started its world-wide spread on a Black Friday in Vienna; to Schumpeter this kind of more or less fraudulent performance appears to be a necessary aspect of entrepreneurship (cf. Schumpeter, 1939: 363).

3. TYPES OF INNOVATION

The railroad inventions in relation to the British coal mines, like Trevitick's first locomotive for rails in 1804, had clear technological implications but they do not play any role in Schumpeter's argument about economic evolution (as they do in Usher, 1971: 54-58). Not even the technical feasibility of a combined solution of rails and locomotives enters directly into the study. Actually, this evolved gradually in the mines. But the breakthrough, the first acts of real entrepreneurship, happened in the preriod 1825-1831 when the first conspicuous examples of profitable implementation of railroad solutions were demonstrated. It is such implementations that are central to Schumpeter's way of thinking, not least the combined activities in railroad promotion and construction of locomotives. Here we have in a nutshell the difference between Schumpeter's saltationism and the gradualistic conception of technological innovation which emphasises that 'a big invention hardly ever springs out of the current of events as Athene did from the head of Zeus' (Schumpeter, 1939: 227). This alternative view is represented by Gilfillan who is an expert on the evolution of ships and, therefore, uses the steam boat rather than the locomotive as his example:

> The common-folk theory that the great inventions were made by certain great men, each at one time and in one place, usually in our own country or related England, is just as untrue as its counterpart in biology, that heroic personal acts in the Garden of Eden, not evolution, account for all the species of plants and animals. I should not waste your time on this great-man theory were it not that it is the basis of the patent system, and is being propagated and perpetuated each day in all our grammar schools. The child is taught, for instance, that the steamboat, which he takes to be the steamboat of today and perhaps the steamship too, was invented by Fulton in the *Clermont* of 1807. He is not told that there were about thirty-five steamboats built before Fulton, who was a diligent student of them, and who added nothing good in the *Clermont* to prior art, except for getting both a big boat and a monopoly on the Hudson river. (Gilfillan, 1945, cit. after Lieberman, 1972: 46)

There appears to be a gulf between this view and a view which must emphasise that Fulton was the first to make the steamboat commercially successful and, so to say, introduce it into the system of economically relevant routines. But Schumpeter points out that the difference is methodological rather than ontological. He points out 'that we may accept a theory of innovation as presented, for example, by Mr. S. C. Gilfillan in

his Sociology of Innovation ... and yet adopt another point of view for our purposes’ (Schumpeter, 1939: 85, cf. 227). Thus one may accept the slow evolution of rails and locomotives in relation to the coal mines and still emphasise the activity of George and Robert Stephenson including their conspicuous contribution to what is often called ‘the first real railway’, the Liverpool-Manchester line which outperformed monopolistic canal transport by many times with respect to price and time.[5] This may thus be considered as the ‘innovation’ in the narrow sense. It included (see figure 1) a summing-up of mail coaches (in the production of first class railroad wagons) but the result was something qualitatively new, a ‘new combination’ of elements which were partly known already. This fact is used by Schumpeter to underline the ‘jerky’ character of innovation by saying: ‘Add as many mail-coaches as you please, you will never get a railroad by so doing.’ (Schumpeter, 1935/51: 136)[6] But it must be emphasised that the railroad is qualitatively new with respect to the system of economically relevant routines only when it has been implemented successfully.

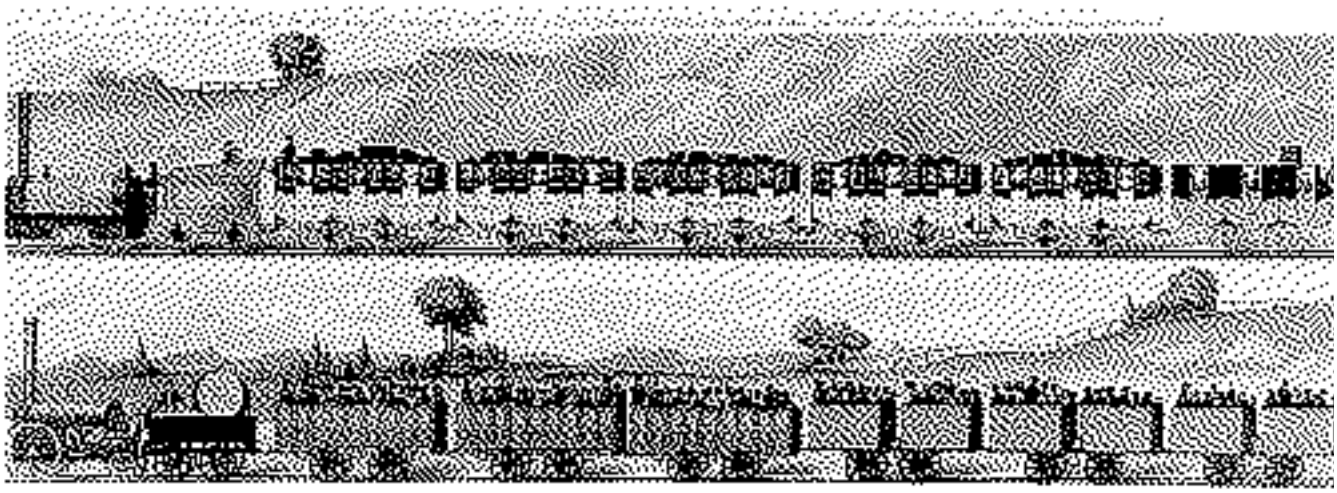

Figure 1. First and second-third class trains on the Liverpool & Manchester Railway, 1831.

The Liverpool-Manchester railway was a paradigm which led to lots of plans all over the world since it combined in an economically convincing way several distinctive elements: ‘a specialised track, mechanical tractation, the accommodation of public traffic and the conveyance of passengers’ (Bagwell, 1974: 88). In this respect

5 However, in many other cases canals were able to compete with respect to prices for customers who were not in a hurry (cf. Schumpeter, 1939: 340 f).

6 Cf. Schumpeter, 1912/34: 64.

... we must remember that the demonstration [of the full potential of the locomotive, etc.] was extraordinarily sudden. We tend to see the Liverpool & Manchester Railway as evolving laboriously, building on the experience of its predecessors; and that is true. But the world at large, which knew very little of those things, became aware of the railway at a single moment of time. Looking back to that opening more than a century later, a skrewd and reflective American [C.F. Adams] remarked: 'The great peculiarity of the locomotive engine and its sequence, the railroad, as compared with other and far more important innovations, was that it burst rather than stole or crept upon the world. Its advent was in the highest degree dramatic. It was even more so than the discovery of America.' (Simmons, 1978: 23)

According to normal assumptions about rational economic behaviour this belated but jerky appearance of the railroad is something of a paradox. When reflecting on a travel with the Liverpool-Manchester railway line the professor of political economy at Cambridge (Pryme) remarks that it is 'extraordinary that it had not been discovered long before' since both horse-driven tramways and steam engines had existed in the late eighteenth century 'and yet no one till nearly 40 years afterwards thought of combining the two' (Simmons, 1978: 22 f). We know that the last sentence is not exactly true. The real but neglected problem is, as emphasised by Schumpeter, that there is often quite a long way from ideas and plans to successful implementations. The paradigmatic role of the Liverpool-Manchester line was created because it overcome the difficulties. But even afterwards it was not easy to implement the increasing number of railroad projects. At least in the beginning each new line in e.g. Britain had the character of a (successively smaller) 'innovation'. And the jump to another nation implied a reappearance of some of the first problems. Therefore Schumpeter talks

... both of the individual [railroad] line—each is an innovation within our meaning of the term—and of the sectional or national [railroad] system—which, as such, constitute innovations of higher order (Schumpeter, 1939: 304)

This is clearly a broader conception of 'innovation' than the most wide-spread uses today. From the viewpoint of 'technological innovation' it is only the 'Stephenson case' (or the Stockton & Darlington Railway of 1825 or whatever contribution we may choose) which is a real innovation while the other cases must be considered as cases of 'diffusion' of the innovation. But Schumpeter has another view which underlines the creative and innovative character of the (first part of the) so-called diffusion process. But he is not altogether precise in the quote given. However, he also argued that the new railroad lines gradually ceased to be 'innovations' because

... the more an innovation becomes established [as a result], the more it loses the character of an innovation [process] and the more it begins to follow the impulses, instead of giving them. ... Railroad construction was now swimming with the stream in a sense in which it had not been before. What was to be done, how it had to be done, was chalked out, and

all the characteristics of induced or completing development were present. This left plenty of problems for the individual case, but they were comparatively easy to solve, further eased by the growth of the environment, and of the type which is characteristic of "exploiting investment opportunity" and "pushing into new economic space." (Schumpeter, 1939: 339, 335)

These formulations give a key to Schumpeter's conception of innovative entrepreneurship. The real entrepreneur is a leader or have some of the characteristics of a leader. Even the first followers in the 'swarm' of railroad projects were basically leaders. They had to persuade the financiers of a new region and to overcome many other types of resistance. And it is this function rather than the introduction of a technological novelty which characterises Schumpeterian entrepreneurship. This kind of novelty may vanish without removing the aspect of innovation. But when the expansion of railroads becomes something like a routine business which responds relatively smoothly to changes in aggregate demand we are dealing with an aspect of 'growth' and not with economic evolution.

The physical location of railroads makes it easy to get a rough picture of this transformation. The pattern of the first railway country, the UK, is particularly revealing (figure 2). After the first period of railway promotion a certain standstill was felt until the autumn of 1844 but then the 'railway mania' break out. In the figure we see the 'fractal' pattern of the expansion during a few years (1844-1852) of the heroic railway age, the 'great development that within a few years created almost the whole skeleton of the English railway system' was the work of the forties. (Schumpeter, 1939: 278) In the beginning major and partly extremely profitable lines were built while smaller were being carried out during the subsequent years. During these years both the labour force, the landowners, the financiers and the Parliament learned how to handle railway projects. But during the same period many less profitable and even highly dubious railway projects were proposed and many of them were implemented, helping to create occasional financial panics.

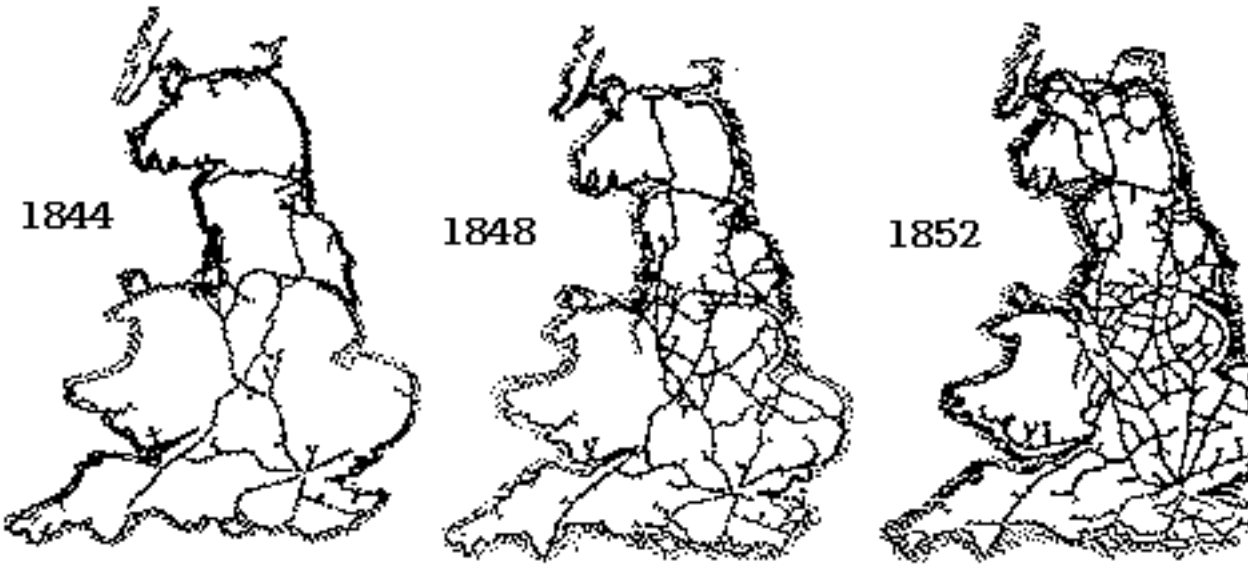

Figure 2. The expansion of the railway network in the UK, 1844-1852.
Source: Gayler, J.L. *et al.*, 1965; cit. after Cipolla, 1972: 208 f.[7]

During these and the subsequent years much know-how and many organisational innovations were also developed about the proper management of the lines and the railroad network (cf. for the US case Chandler, 1977). In Schumpeter's words:

> The entrepreneurial function consisted, in this case, not so much in visualizing possibilities ... or in the solution of technological problems ... as in the leadership of groups, in successfully dealing with politicians and local interests, in the solution of problems of management and of development in the regions the roads opened up. It was "getting things done" and nothing else, a variety of pure entrepreneurship stripped of all accessories. But this entrepreneurship was often split between several individuals and is not always easy to attribute to any single one. (Schumpeter, 1939: 327)

Gradually the question of building or expanding railroad lines became an question of calculus and planning in the (big) railroad companies which were to a large extent able to include into their decisions the factors of demand, supply and finance. These changes created a qualitatively new situation where railroad projects are no longer the speciality of innovative entrepreneurs.

> The heroic age of railroad innovation that revolutionized the economic system was entirely over by about 1860. ... Thus English railroad development from about 1860 on was a consequence of growth in our sense ... responding at every step to existing conditions, rather than an active factor of evolution. (Schumpeter, 1939: 342)

We see that in trying to develop his standard example, Schumpeter reveals some ambiguities in the notion of 'innovation'. Most interesting is that an 'innovation' which was from the start defined as something discrete

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7 More complete maps of the development of the British railway network can be found in Freeman and Aldcroft, 1985.

fades gradually away! Here is clearly a need for conceptual clarification and differentiation which is made apparent by dealing with a concrete case. Another discovery is that the evolution of the data of economic life was not at all stopped when non-jerky types of change replaced 'real' innovation. Thus Schumpeter tells us about the rich harvest of productivity gains in the period 1897-1914:

> The "induced" and "completing" character of railroad achievement during that time shows not only in construction—in the commercial nature of the new trackage and the fact that it was largely built in response to existing demand within an existing framework—but also, and still better, in other elements. ... "[P]roduct" per man-hour in steam railroad operation rose from 104 ... to 138.9 during the period 1895 to 1910. The new administrators improved tracks and roadbeds, raised horsepower installed (between 1899 and 1909) from roughly 21 millions to roughly 45 millions, accepted improvements in safety devices, began to accept automatic train control and mechanical stokers, new types of locomotives and cars, and thus evolved the railroad service that since has come to be looked upon as a matter of course, though many of these things—the electric and the oil-burning locomotive, in particular—did not spread until the postwar downgrade. (Schumpeter, 1939: 402 f)

From these remarks on 'administered' business it is clear, that evolutionary change in no way comes to an immediate halt even if it has changed its type. Actually, this kind of evolution seems to be relatively successful for a period which is even longer than the heroic period of Schumpeterian entrepreneurship in the railroad business 1825-1860. Furthermore, Schumpeter points out that the dominance of managers were not complete and that a new wave of organizational innovation (in the form of the merger movement) took hold of the railroads:

> New types of men took hold of them [the railroads], very different from the type of earlier railroad entrepreneurs. Some of them were not entrepreneurs at all, but simply efficient administrators. ... As far as the new men ... were not administrators, they were organizers and financers ... [who created] new production functions, reorganization of large sectors of the system, increase of productive efficiency all around. Mergers must, therefore, be listed among the innovations that carried that prosperity. (Schumpeter, 1939: 402 f)

How the above mentioned productivity gains in the railroad business should be divided between the factor of innovative mergers and the factor of completing achievements is not discussed by Schumpeter.

Schumpeter is also abstaining from counterfactual discussions about whether or not wide-spread railroadization was inevitable. Some researchers (like Fogel and Fishlow[8]; cf David, 1975) have remarked that canal systems performed relatively well in many (flat) parts of the world in the last part of the nineteenth century and this has lead them to ask: What if large-scale entrepreneurship had developed earlier in the construction of canals than in the construction of railroads? Maybe canal

8 [I have not yet checked the original reference] [Elster etc.]

building and canal services could have been the dominant area of innovation and investment? Schumpeter's answer would probably have been: Maybe. But the railroads won. Or, as he said in another context:

> One essential peculiarity of the working of the capitalist system is that it imposes sequences and rules of timing. Its effectiveness largely rests on this and on the promptness with which it punishes infringement of those sequences and rules. For success in capitalist society it is not sufficient to be right *in abstracto*; one must be right at given dates. (Schumpeter, 1939: 412)

In other words, the greater competitiveness of railroads than canals may be considered as a path-dependent consequence of development.[9] Because rapid change and network-creation was first introduced by the railroads, an environment was created which promoted further railroad expansion and inhibited the full development of a system of waterways. The opposite might also have been the case. In this sense Fislow's argument helps to underline the path-dependency of the evolutionary process. But in the real process the connection of individual canals into a system of water-ways raised great problems and the entrepreneurs as well as the financial system appeared somehow to be better geared to railroad projects. Furthermore, the great successes in railroad construction and service came before many changes in the canal systems which were made in response to the competitive pressure from the railroads.[10]

4. STATISTICS, LOGISTIC DIFFUSION AND THEORY

Schumpeter's view of the shifting character of the railroad 'innovation' makes him cautious in dealing quantitatively with its process of 'diffusion'. One consequence is that he does not use the word 'diffusion'. Another may be that he does not systematise and treat formally the rich quantitative information he has gathered. Therefore, we get in *Business Cycles* a scattered and rather plentiful information on mileage of railroad construction (Schumpeter, 1939: 291, 329, 341 f, 346, 351, 402), freight ton-miles (p. 488), construction and running costs (pp. 402 f), freight prices (p. 340, 523), canal and turnpike prices (p. 342 f), earnings (p. 569), stock prices (pp. 663, 875), new capital issues (pp. 878, 884), shares and loans (pp. 327, 343, 402), etc. In a verbal form railroad construction is related to the different types of business cycles. But nowhere we find a

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9 To use the term developed by David (e.g., 1988) and Arthur (e.g., 1988).

10 For other purposes the two areas may be combined. There we see that 'railroads and canals ... [had a] pivotal importance in breaking up old and conditioning new industrial structures' (Schumpeter, 1939: 368)

systematic attempt to pull all the threads together and even less to treat them with statistical tools or relate them to formal mathematical models.

One reason is, of course, that *Business Cycles* is not a book about railroadization. But the lack of real use of the statistical material is a general characteristic of the book and we have to look for general explanations. Schumpeter gives a kind of answer to the perplexed reader: we cannot really trust the aggregate data, even data aggregated for the railroad sector. If we concentrate on, e.g., railroad capacity and transport services in a country like the US, we are immediately being confronted with the question of their (evolutionary) economic meaning. Similar problems is found in a study of the automobile industry, and so on. Since these problems are typical for Schumpeter's analysis, they are worth commenting upon:

> The theorist's questions—what is a commodity, a factor of production, a country?—acquire omnious significance for most practical purposes. ... If we call motorcars a commodity, we are immediately, as in the case of prices, faced by an index problem. If we restrict the concept to model *X* of the firm *Y*, the material becomes unmagegeable. The factor *labor* brings out the difficulty best of all. A country like the United States, or even France, splits into sectors more different in character than Venezuela is from Canada. (Schumpeter, 1939: 483)

Furthermore:

> As with group prices, it is necessary to bear in mind that [quantity] composites may seriously obscure what precisely is the essential fact about the cyclical process of economic evolution. ...In particular, products require as time goes on, less and less of raw materials, such as coal, steel, and sugar beet, per unit. ... Improving quality, still another striking feature of economic evolution, works in the same way. It also largely escapes us. (Schumpeter, 1939: 484)

Schumpeter's conclusion is rather depressive:

> This really casts doubt on the possibility and meaning of any statement that turns on any but the most outstanding features of our graphs. ... [They] invites to erroneous interpretations if the series is not studied in relation to the history of its industry and technology, which alone gives the key to its meaning. Another research program unfolds itself, quite beyond the means of the individual worker [like Schumpeter]. (Schumpeter, 1939: 484)

Here we have the viewpoint of a radical evolutionist who keeps insisting that the most interesting variety is hidden within the ever-changing contents of the aggregates, a radical heterogeneity thesis which makes one wonder why he did not throw away the 60 graphs and much of the other statistical material in *Business Cycles*. But he kept it, and thus he left to the reader to come to grips with it. In this section I can only take up the question of applying to the simplest mathematical model used in ecological and evolutionary analysis, the logistic or S-curve (see, e.g., Roughgarden, 1979: part 4), which was at that time already applied in long-term industry analysis by Kuznets (1930/67) and which has later

become the trade-mark of the wide-spread study of diffusion of innovation (Rogers, 1983).

A single look at the data of the cumulative railroad kilometres (figures 3 and 4) will recall this curve. We have more or less the same picture in Schumpeter's graph of the railroad freight ton-miles of the US, 1852-1913 (Schumpeter, 1939: 488). However, the present graphs are closer to the question of railroad entrepreneurship than Schumpeter's which is also influenced by the overall development of the demand for railroad services.[11] Figure 3 shows the kilometres of British railroad line open in the years 1825–1913, i.e. the epoch of the spread of the railroad innovation in Great Britain. This is clearly an S-curve with some modifications. The overall structure may with some imagination be interpreted as an S, but one might discern smaller Ss within the large one, e.g., 1825–1843 or 1850–1896. To Schumpeter it is important that we do not stay with an analysis of the background of the overall curve but also consider the "humps" of the curve as starting points for a further exploration of the evolutionary process.

11 If details were included figure 3 would help to follow the details of Schumpeter's arguments on railroad construction. But neither the figures for the US, the UK or Germany are presented in tabular or graphical form. The scattered character of some of the data might be one explanation but not the whole one. Probably the major reason is that the work had already been done by Kuznets (1930/67) in a work which Schumpeter very critical towards (even if we find apparently positive formulations like Schumpeter, 1939: 398). In Kuznets there is full US railroad construction data, the related logistic function and even a graph of the number of railroad miles added annually in the US, 1931-1922 (1930/67: 191, 526 f). Furthermore, there is, e.g., the number of the locomotives produced by the major US producer, the Baldwin Locomotive Works in the period 1835-1923, with interesting oscillations and ending up with some 2000 locomotives annually (pp. 121-123, 410-412). Kuznets treatment of the data may be unsatisfactory but the materials are presented in a form which is much easier to follow than Schumpeter's scattered presentation.

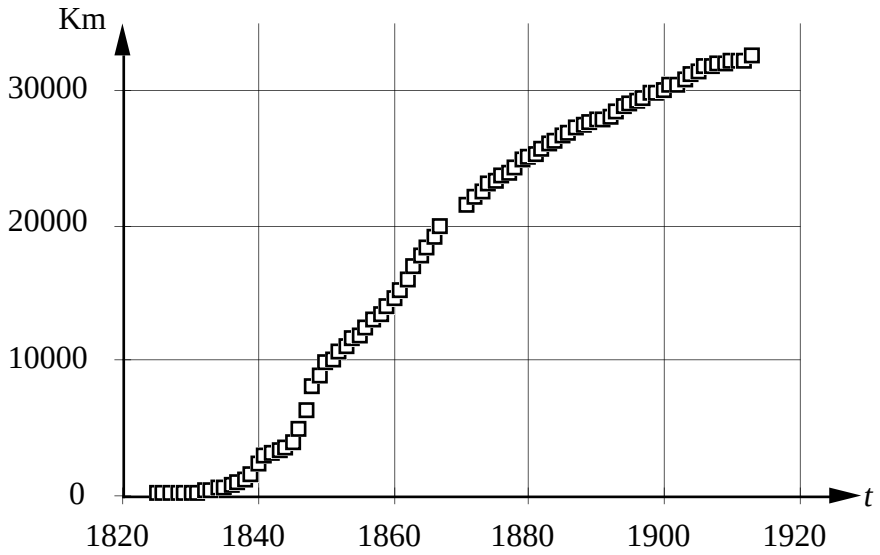

Figure 3. Total length of railroad line open in Great Britain, 1825–1913.
Source: Mitchell, 1988: 541.[12]

By applying a logarithmic scale we may explore some of the properties of the S-curve. At the same time we have the opportunity of comparing the very different scales of "railroadization" in some of the major countries (figure 4). First and foremost, we see is that the growth rate of the "population" of railroad kilometres is decreasing, even if it has not reached zero before World War I. Second, we see an initial but very short period of acceleration of growth in the pioneering countries, especially Great Britain but also France. This reflects the debugging of the innovation as well as the jump in knowledge about railroads related to the much-discussed opening of the Liverpool & Manchester Railway in 1831. The other countries started with a clear-cut paradigm of railroadization and thus with a maximum rate of growth. Third, there are later periods of accelerated growth. For example, we see in the US as well as in Austria-Hungary a period of acceleration in the late 1860s[13] and an increased deceleration after the crisis of 1873. All in all, we see modified versions of a more-or-less S-shaped pattern. But there are no grounds for a strict adherence to a simplistic understanding of logistic growth or even of broader forms of S-shaped growth. Had this been the case, we would have met a really surprising phenomenon since the cases of "railroadization" differ greatly. The cases of Great Britain and the US were characterised by private railroad promotion (in a complex interplay with government)

12 Data for Ireland is not included. Data is lacking or is problematic for 1868-1870.
13 In the US related, of course, to the end of the Civil War.

while government were dominant in railroad construction in the other countries, especially in the later parts of the epoch under consideration.

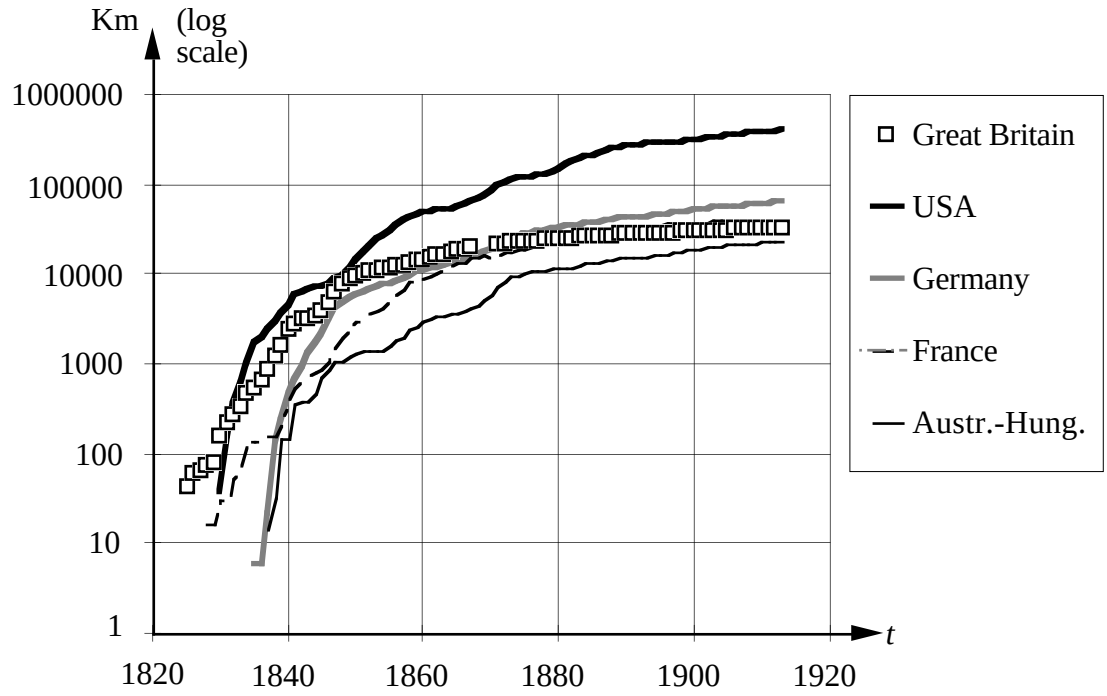

Figure 4. Total length of railroad line open in major countries, 1825-1913 (log. scale).
Source: Mitchell (1981: 609-611; 1983: 656-658; 1988: 541)

The consideration of the process of railroadization during nearly a century as a case if diffusion of a single innovation is just as problematic as it is fascinating. The idea clearly helps to organise our thinking but it may also cripple our analysis if we stick to it too ruthlessly. The ideal is clearly to consider railroadization as an evolutionary process during which the railroad technology as well as the norms and techniques of its "environment" undergo a radical transformation. It was in this interplay that the "development block" (Dahmén, 1970) around the railroad took form and that many of the organisational forms of the modern corporation were developed (Chandler, 1977: pt. 2). These facts help to emphasise that more complex cases of the diffusion of "an" innovation are in themselves processes of innovation.

In general figures 3 and 4 looks well suited for a standard analysis of 'diffusion' in terms of the logistic equation. Schumpeter was fully aware of the possibilities of arriving at a 'descriptive trend' (Schumpeter, 1939: 201) through such a curve-fitting. But he was even more aware of the dangers, especially for aggregate data. Here, e.g., any revealed exponential growth rate has little meaning. He continues:

Still more treacherous and pregnant with danger of speculative temerity may be the application of Verhulst's formula, $y=a/(be^{-t}+1)$, which was intended (1838) to present

certain features of organic or of similar types of growth. ... We are, however, on somewhat safer ground when applying such expressions to the behaviour in time of quantities of individual commodities. (Schumpeter, 1939: 492)

But Schumpeter does not apply the Verhulst's logistic model or discuss the results.[14] Instead we get a verbal and general account:

[I]t is obvious that ... no industry can go on expanding output at the rate of its innovation stage. Each reaches maturity in the sense that it finds its place in the economic organism and the amount of output beyond which it cannot profitably go, unless that amount be increased by some further innovation within it or in some "complementary" industry and by the general effects of ... Growth. (Schumpeter, 1939: 497)

Thus we may conclude that:

Output of a new commodity may easily trace out a Verhulst curve which many students will have no hesitation in interpreting as a trend special to that commodity and distinct from any cycles that may run their course in the same period. From our standpoint, of course, this is never strictly correct, although it may, for purposes of partial analysis, be convenient to express oneself so ... (Schumpeter, 1939: 205)

What Schumpeter demands and does not get is the insertion of the development of the 'population' of the individual commodity or sector (like railroads) into the overall framework with interconnections with other sectors and with the cyclical pulse of economic evolution. But later developments have, in my opinion, shown that it was really not necessary for Schumpeter to stop here. For the logistic formula is not only a tool for curve fitting but also one of the starting points for embarking on theoretical analysis, as we see in the case of (evolutionary) ecology (cf. Kingsland, 1985). Since we will often face similar situations later, it is helpful to go somewhat further than Schumpeter did and see examples of how the formula can be used as a rough theoretical scheme which may help us to organise some of his problems and discussions. For these purposes it is convenient to use a generalised version of the formula, to use the standard parameter names of evolutionary biology and to discuss in terms of the differentiated version of the logistic function. This gives us

14 A somewhat naive presentation of the state of the art in the 1920s is found in Kuznets (1930/67: 64-69, 291), including the Gomperz curve. Actually, the empirical use of the logistic curve, especially in demographic analysis and prognosis, created an overheated debate in the 1920s and 1930s. The major proponent for the use of the model was the biologist Pearl of John Hopkins University while the well-known statistician E.B. Wilson and other staff of Harvard University (including the department of economics where Schumpeter moved to in 1932) were astonishingly sharp in their critiques (cf. Kingsland, 1985: chapters 3-4). In such an environment Schumpeter's own naive idea of an alliance between economic theory and statistical and historical analysis (the econometric research programme) was in great trouble.

the following expressions of the logistic differential and difference[15] equations,

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right) = rN\left(1-\frac{N}{K}\right), \tag{1}$$

$$N_{t+1} = N_t + rN\left(1-\frac{N_t}{K}\right), \tag{2}$$

which may be interpreted in several ways. At present we may think of *N* as some measure of innovation-diffusion (total railroad mileage), *K* as the (long-term) carrying capacity (for the prevailing environmental conditions and the prevailing characteristics of the innovation), and *r* as the 'intrinsic rate of increase' or 'potency of spread' (dependent upon characteristics of entrepreneurs and customers as well as financial conditions).[16] With this interpretation each established railroad unit may be seen as a starting point for further railroad construction, either directly (see figure 2) or indirectly as a rough indicator of the number and strength of entrepreneurs aware of the possibility of joining the railroad business. The effects of the pioneering railroad construction on further growth is only depending on the potency of spread, *r*, which may partly be ascribed to the railroad innovation itself,[17] partly to the innovation-promoting agents and mechanisms (entrepreneurs and bankers) and partly to the (expected and real) reaction time of the customers. But as the established railroad miles increase, the distance to the carrying capacity, *K*, becomes smaller. This means that the effect on further growth of an established railroad unit becomes smaller and smaller—since it is proportionate to the difference between *K* and *N*. In the continuous version (1) this means that *N* is asymptotically approaching *K*. In the discrete case (2) this is not necessarily the case. For some *r*-values *N* will oscillate around *K*, and here we see a surprisingly large number of patterns.[18]

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15 The version of the difference equation recorded in equation 2 have a boundary property which is one of the reasons why most biologists use a slightly more complex version, cf. May, 1981: 12.

16 We may integrate this differential equation and return the a form closely related to Schumpeter's: *y*-curve: $N(t) = K/(ce^{-rt} + 1)$, where *c* is determined by the initial condition $N(0)$, as $c = K/N(0) - 1$. Schumpeter is describing the special case where $r = 1$. However, Schumpeter points to the 'slightly generalised' formulas used in the 1920s by Lotka, Pearl and Reed (Schumpeter, 1939: 492).

17 But the characteristics of railroad construction may also suggest the inclusion of further timelags into equation 2.

18 For high values of *r* we find stable cycles around *K* and for even higher values ($r > 2.570$) we find so-called deterministic chaos which was actually discovered by

The question is now how this interpretation fits Schumpeter's analytical purposes. At least implicitly he appears to suggest that the hypothesis about fixed parameters (or any fixed functional form of the change of r and K) may serve to hide the story about the interesting aspects of the cyclic-evolutionary process of railroadization which Schumpeter is trying to tell. But still the interpretation provides, in my opinion, an analytical framework of considerable heuristical value if we accept the discussion of the many possibilities of parameter change during the process. r_t may change in a very complex way from the introduction of the innovation, t, to the point where we consider it to be "fully spread," $t+n$, because, e.g.:

1. The railroad innovation is undergoing change.
2. The types of entrepreneurs, managers and bankers involved in the railroad business is changing.
3. The macroeconomic conditions are changing.

Similarly, K_t may change because, e.g.:

4. The quality improvements and cost reductions in relation to the innovation.
5. Developments in competing and cooperating sectors.
6. Changes in the macroeconomic variables.

In this perspective we may think that r_t and K_t are increasing as time run in the first part of the process. Such increases may be due to the fact that the first railroad entrepreneurs and bankers pave the way for their followers (network externalities, specialised suppliers, new methods of finance, etc.). Furthermore, the railroad pioneers are themselves helping to move the frontier, the point where saturation is reached. Without this effort there might be much too little demand:

> We may smile now at the opinion of the age that railroads were being overdone, seeing how small a part of what we now know had to be done was accomplished then. But certainly they were in advance of what was then required. Of course they were, for they themselves created the economic world, which was to provide the demand for their services and which never could have developed without them. (Schumpeter, 1934/51: 111)

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studying the logistic difference equation (cf. May, 1981: chapter 2). This level of r has perhaps some relevance in the development of decision-making (but not real mileage) during 'railway manias'. But it must be emphasised that the logistic difference equation is a purely formal tool and we cannot be sure that it is possible to give it any precise economic meaning. As mentioned in the next paragraph, Schumpeter would emphatically deny the constancy of the parameters which underlies discussions on 'chaos'.

Thus, the pioneers did not adapt to existing K's; instead they recreated a 'new world of economic norms' and thus got a demand for their 'innovation'. This is especially clear in new regions of, e.g., the US:

> Typically, a railroad [company] opened a region, built elevators, prepared many things for the would-be farmer, sometimes even furnished instructions about products and methods. (Schumpeter, 1939: 319)

In this way it was secured that there were freight and passengers when the railroad finally arrived to the region. Another reason for our scepticism against fixed K's is understood if

> ... we will recall their [railroads and canals] pivotal importance in breaking up old and conditioning new industrial structures—the fundamental fact about cycles throughout the first half [1843-1860] of that Kondratiev (Schumpeter, 1939: 368)

All in all, it is seems that in Schumpeter's mode of thinking the apparent parameters of the logistic model are becoming the central variables of another model which is not formulated sharply and which appears to have elements which are 'refractory to mathematical formulations' (Schumpeter, 1991a: 230). The reason is basically that we are trying to describe an irrevocable process which are dependent on the timing and character of events to a degree that one tends to say that the model should work in 'historical time'.

Another increase in the heuristic value is created by using the logistic curve as a framework in which to interpret the economic decision-making related to the process of railroadization. Under this interpretation we are dealing with the expected values of the presumably logistic expansion at different future points of time and the effects of these expectations on the new construction of railroads. This interpretation is suggested by Schumpeter's formulations about railroads being 'overdone', railroad companies securing demand by promoting other investments.

Let us take the viewpoint of a firm at a particular point of time, t. The firm has expectations about the growth of output until a point of time, $t+h$, which is determined by their "economic horizon". First, we assume that the firm is basing its expectation on the hypothesis that the output is expanding in a logistic manner. Second, we assume that the firm has hypotheses about the approximate values of r and K for the whole industry. But there is little reason to believe that the resulting expectations are formed in any precise manner. The relevant investment criterion for firm A is rather expressed in terms of whether the railroad business at point $t+h$ will be 'far away from' or 'close to' its theory about the carrying capacity of the industry K^*. This carrying capacity is probably defined in a way which puts emphasis on freight rates and quantities sufficient to uphold a minimum level of profitability. Whether this level

will be reached at point $t+h$ depends on the hypothetical r^*. To make these judgements involve expectations about other sectors and commodities and even different macroeconomic considerations. The 'real' entrepreneur is a person who expects the inovative contents of his project to be so large (with respect to the normal practice in the economic system) that K^* is 'far away'. The actual *K* can only be seen *ex post* and an analysis of how it came about will probably show that that it is 'determined by history', i.e. the path-dependent evolutionary process.

Here we are approaching yet another, and more metaphorical, interpretation of the logistic function. It concerns a classification of the strategies of the economic agents and their relationship to selection processes in uncrowded (with room for *r*-determined expansion) and crowded 'populations' (near the *K*-limit). In the early stages of the railroad diffusion, selection favours the fast action and spread, i.e., pairs of entrepreneurs and financiers able to provide a high *r*-value. Either they proceed in building more railroads or their network is further expanded by others. In this situation we see the relevance of Schumpeter above quoted remarks that 'one must be right at given dates.' (Schumpeter, 1939: 412) One of the problems of timing is related to the fact that fast expansion is normally related to financial vulnerability. If the recession of the economy comes too early failure of the project may follow but still the prospects of rapid creation of a strong position keeps up the 'animal spirits'. Later, when the railroad system is well-developed, fastness is dangerous and does not lead to any results. What is needed is the fine tuning which may give a lead *vis-à-vis* the competitors or which may marginally move the *K*-frontier. We have seen several examples of this in the above discussion of the later railroad developments. They are felt especially clear under an economic downswing where the sustainable level may be below the existing industrial capacity:

> ... Rationalization ... expresses the gist of what we mean by downgrade developments: exploitation to the utmost, partly under duress, of existing possibilities of technological and organizational innovations on lines and principles established before but steadily improved in the process; revision of the whole structure of industry in quest of increased efficiency; systematic struggle with each item of the list of costs ... (Schumpeter, 1939: 759)

The biologists MacArthur and Wilson (1967) have developed a somewhat similar discussion which led to the distinction between

r-selection and *K*-selection, as well as
r-strategists and *K*-strategists.

In the case of biological species we are dealing metaphorically with the term 'strategy' which relates to a behaviour which is genetically determined. The idea might be even more relevant to the area of economic evolution, like the process of railroadization, where agents can have different strategies with respect to innovation. Several examples have already been mentioned but the more systematic view proposed by the ideas of MacArthur and Wilson seems to clarify some of the limitations of Schumpeter's discussion of the railroad case. We may say that he is overemphasising *r*-selection and the related 'entrepreneurial' behaviour while he is to some extent neglecting *K*-selection and the related 'managerial' behaviour to the extent that he sometimes denies it any role in a long-term evolutionary perspective. Whether this is a correct judgement is, of course, an empirical question which cannot be determined terminologically and conceptually. But the examples given suggest a significant evolutionary role for the *K*-strategists who may even produce the bulk of evolutionary change. At least it is clear that it is important to have an analytical framework which is broad enough to cope systematically with both kinds of selection and both kinds of strategy.

However, Schumpeter's basic idea is clear enough as can be seen if we return to an interpretation of figure 3 but stick to our modern evolutionary formulations: There is a clear difference in selection environment and the successful strategies between the years of more-than-exponential (hyperlogistic) growth until 1858 and the years of mature growth in the last ten years of the century (and later). In other words, there is a huge difference with respect to preconditions and consequences between the construction of the first and the last 25.000 track miles of the railroad network. But in between there is a period which is more difficult to handle, not only because the civil war implied a retardation during the 1860s but also for theoretical reasons. This is especially so in relation to Schumpeter's scheme which deliberately concentrates on extremes like the pure types of *r*-strategies and *K*-strategies.

5. ENTREPRENEURSHIP, FINANCE AND CYCLES

Until now I have concentrated the exposition on the development of a single 'population' of productive capacities. But railroad construction and service is an integrated part of a system of economic decision-making which is clearly at the centre of Schumpeter's scheme. It is here we shall find the materials for a further development of the analysis of the microscopic aspects of railroad entrepreneurship which was started in

section 2. And it is also here we find the background for railroad 'manias' and 'panics' as well as for less conspicuous aspects of the relationship between the railroad industry and the overall business cycles, especially the 'normal' Juglar cycles of about 9 years and the Kondratiev cycles (or long waves) of about 50 years. Even if this aspect of macroeconomic dynamics will not be emphasised in the present book, it is helpful to sketch Schumpeter's ideas in relation to the case of railroadization.

But let us start with a technologically oriented description of the railroad innovation. Or, rather, let us look at Schumpeter's list of the many repercussions of the railroad projects which

> ... combine to make the essential features of our evolutionary process more obvious in this [railroad case] than they are in any other case. [These aspects include]
> • [t]he comparatively long periods of gestation, both of the individual line ... and of the sectional and national system ...
> • the quantitative importance of the expenditure involved,
> • the consequent dislocation of all the data [routines, parameters] of economic life,
> • the new investment opportunities
> • and the new possibilities that are created for further innovation,
> • and the (cyclical) disturbances in turn caused by these [possibilities.]
> More easily than in any other case can the usual objections to our analysis be silenced by a simple reference to obvious facts. (Schumpeter, 1939: 304, rearranged)[19]

This list clearly may help to suggest

> ... how railroad construction produces both prosperities and recessions—with the latter, situations which easily slide off into depressions—and in particular, simultaneous cycles of different span ... [Therefore,] railroadization is our standard example by which to illustrate the working of our model. (Schumpeter, 1939: 304)

However, the list is mainly emphasising the technological characteristics of the railroad innovation, and just as a long-term logistic curve, like in figure 3, it does not bring much immediate help for our understanding of the interplay between railroad construction and business cycles. Like the S-curve the list is, of course, reflecting parts of the background for and consequences of the development of railroad capacity

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19 My rearrangement is motivated by the fact that I deal primarily with one of Schumpeter's most complex sentences: 'The comparatively long periods of gestation, both of the individual like—each line is an innovation within our meaning of the term—and of the sectional or national system—which, as such, constitute innovations of a higher order—the quantitative importance of the expenditure involved, the new investment opportunities and the new possibilities that are created for further innovation, combine to make the essential features of our evolutionary process more obvious in this than they are in any other case. More easily than in any other can the usual objections to our analysis be silenced by a simple reference to obvious facts.' (Schumpeter, 1939: 304).

but we do not hear much about the way entrepreneurial decisions are taken and how they influence the economic system. As a shortcut to the world of economic decision-making it is useful to refer to Schumpeter's metaphorical version (or vision) of the 'money market' to which the railroad entrepreneur has to go to get his project financed:

> The money market is always, as it were, the headquarters of the capitalist system from which orders go out to its individual divisions, and that which is debated and decided there is always in essence the settlement of plans for further development. All kinds of credit requirements come to this market; all kinds of economic projects are first brought in relation with one another, and contend for their realisation in it; all kinds of purchasing power, balances of every sort, flow to it to be sold. ... [T]he main function of the money or capital market is trading in credit for the purpose of financing development [like railroad projects]. (Schumpeter, 1912/34: 126 f).

How this 'money or capital market' is organised is not relevant for the moment, just that a possibility exists for the railroad entrepreneur to finance his ambitious project which involves heavy outlays a long time before the expected receipts may show up. At the same time the credit system (in its widest sense, including the stock exchange) links the entrepreneur to the conditions of other entrepreneurs and to other parts of the economic system. It is also here the overall 'state of confidence' is likely to develop and thus the coordinated expectations of many economic agents. And it is here that the finance of (exports to) overseas projects may continue to make railroad entrepreneurship important even after, e.g., the railroad system of the UK was next-to completed.

Schumpeter's restriction of the function of (his 'essentialistic' version of) the credit market to the finance of entrepreneurial project is clearly removing some empirical traits from it. But, on the other hand, it helps to focus our interest on the important question of whether and how entrepreneurial activity can create the wave-like form of economic evolution. A more concrete question is how innovative projects may appear 'discontinuously in groups or swarms' (Schumpeter, 1912/34: 223). The problem is here that even if the sequence of events related to an individual project, like the Manchester-Liverpool line, involves a rather long period before the 'borrowed' money can be returned, the random occurrence of a great many railroad projects will not help to create impulses for a cyclical behaviour of the economic system. To do this, they must be 'bunched' or synchronised. Experience of the epoch of railroadization teaches that we have very characteristic sequences of events: the reasons are that easier projects are being taken up after more difficult ones, imitation sets in a certain points of time, banks and the stock exchange are increasingly willing to finance and provides increasingly suitable services, entrepreneurship is spreading to connected sectors,

multiplier effects are felt, etc. Another reason is related to Schumpeter's already listed characteristics of the railroad projects:

> One railroad or a few lines may be all, or more than all, that can be successfully built in a given environment at a given time. Reaction and absorption may have to follow before a new wave of railroad construction becomes possible. ... In such cases, innovation is carried out in steps each of which constitutes a cycle. (Schumpeter, 1939: 167)

But the cyclical behaviour if the central economic variables is not just a question of constructing the railroads but also of related projects:

> Expenditure on, and the opening of, a new line has some immediate effects on business in general, on competing means of transport, and on the relative position of centers of production. It requires more time to bring into use the opportunities of production newly created by the railroad and to annihilate others. And it takes still longer for population to shift, new cities to develop, other cities to decay, and, generally, the new face of the country to take shape that is adapted to the environment as altered by the railroadization. (Schumpeter, 1939: 168)

According to Schumpeter the story of railroad construction and its possible relationship to business cycles starts in the last 15 years of the Kondratiev long wave of the industrial revolution (1786-1842). From the small but clearly visible beginnings of Stephenson and others (see above), things developed rapidly in the 1830s in a way which made British railroad entrepreneurship a noteworthy factor of the last Juglar cycle of the epoch of the industrial revolution:

> The conspicuous success in 1835 induced speculative excesses immediately afterward, although railway propositions had been sufficiently prominent before to qualify for the title of "bubble speculations." The Liverpool and Manchester [line] was the first entrepreneurial feat of national importance which, indeed, induced not only the "following"—part of the essentials of our schema—but all the phenomena of our Secondary Wave [of multiplier effects, etc.]. The contribution of railroad construction to the Juglar prosperity that preceded the crash of 1837 is beyond doubt. But speculative excitement and its reflex in the talk of the time should not induce us to exaggerate the importance ... The great development ... was the work of the forties ... although all the essentials of railroad enterprise—types of entrepreneurs and methods of financing included—stand out fully fledged in the thirties. (Schumpeter, 1939: 278)

In a way these developments can be seen as a dress rehearsal of the great act of railroadization which came to dominate much of the next, bourgeois Kondratiev wave (1843-1897). This long period is, according to Schumpeter's analytical purposes, divided into several types of subperiods but for readers who do not already know Schumpeter's ideas it is convenient to divide the Kondratiev into two parts. First there are the 'prosperity' years (1843-1869) which include three Juglar cycles (1843-1851, 1852-1860, 1861-1869) and than we have the years of 'recession'

(1870-1897) which also includes three Juglar cycles (1870-1879, 1879-1888, 1889-1897).[20]

According to Schumpeter

> ... nobody could fail to associate it [the whole period 1843-1897] with what we call the railroadization of the world, which obviously was, though not the whole of it, yet its outstanding feature. The latter statement particularly applies to this country [the US], the Western and Middle Western parts of which were, economically speaking, created by the railroad. For England and even for Germany the importance of their own railroads was absolutely and relatively much smaller, and for them our statement should be modified to read that railroad development in the world was the outstanding feature that dominated [through exports and financing] economic activity in those countries also. (Schumpeter, 1939: 303)

Behind all his cautious remarks it is clear that Schumpeter wants us to consider the period 1843-1897, the years of his second Kondratiev wave, as in some way 'carried' by entrepreneurship in railroads (and related innovations). Actually, he is able to argue that railroad construction is 'the carrier of the cyclical movement' (Schumpeter, 1939: 339) in all the Juglar cycles as well as in the overall framework of the Kondratiev wave, especially in the US but through foreign investment also in, e.g., the UK. However, there is little reason in the present context to follow Schumpeter's repetitive application of his cyclical-evolutionary scheme. Instead, I will concentrate on the overall characteristics of the Kondratiev wave.

It is during the years of prosperity that we see the great development which created the core of the UK railroad system (figures 2-4) and which, with some delay, also implied a radical jump forward in the US and in Germany (figure 4). In relation to the above discussion of the logistic differential equation we may say that during these years *r*-strategies dominate but the economic system has much stickiness and this puts a restriction on the size of *r* which is, however, increased during a short period. Then a stage is reached where all available financial resources are rapidly absorbed by the first projects while other projects have to wait until there are possibilities as well as willingness for another burst. However, there is the problem how the ceiling of resources is reached. Traditionally, the answer has been related to the lack of savings. But Schumpeter does not accept this kind of answer as he indicated when discussing the early years of US railroad construction. Instead he

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20 According to Schumpeter, 1939: 396 f. The reader should be aware that parts of the periodisation is only accepted by Schumpeter himself and that he leaves some doubts about the specific timing within the major countries dealt with in *Business Cycles*: the UK, the US and Germany.

emphasises that finance is primarily due to newly created credit rather than being a function of previous savings:

> Previous profits or domestic savings being inadequate, railroad construction was, therefore, mainly financed by credit creation. ... The fact that credit, created *ad hoc* by both the preexisting banks and the many new ones that emerged, to a large extent financed railroad and other innovation, has often been emphasized and never been contested. (Schumpeter, 1939: 328-330)

We should develop all the problems of saving, finance and investment. And we might also consider the problems of the open economy and which, e.g. in the US case, include British finance. I will not develop this kind of mixed empirical—theoretical question much but turn to another kind of ceiling which was restricting the long-term growth of the railroad network. This is, of course, the *K*-ceiling or the 'carrying capacity' of the economic system with respect to railroads and all the related investment projects. This carrying capacity was, as has already been mentioned, changing during the age of railroadization. Whole regions which had difficulties in sustaining a single mail coach was being developed and produced lots of freight and passenger for the railroads. But gradually the ability to construct railroads outperformed the ability to produce coevolution and thus demand for transport service within reasonable time. And competitors, like canal firms, were also investing and kept lower freight prices for slow transport. So, there was a good deal of overinvestment compared to the (temporary) carrying capacity. And a financial crash, which by the way started in the town of Schumpeter's young years, Vienna, where under its way. But still in the late 1860s there was other times.

> The period is known as the "promotor's time" (*Gründerzeit*). Enterprise, spreading from the railroad business and allied lines, extended lightheartedly to everything imaginable, both methods and schemes being clearly fraudulent in many cases. ... Mushroom banks—many little better than bucket shops—sprang up. Everyone knows that often-painted picture. Speculation reached its high-water mark early in 1872 and then began to decline, stock market prices giving way in September. The "crisis" broke in Vienna on May 8, 1873, in a most dramatic way and lasted for about half a year. In Germany there was a great epidemic of financial and industrial bankruptcies, but much less panic. (Schumpeter, 1939: 362 f)

But this turbulence was in a way a necessary element in the basic change of economic norms, or, in other words, that the larger

> ... process—mainly associated with railroad construction—within which the events of 1870 to 1873 constitute a step, had so revolutionized the economic system that liquidation, absorption, adaptation—all of what these terms mean can clearly be observed—was an unusually long and painful affair. (Schumpeter, 1939: 338 f)

But the railroad construction of most countries rapidly overcame the standstill and continued, although often with a decreased 'intrinsic rate of increase'. Furthermore, the railroad entrepreneurs and managers (and

their lenders and stock holders) became more cautious and aware of possible *K*-limits which were made clearer by the sluggish development of demand. Such kinds of behaviour determined the character of the economic game during the second half of the Kondratiev wave (1870-1897). Even in the last part of this period where the 'depression' was over and a 'recovery' had started we see *K*-strategies rather than *r*-strategies. Such a situation has already been described above but it is relevant to take yet another formulation of Schumpeter's which clearly underlines that we are not dealing with a period without 'innovations' (of the induced and/or incremental type):

> Kondratieff downgrades and revivals precisely display a wide variety of induced or complementing innovations which develop and carry to their limits possibilities opened up before, of which railroad building was but the most important. Accordingly, railroad construction, increasingly settling into a predetermined framework and exploiting preexisting investment opportunities, became during the period under discussion much more (though not yet entirely) a function of railroad business and, hence, of the rest of the business organism than it had been before, and the relation became substantially one of mutual dependence [rather than asymmetric impulse and response]. However, the railroad industry had not sown its wild oats yet, either as regards boldness of advance or as regards financial methods. (Schumpeter, 1939: 339)

6. CONCLUSIONS

The presentation of some elements of railroadization as a standard example of Schumpeter's cyclic-evolutionary scheme of analysis has left many questions open. For example, a section on Schumpeter's considerations about the fatal tendency to reast on the laurels is much needed. Furthermore, we should consider the special character of railroad business as the typical provider of a public good because of individibilities and network economies, etc. However, I also think it has demonstrated some of the concreteness and freshness in Schumpeter's mode of thinking which may verify his claim that 'there is nothing in my structures that has not a living piece of reality behind it.' (Schumpeter, 1991a: 230). Moreover, I have in the discussion of the logistic equation suggested that theoretically Schumpeter was implicitly and explicitly presupposing radical changes in the norms (so-called parameters) of economic life. Furthermore, I have pointed to a certain bias against induced and complementary innovation which may stand in the way of a full analysis of the evolutionary process. But most of all I hope to have retold and reconstructed a good story which makes the reader interested in following Schumpeter's hint and continue the study of railroadization as a cyclical-evolutionary process, 'to work out again step by step. For railroadization is our standard example' (Schumpeter, 1939: 304)

We have thus gained many ideas and informations which give meaning to, direct and even sharpen our understanding of core elements of Schumpeter's work. It may also help to characterise differences and similarities between Schumpeter's mode of analysis and the analysis found in Marshall, Darwinian-inspired analyses and much of the modern theories of economic evolution. Furthermore, the case gives concrete insight into Schumpeter's peculiar generalisation from economic evolution to social, including scientific and artistic, evolution. We have already met signs of this widening of the perspective in Schumpeter's naming of 'the bourgeois wave':

> ... the second Kondratieff has a special claim to the epitheton *bourgeois*. By this we mean that the interests and attitudes of the industrial and commercial classes controlled policies and all manifestations of culture in a sense in which this cannot be asserted for any preceding or any subsequent period. (Schumpeter, 1939: 304 f)

Before leaving the case it is, however, necessary to delimit the perspective to economic evolution in a narrower sense. Even in this sense much is left for future work. Thus, the reader will probably while dealing with the innocent-looking exercise on railroadization have found major gaps between Schumpeter's evolutionary scheme and the problems of theoretical-empirical analysis. And he or she will probably look for some 'worked-out solution' presented by the master, by Schumpeter himself. Unfortunately there are no elaborated version of this or any other case. Instead we find that it appears mainly to be Schumpeter's creative mind and his excellent style which hold together the diffuse historical and statistical materials on railroads and economic evolution. In other words, the combination of 'evolutionary scheme' and 'actual analysis' is made in a unique way which cannot be reproduced in a fully systematic manner. Thus, Schumpeter has left us with major tasks of reconstructing and refining his scheme for normal scientific use and of confronting an overwhelming amount of empirically oriented problems. This heritage is admitted in the preface to *Business Cycles* where Schumpeter points out that it

> ... took longer than I thought to turn that scaffolding [*Theory of Development*] into a house, to embody the results of my later work, to present the historical and statistical complement, to expand old horizons. Nevertheless I doubt whether the result warrants that simile. The house is certainly not a finished and furnished one — there are too many glaring lacunae and too many unfulfilled desiderata. ... The younger generation of economists should look upon this book [*Business Cycles*] merely as something to shoot at and to start from — as a motivated program for further research. Nothing, at any rate, could please me more. (Schumpeter, 1939: v)

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