

## **Railroadization as Schumpeter's Standard Example of Capitalist Evolution: An Evolutionary-Ecological Interpretation**

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**Abstract:** In his book on *Business Cycles* Schumpeter declared that the railroad and its consequences for the economic system is the standard example of his analysis of capitalist evolution. This paper demonstrates that Schumpeter went quite far in the analysis of his case of 'railroadization' and in suggesting how his model could be adapted to it. Some of these suggestions are taken up in relation to modern evolutionary economics and to evolutionary-ecological analysis. The parameters of the logistic equation and the Lotka-Volterra equations are shown to be central variables in an evolutionary process that includes different types of economic agent. The specification of the roles in this process helps to redefine entrepreneurs, managers, and financiers. Furthermore, a new interpretation of the system-level dynamics is made, both in general and in relation to the case of railroadization.

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## 1. Introduction

Less than two months before his death, Schumpeter protested against the crowding out of evolutionary perspectives from economics in a way which shocked not only his young colleagues like Samuelson and Goodwin<sup>1</sup> but also broader groups of active researchers in economics and econometrics.<sup>2</sup> The event took place at the Conference on Business Cycles arranged in collaboration between university researchers and the National Bureau of Economic Research.<sup>3</sup> Schumpeter's point of attack in his paper on the 'Historical Approach to the Analysis of Business Cycles' was implicit but clear to all participants: the insensitivity of econometrics and mathematics to the core process of capitalist evolution. Schumpeter choose to 'let the murder out'—i.e. to spoil his own performance and create an unpleasant and intellectually troublesome state of affairs—at this conference which gathered a good deal of the most talented young economic theorists, statisticians and model builders of the US:

To let the murder out and to start my final thesis, what is really required is a large collection of industrial and locational monographs all drawn up according to the same plan and giving proper attention on the one hand to the incessant historical change in production and consumption functions and on the other hand to the quality and behavior of the leading personnel.<sup>4</sup>

The purpose of this apparently idiosyncratic proposal of 'detailed historical case studies'<sup>5</sup> was to elucidate the mechanisms underlying much of the cyclical behaviour of economic aggregates. Even the cyclical behaviour of investment is in itself a surface phenomenon and we have to investigate 'the actual industrial process that produce it and in doing so revolutionize existing economic structures.'<sup>6</sup> The mechanisms of this process had not been studied by Schumpeter's ambitious audience. Actually he thought that

... the most serious shortcoming of modern business-cycle studies is that nobody seems to understand or even to care precisely how industries and individual firms rise and fall and how their rise and fall affects the aggregates and what we call loosely 'general business conditions'.<sup>7</sup>

Due to the evolution of evolutionary economics we are today much better prepared for accepting Schumpeter's heterogeneity principle (which is probably underlying the suggested case studies). Therefore, we can appreciate Schumpeter's aim of influencing the trajectory of modelling work by creating

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<sup>1</sup> See Swedberg, R., *Schumpeter: A Biography*, Princeton, N.J.: Princeton University Press 1991, p. 176.

<sup>2</sup> The shock could have been avoided if other economists had followed Schumpeter's work in the late 1930s and in the 1940s more closely than they did. Schumpeter, J.A., *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*, New York and London: McGraw-Hill 1939 clearly emphasises the historical method, and in his last years Schumpeter got involved with the new Research Center in Entrepreneurial Studies which suggested new developments of his ideas (Swedberg, *Schumpeter*, pp. 172 ff). A possibility of the revitalisation of his theoretical scheme through the interaction with theoretically relevant studies in industrial history appeared to emerge.

<sup>3</sup> Universities-NBER, *Conference on Business Cycles*, National Bureau of Economic Research, New York 1951.

<sup>4</sup> Schumpeter, J.A., *The Historical Approach to the Analysis of Business Cycles*, in Schumpeter, J.A., *Essays on Economic Topics*, ed. R.V. Clemence, Port Washington, N.Y.: Kennikat, p. 314.

<sup>5</sup> *Ibid.*, p. 311.

<sup>6</sup> *Ibid.*, p. 312, emphasis removed.

<sup>7</sup> *Ibid.*, p. 315.

an informal demand specification by means of paradigmatic cases and ‘stylized facts’.<sup>8</sup> We can also understand the difficulties facing Schumpeter when he in the 1930s worked hard to transform his youthful *Theorie der wirtschaftlichen Entwicklung*<sup>9</sup> in a way that made it fit for empirically oriented analysis. The most obvious difficulties found in the more than 1,000 pages of *Business Cycles* are related to Schumpeter’s rather ineffective and inelegant treatment of the historical and statistical material.<sup>10</sup> But this is partially a surface phenomenon. The major underlying problem is that he was unable to make a precise coupling between his core concepts and his empirical information on economic evolution. Basically, his evolutionary framework is phrased in terms of ‘ideal types’ which to him helped little to direct empirical research and which, furthermore, emphasised a large number of doubts about nearly all empirical information about economic change.

There is little doubt about which historical case study Schumpeter especially wanted later researchers to take up. In his *Business Cycles* Schumpeter explicitly presents the ‘railroadization of the world’<sup>11</sup> as the standard example on which to apply his theoretical schema (model) of economic evolution. For instance, it becomes particularly clear ‘how railroad construction produces both prosperities and recessions’.<sup>12</sup> Therefore, Schumpeter suggests that

... the reader should not fail to work out this out again step by step. 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 than in any other can the usual objections to our analysis be silenced by a simple reference to obvious facts.<sup>13</sup>

This paper tries to take Schumpeter seriously by considering the age of railroad construction in the nineteenth century – both in its pioneering and its more mature stages. The pioneering period was the time when the horse-driven mail coaches were outcompeted, railroad towns mushroomed, financial schemes blossomed and failed, industries supplying and using the railroads were set up, etc. The period of maturation was characterised by the routinisation of what earlier had been novelties and the emergence of early forms of the modern corporation, partly as the forced outcome of financial crises and ‘creative destruction’.<sup>14</sup> In general, the age of the railroad was characterised by an irrevocable change, or transformation, of the routines of economic life to adapt to the railroad. To use Schumpeter’s terminology and his spelling, we may talk about a process of ‘railroadization’.<sup>15</sup> This is the most conspicuous

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<sup>8</sup> To use the expression of Kaldor, N., *Capital Accumulation and Economic Growth*, in Lutz, F.A., and Hague, D.L. (eds.), *The Theory of Capital*, London: Macmillan 1961, pp. 178 f.

<sup>9</sup> Schumpeter, J.A., *Theorie der wirtschaftlichen Entwicklung*, Leipzig: Duncker & Humblot 1912. Schumpeter, J.A., *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle*, transl. of 2nd German edn., London: Oxford University Press 1934.

<sup>10</sup> See reviews by Kuznets, S., Schumpeter’s *Business Cycles*, *American Economic Review*, Vol. 30 [1940], pp. 257-271 and Lange, O., *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, by Joseph A. Schumpeter, *Review of Economic Statistics*, Vol. 21 [1941], pp. 190-193. See also Swedberg, *Schumpeter*, pp. 133 ff.

<sup>11</sup> *Ibid.*, p. 303.

<sup>12</sup> *Ibid.*, p. 304.

<sup>13</sup> *Ibid.*, p. 304.

<sup>14</sup> To use the well-known term which reflect ‘the essential fact about capitalism’, cf. Schumpeter, J.A., *Capitalism, Socialism and Democracy*, 3rd edn., New York: Harper 1950, p. 83.

<sup>15</sup> The term is used extensively in Schumpeter, *Business Cycles*, and there is even a whole section on the subject (pp. 325-351). I have chosen to stick to Schumpeter’s American English coining of the term of ‘railroadization’ to emphasise that it is used in Schumpeter’s broad sense. It is not easy to transform it into a well-defined technical term. I also use the word ‘railroad’ instead of ‘railway’.

example of the type of economic and technological transformation that is the core subject of Schumpeterian analysis. It is as part of the mechanisms of such a transformation that Schumpeterian entrepreneurs, bankers, and managers play their roles.

The case of railroadization may help Schumpeterian and post-Schumpeterian analyses of the process of capitalist transformation in four main ways. First, the case may be considered in pedagogical terms. In this perspective, we find scattered over some of Schumpeter's voluminous works what appears to be the rough elements of a nice and handy book about railroadization considered as an example of his analysis. Second, the case may be related to the study of Schumpeter in the history of economic thought. The railroadization case seems to have had a privileged role in providing ideas for Schumpeter's original evolutionary model, and it definitely had an important role in his *Business Cycles* where he attempts to develop his model further through a systematic confrontation with facts. Third, the case may be considered as Schumpeter's preferred area for making testable hypotheses for the study of capitalist transformation. The study of the case will clarify these hypotheses and thus remedy a neglect of Schumpeter's detailed hypotheses in later work (including the new economic history of the railroads<sup>16</sup>). Forth, the case may be considered as a starting point for a modern specification and development of Schumpeter's model of capitalist evolution. The need for such a specification is much larger with respect to Schumpeter than to most other contributors to economic thought and analysis. The reason is that Schumpeter tried to develop a new and evolutionary form of economic analysis that had very little support from formal analytical tools. Modern evolutionary-ecological analysis has provided some of the tools that Schumpeter needed,<sup>17</sup> and the reconstruction of Schumpeterian analysis by means of evolutionary-ecological formalisms can be tested against the railroadization case.

Although all four arguments for a Schumpeterian study of the railroadization case are of relevance, and although section 2 of the paper will partly use the case for a pedagogical illustration of Schumpeter's models, the case will primarily be considered as a starting point for a modern specification and development of these models. In section 3 it is discussed why Schumpeter had problems in dealing with the case by means of railroad statistics, etc., and why he did not use the available mathematical models for analysing the spread of railroads. It is demonstrated that with some care the mathematical tools may be used to express Schumpeter's ideas. In section 4 we turn to the interpretation of the transformation process from the viewpoints of the economic agents. Especially we deal with creative and adaptive behaviour in the transformation of the economic system. To understand such types of behaviour, modern evolutionary-ecological analysis is shown to be useful. Finally, we shall in section 5 discuss how to come from the behavioural microlevel to a system-level dynamics, and to the overall history of railroadization. Even here the tools of modern evolutionary-ecological analysis are important.

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<sup>16</sup> A simple introduction is found in O'Brien, P., *The New Economic History of the Railroads*, London: Croom Helm 1977.

<sup>17</sup> See Andersen, E.S., *Evolutionary Economics: Post-Schumpeterian Contributions*, paperback edn., London and New York: Pinter 1996, Chs. 2-3.

## 2. The model of transformation and the railroadization case

The most obvious potential of the case of railroadization is to illustrate the somewhat different models in Schumpeter's two systematic works on capitalist transformation: *The Theory of Economic Development* which is dealing with conceptually oriented modelling, and *Business Cycles* which apart from a refined model is also presenting an empirically oriented analysis of the relationship between the transformation process and the wave-like movement of the macroeconomic indicators. Let us look at these two potential areas of application in turn.

In relation to *The Theory of Economic Development*, where we only find scattered references to railroads<sup>18</sup>, it is primarily a highly stylised version of the process of railroadization which is relevant. This can easily be seen if we in this book look for the basic scheme of transformation. This analytical scheme has the following form:

1. We start with a system of routine behaviour.
2. This system is radically challenged by the innovative behaviour of a few pioneers.
3. However, sooner or later the equilibrating forces of economic life will establish a *new* system of routines.
4. And then the story starts once more...<sup>19</sup>

To make this scheme more relevant for concrete analyses, Schumpeter fills it with some of the elements of capitalist transformation of the routine system. More specifically, Schumpeter assumes that economic transformation in capitalism is driven by entrepreneurs who implement innovations by means of borrowed capital, and thereby they propagate a wave-like process which ultimately changes the system of economic routines.

1. We start with a non-innovative equilibrium of economic life which follows given routines.
2. Then an irrevocable disturbance of the equilibrium takes place; it is created by entrepreneurs who introduce an innovation with the help of bankers.
3. A movement away from the disturbed state is promoted by the ordinary behaviour of managers, workers, and other economic agents. Their behaviour lead to a new equilibrium which includes a routinised version of what was originally an innovation.
4. The evolutionary process consists in a sequence of such steps.

It is not difficult to see how Schumpeter's early and scattered remarks on the railroad innovation may fit into this scheme:

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<sup>18</sup> In this book we only find scattered references to railroads, cf. Schumpeter, *The Theory*, pp. 62, 66, 84, 215. However, in the two previous German editions of this book we find some more references, e.g. Schumpeter, J.A., *Theorie der wirtschaftlichen Entwicklung: Eine Untersuchung über Unternehmergeinn, Kapital, Kredit, Zins und den Konjunkturzyklus*, 2nd. rev. edn., Munich and Leipzig: Duncker & Humblot 1926, pp. 93-95, 123, 321. One should note that there are also references to railroads in his first book: Schumpeter, J.A., *Das Wesen und der Hauptinhalt der theoretischen Nationalökonomie*, Leipzig: Duncker & Humblot 1908, pp. 189 f., 245, 247, 250, 252 f., 451?, 512-514, 568, 584, 608-612.

<sup>19</sup> Schumpeter's scheme of capitalist transformation is more systematically reconstructed and formalised in Andersen, *Evolutionary*, pp. 26-44.

1. We start with equilibrated system of economic applications of routines, including the routines underlying mail-coach-based transport services.<sup>20</sup>
2. Then the system is disturbed by the introduction of railroad-based transport services with a large potential and large resource needs. The initiative of railroad promoters creates a period of railroad-related economic expansion.
3. After a recession which forces the economic system to adapt to the new railroad system, a (relatively) equilibrated routine system<sup>21</sup> which includes the new norms of railroad transportation is established.
4. Then this system is disturbed by the introduction of a new innovation ...

Such is the basic scheme of capitalist evolution which Schumpeter upheld even though he moved from his early and simplistic views of *The Theory of Economic Development* to the more elaborate and less clear-cut views of *Business Cycles*. As the subtitle of the latter book<sup>22</sup> indicates, we here find a theoretical, historical, and statistical follow-up which puts special emphasis on the macroeconomic consequences and determinants of capitalist transformation. Both the empirical orientation and the aggregate issues meant that Schumpeter had to try to be much more precise about the evolutionary process he wanted to depict, and this is where the railroadization process becomes the supplier of stylised facts. He had to discuss how innovations might occur in ‘clusters’, how the limited capacity of the economic system means that the full potential of a cluster of innovations cannot be exploited in a single cycle of transformation of the economic system, how the cooperative as well as the destructive interaction between the innovative activities and the rest of the economic system takes place, how innovations of the ‘creative’ type are followed by qualitative improvements of a more adaptive type, how other secondary phenomena of e.g. the Keynesian type emerge, etc. In dealing with all these questions, Schumpeter became explicitly interested in the case of railroadization. This is demonstrated by the fact that he not only wrote a section with a historical and statistical account of the core process of railroadization;<sup>23</sup> he was also making numerous other references to, and descriptions and reflections on, different aspects of the case.<sup>24</sup>

The most conspicuous example of the role of railroadization case is the emergence of Schumpeter’s theory of the different innovation-driven cycles and waves which together serve to transform the system of economic routines. This theory and the related model of capitalist transformation seem especially to have been designed to depict the system-level implications of railroadization:

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<sup>20</sup> It is Schumpeter who prefers to refer to mail coaches rather than to simpler road vehicles or to canal boats (which are more important). The reason is probably that he wants to emphasise that we are initially thinking in terms of conspicuous examples rather than the full history.

<sup>21</sup> The railroad tracks are determining some of these routines. It is interesting to note that the Schumpeter’s central German-language metaphor for routines is ‘Bahnen’ (Schumpeter, *Theorie, passim*) while it is in the English translation ‘channels’. The German word means tracks or even railroads (abbreviation for ‘Eisenbahnen’), and it has an active sound like in ‘sich Bahn brechen’: blaze one’s trail, or ‘Bahnbrechend’: epoch making.

<sup>22</sup> I.e., *A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*.

<sup>23</sup> Schumpeter, *Business*, pp. 325-351.

<sup>24</sup> *Ibid.*, e.g. pp. 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.

1. The system of economic applications of routines are not totally equilibrated at the start of a new wave; on the contrary, the (railroad) innovation which is to carry the new wave has already been developing at the microlevel and is developed enough to start influencing macroeconomic events.
2. It is swarms of railroad investment projects and clusters of more or less (railroad-related) innovations which have macroeconomic effects. It takes several (railroad) ‘manias’ and cycles of (railroad) investments before the innovative character of the innovations is removed.
3. The establishment of a new and relatively equilibrated system of economic norms will also take several cycles of relatively routinised (railroad-related) investments. During this period a significant, but cumulative process of adaptation and improvement of many economic activities takes place. Furthermore, some radically innovative activities also takes place.
4. A new long wave emerges when a new ‘carrier’ innovation has matured at the microlevel and when the system of norms is equilibrated to a degree which is supporting a rapid expansion of innovative investment.

These modifications of Schumpeter’s original scheme indicate that the railroadization case is not only applied by Schumpeter for illustrative purposes. This case seems to have supplied many of the ‘stylized facts’<sup>25</sup> which were used to guide his model-building process. This is especially clear in *Business Cycles* where a mix of theoretical, historical, and statistical work is used in an attempt to make a more detailed and realistic version of the ‘scaffolding’ model of *The Theory of Economic Development*, to ‘turn that scaffolding into a house’.<sup>26</sup> He later described the underlying methodology behind this attempt in the following way:

Factual work and ‘theoretical’ work, in an endless relation of give and take, will eventually produce scientific models, the provisional joint products of their interaction with the surviving elements of the original vision, to which increasingly more rigorous standards of consistency and adequacy will be applied.<sup>27</sup>

The question is, of course, how close the model developed in Schumpeter’s *Business Cycles* is to the rather rigorous standards of consistency and adequacy which he himself wanted to apply. Any researcher who have tried to work with the book will answer that the model is still far from being analytically operative: it is quite sketchy with respect to core components (e.g. an operational concept of innovation), it has major problems of consistency (especially with respect to the concepts of equilibrium and evolution), and it gives little guidance with respect to the analysis of major aspects of the wave-like process of capitalist evolution (especially, the micro-to-macro and macro-to-micro relationships which links individual innovations, the transformation of the system of economic routines, and the movement of the macroeconomic indicators).<sup>28</sup> These problems, which are emphasised by the rather disorganised and open-ended treatment of the process of railroadization, were, of course, obvious to Schumpeter. Thus, although there is little doubt ‘that Schumpeter regarded *Business Cycles* as one of his most important

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<sup>25</sup> To use the expression of Kaldor, N., *Capital Accumulation and Economic Growth*, in Lutz, F.A. and Hague, D.L. (eds.), *The Theory of Capital*, London: Macmillan 1961, pp. 178 f.

<sup>26</sup> Schumpeter, *Business*, p. v.

<sup>27</sup> Schumpeter, *History*, p. 42.

contributions, if not the most important',<sup>29</sup> it is clear that he did not think that the book lived up to his own standards. This is demonstrated by the preface to the book where he points out that

... there are too many glaring lacunae and too many unfulfilled desiderata. ... The younger generation of economists should look at this book 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.<sup>30</sup>

On the background of these statements, it is obvious that the railroadization case should not primarily be seen as a simple means of illustrating Schumpeter's model or as an area for deducing testable 'Schumpeter hypotheses'. Instead the case can best be applied in exploratory analyses which serve to specify and develop Schumpeter's model of capitalist evolution.<sup>31</sup> In the present paper it is demonstrated that this specification can to a large extent be made in terms of modern evolutionary-ecological analysis.

### 3. The complex diffusion of railroads

Although Schumpeter's models of economic transformation are based on a micro-oriented analysis of innovative entrepreneurs and routine-following managers, it is convenient to start by a system-level description of the applications of the different old and new 'routines'<sup>32</sup> (commodities and services, production methods, etc.). For each of these routines we consider a yearly measure of its relative frequency of application – either directly or by means of one or more indicators. Given the time series of market shares, modern tools of analysis make us able to discuss the transformation of the system of routines in 'ecological' terms. If the market share of the railroad routine of providing transportation services is still changing rapidly, the economic system is in an early phase of transformation. Gradually the rate of change will decrease, and at some point of time the system may reach a (temporary) state of evolutionary equilibrium. In this equilibrium the market share of mail coaches must also have found its equilibrium value. In the simplistic ecological analysis, this market share may be zero. But horse-driven transportation was not driven to extinction by the railroads; so we have to apply more complex models of transformation.

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<sup>28</sup> A relatively systematic criticism is found in Kuznets, S., Schumpeter's *Business Cycles*, *American Economic Review*, 1940, pp. 257-271.

<sup>29</sup> Freeman, C., Schumpeter's *Business Cycles* Revisited, in Heertje, A. and Perlman, M. (eds.), *Evolving Technology and Market Structure: Studies in Schumpeterian Economics*, Ann Arbor, Mich.: University of Michigan Press 1990, p. 18.

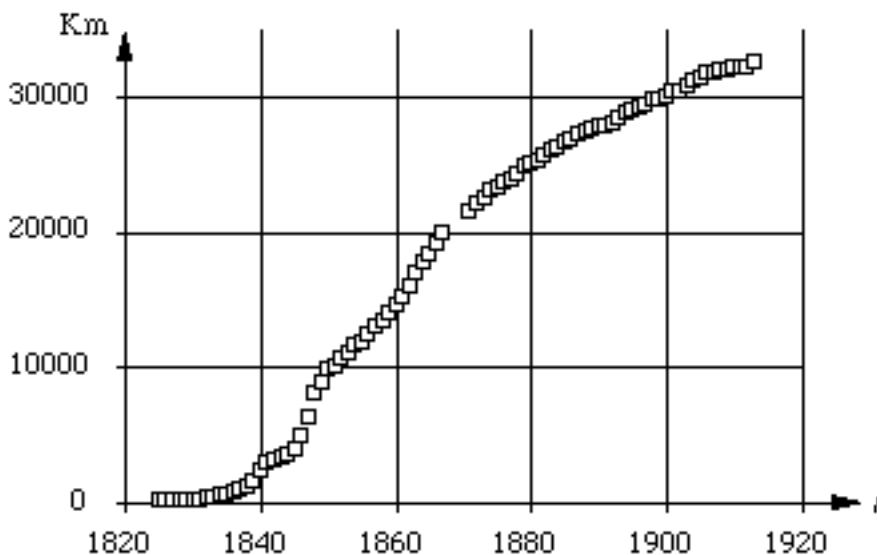
<sup>30</sup> Schumpeter, *Business*, p. v.

<sup>31</sup> In this way the railroadization case has been used in Andersen, *Evolutionary*, Chs. 2-3. Some of the more formal parts of the discussion in the present paper are dealt with in more depths in this book.

<sup>32</sup> The broad use of the term 'routine' is a generalisation in relation to its meaning in Nelson, R.R. and Winter, S.G., *An Evolutionary Theory of Economic Change*, Cambridge, Mass. and London: Belknap Press 1982, pp. 14-19 and *passim*.

### 3.1. Aggregate description

Let us start by presenting a couple of figures which are helpful for structuring a modern analysis but which are missing in *Business Cycles*,<sup>33</sup> namely figures giving an overview over the spread of the railroad innovation. We measure this spread by the length of the railroads open and use the data collected by modern economic historians.



**Figure 1:** Total length of railroad line open in Great Britain, 1825–1913.

Source: Mitchell, B.R., *British Historical Statistics*, Cambridge:Cambridge University Press 1988, p. 541.<sup>34</sup>

Figure 1 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. The overall structure of the curve may with some imagination be interpreted as an S, but one can also discern smaller Ss within the large one, e.g. 1825–1843 and 1850–1896. To Schumpeter, it is important that we do not delimit the analysis to the overall curve but also consider such ‘humps’ of the curve as starting points for a further exploration of the process of transformation. As we shall later see, these humps allow us to see the process of transformation from the perspective of innovative entrepreneurship.

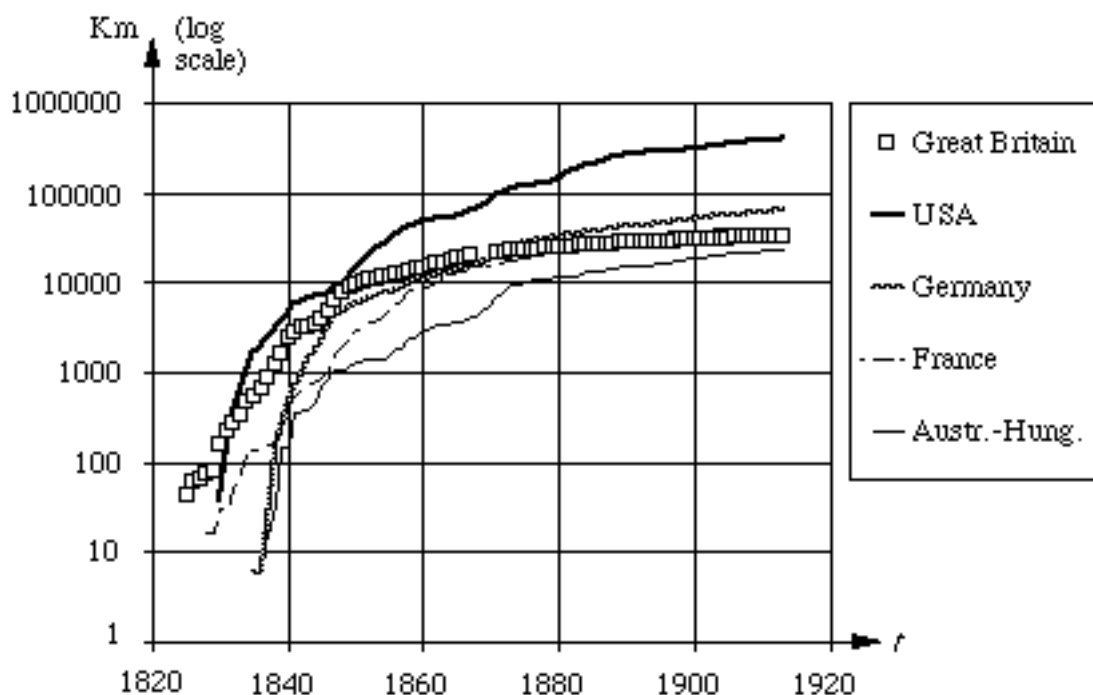
By applying a logarithmic scale,<sup>35</sup> we may explore some of the properties of the S-curve. At the same time we have the opportunity to compare the very different scales of ‘railroadization’ in some of the major countries (figure 2). First and foremost, we see that the growth rate of the ‘population’ of railroad

<sup>33</sup> In Schumpeter, *Business*, we instead find plentiful but disorganised information on other aspects of railroads and railroadization. We are given more or less systematic time series of mileage of railroad construction (pp. 291, 329, 341 f, 346, 351, 402), freight ton-miles (p. 488), construction and running costs (pp. 402 f), freight prices (pp. 340, 523), canal and turnpike prices (pp. 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 then related to the wave-like process of capitalist transformation. But nowhere we find a systematic attempt to pull all the threads together and even less to treat them with statistical tools or relate them to formal mathematical models.

<sup>34</sup> Data for Ireland is not included. In addition, the data for 1868-1870 is lacking or is problematic.

<sup>35</sup> Schumpeter uses extensively a logarithmic transformation in his graphs, but he does not discuss the revealed growth rates.

kilometres decreases, even if it does not reach zero before World War I. Second, we see an initial but very short period of acceleration of growth in the pioneering countries, especially in Great Britain. This probably reflects the increasingly well-functioning innovation, as well as the jump in the entrepreneurial knowledge about railroads which took place after the much-discussed opening of the Liverpool & Manchester Railroad in 1831. The other countries started with a clear-cut British example of railroadization, and thus they could start 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<sup>36</sup> and an increased deceleration after the crisis of 1873.



**Figure 2:** Total length of railroad line open in major countries, 1825-1913.

Sources: Mitchell, B.R., *European Historical Statistics 1750-1975*, 2nd rev. edn., London and Basingstoke: Macmillan 1981, pp. 609-611; Mitchell, B.R., *International Historical Statistics: The Americas and Australasia*, London and Basingstoke: Macmillan 1983, pp. 656-658; Mitchell, B.R., *British Historical Statistics*, Cambridge: Cambridge University Press 1988, pp. 541.

All in all, we see modified versions of a more or less S-shaped pattern. However, we should be aware that the cases depicted vary greatly and that no simple pattern of diffusion should be expected. For instance, we should note that while Great Britain and the US were characterised by private railroad promotion (in a complex interplay with government), governments dominated railroad construction in other countries, especially in the later parts of the epoch under consideration. For this and many other reasons there are no grounds for a strict adherence to a simplistic interpretation of logistic growth or even of broader forms of S-shaped growth.

The study of the diffusion of railroads during nearly a century is just as problematic as it is fascinating. The idea clearly helps to organise our thinking about railroadization, but it may also cripple our analysis if we stick to it too tightly. In *Business Cycles* Schumpeter's ideal was to consider

<sup>36</sup> In the US related, of course, to the end of the Civil War.

railroadization as an evolutionary process during which the railroad technology as well as the norms and techniques of its 'environment' underwent radical transformation. This viewpoint made Schumpeter very sceptical against his own time series of railroad capacity and transport services in a country like the US. Similar problems were found in the study of the automobile industry, and so on. Since these aggregation problems are typical for Schumpeter's analysis, it is relevant to record some of his reflections about them:

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 unmanageable.<sup>37</sup>

Furthermore,

... 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.<sup>38</sup>

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.<sup>39</sup>

Here we have the viewpoints of a radical evolutionist who keeps insisting that the most interesting variety is hidden within the ever-changing contents of the 'population' 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 the next subsections we shall show that it is possible to interpret S-curves in ways which help to understand the evolutionary process of railroadization. But first we have to discuss the simplistic, non-evolutionary S-curve approach.

### 3.2. Density-dependent diffusion

The yearly increase in kilometres of railroad line in different countries may be roughly simulated by means of the logistic difference equation of density-dependent diffusion, which produces a more or less S-shaped pattern.<sup>40</sup> If we consider  $N_t$  to be the number of kilometres of railroad line open in a particular country at time  $t$ , we may calculate the number of kilometres at the next point of time,  $t + 1$ , as

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<sup>37</sup> Schumpeter, *Business*, p. 483.

<sup>38</sup> *Ibid.*, p. 484.

<sup>39</sup> *Ibid.*, p. 484.

<sup>40</sup> We may also apply the logistic equation in its differential form, and study the resultant continuous logistic curve. This would bring us closer to Schumpeter's few remarks on the matter (see below). The present paper applies the discrete form both for pedagogical reasons and because this form allows an overshooting of the carrying capacity and thus comes a little closer to economic reality.

$$N_{t+1} = N_t + rN_t \left( \frac{K - N_t}{K} \right); \quad (1)$$

where  $r$  and  $K$  are parameters.<sup>41</sup> The meaning of these parameters can most easily be explained by explicitly considering the (relative) growth rate of railroad line as a function of the total railroad line:

$$\frac{N_{t+1} - N_t}{N_t} = r \left( \frac{K - N_t}{K} \right); \quad (1a)$$

As indicated by equation 1a, the growth rate depends on two factors. The first factor,  $r$ , is the maximum growth rate; this growth rate is obtained when  $N_t$  is very small in relation to  $K$ . It may partly be ascribed to the railroad innovation itself, partly to the innovation-promoting agents and mechanisms (entrepreneurs and bankers), and partly to the (expected and real) reaction time of the customers. The second factor represents the influence of the total number of established railroad line units on the growth rate. As  $N_t$  approaches  $K$ , the growth rate becomes smaller and smaller. For  $N_t = K$ , the growth rate is zero. However, because the expansion occurs in steps, we might see an overshooting of the goal, i.e.  $N_t > K$ , and a subsequent oscillation around  $K$ . For extreme  $r$ -values, the pattern of oscillation will show deterministic chaos.

$K$  may thus be interpreted as the maximum sustainable level of the application of the railroad innovation in a given environment. If this level is not reached, it is still profitable to expand the total length of railroad line. If the level is exceeded, parts of the railroad network will become unprofitable and more kilometres of lines are scrapped than are being constructed. Taken as an abstract model, there are no problems with this interpretation. By doing so, we may simply define the ‘carrying capacity’ of the (nationally and temporally delimited) environment with respect to the use of railroad-based transport services. But as soon as we address the historical data as well as make theoretical reflections about the price mechanism, the ‘carrying capacity’ becomes a much more controversial concept. However, the idea of a density-dependent growth process reflects the aspect of the process of diffusion of an innovation which is most obviously predictable: the environment of each new application of the innovation tends to become more and more densely populated by other applications of the innovation; in the end we have crowding and zero growth.

The closest Schumpeter comes to this model is a verbal and general account which states that:

... it 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.<sup>43</sup>

These formulations come quite close to the properties of the logistic equation. But as we have already indicated, Schumpeter is very sceptical against a more general application of this equation of density-dependent diffusion (indicated here by the remark on ‘further innovation’). So, even though

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<sup>41</sup> The names of the parameters are taken from the normal notation in ecological modelling. The reason for this is that this ecological notation is wide-spread while there is no standard economic notation.

<sup>42</sup> The last formulation is the one which is further developed in the Lotka-Volterra model, see equations 2.

figures 1 and 2 look well suited for a standard analysis of diffusion, and even though Schumpeter had seen this pattern of railroad diffusion depicted in Kuznets book on industry life cycles,<sup>44</sup> he emphasizes the dangers of wrong interpretations of this ‘descriptive trend’.<sup>45</sup> Starting with the obvious fact that with respect to aggregate data, 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.<sup>46</sup>

Even in the case of individual commodities and technologies, Schumpeter is emphasising the problems rather than the merits in applying Verhulst’s logistic curve:

Output of a new commodity may easily trace out a Verhulst curve which many students [like Kuznets] 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 ...<sup>47</sup>

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 and ever-changing framework with interconnections with other sectors and with the cyclical pulse of economic evolution. But later developments in modelling techniques have 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.<sup>48</sup>

All in all, it seems that in Schumpeter’s mode of thinking, the apparently fixed parameters of the logistic model are becoming the central variables of another model which is not formulated sharply and

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<sup>43</sup> Schumpeter, *Business*, p. 497.

<sup>44</sup> Schumpeter knew such graphs from Kuznets, S., *Secular Movements in Production and Prices: Their Nature and Their Bearing Upon Cyclical Fluctuations*, rpt. edn., New York: Augustus M. Kelley 1967. This book was discussed directly and indirectly by Schumpeter. However, he ignored that Kuznets (ibid., pp. 191, 526 f.) gives full US railroad construction data, the related logistic function, and even a graph of the number of railroad miles added annually in the US, 1831-1922. Kuznets (ibid., pp. 64-69, 291) also presents a discussion of the logistic function and other types of S-curves. This presentation reflects a rather naive view of the applicability of the logistic curve. Actually, the empirical use of the logistic curve (especially in relation to 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 Johns 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, S.E., *Modeling Nature: Episodes in the History of Population Ecology*, Chicago and London: University of Chicago Press 1985, Chs. 3-4. In such an environment Schumpeter’s own naive idea of an alliance between economic theory and statistical and historical analysis was in great trouble (cf. Schumpeter, J.A., *The Common Sense of Econometrics*, 1933, rpt. in Schumpeter, J.A., *Essays on Economic Topics*, Port Washington, N.Y.: Kennikat 1951, pp. 100-107). This may explain why he is so reluctant to exploit the obvious possibilities of the logistic curve.

<sup>45</sup> Schumpeter, *Business*, p. 201.

<sup>46</sup> Ibid., p.492. We may integrate a differential equation similar to the difference equation 1 to see that the result is closely related to Schumpeter’s  $y$ -curve. Schumpeter is describing the special case where  $r = 1$ . However, Schumpeter (ibid., p. 492) points to the ‘slightly generalised’ formulas used in the 1920s by Lotka, Pearl and Reed.

<sup>47</sup> Ibid., p.205.

<sup>48</sup> Cf. Kingsland, *Modeling*.

which appears to have elements which are ‘refractory to mathematical formulations’.<sup>49</sup> 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’.

### 3.3. The coevolution of economic activities

The model of a density-dependent diffusion process is not sufficient since it only holds where an innovation is applied in a new environment with no (significant) competitors or other types of interactions. In practice, this is not the case; instead we see interdependence, both competition and cooperation, between firms and industries. Such cases can be abstractly discussed by means of a simple model where two ‘populations’ (like mail coaches and railroads) are influencing each others’ carrying capacities. This interaction between routine-1 and routine-2 may be described in terms of the Lotka-Volterra equations of coevolution; these equations are simple extensions of the logistic equation equations for routine-1 and routine-2 in order to cover cases where the applications of the routines are influencing each other. In a simplified version, the Lotka-Volterra equations have the following form:

$$N_{1,t+1} = N_{1t} + r_1 N_{1t} \left( \frac{K_1 - N_{1t} + a_{12} N_{2t}}{K_1} \right); \quad (2a)$$

$$N_{2,t+1} = N_{2t} + r_2 N_{2t} \left( \frac{K_2 - N_{2t} + a_{21} N_{1t}}{K_2} \right); \quad (2b)$$

where  $N_{1t}$  and  $N_{2t}$  are the number of applications of two routines (e.g., numbers of kilometres served by the two transport technologies);  $r_1$  and  $r_2$  are the intrinsic growth rates (potencies of spread) of the two routines;  $K_1$  and  $K_2$  are the carrying capacities of the two routine applications if left alone;  $a_{12}$  is the interaction coefficient for the effect of an individual application of routine-2 on the saturation level of routine-1, and  $a_{21}$  indicates the opposite direction of influence. These two parameters thus indicate the inter-routine interaction.

This system of modified logistic equations is closely related to the one-routine case (equation 1). In this case the relative growth rate of the applications of routine-1 becomes zero if the carrying capacity,  $K_1$ , is reached. In the case of two interacting routines, zero growth is obtained at another level of the routine applications. In the case of inter-routine competition, it is reached while  $N_1$  is still less than  $K_1$ ; in the case of cooperation, growth continues even if the population has expanded beyond  $K_1$ . This interpretation can be developed in terms of  $a_{12}$  and  $a_{21}$ . The case where both are zero is trivial. This leaves us with three major possibilities of combinations of signs for  $a_{12}$  and  $a_{21}$ . If both are less than zero (the  $-,-$  case), then we have competition. If both are greater than zero (the  $+,+$  case), we have mutualism. If  $a_{12} < 0$  and  $a_{21} > 0$  (the  $-,+$  case), or if  $a_{12} > 0$  and  $a_{21} < 0$  (the  $+,-$  case), then we have asymmetric interaction of the type which in biology is called predator-prey interaction.

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<sup>49</sup> Letters by Schumpeter in Swedberg, *Schumpeter*, p. 230.

If we consider the long-term effects of a direct competition between routine-1 and routine-2, we will normally assume that the less productive one of them becomes extinct, as railroads won over mail coaches. But there are cases of path-dependency where the least productive routine will win over its competitor. Take, for example, the two competing standard measures of the distance between the rails, i.e. gauges. The Stephensons chose a five feet solution based on mining traditions (dating back to the Romans) while others argued strongly that a seven feet gauge was faster and safer. The latter solution was, however, crowded out by the former.<sup>50</sup> This is an obvious example of how network externalities can lead to a suboptimal lock-in state.<sup>51</sup>

Another problem is related to the long-term coexistence between apparent competitors. This phenomenon can be interpreted as reflecting that the two routines are only partially competing. For instance, we see that in some areas of transport services (e.g. long-distance transport) railroads and horse-driven transport is clearly competing (the -,- case) while in other areas (short-distance transport) they are collaborating (the +,+ case), at least in the early part of the epoch of railroadization. Given the overall competitiveness of railroads, this means that the variants of horse-driven transport which do not compete directly with railroads will increase their frequency relative to other variants. The result is a situation where horse-driven transport has become more specialised, and this reduces the inter-routine competition. In other words, it has found its niche, its core area of competitive strength.<sup>52</sup>

However, this niche may be quite large, and the market may at the same time be expanding. This was the case during the process of railroadization, although the possibilities of specialising competition and symbiosis were overlooked by early commentators. This implied that they made radically wrong predictions about the UK market for horse-driven transportation. While the predictions concluded ‘that the use of 1.000.000 horses would be superseded allowing for the subsistence of 8.000.000 human beings, the railroad instead had the effect of increasing the demand on the horse.’<sup>53</sup> The reason was that horse traction was used for short-distance transport, partly to the railroad. For example, the railroad was central for Sherlock Holmes’ extension of his detective business to broad areas of Britain, but he had to take a horse-driven hansom cab to Victoria Station.

#### 4. Behavioural aspects of railroadization

At the behavioural level, Schumpeter’s models of economic transformation are primarily characterised by two types of economic agent: the innovating entrepreneur and the routine-following manager. Examples are the path-breaking railroad promoter of the early years of railroadization and the manager of a well-established railroad company whose main concerns are time tables and incremental cost reduction. It is

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<sup>50</sup> Simmons, J., *The Railroad in England and Wales 1830-1914*, Vol. 1: Leicester University Press 1978, pp. 26–28, 45–47, 84 f.

<sup>51</sup> Another, near-classical example is the suboptimal QWERTY keyboard of typewriters, cf. David, P.A., Clio and the Economics of QWERTY, *American Economic Review. Papers and Proceedings*, 1985, pp. 332–337.

<sup>52</sup> A similar niche-theoretic study of the modern competition between different modes of transport (rail, road, air travel) is sketched in Reggiani, A. and Nijkamp, P., Evolutionary Dynamics in Technological Systems: A Multi-layer Niche Approach, in Leydesdorff, L. and Besselaar, P.v.d. (eds.), *Evolutionary Economics and Chaos Theory: New Directions in Technology Studies*, London: Pinter 1994, pp. 93-108.

<sup>53</sup> Berg, M., *The Machinery Question and the Making of Political Economy 1815-1848*, Cambridge: Cambridge University Press 1980, p. 30.

obvious that these two agents are characterised by behavioural strategies which are fit for very different tasks. One of the major advantages of the evolutionary-ecological specification of Schumpeterian analysis is that it helps to define the characteristics of these tasks and the related strategies.

#### 4.1. Pioneering and crowding strategies

A rough specification of the two Schumpeterian strategies can be obtained in relation to the early economic history of the United States with its 'frontier' between unexplored possibilities and well-established activities. The behavioural characteristics of the pioneering types of settlement and entrepreneurship were adapted to economic activities far away from their carrying capacities, while the predominant behaviour in established regions was reflecting an economic life much closer to its (preliminary)  $K$  limits. However, if one of the pioneers accepted the tight competition and the more regular mode of behaviour needed to function as the region became 'crowded', he could make a living under more stable conditions.

This picture of a moving frontier can easily be applied to the general transformation of economic life. For instance, investment activities in the first part of the process of railroadization may metaphorically be called pioneering while the later phases can be seen as characterised by more crowded and routinised conditions. However, while the movement of a geographical frontier area will ultimately come to a stop, the evolution of economic life may be viewed reflecting the movement of an 'endless frontier' where there are always possibilities of pioneering or entrepreneurial behaviour: even though the railroad in the end was not defining a major frontier of economic life, new areas were explored by agents who preferred pioneering behaviour to the highly adaptive behaviour needed to survive in established areas. In this way they started a new round of the Schumpeterian story.

A very general specification of the two strategies have been developed by the evolutionary ecologists MacArthur and Wilson.<sup>54</sup> Instead of talking of pioneers and establishment, colonisers and equilibrators,<sup>55</sup> stochasts and Cartesians,<sup>56</sup> or entrepreneurs and managers, they make a distinction between two types of selection environment and two types of strategist in relation to the parameters of the logistic equation (and the Lotka-Volterra equations). If a certain kind of population is far away from the carrying capacity, the major characteristic of successful variants within the population is their ability to obtain a rapid expansion in the environment. It is, in other words, their high potential growth rate,  $r$ , which is important. Therefore, MacArthur and Wilson talk of an environment characterised by  $r$ -selection which favours variants which are called  $r$ -strategists. However, if the population under consideration is

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<sup>54</sup> MacArthur, R.H. and Wilson, E.O., *The Theory of Island Biogeography*, Princeton, N.J.: Princeton University Press 1967.

<sup>55</sup> According to Boulding, K.E., *Evolutionary Economics*, Beverly Hills, Cal. and London: Sage 1981, p. 106: 'Ecological interaction or selection follows rather different patterns in what has been called the "colonizing mode," in which organisms are expanding into a new and unutilized environment, and an "equilibrium mode," in which everything settles down into at least ecological quasi-equilibrium. In the colonizing mode, selection favors mobility, often increased size, efficiency, active competition, and so on. Many new niches are opening, which means that there are payoffs for a high rate of mutation and adaptability. In an equilibrium mode, mutations are fewer, or at least fewer are likely to succeed. The payoffs are for adaptation, probably some small, high risk-aversion adaptation to rather than an escape from an existing environment, and so on.'

<sup>56</sup> Allen, P.M., *Evolution, Innovation and Economics*, in Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. (eds.), *Technical Change and Economic Theory*, London: Pinter 1988, pp. 95-119.

close to the carrying capacity,  $K$ , then it is the finely tuned variants which are successful. Since there is a trade-off between rapid expansion and minute adaptations to intra-species and inter-species competition,  $r$ -strategists will do badly. An environment characterised by  $K$ -selection will instead favour  $K$ -strategists.

In the case of biological species we are dealing metaphorically with the term 'strategy' since it relates to a behaviour which is genetically determined. The idea is more directly relevant to the area of economic transformation, including the process of railroadization. Especially with respect to Schumpeter's handling of the behavioural aspects of railroadization, MacArthur's and Wilson's notions of  $r$ -strategists and  $K$ -strategists seem to be clarifying.

Although a reformulation of Schumpeter's scheme in these terms may appear to be fairly straightforward, its references to the  $r$  and  $K$  parameters should be interpreted with care for at least two reasons. The first problem is that when talking of strategies we are dealing with expectations and not directly with results. Therefore, we should distinguish between the *ex post* parameters of a process of diffusion (which in the case of railroads might be revealed by a study of figures 1 and 2) and the *ex ante* parameters which influence economic decision-making. Since an innovation per definition includes an element of novelty, there is no reason to believe that there is any close correlation between the expected and the real values of the parameters. Furthermore, we find systematic differences between the expectations of the different types of agent. For instance, when an innovation is being introduced,  $r$ -strategists are likely to overestimate its growth potential and carrying capacity while  $K$ -strategists are likely to underestimate these  $r$  and  $K$  values.

The second problem with the reference to  $r$  and  $K$  (and  $a$ ) parameters is that the logistic equation and the Lotka-Volterra equations were originally formulated for homogeneous populations while we are now dealing with heterogeneous population with changing composition and evolving characteristics. For instance, the different parts of the population are characterised by different and changing growth rate potentials, carrying capacities, and interaction coefficients. This means that the  $r$ ,  $K$ , and  $a$  parameters of the aggregate population undergo irreversible changes during the process of economic transformation.

If we, however, recognise that we are referring to  $r$ -selection and  $K$ -selection as well as  $r$ -strategists and  $K$ -strategists in an evolutionary context of economic decision-making, we are provided with an analytical framework of considerable heuristical value. This framework may, for instance, help us to formulate hypotheses on the relative importance of the productivity gains obtained by  $r$ -strategists and  $K$ -strategists. Here Schumpeter appears to overemphasise  $r$ -selection and the related 'entrepreneurial' behaviour while he is to some extent neglects the details of  $K$ -selection and the related 'managerial' behaviour. This is especially the case in *The Theory of Economic Development*, but even in *Business Cycles* there is a tendency to give  $K$ -strategists a very simple role in the long-term evolutionary perspective. However, when Schumpeter was struggling with the empirical evidence on railroadization, he had to recognise a more significant evolutionary role for  $K$ -strategists. A rethinking of his scattered discussion may even suggest that  $K$ -strategists produce the bulk of evolutionary change. For instance, the original railroad entrepreneurs were constructing systems which were characterised by rough combinations of largely pre-existing types of input. Such systems were, of course, error-prone and costly. If they had been generally applied in an unchanged form, they would have had relatively modest carrying capacities. An important task of the  $K$ -strategists was to make systems which had a higher carrying capacity because they were 'debugged' and finely tuned. They were motivated by an environment which favoured fine

tuning as a means of gaining competitive advantage. The pressure was especially clear under long-term economic downswings where the sustainable level was often below the existing 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 ...<sup>57</sup>

In a long-term perspective these ‘induced innovations’<sup>58</sup> were quite decisive in expanding the room for railroads in the economic system. To the extent that they are not a simple result of operating in the railroad business, they become an important area of economic analysis.

## 4.2. Railroad entrepreneurs as *r*-strategists

It is now time to look somewhat closer at the ways in which Schumpeterian entrepreneurs can be considered to be *r*-strategists.<sup>59</sup> According to Schumpeter, the defining characteristic of entrepreneurs is that they perform innovative activities, i.e. the implementation of blueprints or visions into economic practice as long as this is not a routine matter to do so. For instance, we may consider railroad promoters to be the person who carried out a railroad project at the time when this was not a matter of routine. Such entrepreneurs are characterised by the fact that they do not operate against given and constraining carrying capacities. Instead they to some extent create new areas of activity with largely unknown *k* limits.

Such railroad entrepreneurs are first of all *r*-strategists because they have to put emphasis on the timing of their projects rather than on the details of performance. If railroad entrepreneurs were first to construct railroads in their local environments, they would define the rules of the game for future entrants. If simultaneous projects were implemented, they would instead face cut-throat competition (the *-,-* case of interaction). Thus innovators confront the fact that an

... 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.<sup>60</sup>

The problem of timing is also related to the relationship between railroad projects and economic cycles. Early movers had several advantages over laggards in each wave of railroad projects. The former would face lower factor prices than projects which started when the economic system was booming. Similarly, the early movers had the best chance of being well-established when the recession set in.

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<sup>57</sup> Schumpeter, *Business*, p. 759.

<sup>58</sup> *Ibid.*, pp. 327, 339.

<sup>59</sup> The names of the strategies are not fully reflecting Schumpeter’s intentions. Schumpeter would have emphasised that the entrepreneurial *r*-strategists *create* a new economic activity with an apparent *K* limit, and that the following entrepreneurs are in a way moving this limit upwards. Still, there are good reasons for upholding the terminology. First, the terms are well established in evolutionary-ecological theory. Second, the analogy to economic behaviour is rather strong. For instance, the problem of timing is central to entrepreneurial activity. Third, it can be discussed to which degree entrepreneurs create or discover the new *K* limit. For these and several other reasons (including a wish to exploit ideas from evolutionary ecology), we shall uphold the notions of *r*-strategists and *K*-strategists.

Railroad entrepreneurs may also be considered as timing-oriented *r*-strategists because they try to earn a profit by influencing their future customers rather than adapt to them. The possibilities of influencing the knowledge and routines of buyers are much better for early movers than for laggards. The latter are characterised by a wish to act according to revealed demand. The former prefers to enter into projects with a larger degree of novelty. But the consequence is that innovative supply normally runs ahead of demand. In Schumpeter's words:

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. ... [Railroads were] forced by producers on consumers who, more often than not, have resisted the change and have had to be educated ...<sup>61</sup>

Given the benefit of hindsight, the *ex post* knowledge, it is difficult to understand the situation of the early movers who had to believe in the emergence of a sufficient 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.<sup>62</sup>

This brings us to a related aspect of the entrepreneurs' role as *r*-strategists. The most ambitious of them try to exploit possibilities of creating complete 'development blocks' – to use the term of Dahmén.<sup>63</sup> That such a block can only be created once in each area was especially clear in the new regions of 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.<sup>64</sup>

In this way the *r*-strategists secured that there were freight and passengers when the railroad finally arrived to the region. In Dahmén's terms, the company realised a potential, or *ex ante*, development block and helped to create it.

More generally, entrepreneurs are *r*-strategists because it is primarily the early movers who have a chance of internalising externalities from their projects. Because of their effort, others experience that  $r_t$  and  $K_t$  are increasing as time runs 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. Thus there are advantages of being a latecomer and some disadvantages of being an early mover. These disadvantages may, however, be compensated in many ways. For instance, the early mover may provide services and goods to later entrants (the +,+ case of interaction) as we know from the events after the Liverpool-Manchester line had

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<sup>60</sup> Ibid., p. 412.

<sup>61</sup> Ibid., p. 73.

<sup>62</sup> Schumpeter, J.A., *Depressions: Can We Learn from Past Experience?*, in Schumpeter, *Essays*, p. 111.

<sup>63</sup> Cf. Dahmén, E., "Development Blocks" in *Industrial Economics*, *Scandinavian Economic History Review*, 1988, pp. 3-14; Dahmén, E., *Development Blocks and Industrial Transformation: The Dahménian Approach to Economic Development*, ed. by B. Carlsson and R.G.H. Henriksson, Stockholm: Almquist & Wiksell 1991.

<sup>64</sup> Schumpeter, *Business*, p. 319.

been completed in 1831. The central figure behind this line, Stephenson, provided consultancy and locomotives (through a family firm) to later projects. Thus the project was not only paradigmatic in overcoming the basic difficulties and in demonstrating a highly profitable solution. It was also paradigmatic in providing the kinds of services and investments appropriate for a successful railroad. This fact, as well as the network externalities from further projects, made the first movers interested in easing the situation for the subsequent projects which, according to Schumpeter, should be considered as successively smaller innovations. There was also an incentive to support the early jumps to other nations which implied the reappearance of some of the typical problems for entrepreneurs.<sup>65</sup> 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'.<sup>66</sup> But the construction of later railroad systems could use the experience as well as the goods and services which had been developed in relation to the previous ones.

One of the reasons why a first mover can exploit many benefits is that it is difficult to be even relatively late-coming 'innovators'. Their major task was to overcome a large set of personal and social resistances to change. Some of these resistances came from the owners of canals and horse transport systems who foresaw that they would be outcompeted (-,- cases of inter-routine interaction). 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.<sup>67</sup>

But as more and more of the thousands of railroad projects of the age of railroadization were implemented, the solution of some of these and other issues (especially finance) became a matter of routine. In this situation the question where to draw the border-line between innovative and routine projects becomes quite difficult. The question is e.g. whether we shall talk of entrepreneurial or managerial activities in US railroad construction after 1850:

The entrepreneurial function consisted, in this case, not so much in visualizing possibilities – everyone saw them and speculated on them – or in the solution of technological problems – the locomotive functioned sufficiently well by that time and was thenceforth improved almost automatically by a series of typically 'induced' innovations, and no major problems impeded the building of the lines ...<sup>68</sup>

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<sup>65</sup> This view, which underlines the creative and innovative character of the first part of the diffusion process, is clearly including a broader conception of 'innovation' than most present-day researchers. According to the dominant modern view of 'technological innovation', it is only the 'Stephenson case' (or the Stockton & Darlington Railroad of 1825 or whatever contribution we may choose) which is a real innovation; the later applications of the same technology must be considered as diffusion rather than as innovation. Given this modern view, it becomes very difficult to understand Schumpeter.

<sup>66</sup> Ibid., p. 304.

<sup>67</sup> Ibid., pp. 291 f.

<sup>68</sup> Ibid., p. 327.

Such relative adaptive and routine-like tasks as induced innovations are not requiring the action of *r*-strategists. But Schumpeter finds other and ‘purer’ tasks for entrepreneurs

... 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.<sup>69</sup>

This may be a correct description. But the more well-known character of railroad projects of the 1850s made it possible to overcome the indivisibility of the entrepreneurial function and to make a division of labour of different entrepreneurial activities. Thus, we see that ‘this entrepreneurship was often split between several individuals.’<sup>70</sup> This complicates the picture greatly and demonstrates that Schumpeter’s original interpretation of the concept is not always easily applicable to historical analysis.

### 4.3. The limitations of the entrepreneur

The interpretation of Schumpeter’s entrepreneurs as *r*-strategists helps to explain many of his delimitations of the entrepreneurial function which have worried neo-Schumpeterians in the Nelson-and-Winter tradition who operate with complex firms characterised by mixes of *r*-strategies and *K*-strategies. Especially, modern researchers have had difficulties in distinguishing between the ‘radical’ innovations of the entrepreneurs and the ‘incremental’ innovations of the managers. In the present context this distinction is, in principle, clear: Schumpeterian innovations are characterised by large *rs* and major *K* movements (or by the creation of new *Ks*) while Marshallian innovations<sup>71</sup> are related to given activities whose carrying capacities are changing gradually and slowly. Given this distinction, it is possible to explain many of the peculiarities of the Schumpeterian model which fits so well to the railroadization case but only with major modifications to many of the innovative activities in the modern economy.

First of all, the emphasis on *r*-strategies is one of the reasons why Schumpeter makes a sharp distinction between economic innovation, which he studies, and technological invention/innovation, which he omits from his analysis. In a broader model which encompass both activities there are better possibilities for acknowledging the role of *K*-strategists. Here it would become clear that the railroad innovation to a large degree sprang out of gradual improvements within the transportation systems of the coal mines. In such an account the story of the railroads would include Trevitick’s first locomotive for rails in 1804 and other railroad inventions and innovations in relation to the British coal mines.

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<sup>69</sup> Ibid., p. 327.

<sup>70</sup> Ibid., p. 327.

<sup>71</sup> In the present paper there are no possibilities of discussing the relationship between Schumpeterian and Marshallian innovations. A whole paper could be devoted to such a comparison in relation to the railroadization case. The Marshallian treatment of the railroad case is especially found in Marshall, A., *Industry and Trade: A Study of Industrial Technique and Business Organization; and their Influences on the Conditions of Various Classes and Nations*, 2 edn., London: Macmillan 1919, pp. 68-71, 89-91, 150-153, 322 f., 445-506, 785 f., 830-845. Even though this discussion is to a large extent reflecting economic evolution, we find no cross-fertilisation between Marshall’s and Schumpeter’s treatments of the railroad case. Thus we find no reference to Marshall’s extended discussion of railroad problems and railroad history in Schumpeter, *Business*. The reason is probably that any reference to Marshall’s work with its mixture of facts and a gradualistic theory of evolution would have demanded an extended explanation by Schumpeter. Marshall’s book is, however, well suited for studying the similarities and differences between two treatments of the railroad case.

However, these activities do not play any role in Schumpeter's argument about railroadization.<sup>72</sup> Not even the evolution of a technically and economically feasible version of the combined solution of rails and locomotives (again in relation to the mines) enters directly into the study. Instead the breakthrough, the first acts of real economic entrepreneurship, appears to have happened in the period 1825-1831 when the first conspicuous examples of profitable implementation of broadly applicable 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 market-oriented construction of locomotives. In this way the emphasis is put on the actions of a few pioneers. But the more routine-oriented activities in the mines are excluded from the analysis.

Second, Schumpeter's *r*-strategy focus explains his heavy emphasis on the jump-wise character of economic evolution. This model was partly developed in opposition to Marshall's gradualistic model of evolution which had no room for *r*-strategists. Schumpeter's vision of economic transformation, which apparently had a close relationship to the railroadization case, made him protest against this exclusion. Instead he created his model of 'punctuated equilibria' (to use a modern expression<sup>73</sup>). This model was not intended to imply that the railroad inventions behind the innovations which changed the economic world emerged out of nothing. He does not deny that big invention hardly ever springs out of the current of events as Athene did from the head of Zeus'.<sup>74</sup> He points out 'that we may accept a theory of invention as presented, for example, by Mr. S. C. Gilfillan in his *Sociology of Invention ...* and yet adopt another point of view for our purposes'.<sup>75</sup> Thus one may accept the slow technological and economic 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 railroad', the Liverpool-Manchester line which outperformed monopolistic canal transport by many times with respect to price and time.<sup>76</sup> This may thus be considered as the central economic innovation<sup>77</sup> which suddenly changed the perceived carrying capacity of railroads as well as their possible expansion rate.

Third, the analytical intention to focus on *r*-strategists explain why Schumpeter narrowed the definition of innovation so that it does not encompass adaptations made by managers (interpreted as *K*-

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<sup>72</sup> As they do in the work of one Schumpeter's Harvard colleagues, cf. Usher, A.P., *Technical Change and Capital Formation*, in Rosenberg, N. (ed.), *The Economics of Technological Change: Selected Readings*, Harmondsworth: Penguin 1971, pp. 54-58.

<sup>73</sup> Cf. Gould, S.J. and Eldredge, N., *Punctuated Equilibria: The Tempo and Mode of Evolution Reconsidered*, *Paleobiology*, 1977, pp. 115-151; Awan, A.A., *Marshallian and Schumpeterian Theories of Economic Evolution: Gradualism versus Punctualism*, 1986, rpt. in Wood, J.C. (ed.), *J. A. Schumpeter: Critical Assessments*, Vol. 4, London and New York: Routledge 1991, pp. 436-453.

<sup>74</sup> Schumpeter, *Business*, p. 227.

<sup>75</sup> *Ibid.*, p. 85; see also p. 227.

<sup>76</sup> However, in many other cases canals were able to compete with respect to prices for customers who were not in a hurry (see *ibid.*, pp. 340 f.).

<sup>77</sup> This innovation included a summing-up of mail coaches (in the production of first class railroad wagons) but the result was something qualitatively new with respect to the overall system of economic decision-making, a 'new combination' of economic 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, J.A., *The Analysis of Economic Change*, in Schumpeter, *Essays*, p. 136; cf. Schumpeter, *The Theory*, p. 64.) But it must be emphasised that the all-round railroad is qualitatively new with respect to the system of economically relevant routines only when it has been implemented successfully.

strategists).<sup>78</sup> This does not mean that their ‘induced innovations’<sup>79</sup> are totally ignored in Schumpeter’s work but their role can be difficult to see because they are often together with many other ‘secondary phenomena’ which are seen as the outcome of the propelling forces of real innovations.<sup>80</sup> We find this near-invisibility of induced innovations in *The Theory of Economic Development* while the empirical treatment of the railroadization case forces Schumpeter to be more explicit about them in *Business Cycles*. For instance, he 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 ... The new administrators improved tracks and roadbeds, ... 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 ...<sup>81</sup>

From these remarks on ‘administered’ adaptations, it is clear that evolutionary change in no way comes to an immediate halt in periods of crowding. On the contrary, this kind of evolution seems to be relatively successful although it may in the end face decreasing returns to incremental innovation. The successful period of adaptive modifications of the railroad system is, however, longer than the heroic period of Schumpeterian entrepreneurship in the railroad business which he normally delimits to the years 1825-1860. Furthermore, Schumpeter points out that the dominance of managers was not complete, and that a new wave of organisational 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 financiers ... [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.<sup>82</sup>

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 in this connection. However, in another context he belittles the productivity improving effects of state ownership which was the European Continent parallel to US big business.

This brings us to a fourth characteristic of Schumpeter’s conception of economic transformation: Although he does not deny the productivity gains of e.g. state-owned corporations, he emphasises that these gains are not necessarily ascribable to these organisations themselves:

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<sup>78</sup> By the way, many of these are trying to find disequilibria and earn profits by providing a larger degree of equilibrium. Agents with this function are called ‘entrepreneurs’ by Kirzner, I.M., *Competition and Entrepreneurship*, Chicago and London: University of Chicago Press 1973. They are clearly not ‘entrepreneurs’ in Schumpeter’s sense.

<sup>79</sup> Schumpeter, *Business*, p. 327.

<sup>80</sup> Schumpeter, *The Instability*, pp. 376 f.

<sup>81</sup> Schumpeter, *Business*, pp. 402 f.

<sup>82</sup> *Ibid.*, pp. 402 f.

If the primary change results in turning out better tools of production, naturally this will expand the industries which use them. This must be taken account of in judging the comparative success of some State-managed railroads surrounded by private industries, which force on them improved engines, fittings, and so on.<sup>83</sup>

In other words: private entrepreneurs will probably make autonomous improvements of their output which can then be used by the publicly owned railroads. The reason is obviously that Schumpeter considers state-owned corporations as an extreme version of *K*-strategists. For the same reason he belittles or ignores the role of the labour movement and the emergence of consumers' norms in creating an environment for innovative activities. However, he thereby ignores the possibility that radical innovations spring out of apparently trivial activities near the carrying capacities of the economic activities.

## 5. Towards system-level dynamics

### 5.1. Finance and the synchronisation of innovations

The interpretation of entrepreneurs and managers as *r*-strategists and *K*-strategists helps us to rethink Schumpeter's model of the wave-form movement of the process of economic transformation. As a first step, we shall consider a rough reformulation of Schumpeter's scheme of economic transformation (see section 2):

1. We start with an economic system where mail coach transport and other types of routine applications are close to their carrying capacities. Here finely tuned *K*-strategies are dominant. Occasionally, *r*-strategists try to change this situation by engaging in potentially radical innovations.
2. The success of the railroad innovation disturbs the stable environment. It favours *r*-strategists who move rapidly into railroad construction or into the positively related areas (the +,+ cases). When more cautious agents decide to follow the lead, they are likely to show a bad timing *vis-à-vis* competing investment projects and the macroeconomic movement of the economic system.
3. After several waves of construction and prosperity as well as recessions, all industries approach their new carrying capacities (including wide-spread railroads and zero long-distance transport by mail coaches). The successful firms are now following finely tuned *K*-strategies which allow them to survive in a highly competitive environment.
4. Then a new innovation enters into the centre of the economic scene and, once more, *r*-strategists are favoured.

This version of the Schumpeterian scheme puts the core (railroad) innovation into the centre of the process; and this is quite congruent with Schumpeter's ideas:

The changes in the economic process brought about by innovation, together with all their effects, and the response to them by the economic system, we shall designate by the term Economic Evolution. ... This

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<sup>83</sup> Schumpeter, *The Instability*, p. 376.

terminological decision is, of course, but the expression of an analytic intention, namely, the intention to make the facts of innovation the basis of our model of the process of economic change.<sup>84</sup>

It is also clear that the railroad innovation is well-suited for Schumpeter's scheme of analysis. The economic importance of this innovation can be seen by describing some of the characteristics of the railroad innovation. For this purpose Schumpeter has provided a list of the many repercussions of the railroad projects:

[1] The comparatively long periods of gestation, both of the individual line ... and of the sectional and national system ... [2] the quantitative importance of the expenditure involved, [3] the consequent dislocation of all the data [routines, parameters] of economic life, [4] the new investment opportunities and [5] the new possibilities that are created for further innovation, and [6] the (cyclical) disturbances in turn caused by these [possibilities], combine to make the essential features of our evolutionary process more obvious in this than they are in any other case.<sup>85</sup>

This list clearly helps 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.<sup>86</sup>

The most conspicuous result emerging from the characteristics of railroadization is the theory of the different innovation-driven cycles and waves which occur simultaneously in the economic system. This theory is easy to describe. To begin with, we assume a relatively equilibrated state with economic norms. This is not disturbed by the early applications of the railroad innovation like the Liverpool-Manchester line. The disturbance comes at a point of time when railroads have become so well-known that railroad investments, together with related innovative investments, can begin to have a significant macroeconomic effect. However, only a limited number of investment projects can be performed at a time. Since investments necessary to implement the railroad-related system are enormous, the economically relevant part of the pioneering period of railroadization consists of several 'cycles'. Each of these cycles are 'carried' by a cluster of investment projects in railroads and related innovative fields.

When the railroad innovation approaches maturity, it becomes easy to implement new investment projects while at the same time only the least profitable projects are left. This means that conspicuous failures are likely to occur. The result of such failures is that interest is moved towards other types of project. The previous emphasis on expansion rather than fine tuning means that there are large numbers of profitable *K*-projects available in railroads and elsewhere. However, these projects are not sufficient to uphold aggregate investment demand at the previous level. Furthermore, their very purpose is to reduce employment and other factor inputs. Therefore, the upswings become more limited and the downswings more marked. Under such conditions we see a 'creative destruction' of many weaker and more or less outcompeted areas of economic life.

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<sup>84</sup> Schumpeter, *Business*, pp. 86 f.

<sup>85</sup> *Ibid.*, p. 304. This is one of Schumpeter's most complex sentences. For this reason, I have in brackets included numbers and a few extra words.

<sup>86</sup> *Ibid.*, p. 304.

Finally, the different economic activities have reached their new carrying capacities. Under these conditions the only long-term reason for new investment is the balanced growth of all the sectors of the economic system. However, this situation is not stable. Sooner or later  $r$ -projects will once more dominate economic life. However, the successor innovations which were to ‘carry’ large-scale economic transformation were not as clear-cut as the railroad innovation. This is indicated by the fact that the epoch starting around the turn of the century is not as well defined in Schumpeterian terms as the epoch of railroadization.

The simplified scheme presupposes that radical innovation projects occur in a way which generates the macroscopic pattern of economic transformation. The fact that innovative projects appear ‘discontinuously in groups or swarms’<sup>87</sup> should not be presupposed but explained. Otherwise, one might draw the conclusion that  $r$ -strategists could just as well function continuously so that no resultant wave-form movement of the macroeconomic variables will occur. To explain the macroscopic phenomena we may, for instance, look for mechanisms which tend to ‘bunch’ major technological innovations during periods of depression<sup>88</sup> or for techno-economic paradigms which generate such a bunching and thus long waves of economic life.<sup>89</sup> But it is simpler and, perhaps, closer to Schumpeter’s intentions to look for an explanation by introducing the financial system into the model. More specifically, we have to consider how  $r$ -strategists and  $K$ -strategists interact with banks and stock markets.<sup>90</sup>

It is convenient to start the analysis by referring to Schumpeter’s metaphorical version (or vision) of the ‘money market’ to which the 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.<sup>91</sup>

How this ‘money or capital market’ is organised is not relevant for the moment, just that a possibility exists for railroad entrepreneurs to finance their ambitious projects which involves heavy outlays a long time before the expected receipts may show up. At the same time the credit system 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’<sup>92</sup> 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 the railroad system of the UK was next-to completed.

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<sup>87</sup> Ibid., p. 223.

<sup>88</sup> Mensch, G., *Stalemate in Technology*, New York: Ballinger 1979.

<sup>89</sup> Freeman, C. and Perez, C., Structural Crises of Adjustment, Business Cycles and Investment Behaviour, in Dosi *et al.*, *Technical*, pp. 38-66.

<sup>90</sup> An alternative is to consider firms with mixed strategies, and explain the shifts between these strategies by means of a ‘Schumpeter Clock’. This has been done by Haag, G., Weidlich, W. and Mensch, G., The Schumpeter Clock, in Batten, D., Casti, J. and Johansson, B. (eds.), *Economic Evolution and Structural Adjustment*, Berlin: Springer 1987, pp. 187-226. Here the immediate analysis concerns expansionary and rationalising investments which are related to but not exactly the same as  $r$ -investments and  $K$ -investments.

<sup>91</sup> Schumpeter, *The Theory*, pp. 126 f.

<sup>92</sup> To use a Keynesian expression.

One reason for the bunching of  $r$ -projects through the financial system is simply that the carrying capacity with respect to investment projects is limited in the medium term:

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.<sup>93</sup>

This simple form of bunching of  $r$ -projects is, however, not at the centre of Schumpeter's discussion. As emphasised by his scheme of economic transformation, his main interest relates to the overall process of railroadization. But even here the financial system may function as a coordinator. Let us consider a simple version of such a mechanism.

First, we should recognise that Schumpeter's initial period with a non-railroad-based system of transport might only appear to be tranquil. In a more realistic analysis we should recognise that the initial state will normally have a prehistory of financial failures in relation to innovative projects. Therefore, the financial system puts heavy emphasis on the trustworthiness of innovative projects. This favours  $K$ -strategists who have detailed projects with relatively certain but small benefits while the  $r$ -strategists have visionary projects with potentially huge but essentially uncertain benefits. Furthermore, the projects of the  $r$ -strategists are often characterised by strong (network) externalities while the projects of the  $K$ -strategists can easily be performed individually. Under these conditions, financial systems tend to favour strongly the projects of the  $K$ -strategists. However, this situation is clearly unstable since the expected profitability of the  $K$ -oriented projects are gradually decreasing while the experiences on unsound  $r$ -projects are fading away.

Second, a few successful investment projects of  $r$ -strategists may suddenly change the situation. The reasons are that (1) to a significant part of the investors, the problem of rationalistic trustworthiness have disappeared; (2) the interest rate is approaching zero so the time horizon of investors is approaching infinity; <sup>94</sup>(3) the most obvious projects of  $r$ -strategists are really good. Therefore, a 'mania' of investing in  $r$ -projects may easily break out. The financial institutions who preaches caution are ignored, and new institutions adapted to the needs of  $r$ -strategists emerge. The only clear-cut limit to the subsequent boom is defined by the overall resources of the economic system. The necessary pause of the investment process does not necessarily mean that a new wave of  $r$ -projects cannot be initiated afterwards. On the contrary, the investors retain their basically optimistic view of  $r$ -projects.

Third, the situation shifts in favour of  $K$ -projects. The reasons are that (1) more and more investors have experiences unsound  $r$ -projects and emphasise trustworthiness; (2) the long-term interest rate is increasing so that visionary projects appear to be uninteresting. Instead investors turn massively towards  $K$ -projects. This change may be triggered by macroeconomic catastrophes. It means that e.g. credit rationing for trustworthy customers is reintroduced at a massive scale.

Fourth, it is in the end recognised that there has been an over-emphasis on  $K$ -projects, and so the story start once more.

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<sup>93</sup> Schumpeter, *Business*, p. 167.

<sup>94</sup> The decreasing interest rate may thus be considered as a characteristic which tends to undermine Schumpeter's circular flow.

## 5.2. The history of railroadization

We are now ready to appreciate the historical drama beneath the relative smooth surface of the S-curves of figures 1 and 2. Take, for instance, the railroadization of the UK and the US. It is now clear that we should not abstract from the huge differences between railroad projects in e.g. 1835, 1865, and 1895. In the first case they were the business of pioneers and were mainly of local interest; in the second case a new wave of railroad expansion was starting at a massive scale in the US; in the third case the big railroad companies were interested in rationalisation projects. It is also clear that we should not ignore the ‘humps’ on the S-curves, like the relative stand-still in the early 1840s and the subsequent acceleration of railroad construction. Behind this are major changes in financial conditions. Even more dramatic events took place in Austria-Hungary (see figure 2) where a railroad boom of the 1860s and early 1870s was changed into a nearly complete stand-still of railroad construction.

Schumpeter’s description of the drama of railroadization emphasises ‘business cycles’ as the form in which capitalist transformation takes place. His overall drama is told in terms of Kondratiev waves of about 50 years which are divided into acts of about 9 years – the Juglar cycles. However, the full story of railroadization spans over at least three Kondratiev waves.

Schumpeter’s 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 first long wave):

The conspicuous success in 1835 induced speculative excesses immediately afterward, although railroad 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.<sup>95</sup>

The evolution may also be interpreted in terms of ‘network externalities’:<sup>96</sup> a single railroad line between two locations is of primary relevance to a limited set of customers. As the network of railroad lines becomes established, the system attracts more and more customers. A series of maps of the railroad network at different points of time gives us a rough picture of the transformation. We may e.g. think of the geographical pattern of railroad diffusion in the first railroad country, the UK.<sup>97</sup> After the first period

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<sup>95</sup> Ibid., p. 278.

<sup>96</sup> See David, P.A., Path-Dependence and Predictability in Dynamic Systems with Local Network Externalities: A Paradigm for Historical Economics, in Foray, D. and Freeman, C. (eds.), *Technology and the Wealth of Nations: The Dynamics of Constructed Advantage*, London and New York: Pinter 1993, pp. 208-231.

<sup>97</sup> Cipolla, C.M. (ed.), *The Industrial Revolution*, The Fontana Economic History of Europe, Vol. 3, Glasgow: Collins/Fontana 1972, pp. 208 f.; Freeman, M. and Aldcroft, D.H., *The Atlas of British Railroad History*, London: Croom Helm 1985.

of railroad promotion, a certain standstill was felt until the autumn of 1844, but then the 'railroad mania' broke out. During the next few years (1844-1852) we see what we today may call the 'fractal pattern' of the expansion. This 'great development that within a few years created almost the whole skeleton of the English railroad system' was the work of the forties.<sup>98</sup> 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 railroad projects. But during the same period many less profitable and even highly dubious railroad projects were proposed and many of them were implemented, helping to create occasional financial panics.

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.<sup>99</sup> And 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. Instead the age of the managers were emerging.

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.<sup>100</sup>

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' or 'railroad Kondratieff'<sup>101</sup> (1843-1897). This long period is, according to Schumpeter's analytical purposes, divided into several types of subperiods, but for the present purposes it is sufficient 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 then we have the years of 'recession' (1870-1897) which also includes three Juglar cycles (1870-1879, 1879-1888, 1889-1897).<sup>102</sup>

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.<sup>103</sup>

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<sup>98</sup> Schumpeter, *Business*, p. 278.

<sup>99</sup> See for the US case Chandler, A.D., *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, Mass.: Harvard University Press 1977, Part II.

<sup>100</sup> Schumpeter, *Business*, p. 342.

<sup>101</sup> *Ibid.*, pp. 304, 1020.

<sup>102</sup> According to Schumpeter (*ibid.*, pp. 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.

<sup>103</sup> *Ibid.*, p. 303. The results of the new economic history cast doubts on this statement. As a partial rescue it should be noted that Schumpeter is not stating his argument in terms of economic growth. Rather it is a

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 argues that railroad construction is ‘the carrier of the cyclical movement’<sup>104</sup> in all the Juglar cycles as well as in the overall framework of the Kondratiev wave. This is especially the case 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. But the general idea of the railroad as the carrier of expansion and the cause of recession may be compared with other explanations, e.g. in terms of changing propensities to save. Schumpeter clearly rejects such an explanation. Instead he 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.<sup>105</sup>

However, railroads are not constructed *ad libitum*. Sooner or later a more or less fixed ceiling is reached for the railroad network (or rather: for the transport services delivered by it). Once again, the terms of evolutionary-ecological biologists appear to help to express Schumpeter’s thoughts. In the present case we may try to think in terms of the carrying capacity (the *K* ceiling) of the given economic system with respect to railroads and all the related investment projects. This carrying capacity was, however, changing during the age of railroadization. Whole regions which had difficulties in sustaining a single mail coach were being developed and produced lots of freight and passenger for the railroads through a process of coevolution (the +,+ case). But gradually the ability to construct railroads outperformed the ability to produce transport-demanding economic activities. And competitors, like canal firms, were also investing and kept lower freight prices for slow transport (they found relatively large niches which the railroads could not serve appropriately). 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.<sup>106</sup>

This turbulence indicated the start of a period where the full transformation of economic norms took place. In this period we saw that the larger

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question of the direct and indirect importance of railroadization (including the related cluster of innovations and industries) for general changes in investment decisions, etc.

<sup>104</sup> Ibid., p. 339.

<sup>105</sup> Ibid., pp. 328-330.

<sup>106</sup> Ibid., p. 362 f.

... 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.<sup>107</sup>

In this period of equilibrating transformation railroad construction of most countries rapidly overcame the standstill and continued, although normally in a much less expansionist way. Furthermore, the railroad promoters and managers (and their lenders and stock holders) became more cautious and aware of possible 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 mature-state *K*-strategies rather than pioneering *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.<sup>108</sup>

However, in the end the great days were over and railroad transportation became an fully integrated element in the larger system of economic routines. Now it had no particular power as a source of system-disturbing innovations. Railroadization had finished its macroscopic life cycle. But during the period of equilibration new innovations had been developing and around the turn of the century a new Kondratiev wave emerged, based on the process of electrification, trustification, etc.

## 6. Conclusions and perspectives

In the beginning of this paper four reasons were given for studying railroadization as Schumpeter’s standard case. All these reasons have proved to be important.

The first reason is pedagogical: no other well-known case leads so directly into the core of Schumpeter’s mode of thinking and his analytical scheme. The adequacy of the railroadization case in this respect has been demonstrated in several ways. First, the case leads us to a clear-cut distinction between entrepreneurs (railroad promoters) and managers (of established railroad companies). Second, the case explains why Schumpeter considered not only the first but also the following railroad promoters to be innovators (and not simply imitators). Third, the distinction between technological inventions (in the mines) and the economic innovation becomes clear. Fourth, the distinction between Schumpeter Mark I (exemplified by railroadization) and Schumpeter Mark II (exemplified by the chemical and electrical

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<sup>107</sup> Ibid., pp. 338 f.

industry) becomes clear. In the latter case we see the emergence of large firms which are at the same time managing given positions and trying to expand into new areas (with the help of intra-firm R&D).

The second reason for dealing with Schumpeter's standard case is that it helps to clarify his role in the history of economic thought. While other economists (e.g. Dupuit) were inspired by the problems of the management of given railroad systems, Schumpeter might have derived his vision more or less directly from the problems of railroad promotion. While this suggestion is largely a matter of speculation, there is clear evidence in *Business Cycles* that the case of railroadization suggested many developments and modifications of his theory. It also gives an indication of Schumpeter's over-ambitious and daring methodology. The latter was heavily influenced by Max Weber who in the beginning of the twentieth century suggested a solution to the long-term *Methodenstreit*, the controversy on methods among German and Austrian economists. Both Weber's and Schumpeter's programmatic aim was to develop a unified economic science, a *Sozialökonomik*, covering economic history, statistics, economic theory, and economic sociology.<sup>109</sup> Schumpeter's attempts to promote this unified science has been considered as 'the major theme in his life-work as an economist'.<sup>110</sup> In this perspective, the mix of theoretical, historical, and statistical work in relation to the study of 'the railroadization of the world'<sup>111</sup> should be regarded as part of an attempt to fulfil a life-long endeavour.

The third reason for exploring Schumpeter's railroadization case is that it helps us to see that his testable hypotheses on the process of economic transformation are more history-specific than is generally thought. Schumpeter has often been considered as delivering general hypotheses on e.g. the multiplicity of cycles, the unimportance of consumers in innovation, and the dominance of modern corporations in innovation.<sup>112</sup> However, a reflection about the relation between Schumpeter's models and the case of railroadization brings into mind Nelson's and Winter's discussion of formal and appreciative theory.<sup>113</sup> Just like these modern authors, Schumpeter seems to think that 'evolutionary theory is good appreciative theory about the phenomena in question'<sup>114</sup> and, thus, that elaborated theories are context-sensitive both with respect to their development and application. Even such apparently similar processes as railroadization and 'motorization' or 'automobilization'<sup>115</sup> do not suggest the same models and do not fit equally well into the same framework for appreciation. To learn more from Schumpeter and to be better

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<sup>108</sup> Ibid., pp. 339.

<sup>109</sup> This ambition in underlying the exposition in Schumpeter, *History*, Ch. 2. Schumpeter published the forerunner of his *History* was in a series of books edited by Weber, cf. Schumpeter, J.A., *Epochen der Dogmen- und Methodengeschichte*, in *Grundriss der Sozialökonomik. I. Abteilung: Wirtschaft und Wirtschaftswissenschaft*, Tübingen: J.C.B. Mohr (Paul Siebeck) 1914, pp. 19-124.

<sup>110</sup> Swedberg, *Schumpeter*, p. 23. See also Streissler, E.W., *The Influence of German and Austrian Economics on Joseph A. Schumpeter*, in Shionoya, Y. and Perlman, M. (eds.), *Schumpeter in the History of Ideas*, Ann Arbor, Mich.: University of Michigan Press 1994, pp. 13-38.

<sup>111</sup> Schumpeter, *Business*, p. 303.

<sup>112</sup> See the relevant entries in the index of Augello, M.M., *Joseph Alois Schumpeter: A Reference Guide*, Berlin: Springer 1990. See also Wood, J. A. *Schumpeter*. For a critique of the way the problems of 'firm size and innovation' and 'technology-push and demand-pull in innovation' have been formulated, see Freeman, C. and Soete, L., *The Economics of Industrial Innovation*, 3rd edn., London: Pinter 1997.

<sup>113</sup> Nelson and Winter, *An Evolutionary*, pp. 45-48.

<sup>114</sup> Nelson, R.R., *Economic Growth via the Coevolution of Technology and Institutions*, in Leydesdorff and Besselaar, *Evolutionary*, p. 22.

<sup>115</sup> Schumpeter, *Business*, pp. 167, 774. Schumpeter remarks that the 'automobile industry ... qualify ... well for the role of standard example for the processes embodied in our model' (ibid., p. 772). Some developments of the automobile case are found in ibid., pp. 415-418, 772-777. However, this is not the

to transcend him, modern researchers should supplement their interest in automobilization with an interest in railroadization.<sup>116</sup>

The fourth reason for dealing with Schumpeter's railroadization case is, according to this paper, the most important: the case can function as a starting point for a modern specification and development of Schumpeter's model of capitalist evolution. The need for such a specification is clear from the previous conclusions as well as from Schumpeter's own remarks on his work as a motivated program for further research. The railroadization case helps to demonstrate that in *Business Cycles* is not just making a juxtaposition of theory, history, and statistics. Instead he is more or less openly acknowledging the need for further developments of his theory to cope with the facts, not least the stylised facts of the process of railroadization. The paper tries to take Schumpeter seriously and sketch an appropriate evolutionary-ecological analysis. First, modern evolutionary-ecological analysis serves to put the initial focus on the evolution of the (relative) frequencies of different economic routines rather than on the aggregate patterns of growth and cycles. Second, the logistic equation and the Lotka-Volterra equations serve to find the rough characteristics of the statistical time series of the application of different routines, especially the maximum growth rates and the long-term carrying capacities. They also serve to focus attention on the major deviations from standard patterns. Third, the parameters of the ecological equations can be considered as central variables in the evolutionary game between the different economic agents. Some agents are *r*-strategists who emphasise an increase in their ability to make an increase in their ability to make fast projects while others are *K*-strategists who try to enhance their detailed performance in areas which are near their carrying capacities. Fourth, the financial system can be considered as a central selection environment which determines the relative success of *r*-strategists and *K*-strategists. However, this selection environment is not stable. On the contrary, it tends to switch between periods where *K*-strategists are favoured and periods where *r*-strategists are favoured. The macroeconomic dynamics is determined by such switches as well as by the multiplier-accelerator effects, etc. of the investment projects.

This analysis was developed through a combination of (1) stylised facts of the process of railroadization, (2) Schumpeter's scheme of economic transformation and its core agents, and (3) modern evolutionary-ecological analysis from biology as well as evolutionary economics. The fruitfulness of such an untraditional combination cannot be judged fully from its application in a single paper. However, several results have been obtained which suggest some merits of the approach. First, it has been made very clear that Schumpeter is considering a process of evolution where it has little meaning to talk of simple diffusion of a single innovation. To think of an innovation as having a fixed carrying capacity from the very moment it emerges is not in correspondence with Schumpeter's discussions in *Business Cycles*. The present analysis helps to bring out this message clearly. Second, it is both entrepreneurs and managers who engage in parameter-changing projects. However, Schumpeter is primarily interested in the

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example of the young Schumpeter, and it is clearly not as close to his basic vision and analytical scheme as the case of railroadization.

<sup>116</sup> For instance, Nelson, *Economic*, summarises the ideas behind a new project in evolutionary economic modelling which will formalise and test some of the ideas of the life-cycle theory of technologies and industries – especially the possible emergence of dominant designs. Nelson's new modelling and simulation work will explicitly reflect the fact that this theory is to a large degree based in studies of the US automobile industry. A competing evolutionary model relating more or less directly to the US railroadization would be very useful, but also very complex.

timing-sensitive projects of entrepreneurs who act in and partly create far-from-equilibrium situations. On the other hand, Schumpeter treats the incremental innovations of the *K*-strategists together with many other 'secondary phenomena'. Third, Schumpeter's 'circular flow' is not stable in any ordinary sense. It is rather an 'ideal type' which may help theorists and perhaps also economic agents to orient themselves in the chaos of economic life. It is simply a state where all the well-known routines have reached their carrying capacities (given the coefficients of interaction). However, when the economic system approaches such a state, an interest in the more or less novel projects of *r*-strategists are likely to emerge. Sooner or later these projects will disequilibrate the system. Fourth, the analysis of the financial system emphasises the importance of trust and waves of creative forgetting of mistrust. Thus the analysis emphasises a characteristic of the entrepreneur which is largely missing in Schumpeter's analysis: the ability to appear trustworthy with respect to *r*-projects which are basically problematic from a decision-making point of view. Fifth, the approach suggests that there is a complex interaction between *r*-strategists and *K*-strategists, not least between radical innovation and incremental innovation. A further study of this interaction might bring out managers, workers, and government officials as important counterparts to entrepreneurs in the evolutionary game.