The Linz-Budweis Railway: Technology, Science and the Economy[1]

Herman Freudenberger

Tulane University, New Orleans

Reputedly the first public rail-line on the European continent, the approximately 120 km horse-drawn railway between Linz on the Danube and Budweis (Česky Budějovice) on the Moldau (Vltava), constructed in the 1820s, demonstrates a rather interesting combination of the interplay between technology, science and the economy.[2] It may thus provide evidence for the question that has often been raised as to whether and how these factors were interrelated.[3] At times it has been said that in England the Industrial Revolution, of which railroads were a major component, was nothing more than a result of the tinkering of gifted but untrained men concerned above all with economic gain. This as well as the opposite assertion that science and technology as independent factors were and are possibly mainly responsible for creating the basis for industrialization and economic growth call for examination.[4]

[1] I wish to thank Frank Durham and Alfred Freudenberger for their suggestions after reading through this paper.

[2] Technisches Museum - Wien, 150 Jahre Pferdeeisenbahn Linz-Budweis: Jubileum der ersten Eisenbahn des Kontinents (Wien n.d.).

[3] Cf. A.E. Musson & Eric Robinson, *Science and Technology in the Industrial Revolution* (Manchester 1969), Chapters 2 and 3.

[4] Kristine Bruland, "Say's Law and the Single Factor Explanation of British Industrialization: a Comment," *Journal of European Economic History* 14 (1985), pp. 187-192; John F. Gaski, "The Cause of the Industrial Revolution: a Brief 'Single Factor' Argument," *Journal of European Economic History* 11(1982), pp. 227-234; Ian Inkster, "Technology as the Cause of the Industrial Revolution: Some Comments," *Journal of European Economic* History 12 (1983), pp. 651-657; Peter Mathias, "Who Unbound Prometheus? Science and Technical Change, 1600-1800," in *Science and Society 1600-1900*, edited by Peter Mathias (Cambridge 1972), pp. 54-80.

In the case of the horse-drawn railroad that I wish to discuss, it is clear that this novelty was already fairly well known, going back possibly to the late Middle Ages and certainly since the sixteenth century when Georg Agricola mentioned it in his famous book on mining.[5] One of the main actors in my story, Franz Anton Ritter von Gerstner, reported that in 1822, when he took his first study trip to England, several hundred German miles (1 German mile was equal to about 7.5 km) of railways existed there, none to be sure longer than thirty English miles and all devoted solely to industrial and commercial purposes.[6] At that time neither the Stockton & Darlington nor the Liverpool & Manchester railways, the organizations that are usually credited with starting the railway age, had yet been put in operation. But a fairly active discussion on the usefulness of railways had been going on for some time, as indicated by a report to the English Parliament in 1799 and an analysis by O'Reilly in the *Annales des Arts et Manufactures* in 1801.[7] We need not concern ourselves consequently with the question of originality for the Habsburg Monarchy. Nevertheless, the project does indicate a rather early interest in introducing a major innovation into an area that is more known in the historical literature for its backwardness relative to west European countries like England, France and Belgium as well as to its central European neighbour Germany. The first article on the benefits of railways in Germany was written in 1825 by the Rhenish industrialist Friedrich Harkort.[8]

It is therefore of considerable interest to determine what the motivation behind the plan to construct a rail-line between Linz and Budweis was. We wish also to know how the entrepreneurial

[5] C. Hamilton Ellis, "The Development of Railway Engineering," in Charles Singer et al., eds., *A History of Technology* (Oxford 1958), V, p. 322.

[6] Franz Anton von Gerstner, *Über die Vortheile der Anlage einer Eisenbahn zwischen der Moldau und Donau* (Wien 1824), pp. 40f, 62f.

[7] Ibid., 40f. The report of 1799, cited by Gerstner, has not yet been located.

[8] G. Wolfgang Heinze and Heinrich H. Kill, "The Development of the German Railroad System," in *The Development of Large Technical Systems*, edited by Renate Mayntz and Thomas P. Hughes, (Frankfurt a/M & Boulder 1988), p. 115.

decisions were made and, very importantly, what role government authorities and private sector investors played. Lastly, the intriguing question of the interplay between science, technology and economy presents itself here. In respect to the construction of its first railroad, it appears that the Habsburg Monarchy was unique among European countries in the combination of these factors.

I wish to consider the last question first. I do not, however, profess to answer the question in any conclusive way even for the Habsburg Monarchy in the early nineteenth century. A. E. Musson and Eric Robinson have made a persuasive case that in England scientists and scientific thinking contributed vitally to the industrialization of that country.[9] The formal as well as the informal means used for this purpose, that is, research and teaching institutions as well as amateur scientists and economic practitioners functioning in a less structured environment, represent an important element of the infrastructure on which industrialization was based. They represent the "library" of knowledge that Peter Mathias feels is necessary, although not sufficient, for industrial progress.[10]

To demonstrate this proposition two examples from the United States and Germany should prove enlightening. In the United States a major innovation in agriculture was introduced in the second half of the nineteenth century by several American agricultural chemists who had been taught in the University of Göttingen in Germany. They pioneered the establishment of agricultural extension stations, whose purpose it was to make the findings of university research available for practical implementation.[11] In a similar way the

[9] Musson and Robinson, *Science and Technology*, pp. 10-59, 87-189. See also, Neil McKendrick, "The Role of Science in the Industrial Revolution," in *Changing Perspectives in the History of Science* , edited by Mikuláš Teich and Robert Young, (Dordrecht & Boston 1973), pp. 274-319.

[10] Mathias, "Prometheus," p. 70.

[11] Charles E. Rosenberg, "Science and Social Values in the Nineteenth-Century America: A Case Study in the Growth of Scientific Institutions," in *Science and Values*, edited by Arnold Thackray and Everett Mendelsohn, (New York 1974), pp. 21-42.

German chemist Justus Liebig, who, besides training many industrial chemists, was closely associated with a pharmacist in Darmstadt, Heinrich Emanuel Merck, the founder of the world famous firm by that name.[12] These cases, in addition to that of the Austrian railroad, (to be detailed below) clearly show how science and economic factors could be combined to provide part of the infrastructure useful for economic growth.

To approach the problem from a different perspective, they represented "key variables" for the development of innovative activity with the potential of creating economic growth. In the Habsburg Monarchy, the United States and Germany there seems to have existed in possibly a more overt manner than in England of the time, a symbiotic relationship between science and economic development. If this assertion can in fact be generalized, then it could suggest that the imitator countries tend to resort to more formal and self-conscious methods to gain the presumed benefits that the original country possesses.[13] But to integrate a borrowed innovation successfully into an economy usually also requires a receptive environment.

My case-study to examine this proposition concerns the work of a mathematician of note in Prague and his son. The younger man wrote what is still considered the most authoritative study of the early American railroad system, which was published after his death in Philadelphia in 1840. Franz Joseph Ritter von Gerstner, the father, was a mathematician, astronomer, land surveyor and engineer, and while never having visited England, was nevertheless strongly influenced by the technical accomplishments of that

[12] Wilhelm Treue, "Das Verhältnis der Universitäten und Technischen Hochschulen und die Bedeutung für die Wirtschaft," in *Die wirtschaftliche Situation in Deutschland und Österreich um die Wende vom 18. Jahrhundert*, edited by Friedrich Lütge, (Stuttgart 1964), pp. 228f.

[13] David S. Landes, *The Unbound Prometheus* (Cambridge 1969), p. 151.

[14] K.A. Neumann, "Technology und Mathematik. Neueste Verhandlungen ‚ber das Frachtwesen, Fuhrwerke und Strassen, insbesondere Eisenbahnen, und Schifffahrtskanäle," *Hesperus* 21(1816), pp. 161-166, 174-176, 181-184,

country. A contemporaneously published report on his work was significantly headed "Technology and Mathematics."[14] His son Franz Anton, who had been a student in his father's classes at the Polytechnical Institute of Prague, actually went to England several times to study the construction and operation of railroads. At the time of his first visit in 1822 most of the railways in England and elsewhere were used to haul raw materials from pit heads to navigable places for transhipment. For both father and son considerations of profit and loss, while certainly not absent, seem to have been subordinate considerations. Deeply committed to technological progress, the two Gerstners represented an element in the Habsburg Monarchy that was devoted to bringing the country to the forefront of European science and technology. For the elder Gerstner "the country that does not have an interest in astronomy cannot expect to have good textile factories."[15] He obviously used astronomy as a proxy for the pure sciences and clearly saw a direct connection between them and economic growth and development. In the early 1790s, well before the railway project was even in its embryonic stage, the elder Gerstner wrote several longer memoranda for the Royal Bohemian Society of Sciences on the need for a scientific study of the kingdom's natural wealth so that it could be used for industrial and commercial development.[16]

Born in 1756 the son of a craftsman in the town Chomutov (Komotau) in northwest Bohemia, Franz Joseph Gerstner became professor of mathematics at the University of Prague in 1789. In 1798 he proposed the creation of a polytechnical institute in Prague on the model of the Paris institution and became its first director when it was in fact established in 1806.[17] The success of this proposal was without doubt due to a very large extent to the

[15] František Jílek and Václav Lomic, *Dějiny České Vysokeho Uceni; Technického* (History of the Czech Higher Technical Institute) (Praha 1973), I, p. 161.

[16] Mikulaš Teich Královska, *Česká společnost nauk a počátky vědeckého průzkumu přírody v Čechach* (Royal Bohemian Society of Sciences and the Beginning of Research in the Natural Sciences in Bohemia) (Praha 1959), p. 20.

[17] Carl Jelinek, *Das ständisch-polytechnische Institut in Prag* (Prag 1856), pp. 26f.

consistent support of Count Heinrich Franz von Rottenhan, the head of the commission for the reform of the Habsburg educational system and coincidentally, the owner of the estate Rothenhaus near where Gerstner was born. He was also the owner of iron and textile factories using state of the art technology. Rottenhan, though a powerful man at the imperial court in Vienna, came from a family that had only recently migrated from Bamberg, Germany.[18] Whether his status as somewhat of an outsider and Gerstner's position as originally a commoner born into a lower middle-class family had anything to do with their espousal of technologically, scientifically and economically progressive positions remains an open question that could only be answered by far more detailed, comparative studies. Moreover, it is of some interest that Rottenhan's son-in-law and successor in the ownership of the estate, Count Georg Buqouy, was himself one of the leading persons in the Habsburg Monarchy in the first half of the nineteenth century in pursuit of technological and economic progress.[19]

In the study of the diffusion of technological innovations there is at times a debate over whether direct person-to-person transfers are the most propitious. Gerstner as well as the great German agronomist Albrecht Thaer are two fine examples showing that a thorough perusal of the literature can bring about the desired result.[20] The Bohemian professor used the available literature as a base on which he made his own analysis.

Borrowing ideas from abroad was of course nothing unique to the Habsburg Monarchy nor for the late eighteenth and the nineteenth centuries. To use only one example of many, important

[18] Anon., "Heinrich Franz, Graf von Rottenhan," Vaterländische Blätter (1809), pp. 77-79.

[19] Graf Georg Buquoy, Beschreibung einer im Jahre 1813 am Kunstschachte eines Kohlenbergwerkes in *Böhmen erbauten äusserst einfachen, wohlfeilen und allenthalben leicht ausführbahren Dampfmaschine* (Prag 1814); idem., *Die Theorie der Nationalwirtschaft* (Leipzig 1815).

[20] Cf. Ron Johnston, "Coupling Patterns in Science and Technology," in *Technology Transfers* edited by Marvin J. Citron and Joel D. Goldhar, (Leiden 1974), p. 81.

elements of iron technology seem to have entered Europe by way of the Middle East from China in the late XIVth century.[21] And there are numerous examples of the transfer of technology from continental Europe to England relating to iron, textile and paper production and the use of steam power, to mention only a few.[22] It is a curious but widespread nationalistic conceit that a particular country was the sole originator of major technological achievements.

There is evidence that the Habsburg Monarchy was not totally unprepared as a receptor of advanced technology. At one time in some industrial branches its technology was the equal of the best in European industry. In the field of mining technology, for example, Bohemia in the XVIth century held an eminent place as evidenced by Georg Agricola's famous work, which was based on his observations in Jachymov (Joachimsthal), where he served as a physician. Styria, an Austrian province south of Vienna, enjoyed an excellent reputation for a long time throughout Europe for its scythes and sickles and other iron and steel instruments. For a brief time at the end of the sixteenth and the beginning of the seventeenth century Prague enjoyed a rare clustering of great astronomers in the persons of Tycho Brahe and Johannes Kepler.[23]

Other bits of evidence of progressive thinking and consequently intellectual preparation for new technology include the trip to Belgium that a Bohemian official, accompanied by a skilled iron master, undertook in 1717 in order to investigate the use of coal for the smelting of iron and to recruit skilled workers to introduce this method in Bohemia. That he was frustrated in

[21] Joseph Needham, "Chinese Priorities in Cast Iron Metallurgy," *Technology and Culture* 5(1964), 402; Theodore A. Wertine, "Asian Influences on European Metallurgy," *Technology and Culture* 5(1964), pp. 391-397.

[22] C.F. Dendy Marshall, "The Germs and Development of some Mechanical Inventions," *Transactions of the Newcomen Society* 16 (1935/6), pp. 1-26; see also, George Basalla, *The Evolution of Technology* (Cambridge 1988), pp. 78ff.

[23] Josef Smolka, "The Scientific Revolution in Bohemia," in *The Scientific Revolution in a National Context*, edited by Roy Porter and Mikulaš Teich (Cambridge 1992), pp. 210-239.

this respect need not surprise us since it was only a short time after Abraham Darby had become the first person to successfully use this method. There is no evidence whatsoever that the Bohemians knew about this event. The Bohemian official did report, however, that coal was being used for other purposes and brought back with him a master craftsman who could teach its use in Bohemia.[24] Whether such other uses of mined coal were actually introduced or even whether modifications in the Bohemian blast furnaces to make them conform to those commonly used in the Liège area were adopted, is unknown. While this incident and the fact that in the 1720s a Newcomen steam engine was being operated in Nová Baňa (Königsberg) in northern Hungary (today's Slovakia) suggests an openness to the rest of the world, other parts of the Habsburg Monarchy such as Styria showed a more regressive attitude in its metallurgical industry, both in technological and economic terms.[25] It is of considerable interest that the first academy of mining in central Europe was placed in Banská Štiavnica (Schemnitz), not far from where the steam engine was located.[26] Established at government expense in 1763, this educational institution was enjoined to combine the theories of chemistry, mineralogy and metallurgy with practical applications. In this way the academy departed from mining instruction elsewhere where mining law was stressed. One of the first professors to lecture and do research at the academy was a well-known chemist, Nicolaus Jacquin, who not long after his tenure there was called to assume a professorship at the University of Vienna.

[24] Statni ustředny archiv (Central state archive) (Prague), ČG Commerc 1716-1730, 1717 J/1

[25] Elisabeth Reiner, "Karl von Zinzendorf und das Eisenwesen in Innerösstereich," *Mitteilungen des Österreichischen Staatsarchivs*, 13(1960), 264f; Mikulaš Teich, "Diffusion of Steam-, Water-, and Air-Power to and from Slovakia during the 18th Century and the Problem of the Industrial Revolution," in *L'acquisition des techniques par les pays non-initiateurs* (Paris 1973) p. 352.

[26] Josef Vlachovic, "Die Bergakademie in Bansk· ätiavnica (Schemnitz) im 18. Jahrhundert, " *Studia historica slovaca*, 2 (1964), 103-139. Cf. Karl-Heinz Manegold, *Universität, Technische Hochschule und Industrie* (Berlin 1970), p. 24f.

A further bit of evidence in this connection is the plan in the 1740s of the feudal Estates of Bohemia to establish an academy for the education of young noblemen in Prague.[27] Lastly as support for the assertion of intellectual openness is the work of a highly talented member of the Prague Polytechnical Institute, Josef Bošek, who in 1817 put on a demonstration of a steamship that he had constructed. Two years earlier he had showed off to wide approval a "steam waggon" (*Dampfwagen*), which he had constructed.[28] This is of course not to say that Bošek was the first to construct such a machine, merely that persons in the Bohemian capital were informed of the latest technological discoveries.[29]

Unlike Great Britain where there existed an active competition between scientific institutions located in the centre, namely London, and the provinces such as in Manchester, Bristol and Edinburgh, if the latter city may be considered a provincial city, there seems to have been less overt rivalry in the Habsburg Monarchy.[30] Nevertheless, Gerstner, father and son, both natives of Bohemia, as were many of their patrons and other like, minded persons, represented a unique environment for the study of technology, science and the economy. *Landespatriotismus,* patriotism and pride for the traditional greatness of Bohemia, was unquestionably a factor in the political and intellectual life.[31]

While my main emphasis is on two personalities, I wish to reiterate a frequently held position that innovations cannot take hold without sufficient preparation and that their eventual success

[27] Josef Hanuš, *Narodní museum a naše obrození* (The national museum and our reawakening) (Praha 1921), I, p. 57.

[28] Jělek and Lomic, *Dejiny,* I, p. 259.

[29] Neil Cossons, "The Grenville Steam Carriage," *Transport History* 1 (1969), pp. 277-284.

[30] Ian Inkster, "Introduction: Aspects of the History of Science and Science Culture in Britain, 1780-1850 and beyond," in *Metropolis and Province: Science in British Culture, 1780-1850* edited by Ian Inkster and Jack Morrell, (London 1983), pp. 11-54.

[31] Herman Freudenberger, "Progressive Bohemian and Moravian Aristocrats," in *Intellectual and Social Developments in the Habsburg Empire from Maria Theresa to World War I* edited by S.B. Winters and Joseph Held, (New York and London 1975), pp. 115-130. See also, Eduard Maur, "Karl Egon I [Fürstenberg] als Oberburggraf in Prag," in *Die Fürstenberger,* edited by Erwein H. Eltz and Arno Strohmeyer, (Korneuburg 1994), pp. 290ff.

depends much on learning-by-doing, also known as the "Horndal Effect."[32] 'Sufficient', I fear, will have to be defined by the success of the operation. In a retrospective sense, the relevant evidence in the case of the Linz-Budweis railroad can be found in the activities of persons like the Gerstners and the great aristocrats like Lobkowitz and Schwarzenberg, who had a considerable effect on the informed opinion and on political policies of their day. These men were part of the "ancien régime" or the feudalistic society that Marxists have often preferred to call it. At the same time, however, they worked actively, though not openly or self-consciously, to destroy the old system. In economic terms, they were aware of an increasingly strong market system. In that respect as well as in the narrower sense of technological innovation they looked to England as their model. "Industrious" England was the country "where every idea that promised to reduce time and energy for the mechanically driven life [was] greedily taken up and where no expense was rejected to adopt inventions that held out hope of positive benefit."[33] Even if their main interest was to prove to themselves nothing else than that they were up to the highest standards in scientific and intellectual matters, they nevertheless in this way became the means for the destruction of the old society and, more importantly, for the foundation of the new, more industrialized and hopefully more benevolent age.

It was not only some great landowners who were responsible for the vibrancy of intellectual life in Prague and in the kingdom of Bohemia. Besides the elder Gerstner there was also another important if rather contentious personality in intellectual life there. This was Bernard Bolzano, a priest, philosopher and mathematician - a former student of Professor Gerstner's at the University of Prague - who was expelled from his position as professor of religion at the university at the request of church

[32] Nathan Rosenberg, "Factors Affecting the Diffusion of Technology," *Explorations in Economic History* 10 (1972), p. 16.

[33] Anon., "Technologie. Ueber Eisenbahnen und ihre ausgebreitere Anwendung," *Hesperus* 25 (1818), p. 193.

authorities but who continued to enjoy a considerable following even afterward.[34] At the same time the famous physicist Christian Doppler was at the University of Prague for 12 years and in association with Bolzano created in Prague a scientific environment of note. Doppler left that city to accept a chair at the University of Vienna, where he died not many years afterwards.[35]

Before leaving the question of the importance of the periphery and the centre, note should also be taken of another provincial centre where science, technology and the economy were combined in a symbiotic relationship. Here the reference is to the Moravian capital Brno (Brünn) where an exceptionally strong push to industrial and agricultural progress can be identified and where the woollen cloth industry led by a number of German Protestants proved to be the catalyst. Also two leading journals, one on agricultural change and the other on industrial innovation, were published here by one Christian Carl André, who was eventually expelled from the Habsburg Monarchy for his liberal leanings. He was strongly supported by rich landowners, the most noteworthy of whom was Hugo Altgraf von Salm-Reifferscheidt, who was among other things an industrial entrepreneur on his father's properties, which he managed, and an amateur scientist in the best sense of the word. In Brno, too, originated one of the great encyclopedias of the German-speaking world, published in the late eighteenth century by Johann Georg Krünitz and eventually encompassing 137 volumes.[36] Undoubtedly the atmosphere created by these men and others with similar interests proved to be beneficial to the work of the founder of genetics, Gregor Mendel, who was a member of an Augustinian monastery and a teacher at a local secondary school in the middle of the nineteenth century.

It is rather instructive to realize that the Vienna Polytechnical Institute that was first opened in 1816 trailed that of Prague by 10

[34] Eduard Winter, *Romantismus, Restauration und Frühliberalismus im österreichischen Vormärz* (Wien 1968).

[35] Jílek and Lomič, *Dějiny*, p. 304f.

[36] Anon., *Anderthalb Jahrhunderte Rudolph M. Rohrer, 1786-1936* (Brünn 1937), p. 13.

years but even then preceded those of other German-speaking areas.[37] The most active person responsible for the Prague Institute was, as pointed out above, the elder Gerstner, in whom we are interested, of course, primarily for his pioneering work in the field of transportation.

The Gerstners were joined in the quest of combining science, technology and the economy by a number of rich aristocrats and *nouveaux riches* bankers, most prominent of whom was the head of the Vienna house of Rothschild. That they and their successors never accomplished the feat of fast growth and that instead there may be justification to refer to the Monarchy as a backward country poses a puzzle that I feel prepared to answer only in a limited sense. I would merely wish to assert that the intellectual and economic conditions of the Monarchy in the first quarter of the nineteenth century were propitious enough to be considered equal to those of Germany at the time.[38]

While the role of the private sector was dominant in the construction and operation of the Linz-Budweis railroad, the central government was indirectly, but nevertheless importantly, part of this process. Railroads, of course, generally required government franchises in all countries. In respect to the Austrian Empire the student is frequently confronted with the somewhat simplistic generalization that Emperor Franz and his chief minister Prince Metternich were unalterably opposed to any innovation for fear that it would bring in its train radical ideas. If, as is likely, he held such sentiments, he was probably in agreement with his fellow princes in Prussia and Hannover to whom a railroad meant almost a derogation of rank. As the King of Hannover said: "I don't want every cobbler and tailor to be able to travel as fast as I can."[39] In the

[37] Treue, "Verhältnis," p. 225f.

[38] Cf. John Komlos, "Austria and European Economic Development," in *State and Society in early Modern Austria* edited by Charles W. Ingrao, (West Lafayette 1994), pp. 215-225.

[39] Hans Mottek, "Einleitende Bemerkungen - Zum Verlauf und zu einigen Hauptproblemen der industriellen Revolution in Deutschland," in *Studien zur Geschichte der industriellen Revolution in Deutschland* edited by Hans Mottek, (Berlin 1960), p. 36.

Habsburg Monarchy the period 1815-1848 appears more an anomaly during which cultural conservatism and technological progress were the rule.[40] A case in point, Solomon Rothschild, despite his close relationship with Metternich, had to wait for the death of the Emperor before he could get government approval for a new, large railway project.

Was the project in which the Gerstners were involved part of an early economic spurt that failed in the sense that Alexander Gerschenkron posited for the grand but abortive infrastructural scheme in Austria at the beginning of the twentieth century?[41] Gerschenkron believed that the industrialization of backward countries often resulted from discontinuities during which an economy enjoyed a sharp spurt forward. A multiplier effect that brought with it a substantial increase in other economic activity would be expected to follow the spurt. This process could also be called a "key innovation" following which strong economic growth could be observed.[42] An infrastructural project such as the Linz-Budweis railroad is an excellent candidate for such a designation, although it may not have been large enough to induce widespread growth. On the other hand, it may have paid the price of the pioneer since its horse-drawn technology was obsolete even at the start, as the younger Gerstner asserted with some vehemence, causing his dismissal as managing director of the company.

There was some discussion among the bureaucrats in Vienna on its possible macroeconomic usefulness in the Gerschenkronian sense, but this did not go beyond vague generalizations. The exchange of views among the agencies of the central government was in the context of a grand design of connecting the North Sea and the Baltic Sea with the Danube River and eventually with the

[40] Roger Paulin, "The Biedermeier Anomaly: Cultural Conservatism and Technological Progress," in *The Austrian Enlightenment and its Aftermath* edited by Ritchie Robertson and Edward Timms, (Edinburgh, 1991), pp. 88-101.

[41] Alexander Gerschenkron, *An Economic Spurt that Failed: Four Lectures in Austrian History* (Princeton 1977).

[42] Herman Freudenberger and Gerhard Mensch, *Von der Provinzstadt zur Industrieregion* (Brünn-Studie) (Göttingen 1975), pp. 47ff.

Black Sea and the Mediterranean Sea, a plan that had been considered as far back as 1375. Supposedly at that time the population living along the Danube destroyed the sections of a canal that had been dug for fear that the great river would in this way have been obliterated, along with their livelihood.[43]

This project was again seriously taken up by the famous *generalissimo* of the Thirty-Years War, Wallenstein, who proposed that the Bohemian rivers be made navigable and connected with the Danube. Continuous warfare and his assassination aborted this effort. Some sixty years later, at the end of the seventeenth century, a cleric from Lorraine, Lothar Vogemonte, who was in Vienna on diplomatic business, apparently spontaneously came to the conclusion that the Habsburg Monarchy could be made more prosperous by effecting an all-water route from north to south.[44] Approximately a hundred years later, Bohemian aristocratic landowners supported Vogemonte's proposal and were willing to supply funds as long as the canal could be used to haul goods from their estates. Despite the enthusiastic lobbying efforts of the clergyman from Lorraine, the canal connecting the Danube and Moldau rivers did not become reality. It may have been because of the technological difficulties that the Gerstners elaborated on more than a century later, accusing Vogemonte in the process of being unduly and possibly ignorantly optimistic. Other similar projects, all without success, were discussed during the eighteenth century.

The last all-water route project that concerns us was taken up in 1807. On the basis of an anonymous proposal the political authorities (Hofkanzley) in Vienna requested the governor's office (Gubernium) in Prague to respond in eight days with an analysis of its feasibility. One may ask oneself what the big rush was after centuries of considering the problem. But then the central

[43] Ottocar Weber, "Die böhmisch-hydrotechnische Privatgesellschaft (1807-1809)", *Mitteilungen des Vereines für Geschichte für Deutschen in Böhmen* 29 (1891), p. 323.

[44] Weber, "Böhmisch-hydrotechnische Privatgesellschaft," 323f. Franz Ritter Gerstner, *Zwey Abhandlungen „uber Frachtwagen und Strassen* (Prag 1813), pp. 118ff. See also, Gerstner, *Über die Vortheile*, pp. 8-16.

government authorities may well have felt that all the pertinent material had by now been brought together and all the problems considered. It is not clear whether the governor in Prague gave his answer within the required time. What is of greater importance for our purposes is that a group of 46 persons and one corporation joined together in a company to conduct a preliminary study. Each participant paid 500 *gulden* for a total sum of well over 20,000 *gulden* (_ 1 =10 1/2 gulden = ca. $4 1/2) to defray the costs of a feasibility study. Headed by Prince Anton Isidor Lobkowitz, the "Bohemian Hydrotechnical Private Company" (*Böhmisch Hydrotechnische Privatgesellschaft*), was organized to make the Bohemian rivers navigable and above all to connect them with the Danube. All but a few of the members of the company were aristocrats including Prince Joseph Schwarzenberg and Prince Niclas Esterhazy, (the latter the well-known patron of the composer and musician Johann Joseph Haydn) the richest landowners in the Habsburg Monarchy, and including two ladies. One of the named shareholders was a corporation, the Royal Privileged Hungarian Canal and Shipping Company. It should be added that a number of corporations (*Aktiengesellschaften*) existed at this time in which aristocrats were major shareholders and presumably carried out entrepreneurial functions. One of the most interesting of these persons was Prince Joseph Schwarzenberg, who controlled a large bank in Vienna as well as reputedly the largest cotton spinning factory on the European continent.[45] The Linz-Budweis canal, too, was to be operated by a corporation.

At the meeting at which the preliminary company was formed the elder Gerstner was appointed as *scientischer Direktor* to carry out a feasibility study.[46] He soon came to the conclusion that the

[45] Herman Freudenberger, "The Schwarzenberg Bank: A Forgotten Contributor to Austrian Economic Development, 1788-1830," *Austrian History Yearbook* 27 (1996), pp. 41-64.

[46] Anon., "Neuere Nachricht über die böhmische hydrotechnische Privatgesellschaft," *Vaterländische Blätter*, 60 and 61(1808), pp. 431-434; 63(1808), pp. 439-440; Weber, *"Böhmische hydrotechnische Privatgesellschaft,"* pp. 321-344.

preferable solution was to build an iron railroad, having become convinced from his reading in the literature that it represented the wave of the future and at the same time was cheaper to construct than the water route.[47] No other known canal had ever been required to conquer such heights and would need so many expensive locks as would the proposed route from Linz to Budweis. The only way that such a canal would be feasible, the scientific director added, was if the government were to build it and present it to the company as a gift, as the French government had done with the canal of Languedoc (also called the *canal de Midi*).[48] There was no question in his mind that freight costs on a railroad would be lower than on a canal. As a further means to convince the shareholders at the meeting where he gave his report, Gerstner showed a model railroad with freight cars.[49] Despite the enthusiastic approval of Gerstner's proposal, the company disbanded possibly on account of the war and the fact that Lobkowitz, the leading personage in the company, and others died before a decision had been made.[50]

Large infrastucture proposals can of course not be expected to become reality in a short period of time. Thus it was with the connection between the two Habsburg rivers. Gerstner himself came out with a scholarly treatise to enlighten the interested public with carefully thought-through options concerning transportation improvements.[51] But it took a conference in Dresden in 1819 of the ten riparian states on the Elbe river to bring the proposal to the centre of discussion. As a result of this meeting, which in 1821 led to the signing of an agreement to free the entire length of the Elbe to commerce, the head of the imperial commerce commission asked the younger Gerstner in 1820 to undertake a new feasibility study.[52]

[47] H. Huyer, "Die Budweis-Linzer Pferdebahn," *Mittheilungen des Vereins für Geschichte der Deutschen in Böhmen* 31(1893), pp. 78ff.
[48] Gerstner, *Zwey Abhandlungen*, pp. 112-118.
[49] "Neuere Nachricht," Nr. 62 (1808), p. 440.
[50] Gerstner, *Über die Vortheile*, iv.
[51] Gerstner, *Zwey Abhandlungen.*
[52] Gerstner, *Über die Vortheile*, vi.

Pleading too many official duties to undertake the task himself, his father had recommended that his son, then 26 and a professor at the recently opened Polytechnical Institute in Vienna, be asked to study the problem and make appropriate recommendations. Shortly after the young Gerstner was appointed, he left at his own expense for England to study railway technology and consult with experts on the economic feasibility of this form of transportation.[53] To demonstrate how seriously he took his task and to gain the necessary experience he travelled by water to Hamburg and from there sailed to England so that he could make a first-hand appraisal of the problem.

A railway connection between the Danube and Moldau rivers was still a revolutionary undertaking in the 1820s. Consequently, it is understandable that the canal option had many proponents. As late as 1834, when a canal connecting the Danube and the Main was being constructed in Germany, the relevant decision makers rejected a railway solution on account of the presumed unreliability of the machinery.[54] The younger Gerstner felt it necessary therefore to survey the area again thoroughly with the option of a canal in mind. He found that, at a minimum, 234 locks would have to be installed because of the mountainous nature of the land. Moreover, he came to the conclusion that a canal between Linz and Budweis would compare unfavourably with the *Canal de Midi*, one of the best known canals on the European continent, both as to construction and upkeep costs, thus coming to the same conclusion, presumably with evidence that he himself had collected, as his father some fifteen years before. But, even so, the French canal did not return 5% in interest payments.[55] It was common at the time for shares to return a fixed-interest payment to the investors before dividends could be paid out. The shares were thus a combination of what today are called preferred stock and common stock. Not only

[53] Huyer, "Pferdebahn," pp. 82ff. Gerstner's action was not unique. It seems to be a counter example to Landes' assertion that "only governments could afford to send officials on costly tours of inspection." Landes, *Prometheus*, pp. 151.

[54] Heinze and Kill, "German Railroad," p. 114.

[55] Gerstner, *Über die Vortheile*, pp. 27-29.

could Gerstner show a low return on one of the great canals in Europe, but he also provided a list of the market share-prices and the nominal par-prices of shares of 39 English canals and found that on average they had dropped from £ 100 to £ 40.[56] Two provisos must be made: 1) As Gerstner pointed out 1822 was a dry year with many canals having to suspend operations. This list was printed in a book published in 1823. 2)The nominal price on a share did not necessarily reflect the actual amount of money that had been paid in. Often the investor expected to pay up his nominal share price through the reinvestment of dividends. The market prices of the shares may thus have reflected no more than the value in terms of the amount actually paid up, both from the original sum and the reinvested profits. Consequently, Gerstner used some questionable methods, if it was his purpose to demonstrate how poorly canals performed financially. Moreover, he reported that these were a sample of a total of 103 "larger" canals in England, many of which had paid their interest regularly and some having returned 10-20 times the invested money.

It is of considerable interest that the impulse for technological and economic progress in this case emanated to a large extent from Prague and less from the centre of imperial power in Vienna. To be sure, the immediate reason for the younger Gerstner to undertake the study trip to England and to conduct a personal survey of the likely route for the railway connecting Danube and Moldau was a request from the central government's commercial commission. But it was Bohemian noblemen who strongly supported his quest. In his book explaining and analyzing the various options for this project, Gerstner also reported that several aristocratic landowners and industrialists had offered to supply him with construction materials on credit and some at reduced prices.

Even though 1822, when the younger Gerstner went to England, was still several years before the Stockton & Darlington

[56] Gerstner, *Über die Vortheile*, pp. 61-63.

and the Liverpool & Manchester lines, firms that are usually accorded the honour of opening the railroad age, were in operation, he was able to visit numerous railways in industrial establishments, mines and harbours and he became convinced, as his father had before him, that the future lay with railroads for the haulage of commodities and passengers. He also came back with the distinct impression that steam locomotives should be used. It was not until 1830, eight years later, that the debate in England about the usefulness of the locomotive over horse traction was finally resolved in favour of the former.[57] Moreover, he even found English capitalists willing to invest in Austrian railways as long as the companies would operate under government charters similar to those in England. Like his father he was convinced that railroads would reduce shipping costs considerably even when compared to canals. Interestingly enough the younger Gerstner also came to the conclusion that inclined planes were to be avoided with a railroad, a problem that was at this time still being debated in the United States with the plans for a route from Philadelphia to Pittsburgh.[58]

Equipped with wooden rails on which wrought iron plates were fastened and with carriages that were less heavy than the ones that he had observed in England, the railroad through the mountainous area between Linz and Budweis called for an outlay of one million *gulden* or 40,000 *gulden* per Austrian mile (ca. 7 1/2 km.), an amount comparable to the cost of an ordinary road.[59] He had made his calculations on the basis of those written up in the Newcastle Magazine (May, 1822) by Benjamin Thompson, a civil engineer and William Buddle the manager of several coal mines in the Newcastle area and himself the owner of a coal mine, who allowed Gerstner to view the books of the mines relating to railways that Buddle himself had constructed.[60] He also went to the trouble of finding out at

[57] Jack Simmons, "For and Against the Locomotive," *Journal of Transport History 2* (1956), p. 144.
[58] Julius Rubin, *Canal or Railroad?* (Philadelphia 1961).
[59] Huyer, "Pferdebahn," p. 91f. See also, Gerstner, *Über die Vortheile*, p. 95.
[60] Gerstner, *Über die Vortheile*, pp. 68-97.

what prices he could procure the wrought iron that he preferred for the rails from Bohemian iron works. It is not clear from his book whether the wrought iron was to be attached to wooden rails or whether the entire rail was to be made of wrought iron. When it came to the freight cars that he proposed, he opted for lighter cars than those used in England because they would be likely to damage the rails less and would result in having the horses pull more weight because the freight would be more evenly dispersed. In addition, a horse would be able to pull more weight when more wheels were put on each freight car, as his father had proposed. Cast-iron rails he rejected both because of their weight and their brittleness. Lastly, he adopted the normal British gauge of 4 1/4 Vienna feet. Interestingly, when he built the first Russian railroad he used a wider gauge and thereby set a tradition that still holds. He ended his book with a section that carefully laid out the likely benefits to be derived from the railroad by showing how much salt, the main good to be hauled, had been transported on the road over the 12-months period from November 1822 to October 1823 as well as another table that showed the annual amount of salt and of other freight, giving the total sums that had been expended for haulage. He assumed that the railway would charge 33 percent less than road haulers and at the end the result would be a 10 percent return to investors.[61] Despite his efforts to be as precise as possible and presumably to be conservative in his projections, Gerstner like most other railroad entrepreneurs was overly optimistic. Nevertheless, it seems somewhat strange that his careful estimates both in his book on the feasibility of the Linz-Budweis railway itself or in his textbook on mechanics were apparently not used by prospective investors in Germany proper or, for that matter, in France.[62]

Young Gerstner's programme was accepted only in part. By

[61] Gerstner, *Über die Vortheile*, pp. 97-118.

[62] Heinze and Kill, "German Railroad," 117; François Caron, "The Evolution of the Technical System of Railways in France from 1832 to 1937," in *The Development of Large Technical Systems*, edited by Renate Mayntz and Thomas P. Hughes, (Frankfurt a/M & Boulder 1988), p. 75f.

1824 when this project was being actively discussed among the bureaucratic agencies of Austria's imperial government, there was agreement that some major improvement in transportation was required. But there were still strong proponents of canal systems. One of these would connect the harbour city of Trieste with the Elbe by way of Vienna. There were even persons who favoured a grand all-water route connecting the North Sea with the Black Sea and the Mediterranean. Among the proposals was also one that would connect the recently-opened canal south of Vienna, the Wiener Neustadt canal, with the Elbe. Gerstner, senior, a good Bohemian, objected because these plans would prove of no benefit at all to Prague. There was a substantial conflict between the imperial construction authority (*Hofbaurath*) that opted for a canal system, preferably in eastern Austria, and the Gerstners who stuck consistently to a railroad connection between Linz and Budweis. The Viennese agency pointed out that railroads could only be built by private-sector organizations, why is not stated. This quality should certainly have made it attractive to a government that was constantly strapped for funds. Even those agencies in the government that fought for a grand canal system agreed that it would have to be financed out of public funds; they warned that the proponents of a railway transportation system vastly exaggerated its benefits and contended that it could not be under any condition as valuable as a water system. At a time when as usual the Habsburg government was subject to financial stress it is difficult to understand why the construction agency should opt for canals, given its own criteria.

In this conflict of bureaucracies concerning the most appropriate connection between the Danube and the Elbe rivers, the central construction agency (*Hofbauamt*) was supported by the directors of the Vienna Polytechnical Institute whereas the Hofkanzley, the political, policy-making agency strongly (*nachdrücklich*) backed the Gerstners. The latter agency based its position on the report of the imperial commercial commission (*Kommerzhofkommission*), which had earlier been assigned to investigating the Gerstner proposal for

which it was the original instigator. The *Hofkanzley* conceded that a canal system would be preferable but pointed out that the government lacked the necessary funds, whereas the railroad project would be financed in the private sector, and it therefore opted for the Gerstners' programme. In a somewhat contradictory way it pointed to a dearth of investment funds in the private sector and at the same time asserted that, what today would be called a crowding-out phenomenon in the financial markets, existed with potential lenders opting for the more attractive government securities. Moreover, the agency emphasized that the government's role in this case should be to serve as a guide so that the public would be benefited most. This attitude was, of course, in accordance with the prevailing sentiments of economic theorists in England but also seems to have reflected policies that the Emperor Franz had adhered to for the previous twenty years, an economic liberalism that was at odds with the repressive intellectual atmosphere that he also fostered. Gerstner's suggestion that the government invest 800,000 *gulden,* or approximately half of the projected construction costs, was rejected despite the expected savings of haulage charges for salt shipments on the Linz-Budweis railway, salt production and sales being at the time a government-owned monopoly. The Court Chancellery (*Hofkanzley*) pointed in this respect especially to the great risk involved in constructing a railroad of a length hitherto unknown in England or anywhere else.

In the end the *Hofkanzley* proposed a concession for fifty years with a renewal option for another fifty years, on the English model, for a company that would be newly created for the purpose. Interestingly and hitherto not mentioned in the relevant literature, the agency reported that the Paris branch of the house of Rothschild had expressed an active interest in this project and promised to bring together a number of investors as soon as negotiations with the Austrian government would be completed.[63]

[63] Hofkammerarchiv (Vienna), red No. 1188, ff. 1484-1551. Cf. Barrie M. Ratcliffe, "The Origins of the Paris-Saint-Germain Railway," *Journal of Transport History,* NS 1(1972), p. 197.

This possibility did not come to fruition although Solomon Rothschild, head of the Austrian house, was responsible for the building and operation of a much longer railway line in the 1830s and was in fact a shareholder in the horse-drawn railway from Linz to Budweis as well.[64] According to the Court Chancellery the franchise to build the Linz-Budweis line was given to the younger Gerstner, who had requested the concession. Being a young professor of engineering and clearly not connected with any network of potential investors, Franz Anton Gerstner turned his government franchise over to a joint-stock company led by several of the most potent Viennese private banking houses including Geymüller, Sina and Stametz whose heads associated themselves apparently as private persons in this undertaking. They agreed to invest 800,000 *gulden* for construction costs.[65] When analyzing the project in 1839 the younger Gerstner remarked that much of the capital had been raised through short-term loans and that part of the shares had been sold below their par value, both weaknesses in financing the enterprise.[66] At the same time he maintained that in the end the railroad had cost $800,000 (approximately 2 million *gulden*)[67] or $10,000 per mile to build and thus substantially more than what the Viennese bankers had agreed to. Nevertheless, according to Gerstner, the railroad threw off a net profit of 5% per year since its opening in 1833 although M'Culloch's *Gazetteer* maintained that by c. 1839 no dividends had been paid out.[68]

Actually, according to Gerstner's own statement in 1832 in the textbook that he edited of his father's lecture notes, he reported that no dividends were paid out because in 1829 the government freed the trade in salt, the railway having previously enjoyed an exclusive contract with the government for the haulage of all salt

[64] Alfred Horn, *Die Kaiser-Ferdinands-Nordbahn* (Vienna 1971)
[65] Huyer, "Pferdebahn," pp. 165-169.
[66] Gamst, "Gerstner," p. 64.
[67] £ 1 = $ 4.44 = 10 1/2 gulden; Franz Joseph Ritter von Gerstner, *Handbuch der Mechanik*, (Prag, 1833), II, xii.
[68] M'Culloch, *Universal Gazetteer* /2 vols. (New York 1852),I, p. 226.

between Linz and Budweis.[69] Since the younger Gerstner's cryptic statement is not accompanied by any further explanation except that it represented a breach of contract, we can infer that the freight charges had to be reduced or that road transportation successfully competed with the railroad on price. The brochure of the technical museum accompanying its exhibit on the 150th anniversary of the railway simply asserts that the haulage of salt declined "almost completely" for several months in 1830 and then recovered by November 1830, hardly what one would expect to be responsible for continuing poor financial performance. Nor is it clear whether this meant that the investors received no payments whatsoever; they could have continued to receive the fixed percentage of the par price without, however, having received any dividends.

Actually, it turned out that the projection for the haulage of salt proved to be inflated and the carriage of persons was more profitable than expected. In 1834, according to the technical museum, the railway carried 2,425 persons and 22,700 tons of merchandise. M'Culloch's *Gazeteer* reported that in 1837 the railroad carried 291,286 cwt (14,802 metric tons) of salt, 151,288 cwt (7,685 metric tons) of general merchandise and 3,888 persons, producing a revenue of £ 8,130 (85,365 *gulden*). In the absence of cost figures or other similar evidence we do not know what the payout was for the 13,183 shares (at 50 *gulden* each) that were outstanding at the time.[70]

Gerstner insisted that if the owners had followed his recommendation and increased their commitment to $925,000 or $11,562 per mile, he could have constructed a railway line on which light locomotives could have been used and thus the financial returns would have been increased to 6 1/2 percent. Although the younger Gerstner like his father was not oblivious to profit and loss considerations, the financial problems associated with this enterprise proved to be overwhelming. He clearly would

[69] Gerstner, *Handbuch*, I, p. 661; Technische Museum, *150 Jahre*, p. 14.
[70] Technisches Museum, *150 Jahre*, p. 29; M'Culloch, *Universal Gazetteer*, I, p. 226.

have to be found wanting when compared to Emile Pereire, whose relationships to the Parisian world of finance proved to be vital in the construction of the Paris-Saint-Germain railroad, the first French public railroad, in the 1830s. While Gerstner was above all an engineer, Pereire was experienced as a stock-jobber and publicist.[71] Both shared an abounding faith in the future of railroads with the latter, of course, being far better known in the historical literature as a result of his participation in the *Crédit Mobilier* bank system.

After a second trip to England in 1827 to make himself privy to the latest innovations in railroading, Gerstner was more convinced than ever that the line had to be built with smaller gradients and wider curves so that steam locomotives could be used. This would have required a greater expense than the shareholders were willing to tolerate. Gerstner had not made his life any simpler by choosing the most difficult terrain to begin construction. As a true engineer he had meant in this way to demonstrate the technical feasibility of the railroad. To his financial backers it meant, however, a larger expenditure than they had expected and, since this stretch of railway was somewhere in the middle of the projected line, there would be no income that could have been gained for the haulage of salt and other goods at least over part of the route. Thus, the general meeting of shareholders in 1829 accepted his resignation and appointed in his stead his former student and then assistant Mathias Schönerer, whose surname has become famous in history since his son's ideas directly influenced Adolf Hitler.[72] The Linz-Budweis railway was thus comprised of one part over which steam locomotives could operate (but did not) and the other part, built after Gerstner's dismissal, which was solely fit for horse traction. It was only in 1854 that the Budweis-Linz railway line was reconstructed to allow for steam locomotives.[73] A few years after his dismissal from the Austrian railroad project, Gerstner built the first railway line in Russia.

[71] Ratcliffe, "Origins," p. 200.
[72] Huyer, "Pferdebahn," 32(1894), pp. 170-177.
[73] Ibid., (1894), p. 179.

The difficulties that the construction project experienced with the company's shareholders, few of whom lived in the vicinity of the railroad and therefore unlike many American and English investors saw no direct returns for themselves, were only part of the problem. The population of the area through which the railway was to go was hostile in general and fearful of this "creation of the devil." There was no question that old vested interests would be harmed. Salt haulers with their horse-drawn wagons, innkeepers and many others faced a severe loss of incomes. As was also experienced in England there were difficulties in acquiring the right-of-way. The construction workers and the contractors that employed them caused problems. Workers refused frequently to adhere to the technical regulations and unexplained absenteeism was flagrant. This as well as the fraudulent behaviour of some contractors who left the construction site without paying their workers, was, of course, also a problem in American and British railway building. Austrian railway construction was to be plagued by this problem for many years to come.[74] The merchants of Budweis took an especially strong stand against the railroad. In 1833 they proclaimed that their grain trade had been completely destroyed by the railroad and caused them a loss of 250,000 *gulden* in the "circulation" of money. Moreover, they maintained that 25,000 hauliers and peasants had lost their livelihood. This view proved to be a highly misplaced hyperbole, for only a few months later the city council of Budweis took exactly the opposite stand.[75]

The story of the initiation of the horse railway leading from Linz on the Danube to Budweis on the Moldau is instructive in several ways. The chief impulse for its construction came from a man who was able to claim a role as a mathematician, astronomer, engineer, land surveyor and consultant to many industrial enterprises. With Franz Joseph Ritter von Gerstner, technology,

[74] Paul Mechtler, "Bauunternehmer und Arbeiter in der ersten Staatsbahnperiode Österreichs (1842-1858)," *Österreich in Geschichte und Literatur* 12 (1968), pp. 317-330.
[75] Huyer, "Pferdebahn," 31 (1893), pp. 176-181; 32 (1894), pp. 179-183.

science and the economy were indeed joined. He no less than James Watt merged in his approach to problems practicality and science.[76] On a naive level, one that I wish to adopt, his objective as he himself declared was to encourage the industry and aid in the growth of the economy of Bohemia in general. On a more cynical level it cannot be denied that this son of a small craftsman undoubtedly enjoyed his elevation to a relatively high status of knight (Ritter). Similarly, his association with the great Bohemian aristocrats of his time unquestionably added to his feeling of personal satisfaction. Yet, the direct evidence that he was possibly driven by a desire to be among the cultural elite, a suggestion that has been made for the motivation of British scientists, is absent.[77] If he, in fact, was above all concerned with creating greater opportunities for the economic growth of his country, he could hardly have accomplished this without the support of the economic and probably also political elites.

His son was obviously precocious. Even his father's influence could not completely account for his appointment as full professor to the Polytechnical Institute in Vienna in his early twenties. While not as broadly schooled nor as intellectually motivated as his father, his approach to his chosen field, namely railroading, was thoroughly scientific, mixed with a strong technological strain that can be clearly detected in the book that he wrote on American railroads and even more his textbook on mechanics, based on the lectures of his father.[78] His published work, not only included his Austrian experience and his investigations of British railway accomplishments, but also employed lessons learned from his construction of Russia's first railroad. While primarily concerned with the technological aspects of railroading in Europe and the United States, he also made careful observations of economic factors.

[76] D.S.L. Cardwell, "Power Technologies and the Advance of Science, 1700-1825," *Technology and Culture* 6 (1965), p. 205.

[77] Inkster, "Introduction."

[78] Franz Anton Ritter von Gerstner, *Die inneren Communicationen der Vereinigten Staaten von Nord-Amerika* (Wien 1842-1843); Gerstner, *Handbuch*.

The story of this horse-drawn railroad does not provide anywhere near enough evidence for an estimate of its measurable effect on the Bohemian, let alone the Habsburg, economy. It serves, however, as an impressionistic view of the Monarchy's economic development potential. One cannot help but make comparisons with Germany. By the end of the nineteenth century a united Germany had become unquestionably one of the economic giants of the world. At the beginning of the century the impression seems warranted that the Habsburg Monarchy held its own in comparison with Germany. What may have accounted for the sharply divergent courses in economic growth that the two countries took in the course of the nineteenth century? One possibility in explaining this phenomenon exists in the different economic histories of the two countries. Even more to the point, one ought to look at regions within countries, as Sidney Pollard has insisted not so long ago.[79] For purposes of this essay this would mean that Bohemia, Upper Austria and other western parts of the Austrian Empire should be considered. A momentum for economic growth and technological innovation is clearly discernible there. Eventually it is very likely that the more backward parts of the empire proved to be a serious retarding factor.

Germany, too, can be analyzed in a similar way. Rather than stressing Prussia's forceful policies and the benefits of a unified empire as a result of Bismarck's machinations, I would prefer the explanation suggested by the German economic historian Max Barkhausen some forty years ago.[80] By stressing the strength of the private sector in the Rhineland and Westphalia, in part the result of

[79] Sidney Pollard, *Region and Industrialisierung* (Göttingen 1980), p. 12.

[80] Max Barkhausen, "Der Aufstieg der rheinischen Industrie im 18. Jahrhundert und die Entstehung eines industriellen Grossbürgertums," *Rheinische Vierteljahresblätter* 19(1954), pp. 135-177; idem., "Staatliche Wirtschaftslenkung und freies Unternehmertum im westdeutschen und im nord-und südniederländischen Raum bei der Entstehung der neuzeitlichen Industrie im 18. Jahrhundert," *Vierteljahrschrift für Sozial-und Wirtschaftsgeschichte* 45(1958), pp. 168-241. See also Jürgen Reulecke, " Nachzügler und Pioneer zugleich: das Bergische Land und der Beginn der Industrialisierung in Deutschland," in *Region und Industrialisierung*, edited by Sidney Pollard, pp. 52-68.

weak political principalities, he emphasized the benefits of a relatively free, competitive economy that had existed for many centuries. He also pointed to that area's strong association with the economies of Belgium and the Netherlands. In this way the west German economy had enjoyed a long period of sophisticated economic relationships during which the economic and political institutions had had a chance to produce a benevolent environment. The old Prussia was backward in comparison but it obviously proved to be less of a drag on the economy of the whole state and eventually of the whole of Germany than the Hungarian, Croatian and Galician sections did on the economy of the Habsburg Monarchy.

There was clearly a scientific approach to technology abroad in eighteenth-century Germany including the western parts of the Habsburg Monarchy, as is indicated in a response to a prize competition announced by the British Academy of Science in Göttingen in 1754:[81] "The improvements of the natural sciences belong to the finest efforts of humanity. They are even more important when one wishes to analyze the craftman's knowledge in order to improve the wellbeing of people, although it is rare to find people who are capable to treat the crafts scientifically (*scientisch*). I and, I am sure, other owners of iron works wish profoundly that this would happen. Those who concede to me that not every chemist (*Chymicus*) is a consummate expert in mineralogy, mechanics and hydraulics, disciplines that are absolutely necessary to solve these problems, will nevertheless agree that observation and experiment must provide the base along with the sciences."

While the episode of the horse-drawn railroad here related shows without question that potent economic actors were allied with technological and scientific trends, it may also indicate that the required entrepreneurial talent did not exist in sufficient depth in

[81] Anon., "Beantwortung der von der Königl. Grossbritanischen Gesellschaft der Wissenschaften zu Göttingen im Jahre 1754 vorgelegten Fragen," in *Neue Sammlung verschiedener in die Cameralwissenschaften einschlagender Abhandlungen und Urkunden*, edited by Daniel Gottfried Schreber, (Bützow & Wismar 1762), I, pp. 5-15.

the Austrian Empire. The two Gerstners were indeed enterprising and far-sighted people but they were not good entrepreneurs in an economic sense. Similarly, the aristocrats who were associated with this project were well-meaning but one cannot escape the suspicion that they were dilettantes to a considerable degree. The third group prominently associated with this project were private bankers in Vienna. Possibly there were too few of them to create a permanent cadre of creative entrepreneurs. Unquestionably, Solomon Rothschild can be grouped among the great entrepreneurs anywhere in the world. A minor shareholder in the Linz-Budweis railway company, he became in the decades following its creation a great railroad builder and the owner of one of the technologically most advanced iron works in the Habsburg Monarchy. There were other personages who without doubt deserve to be mentioned with progressive industrialists and bankers elsewhere in Europe. It was thanks to them that the Austrian Empire did, in fact, register considerable economic growth by the end of the nineteenth century. One is nevertheless left with the bothersome question why its seemingly great potential at the beginning of the century was not realized by the end. A contributing factor may have been that the human capital in entrepreneurship, technology and workmanship in the Habsburg Monarchy was not yet sufficiently seasoned for a serious forward thrust of its economy. Unquestionably there were many other factors, including intellectual life, political and diplomatic goals, that contributed to the slow growth and development of the Austrian economy but they cannot be discussed at this point.