Portuguese Railway History and Kranzberg's Laws: looking at the past, preparing the future

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Abstract

In 1985, Melvin Kranzberg summarised his work around the relevance of context and human agency for technological development in six general principles that later became known as Kranzberg's Laws. His reflections became very important and useful for the communities of historians and philosophers of technology, in the sense that they analyse critically the nature of technological systems and artefacts, their historical influence in society, and the entangled relationship between technologists, users, and the sociocultural contexts that surrounds them. In this chapter, I use Kranzberg's Laws to analyse the historical evolution of the Portuguese railway system, since its inception in the 1850s to the current challenges faced by Portuguese policymakers. I offer that Kranzberg's teachings are crucial to illustrate how the construction of railways in Portugal was a very much human activity, which contributes not only to understand the past but also to face current challenges and problems.

Introduction

In 1985, Melvin Kranzberg presented his presidential address to the audience of the Society for the History of Technology gathered in Dearborn, Michigan. In his lecture, he spoke of his thirty-year work on the significance of human agency in the history of technology and the relevance of the contextual approach in understanding technical developments. Throughout the years, his reflections took the form of six general principles – truisms, as he calls them – that eventually became known as Kranzberg's Laws (Kranzberg 1986). His reflections resonate closely with Philosophy of Technology, as they also offer a critical analysis of the nature of technology, its impacts in human societies, and the interactions between

technologists and the sociocultural contexts they operate in (Aslaksen, 2017, p. 119; Baskoy, 2018, p. 139).

Kranzberg's six principles or laws underscore the importance of human intervention in the technological development, the need to include context (geographical, chronological, sociocultural) in the evaluation of technological efficacy, the drive for constant innovation imposed by technology, the ramifications of technology in other subsidiary systems, and the importance of History of Technology not only to understand technological development and to teach History more compellingly, but also to address present-day technological challenges, by offering its analysis of the experience of the past.

The relevance of Kranzberg's work for the field of History and Philosophy of Technology is certified by the number of times they were used in academic debate: according with Scopus, Kranzberg's seminal work was cited 243 times, between 1988 and 2021.[1] What is more, his Laws were tested and confirmed by different authors. Thomas Parker Hughes illustrated the continuous technological adaptation and innovation in electric systems (what he called the reverse salient) and how they require other technical systems to operate efficiently (Hughes 1983, 1998). The implications of the sociocultural context in technology have been persuasively demonstrated by Wiebe Bijker and John Law, who claim the existence of a seamless web weaved out of social and technical aspects (Bijker and Law 1992). Another metaphor that emphasises the sociotechnical complexity of technology is that proposed by Bruno Latour, who argues that between the inputs necessary to make technology work and the outputs or results of that technology lies a black box, which needs to be opened to understand technology's sociotechnical complexity (Latour 1999, pp. 304–306). Greet de Block (2011) and myself (Pereira 2020) added to Kranzberg's Fourth Law, by underscoring the relevance of utopia in the planification of large transportation systems, in the Belgian and Portuguese contexts, respectively. Focusing on users, Nelly Oudshoorn and Trevor Pinch illustrate their importance and role in the co-construction of technology (Oudshoorn and Pinch 2005). Andreas Fickers took inspiration from Kranzberg's First Law to maintain that technologies related with media, which are usually considered as 'good', may have dire consequences on society (Fickers 2014). Paula Diogo and Ana Simões advocated the importance of History and Philosophy of Technology to face the current challenges posed by the Anthropocene, using Kranzberg's teachings (Diogo and Simões 2016). Finally,

[1] According to the data calculated by www.scopus.com.

Kranzberg's teachings also inspired debates on Philosophy and Ethics of Engineering, as this article of Carl Mitcham (2009) clearly illustrates.

In this essay, I analyse the historical evolution of the Portuguese railway sector using the framework provided by Kranzberg's Laws. The inception of the Portuguese railway sector goes back to mid nineteenth century when the first contracts were signed (1845) and the first track was inaugurated (1856). In the following decades, the network grew to reach a maximum extension of 3,616 km in 1982, using different technologies (e. g. narrow gauge and broad gauge), accomplishing different goals, and appeasing different technical, economic, political, and social actors. In the late 1980s, the network's extension diminished considerably, as many low-traffic lines closed being replaced by motorways (Isidoro et al. 2017). Currently, Portuguese policymakers debate the reopening of lines and the construction of high-speed tracks that connect Portugal to the European high-speed network.

I propose a twofold approach to my analysis, including what we know about the history of Portuguese railways, and how may this knowledge be used today in teaching and policymaking. The structure of the text is divided in five sections, following Kranzberg's Laws.

Railways are not bad, nor good, nor neutral

Kranzberg's First Law claims that technology is neither good, nor bad, nor is it neutral. With this, Kranzberg meant that the application of a given technology in a certain social ecology may have unforeseen or different consequences from those touted by its promoters, depending on the social, economic, and/or political context (Kranzberg 1986, p. 545–546).

The implementation of railways in Europe's core nations since the 1820s brought about economic and financial consequences that countries from the European periphery sought to emulate. In Portugal, technocrats and policymakers shared a very simplistic view of the process: build railways and economic development would follow, especially through those towards the border (Pereira 2020). However, context in the periphery and in the centre of Europe was very different. Countries like Britain, France, Germany, or Belgium had stable trade routes that railways enhanced; they had strong banking systems and industries that supported and benefitted from railway construction; they had large cities and modern seaports. Peripheral countries like Portugal lacked many of these features. Mobility was restricted, unsafe, and expensive due to the lack of roads; the banking system was underdeveloped and heavy industry non-existent; population was scarce and centred in two

cities (Porto and Lisbon), where the main ports needed substantial improvements. What is more, Spain was not interested in increasing cross-border traffic with Portugal (Alegria 1990, pp. 31–94).

Consequently, the operational results were far from expected, and the investment became an unexpected financial burden to the Portuguese treasury, increased Portugal's dependence on foreign agents, and diverted resources from other sectors of the economy (Pinheiro 1986). In demographic terms, railways increased the migration of the Portuguese population in the countryside to the coastline, instead of developing local and regional economies of the inner peripheral territories (Silveira et al. 2011). Likely, something similar happened with industry that concentrated mostly in the coast.

If one looks beyond the economic and financial aspects of the investment, railways had other more advantageous consequences for the nation. A steady flow of technical knowledge from the European core was created by foreign engineers who came to work in Portugal and by Portuguese engineers that enhanced their expertise while studying abroad; it placed Portugal in global fluxes of trade, commerce, and finance; it approximated the peripheral provinces from the main cities in the coast (especially the capital-city Lisbon) by replacing the old stagecoaches and oxcarts by trains; it inaugurated a faster access point to northern and central Europe, and its cities, culture, and landscape (Pereira 2021a); eventually, it even supported an industrial surge in the first half of the twentieth century (Santos 2011).

The example of the Portuguese railway network illustrates well Kranzberg's First Law and underscores the necessity of understanding the changing social context and evaluating both the short-range (the great expectations created by technologists) but also the long-range impacts of technology (the results of its implementation). This is valid not only for historical analysis, but also for present-day discussions about technology. As I write this text, the Portuguese government is again debating the reopening of closed lines and the construction of high-speed railways towards the European networks. It is important to include in the discussion sociocultural features that will affect the operation of high-speed trains (e.g.: how will mayors of those municipalities traversed by the lines react to the possibility of trains not stopping and not serving their constituencies? Will high-speed trains increase the gap between the coast and inner regions of Portugal? How will the Portuguese, used to flying, turn to a slower and predictably more expensive means of transportation?). What is more, it is important to emphasise that, like in the past, the short-run benefits will be a small comfort for present generations who will have to pay the investment; but a long-run perspective can

illustrate the future advantages in terms of sustainability, cleaner long-distance mobility, and more efficient freight transportation.

Railways induce and require innovations

In this section I merge Kranzberg's Second and Third Laws to demonstrate how the implementation of railways in Portugal was closely associated with different innovations needed to make railways work properly. In his Second Law, Kranzberg argues that invention is the mother of necessity, that technical innovations require additional advances to be fully effective; whereas his Third Law claims that any technology involves different systems and components without which it could not function suitably (Kranzberg 1986, pp. 548–550).

Portuguese railways provide a good stage to study the application of these laws. When the implementation of railways in Portugal, an absence of different components (or packages to use the expression of Kranzberg) was noticeable.

One of those packages was roads. In the 1850s, the road network was practically non-existent. Railways were being laid down in different parts of the territory, but without roads to feed the stations with traffic, their operation was insignificant, as were the benefits to the population. In 1890, MP Pinto Moreira poetically regretted how his electors "see, every day, more than once, shouting with joy, that immense machine of progress [the locomotive hauling a train] that hails them, and at the same time they acknowledge that they are condemned to a true Tantalian punishment, for they cannot use that conquest of science and human ingenuity".[2] This was a complaint shared by railway companies, who blamed the lack of roads for their disappointing operational figures. This forced a change in the strategy set out for the road network. Instead of a grid that covered the territory evenly, roads concentrated around rail tracks, leaving some areas without railways or roads (Alegria 1990, pp. 121–122, 334–335) – thus promoting an uneven development of the territory, a shortcoming that was not anticipated by any policymaker. In the twentieth century, especially in its second half, the relationship between road and railway changed. As the road network grew and automobility became widespread, users preferred them to the train. Cars and lorries were more comfortable, cheaper, and more flexible than trains – as importantly, they were the new token of progress (Sousa 2016, pp. 29, 154, 235, 457). Some railways no longer could maintain their vitality – to borrow an expression from Philosophy of Technology (Wang and

[2] Diario da Camara dos Deputados, May 21 1890, p. 345.

Li, 2018, p. 117). In the late 1980s, the government implemented an extensive programme of closure of low-traffic lines (particularly narrow-gauged), replaced by motorways. This illustrates what Kranzberg (1986, p. 549) calls a technological imbalance – those situations in which an improvement in one system causes unbalance and motivates innovation to re-establish equilibrium. The following paragraphs illustrate other examples of this phenomenon.

Another innovation motivated by railways was the construction of modern ports. The main goal of building railways was to turn Portugal into a relay platform between Europe and the transatlantic continents. However, most Portuguese harbours lacked basic infrastructures. Therefore, as soon as the main transnational lines were nearing the border with Spain, in the 1880s, different improvements were planned for the seaports of the main cities of Porto and Lisbon (in the former case a new infrastructure was built from scratch, while in the latter the existing harbour benefited from several enhancements). Throughout the twentieth century, other seaports were also improved or linked to the railway network (Prata 2011).

The best example of an innovation brought about by railways was arguably narrow-gauge lines. Portuguese railways used a gauge (distance between rails) of 1.67 m, which rendered construction in the hilliest areas difficult. Considering that these were also poor areas, laying down a *regular* line was not justifiable. To solve this problem, a few Portuguese engineers went abroad in 1870s to study narrow-gauge railways. This technology allowed the construction of narrower curves and steeper inclines and therefore permitted circumventing the most sizeable landforms and avoiding the building of expensive engineering works. Between the 1870s and the 1940s, the narrow-gauge network grew to an extension of 765 km (21 percent of the entire network) and accounted for around 15 percent of overall traffic. These lines required further innovation, but they benefited from very little modernization efforts, soon became obsolete, and most were terminated (Pereira 2021b).

Finally, I would like to underscore the innovations in industry and technical knowledge brought about by railways. When construction began in the 1850s, there was no expertise to manufacture railway components, therefore, every utensil, pieces of permanent way, and rolling stock had to be imported. Throughout the nineteenth century, Portuguese labourers acquired different skills to manufacture assorted utensils (splints, fishplates, treenails), wagons, and coaches, and in the twentieth century, the production of locomotives was initiated (Oliveira 2010; Pinheiro 1988, pp. 751–752).

Kranzberg (1986, p. 549) stresses the agency of the “original invention” (in this case, railways) in the mothering of necessity and subsequent innovation, although it can be argued

that each improvement was motivated by a specific need. Something similar may be said about the Portuguese railway sector. The investment in roads (and the reconfiguration of the network), in ports, and in narrow-gauge was directly driven by a previous investment in railways, even though each of them was set to respond to a specific need. This also supports Kranzberg's (1986, p. 550) claim that a technical system cannot be studied alone; it must be analysed in its interrelations with other systems that compose or interact with it. This also includes the social, political, economic, and cultural *systems* or contexts.

Opening the black box

The last reflection of the previous paragraph brings me to Kranzberg's (1986, p. 550) Fourth Law that states that technology may be a key factor in policymaking, but often nontechnical elements take priority in decision-making about technology. This thought resonates with the sociotechnical construction approach and with the translational approach offered by Philosophy of Technology that wanders from the reflection on design, implementation, and operation of technology to the social and cultural motivated choices regarding technical systems or artefacts (Fritzsche and Oks, 2018, p. 4; Zhang, 2017). I recently analysed the application of this law to policymaking in the Portuguese railway sector in the nineteenth century (Pereira 2020). This section builds upon that article and adds further discussion about decision-making in the twentieth and twenty-first centuries.

The main argument of Kranzberg's Fourth Law is that varied sociocultural factors are involved in what appear to be purely technical decisions (Kranzberg 1986, p. 551). In my article in the *Journal of Transport History*, I illustrated the consensus between technologists and non-technologists regarding the utopia of using railways to turn Lisbon into a relay platform between the Old and the New Worlds. Additionally, I showed that in other questions regarding policymaking, financing, construction, and operation in the railway sector, seldom there was an accord between the engineering class, which was due not only to technical disagreements but also for personal motivations of the engineers (namely their employment status, their political allegiance, their own pecuniary interests, or the will to benefit their hometown with a rail line). When eventually they agreed upon a plan for the configuration of the network, their suggestions were overridden by the government, as policymakers seated therein and in parliament were forced to weigh in other nontechnical factors. The most important was arguably the power of private investors. As Portugal lacked financial resources to undertake construction, it had to rely on the financial influence of more or less shady

investors, who had a substantial weight on the decision of which lines to build. What is more, the inaccurate perceptions about the geography and economy of the kingdom (considering the lack of trustworthy statistical and topographical data) played an important role in the laying down of the grid, as stakeholders directed railways to those areas believed to hold more agricultural or industrial production or to be flatter (hence, less expensive to build a railway). Moreover, politicians at regional or local level lobbied for railways on their constituencies or areas of influence; policymakers in the government often bargained with those local rulers to extend the power of the central state to the peripheries. Finally, concerns about the defence of the kingdom also played a part in the configuration of the network, although, for the most part, the advice of the military was dismissed. By 1900, the network included its main branches, but it was different from that proposed by engineers, evincing the effect of nontechnical inputs on its construction and the web of interactions between a diverse array of social actors and institutions (cf. Fickers 2014, p. 31).

The performance of the Portuguese railway sector in the twentieth century is not as well studied as in the previous century, but a few instances when Kranzberg's Fourth Law may be applied are well known. For instance, the preference for the investment in motorways and automobility, starting in the 1930s, was supported by younger generations of engineers, but it was also influenced by sociocultural factors. One of them was politically motivated. The 1930s witnessed the ascension of a right-wing dictatorship in Portugal. Considering that the railway workforce was highly unionised, to invest in a rival transportation system was a form to erode the power of railwaymen. Furthermore, as I mentioned above, by that time there was a change in the understanding of the notion of progress, which no longer favoured trains, but preferred the individuality of cars and the flexibility of motorways. This notion of modernity was shared by stakeholders after the transition to democracy, which justified further investment in motorways and the closure of low-traffic lines, as I explained before. Kranzberg's Fourth Law is also visible in the decision-making process regarding high-speed trains, which took place in the mid-2000s. There were valid technical grounds for the investment, but it was postponed for political bickering in the parliament. A few years later, the European debt crisis prevented any large-scale spending in railway building. Recently, this discussion was resumed, accompanied by a debate of reopening closed lines, or building new ones. Again, there are technical grounds in favour of these proposals, but a nontechnical concern – the development of a more environment-friendly transportation system – is perhaps more important in the debate.

Learning from History

In his address to the SHOT audience, Kranzberg (1986, p. 553-554) claimed that History of Technology was the most relevant field in History – this was his Fifth Law. He argued this importance was visible in teaching History, considering that classes that ignore the technological element leads to students failing to see the relevance of History to their present and future. Additionally, in view of the naturalisation and familiarity of technology since the eighteenth century, today's alumni know they live in a technological age, therefore, History courses should include the technological factor to assist them to grasp how their world came into being (see also Diogo and Simões 2016, 1). Philosophers of technology also advocate for non-technical education in technological degrees to enhance future technologists' skills to engage with other areas and human communities (Moloney, Badenhorst, and Rosales, 2018, p. 202-203; Zhang, 2017, p. 135).

For the goals of this paper, I am more interested in the capability of History of Technology to shed light on assorted parameters of past technological conundrums. The knowledge it provides about how past technical problems were overcome help to face and recast contemporary challenges. Moreover, History of Technology offers the historical feedback about an important facet of technological development, that is, the transfer of technology, which is still useful today. In the same respect, it helps to relativise and put into context periods of technophobia/technological pessimism and technophilia/technological optimism, warning about the dangers of regarding technology as something good, bad, or neutral – which brings us full circle to Kranzberg First Law (Kranzberg 1986, p. 556; Diogo and Simões 2016, pp. 2 and 6).

Applying these reflections on the railway sector, it is important to highlight that – as transportation experts, Colin Divall, Julian Hine, and Colin Pooley, argue – transportation technologies that we utilise today, like railways, are astonishingly constant; notwithstanding the significant technical enhancements and innovations they benefited from in the past centuries, they have essentially remained the same, offering the same services. Railways, for instance, continue performing the same job of transporting people and goods from one place to the other, as they did since the 1820s. The main difference is that they do it faster, more comfortably, and carrying more load, using different materials and fuels. Consequently, in varied instances, a better understanding of pasts decisions (and contexts where they were taken) can lead to more efficient policymaking in transport planning. This demands that policy makers know the past better and that historians portray the past in a useful way for

present decisionmakers (Divall et al. 2016, pp. 1–2). This approach should have a transnational perspective, including the past experiences of other countries and the problems their railway sectors faced and how were they solved.

Such a proposal may be very useful to tackle the main challenges faced by the Portuguese railway sector presently, mainly, the investment in high-speed trains, which has been resumed recently. History of Technology offers and overarching methodological umbrella that permits to understand the sociotechnical complexity of large technical systems, underscoring the interconnections between technical and nontechnical factors (including the agency of engineers, entrepreneurs, decisionmakers, lobbyists, users). This leads to a thorough knowledge of past challenges, including the operation and financing of the system, the decision regarding the railway routes, the competition with other transport systems, the role of the state, the negotiations with Spain regarding cross-border rail links,[3] the impact on cities served by train stations, or railways impact on the establishment of global fluxes from and to Portugal.

I mentioned the case of high-speed trains because it is currently the most pressing matter in railway transport planning in Portugal. But the knowledge provided by railway studies using the lens of History of Technology can be used to deal with other problems, for instance, the reutilization of abandoned infrastructures or material. History has shown how some railways contributed to the integration of the peripheries, but its original route became obsolete, or how some rolling stock was very successful amongst users. This knowledge can support the planning of new lines with a more competitive direction, or the recovery of rolling stock abandoned years ago. In the matter of railway tourism, it is known that railway enthusiasts privilege the genuineness and authenticity of recovered stations, sheds, or trains, and – again – History of Technology can provide an unvaluable input providing accurate and all-embracing data not only about the railway technology itself, but also the sociotechnical environment that surrounded it.

[3] In the nineteenth century, transnational railways between Portugal and Spain did not carry enough traffic to justify the investment. This occurred because Spain was not interested in using railways to promote international trade, and, more importantly, it preferred to use its network to serve its harbours instead of those in Portugal (Pereira 2017, pp. 186-189). In the 2020s, it is legitimate to wonder to what extent Madrid will not try to promote traffic towards its own ports, rather than the Portuguese border, even if considering the substantially different political and international context. History may advise diplomats and stakeholders as to not repeat past experiences with cross-border lines.

These are just some possible scenarios where History of Technology may help policymakers in improving the Portuguese railway sector, and improve it to be more sustainable, resilient, inclusive, innovative, and sustainable, as recommended by one of the United Nations' sustainable development goals for the decade.

Conclusion: the human agency in Portuguese railways

Kranzberg's final Law sums up his previous Laws, stressing the predominance of human agency in the development, implementation, innovation, utilisation, and contestation of technological systems, and in the writing and telling of its history (Kranzberg 1986, pp. 557–559). Obviously, that human prevalence is also present and clearly visible in the history of Portuguese railways since the first voyage in 1856 to present-day discussions about the construction of new lines, including those prepared for high-speed trains.

This paper illustrates this, by iterating through Kranzberg's Laws, applying them to the case of Portuguese railways in the long run (over a century and a half). I show how the discussion, construction, and operation of the network was determined to a high degree by nontechnical factors, ranging from utopian beliefs about the impact railways would have on the Portuguese economy and society, to financial dependency, political lobbying, and personal agendas. The innovation undertaken in the railway sector and its coordination (or competition) with other associated systems can also be explained by the predominance of human factors. Originally, the road network supposedly should cover the territory evenly, but it was developed more thoroughly round railway lines, due to the lobbying of locals and of private companies. Something similar may be said about the research and implementation of narrow-gauge lines that met the demands of peripheral territories and their leaders for modern transportation systems and provided engineers with more job opportunities in the most modern and impactful transportation sector of the time. Nevertheless, the technical factor also played a relevant role, visible in the projects to build ports that served as outlets for the expected transnational traffic carried in cross-border rail links.

The human factor is also very much present in the appraisal of the historical impact of technology. In Portuguese railway history, some stress the dire impact it had on the national finances or the uneven regional development they brought about, benefiting those regions that had access to railway stations at the expense of those without railways. Other researchers highlighted the positive impact in the circulation and transfer of technical and nontechnical knowledge, or the inclusion of Portugal in global flows of trade, commerce, and finance.

Additionally, those histories written by railway enthusiasts are often very laudatory of the role played by the network in the development of the country. Kranzberg stresses the need to look at the whole picture and understand that one technology may consummate (or even exceed) the expectations created by its touters, but it can also bring about unexpected and undesirable consequences. In either case, technology is by no means neutral. The case of Portuguese railways in the long run illustrates this truism perfectly. By doing so, the study of its historical evolution, using the lens of History of Technology, contributes to restrict the alluring temptation of both technophobia and technophilia, by showing that it had positive and negative consequences. Furthermore, it illustrates how some past challenges (that might reoccur in the future) were managed, and how some past mistakes or poor strategies may be averted in present policymaking. In a time, when Portugal seeks again to invest in the railway sector, the arguments provided by History of Technology are invaluable and should be included in the debate between policymakers, stakeholders, and future users.

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