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ORIGINAL ARTICLE

Engineering Value: The Transandine Railway and the 'Techno-Capital' State in Chile at the End of the Nineteenth Century

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Abstract

By the end of the nineteenth century, railway expansion had led to the formation of a technocratic bureaucracy in Chile and other countries in Latin America. Central to this formation were the engineers who oversaw and regulated both public and private railways. Recently, historians have begun to re-examine engineers' roles in this period. By employing methods and theoretical framings from the history of technology, this article argues that engineering was an important framework through which state–capital relations evolved, making engineers pivotal actors in the evolution of political economy at the time.

Keywords: Transandine railway; engineers; technology; value; political economy; state formation; capitalism

Introduction

The Transandine railway's construction, taking place between 1887 and 1910 to connect Argentina and Chile across the Andes mountains, was an example of the emerging connections between the development of finance capitalism and the consolidation of the nation-state in Latin America in the late nineteenth century.[1] These connections, as this article will argue, largely relied on engineers and engineering. In the years 1880–1910, approximately 70,000 kilometres of railway track were built (81 per cent of total railway track up to 1910 and 57 per cent by 1930).[2] These railways, along with other infrastructure projects, necessitated the growth of state bureaucracies, massive amounts of capital investment, and technical labour, often in the form of engineering. While the Transandine was exceptional in respect of its engineering requirements as a mountain-crossing railway, it was typical as a project that brought together states, capital and engineering. In this article,

[1]For the Transandine, broadly: Pablo Lacoste, *El Ferrocarril Trasandino 1872–1984: Un siglo de ideas, política y transporte en el sur de América* (Santiago: Centro de Investigaciones Diego Barros Arana, 2000).

[2]Sandra Kuntz Ficker (ed.), *Historia mínima de la expansión ferroviaria en América Latina* (Mexico City: El Colegio de México, 2015), pp. 345–53.

I use the case of the Chilean section of the Transandine railway to examine the role of engineers and engineering in the transformation of state–capital relationships at the time.

By the end of the nineteenth century, massive infrastructure projects, such as the Transandine, had fostered changes in state–capital relationships in Latin America, namely the emerging connections between liberal nation-states and financial capital. Starting in the middle of the nineteenth century, emerging liberal nation-states began to tie their power and stability to railway construction.[3] Those projects, of course, required substantial amounts of capital, which in large part came from growing concentrations of it in financial centres, such as London and Paris.[4] Bearers of those growing concentrations of capital needed to find places of, and mechanisms for, secure investment.[5] The development of infrastructure projects provided capitalists with investment opportunities whether through direct investment in private construction or via state loans, which were often destined to support railways and other infrastructure projects.[6] Therefore, in the course of the second half of the nineteenth century, the railway concretised these emerging connections between liberal nation-states in Latin America and global financial capital. Important to the simultaneous rise of the liberal nation as the primary state form and finance as the dominant form of capital in Latin America were the engineers who managed these projects.

Globally, in the nineteenth century, engineering emerged as an essential modern profession.[7] In Latin America, as 'liberal' reforms in the latter half of the century encouraged greater technical training and massive infrastructure projects became

[3]For the growth and impact of railways in the region: William R. Summerhill, *Order Against Progress: Government, Foreign Investment, and Railroads in Brazil, 1854–1913* (Stanford, CA: Stanford University Press, 2003); Ian Thomson, *Historia del ferrocarril en Chile* (Santiago: DIBAM, Centro de Investigaciones Diego Barros Arana, 1997); Colin Lewis, *British Railways in Argentina 1857–1914* (London: Athlone Press, 1983); John H. Coatsworth, *Growth against Development: The Economic Impact of Railroads in Porfirian Mexico* (DeKalb, IL: Northern Illinois University Press, 1981).

[4]Particular railway-growth models varied by country and changed over time. For a review of these models: Colin M. Lewis, 'The Financing of Railway Development in Latin America, 1850–1914', *Ibero-amerikanisches Archiv*, 9: 3/4 (1983), pp. 255–78. For capital exports at the time: Youssef Cassis, *Capitals of Capital: A History of International Financial Centres, 1780–2005*, trans. Jacqueline Collier (New York: Cambridge University Press, 2006), pp. 41–61, 78–80.

[5]The 'surplus-capital disposal problem', as articulated by David Harvey, has been helpful for me in framing these relationships theoretically. See David Harvey, 'The Right to the City', *New Left Review*, 53 (Sept.–Oct. 2008), pp. 24–6.

[6]For foreign debt in the region and infrastructure projects at the time: Carlos Marichal, *A Century of Debt Crises in Latin America: From Independence to the Great Depression, 1820–1930* (Princeton, NJ: Princeton University Press, 1989), pp. 70, 129–30.

[7]Tom F. Peters, *Building the Nineteenth Century* (Cambridge, MA: MIT Press, 1996); Eda Kranakis, *Constructing a Bridge: An Exploration of Engineering Culture, Design, and Research in Nineteenth-Century France and America* (Cambridge, MA: MIT Press, 1997). For a sample of important texts in engineering studies, see Gary L. Downey, Arthur Donovan and Timothy J. Elliot, 'The Invisible Engineer: How Engineering Ceased to Be a Problem in Science and Technology Studies', in Lowell Hargens, Robert Alun Jones and Andrew Pickering, *Knowledge and Society: Studies in the Sociology of Culture Past and Present*, vol. 8 (Greenwich, CT: JAI Press, 1989), pp. 189–216; Gary Lee Downey, 'What is Engineering Studies For? Dominant Practices and Scalable Scholarship', *Engineering Studies*, 1: 1 (2009), pp. 55–76; Peter Meiksins and Chris Smith, *Engineering Labour: Technical Workers in Comparative Perspective* (New York: Verso, 1996).

central for Latin American states, engineering became increasingly important to the growth and character of the state, including to the construction of national identity and state bureaucracy.[8] Important for this article, engineers provided oversight for private projects, approved public works contracts and occupied key posts in an ever-expanding public works bureaucracy, which accounted for an increasingly large part of state expenditures (roughly 25 per cent in Chile in 1888, the first year of the Ministry of Industry and Public Works).[9] As the day-to-day overseers of substantial portions of state finances, engineers were central figures in the construction of an apparently autonomous 'techno-political' state, a state that neutralised and legitimised its political decisions through the supposedly non-political character of engineering and other technical and scientific professions.[10]

While works on technocracy and techno-politics often have been used to understand the appearance of an autonomous state and the development of a distinct state logic, these concepts could equally be deployed for understanding state–capital relations.[11] Rather than being external to one another, state and capital unfolded together dialectically, with engineering serving as a common framework through which that historical dialectic progressed. Indeed, by the turn of the century, engineering had become the 'accepted language of the day' for both the state and

[8]Diego Barría Traverso, 'Rasgos burocráticos en las reformas administrativas en el Chile de la década de 1880', *Historia Crítica*, 56 (April.–June 2015), p. 75; Guillermo Guajardo Soto, 'Obras públicas y negocios en la conformación de la tecnocracia de Chile durante la primera globalización, 1850–1914', *H-industri@*, 9: 16 (2015), pp. 67–78; Elena Salerno, 'Los ingenieros, la tecnocracia de los Ferrocarriles del Estado', *H-industri@*, 9: 16 (2015), pp. 13–34; Guillermo Guajardo Soto, *Trabajo y tecnología en los ferrocarriles de México: Una visión histórica, 1850–1950* (Mexico City: Consejo Nacional para la Cultura y las Artes, 2010); Juan C. Lucena, 'Imagining Nation, Envisioning Progress: Emperor, Agricultural Elites, and Imperial Ministers in Search of Engineers in 19th Century Brazil', *Engineering Studies*, 1: 3 (2009), pp. 191–216; Andrés Valderrama, Juan Camargo, Idelman Mejía, Antonio Mejía, Ernesto Lleras and Antonio García, 'Engineering Education and the Identities of Engineers in Colombia, 1887–1972', *Technology and Culture*, 50: 4 (2009), pp. 814–18; Guillermo Guajardo Soto, *Tecnología, estado y ferrocarriles en Chile, 1850–1950* (Mexico City: Universidad Nacional Autónoma de México, 2007); Juan C. Lucena, 'De Criollos a Mexicanos: Engineers' Identity and the Construction of Mexico', *History and Technology*, 23: 3 (2007), pp. 275–88; Silvana Palermo, 'Elite técnica y estado liberal: La creación de una administración moderna en los Ferrocarriles del Estado (1870–1910)', *Estudios Sociales*, 30: 1 (2006), pp. 9–41; Frank Safford, *The Ideal of the Practical: Colombia's Struggle to Form a Technical Elite* (Austin, TX: University of Texas Press, 1976); Warren Winfield Crowther, 'Technological Change as Political Choice: The Civil Engineers and the Modernization of the Chilean State Railways', unpubl. PhD diss., University of California, Berkeley, 1973. Works on state-building and engineering in other contexts have been important for my work. See Chandra Mukerji, *Impossible Engineering: Technology and Territoriality on the Canal du Midi* (Princeton, NJ: Princeton University Press, 2009); Patrick Carroll, *Science, Culture, and State Formation* (Berkeley, CA: University of California Press, 2006).

[9]Legación de Chile, *Resumen de la hacienda pública de Chile desde 1833 hasta 1914/Summary of the Finances of Chile from 1833 to 1914* (London: Spottiswoode and Co., 1914), pp. 48–9.

[10]Timothy Mitchell, *Rule of Experts: Egypt, Techno-Politics, Modernity* (Berkeley, CA: University of California Press, 2002), pp. 42–3. For an alternative definition of 'techno-politics', see Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity After World War II* (Cambridge, MA: MIT Press, 1998), p. 15; Eden Medina, *Cybernetic Revolutionaries: Technology and Politics in Allende's Chile* (Cambridge, MA: MIT Press, 2011), p. 244, fn. 12.

[11]For a key, albeit now controversial, work on this state logic, see James C. Scott, *Seeing like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven, CT: Yale University Press, 1998).

capital.[12] As native speakers of this lingua franca, engineers served as conduits between the two. As intermediaries, engineers translated the particularities of infrastructure projects, from technical details to their useful value to society, into the general monetary terms required for state and capital to interact. In turn, they provided the state with a sense of stability and certainty in projecting itself into the future. In this way, engineering constituted a pillar of what I will be calling throughout this article the 'techno-capital' state in Latin America, one characterised by its relationship to capital in increasingly technical and scientific terms.[13] This techno-capital state made engineers important political economic actors, and engineering the framework through which political economic concerns were addressed.

Despite the importance of engineers in the history of some of the most pressing political economic concerns of late-nineteenth-century Latin America (railways and infrastructure projects), often historians have not considered them to be central political economic actors in this period.[14] When engineers have become fundamental to histories of state–capital developments, historians have often understood them as interested actors whose centrality in state bureaucracies or capitalist enterprise was important to the development of dependency relationships or to national industrial development.[15] My aim is not to undermine the truth of those claims, but rather to bracket the question of engineers as interested actors with specific sociological backgrounds in favour of how engineering functioned as a distinct technology of political economy in the development of the techno-capital state.

To elucidate the importance of engineering to state–capital relationships, I analyse the case of the Chilean Transandine's early years of construction (1887–93). Despite being a period of little material construction, it was important in revealing how state engineers attempted to assess this technically complicated project and business interests attempted to make money from its construction, and how

[12]Steven W. Usselman, *Regulating Railroad Innovation: Business, Technology, and Politics in America, 1840–1920* (Cambridge: Cambridge University Press, 2002), p. 11.

[13]This is not to be confused with recent theories on 'techno-capitalism'. See, for example, Luis Suarez-Villa, *Technocapitalism: A Critical Perspective on Technological Innovation and Corporatism* (Philadelphia, PA: Temple University Press, 2009).

[14]For engineers as political economic actors in a different context: Antoine Picon, 'The Engineer as Judge: Engineering Analysis and Political Economy in Eighteenth-Century France', *Engineering Studies*, 1: 1 (2009), pp. 19–34. Generally, for Latin America, historians have centred on the contingent interests of other actors in the formation of state political economy, such as lawyers, intellectuals, statesmen, as well as artisans and merchants. See Gabriel Palma, 'Trying to "Tax and Spend" Oneself out of the "Dutch Disease": The Chilean Economy from the War of the Pacific to the Great Depression', in Enrique Cárdenas, José Antonio Ocampo and Rosemary Thorp (eds.), *An Economic History of Twentieth-Century Latin America*, vol. 1: *The Export Age: The Latin American Economies in the Late Nineteenth and Early Twentieth Centuries* (New York: Palgrave, 2000), pp. 217–64; Jeremy Adelman, *Republic of Capital: Buenos Aires and the Legal Transformation of the Atlantic World* (Stanford, CA: Stanford University Press, 1999); Paul Gootenberg, *Imagining Development: Economic Ideas in Peru's 'Fictitious Prosperity' of Guano, 1840–1880* (Berkeley, CA: University of California Press, 1993); Joseph L. Love and Nils Jacobsen (eds.), *Guiding the Invisible Hand: Economic Liberalism and the State in Latin American History* (New York: Praeger, 1988).

[15]Jonathan Curry-Machado, '"Rich Flames and Hired Tears": Sugar, Sub-imperial Agents and the Cuban Phoenix of Empire', *Journal of Global History*, 4: 1 (2009), pp. 33–56; Guillermo Guajardo Soto, 'Mecánicos, empresarios e ingenieros en los orígenes de la industria de material ferroviario de Chile, 1850–1920', *Revista de la Historia de la Economía y de la Empresa*, 5 (Jan. 2011), pp. 119–47.

those seemingly distant histories came together. The focal point in this article for these distant histories is the concession that the Chilean state granted to Juan Clark, a Chilean (born to an Argentine mother and British father) railway prospector with additional railway projects in Argentina and Venezuela.[16] I rely on sources related to the concession, including engineering reports, state regulations, business records and congressional debates from archives in Chile and the United Kingdom. As something that structured state regulations and engineering reports, as well as private business negotiations and decisions, the concession serves as a lens for viewing the coming together of engineers' technical expertise, private business interests and state bureaucracy in the evolution of a techno-capital state order.

Using an analysis of the concession, I argue that the driving contradiction in the construction and regulation of the railway was between competing and mutually exclusive notions of the railway's value: between estimates and final construction costs, and between its quantitative monetary value and its value as a useful railway.[17] As experts in the emerging techno-capital state in Chile, engineers mediated these contradictions by providing rational certainty and stability, which could overshadow and neutralise the less rationalisable and more contentious aspects of the railway, such as debates among engineers, politicians, railway prospectors and financiers over the railway's utility and the problematic terms of the state-sanctioned guarantees meant to attract capital and encourage railway construction.

Regulating the Question of Value

In May 1887, the Chilean government granted Clark a concession to build the Transandine railway from Santa Rosa de los Andes to the border with Argentina.[18] While Clark received the concession for the Argentine section a decade earlier, the Chilean concession came in the context of a massive state-led railway-building project in Chile, beginning in the aftermath of the War of the

[16]While the government gave the concession to Juan Clark, it is important to note that Juan and his brother Mateo Clark were partners on this project. I refer throughout the article to Juan Clark as the concessionaire for simplicity's sake. For the Clark brothers, see Santiago Marín Vicuña, *Los Hermanos Clark* (Santiago: Balcells and Co., 1929).

[17]One productive way that I have found for working through these problems of value is in reference to the debates around subjective and objective theories of value that took place in the second half of the nineteenth century. See Karl Marx, *Capital: A Critique of Political Economy,* vol. 1, trans. Ben Fowkes (New York: Penguin, 1990), pp. 125–39; Carl Menger, *Principles of Economics: First, General Part*, trans. James Dingwall and Bert F. Hoselitz (Glencoe, IL: Free Press, 1950), pp. 114–45; Eugen von Böhm-Bawerk, *The Positive Theory of Capital*, trans. William Smart (New York: G. E. Stechert and Co., 1923), pp. 129–37.

[18]Cámara de Senadores, no. 250, approval of proposed law, 12 May 1887, Archivo Nacional Histórico de Chile, Santiago (hereafter ANH), Fondo Ministerio de Industria y Obras Públicas (hereafter MOBR), vol. 152, folio 1/1. The following is based on this version of the law, which the Congress approved on 12 May, the Consejo de Estado approved on 12 May and the Ministerio del Interior approved on 14 May. For these subsequent approvals, see Secretaria del Consejo de Estado, 12 May 1887, ANH, MOBR, vol. 152, folio 1/5; and Ministerio del Interior, República de Chile, 14 May 1887, ANH, MOBR, vol. 152, folios 1–6/6–11. Note on citations: for ANH, MOBR, vol. 152, I use two numbers for folios. The first number is for the individual document, whereas the second number is for the volume generally. An 'r' or 'v' after a number indicates recto or verso. This is not how the volume is paginated (it is not paginated), but my intention is to provide the reader with the ability to reference the documents within the volume quickly.

Pacific at the beginning of the decade.[19] Different from many of these state-built lines, the Transandine was a private project, and as such required a concession from the state to private interests. As with most railway concessions, the central question was how to determine the monetary value of a project that had not yet been constructed. Determining that value helped create the incentives for financing railway construction, specifically through state guarantees. Although less common in Chile than in some other Latin American countries, state guarantees were meant to help concessionaires attract investment by providing capital-friendly environments, such as by awarding annually a certain percentage of costs incurred by building the railway.[20] These kinds of guarantees helped mitigate the risks of undertaking a project that would become profitable only after significant capital investments and several years of construction and operation.

In the case of the Transandine, the concession awarded to Clark addressed the common problem of determining the railway's value by deferring it to the future. Addressing this problem was done through setting up two different categories of value for assessing the Chilean government's guarantee. The first was a nominal guarantee, set at 5 million Chilean pesos (hereafter CL\$).[21] This figure, however, was intended to be merely a placeholder. Once Clark finished constructing the railway, the government would change the nominal 'guaranteed' value to reflect 'the *effective and proven costs of the line*', or, in other words, the total construction costs.[22] The concession's central goal, therefore, was to substitute the railway's nominal 'guaranteed' value for its 'proven' value. While the 'guaranteed' value was merely a placeholder for the state, for Clark and others involved in the project, it was fundamental for attracting investors as a fixed, unchanging figure. 'Proven' value may have represented certainty for the Chilean state, but its indeterminacy at any given moment before construction finished represented uncertainty for capital. That contradiction, embedded in the initial concession, would become one of the driving forces behind the unfolding of the project in its early years (coming to a head in 1892) and the development of the relationships between state and capital in this context.

If the concession established a basic contradiction for the unfolding of the railway's history, state engineers were to be the primary mediators of that contradiction. In order to realise the concession's goal of a simple 'proven' value for the railway, the state created regulatory mechanisms to oversee and stabilise the railway's valorisation. The primary mechanism for stabilising the railway's value was

[19]Diego Barría Traverso, 'La autonomía estatal y clase dominante en el siglo XIX chileno: La guerra civil de 1891', unpub. PhD diss., Universiteit Leiden, 2013, pp. 97–8; Guajardo Soto, *Tecnología, estado y ferrocarriles*, p. 61. For the original Argentine concession, see República Argentina, *Registro nacional de la República Argentina, tomo décimo-tercio, año 1874* (Buenos Aires: Mercurio, 1875), pp. 75–80.

[20]By this period, the Chilean railways were mostly state-owned, but Chile was one of the first countries in the region to utilise this kind of guarantee. See Lewis, 'The Financing of Railway Development in Latin America', pp. 262–4.

[21]Note on currency: in 1887, £1 was equal to CL\$9.8. To put the concession numbers in perspective, CL \$5 million was equivalent to 8.8 per cent of state expenditures in 1887, with the full annual guarantee representing *up to* 0.44 per cent of state expenditures that year. See Legación de Chile, *Resumen de la hacienda pública de Chile desde 1833 hasta 1914*, pp. 43–4.

[22]Cámara de Senadores, no. 250, Article 6, Section 1, 12 May 1887, ANH, MOBR, vol. 152, folio 3r. Emphasis added.

the submission of detailed plans for construction. Immediately after the concession went into effect, Clark began submitting plans to the Chilean government for approval.[23] Upon the government's receipt of the plans, however, it became evident that what exactly constituted 'plans' was unclear. The Ministry of the Interior appointed two state engineers, Enrique Budge and Domingo Víctor Santa María, to review the plans and report back to the government with a recommendation for their approval.[24] In many ways, the two were emblematic of an emerging technocratic engineering elite in Chile, both in their vision of state engineering's purpose and their cosmopolitan backgrounds. The son of a former president and trained as an engineer in Belgium, Santa María was 'a firm believer in the essentially non-political nature of engineering'.[25] For his part, Budge was born to a British father and Chilean mother and never lost his ties to the United Kingdom, joining the British Institution of Civil Engineers (ICE) in 1879.[26] While their backgrounds were certainly relevant, what is important for this article is how their centrality and that of other engineers in the state's emerging regulatory apparatus allowed them 'to dominate the development of ideas regarding the economy of public works' and to make engineering the primary language through which those dominant ideas were framed.[27]

In reviewing Clark's plans, Budge and Santa María did not merely report on the feasibility of the plans, but instead saw themselves as interpreters of the concession itself. For Budge and Santa María, plans had to conform to the concession's goal of clarifying the 'effective and proven costs of the line'. For plans to function as plans, they would need to demonstrate the kind of 'information and documents that justify the true cost that the works would demand'.[28] While they did not specify the documents and information needed, they made clear what details were required to be considered plans. In their expert opinion, Clark's plans lacked any reference to curve radii, bridge and station works and cross-section plans.[29] Those details constituted what Budge and Santa María considered to be plans and clarified the railway's 'proven' value. Ultimately, Budge and Santa María recommended that the government approve the plans as 'general plans', but require the company to submit new plans based on the need to evaluate the 'effective and proven costs of the line' before beginning construction.[30]

In response to Budge and Santa María's report, the minister of industry and public works issued a decree to clarify oversight of the project.[31] Firstly, he agreed

[23]Alberto Riofrío (Clark's representative) to Ministro del Interior, 28 May 1887, ANH, MOBR, vol. 152, folio 1r/13r.

[24]Ministerio del Interior, Decree no. 2114, 2 May 1887, ANH, MOBR, vol. 152, folio 1/14. The date was likely an error. Considering that the decree refers to the 14 May law and the petition made by Riofrío on 28 May, it would seem that perhaps 29 May or 2 June was the actual date.

[25]Crowther, 'Technological Change as Political Choice', p. 409.

[26]For Budge's application to the ICE, see Institution of Civil Engineers, Form A/4381/141, proposed 6 Feb. 1879, balloted for on 1 April 1879, Archive of the Institution of Civil Engineers (AICE).

[27]Crowther, 'Technological Change as Political Choice', p. 412.

[28]Enrique Budge and Domingo Víctor Santa María (Ferrocarriles del Estado) to Ministro del Interior, 30 June 1887, ANH, MOBR, vol. 152, folio 2/16.

[29]*Ibid.*, folio 1r/15r.

[30]*Ibid.*, folios 1r–2r/15r–16r.

[31]Ministerio de Industria y Obras Públicas, Decree no. 95, 26 July 1887, ANH, MOBR, vol. 152, folios 1r–2v/17r–18v.

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with their recommendations and interpretation of the concession. In order for plans to be approved, they would have to include the details that would permit an evaluation of the costs of works.[32] Secondly, he created a regulatory structure for the oversight of construction and particularly the cost of works as they were taking place. For this, the 'government would appoint an inspector engineer' who was to be in charge of overseeing construction and affirming or contesting the fairness of construction prices as stated in the company's books or receipts.[33] At the same time, the inspector engineer was to report on the line's operating costs and receipts in order to evaluate how much of the guarantee the government would pay out once the line was operational.[34] Within the first few months of the concession, therefore, the government created the basic architecture of a regulatory apparatus, putting details such as gradients and radii at the heart of indicating value, and engineers at the centre of evaluating and interpreting those details. It was through data and engineers' interpretations of them that the government gave certainty to the evaluation of construction costs. That certainty, as soon would become clear, would also be important to overcoming the problems presented by the less certain and less rationalisable aspects of the project, specifically its utility.

Paper Construction

While the state had created a regulatory structure to oversee construction, Clark still had to submit plans and build. He was both hesitant and pressured to submit plans and begin building the railway. For nearly a year and a half after initial uncertainties surrounding the plans were clarified, Clark did not submit plans of any kind. His hesitancy was reasonable. Under the terms of the original concession, construction was hardly a profitable endeavour on its own. As the guarantee was to be assessed on the cost of construction and paid out on the basis of the operating railway, construction's profitability depended on the operating railway's profitability. Construction was a means to profitability, but not, in and of itself, a profitable endeavour, meaning that positive incentives to construct were few and far between. However, if profitability was lacking, the Chilean state's expectations were not. Clark was obligated by the concession to finish the entire line within five years, with a potential two-year extension.[35] Therefore, while railway construction was not an immediately profitable activity, Clark was under pressure to construct. To resolve this problem and to create the structures for attracting investors, Clark signed a contract on 21 December 1888 with a London-based joint stock company, Clark's Transandine Railway Company (CTR), which was formed for the purpose of purchasing the concession from Clark.[36]

In exchange for the eventual transfer of the concession to CTR, the company provided Clark with two guarantees. Firstly, CTR had to 'indemnify […] Clark

[32]*Ibid.*, Article 1, folio 1v/17v.

[33]*Ibid.*, Articles 2–4, folios 1v–2r/17v–18r.

[34]*Ibid.*, Article 5, folio 2r/18r.

[35]Cámara de Senadores, no. 250, Article 1, Section 3, 12 May 1887, ANH, MOBR, vol. 152, folio 1v.

[36]Memorandum of Association of Clark's Transandine Railway Company Limited, Article 3, Section A, 15 Feb. 1888, The National Archives, London (hereafter TNA), Board of Trade (hereafter BT) 31/39084/25916/25133/1, Registered 3002, 20 Feb. 1888, p. 3.

against all liabilities' connected with the concession. Secondly, once the terms of the contract were enforced, CTR was to pay Clark £100,000 in ordinary shares of the company.[37] In effect, Clark was guaranteed not only the costs of building the railway, but also a profit margin in the form of CTR shares. Therefore, although construction's profitability was still tied to the operating railway in some forms, the contract began to carve out an explicitly profitable role for railway construction by splitting the railway into two different pieces of property (a service and a thing). The planned transfer of the concession should not necessarily suggest that Clark wanted to cede all of the control that the concession had granted him over the railway in all its forms. Rather, the contract was financially necessary and maintaining control over the concession for Clark would become a matter of maintaining control over CTR.[38]

After Clark established his position as a constructor, he quickly worked to build that image. On 31 December 1888, ten days after signing the contract with CTR, Clark submitted the first detailed plans to the government for the first ten kilometres of the line.[39] The submission included plans for drainage systems, excavation works, bridges, the basic cross-section plan, the kinds of materials to be used and how those materials were to be elaborated, all to the end of clarifying 'proven' value. Within weeks the inspector engineer reviewed the plans and the minister of industry and public works approved them.[40] Over the next year and a half, Clark submitted similar plans for different sections of the line. Each time, the inspector engineer reviewed the plans and submitted his recommendation to the director of public works, who in turn reiterated this recommendation to the minister, who gave the final decree approving the plans.[41] This process of

[37]Juan Eduardo Clark and Clark's Transandine Railway Company Limited, Memorandum of Agreement, 21 Dec. 1888, TNA, BT 31/39084/25916/9, Registered 8094, 17 March 1893, pp. 1–2.

[38]For example, while Juan Clark was not an original shareholder in the company, in 1890 or 1891 the Clark brothers became shareholders in the company in a likely attempt to maintain some control over CTR's board. See Summary of Capital and Shares of Clark's Transandine Railway Company Limited, 7 Jan. 1891, TNA, BT 31/39084/25916/6, Registered 669, 8 Jan. 1891. For how the Clarks maintained control over the railway despite the need to make deals with companies and creditors that nominally diminished such control, see Kyle Edmund Harvey, 'Prepositional Geographies: Rebellion, Railroads, and the Transandean, 1830s–1910s', unpubl. PhD diss., Cornell University, 2019, pp. 271–92.

[39]Riofrío to Ministro de Industria y Obras Públicas, 10 Nov. 1888, ANH, MOBR, vol. 152, folio 1/38. However, the first submission of detailed plans to the government occurred a month later. Ferrocarril Trasandino Clark (Riofrío en representación de Juan E. Clark) to Ministro de Industria y Obras Públicas, 31 Dec. 1888, ANH, MOBR, vol. 152, folio 1/39.

[40]For engineer's recommendation for approving the plans: Santa María to Ministro de Industria y Obras Públicas, 8 Jan. 1888 [*sic*, should be 1889], ANH, MOBR, vol. 152, folio 1r/40r. For the ministry's decree on approving the plans: Ministerio de Industria y Obras Públicas, Decree no. 37, 11 Jan. 1889, ANH, MOBR, vol. 152, folio 1r/42r.

[41]Submission, evaluation and approval of plans for kilometres 10–13.7: Riofrío (for Juan Clark) to Ministro de Industria y Obras Públicas, 10 Sept. 1889, ANH, MOBR, vol. 152, folio 1v/50v; Benjamín Vivanco (Dirección General de Obras Públicas, 1ª sección) to Director de la Oficina de Obras Públicas, no. 498, 12 Sept. 1889, ANH, MOBR, vol. 152, folio 1/51; J. Sotomayor (Dirección General de Obras Públicas) to Ministro de Obras Públicas, no. 1608, 13 Sept. 1889, ANH, MOBR, vol. 152, folio 1r/52r; Ministerio de Industria y Obras Públicas, Decree no. 2145, 23 Sept. 1889, ANH, MOBR, vol. 152, folio 1/53. Submission, evaluation and approval of plans for section from Juncal to the Argentine border: Riofrío (Ferrocarril Trasandino Clark Limitada) to Ministro de Industria y Obras Públicas, 22 Oct. 1889, ANH, MOBR, vol. 152, folio 1r/54r; Vivanco (Dirección General de Obras Públicas, 1ª sección) to

submission and approval, however, did not always go smoothly; and contestations over plans revealed the power of engineering logic in the development of a techno-capital state in Chile, as well as its limitations.

While most of the plans were approved without problems, plans for one of the more technically challenging sections of the line caused a great deal of discussion. In June 1890, state engineers began evaluating a 30-kilometre stretch of the line, approximately from Salto del Soldado to Juncal.[42] At the heart of their consideration of the plans was the rack system, or *cremallera*, which was used to scale steep mountain slopes. Unlike simple adhesion (the standard traction system for railways), the rack system functioned with the addition of a rack between the two rails, which corresponded to a cogwheel fitted to the base of a locomotive. With the rack and third wheel, the goal was to provide the train with greater traction than simple adhesion and thereby reduce the impact of steep gradients on the train, namely the costs associated with pulling the train's weight up steep inclines under simple adhesion, such as increased fuel costs.[43]

While state engineers could agree on what the system was, they had trouble coming to an agreement about the specific capacity, utility and necessity of it. The sub-chief engineer inspecting the line, Enrique Vergara, argued that the rack system was an improvement over the alternatives because it increased maximum gradients up to two times and in some cases three times over simple adhesion. Thus, according to Vergara, constructors would have flexibility in where they could build, allowing them to select stable but steep lands, such as the thalweg (the deepest point of a valley), rather than opting for the kind of unstable mountain-side cuts that simple adhesion would have demanded.[44] At the same time, Vergara argued that the rack

Director General de Obras Públicas, no. 622, 15 Nov. 1889, ANH, MOBR, vol. 152, folios 1r–4r/55r–58r; Sotomayor (Dirección General de Obras Públicas) to Ministro de Industria y Obras Públicas, 16 Nov. 1889, ANH, MOBR, vol. 152, folio 1r/59r; Ministerio de Industria y Obras Públicas, Decree no. 2575, 16 Nov. 1889, ANH, MOBR, vol. 152, folio 1/60. Submission, evaluation and approval of plans for kilometres 13.7–19: Riofrío to Ministro de Industria y Obras Públicas, 27 Feb. 1890, ANH, MOBR, vol. 152, folio 1r/63r; J. Bastide (Dirección General de Obras Públicas) to Director General de Obras Públicas, n.d. (it is probable that it was between 27 and 31 March), ANH, MOBR, vol. 152, folio 1r/64r; Sotomayor (Dirección de Obras Públicas) to Ministro de Industria y Obras Públicas, no. 53, 31 March 1890, ANH, MOBR, vol. 152, folio 1r/65r; Ministerio de Industria y Obras Públicas, Decree no. 799, 2 April 1890, ANH, MOBR, vol. 152, folio 1/66.

[42]There were three reports submitted: Enrique Vergara to Director General de la Oficina de Obras Públicas, 30 June 1890, copy, ANH, MOBR, vol. 152, folios 1r–18r/74r–92r; Augusto Knudsen to Director General de la Oficina de Obras Públicas, 2 July 1890, copy, ANH, MOBR, vol. 152, folios 1r–26r/93r–118r; Louis Cousin (Dirección General de Obras Públicas, 2ª sección) to Director General de la Oficina de Obras Públicas, 16 July 1890, ANH, MOBR, vol. 152, folios 1r–7r/119r–125r.

[43]Knudsen to Director General de la Oficina de Obras Públicas, 2 July 1890, ANH, MOBR, vol. 152, folios 11r–12r/103r–104r; Vergara to Director General de la Oficina de Obras Públicas, 30 June 1890, ANH, MOBR, vol. 152, folios 5r–6r/78r–79r; Cousin to Director General de la Oficina de Obras Públicas, 16 July 1890, ANH, MOBR, vol. 152, folios 1r–2r/119r–120r. There is also a description of the rack system in the study presented by the company. See Ferrocarril Trasandino Clark, 'Informes del Ingeniero A. Schatzmann sobre los estudios hechos para el paso de la Cordillera de Los Andes por la provincial de Aconcagua i [*sic*] sobre la aplicación de la tracción mixta Sistema Abt', 1889, ANH, MOBR, vol. 152, folios 1r–20r/143r–163r.

[44]Vergara to Director General de la Oficina de Obras Públicas, 30 June 1890, copy, ANH, MOBR, vol. 152, folios 4r–8r/77r–81r.

system would allow for greater utilisation of energy and a safer operating railway than simple adhesion, all of which would permit moderate operating costs.[45] Augusto Knudsen (Vergara's superior and the chief engineer inspecting the line) was not convinced. Contrary to Vergara's endorsement of the system, Knudsen advocated for a complete rejection of it. He argued that the rack system was unsafe, created unnecessary and excessive repair costs, and was unsuited to local conditions. He even went as far as to refute the gradient equivalency between simple adhesion and the rack system that Clark and his engineers were employing, which allowed him to claim that the system's supposed benefits did not outweigh its disadvantages.[46]

Embedded in these debates was another problem, one that revealed the limitations of evaluating the construction project purely on the basis of objective, 'proven' value. It became clear that technical considerations about construction required parallel discussion about the operating line's utility. In their reports, Knudsen and Vergara took it upon themselves to make assertions about the specific utility of the line, which seemingly deviated from the decreed purpose of these kinds of reports: whether or not the plans were economical as *construction* plans. For example, when analysing various sections of this stretch, Vergara questioned how the rack system was to be employed and its relationship to future cargo. The 16-kilometre section between Río Blanco and Juncal (the penultimate section of the Chilean side) rotated between rack and simple adhesion about a half-dozen times.[47] For Vergara, this method needed to be considered in light of the fact that transporting livestock would be one of the most important services that the line would provide. For simple adhesion, the problem was figuring out how to reduce the effect, specifically bruising, that tight curves had on livestock. In Vergara's estimation, while the rack system alleviated some of those problems, it also presented new ones. For one, the vibrations and jostling from riding over the rack, along with steep inclines, would keep livestock 'in continuous disequilibrium'.[48] Ultimately, Vergara was concerned that if livestock could not be transported efficiently and safely, then the line was bound to lose an important source of revenue, thereby increasing its reliance on the state guarantee. Vergara proposed that the government request another study of the rack system, one that would address the possibility of dividing the section into two parts, one exclusively simple adhesion and the other exclusively rack in order to at least alleviate the jostling produced when the train took up the rack.[49] Knudsen had similar concerns. Acknowledging that transporting cattle would be the Transandine's most important service, he suggested that the government ask ranchers and cattle traders if they would want to transport their cattle over such steep gradients, and consider if the decrease in traffic would be worth it.[50] Thus, despite their many disagreements

[45] *Ibid.*, folios 6r–8r/79r–81r.

[46] Knudsen to Director General de la Oficina de Obras Públicas, 2 July 1890, copy, ANH, MOBR, vol. 152 folios 19r–26r/111r–118r.

[47] Vergara to Director General de la Oficina de Obras Públicas, 30 June 1890, copy, ANH, MOBR, vol. 152, folio 14r/88r.

[48] *Ibid.*, folio 15r/89r.

[49] *Ibid.*, folios 15r–16r/89r–90r.

[50] Knudsen to Director General de la Oficina de Obras Públicas, 2 July 1890, copy, ANH, MOBR, vol. 152, folios 19r–20r/111r–112r.

about the construction plans and the rack system, Vergara and Knudsen both considered the potential cargo of the line to be an important factor in analysing and approving plans. Not everyone agreed, however, about the line's utility; and these disagreements had technical implications.

The third report on the rack system drew into question Vergara's and Knudsen's assumptions about the capacity for such a railway to carry freight at all. To provide another perspective on the construction plans, the Chilean government contracted Belgian engineer and professor of engineering at the Universidad de Chile, Louis Cousin.[51] Cousin pointed out in his introductory statements that the rack system, or any other system that employed such high gradients, would be useless for transporting freight of any kind.[52] In that sense, like other railways employing steep gradients, the Transandine was destined to be devoted mostly to passenger traffic and not significantly reliant on freight. Although his report was widely ignored, it illustrates the agreement among engineers that determining the 'proven' value of railway construction was futile or at least incomplete without first understanding what the line's usefulness was going to be.[53]

Accounting for a line's potential traffic was not merely a special consideration for the Transandine, but rather fundamental to understanding exactly what constructing a railway 'economically' and efficiently meant. In the introduction to his study, Vergara argued that the most important issue to consider was that all technical details, '[t]he gauge, maximum curves, and maximum gradients depend[ed] only on the services that the railway was called on to provide'.[54] In other words, the data that were to serve for the estimates of the line's 'proven' value were only meaningful in light of the line's utility. Understanding potential traffic, therefore, was essential to the state's ability to estimate and assess 'proven' value. At the same time, it was fundamental for the state in assessing the risk of a railway project, since an unprofitable railway would have to rely heavily on the state guarantee, thus becoming a burden on the state. Without recourse to explicit and reliable estimates on potential traffic, engineers had to pull from their assumptions

[51]For a biography of Louis (or Luis) Cousin, see Instituto de Ingenieros de Chile, 'Necrolojía Don Luis Cousin', *Anales del Instituto de Ingenieros de Chile*, 13: 10 (1913), pp. 463–4.

[52]Cousin (Dirección de Obras Públicas) to Director General de la Oficina de Obras Públicas, 16 July 1890, ANH, MOBR, vol. 152, folio 1r/119r.

[53]For the most part, Vergara's and Knudsen's reports received more attention from ministers, directors, engineers and company representatives than Cousin's report. For example, the director of public works based his ultimate recommendation on Vergara's report. Clark's representative, Riofrío, later commented in a letter on the studies that Cousin's report was general and not really based on the local particularities, and therefore was less important to consider than Vergara's and Knudsen's reports. In the final report, Budge mentioned having read Cousin's report, but spent most of his energies on critiquing Vergara's and Knudsen's reports. See Sotomayor (Dirección de Obras Públicas) to Ministro de Industria y Obras Públicas, no. 720, 21 June 1890, ANH, MOBR, vol. 152, folio 2/132; Riofrío to Ministro de Industria y Obras Públicas, received 18 Aug. 1890, ANH, MOBR, vol. 152, folio 1r/143r/1r; Enrique Budge to Ministro de Obras Públicas, 'Informe del ingeniero don Enrique Budge relativo al trazado del ferrocarril trasandino, vía Uspallata, en la sección de Río Blanco a Juncal', 7 Oct. 1890, ANH, MOBR, vol. 152, folios 1r–11r/198r–208r/217r–227r. In sources with three foilio numbers, the last one indicates the pagination written on the source.

[54]Vergara to Director General de la Oficina de Obras Públicas, 30 June 1890, copy, ANH, MOBR, vol. 152, folios 2r–3r/75r–76r.

about what the railway was for and what its importance was going to be. Assumptions about the Transandine's utility, as the next section will show, were drawn less from scientific study than from the various ways in which it had been circulating as an idea since it was originally conceived decades earlier.

Resolving Problems of Uncertain Utility

While Knudsen and Vergara unquestioningly assumed the cattle trade's centrality to the future potential of the Transandine, there was never any consensus on the specific utility of the line. Ambiguity, of course, was no accident. Rather, it was a central component of the line's creation. When Clark submitted a general proposal to the Chilean government in 1877, for example, he used a variety of different benefits to market the line. He claimed that some of the most important traffic would consist of minerals, labour, cattle, refrigerated meat, and manufactured goods.[55] One of the most provocative aspects of the Transandine was its capacity to rearrange global transportation routes. Nearly 40 years before the inauguration of the Panama Canal, Clark claimed that the Transandine would provide passengers going between the western Pacific and Europe with the shortest route, beating the Suez Canal by a week, Cape Horn and the Cape of Good Hope by 18 days and the newly established transcontinental railway in the United States by three days.[56] In order to get the state to buy into the project, Clark needed it to be anything and everything to anyone. A common marketing tactic, ambiguity was something that helped the project not just sell, but also circulate in different contexts.

A decade later, after the government had approved the concession, the line's utility took on different meanings for state officials. In his annual report to Congress, for example, the minister of the interior described the line's utility differently from the way either Clark had or state engineers would in the coming years. He noted that the line would 'provide easy exit and secure markets for the production of our industry and of the agriculture of the most important zone in the territory of Chile'.[57] Perhaps the minister's agro-export-oriented focus should not come as a surprise in the context of a collapsing grain-export sector.[58] Western Argentina, therefore, could offer a potential market to service both agricultural exports and even industrial production. For engineers, transporting cattle was the railway's primary utility; for the minister of the interior, it was exporting grain; and for Clark, the railway was to serve a variety of different uses, which was important for convincing different people and groups to accept the project. This uncertainty about utility was not unique to the Transandine, nor was the problem lost on engineers at the time.

[55]Clark and Co. to Exmo. Sr. D. Aníbal Pinto, Presidente de la República, Valparaíso, 23 April 1877, in Clark y Cía., *El Ferro-carril trasandino interoceánico entre Buenos Aires y Valparaíso: Algunos datos sobre el estado actual de la empresa* (Buenos Aires: Imprenta de La Nación, 1877), pp. 20–4.

[56]*Ibid.*, p. 25.

[57]República de Chile, Ministerio del Interior, *Memoria del Ministerio del Interior presentada al Congreso Nacional en 1887* (Santiago: Imprenta Nacional, 1887), p. xliv.

[58]Gabriel Salazar and Julio Pinto, *Historia contemporánea de Chile*, vol. 3: *La economía: Mercado, empresarios y trabajadores* (Santiago: LOM Ediciones, 2002), p. 33; Arnold Bauer, *Chilean Rural Society from the Spanish Conquest to 1930* (New York: Cambridge University Press, 1975), pp. 70–2.

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The problem of utility was at the heart of railway engineering theory in many ways at the turn of the century. When Santa María published an article on selecting the best path for any given railway in early 1892, a little over a year after debates on the rack system were being 'resolved', he recognised the importance of utility and the problems of determining it with any certainty.[59] Drawing on a number of different methods and theories from across the engineering world, Santa María began his exposition with the most important consideration: a review of the various methods for calculating utility, or probable traffic.[60] Being able to estimate utility precisely was paramount for the state if it wanted to avoid endless subsidies for expensive but relatively useless lines.[61] Of course, as Santa María demonstrated throughout, calculating these figures was difficult as it required substantial statistical data from the state, as well as emerging theoretical assumptions developed by engineers globally on commercial and industrial economics.[62] These issues of utility, state policy and quantifiable economics also resonated across the border.

In Argentina, around the same time, Alberto Schneidewind, an engineering professor and bureaucrat born in Buenos Aires and trained in Germany, was teaching his students at the Universidad de Buenos Aires similar theories, which he had learned from his time in Germany under the tutelage of Wilhelm Launhardt, one of the forerunners of mathematical economics.[63] Years later, Schneidewind would become known worldwide as the 'authority on railways economics' for his theory on fares, which was meant to rationalise and bolster the utility of railways for national economies.[64] All this is to say that the usefulness of railways, in designing them, was an important question in the global engineering profession, reflecting an acknowledgement that utility was not only important, an obvious statement to say the least, but also problematic as it required a great deal of theorising and state power (in the form of statistics) to be resolved.

Unwilling or, more likely, unable to calculate probable traffic or determine the exact utility of the Transandine, engineers resolved the problem of the line's uncertain utility by concealing it under familiar and stable forms of engineering rationality, such as plans, estimates and construction figures. When the director of public works reviewed Vergara's and Knudsen's reports, he agreed that further consideration needed to be given to the section and recommended that the government

[59]Domingo Víctor Santa María, 'Comparación de varios trazados de un ferrocarril entre dos puntos dados', *Anales del Instituto de Ingenieros*, 3: 14 and 15 (1892), pp. 595–648 and pp. 665–729 respectively.

[60]*Ibid*., pp. 596–609.

[61]*Ibid*., p. 667.

[62]*Ibid*., pp. 604–8.

[63]Señor Don M. Nireustein to Señor Pro-Secretario General de la Universidad Nacional de Buenos Aires, Sept. 1908, Archivo Histórico de la Universidad de Buenos Aires, R-122/G11-01-10; Alberto Schneidewind, 'Teoría del trazado de ferrocarriles', *Anales de la Sociedad Científica Argentina*, 39: 1 (1895), pp. 5–6; Ursula Backhaus, 'An Engineer's View of Economics: Wilhelm Launhardt's Contributions', *Journal of Economic Studies*, 27: 4/5 (2000), pp. 424–76.

[64]Manuel Fernández López, 'Ugo Broggi: A Precursor in Mathematical Economics', *European Journal of the History of Economic Thought*, 10: 2 (2003), p. 313; Alberto Schneidewind, *Teoría de las tarifas: Extracto de las conferencias dadas en la Facultad de Ingeniería por el Catedrático de la asignatura Ingeniero Alberto Schneidewind* (Buenos Aires: M. Biedma e Hijo, 1906).

conduct a new report on the line.[65] To that end, the government appointed Budge to compile another report, which he completed in October 1890.[66] His report focused heavily on the question of the rack system. On that question, he rejected any uncertainties surrounding it. In his evaluation of Knudsen's report, for example, Budge rejected his proposal to abandon the rack system altogether on two primary points. Firstly, Budge criticised Knudsen's technical details. He argued that Knudsen had changed some altitudes in his plans, which skewed the gradients in his proposal. Secondly, he argued that Knudsen's proposal would require much greater auxiliary costs associated with retaining walls and additional tunnels.[67] Ultimately, Budge argued that the rack system was the best available and recommended that the government approve the plans as presented.[68]

Interestingly, while Budge addressed many of the technical construction concerns brought up by Knudsen and Vergara, he did not engage directly with the one point of consensus among all three previous reports: that potential traffic was paramount to evaluating the construction plans and that the plans possibly conflicted with the particularities of potential traffic. For Budge, the task of approving the plans in the face of uncertainty required relying on knowable and precise data, which allowed the Chilean state and the capitalist Clark to communicate with one another, with engineers being the translators of this important ongoing conversation. While engineering rationalised state–capital relationships, it also helped obscure the less rationalisable components of the railway, namely its utility, which always remained an uncertain but nevertheless fundamental component of the concession. While all could agree that the railway was desirable, why specifically remained up for debate. Therefore, the engineering metrics for assessing 'proven' value (curve radii, gradients, retaining walls, station works, etc.) brought certainty to the railway's uncertain utility. That ability to use the certainty of construction estimates and engineering reports to conceal the uncertainty of the railway's utility was an important component of the techno-capital state. All the hopes and anxieties of late-century state–capital relationships – growth, development, national pride, debt, defaults, state budgets, depressions, etc. – were inherent to public works concessions; and the technical side of those projects worked to obscure the social and political complexity of those hopes and anxieties by burying them under concrete construction plans and authoritative engineering reasoning.[69] In the case of the Transandine, state engineering would become central to resolving one of the basic state–capital contradictions of the concession as it was initially established: the mutually exclusive forms of value, 'guaranteed' and 'proven'. For

[65]Sotomayor (Dirección de Obras Públicas) to Ministro de Obras Públicas, no. 720, 21 July 1890, ANH, MOBR, vol. 152, folios 1v–2v/131v–132v.

[66]Sotomayor (Dirección General de Obras Públicas) to Ministro de Obras Públicas, no. 917, 20 Aug. 1890, ANH, MOBR, vol. 152, folio 1/147.

[67]Budge to Ministro de Obras Públicas, 'Informe del ingeniero don Enrique Budge relativo al trazado del ferrocarril trasandino, vía Uspallata, en la sección de Río Blanco a Juncal', 7 Oct. 1890, ANH, MOBR, vol. 152, folios 2v–9v/200v–207v/218v–225v.

[68]*Ibid.*, folio 11r/209r/227r.

[69]On how 'technology' embodied and obscured important changes in the nineteenth century, see Leo Marx, 'Technology: The Emergence of a Hazardous Concept', *Technology and Culture*, 51: 3 (2010), pp. 561–77.

the Chilean state, 'guaranteed' value was a placeholder, but for Clark it was what attracted investment and therefore needed to be fixed, especially considering the crisis of capital that would befall the project in the coming months and years. When these competing forms of value came to a head in 1892, engineering reasoning would help in resolving those tensions.

Divergent Construction Interests and the End of 'Proven' Value

Within three months of Budge's report, two crises befell Clark's project: the Baring Crisis, an international financial crisis that struck Argentina particularly hard, beginning in November 1890; and the 1891 civil war in Chile beginning in January of that year. The direct impact of the civil war on the Chilean section of the Transandine is difficult to assess, but it is clear that the Baring Crisis took its toll on the project in the following years. In 1891–2, Clark was faced with a familiar tension between obligations to construct and a lack of resources to do so. Juggling railway interests in at least three different countries (Argentina, Chile and Venezuela), Clark and his brother, Mateo, had amassed over £400,000 in liabilities by November 1891.[70] While their assets were substantial, totalling approximately £1.1 million, the problem was that most of that money was contingent on finishing different railway projects, collecting on government guarantees and issuing stocks and shares by the respective railway companies.[71] Many investors remained unconvinced by the prospects of Clark's different projects, including and most especially the Chilean Transandine, which three years after being formed only counted among its 'investors' the basic members of the initial group that formed the company, indicating that the company was not yet ready to issue stocks and shares from its office in London.[72] Restoring faith in these projects was going to be difficult for Clark as he had already begun to default on a number of loans, including in Argentina.[73]

Attracting investors depended on Clark's ability to continue advancing these construction projects, but, without the resources to do so, Clark turned to stopgap measures. In Argentina, for example, Clark may have simply resorted to cheating his workforce. Despite Clark's financial difficulties, construction continued to advance on the Argentine side; but accusations began to mount against Clark and the company that they were not paying sub-contractors and labourers. Labour agitation reached fever pitch in 1891–2 as workers took action against the company and publicised labour abuses in the local newspapers in Mendoza.[74] It took a year and a half for Clark to pay sub-contractors and labourers;

[70]Anglo-American Construction Company, 'Memorandum read at the Board Meeting of the Anglo-American Construction Company, signed Mateo Clark, read by J. M. Macalaster', 3 Nov. 1891, Norfolk Record Office (hereafter NRO), MC 84/375, 532x2, folio 1r.

[71]*Ibid.*, folios 2r–3r.

[72]Summary of Capital and Shares of Clark's Transandine Railway Company Limited, 13 Jan. 1892, TNA, BT 31/39084/25916/7, Registered 2467, 28 Jan. 1892. The one added member by 1892 was Henry Baggallay, engineer. The member who left was Charles Augustin Prevost.

[73]Clark y Cía., *Su concurso: Informes del síndico provisorio y del contador* (Buenos Aires: Jacobo Peuser, 1893), NRO, MC 84/377, 532x2.

[74]'Reclamos de obreros', *Los Andes*, 25 Feb. 1891, p. 1; 'Informalidad de una empresa', *Los Andes,* 1 Oct. 1891, p. 2; 'Campo Neutral', *Los Andes*, 19 Feb. 1892, p. 2; 'Pobres jentes!' (*sic*), *Los Andes*, 2 April 1892.

he paid during a visit in October 1892, but only after, according to contested reports, a group of workers threatened him and demanded payment.[75] While labour agitation, an important component of the Transandine's history, is beyond the scope of this article, this instance of conflict over payment shows one of the ways that Clark navigated the difficult situation of having to continue construction to attract investors without the capital to do so.

In Chile, meanwhile, local creditors added a different dimension to this tension between construction and a paucity of funds. By 1891, Clark had amassed substantial debts with a dozen different creditors in Chile. Frustrated by his inability to pay them back, Clark's creditors attempted to create a schedule for repayment, and in July of that year they agreed to terms. His creditors agreed to grant him an extension for one year. Since Clark used the railway as the guarantee backing the agreement, his creditors required him to continue construction as part of the terms of debt restructuring in order to provide more value to the collateral.[76] Of course, Clark did not need further incentives to continue construction. The deadline for finishing construction was less than two years away and fast approaching.[77] Thus, Clark was caught between a lack of capital to advance construction and obligations put on him by the government and his creditors to continue.

By early 1892, compelled by deals with creditors and legal obligations to build, Clark began construction once again. But what did 'construction' mean? While construction was happening from the perspective of state engineers overseeing the project and accounting for every centavo spent, Clark's partners casually remarked in 1893 that construction had stopped after 1890.[78] Indeed, engineering reports from 1892 indicate that the pace of construction was so slow that one could hardly have expected even the first and least technically difficult section to be completed by the end of the century.[79]

[75]'El asunto del Trasandino', *Los Andes*, 7 Oct. 1892, p. 1; 'El señor Juan E. Clark', *Los Andes,* 8 Oct. 1892, p. 1.

[76]Banco Comercial de Chile, Banco de Valparaíso and others to Juan Clark, Prórroga (Extension), no. 20, 3 July 1891, Archivo Nacional de la Administración Chile (hereafter ARNAD), Notarios de Valparaíso, vol. 313, folios 30v–37v.

[77]Cámara de Senadores, no. 250, Article 1, Section 3, 12 May 1887, ANH, MOBR, vol. 152, folio 1v. There were no explicit mentions of when construction began, but the best indications are sometime in early 1888. For example, see 'Ferrocarril trasandino', *El Mercurio*, 19 March 1888, p. 2.

[78]Baggallay, 'Clark's Transandine Railway Company', May 1893, NRO, MC 84/377, 532x2, folio 1.

[79]Santa María (Dirección General de Obras Públicas) to Ministro de Obras Públicas, no. 3455, 24 May 1892, AHN, MOBR, vol. 152, folios 1–2/236–7; Santa María (Dirección General de Obras Públicas) to Ministro de Obras Públicas, no. 3669, 20 June 1892, AHN, MOBR, vol. 152, folio 1/239; Santa María (Dirección General de Obras Públicas) to Ministro de Obras Públicas, no. 3875, 25 July 1892, AHN, MOBR, vol. 152, folios 1–2/241–2; Santa María (Dirección General de Obras Públicas) to Ministro de Obras Públicas, no. 4100, 23 Aug. 1892, AHN, MOBR, vol. 152, folios 1–2/221–2. I estimate eight and a half years by taking the construction totals for April through to July, CL$7,539.64, and multiplying it out by three to get a figure that represents annual construction progress (CL$22,618.92). I use contemporaneous estimates from one of the company engineers, J. Travenetti, to compare how much money the company estimated it would need to complete the section to the actual progress made on the railway. Travenetti estimated that completing that section would cost CL$197,340. Thus, at the rate the company was building (CL$22,618.92/year) it would have taken approximately eight years and eight months to finish the section. See J. Travenetti, 'Presupuesto para terminar la línea hasta km. 30', 7 Sept. 1892, NRO, MC 84/377, 532x2, folios 1–3.

Rather than understanding conflicting views on whether or not construction was truly underway as an indication that it was a Potemkin construction project meant merely to placate creditors and the Chilean state, it could also be seen as revelatory of something else. The degree to which business partners and state officials saw construction as having happened was about the extent to which their interests were advancing. While the Chilean state's interest was in accounting for the money spent on construction, potential investors would be interested in a return, which was best secured through a pre-established 'guaranteed' value, not the state's 'proven' value. In the preceding years, engineers had obscured that inherent contradiction through the apparent certainty and stability of completed construction ledgers, estimates and engineering plans. By the end of 1892, engineering rationality could no longer sustain these tensions and it became clear to Clark and his partners that the current concession was no longer viable.

In September 1892, Alberto Riofrío, the railway's representative in Chile, presented a petition requesting that the government alter the terms of the concession. Riofrío prefaced the petition by depicting Clark as a hero worthy of support from the national government in the form of better concession terms than the original had been affording him. Despite the difficulties faced by Clark, he had pushed forward in his mission to construct the railway. Riofrío argued that in the face of crisis, Clark 'agreed to undertake construction with his own resources, encouraged by the hope that by undertaking construction, the country would recognise the benefit of this railway in practice, and in the confidence that, once the practicality of the work was proven […] the Congress would agree to give its indispensable assistance to see it to its happy conclusion'.[80] Although Clark was required to carry out construction by law and by agreements with creditors, Riofrío appropriated this situation and turned it into a quality of personal valour and determination to provide a service to the nation.

The primary thrust of the petition was that the very idea of 'proven' value was at odds with the reality of constructing the railway. The petition requested that the stipulation regarding the requirement for the line's value to be based on the 'effective and proven cost of the line' be replaced with a fixed, 'guaranteed' value. 'Proven' value, Riofrío argued, was 'an insurmountable obstacle to raising the capital required to bring the work to completion, because it [was] not possible to organise a business from uncertain capital'.[81] In other words, investors were hesitant to invest in a project that was unable to secure investments with a fixed, guaranteed interest rate on a fixed, guaranteed value. Therefore, the certainty of 'proven' value for the government continued to be incompatible with the certainty of a fixed, 'guaranteed' value for Clark and the company. By petitioning the government, Clark and the company hoped to overturn the value hierarchy set out in the original concession, turning the placeholding 'guaranteed' value into a permanent figure.

The government commission charged with the task of evaluating the petition took a favourable view of it. Its perspective relied on two fundamental points of

[80] República de Chile, Cámara de Senadores, *Boletín de las Sesiones Ordinarias en 1892* (Santiago: Imprenta Nacional, 1892), p. 337.

[81] *Ibid.*, p. 338.

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reasoning. On the one hand, modifications to the construction plans legitimised the petition. The commission's report noted that, since the original concession, significant changes had been made to the construction plans. Based on engineering reasoning, those changes were sufficient grounds for increasing the amount of capital on which the guarantee was based, according to the report. Moreover, the government's construction estimates were in fact higher than what the petition was requesting. On the other hand, utility emerged to assuage any doubts. The minister of the interior, Ramón Barros Luco, argued that the railway's productive capacity would facilitate great commercial development and the construction of more railways.[82] In effect, support for the revised concession relied on a familiar refrain: the ambiguous utility of the line and the soundness of engineering-backed construction plans.

Those opposed to the concession's revisions had various reasons, from Clark's financial state to the legitimacy of the guarantee system as a whole. One senator, Francisco Puelma, renewed questions surrounding the utility of the line itself. For Puelma, it was doubtful that the company would be able to survive independent of the guarantee. The problem was that the guarantee, in its ideal form, was merely nominal for the purposes of raising capital. Puelma argued that it was not certain that the 'guaranteed' value would remain in its nominal state.[83] Apparently, he did not share his compatriots' faith in the line's productive capacity. Of course, this faith was much more about the Transandine's ambiguity as an operational railway than any kind of definite evaluation of its likely revenues. That the Transandine's utility could mean different things to different people was what made it so attractive, initially, and so problematic for engineers. For Puelma, and perhaps others, that uncertainty was a cause not for hope, but rather for caution.

Despite concerns surrounding the revised concession, it passed both houses of Congress in February 1893.[84] In no small part, the revised concession's legislative success seemed to rely on a combination of continued ambiguity surrounding the line's utility and a sense of certainty fostered by fixed construction plans. Like the state engineers before, the commission and Barros Luco relied on reckonable construction metrics to determine the acceptability of the petition. What they did not discuss, however, was whether or not the productive value, or utility of the line, justified the increase on the guarantee. As was pointed out during debates, the entire purpose of the guarantee was for it to be nominal. Ensuring it would only be nominal, however, was possible only insofar as the railway's revenues (a partial reflection of utility) exceeded it.[85] Faced with the complicated task of calculating

[82]Government commission's report: República de Chile, Cámara de Senadores, *Boletín de las Sesiones Extraordinarias en 1893* (Santiago: Imprenta Nacional, 1893), pp. 965–6.

[83]*Ibid.*, p. 966.

[84]República de Chile, Law no. 28, 'Ferrocarril trasandino por Aconcagua – modificaciones de la ley del 14 de Mayo de 1887', 4 Feb. 1893, *Boletín de las leyes y decretos del gobierno, libro LXII, núm. 2, año 1893 – tomo I, primer cuatrimestre* (Santiago: Imprenta Nacional, 1893), pp. 97–9.

[85]That the guarantee's nominality was directly related to the railway's productive capacity is not merely my *post facto* interpretation. Aside from the debates on the Transandine, the debate on the guarantee system in general also revolved around this point. The interior minister, Pedro Montt, argued against establishing a standardised system for evaluating guarantees based on the fact that the law would have diminished the government's ability to evaluate the 'utility' of the railway to the country. According to

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the railway's utility and future revenues, ministers and legislators fell back on familiar engineering reasoning and calculable construction plans. These familiar devices were clearly becoming part of the emerging techno-capital state in Chile. They allowed the state to simplify the political economic difficulties surrounding the railway and the railway concession (such as assessing its utility, helping to attract investors, predicting future revenues, etc.). If those difficulties were nearly impossible to resolve with any degree of certainty, construction plans and the authoritativeness of engineering reasoning gave the veneer of stability to the inherently contradictory and contentious relationships between state and capital.

Engineering reasoning was fundamental not only to the state, but also to financial capital. In May 1893, only months after the new concession terms were approved, the government received a request for the approval of major modifications to the construction plans, particularly the summit-tunnel section.[86] The new construction plans were drafted in the context of new business partnerships in London. In the midst of Clark's financial difficulties, the Anglo-American Construction Company (AACC) in London had agreed to take on Clark's mounting debts in exchange for his assets, which would allow Clark to seek new lines of credit while still maintaining some control over his projects through a new management position.[87] In that context, the AACC began to take a lead on the construction project.[88] In order to assess the line and assure potential investors of its feasibility, the company sent engineer Henry Baggallay to Chile in late 1892 to conduct a study of the Transandine.[89]

The primary problem that Baggallay addressed during his visit involved the final section before the border, which included the tunnels for crossing the mountains. There were two systems that had been considered up to that point. The first plan,

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Montt, it was that criterion, the railway's productive capacity, that was '[t]he fundamental point that should determine the concession of the guarantee'. See Cámara de Diputados, *Boletín de Sesiones Ordinarias en 1893* (Santiago: Imprenta Nacional, 1893), p. 54.

[86]For the petition for the modified construction plans, see Riofrío to Ministro de Industria y Obras Públicas, received 10 May 1893, ANH, MOBR, vol. 152, folios 1–2/243–4; for the government's response, see Dirección General de Obras Públicas to Ministro de Obras Públicas, no. 1254, 4 July 1893, ANH, MOBR, vol. 152, folios 1–2/255–6.

[87]For the position of managing directors, see Messrs M. E. Clark and M. Clark to the Anglo-American Construction Company Limited, Agreement for Transfer of Business, 12 Sept. 1891, TNA, BT 31/5151/34791/5, Registered 29112, 11 Nov. 1891, p. 3. For the assets, see Anglo-American Construction Company, 'Memorandum read at the Board Meeting of the Anglo-American Construction Company, signed Mateo Clark, read by J. M. Macalaster', 3 Nov. 1891, NRO, MC 84/375, 532x2. While its memorandum of association did not explicitly state it, the Anglo-American Construction Company was formed to take over the Clark brothers' assets, indicated by the company's formation date and the common shareholders it had with the railway company, namely John Muir Macalaster, Kenneth Edward Mackenzie and Ernest Charles Cartner Smith. See Memorandum of Association of the Anglo-American Construction Company Limited, 11 Sept. 1891, TNA, BT 31/5151/34791/33860/2, Registered 25032, 11 Sept. 1891; Summary of Capital and Shares of the Anglo-American Construction Company Limited, 25 Jan. 1892, TNA, BT 31/5151/34791/6, Registered 2471, 28 Jan. 1892; Summary of Capital and Shares of Clark's Transandine Railway Company Limited, 13 Jan. 1892, TNA, BT 31/39084/25916/7, Registered 2467, 28 Jan. 1892.

[88]Messrs M. E. Clark and M. Clark to the Anglo-American Construction Company Limited, Agreement for Transfer of Business, 12 Sept. 1891.

[89]Baggallay, 'Clark's Transandine Railway', May 1893, NRO, MC 84/377, folio 2r.

developed by Emilio Olivieri in the 1870s, employed a series of short tunnels at the summit, which would allow for relatively quick construction and simple ventilation. However, it was discovered to be insufficient as soon as it became clear that winter snow would make the exposed lines exceedingly problematic for the operating railway. To resolve the problem, another engineer, Alfred Schatzmann, devised a second plan in 1889–90. Rather than utilise a number of short tunnels at the summit, the plan employed two long tunnels. Eventually, as Baggallay pointed out, that second plan would take much longer than the previous plan, something that became particularly unacceptable as time went on and the progress of other parts of the line slowed to a standstill. The goal for Baggallay, therefore, was to combine the advantages of both plans: protection from snow and quick building time.[90] The survey provided him with the opportunity to perfect some of the shortcomings that he perceived in previous engineers' plans on the line as a whole. Throughout his report, Baggallay took it upon himself to alter other parts of the construction plans, such as cutting out redundant bridges or changing the arch structure on others.[91] He returned with a report that reflected these minor improvements as well as resolving the main problem of the summit-tunnel section, or at least split the difference between the two previous plans.

Although Baggallay returned to London, he remained involved in the Chilean Transandine. About a month after he presented his report, Blanche and Mateo Clark, Juan's sister-in-law and brother, left London for Argentina and Chile to assess the state of the respective projects.[92] Throughout their stay, they kept in regular contact with Baggallay. One of the main topics of those correspondences was the primary mission of the trip: the renegotiation of the concession that had been modified only four months earlier. By September 1893, Mateo had petitioned the government for another modification to the concession.[93] His petition (and concession modification petitions in general) represented a pivotal dynamic in the unfolding of state–capital relations. With each new group of investors, assurances had to be made about the viability of their investment. Those assurances came in the form of new plans. To prove their relevancy, engineers were eager to claim that their studies reflected goals of rational efficiency and technical superiority more than the last ones. Based on state regulations, state engineers then evaluated the new plans. If new plans represented improved capital efficiency and returns in construction, improved concession terms were also attractive for capital investment; and engineering plans functioned as the monetary reference point for renegotiating the concession. The petition, in this equation, was a way of bringing the state and capital into direct conversation with one another. Engineering, as this article has shown, framed that conversation, providing stability for the unfolding of dynamic, ever-changing state–capital relations, which materialised as rails, tunnels, stations and the vast assemblage of infrastructures underpinning the circulation of people and commodities.

[90] *Ibid.*, folio 1r.
[91] In particular, see *ibid.*, folios 4r–5r.
[92] Mateo Clark to Baggallay, 19 June 1893, NRO, MC 84/379, 532x2.
[93] Petition by Mateo Clark, n.d., ANH, MOBR, vol. 152, folios 1–2/269–70. He likely sent the petition to the government, not the Congress, in Aug. or Sept. of 1893. See Mateo Clark to Baggallay, 25 Aug. 1893; Mateo Clark to Baggallay, 22 Sept. 1893; and Mateo Clark to Baggallay, 9 Oct. 1893, NRO, MC 84/379.

Conclusion

It took another 17 years to complete the project. In the meantime, Clark and various businesses connected with the project continued to struggle with financing and constructing the Transandine. It was not until the early twentieth century that the railway's fortunes changed and construction of the most technically difficult summit-tunnel sections took place. Then, on 5 April 1910, the line officially opened to the public. By that time, Juan Clark had died, but his brother would get to see the fruits of their efforts.[94] When Mateo spoke to a group of engineers in London three years after the line's inauguration, he joined in the celebration of the technical feats of the railway. He reminded them, however, of 'the very important subject of the cost of the railway [… as] it was really the most interesting question'.[95] As this article has shown, it was the most interesting question for not just politicians and capitalists, but engineers, as well. Through their capacity to bring together state and capital on rational, quantifiable terms, they helped obscure and explain away those aspects of relationships between consolidating nation-states and global financial interests that were less rational and quantifiable.

Toward the end of the nineteenth century, those aspects manifested themselves in some basic tensions. Latin American states, striving to consolidate power and to unify disparate territories, relied on infrastructure projects as practical and symbolic edifications of that power. In need of capital to complete those projects, states turned to those with connections to the financial sector (such as the Clarks), a sector often looking for new places and opportunities for investment. While investors needed states to guarantee their profits, states needed to ensure that investors would not actually need the state to make good on those guarantees, lest their budgets collapse under the weight of those promises. Neither wanted to take on the risk and uncertainty of massively expensive projects that took years if not decades to complete, but both wanted to reap the benefits of them. Engineers and engineering rationality in this context provided a sense of certainty and commensurability to projects and relationships that had neither; but in their disagreements, they revealed the fragility of that certainty. In that way, state engineers served as early political economic experts in the region, a central pillar to the emerging techno-capital state. Their political economic education, professional culture and influence on twentieth-century economic expertise still demands further attention and study from historians.

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[94] Marín Vicuña, *Los Hermanos Clark*, p. 230.

[95] Brodie Haldane Henderson, Paper no. 4068, 'The Transandine Railway', in J. H. T. Tudsbery (ed.), *Minutes of the Proceedings of the Institution of Civil Engineers; With Other Selected and Abstracted Papers*, vol. 195 (London: ICE, 1914), p. 173.

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Spanish abstract
A finales del siglo XIX, la expansión ferrocarrilera llevó a la formación de una burocracia tecnócrata en Chile y en otros países en América Latina. Algo central en dicha formación fueron los ingenieros que supervisaron y regularon el sistema ferrocarrilero, tanto público como privado. Recientemente, los historiadores han comenzado a reexaminar el papel de los ingenieros en este periodo. Al emplear métodos y marcos teóricos de la historia de la tecnología, este artículo sostiene que la ingeniería fue un marco de referencia importante en el que las relaciones Estado–capital evolucionaron, convirtiendo a los ingenieros en actores centrales dentro de la economía política de ese tiempo.

Spanish keywords: Ferrocarril Transandino; ingenieros; tecnología; valor; economía política; formación estatal; capitalismo

Portuguese abstract
Ao final do século dezenove, a expansão do transporte ferroviário levou à formação de uma burocracia tecnocrática no Chile e em outros países da América Latina. Os engenheiros que supervisionaram e regulamentaram ambas as ferrovias públicas e privadas foram fundamentais nesse processo. Recentemente, historiadores começaram a re-examinar a função dos engenheiros durante esse período. Através de aplicação de métodos e enquadramentos teóricos oriundos da história da tecnologia, este artigo argumenta que a engenharia foi uma importante estrutura através da qual as relações entre o Estado e o capital evoluíram, tornando os engenheiros atores centrais da economia política da época.

Portuguese keywords: Ferrovia Transandina; engenheiros; tecnologia; valor; economia política; formação de Estado; capitalismo

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