The Politics of High-Speed Rail - Understanding the Role of Intellectual Property Rights and Technology Standards for China's Overseas Rail Investments

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THE POLITICS OF HIGH-SPEED RAIL

UNDERSTANDING THE ROLE OF INTELLECTUAL PROPERTY RIGHTS AND TECHNOLOGY STANDARDS IN CHINA'S OVERSEAS RAIL INVESTMENTS

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Abstract

In little more than a decade, China has developed the largest national High-Speed Rail (HSR) network, operating more than two thirds of worldwide infrastructure. After being initially dependent on foreign technologies for construction and trainsets, a domestic ecosystem has rapidly emerged being supported by the government's industrial policies and technology transfers from abroad. Today, the Chinese railway and HSR industry is the largest and among the technologically most advanced on the global market. As domestic development reaches saturation, the artificially inflated ecosystem is looking for new business opportunities abroad, constructing and proposing HSR lines in many emerging economies around the world, using the *Belt and Road Initiative* and the *Made in China 2025* strategy as supportive frameworks. Many of these projects are also financed with Chinese loans, and as they are usually found in countries with weak economic performance, they come with substantial risks, leading to several already being cancelled, questioning such investments. This thesis suggests that the motivation of Chinese stakeholders to invest in these projects has never been of financial nature. While also looking at geopolitical and domestic-economic explanations, the present work focuses on economic-strategic motivations of China's ambitions on the global HSR market. More concretely, it analyzes the relevance of technology standard-setting and approaches to intellectual property rights in the sector, by investigating their role in 109 Chinese rail projects around the world. The analysis has revealed a long-term mechanism which enabled the Chinese HSR industry to develop well-tested and competitive technology standards by making use of the country's flexible approach to intellectual property rights. As a first-mover in the fields, it is now attempted to internationalize Chinese domestic standards with investments in HSR projects overseas, following two pathways: First, by increasing China's engagement in international standard-setting organizations and creating powerful coalitions to lobby for its interests, and, second, by setting de-facto standards on key sections of regional networks which might see future development. It has been found that for the present case especially the second approach can be provided with strong evidence from several Chinese HSR projects overseas, while the first approach could not be entirely confirmed. The present research and its findings may be relevant for researchers from several fields, including scholars interested in technology standards, intellectual property rights, (railway) infrastructure development, the Belt and Road initiative, or China's industrial and innovation policies.

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Table of Abbreviations

ASEAN	Association of Southeast Asian Nations
BOT	Build-Operate-Transfer (Contract)
BRI	Belt & Road Initiative (also: *One Belt, One Road (OBOR))*
CR	China Railway
CRRC	China Railway Rolling Stock Corporation
ERA	European Union Agency for Railways
GDP	Gross Domestic Product
HSR	High-Speed Rail
ICT	Information and Communication Technology
IHRA	International High-Speed Rail Association
IPR	Intellectual Property Right(s)
MERICS	Mercator Institute for China Studies
SSO	Standard-Setting Organization
WTO	World Trade Organization

Personal Acknowledgments

This thesis marks the end of my educational academic studies in which I followed a somewhat unusual path. After finishing an undergraduate career in mechanical engineering, I refocused and pursued a master's degree in social sciences, the freshly introduced M.Sc. Politics & Technology at the TUM School of Governance. In the first year, I dedicated most of my research interest towards the field of industrial digitization and automatization and its political and societal effects, e.g. on the labor market and the perception of technology within our society. This sector was buzz-worded as *Industrie 4.0* by the German *National Academy of Science and Engineering*, in short *acatech*. In this institute I spent a significant time during my first semesters as research associate in a newly set-up policy-focused platform bringing together expertise in the field of artificial intelligence. During this time, I picked up my interest on China as a new dominant player in the field of highly advanced technologies and I chose to spend the following semester abroad, at the Nanjing University in Jiangsu province. Meanwhile, my research focus shifted too, from industrial appliances towards transport and mobility, a sector in which I have been working as an engineer earlier. Here, I consider the railway industry as one of the most severely under-represented sectors in both civil discussion and scientific research interest. After travelling parts of China with the super-fast *gaotie*, I have always been impressed by the sheer scale of China's high-speed rail network and the corresponding industry. When visiting the Chinese border regions of Yunnan and

Xinjiang in mid-2019, I got reminded of the enormous consequences such projects can bring to affected regions, including environmental problems, cultural changes, or geopolitical tensions. I have long considered to focus this work on the political motivations of HSR development *within* China, most notably regarding the human-rights situation in Xinjiang, but also Beijing's internal relationships with Hong Kong or Tibet. However, without being an expert on Chinese domestic politics, I backed away from this approach due to its high complexity and shifted focus on overseas projects within the Belt and Road Initiative. Additionally, within the presented analysis, I was able to bring in my expertise as engineer regarding technology standardization, an area which I consider as politically extremely relevant but mostly overlooked within contemporary political sciences, or – as Mattli and Büthe (2003) put it – one which received "scant attention from scholars and nonscholars alike, [being] invisible to all but a few experts in engineering and related fields, […] deemed […] unworthy of […] attention, [and] seemed hopelessly technical and dry" (p. 3) – all of which are attributions the authors intended to wipe away within their corresponding studies (cf. Büthe and Mattli 2013). I tried to pursue this spirit as well in the presented topic, even though it is sometimes hard to balance technological details and high-level politics. The approach and findings of this research would most likely have been remarkably similar when looking at other advanced technologies like those in the ICT industry. However, as a large amount of existing literature is already focusing on this issue, causing high public awareness for issues like Huawei's involvement in the world's 5G networks, I have decided to focus on high-speed rail, which I see as an underrepresented topic both in research and public discussion when compared to its investment volumes.

1 Introduction

1.1 A Tale of Space Shuttles and Horse Bottoms

When the first Space Shuttle *Columbia* set off in 1981, a legendary story evolved around one of its main metrics, the size of its two booster rockets sitting on each side of the main tank. Allegedly, the engineers of the boosters “preferred to make them a bit fatter” (Mikkelson 2001), but as they needed to be shipped through an old railway tunnel from the factory in Utah to the final assembly at the *Kennedy Space Center* in Florida, the size was determined by the width of that tunnel. The tunnel was itself built to accommodate a standard railway carriage, which, of course, was physically limited by the track gauge. Railroad gauges in the US and most other countries have been standardized to 1,435 mm, a measure which originates from the standard in England, the home country of railways during industrialization in the 19th century. The English did not just choose their gauge standard at random – it was exactly as wide as the standard horse-drawn road-tramway carriages of that time, see Figure 1. This allowed them to reuse old carriages on the new railway tracks. The corresponding standard for them had already existed for a long time, as carriages had been in use on many of the old long-distance roads in pre-industrialized England. These roads all had the same spacing of wheel ruts, see Figure 1, and deviating from the standard wheel gauge would therefore destroy vehicles quickly. The roads had been like this for millennia – initially they were put into operation by the Romans during their occupation of Britain. The Romans, masters of standardization (cf. Mitchell 2007), built roads for being used by their standard war chariots, which, again, “were made just wide enough to accommodate the back ends of two war horses” (Mikkelson 2001). So, in fact, the Space Shuttle’s rocket boosters are exactly as wide as two horses’ bottoms. Even if this story is only remotely true, it tells an important lesson: Choose standards wisely, they may be in place for a long time and have many unanticipated consequences!

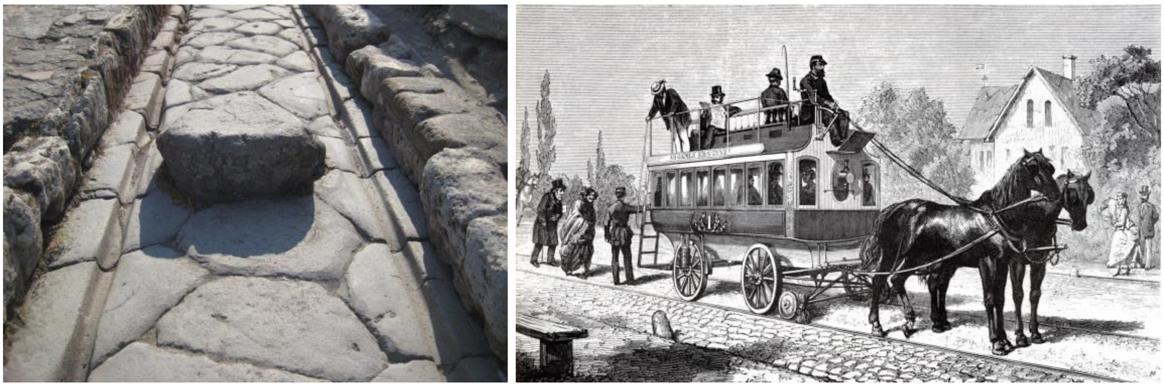

Figure 1: Roman Roads (Gredler 2012) & English Tram Carriages (Vanagas 2017)

1.2 When All Roads Lead to Beijing[1]

Today, two millennia after the Romans set out to conquer Europe and build their standardized roads in England, once again a world power is heavily investing in infrastructure projects far away from its home territory. Since 2013, China is pushing overseas investments with the *Belt and Road Initiative* (BRI), see Figure 2.

Figure 2: Overview of BRI projects in the eastern hemisphere (Ziegler 2020)

The initiative, among other objectives, aims to re-centralize the world's – or at least Asia's – economy towards the former *Middle Kingdom*[2] (cf. CSIS 2017; Miller 2019; Bird et al. 2019). With assistance of the massive building and planning capacities accumulated during decades of rapid domestic growth, Chinese companies are now engaged in projects for coal power plants and motorways in Pakistan (Eder and Mardell 2018b; Hielscher and Ibold 2020), a deep-water port in Greece, oil and gas pipelines in Kazakhstan (MERICS 2018a), and railway lines in Kenya (Onyango 2019), to just name a few. Many of these projects come as all-in-one packages with planning, building, operation, and financing included (Miller

[1] Casarini (2016).

[2] A key party rhetoric in this respect is the proclamation of *The Chinese Dream* (Chinese: *Zhōngguó Mèng;* 中国梦*)*, which calls for "the great rejuvenation of the Chinese nation" by 2049 (Kuhn 2013; Aoyama 2016) and the re-*centralization* of *Zhōngguó* (中国, translating to *The Middle Kingdom*) within Asia, a status Chinese bureaucrats had claimed for China for centuries (Miller 2019; Kissinger and Dierlamm 2011; Mohanty 2013).

2019). Corruption accusations have been frequent (Hillman 2019; Cuenca 2020; Brinza 2020), but most projects indeed seem to serve a greater purpose for both the host country and China: Pipelines from Western Asia secure China's oil and gas supply without being dependent on sea-bound transports through the heavily trafficked Malacca Strait controlled by the US-allies Indonesia and Singapore – and increase sales for many of the Gulf states, while easing political tensions around the Strait of Hormuz (cf. Deepak 2018; Miller 2019). Chinese-run deep-water ports aim to form a dense maritime network – and promote economic development for host countries at its logistical center, the Indian Ocean, a body of water which does not even border Chinese territories (Kanwal 2018; Hielscher and Ibold 2020; Wang and Zhu 2016). Railway lines in Africa serve to transport resources crucial for China's economy from underdeveloped inland regions to the coast and from there to the Eastern Chinese maritime ports – while helping those landlocked regions to access the global markets (cf. Djankov and Miner 2016). On the Eurasian continent, railroads and highways are more directly oriented towards China, both to speed up and increase capacity for imports and exports to and through the geographically difficult terrains of Central Asia – and thereby boosting regional economic development (Sternberg et al. 2017; Baniya et al. 2020; Boffa 2018). Power plants and hydro dams in South-East Asia and Pakistan secure regional energy supply – and improve reliability for local operations of Chinese businesses (Eder and Mardell 2019; Hielscher and Ibold 2020). Yet, for some BRI projects, it is not that easy to understand the motivation for China's investments. Of course, contracts for Chinese construction companies should deliver financial revenues as well. However, funding usually also comes from Chinese banks (Leandro and Duarte 2020) and interest rates are often record-low and well beyond usual market conditions, while most host countries are all but fiscally stable partners (cf. Eder and Mardell 2018b; Shao et al. 2018; Miller 2019). With over-the-top infrastructure projects – so-called *white elephants* (cf. Cai 2017) – being worth a significant share of national GDPs, many countries already find themselves in troubling debt relationships with China (CSIS 2017; Eder and Mardell 2018a; Kynge et al. 2017b; Figiaconi 2019). A prime example for such projects is passenger high-speed rail (HSR) lines. Over the last decade, China has built the largest national HSR network worldwide, accounting for more than two thirds of global HSR tracks (UIC 2020a). Now, with domestic development reaching saturation, China's artificially inflated railway industry seeks new business opportunities overseas. Official documents consider the involvement in dozens of multi-billion projects all around the world, among them awe-dropping aspirations like an HSR link from London to Singapore via Beijing, able to run the entire distance of 11,000 km in just under three days (Wang 2014; Xu 2018). At the same time, existing HSR services rarely operate profitably, even such in rich and densely populated regions (Westin and Kågeson 2012). Under these circumstances it is highly questionable if HSR lines on the territory of BRI partners – which are mostly developing countries – ever reach a financial return on investment for any party involved (cf. Nash 2013). Considering construction costs for large infrastructure projects overseas are always the same regardless of the origin of the contracted companies (Flyvbjerg 2007; Ansar et al. 2016), it can be assumed that Chinese companies are suffering severe financial losses when undercutting market prices as happened in Indonesia or Thailand (Pavlicevic and Kratz 2017a). Additionally, many projects recently face delays and cost overruns, suggesting that they struggle to deliver the same quality standards at the same price and pace abroad as they would domestically (Ollivier et al. 2014c; Brinza 2020; Jibiki 2020; Ker 2017). Even if such projects could be constructed at significantly lower costs, if the corresponding loans issued by Chinese banks are not serviced, they still come at a high cost for China's national economy. Investment in non-profitable infrastructure might still make sense domestically, where economic spillover effects or political benefits guarantee a positive societal return on investment (cf. de Rus 2016). For foreign stakeholders though, it can be assumed that investments only make sense if they bring financial gains – which is apparently not the case for Chinese overseas HSR projects (Eder and Mardell 2018b; UIC 2018). Still, overseas investments in HSR lines by Chinese stakeholders are booming. The present research alone identified projects worth more than $120bn in an advanced stage. Concluding, with domestic development still being capable of improvement in other sectors, the question remains **why China would invest in such risky projects overseas, if they most obviously are a financial loss?** This thesis is investigating this research question for the case of HSR and suggests that one of the key motivations by Beijing's decision-makers is to internationalize China's domestic rules and norms regarding intellectual property rights (IPRs) and technology standards.

2 Methodology & Structure

This chapter shortly outlines the methodology and structure for this thesis, while more detailed methods will be explained along the respective sections. First, based on suggestions from existing literature, several hypotheses to answer the research question will be developed. As the scope of this work is limited, the subsequent analysis will only focus on one of these hypotheses. Second, a literature review will provide an overview of the most relevant research in adjacent fields. Third, background information about HSR worldwide and in China as well as further plans within the BRI will be provided. This knowledge is necessary to fully understand the magnitude of technology standards and China's engagement on the global HSR market. Here, I will give an overview in the historical development and future prospects of worldwide HSR systems and its industry, while also considering economic, societal and environmental aspects. This section will also include more information about the BRI, and the relevance of railway and HSR within it. Fourth, as many Chinese HSR projects overseas have been found to be unsubstantiated, this research includes an investigation of 109 Chinese rail projects in all regions of the world. To provide a substantial basis for studying the relevance of the introduced hypothesis on these projects, this database has been screened to exclude projects without sufficient information, significant progress or credible commitment by Chinese institutions or companies. Fifth, one chapter each will introduce into international regimes and mechanisms regarding IPR approaches and technology standard-setting, including basics on the most influential organizations in the field and current standards in the railway and HSR sector. This section elaborates on the role of the industrial policy strategy *Made in China 2025* and describes a theoretical framework by Seaman (2020), showing several pathways for internationalizing domestic technology standards. Sixth, a two-step analysis will first describe a mechanism with which China became a global leader in HSR technology standards by making use of its flexible approaches to IPR, and government-backed support for innovation and market penetration, with the aim of internationalizing Chinese domestic standards. Here, the second part of the analysis will use the formerly introduced theory by Seaman to empirically examine how the before selected projects contribute to this step – either by increasing China's influence in international organizations or by creating path dependencies and technological lock-in situations.

3 Hypotheses Development

Existing literature suggests several explanations for answering the introduced research question. This chapter presents the most relevant indications and groups them into three categories regarding their policy domain: (1) Geopolitical Power, (2) Long-Term Economic Strategy, and (3) Domestic Political Economy. Because of the limited scope of this work, only the second hypothesis was chosen for an in-depth analysis, as it has been considered to fit best for HSR, while also revealing new insights in an otherwise underexposed research field.

3.1 The Global Strategy of China High-Speed Railway[3]

Among all scholars in the field, Fei Xu, vice president of the China Railway Society, introduced the most diverse and comprehensive set of such explanations – of which some have also been suggested by other researchers – in his book 'The Global Strategy of China High-

[3] Adopted from Xu 2018

Speed Railway' (2018). He broadly describes the historical development of China's HSR network and industry, before exposing motivation, opportunities, and risks of its expansion to the global markets. While not written from a scholarly perspective and thus potentially lacking scientific independence, the work is a first-hand account with undistorted, open, and critical thoughts, and offers valuable insights into China's strategy in the sector. Xu actively promotes Chinese technology for overseas markets and tends to overpraise its competitiveness, exaggerating benefits of an export oriented Chinese HSR industry while often underscoring negative aspects[4]. For him, exporting HSR infrastructure and "showcase Chinese HSR technology" (Ker 2017, p. 11) in "flagship projects" (Xu 2018, p. 125) has a marketing function for "Chinese indigenous innovations" (p. 4), in order to increase international acceptance of products made in China (cf. Chen and Zhang 2015) by promoting "national champions in the railway supply industry" (Preston 2016, p. 48). In this respect, Michelle Ker (2017), in an analysis of 'China's HSR Diplomacy', suggests that "the country's rail export push […] provides a powerful means to project broader political influence and deepen bilateral ties", but also serves as "part of Beijing's plans to become a global leader in high-value added manufacturing" (both p. 3). At the same time, like many BRI projects, the construction of overseas HSR lines can "digest [domestic] overcapacity in […] iron, steel and cement [industries]" (Xu 2018, p. 36), a conclusion shared by many other scholars (cf. Hillman 2018; Miller 2019; Rolland 2017; Chen and Zhang 2015; Cai 2017; Ker 2017). Xu admits that Chinese HSR projects within the BRI will almost certainly be "profitless" (p. 79-80) and carry high investment risks. However, he claims, Eurasian HSR projects may have a significant geopolitical impact because "China will be able to break the containment in the Pacific Ocean by the US and its Allies" (p. 39) by diversifying its trade routes towards the West and North. Additionally, by integrating financing models for large infrastructure projects abroad, they can help to "dissolve the risk of China's huge foreign exchange reserves" (p. 41) (also cf. Chen and Zhang 2015). Xu outlines ten major challenges for Chinese HSR exports, among them the need to "raise the international recognition of China's HSR standards" (p. 102). He is lamenting their weak position on the global market, suggesting partiality in other nations: "The international HSR market can accept the European standards, American standards and Japanese standards, why it cannot accept Chinese standards?" (p. 103).

[4] More concretely, he understates issues regarding quality and safety standards of Chinese HSR technology, e.g. as he blurs technological problems from the Wenzhou rail accident in 2011. He blames other factors than domestically developed technology and claims there "has been *misunderstanding* […] concerning the safety of [China's HSR technology] since the […] *incident*" (p. 14). Also, he generally wipes away concerns regarding the unwillingness of other governments to contract Chinese companies for critical infrastructure projects and exaggerates the global demand for new HSR lines. Additionally, he does not comment on the challenges in overseas markets regarding land acquisition, maintenance, and bureaucratic processes, neglecting a discussion on critical factors which may be beyond Beijing's control.

To deal with this problem, he proposes to create strong and distinctive Chinese HSR standards as well as their promotion e.g. by "demonstrative projects that are built entirely in conformity with [them]" (p. 104), preferably in countries where "the adoption of European standards or Chinese standards has nothing to do with their own interests" (p. 105). Other scholars even propose that the entire BRI is primarily set up to drive the internationalization of Chinese standards (Seaman 2020), and introduce "new or alternative global standards [to promote] China's new approach to international IP practice" (Yingqiu 2018, p. 1) and "upgrad[e] the country's industry" (Cai 2017, p. 1). The next chapter will group these explanations in the three categories introduced before. It will be shown that the geopolitical and the domestic-economic line of argument does not fit the present case explicitly well. Instead, it will be suggested that **a key motivation for Chinese investments in overseas HSR projects is to internationalize China's domestic technology standards as well as its approaches regarding IPRs, in order to strengthen the long-term competitiveness of its industry.**

3.2 HSR increases China's Geopolitical Power

First, like many BRI projects, also HSR can increase China's geopolitical leverage. The idea of a high-performance and densely developed HSR system across all of Eurasia erupting from Beijing certainly puts China in the center of the world's most advanced infrastructure network, as described by Xu (2018). In a highly connected and digitized world, efficient and rapid flow of passengers may end up being as important as material transport. As the densely populated regions of Southern and Eastern Asia are progressing to become one of the global economic epicenters, controlling a fair share of its ground infrastructure is a key to political power – especially in a time in which air traffic may increasingly being questioned as environmentally irresponsible. If Chinese companies not only build infrastructure and supply technology for HSR lines, but even operate the corresponding services, host countries put themselves in a vulnerable position, as key business decisions of these firms – whether state-owned or private – might be under Beijing's control. However, until these large-scale societal developments take effect – which may never happen – HSR tracks are probably constituting only a minor geopolitical asset. Of course, tracks could also be used as overpriced cargo lines to transport freight and therefore strengthen China's ambitions to put itself at the center of the Eurasian rail network[5]. But as long as they are used for regular HSR services,

[5] This is also the main geopolitical rational in Xu's text, however, it remains unclear why HSR is necessary for it. A densely developed railway network connecting East Asia with deep water parts at the Indian Ocean, e.g.

cargo capacity is strongly limited due to operational problems of mixed-use infrastructures (cf. Harrod 2009). The multi-billion investments for building HSR-capable tracks and the staggering extra costs for straightening lines with endless miles of tunnels and bridges are also not worth to serve the simple use case of freight transport, as conventional railways can be built much cheaper. Also, first evidence suggests that Beijing is not even prioritizing projects with the seemingly highest geopolitical influence (Shao et al. 2018; Kynge et al. 2017b). Indeed, out of the most-advanced projects, only the rail line in Laos – which only with very good will can be considered as true HSR – is even touching China's periphery, while projects in far-away Turkey, Indonesia, Venezuela, Mexico and Russia may at best bring very limited geopolitical benefits. This pattern can be observed throughout BRI projects of all kinds (Hillman 2018). Concluding, the here introduced geopolitical hypothesis is certainly useful when studying the intentions behind the BRI overall, certain focus areas like Pakistan, or the development of conventional railway networks and cargo transport, all of which has been done by other scholars already (Eder and Mardell 2018b; Deepak 2018; Sidaway and Woon 2017). For HSR passenger projects on the other side, the geopolitical argument seems weaker, and benefits – if any – would only be a long-term result from the increased economic power and hence political leverage entailed in the next hypothesis.

3.3 HSR brings Long-Term Economic-Strategic Benefits

Second, by exporting indigenously developed HSR technology, China aims to internationalize its domestic standards as well as its approaches towards IPRs. This could not only improve the international recognition of Chinese-made products, but also consolidate the stance of Chinese railway and construction firms in the global market by creating long-term dependencies on Chinese technology through technological lock-in effects. Initial financial losses from the first overseas HSR 'showcase'-projects would later be outweighed by both the creation of new markets and the subsequent dominance on them. Both China's industrial policy strategies and its approaches towards technology transfer and IPRs are critical factors on reaching these goals. On a perception-based level, high-quality, well performing, and efficient high-tech assets like HSR have the potential to **lift the formerly scorned label *'Made in China'*** by providing proof of the country's massive innovation capabilities and technical skills (Xu 2018). On a technological level, China is trying to change the global

in Pakistan or Myanmar, could indeed break up the geopolitical containment in the South China Sea and especially the Strait of Malacca, where China is currently substantially constrained in its flexibility regarding its relations with adjacent states like Singapore or Malaysia. In combination with canals and waterways cutting through the Malay peninsula as well as oil and gas pipelines towards North and West Asia, this strategy is usually referred to as the String of Pearls and is considered to have long-term regional security implications, opening up new diplomatic options for Beijing (Khurana 2008).

IPR paradigm from expensive licensing models to enforcement of technology transfer in exchange for market access and cheap access to innovative technologies. These practices have been heavily criticized by trade partners as they create trade barriers and potentially deprive innovative companies of their business model, hence curbing interest for innovation (EC 2018). The corresponding policy manifesto, the *Made in China 2025* strategy, entails ten so-called *key sectors* for industrial development. One of them – besides the much-observed Information and Communication Technology (ICT) industry (cf. Li 2018) – is 'Railway Equipment' (Wübbeke et al. 2016), in which China is already a global leader not only in quantity but also through its technologically very advanced products (Kunze and Windels 2018). After a decade of rapid domestic development, **China now seeks to showcase its technology abroad and earn better brand recognition for its indigenous innovation advancements**. By pushing aggressively on the market without being kept in check by domestic antitrust legislations (Wübbeke et al. 2016), the sheer size of the country's largest trainmaker, the *China Railway Rolling Stock Company* (CRRC), is dominating the global railway technology market (Shiraishi 2020). In project tenders focused on price and delivery speed, the standardized processes of China's infrastructure-building industry provide it with the ability to outperform other bidders simply by economies of scale and recklessly sped-up implementation phases, which both are globally uncontested (Ollivier et al. 2014c; Mitchell and Liu 2018; CSIS 2017). Additionally, its IPR approach causes that traditional tendering procedures are bypassed, encouraging corruption and untransparent deals (Meschi 2009). In future, the lack of competitors with sufficient capacities for large-scale infrastructure projects, could **make Chinese railways consortia a de-facto monopoly market leader (cf. Briginshaw 2020)**. Such a global hegemon may then be able to successfully **internationalize its technology by setting de-facto standards**, which will remain unchallenged as most of the existing and newly planned projects must be based on them. Costs for transport infrastructure are mainly driven its initial establishment and maintaining technological imperfections is most often the better option than switching technology (cf. Cantarelli et al. 2010). This path dependency then creates a technological lock-in situation with one monopolistic or few oligopolistic players (cf. Liebowitz and Margolis 1995), enabling quick and compatible infrastructure development, but also naturally discouraging competition and innovation and therefore favors abrupt disruption over steady progress and improvement (cf. Schumpeter 1911; Schumpeter 1942). Of course, Western nations have an interest to not leave the HSR industry completely to China, but – in stark contrast to the ICT industry – they do little to support cooperation models of their railway companies to outcompete Chinese tenders (Zhu 2019). In fact, their application of antitrust laws is intentionally limiting the market power of technology providers, as could be observed recently when the merger of the Siemens rail sector with Alstom was disallowed by the European Commission (EC 2019). Hence, the current setup encourages China to seek global leadership in the HSR sector, and the potential loss of billions with the first projects may well pay off later when Chinese companies succeeded in setting international standards to exclusively dominate global markets in the long run (cf. Reed and Trubetskoy 2019). The elements of this hypothesis have not been subject to much research yet, and – due to its high-tech focus – it appears to fit the HSR case explicitly well.

3.4 Domestic Political Economy

Third, large investments in HSR projects overseas can help China to solve some of its domestic economic issues. After decades of rapid progress and infrastructure development, China has built up massive capacities in certain industries which are no longer needed for domestic development as it reaches saturation. Millions of people are working in steel and cement production, as well as those in the building and energy sector, and cannot simply be laid off without the risk of social and political disruption. As a result, investing in large infrastructure projects abroad may not even need to be profitable – its losses just need to be smaller than the (financial and political) opportunity costs of running an economy in idle before necessary restructuring can take effect (Kratz 2015). Here, even geopolitical or economic-strategic aspects are perceived as secondary, as Hillman (2018) notes: "China's overcapacity challenges are so big that these firms likely cannot afford to discriminate […]. Most likely, their guiding drive is to build, regardless of location". Especially the HSR sector has seen very rapid growth rates without demand keeping pace, so projects overseas promise less damage than doing nothing, as they are at least partly able to digest these massive overcapacities (cf. Xu 2018). This constraint provokes lower-than-market prices in tendering processes and leaves Chinese companies uncontested (cf. Ollivier 2014a). Backed by generous funding terms in cooperation with the state-owned banks, and diplomatically promoted by the Politburo's foreign policy branch, China is even able to sell this kind of dumping as an act of political friendliness to please much-needed new international partners (cf. Cohen 2015). At the same time, the country is tackling another serious domestic economic problem: China's economy has been very export-oriented for many years and decades. Meanwhile, imports remained comparatively lower with a domestic market serving most of its own necessities, creating large account surpluses. The renminbi is far from being one of the most powerful reserve currencies, being topped not only by the US Dollar and the Euro, but also by the Japanese Yen and Pound Sterling (IMF 2020). As a result, China has accumulated a large excess of foreign exchange reserves, which cannot be appropriately used up in the own country (Xu 2018; Hillman 2018; CSIS 2017). If large overseas infrastructure projects are not only constructed but also financed by Chinese institutions, they can help transferring these surpluses in more exploitable assets. Still, for the case of HSR these explanations do not seem explicitly viable. Most of above-mentioned goals can also be reached by other BRI projects and, among those, there are plenty which also serve other political interests better. For example, China's railway companies are at least as capable of building conventional rail lines and are therefore not explicitly bound to the expensive and geopolitically less interesting HSR technology, which primarily aims at transporting passengers. It is even highly contested if overseas projects are indeed suited to deal with China's industrial overcapacities, as their scale is still much lower than former domestic development, making them just a drop in the ocean (Miller 2019). Also, many partner countries request "overseas manufacturing bases" (Zhu 2019), in order to boost local employment during construction and operation, defeating the logic of overcapacity digestion lacks here (cf. Kynge et al. 2017b). The argument of dissolving the risk of China's excess exchange reserves is valid, but as it can only be a means to an end it cannot be a decisive factor for investment decisions. Overall, domestic-economic pressures are certainly not obstructive, but they can only partly explain Chinese engagement in unprofitable HSR projects overseas.

3.5 Review of Hypotheses & Scope of this Work

The above-proposed hypotheses scheme could be introduced for any kind of BRI projects, or also for the initiative as a whole. As shown, depending on the purpose the respective infrastructure system serves, the hypotheses are not equally important, which is a core insight of this research. As an example, plans for gas and oil pipelines or cargo railway lines are certainly more affected by security and geopolitical considerations, as access to natural resources is fundamental for China's large and energy-demanding domestic economy. In contrary, HSR with its comparatively weak geopolitical effect, is special among BRI projects, which is why the economic-strategic argument is considered as explicitly valid for this thesis: First, there is no direct long-term advantage for the Chinese domestic economy if high-speed trains run through alien countries – indeed, helping other nations to achieve a similar HSR network as China might even alleviate this national competitive advantage for the future. Second, contrary to other projects such as conventional railways or power plants, HSR lines are unlikely to ever make profit, so that even the mentioned investment models including building, financing, and operation, will not realize any financial gains – especially not in the BRI's emerging economies. Third, in contrast to other industries, the HSR sector has not seen a strong move to international standardization yet, meaning there is much room for shaping future development by a dominant established player. Indeed, as China is already a world leader in HSR technology, the described strategies to internationalize its well-advanced domestic standards could work comparatively well. As a substantial research gap in this last field could be identified, the economic-strategic hypothesis string has therefore been chosen for an in-depth analysis within this work. Surely, an analysis of the other two hypotheses may also bear interesting and eligible insights, and the economic-strategic approach can probably only to a certain degree fully explain Chinas global HSR ambitions. However, the scope of this work only allows a full investigation of one hypothesis. After providing more background information on the issue, the analytical part of this thesis will therefore focus on the relevance of China's approach to IPRs and technology standard-setting for the case of overseas HSR projects.

4 Literature Review

This thesis connects research from both technological and political fields: (1) HSR systems worldwide and in China including future development; (2) China's foreign and industrial policies in context, explicitly the BRI and the *Made in China 2025* strategy; (3) International standard-setting regimes and railway technology standards; and (4) Global policy approaches on IPRs.

4.1 High-Speed Rail

To understand the mechanisms of technology standards within the HSR sector, a basic understanding of its development and worldwide systems is necessary. Early research on HSR systems was mostly focused on Western Europe and Japan, as these regions have long been the only ones with noteworthy domestic networks. North (1993), with his a book on 'Modern Railway Transportation' was among the first to comprehensively describe HSR developments around the world. Vickerman (1997) criticized the visionary but doomed-to-fail European approach to connect the EU member states via HSR for its lack of centralized network planning. Givoni (2006) and Campos and de Rus (2009) provided an overview of global HSR approaches before the rapid evolvement of the Chinese network began in the late 2000s. Nash (2009, 2013), Amos et al. (2010), Lou et al. (2011) and Wu et al. (2014) discussed the conditions under which it would be viable for a nation to invest in HSR lines and whether those are met by China. Albalate and Bel (2012) and Perl and Goetz (2015) used new insights from China and Spain to update former comparisons on HSR strategies. The World Bank and its scholars Bullock et al. (2012), Salzberg et al. (2013), Jin et al. (2014), Ollivier et al. (2014b; 2014c), and Zhou et al. (2016) acknowledged the new Chinese dominance in the

HSR industry early on and published an extensive research series on it. Within a compilation by Albalate and Bel (2016), other Western scholars looked at HSR from multiple disciplines – with many of them still seeing different global development models evenly developed at a point in time when China had already built more kilometers of HSR tracks than the rest of the world combined. Only in recent years, the focus of research in the sector has shifted towards China, including more and more Chinese scholars in academia like Zhang (2015), Zhu (2015) and Chan (2017), resulting in broad Western acknowledgement of Chinese HSR prevalence (Nunno 2018; Lawrence et al. 2019b; Ker 2017).

4.2 Belt and Road Initiative

Numerous scholars have been studying the economic impact and political motivation of the BRI, but without a specific focus on HSR (Casarini 2016; Deepak 2018; Djankov and Miner 2016; Ferdinand 2016; Lo 2015; Wang 2016a; Wang 2016b; CSIS 2017; Du 2016; Eder 2018; Hillman 2018; Aoyama 2016; Tai et al. 2016; Rolland 2017; Miller 2019; Godement 2015; Kratz 2015; Ruta et al. 2019). Several China-based scholars, such as Zhiping (2014) and Huang (2016), but also the above-introduced Xu (2018) as well as Chen and Zhang (2015) for the case of HSR, deliver valuable insights describing the BRI's strategy and political challenges from an internal viewpoint. Shao et al. (2018) proposed a construction priority model for possible HSR links in Eurasia, considering geopolitical, economic and security factors. Michelle Ker (2017) connects the dots between the BRI and *Made in China 2025*, suggesting that "HSR projects exemplify the type of infrastructure [BRI] seeks to promote", as it helps China to "rebalance its economy" towards "high value-added" products and "expand or create markets for Chinese rail companies" (all p. 4). James Kynge et al. (2017b), rather pessimistically, suggests that "China's railway diplomacy [within the BRI] [has] hit the buffers", analyzing the failure of abandoned or cancelled projects – as did Zhu (2019). These essays are also providing a good general overview of the most important Chinese-backed HSR projects overseas.

4.3 Made in China 2025

The *Made in China 2025* (国务院 2020) strategy is an elementary part of China's industrial policy, and as it contains the HSR industry as a key sector it will also be taken into account in this thesis. The *Mercator Institute for China Studies* (MERICS) has published an extensive report on the strategy and its implications for other countries (Wübbeke et al. 2016). Kenderdine (2017) compared it to China's traditional approach towards industrial policy. Wu and Duan (2018) analyzed how the label 'Made in China' has transformed during recent years. Al-Sayed and Yang (2018) explored how the strategy interrelates with the BRI and showed that, while China is certainly progressing in terms of creating an "innovation-based smart manufacturing ecosystem" (p.17), it is still facing several challenges to expand such concepts nationwide and abroad. Li (2018) compared the strategy with the German *Industrie 4.0* label and analyzed its socio-economic impacts. Kunze and Windels (2018) analyzes how the strategy interrelates with Chinese overseas investments in high-tech companies for establishing a worldwide technology leadership. Zhu (2019) investigated the same issue for the railway sector and analyzed the competition between China and Europe.

4.4 Setting International Technology Standards

To analyze the relevance of standards within China's overseas HSR investments, this thesis will be working with existing literature about the evolvement of technology standards and mechanisms in international standard-setting. Several scholars have shown the political importance of standards in international governance and argue that the process for setting standards is necessarily a tug-of-war between "technological rationality" (Mattli and Büthe 2003, p. 1) and politics of power (cf. Shy 1991). Besides them, Abbott and Snidal (2001) studied standards as "mechanisms of international governance" (p. 1), proposing preferable modes of governance for coming off best in standard-setting processes. A later work by Mattli and Büthe in 2013 discovered differences in policy approaches towards standardization in Europe and the US, but without any consideration of China. Kennedy (2006) and Lee and Oh (2008) analyzed how China failed with its first attempts to set international high-tech standards by lacking powerful coalitions supporting its standards. Mu and Wu (2005) provided an historical overview of China's standards strategies, and Suttmeier et al. (2009) analyzed how they are interrelating with its industrial policies. Ping (2017) describes the enormous importance China's government is assigning to standard-setting by its emphasis it in the corresponding strategy paper (China OBOR Network 2018). The institutionalization of standard-setting within the BRI and *Made in China 2025* also increased the interest of international scholars, several of which analyzed how China's standardization strategy differs from the US and Europe, describing potential impacts on industry and trade (Liu and Cargill 2017; McGeachy 2019; Fägersten and Rühlig 2019; Kamensky 2020a; 2020b). Others have further developed and concretized such considerations, most of them with a focus on the ICT industry and 5G standards (Arcesati 2019; Beattie 2019; Duesterberg 2019; Strayer et al. 2019). Amighini (2018) critically evaluates China's ability to fully integrate in the world's economy in her book, balancing the question if "China will adhere to and comply with international rules and standards, or instead will be increasingly active in setting her own" (p. 37), a viewpoint which is also shared by other scholars (Yingqiu 2018) and was adopted for the present work too. Seaman (2020), following a similar way of thinking, proposed a more integrative “dual-track approach” (p. 2), suggesting China both attempts to export its technology standards while also increasing its influence in existing international SSOs.

4.5 IPR & Innovation Policies

Earlier research on IPRs in China have mostly studied “the problems of copyright piracy and trademark counterfeiting” (Chang 2011, p. 1) as well as patent infringements (Dimitrov 2009; Mertha 2007; Cheung 2009). With China enhancing its own innovation capabilities, scholars have moved to focus on the implications a different approach to IPRs by China would mean for existent paradigms within the field. The report by Breznitz and Murphree (2013) reviews the Chinese IPR approach and standardization system and deduces corresponding challenges for the US industry. They conclude that, while China is using “technology standards as a protectionist tool”, the main threat for US firms is the establishment of “new norms” (both p. 2) regarding the handling of IPRs. Morin et al. (2018), building on former work by Serrano (2016) and Krizic and Serrano (2017), analyzed the integration of emerging economies in existing regimes on international patent law and IPR legislation, assigning them a role change “from rule-breakers to rule-changers and rule-makers” (p. 1) (also cf. Seaman 2020). Regarding China, their case study views its transformation as having mostly stopped at “rule-tak[ing]” (p. 10), but this would not apply “in all domains” (p. 11), fitting the argument of this thesis, which suggests that China is rather transforming to a ‘rule-maker’ within the railway and HSR sector.

5 High-Speed Rail – The Future of Travel?

This chapter outlines the historical development of HSR systems around the world and the relevance of Chinese technology in the field. It will be shown why HSR operations are rarely profitable and that construction of HSR lines is usually only reasonable if losses are compensated by domestic stakeholders. This principle is questioned by Chinese investments in HSR projects within the BRI, which will be introduced and set in context.

5.1 High-Speed Rail around the World

The history of high-speed rail goes back for decades. While electric railway speed records have topped 200 km/h – the minimum threshold for ‘high-speed’ (UIC 2020b) – already in 1903, operational speed rarely reached 180 km/h until the opening of the first Japanese Shinkansen line in 1964, which was running at 210 km/h from Tokyo to Shin-Osaka. While Japan further developed its HSR system early on, the first lines in Europe did not open until 1981, when, in France, the first TGV started operation from Paris to Lyon at a maximum speed of 260 km/h[6] (North 1993). This line has probably been the most influential for advancing common European standards for HSR (Campos and de Rus 2009), especially as, “in contrast to the Shinkansen concept, the new [system] was fully compatible with existing railways” (UIC 2020b). Soon, other countries started to adjust their domestic rail networks for operating at higher speeds, both by building new dedicated tracks (France/Italy/Spain), or by putting HSR trains on upgraded conventional tracks (Germany), a strategy which brings cost advantages but heavily affects maximum speeds (Perl and Goetz 2015). Today, several links between these domestic networks have formed a European HSR system. Still, few HSR services run across Schengen borders, such as the *Eurostar* train running from Paris or Brussels to London, using the rail-only Eurotunnel (Norman and Vickerman 1999). Infrastructure has not yet been fully standardized, meaning that a large-scale integration of domestic networks and seamless operations often remain problematic and lag far behind the EU’s ambitious goals set in 1996 (ECA 2018; Gutiérrez et al. 1996), see Figure 3.

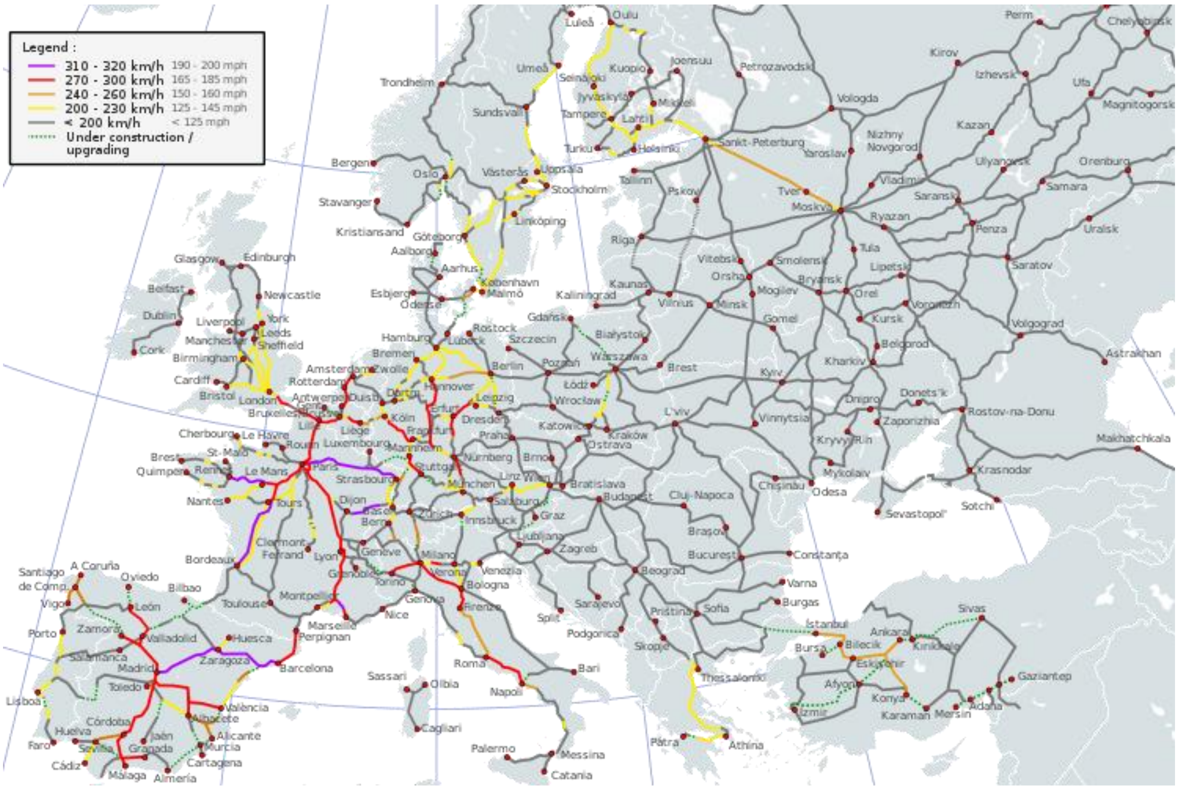

Figure 3: European Railway Network; Colored lines: HSR (Wikimedia C. 2020c)

Triggered by low airfares and increasingly well-developed air traffic, HSR development has slowed around the millennium, and as many projects have experienced significant delays and cost overruns, the technology was considered as too inflexible and expensive (Marti-Henneberg 2015). Few new projects have been announced in the Western world, and main

[6] In fact, the first European HSR line was built in Italy between Florence and Rome. Sections of the route opened already in 1978, however, the entire route did not become operational until 1992 (North 1993).

progress was seen in East Asia, considerably South Korea and Taiwan (Givoni 2006). In 2008, China opened its first HSR line and was from then on changing the industry permanently. First considered as an Olympic Games infrastructure project, the Chinese HSR network grew rapidly beyond its initial link between Beijing and Tianjin and quickly became the largest worldwide (UIC 2020b; Lawrence et al. 2019b). The tragic 2011 accident near Wenzhou, killing 40 and injuring 200, and disputes over corruption paused Chinese ambitions only for about a year (Ker 2017), however, it did put a permanent stigma on the trustworthiness of Chinese HSR technology (Xu 2018; Yu et al. 2012). After a decade of rapid development, China's domestic HSR network reached a length of 35,388 km in 2020, more than two thirds of worldwide HSR infrastructure, with plans to further expand it to 45,000 km by 2030 (Lawrence et al. 2019b; NDRC 2016; UIC 2020a).

Figure 4: China's Domestic HSR Network; Colored Lines: HSR (Wikimedia C. 2020b)

While the first lines have been mostly built and supplied by foreign technology leaders, see chapter 0, most of the network was subsequently developed by Chinese firms, demonstrating the scaling abilities of the domestic HSR industry (Akiyama 2014; Railway Technology 2017; Xu 2018). Today, the national HSR network stretches all across the nation, from Heilongjiang bordering Russia in the Northeast to Yunnan in the South, and from Xinjiang in the West to Shanghai in the East, see Figure 4. Currently, the only formal border crossing is between Shenzhen and Hong Kong. The network follows a strict geographical, almost mathematical model, consisting of four parallel lines for each direction (North-South & East-West), and is planned to be expanded to eight, respectively (Xu 2018). China's astonishing success spurred HSR initiatives in other countries, including developing or emerging economies (UIC 2018). Today operational HSR services can also be found in Russia, Turkey, Saudi Arabia, Uzbekistan, and Morocco. Further lines are being constructed in India, Indonesia, Malaysia and Iran, and planning is well advanced in Thailand, Egypt, and South Africa (UIC 2020a). Debates about climate change and the environmental impact of aviation have revived aspirations for more extensive networks in the US and the EU, and prolonged the list of wished-for HSR links and services (cf. Nunno 2018; Holvad et al. 2016; Hoyos et al. 2016; Minn 2013).

5.2 Profitability of High-Speed Rail

A fundamental assumption for this thesis is that, due to the enormous construction and operating costs, **HSR is generally not profitable.** This is an important insight because if HSR would usually offer commercial gains, the motivation for overseas investments would be clear. Yet, there is enough empirical evidence to say that HSR is per se not bringing financial returns on investment. While most scholars usually only consider three lines worldwide as profitable[7], Yu Weiping, vice-president of CRRC, claims that six Chinese HSR lines have been profitable in 2015, but – similar to Xu (2018) – "agrees that the question of profitability […] is a valid one" (Kynge et al. 2017b). According to the World Bank, profitability can only be reached if HSR services are "able to attract at least 4 million passengers per year, [but] given the relatively affordable fares charged in China", it tends more towards "40+ million passengers per year" (all Lawrence 2019a), a figure few lines in China reach[8] (Ollivier et al. 2014b). While construction costs in China are significantly lower than elsewhere (Ollivier et al. 2014c), the high share of costly engineering constructions like bridges and tunnels eliminates this advantage (He et al. 2017). If counting social, environmental, and broader economic gains, overall societal profitability can be reached earlier (Westin and Kågeson 2012; Wilhelms 2014), however, studies from Spain[9] show that even industrialized countries struggle with getting their lines profitable. Betancor and Llobet (2016) even claim

[7] Paris-Lyon (FRA); Tokyo-Osaka (JPN) ; Beijing-Shanghai (CHN) (Yu 2016; Xu 2018; Feigenbaum 2013).
[8] The average HSR route in China had 22.5 million passengers in 2013, and passenger numbers outgrew network growth since then, so this number must have slightly increased since. However, certain lines are responsible for a lion's share of these figures, e.g. the Beijing-Shanghai line counted more than 100 million passengers in 2013, meaning most services in China are only selling a few million tickets annually (Ollivier et al. 2014b).
[9] At the time of research, no single Spanish HSR line is operating profitable, not even the popular route from Madrid to Barcelona, where demand has by far overtaken air traffic (Pérez Henríquez and Deakin 2017).

that "under reasonable assumptions, [the Spanish] society will not recover the infrastructure costs [of its HSR network]" (p. 23). The failed attempts to establish Public-Private Partnerships in the HSR sector also suggest that it is hardly possible to make it a business case – even in populated regions with high median incomes (Dutzik et al. 2011).

5.3 Belt and Road Initiative

The *Belt and Road Initiative* was announced by Chinese President Xi Jinping during an overseas trip to Kazakhstan in 2013. Starting under the label *One Belt, One Road* (OBOR)[10], China aims to better develop its trade routes by connecting East Asia with both adjacent economies as well as emerging or developed economies in other parts of the world. Dozens of infrastructure projects – as shown in the introduction – are planned to one day create the *Silk Road Economic Belt* on land, cutting through Central Asia and Eastern Europe, and the *21st Century Maritime Silk Road*, focusing the world's maritime trade on large deep-water seaports in the Indian Ocean (Al-Sayed and Yang 2018; Cai 2017; Miller 2019). As of March 2020, as many as 138 countries all around the world are claimed to be part of the BRI (Belt and Road Portal 2020). International scholars see the BRI as a tool which "ultimate purpose is to build a Sinocentric Eurasian order in which Beijing's influence and power have significantly expanded" (Rolland 2017), following a "newly assertive policy that prioritizes China's economic leadership in Asia" (Miller 2019). This narrative does not entirely fit the Chinese viewpoint of the BRI mainly bringing "win-win benefits for the global community" (Sidaway and Woon 2017, p. 10; cf. Du 2016). A very distinctive feature of the BRI when comparing it to other infrastructure development or foreign aid programs is the degree of Chinese involvement for planning, financing, constructing and operating projects. To maximize the integration of Chinese firms in these processes, China frequently offers so-called Build-Operate-Transfer (BOT) contracts to the governments of partner countries (Ruta et al. 2019; Xu 2018), a model usually observed within public-private partnership projects (Flyvbjerg 2007). As large infrastructure projects seem to be doomed to fail even in many developed nations (Flyvbjerg 2007), and "underdeveloped and often fragile states" (Miller 2019) are struggling to access appropriate funding options on the global capital markets, the all-in-one solutions offered by Chinese consortia come in handy – especially for very large projects, which often couldn't even be handled by any other supplier alone. Here, "China's

[10] Multiple names have been communicated in both Chinese and English. The original term *Yīdài Yīlù* (一带一路) translates to *One Belt, One Road (OBOR)* and is still being used in China. But as it has caused confusion in English-speaking countries, the term *Belt and Road Initiative (BRI)* was coined (Bērziņa-Čerenkova 2016), as well as *The New Silk Road* which can be considered more as marketing gag referring to the ancient silk road on which goods were transported between Asia and Europe (Chatzky and McBride 2019). This thesis will use the abbreviation BRI.

economic diplomacy is most effective in small countries, where its leverage is greater. […] Developed economies, by contrast, have less to fear: Japan and South Korea are powerful countries in their own right. Far from needing the Chinese to build and finance infrastructure, they are competitors in the game of infrastructure diplomacy." (Miller 2019). From an engineering perspective, the scaling capabilities and planning and execution speed of Chinese construction firms are astonishing and unprecedented. Surely, the Chinese way of infrastructure development is not working as seamlessly in the pluralistic systems of BRI partner countries as it does in the centrally-planned domestic economy (cf. Kynge et al. 2017b; Zhu 2019), but other industrialized countries also struggle at delivering large infrastructure projects in time and budgets (Flyvbjerg 2007). Many scholars claim that the BRI is not an *initiative* or *project* on its own, because it is neither conclusive nor is there any kind of official *plan*, which would list all BRI projects or explicitly state concrete goals. Also, there is no empiric evidence that Chinese investments explicitly target the BRI corridor's, see Figure 2. This obviously questions any assumption of a strategy behind the BRI, and suggests that Beijing is having a "control problem" (Hillman 2018) if there truly is any political motivation for the assigned corridors. For this thesis, too, the BRI will not be understood as a *project*, but instead as a *label* for China's economic and geopolitical ambitions in Eurasia and the world (cf. Cai 2017; Belt and Road Portal 2020; Miller 2019; Eder 2018). When looking at railroad development, the BRI is mainly aiming to speed up[11] cargo trains on the conventional railroad infrastructure between its large manufacturing hubs in the East and consumer markets in Western Europe, but also in South-East Asia and some coastal parts of Africa (Miller 2019). The degree of integration of HSR in these plans differs greatly (Shao et al. 2018; Chen and Zhang 2015; Xu 2018), as shown in the next chapter.

5.4 How China High-Speed Rail Technology is 'Going Global'[12]

As apparent in Figure 4, China's domestic HSR development is reaching saturation. The massive domestic industry built up for the construction of this network is now starting to focus on overseas markets, using the BRI as main export channel. China aims to connect its HSR network to those of adjacent countries, see map in annex A2, which is – given the enormous geographical and political difficulties – all but an easy task (cf. Xu 2018). Nevertheless, plans have been announced for drilling through the mountains of Indochina to create an South-East-Asian HSR network (Obe and Kishimoto 2019); connecting to India either through Myanmar (Nag 2018) or by tunneling the Himalaya mountain range (SCMP 2020;

[11] Railway cargo from China to Western Europe is already deliverable within less than two weeks on land, while seabound transport takes significantly longer (Miller 2019).
[12] Xu (2018).

Ray 2018); crossing the deserts and mountains of Central Asia to reach Karachi (Phillips 2017), Tehran (Macauley 2015), or Moscow – and later Berlin and London (Railway Pro 2017); and bridging the gaps to Taiwan (Chen 2018; Tang 2019), South Korea and Japan (Reconnecting Asia 2020a; Korea Herald 2010) – each of those sea crossing would be the world's longest. Other plans even foresee an HSR network across Latin America or from China to the US via a crossing over the Bering Strait. All these mega-scale projects – and more – have been announced by railway officials and party representatives, making it hard to entirely ignore them (Xu 2018). In most of China's neighboring countries, though, enthusiasm for such ideas is limited, and skepticism about the growing influence of Beijing is growing – especially in East Asia, including in the more-or-less disputed territories[13] of Taiwan (Chen 2018), Hong Kong (Huang 2018; Bland 2018), Tibet (Reuters 2016), and Xinjiang (Denyer 2014; Phillips 2017). While, in this respect, Chinese leadership generally tries to cool down political disagreements with its direct neighbors (cf. Pavlicevic and Kratz 2017b), its HSR industry is moving to action already, having already constructed lines in Turkey, Venezuela, and Saudi Arabia, Indonesia, Laos, and Serbia.

6 All Talk, No Action?

To analyze the relevance of standards within Chinese overseas HSR projects, this study has been taking in account all projects which have ever been proposed or announced to be supported by Chinese stakeholders. This list was then narrowed down regarding several parameters to find appropriate cases to study the research question and distinguish well-elaborated plans from unsubstantiated visions and hard-to-realize pipe dreams. Besides project status and specifications, project selection will be mostly based on a parameter phrased *credible commitment* by Chinese institutions or companies. For most instances, this means financial expenses, loans, or guarantees – but serious political engagement as well as opportunity costs or expenses for related projects has also been considered (cf. Wu and Chong 2018). This will also include projects which have been announced by both China and partner countries but have then been blown off. As outlined in chapter 10.1, data gathering suffered under extremely heterogeneous, unreliable, or outdated sources, which meant that many of these parameters could not be conclusively quantified. Therefore, only projects with sufficient and trustworthy information have been considered. This chapter will describe how this selection

[13] Domestically, Beijing has long used infrastructure development as a tool for "nation building and political integration" (Preston 2016, p. 49) and "address[ing] […] regional disparity" (Cai 2017, p. 1), in return for political stability and economic development in border regions (Chen et al. 2016). This can most notably be observed with the railway lines to Xinjiang, Tibet and some parts of Yunnan (Mitchell and Liu 2018; Reuters 2016; People's Daily Online 2019; Cai and Zhao 2014).

process has been conducted. First, I will present the methods used for gathering the raw data. Second, I propose methods for screening and selecting useful data and analyzable projects based on several quantitative and qualitative indicators. Third, I will describe the selected projects in more detail to show their respective circumstances and particularities.

6.1 Data Gathering & Selection Criteria

Not all Chinese HSR projects overseas can explicitly be counted as being part of the BRI, nor does a "definitive list of projects" (Mardell 2019) exist. Therefore, this research connects data from various sources to build a project database as complete as possible. Most of the data builds on an exclusive HSR dataset from the *International Union of Railways* (UIC)[14], but significant parts have also been added from other sources, such as the BRI tracker of MERICS (2018b; Eder 2018), the database of Reconnecting Asia (2020b), and some less extensive lists by Zhu (2019), Hielscher and Ibold (2020) and Kynge et al. (2017b). Methodologies within these sources differ, so that it has been necessary to streamline their data. Some sources only consider projects which have been mentioned in e.g. "Chinese policy documents and that entail a Chinese role in funding or implementation" (MERICS 2018a), but especially the UIC dataset does not discriminate for this criteria. Where available, official project information has been added, but, as projects vary greatly regarding status and transparency, some data points had to be added by relying on information from internet documents or newspaper articles. This method resulted in a project database of 109 HSR projects in 59 countries, see annex A1. This is a significant reduction from the UIC database (589 entries), which is not focused on Chinese involvement. A first screening identified Chinese railway projects in 23 more countries, see Figure 5, but as they are conventional lines they have been excluded. Additionally, I have filtered projects in (1) China, as they are obviously not overseas from China, (2) countries with a strong domestic HSR industry as well as their immediate neighbors[15], as currently none of them plans to use Chinese HSR technology (3) countries with a strong and expressed commitment to non-Chinese technology for political reasons[16], and (4) countries which have existing HSR infrastructure and already coupled it to non-Chinese technology[17]. Projects in the USA, the UK, Canada, and Australia – all of them are countries in which Chinese involvement has been discussed (UIC 2018) – have

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[14] A part of this exclusive dataset is also available online via https://uic.org/passenger/highspeed/article/high-speed-database-maps (UIC 2020a). The full dataset was sent to me by the UIC in October 2019 but cannot be shared here due to a non-disclosure agreement. Information on the UIC can be found in chapter 8.3

[15] Japan, Germany, France, Spain, and Italy, as well as smaller adjacent European countries like Belgium, Netherlands and Switzerland. (Akiyama 2014).

[16] Taiwan, South Korea, and India (Railway Technology 2020b; Strong 2019; SCMP 2018; Shepard 2017).

[17] Uzbekistan (Spanish AVE), Morocco (French TGV). Exception: Russia (German ICE, but planning for Chinese technology on the Moscow-Kazan line) (Akiyama 2014).

been included in the dataset. However, currently, no project in these countries is in a development stage beyond an initial memorandum of understanding, and the political climate of recent years suggest that none of these countries would let China be involved in their infrastructure projects, which is why they have not been further analyzed.

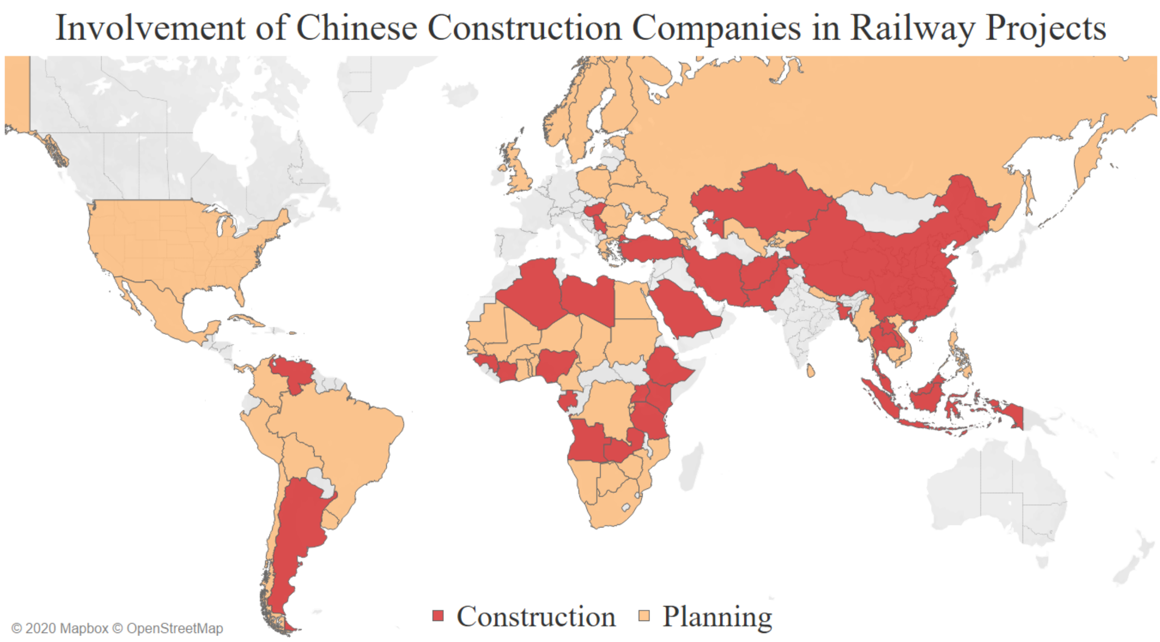

Figure 5: Chinese Involvement in Railway Projects (Own Research)

A special case is Turkey, as it is the only country in the world with an extensive HSR network and further expansion plans, which has not yet fully committed to the technology of one supplier. The list of future projects in Turkey is quite long and poorly documented. For the purpose of the discussion in this document, one route has been selected as the representative project for Turkey's domestic HSR network within the dataset[18], complemented by the international line between Iran and Turkey. Another challenge within the dataset lies within the definition of *high speed*. The UIC defines HSR as newly built lines with an operational speed of 250 km/h or more or existing lines with an upgrade to reach operational speeds of 200 km/h or more. By and large, this definition will be adopted for this research. However, certain exceptions were made: First, some lines are partly built in extremely difficult geographical terrain, making it hardly possible to ever reach 250 km/h safely. Nevertheless, when looking at the entire route, many of these projects can certainly be considered as *high-speed* rail[19]. Such cases have been included, e.g. the railway line from Kunming to the Laotian capital Vientiane, where operational speed is set at 160 km/h, but further upgrades could

[18] HSR line from Ankara to Istanbul, operational since 2009/2014 (UIC 2020a).
[19] A good example to show this dilemma is the rail link between Paris and London, where trains usually run at speeds of 250+ km/h, but the *Eurotunnel* limits trains to 160 km/h on 50 km. Certainly this route would still be considered *high-speed* rail.

easily lift the threshold to 250 km/h once necessary[20]. On the other side, older conventional lines with only negligible speed improvements by minor upgrades to reach just above 200 km/h[21], have been dropped. The last filter applied was looking at the degree of Chinese involvement and their current progress. To be selected for this study, projects were required to show *credible commitment* by Chinese institutions, either financially or politically. This means that projects without anything more tangible than a simple memorandum of understanding between governments or a carried-out feasibility study have also been excluded.

6.2 Suitable Projects

A total of 15 HSR projects have been found to meet the above-introduced criteria and are suitable to provide evidence for the testing of the hypotheses formulated for this study. This includes three failed projects, which have already seen significant project progress or even construction, but have ultimately been halted, cancelled, or abandoned. The selected projects will be presented in the following, clustered in six regions or categories.

6.2.1 Pan-Asia HSR Network

The so-called *Pan* or *Trans-Asia HSR Network* is certainly at the core of China's HSR ambitions overseas. It covers all countries of mainland Southeast Asia (ASEAN) plus Singapore. Ultimately, the 3,000 km network is planned to connect Southern China with Bangkok via three different routes and from there continuing to Singapore, see Figure 6. The network is planned to include a central route cutting through Laos and Northeast Thailand, an eastern route along most of the Vietnamese coast and crossing Cambodia before reaching Bangkok, and a western route which follows the length of Myanmar all the way to the start of the Malay peninsula. In Bangkok, the three routes are planned to unite and continue through Malaysia via Kuala Lumpur to Singapore. These plans might be complemented by domestic routes in Thailand and Cambodia, while other sources have also considered further routes in Myanmar and Malaysia, and a more direct line from eastern Thailand to central Vietnam by crossing southern Laos (Pavlicevic and Kratz 2017b; Deepak 2018; Chen and Zhang 2015; Xu 2018; Shao et al. 2018; Zhao 2019; MERICS 2018b; Kratz and Pavlicevic 2017). By 2020, most parts of the network have at least been in planning or under construction. Especially the hinterland connections in China to the respective borders have progressed quickly. Also, the Laotian line from the Chinese border to the capital Vientiane is mostly finished

[20] Without a comprehensive HSR network throughout South-East Asia, speeding up the Laotian line to higher speeds makes even less economic sense than building the railway in the first place. Still, the newly built line was already prepared for higher speeds in the future (Kynge et al. 2017b).

[21] This primarily affects projects way in the past such as the North-East-Corridor in the USA or multiple lines from London to other parts of England, where operational speeds are at 201 km/h, which – according to the UIC – officially makes them countries with HSR infrastructure.

(McBeth 2020; Freeman 2019; Yu 2019). Thailand has started tendering or construction for the lines from Bangkok to Chiang Mai, Nakhon Ratchasima and Rayong (D'Silva 2019; Burton 2019; Luekens 2019; Obe and Kishimoto 2019). Plans for the eastern route in Vietnam have seen the slowest progress as it is the longest and most capital-intensive part (Onishi 2019). Myanmar has, after years of enthusiastic support, currently backed away from participation in the project, especially regarding the link from Yangon to Thailand (Lintner 2019; Wu 2019; Lwin 2019).

Figure 6: Pan-Asia HSR Network (Ganjanakhundee 2018)

Regarding the southern part of the network on Malay peninsula, Thailand has pronounced little interest in advancing planning (Burton 2019) and Malaysia cancelled agreements with China for the construction of the East Coast Rail Link, going north from its capital (Reuters 2019). The most promising part to be approached next is the last 300 kilometers from Kuala Lumpur to Singapore, which would already connect a fair share of Malaysian cities by just standing alone - but even this project is currently suspended (Zhuo 2020). When announced, China planned to build and equip most of the Pan-Asia HSR lines itself. However, especially Thailand with its central location and crucial railway hub Bangkok has blocked this development by favoring Japanese Shinkansen technology over the Chinese proposal for its line to Chiang Mai (Kotani 2018). China is still heavily involved in the lines to Rayong and Nong Khai (cf. Ono 2017), but as the Thai government has decided against Chinese financing, little but symbolic progress has been made in recent years (Burton 2019; Green 2019). As of now, China funded 95% of the $5.8bn for the 417 km Laos line and invested in its domestic network to reach the Laotian border from Kunming (Freeman 2019). This part of the network is expected to become operational by 2021, but as it full-stops before crossing to Thailand, it is expected to be little used for international traffic, lacking compatibility and purpose. Even if the line will be finished one day, few people in both Thailand and impoverished Laos are likely to be able to afford tickets for HSR services anyway (Lam 2019; Ono and Kotani 2017). Considering that international HSR traffic is not even working well in border-free areas like the EU, see chapter 5.1, sufficient utilization for profitability can hardly be assumed (cf. Mori 2014). Of course, lines may be increasingly used for freight transport in the meantime, but construction standards and design could have been significantly less sophisticated for this purpose, making the current line unnecessarily expensive.

6.2.2 Indonesia

In Indonesia, plans have originally foreseen a fully developed HSR line across all of Java island, connecting four of the country's five largest cities. After years of negotiations, including a skewed tender process which the Indonesian government first cancelled off before renegotiating and approving it to China in a untransparent "backroom deal" (Kynge et al. 2017b), plans have been slimmed down to the 142 km long line from the capital Jakarta to Bandung. In 2015, Xi Jinping and Indonesian president Joko Widodo agreed on the terms for a Chinese-built HSR link to connect the capital Jakarta with Bandung. The line is planned to be 142 km long and cost $5.2bn, financed entirely by the China Development Bank without demanding any government guarantees (Harner 2015; Leandro and Duarte 2020). Plans to extend the line by more than 600 km to Surabaya have initially been abandoned, before it was decided to contract a Japanese consortium for building a second line from Jakarta while limiting speeds to 160 km/h, significantly reducing investment cost. This “political decision” (Japan Times 2019) was made to ease tensions with Japan after Tokyo has been outraged over the lost tender for the HSR line to Bandung. As of mid-2020, the Chinese HSR project has seen significant delays and budget overruns, which is why the Indonesian government proposed that China and Japan should join forces, extending the original HSR line to Surabaya, instead of building two lines, see Figure 7 (Mufti 2020; Jibiki 2020).

Figure 7: Indonesia's HSR Network Plans (Jibiki 2020)

6.2.3 Hungary & Serbia

One of the proclaimed aims of the BRI is to strengthen China’s foothold in (South-)Eastern Europe, and recent investments in Greece, Poland or Turkey have underlined these aspirations (MERICS 2018b; Cai 2017). Among these projects is the infamous 350 km long HSR line connecting the capitals of Hungary (Budapest) and Serbia (Belgrade), considered to be part of a larger Chinese plan to link its newly acquired port in Piraeus with Central Europe, (Kynge et al. 2017a), see Figure 8. The Balkan regions has long suffered under its chronically underdeveloped railway system, and as development aid by western powers is conceived as scarce, political leaders have welcomed Chinese initiatives for investments (Bellezit 2020). The project has been announced to cost \$2.89bn, and 85% of it is financed with 20-year loans by China Export-Import Bank (Brinza 2020). Others estimate real costs including interest are much higher (Kynge et al. 2017b), suggesting “it will take 2500 years to make profit on the […] line” (Miller 2019). In 2016, the difficulties around the project reached a new level when the construction of the Hungarian section has been put on hold by EU investigations regarding infringements during the public tender (Kynge et al. 2017a). As of 2020, it is currently unclear when and whether the line will ever be operational, while the long pause has already made it a financial disaster for participating Chinese companies, and it is unclear if Serbia and Hungary are ever able to pay their debts back (Brinza 2020).

Figure 8: 'Land Sea Express Route' from Piraeus port to Budapest (Kynge et al. 2017a)

6.2.4 Russia

Since opening its first HSR line between Moscow and St. Petersburg in 2009, Russia has been among the countries with the most ambitious plans for further development (Yakunin 2010). A decade later, few of them seem to become reality anytime soon (UIC 2020a). The most advanced project is the 770-km long line from Moscow to Kazan where trains are planned to run at record-breaking speeds of up to 400 km/h, which would make it the fastest operating train service worldwide[22]. Its central location between Moscow and any destination further east necessarily puts this route at the heart of a potential long-distance Europe-China HSR line[23], see Figure 9. The project is estimated to cost $22.4bn, and, in 2016, a Chinese construction firm has agreed to provide a first ₽400bn or $6.2bn loan for it (Railway

[22] Considering other, even faster lines are not opening before. MAGLEV (magnetic levitation) trains, running at up to 600 km/h, are not taken into account here (Chan 2019; Japan Rail Pass 2019).
[23] An HSR link between Western Europe and Beijing might sound ludicrous from a European viewpoint, but it is in fact not entirely unrealistic. The 1,785 km long line Lanzhou-Urumqi HSR line to Xinjiang already put the Chinese railhead already substantially westwards (UIC 2020a). Considering the realization of a Russian line between Moscow and Yekaterinburg via Kazan and the long-discussed improvement of the link between Moscow and Berlin (Railway Pro 2017), linking the two networks would 'only' require a 2,500 km long line crossing Kazakhstan, where, too, an HSR line has been announced to connect its capital Astana/Nur-Sultan and the largest city Almaty, close to the Chinese border (Railway Technology 2013). If finalized, HSR trains could cover the distance between London and Beijing in well below 72 or even 48 hours. Of course, the recent emergence of magnetically powered transportation systems in vacuum tubes like the *Hyperloop* is questioning the usefulness of such proposals (van Goeverden et al. 2018).

Technology 2018). While no cash has been transferred yet and reports claim the line has been postponed without further notice (RaillyNews 2020), a bilateral agreement at very favorable terms for crisis-struck Russia proves China's commitment to develop Russia's vast territory with HSR infrastructure (Reconnecting Asia 2020b). A German consortium has also been interest in the project, willing to finance €2.7bn (Ilie 2016), a step which appears logical as the current HSR trains in Russia are already running on a broad-gauge adaptation of the *ICE* technology provided by the German tech company *Siemens* (Akiyama 2014).

Figure 9: Conceptual Plans of a Beijing-Berlin HSR Route (Barisitz 2019)

6.2.5 West Asia and Middle East

China has recently tried more often to increase its engagement in the emerging economies of the Middle East and West Asia – in a time in which their relations with the West have deteriorated. Turkey has started to construct its domestic HSR network already in the 2000s and soon plans to have Europe's biggest. The Iran and Saudi Arabia, as well as most other gulf nations have declared their intentions of upgrading their railway network and including HSR lines in their plans (Railway Pro 2016). The 453 km long *Haramain* line from Medina and Mecca has started operation in 2018 and construction is well advanced on the 410 km long HSR line between Tehran and Isfahan (Reconnecting Asia 2020b; UIC 2020a). For latter, the main project partner is a Chinese construction company and the line is financed by an $2.4bn loan by the China Export-Import Bank (GCR 2019). Additionally, the electrification of the Tehran-Mashhad conventional railway has, together with a $1.5bn credit line, already been awarded to China (Railway Pro 2018). This line is a crucial section of any potential HSR link between China and Iran, using parts of the existing HSR networks in Uzbekistan and Xinjiang[24], see Figure 10. From Iran, this link could further lead to Europe,

[24] A straightened and electrified Tehran-Mashhad conventional line can be assumed to be easily transformed to a true HSR line. The credible commitment by China in this case is not only the electrification fund for crisis-struck Iran, but also their domestic HSR line from Lanzhou to Xinjiang's capital Urumqi, a 1,785 km long stretch in the desert which is heavily underused (UIC 2020a; Zhao 2019).

connecting to the Turkish and Hungarian-Serbian section introduced before. All these nations have – in contrast to the formerly introduced projects – not entirely committed themselves to Chinese railway technology. In both Turkey and Saudi Arabia, Chinese companies have been contracted for some construction tasks but not for the overall projects, while rolling stock is also coming from European suppliers (GCR 2014; Railway Technology 2020a). In Iran, the Qom-Arak HSR project has first been awarded to Italian firms – but following the US sanctions, the project has been delegated to China, suggesting that Iran could in future entirely commit to Chinese technology for HSR infrastructure development, an issue which could arise in Turkey too if political tensions remain (Global Tenders 2018).

Figure 10: 'Silk Road Railway' between China and Iran (Dominguez 2015)

6.2.6 Abandoned or Cancelled Projects

This section introduces Chinese overseas HSR projects which have been announced, planned and in some instances even partly constructed, but have finally been cancelled or abandoned. This was the case in Mexico, Venezuela, and Libya. In Libya, Chinese workers have abandoned the construction scene after the start of the civil war in 2011 eradicated plans for a $2.6bn HSR line from Khums to Sirte, hometown of the former dictator Gaddafi. The line was planned as an extension to the $2.9bn HSR link between Benghazi and Sirte, which was contracted to a Russian consortium in 2008 but also remains unfinished (Kynge et al. 2017b; MEED 2010). In the Venezuelan hinterland, the 468 km long HSR line between Anaco and Tinaco has not seen significantly more progress, after Chinese companies abandoned the $7.5bn project as the national crisis intensified in 2015, leaving behind what was called a "red elephant"[25]. The loan for the – meanwhile dismantled – line constitutes a lion's share of the $20bn debt the busted nation owes to China (Kynge et al. 2017b; Goodman 2016). It is unclear how much investments have been made before abandoning the projects, but it can be assumed that Chinese loans remain unpaid until today as both Libya and Venezuela still suffer under a political crisis and turmoil. In Mexico, 2014, the government cancelled an awarded $3.7bn contract to Chinese firms for building a 210 km long HSR line between Mexico City and Queretaro, by citing irregularities regarding the tender (Kynge et al. 2017b). Here, instead of renegotiating terms in favor of the host country, as has happened in Indonesia, the CRRC demanded a compensation of $1.31m for the unfulfilled contract (BBC 2015). There have been other cancelled overseas HSR projects initiated in China, most notably in Myanmar and the US, but as they have never made it beyond the planning stage. Kynge et al. (2017b) values the total of all cancelled projects at $47.5bn and rightfully claims that some failures have been "beyond Beijing's control". Still, especially the cases in Libya and Venezuela are prime examples for the enormous financial risk coming with investments in large infrastructure projects in crisis-stricken countries, a problem which can be observed throughout many plans of the BRI and does not seem to be high on the agenda of Beijing's decision-makers (cf. Shao et al. 2018).

7 Industrial Policy is Dead? Long Live Industrial Policy!

7.1 Made in China 2025

The *Made in China 2025* strategy has often been compared to Germany's *Industrie 4.0* industrial policy strategy and is an fundamental part of Beijing's ideas to close the quality gap between China and the world's leading industrialized nations (Wübbeke et al. 2016; Li 2018; Al-Sayed and Yang 2018; Kennedy 2015). With it, the government wants to "upgrad[e] the mostly backward industrial processes of China's manufacturing sector […] to enhance the competitiveness of its enterprises on domestic markets and to propel their global expansion" (Wübbeke et al. 2016, p. 6) by setting "clear and specific goals for innovation, quality, intelligent manufacturing, and green production" (Kennedy 2015), most similar to a five-year plan. Specifically, the strategy strives to advance Chinese industry excellence in various *key sectors* such as artificial intelligence, communications, biotech, and others, including railway equipment (Al-Sayed and Yang 2018; Morrison 2019). The import dependency of China for high-tech products should be decreased, reaching "self-sufficiency" through more "indigenous innovations" (both Wübbeke et al. 2016, p. 7; cf. Colback 2020). To achieve

[25] This term adapts the idea of *white elephants* with the association of the color red to the socialistic-communistic regimes in Venezuela and China (Goodman 2016).

this, many leading Chinese tech firms are heavily backed by the state regarding funding for research and development as well as protection from foreign competition by setting trade barriers and a low-cost approach to IPRs (Wübbeke et al. 2016).

7.2 How China is Changing the Global IP Paradigm

In line with upgrading domestic industries with the *Made in China 2025* strategy, the government is taking measures to spread, but also control, China's indigenous innovations in the high-tech industry (Cai 2017). In recent decades, China has drastically altered its policies regarding the development of indigenous innovations and intellectual property rights. Already since 1984, when the first IP law in China was introduced, patent laws have been "designed to promote local innovation and seek technology transfer and the diffusion of IP-protected technology" (Yingqiu 2018). China has long demanded foreign firms to establish joined ventures in cooperation with domestic players in exchange for access to the Chinese market. This policy enforced technology transfers from abroad, enabling the development of an own innovative high-tech ecosystem (Salem 1981; Tsang 1995), a strategy which worked very well in certain sectors, e.g. the automotive or photovoltaics industry (La Tour et al. 2011; Zhang and Taylor 2001). After decades of being heavily criticized for ignoring the international dominant rules on IPRs (Bown 2009; EC 2018; Morrison 2019), China is now itself a producer of innovations and therefore became more interested in protecting its innovations (Serrano 2016; Morin et al. 2018; Krizic and Serrano 2017). Here, while generally "aligning its IP legislation […] with standards promoted by the EU and the US" (Krizic and Serrano 2017, p. 57), China is following a different approach than the existing hegemons on the global tech market (cf. Yingqiu 2018; Amighini 2018). The predominant IPR model in the West is that innovation capability and technology development are seen as a fair part of the value-added chain (Breznitz and Murphree 2013), which is why innovators ask for expensive royalty options to use their technologies, fees of which no country pays more than China (Arcesati 2019). In contrast, the Chinese industry is "emphasiz[ing] IP as another factor of production, not as a source of profit or unique competitive advantage" (Breznitz and Murphree 2013, p. 3). This means Chinese firms can access domestically developed technologies without spending significant amounts for royalty fees. This model of "cheap or royalty free licensing" (p. 28) is challenging global markets and "pushes foreign standard alliances to lower royalty rates" (p. 2), thus changing the traditional "global IP paradigm" (Stevenson-Yang and DeWoskin 2005, p. 9; Morin 2014, p. 1). This new approach, manifested by *Made in China 2025*, aims to boost "low-cost and rapid innovation [to] serve unmet needs in emerging [BRI] markets […], transform China into a world innovation hub [and] a global center for open source manufacturing […] with faster and less expensive development cycle to commercialize a new innovation" (Al-Sayed and Yang 2018, p. 3). The strong involvement by state agencies and the government in standard-setting and IPR policy is creating a large ecosystem, in which firms can "develop and test technologies domestically before seeking their inclusion in international standards" (Breznitz and Murphree 2013, p. 3). Therefore, once global standards are set, Chinese domestic standards tend to be more mature, which makes them preferable to other, less tested standards.

8 Standards – The Universal Language of the World?

Parallel with its changing approach towards IPRs, China is also increasing its engagement in the sphere of international standard-setting. This chapter puts this effort into context, by first describing the historical development of technology standardization and its corresponding institutions. Then, the theory by Seaman (2020), describing a "dual-track approach" (p. 2) with which China is trying to internationalize its domestic standards, will be introduced. This is the main framework which will later be used as groundwork to study the relevance of standards within Chinese HSR projects overseas. In order to provide sufficient background information for finding evidence within these projects, this chapter concludes by presenting the most relevant standards in the railway sector, focusing on HSR.

8.1 Who sets Global Standards?

While certain standards may have long existed on local or regional levels – mostly consisting of non-institutionalized de-facto standards like the Roman roads introduced in the beginning – it took the international community long to set up institutions powerful enough to propose common standards and enforce their use. Before the 1980s, only few industries agreed on common global standards and standard setting was mostly carried out on a regional or national level. Today, with the ongoing globalization of the international economy, common standards have become ever more important across all industry sectors (Boli and Thomas 1999; Mattli and Büthe 2003). The first global standards organization, the *International Electrotechnical Commission* (IEC), was formed in 1906, and introduced various standards for electrotechnical units and appliances (IEC 2020). Then, with the foundation of the *International Standards Organization* (ISO) in 1947, machinery became one of the first industries to widely introduce globally accepted standards, especially for bulk products like screws or bearings, and wearing parts of vehicles like tires or belts. Among these early standards, one could also find many *abstract* standards, such as reference temperatures or other calculation measures. To find appropriate standards, ISO often adopted existing norms from its national member bodies like the *British Standards Institution* (BSI) or the German *Deutsches Insitut* *für Normung* (DIN), which – at that time – had been existing for decades already (ISO 2020; Villarreal 2018). The *World Trade Organization* (WTO) requires its members that standards should “not create unnecessary obstacles” (WTO 2020) within the *Technical Barriers to Trade Agreement* (TBT), and has also been one of the most important and influential entities in international standardization (WTO 2020). These organizations are only few of thousands of standard bodies worldwide – many sectoral and with geographically limited influence – and have long since stopped limiting themselves to pure technical standard-setting. They are increasingly also formulating standards for societal or environmental issues, behavioral, assessment or process standards and more general recommendations. As shown in the literature review, numerous scholars have studied how national or commercial actors are exerting influence on the processes of standard-setting in their own interest, e.g. by active participation in the above-introduced SSOs or by developing own standards and forging alliances to support and spread their use. With China being disintegrated in the global economy for much of the 20th century, it missed early participation opportunities and a consolidation of power in the international standardization regime, contrary to many of the Western powers. The international SSO introduced before have long been – and are still today – dominated by European nations and Japan, and, compared to other international organizations, with a relatively little share by the US (Seaman 2020; Fägersten and Rühlig 2019; Mu and Wu 2005). Only in the last two decades, after its admission to the WTO, China managed to increase its influence in these organizations. National strategies regarding standardization and innovation policy have since been continuously modified (Mu and Wu 2005; Breznitz and Murphree 2013; Seaman 2020; Zhang 2005). Undeniably, China is today seeking a more dominant position in the international standard setting regime. However, the first attempts of China internationalize some of their standards within the high-tech industry have failed, as the “coalitions supporting [them], have been narrow and weak relative to […] their foreign competitors” (Kennedy 2006, p. 42). Consequently, the Chinese leadership increasingly started to see standard-setting as an important tool to boost its domestic industry and improve competitiveness on the global market (cf. Sun 2019). Breznitz and Murphree (2013) even cites the mindset of Chinese bureaucrats with the dictum[26]: “[countries with] third tier companies make products; second tier make technology; first tier make standards” (p. 4). Active participation in the international SSO is sought and China’s support for global standards is emphasized at every opportunity. Here, the BRI is supposed to play a crucial role to trigger foreign interest for Chinese standards, as, for instance, formalized in the BRI-specific three-

[26] Corresponding “Chinese saying”: “三流企业做产品; 二流企业做技术; 一流企业做标准” (sānliú qǐyè zuò chǎnpǐn; èrliú qǐyè zuò jìshù; yìliú qǐyè zuò biāozhǔn) (Breznitz and Murphree 2013, p. 4).

year-plans of the state-owned telecommunications firm *China Unicom*. The importance assigned to standards is very vividly shown by the opening statement of these documents: “Standards are the fruit of the progress of human civilization and the universal language of the world. Standards promote world connectivity” (China OBOR Network 2018, p. 1).

8.2 China’s Dual-Track Approach on Standard-Setting

A very recent analysis of Chinas engagement in international standard-setting has been described by John Seaman (2020). According to Seaman, standards-setting is a central policy domain for the Chinese government, and “policymakers view standards development as a fundamental component in facilitating China’s industrial transformation” (p. 14), ergo, comply with the *Made in China 2025* strategy. Similar to Breznitz and Murphree, he concludes that “China’s industrial strategy seeks to transform the country […] into a first-tier, innovation-driven economy capable of setting global technology standards, [which] allows firms to gain first-mover advantage and acquire market share or market dominance” (p. 14). The theory of first-mover advantage – a privilege formerly only leveraged by select Western economies – was already introduced by Mattli and Büthe (2003). To achieve the same privilege for China, Seaman proposes two possible pathways, describing a “dual-track approach” (p. 2). First, China tries to increase its influence in international standard-setting by its engagement in the major SSOs, especially for “areas where China is competitive” (p. 20). This strategy is introduced as the “cooperative approach” (p. 20) where integration in existing international institutions and cooperation with other stakeholders is actively sought. However, institutional standard-setting tend to lengthy processes with little chances of rapid progress, especially if the proposing stakeholder is from China. The current reluctance of many countries around the world to implement the 5G standards developed by the communications firm *Huawei* proves that, from a Chinese viewpoint, the odds for successful engagement in these organizations are slim (cf. Kaska et al. 2019). Eventually, the cooperative approach may lead to no more success than the failed attempts to internationalize the TD-SCDMA (for mobile communications) and WAPI (for Wireless LAN encryption) standards back in the 2000s. Western alternatives have been chosen instead, although the Chinese counterparts were not technologically inferior (Lee and Oh 2008). To address these problems of the cooperative approach, Seaman introduces a second strategy with which China is trying to internationalize its standards with smaller but allegedly more effective steps. By using its investment capabilities and the BRI framework, this “China-centered approach [is using] the multiplication of bilateral cooperation agreements” (p. 24) to export Chinese domestic standards. In fact, he claims, this has caused that “an increasing amount of technical standards has bypassed [the international SSO] system" (p. 29). Instead, "the diffusion of Chinese technological standards is […] drawn forward through […] physical infrastructure" (p. 27), for which China has the ideal framework in financial regards and capacity abilities. This thesis further frames this approach as *de-facto standard-setting*, for which legal agreements apart of "mutual standards recognition" (p. 25) are rarely or not at all necessary. Seaman believes that the question which of the two pathways will prevail depends on "the degree to which China believes in its ability to shape the [cooperative] process" (p. 29). As a latecomer, it has so far seen difficulties in lobbying for its interests in the existing international framework, but "as China's [technological] ability to propose innovations […] grows […], its ability to transform the international standardization landscape will also expand" (p. 28).

8.3 Standardization in the Railway Industry

This section introduces the most relevant SSOs in the railway sector and the most important standards in railway infrastructure, technology, and operation. It will be shown why it has been hard to develop uniform standards worldwide, and why this specifically applies to the HSR industry. The *International Union of Railways* (UIC) has been the main global SSO in the railway sector since its foundation in 1922. The UIC claims that its "core objective [has been] the technical harmonisation of the railway system [to create] common rules to ensure safety and efficiency in the design, construction, operation and maintenance of the railway system" (UIC 2020d). Several other institutions are also claiming a role as regional or even international SSOs (Rao and Tsai 2007). In the EU, the *European Union Agency for Railways* is in a predominant position to define standards for the railways sector and the European HSR system (ERA 2020; EU 2010). The iconically named *International High-Speed Rail Association* (IHRA) wants to "establish an international HSR standard based on the principle of 'Crash Avoidance'" (IHRA 2020a), but as it consists only of Japanese and Taiwanese members, it is far from being a truly multilateral international organization (IHRA 2020b). The US has established the *Federal Railroad Administration* within the *U.S. Department of Transportation* (FRA 2020), but as the US has nearly no HSR tracks are currently in operation, a uniform national standard for it does not even exist and is still in development (cf. Petty 2009). Although – or because – so many institutions claim leadership in the railways standards sector, few standards have reached global consensus, almost a century after the foundation of the UIC. Global rail infrastructure is a hotchpotch of different systems, and rail technology remains largely heterogenous and incompatible. The most important standard for railway infrastructure is certainly the track gauge, meaning the spacing between the two metal bars forming the track. It has been technically sensible to use different gauges throughout the world, depending on transport requirements as well as local geography and geology, see Figure 11.. Narrow gauges use less space and are better suited for mountainous regions, as they can cling better to steep slopes and lines need less engineering structures like bridges or tunnels. Broad gauges are better for reaching high speeds, as railcars are less likely to derail. They also better distribute weight and are therefore often used for swampy or instable terrain (RailSystem 2020).

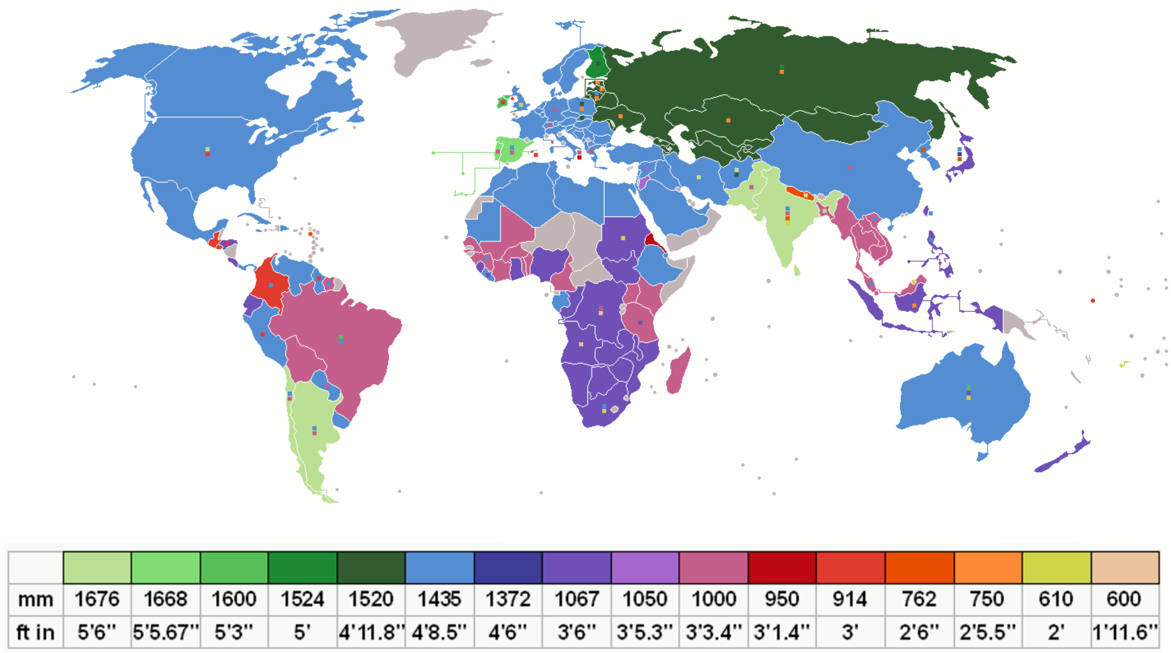

Figure 11: Different Railroad Gauges Worldwide (Wikimedia C. 2017)

To operate services between areas with different gauges, the trains' bogies need to be refitted at break-of-gauge-stations. This procedure takes up to several hours and is therefore not applicable for HSR services, which is why all contagious HSR networks today tend to use the same gauge, respectively. Another option is to use trains with gauge changers and variable bogies, but they are technically complex and cannot reach top speeds safely (Puffert 2009). Today, most countries use the 1,435 mm *standard* gauge. However, still only around 55% of modern rail infrastructure uses the standard gauge[27] (Puffert 2009). In some instances, choosing non-standard gauges was even a political decision. When the Russian empire decided to accelerate the development of its railroad network in the 19th century, it has been a laggard to many other powers, especially those in Western Europe (Acemoglu and Robinson 2012). However, with the knowledge of existing gauge standards in England, France and especially the hostile German empire, the Russian czars deliberately decided to choose a

[27] Other noteworthy gauges are the 1,520 mm broad gauge used in the contiguous system of former Soviet Union members and adjacent countries, the 1,676 mm Indian gauge used in South Asia, Argentina and Chile, the 1,067 mm narrow gauge used in most of Africa, as well as Australia and parts of East Asia and, and the 1,000 mm meter gauge used in many mountainous networks throughout the world, e.g. in the Andes, South-East Asia, East Africa and parts of Switzerland (Puffert 2009).

different track gauge than its neighbors to the West, a 1,520 mm broad-gauge instead of the 1,435 mm standard-gauge. From a militaristic viewpoint, this perfectly made sense. If one day, enemy troops would take over part of Russia's territory, the existing railway infrastructure would be rather useless to them, both for economic and military purposes, as wagons and locomotives would not fit on the newly conquered tracks. Regarding the long and swampy supply lines in Eastern Europe, this played out as a unique defense advantage. Whenever Russia feared an invasion, they could just retrench all rolling stock to the East and opponents where left with nothing more than metal bars (Acemoglu and Robinson 2012). When the Soviet Union later took control of the vast territories of Central Asia and much of Eastern Europe, they exported their broad-gauge standard to its satellite states. Although not recognized as global standard, the enormous expansion of the Soviet Union led to a *de-facto standard* in the region and, even today, there is no rail line which connects East Asia with Europe without at least two break-of-gauges (Putz 2016). Because converting gauges is expensive and impractical while maintaining a running economy, it is unlikely that this will change anytime soon. The second-most important specification for railways is the electrification system, which can vary regarding current (AC/DC), voltage and frequency (He et al. 2016). Different systems are widely distributed worldwide, see Figure 12 (ABB 2010). While some trains are designed to switch between electrification systems, such adaptations are expensive and technically limited (Puente 2013). As Nunno (2018) explains, "France's early adoption of [HSR] and its central position [led to] most other [HSR] lines in Europe [being] built to the French standards for speeds, voltage and signaling". These systems run with 25 kV AC at 50 Hz and have later been used worldwide (EU 2010; ABB 2010), but this usually restricts trains from using other conventional tracks. In Germany, where HSR trains run on the same tracks as slower passenger traffic or freight, the entire system uses German railway standards with. an older, less powerful 15 kV AC system at 16.7 Hz (Nunno 2018; ABB 2010). Hence, only specialized trains can run across borders and connect to other HSR networks, such as those in France or Belgium (Jamasb et al. 2006; ABB 2010). Outside of Europe, most other HSR networks are also using 25 kV systems (Puffert 2009). Besides gauge width and electrification systems, numerous other specifications must be defined when constructing a new HSR line, e.g. minimum curve radii at defined speeds, signaling systems or communication systems (UIC 2020d). Japan, as an example, heavily counts on their indigenous technologies, especially regarding trainsets (Sone 2015; Rao and Tsai 2007; Japanese Railway Bureau 2012). In contrast to Germany, this obviously does not affect interoperability as Japan's island network is not connected to other HSR systems. However, as choosing Japanese HSR standards for a new domestic network is leading to a strong path dependency, it certainly affects the business opportunities of Japanese HSR firms for overseas contracts in countries which place importance to international connectivity.

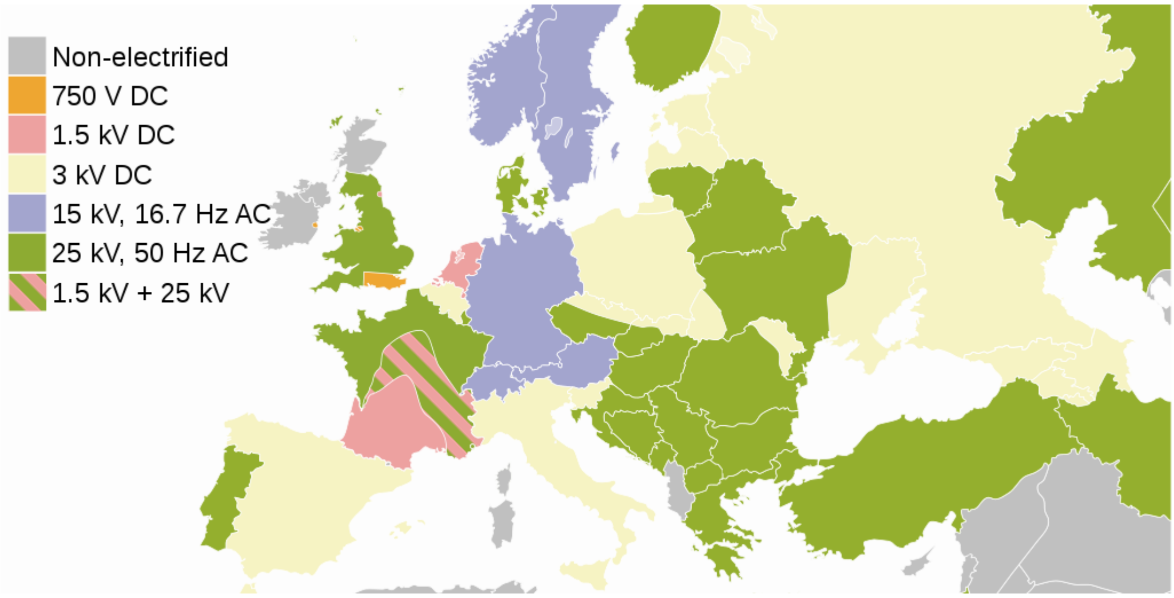

Figure 12: Railroad Electrification Systems across Europe (Wikimedia C. 2020a)

Concluding, the world still lacks uniform standards for HSR systems and technologies vary across providers. Countries without an own domestic HSR industry tend to stick to the respective standards established by the contractor for their first line. This tendency can be observed in Morocco and South Korea (with French TGV technology), in Uzbekistan and Saudi Arabia (with Spanish AVE technology), in Russia (with a broad-gauge adaptation of German ICE technology) and in Taiwan (with Japanese Shinkansen technology) (cf. Akiyama 2014). The lack of uniform international standards in the field is best illustrated by the (seemingly desperate) US search to copy other national standards during the planning phase for their first HSR line (Petty 2009). Switching or using different standards across the network would lead to high adaptation costs or lead to incompatibility, thus, decreasing flexibility and service reliability. This path dependency naturally leads to market imperfections and restricts many HSR network of connecting across international borders (Akiyama 2014). Therefore, only few countries chose to contract suppliers from countries with different standards, among them the rapidly expanding network in Turkey, where Spanish, Italian and Chinese companies have collectively been involved (UIC 2018). The weak conformity of international standards in the HSR sector can be explained due to the fact, that infrastructure is by definition *immobile*, which means that train makers which are not operating in a highly inclusive market, such as China or the EU, simply do not see the necessity of global standards. While the world hasn't even completely agreed on a common track gauge for conventional railways, and even Japan, the birthland of HSR traffic, operates two domestic networks with different gauge, the highest supranational level railway standardization has successfully gone so far is to the European one[28]. Another reason for lacking interest of national manufacturers in international standardization is that the HSR market tends to value national brand recognition. The trademarks *Shinkansen*[29], *Bullet Train*[30], *TGV*[31], or *ICE*[32] are highly appreciated and well-known throughout the world, probably way less than the later introduced Spanish *AVE*[33], and the Chinese versions *gaotie*[34], *hexie*[35], or *fuxing*[36] (cf. Ma 2015), all of which use highly politicized vocabulary (cf. Xu 2018). Traditional national manufacturers are not interested in losing this privileged status, so they would hardly aim to standardize systems as this would deprive them of their claim for technological uniqueness, a dilemma further increasing China's motivation in uniform global HSR standards.

9 From Technology Transfer to De-Facto Standard-Setting

This chapter explores the relevance of China's approaches to IPRs and international standard-setting within the above introduced HSR projects by revealing an underlying mechanism between its policy of forced technology transfer in exchange for market access and the long-term internationalization of Chinese domestic standards. It will be shown that China's commitment to innovation within its industrial policies, the strong support for inexpensive access to intellectual property and standards, and the subsidies for both domestic and overseas development are all crucial elements of this mechanism. Eventually, with this foundation being built, internationalizing the domestic standards developed indigenously within this process is following the two pathways proposed by Seaman (2020): First, by increasing China's influence in the relevant international SSOs and strengthening alliances which support its standards there, and, second, by creating a technological lock-in situation in key regions of potential future development and therefore increasing the dependency on Chinese standards. The analysis will show if and how the selected HSR projects overseas contribute to these strategies, using them to provide evidence along the individual steps of the mechanism.

[28] Here, the most relevant framework is the European Train Control System (ETCS), a signaling and management system which is one day planned to apply to all European railway operations. However, implementation is stalling, and few countries invested in ETCS technology so far (Schnieder 2019).
[29] Japanese: 新幹線 (literally: New Trunk Line)
[30] Colloquial term for Japanese HSR trains due to their unique shape, which is still used today, although it is technically not necessary anymore
[31] French: Train á Grand Vitesse (literally: Train at/of high speed)
[32] Inter-City Express (Germany)
[33] Spanish: Alta Velocidad Española (literally: Spanish High-Speed)
[34] Chinese: 高铁 (literally: High[-Speed] Train)
[35] Chinese: 和谐号 (literally: Harmony)
[36] Chinese: 复兴号 (literally: Rejuvenation)

9.1 Adoption of Foreign Technology

When China started the development of its domestic HSR network in the 2000s, it was lacking an own industry and therefore dependent on foreign suppliers. While, as shown, most other countries chose to stick with one firm to supply construction, electrification, signaling, and rolling stock, China contracted firms from Japan, France, and Germany – all using different technologies and standards (Akiyama 2014). As described in chapter 7.2, in exchange for market access, these companies were demanded to share their technologies and intellectual property with Chinese domestic firms. This large-scale technology transfer of long developed high-tech products like HSR trainsets (compare Figure 13), digitized communications and signaling infrastructure, and software optimized for HSR operations, allowed newly established Chinese railway companies to “rapidly adapt and improve the designs for local use”, transforming the diverse foreign standards in one uniform Chinese standard. This approach was “supported by the decision in 2008 to make China as self-sufficient as possible in HSR technology by mobilizing research and development resources on a massive scale to establish China’s own systems and standards” (both Lawrence et al. 2019b, p. 18), a claim also found in the *Made in China 2025* strategy (Wübbeke et al. 2016), see chapter 4.3.

Figure 13: China’s CRH3 in comparison with a German ICE3 (Akiyama 2014)

9.2 Establishment of an Innovation Ecosystem

Not only by setting up companies which import and adapt foreign innovations, also by “develop[ing] a broad ‘ecosystem’ of universities and research organizations”, China has built up enormous “research and development capacity” in its HSR industry. In few years, thousands of researchers and engineers have developed an indigenous “technological base for both infrastructure components and rolling stock” (all Lawrence et al. 2019b, p. 18). These efforts are heavily influenced by public policy bodies controlled by the Chinese government, such as the Ministry of Railways, which introduced a “management model” for the HSR industry in which “everything has a standard, everything has a process, everything has a responsible person” (both Lawrence 2019a, p. 45), demands which are manifested in the *Cooperation Agreement of China High-speed Train Independent Innovation Joint Action Plan*. China’s low-cost IPR approach described by Breznitz and Murphree and the support by its industrial policy, like the *Made in China 2025* strategy, has allowed many new collaborators to quickly join the ecosystem, efficiently scaling it up and creating the largest such industry worldwide. Today, China is home to the world’s by far largest rolling stock company, see Figure 14, the five (sic!) largest construction companies (Statista 2019), among them two railway construction firms, and the largest electrified railway network (UIC 2020c). The benefits through China’s inexpensive access to uniform HSR technology standards has given its industry a significant cost advantage over foreign competitors from Europe or Japan, who are also often forced to ask for higher margins in order to finance the use of IPRs (cf. Wang 2018 - 2018). This is one of the reasons why China is able to build one kilometer of HSR track for 30-50% less than in Europe (Ollivier et al. 2014c; Lawrence et al. 2019b).

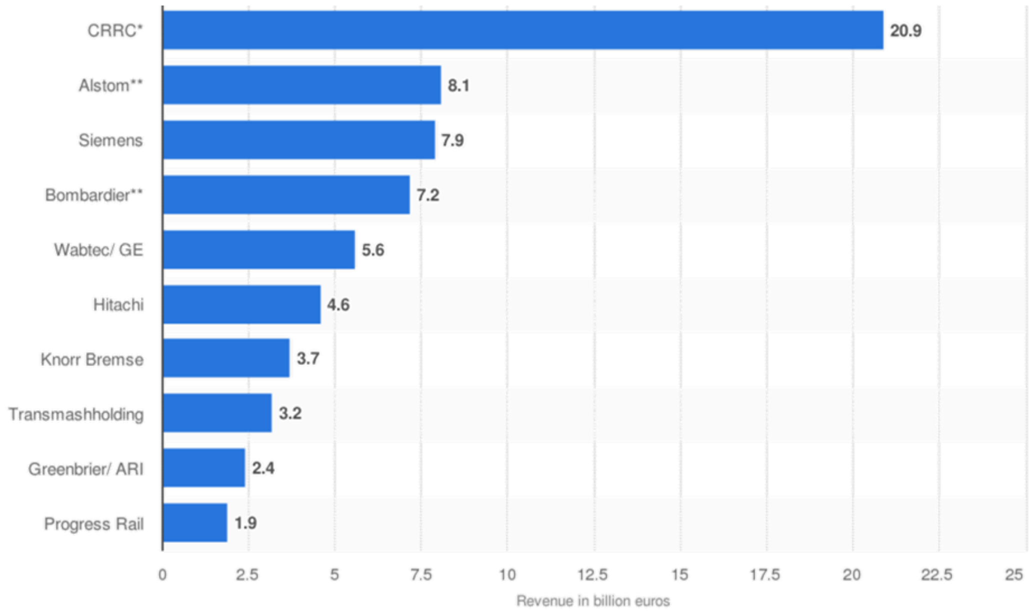

Figure 14: Revenues of Rolling Stock Manufacturers, 2018 (Statista 2020)

9.3 Creation of an Artificially Large Domestic Market

The competitive advantage is further increased by the large scaling opportunities the Chinese HSR industry could access for manufacturing of rolling stock and construction of HSR tracks by its massive domestic market. As Serrano (2016) notes, China is using this strategy across many industries by “mak[ing] good use of the gravitational pull of its enormous and rapidly growing domestic market to push for its development priorities” (p. 358). While most HSR lines in China are not operating profitable, see chapter 5.2, and some of them being completely underused, the high market demand in this sector can be considered as entirely artificial and fully subsidized by the government (Mitchell and Liu 2018). Consequently, the state-owned firms in the sector are all assumed to be heavily indebted. The *China Railway Corporation*, operator and investor of the domestic rail network, reported debts of an astonishing $770bn as of June 2020 (Watanabe 2020), while further losing money as “interest payments exceed operating profits” (Mitchell and Liu 2018). Reliable financial information on the other conglomerates in the sector could not be found, but latter scholars estimate their financial situation as no better, an assumption which appears logical looking at the funding situation of the projects presented before. Whether the losses are eventually registered by the state, state-owned banks, or state-owned construction companies does not matter – as “Li Hongchang, a transport expert at Beijing Jiaotong University [comments:] China Railway’s debt is government-backed […]. It won’t default.” (Mitchell and Liu 2018).

9.4 Improvement of Technology and Standards

This artificial demand may as well only serve as a means to an end, as it provided innovators with the opportunity of testing their technologies and standards on a large scale. The positive feedback circle between domestic development and high demand helped to create products which are indeed in no way inferior than those of the further HSR hegemons (Kunze and Windels 2018; Zhang 2018). While Western nations still claim "it will take a very long time before they (Chinese suppliers) can become credible suppliers for European infrastructure managers" (EC 2019), the emerging and now market-leading Chinese manufacturers nowadays can very well keep up with the international competition, a claim recently proved by the operative launch of the first world’s autonomous HSR system (Wilson 2020). The Chinese HSR industry could therefore rightly demand more international recognition for their products – even in industrialized countries. De facto, due to the enormous length of the network, there are no HSR standards for construction, operation, and safety, which have been tested more than those of the Chinese HSR ecosystem. This gives China the power of the before-cited *first-mover advantage*, see chapter 8.2. Once uniform global HSR standards will be discussed, the Chinese standards will most likely be more robust[37] and applicable than those of the competitors from Germany, Japan, or France.

[37] Of course, the 2011 accident near Wenzhou has raised questions regarding safety standards of the Chinese HSR industry. However, except for the Shinkansen system, no sizeable domestic network has been running without any major accidents since its establishment (Sone 2015). Indeed, the most fatal accident in HSR history happened in Germany, where an ICE collided with a road bridge at 200 km/h, killing 101 (Rao and Tsai 2007).

9.5 Establishment of Inexpensive IPR Models

So far, it has been shown how China used its industrial policy and IPR legislation to support the development of domestic technology standards within the HSR sector. Once this has been achieved, what role do the introduced overseas HSR projects play in this context and why are they ultimately relevant for this mechanism to work? The second part of this analysis will show how they contribute to establishing a changed IP paradigm worldwide and internationalize Chinese HSR standards. Overseas HSR projects can here be seen as a platform to export the Chinese model of cheap IP licensing. The inexpensive availability of standards and IP on technology is a crucial factor for other – especially emerging – countries to decide for Chinese involvement in their HSR projects (cf. Mattli and Büthe 2003). To further benefit of this, the formerly introduced concept of creating joint ventures which transfer technology to host countries has been taken back from China to foreign countries. In some of the presented projects, e.g. in Indonesia, Iran and Hungary/Serbia, the integration of local companies and workers has been a high-priority demand by the respective government. Chinese partners have been more than happily fulfilling these requests and sharing their IP through technology transfer models, while carefully watching that non-Chinese stakeholders would not gain usable leverage over the project. In the following, this will be concretely outlined for the HSR project in Laos. Here, a "close-door consensus" (Janssen 2017) between both governments has agreed on BOT contract, an approach which allows Chinese long-term involvement to the greatest possible extent, see chapter 5.3. Reports claim that the country has hardly benefitted from the need of workforce during construction as "Chinese companies [have been] responsible for 90 [%] of the total construction work" (Qingqing 2017), and Laotians have usually been left to side jobs (Gronholt-Pedersen 2012). Estimates range from 30,000 to 200,000 Chinese workers, which have flooded the mostly rural nation, home to just 6.8 million people, not only for the construction of the railway, but also a parallel highway (Janssen 2017; Calderon 2013). China's investments in Laos does also generate local jobs, but with most of them being in border regions and Chinese workers often being more skilled than their Laotian counterparts, a lion's share of the new lucrative jobs may go to them (McBeth 2020). By using a BOT contract, China is indeed training local enterprises and workers in the field, but as they need to adhere to Chinese standards (they do not even have their own ones) the development of a regional HSR ecosystem is consequently following Chinese rules regarding IPR availability. For Beijing, such mechanisms have been a welcomed opportunity to point out some of the proclaimed main goals of the BRI: To create "mutual benefit, [to] maintain closer economic ties, [to] enhance cultural exchanges; to encourage different civilizations to learn from each other and flourish together; and to promote mutual understanding, peace and friendship among people of all countries" (Du 2016, p. 36). Hiding behind flowery language, China has eventually reached one of its main goals: As other countries have benefitted of the Chinese model for IPRs, they are more likely to join an alliance to change the worldwide paradigm on these issues.

9.6 Subsidization of Technology Export

Not only the inexpensive availability of IP and technology standards is supporting the case of Chinese HSR projects overseas. Additionally, the BRI offers the perfect framework to convince other countries in advancing the Chinese model of infrastructure development. The apparently untamable support given for BRI projects allows Chinese firms to bid for HSR projects at below-cost dumping prices. While developed countries or such with strained relationships to China may resist such offers, for many of the emerging countries in South-East or Central Asia Chinese involvement in infrastructure projects can be considered as the only viable choice. Meanwhile, the Chinese government is more than dedicated in making this cooperation happen. Such a 'whatever-it-costs' mentality could have been well observed at the Indonesian case, where, after an initial tender was cancelled off, political talks between the heads of state have suddenly enabled a new, much lower bid for the project by Chinese consortia, leaving Japanese competition unnoticed, see chapter 6.2.2. Evidence for irregularities in tenders such as untransparent bidding processes or other infringements could also be found for the projects in Hungary/Serbia, see chapter 6.2.3, and Mexico, see chapter 6.2.6.

9.7 From Standards-Taker to Standards-Maker[38]

The last step of the proposed mechanism is the internationalization of Chinese technology standards. This chapter analyzes if this is the case and how overseas HSR projects contribute to it, using the dual-track approach framework proposed by Seaman, see chapter 8.2.

9.7.1 Increasing Involvement in International SSOs

Seaman proposes that China is aiming to set standards with a *cooperative* approach, by increasing its involvement in international organizations. As indicated in chapter 0, the largest international SSOs are mostly dominated by advanced industrial countries, especially by Germany, the US, and the UK (cf. Seaman 2020; Utting et al. 2012). Apart from China, no other developing country has managed to significantly increase its share of secretariats held at ISO and IEC in the last decades, let alone chairmanships (Stephenson and Group, W.B.D.R. 1997), see chapter 0. In fact, as a result of the decline of the Soviet Union, many countries from Eastern Europe and Central Asia had to relinquish some of their powers in

[38] Seaman (2020) ; cf. Morin et al. (2018).

the committee, although they were not even represented evenly ever before. With its engagement in Russia, Kazakhstan, and Serbia, China is now investing in HSR projects in many of these nations. As the ability to set international standards is crucial to wield political and economic power, it is unlikely that the dominating western nations voluntarily waive their high influence in these bodies. However, especially the BRIICS[39] nations have demanded a fairer share in SSOs (Fägersten and Rühlig 2019). Still, although China is investing in Indonesia and Russia, and intentions have been announced in Brazil, South Africa and even India, the ideological ties to western powers suggest that it is unlikely that these countries intent to cooperate and build up a large standard coalitions with China against the currently dominating nations (cf. Kennedy 2006). As shown in chapter 8.2, earlier attempts by China – in cooperation with South Korea – to build up coalitions of power for technology standards have failed. When looking at the railway sector, the international standard-setting regime in can be considered as explicitly weak, see chapter 8.3. Few uniform standards have been developed and implemented for conventional rail applications, let alone HSR technologies. Following the argument of Seaman, China, with its elaborated standards and its strong motivation for setting standards, would now try to change this narrative by increasing its engagement in international organizations and trying to propose uniform global standards as a first-mover. Already during the early phase of scaling up its HSR ecosystem, "China has worked with the [UIC] to develop international standards for HSR equipment, and its technology is compliant with these standards" (Lawrence et al. 2019b, p. 18). Beijing's officially declared aim is to make 'these standards'[40] available worldwide, claiming that "as a great power, it must be an active participant in global affairs, helping to make the international rules" (Miller 2019). The collaboration with the UIC is an evidence that China is trying to make use of its first-mover advantage and exert influence on the SSO. In 2020, the 11th world congress on HSR hosted by the UIC was planned to take place in Beijing. The event was eventually postponed due to the Covid19 pandemic, but its announcement seemed heavily influenced by China's Politburo, emphasizing the "latest developments of HSR systems in China and across the world" (UIC 2019b). The secretariat for 'Intercity & High Speed' within the 'Passenger Department' as well as the 'UIC Asia-Pacific' department are chaired by China Railway representatives, of which latter declared "long-term strategic visions for 2050[41] [and a] three-year […] plan" (UIC 2019a), both terms which show remarkable re-

[39] Brazil, Russia, India, Indonesia, China & South Africa
[40] Concretely, this would currently apply to the standard TB 10621-2014 (CODCHI 2014).
[41] Oddly enough, this is one year after the planned fulfillment of the 'great rejuvenation of the Chinese nation' in 2049, see chapter 1.2.

semblance with Chinese politics vocabulary. The HSR industry in Europe and Japan is focused on its own SSOs, see chapter 8.3, and the US is generally reluctant towards powerful SSOs (cf. Mattli and Büthe 2003). This dispersion of power in the sector suggests that China – as the last remaining great power not having control over an own SSO – could plan to become the most influential actor within the UIC, with the intention of making it the dominant SSO in the railway sector. Here, it can be assumed that any HSR line outside of Japan or Europe tends to be claimed as being represented by the UIC, not by IHRA or the ERA, making the organization de facto more powerful. If China manages to use its current HSR projects in Indonesia, Russia, and Iran – all large emerging countries which are interested in inexpensive standards – to build a more powerful coalition in the UIC, it could be more successful in internationalizing its technology standards as it has been at the WAPI case, see chapter 8.2. However, apart from the engagement above, no evidence for disproportionate engagement of Chinese stakeholders could be found within the UIC, regarding e.g. financial support to its budget or public support by the SSO for the introduced Chinese HSR projects. Nevertheless, whether this cooperative approach is actively pursued by Beijing's decisionmakers or not, China's demand for increased participation in international SSOs puts current Western hegemons in a dilemma. On the one side, if they integrate Chinese standards better by establishing them in some sectors (e.g. HSR), they might lose political control over these institutions, risking their multilateral and democratic legitimization. On the other side, blocking the most populated country and soon-to-be largest economy from influencing such central global mechanisms could risk a meltdown of the traditional standard-setting system. Once other emerging economies do not see their development recognized appropriately, facing a similar destiny as China regarding their own role in international organizations, they might completely sideline with China here – and establish alternative standard-setting regimes (cf. Seaman 2020), such as changing the global narrative on standard-setting from institutional engagement to de-facto standards, as outlined in the following chapter.

9.7.2 Setting De-Facto Standards

In addition to the cooperative approach by increasing influence in international organizations, Seaman opened up another pathway for China to set global standards. As described in chapter 8.2, this approach can be transferred to the HSR sector as a *de-facto standard-setting* strategy, triggered by a path dependency and a technological lock-in situation which easily evolves in formerly underdeveloped infrastructure systems like HSR see chapter 8.3. Once a first route within a domestic network has been constructed and taken into operation, it is not practical to switch to other standards later. Perl and Goetz (2015), when describing "three global development strategies for [HSR]" (p. 134), have also pointed out that – even if inconsistencies are discovered – the initial decision for a specific HSR system is usually not being changed later, as the opportunity costs are too high. This specifically applies to dedicated HSR lines, meaning tracks which exclude any other traffic than high-speed, whether they are designed as "exclusive corridors" (like in Japan) or "comprehensive national networks" (like in China) (both Perl and Goetz 2015, p. 136). If we consider that HSR is in future developing as a major mode of transportation across many regions of the world[42], most countries and regions need to make this critical decision for path dependency in this or the next decade. In contrast to the HSR ecosystems of Japan and Europe, the Chinese HSR industry is not limiting itself to certain world's regions but claims control over *global* HSR development (cf. Xu 2018). If China manages to establish its domestic HSR standards on certain key routes of newly developing regional networks, it increases the opportunity costs of switching to other suppliers later and, hence, ties long-term demand to its technology. Additionally, providing technology for the first lines in closed networks – such as on islands or otherwise geographically (or politically) constrained regions – is having the same lock-in effect on a smaller scale. Most of the introduced Chinese HSR projects have been found to be at the very core of such regional networks. The HSR line in Laos is constructed on the most direct line between Southern China and Bangkok, suggesting that any future link between these regions would use the link (cf. Janssen 2017). The same applies to any part of a possible route between Bangkok and Singapore, such as the East Coast Rail Link along the coast of Malaysia. In South-Eastern Europe, any future development of the corridor Turkey/Greece towards Central and Western Europe would make use of the Chinese-constructed HSR line between Belgrade and Budapest. In Russia, the HSR line between Moscow and Kazan lies on the most direct line of any connection between Europe and East Asia – in case such travels ever became feasible. Similar central importance can be applied to the HSR lines in Iran, as Tehran would always become a regional hub due to the geographical constraints given by the Caspian Sea to the North and the Indian Ocean to the South. While Chinese companies have been contracted for parts of the line, they have not succeeded in establishing their standards on the link between Turkey's capital Ankara and Istanbul, the

[42] Few large nations have not at least announced plans for building a very first HSR line, see chapter 5.1. Certainly, some among them will set such plans aside for a while. However, when studying the long list of plans provided by the UIC, it appears unlikely that HSR lines are not to be found in most major economies by 2050. This specifically applies to the large and populated emerging economies of South-East Asia, India and Bangladesh, Pakistan, Russia and (South-)Eastern Europe, Iran, Turkey, Egypt, South Africa, Nigeria, Brazil, and Mexico, plus those industrialized countries which still lack HSR infrastructure like the USA, the UK, Australia, and Canada.

central gateway between the Middle East and Europe. This failure is likely to be repeated in Thailand, with the government's decision to favor Japanese technology for its first major HSR line, see chapter 6.2.1. Still, tenders for other new lines will probably be approved to Chinese companies, after renegotiations has left them as the only bidders (which suggests another 'whatever-it-costs' project, see chapter 9.6). China has also invested in or announced interest for the first lines of other, more isolated regional networks. This applies to the Jakarta-Bandung HSR line on Java island in Indonesia, the Mexican HSR project from its capital to Queretaro, the Libyan HSR project for the entire North African region, as well as other, not explicitly mentioned projects in Saudi Arabia and the Gulf nations, Pakistan, Brazil, South Africa, Australia, the US, and the UK. In most regions, the eventual technological lock-in effect is mainly triggered by regional track gauges, but also by implementing Chinese standards in signaling and electrification, see chapter 8.3. Both the HSR projects in South-East Asia and in Russia or Central Asia are in regions which do not use the standard gauge of 1,435 mm. While adaptations of HSR systems for other gauges are feasible – as proved by the Russian and Uzbek broad-gauge HSR lines – exceptions for each project would largely spoil China's cost advantage gained by standardized manufacturing, construction, and implementation. Indeed, any Chinese proposals for HSR systems overseas only include standard-gauge offers, no matter if constructed in regions with meter-gauge systems like South-East Asia or with broad-gauge systems like in Central and Northern Asia, see Figure 11. With conventional networks in these regions mostly being in a bad shape, local planners do not immediately reject the idea of installing parallel standard-gauge lines in their countries. Given that refitting existent lines to standard gauge is economically not practical, new domestic railway networks would entirely build upon Chinese technology. For the South-East Asian corridor to Singapore this effect would transform any future standard-gauge lines to overseas extensions of the Chinese HSR network. In Central Asia, a switch from the old Soviet standard, see chapter 8.3, to standard gauge – motivated by Chinese interference – can be considered as nothing less as a complete narrative change for the entire region (cf. Djankov and Miner 2016), which is already orienting itself more towards Beijing than Moscow, hence, fulfilling one of the major goals of the BRI (cf. Ferdinand 2016). Even Russia itself could break up the dominance of its broad-gauge system by preferring a standard gauge track for the Moscow-Kazan HSR line due to its large cost savings. This change of mind is explicitly interesting as, when carried out with a German consortium back in the 2000s, a standard-gauge line has been considered as no option in the planning for the Moscow-St. Petersburg HSR line (Akiyama 2014), making it unclear if Russia would join a group of countries favoring Chinese standards like in South-East Asia or Iran – or if it follows the approach by Turkey and Saudi Arabia, which contracted suppliers from several nations. All these questions regarding track gauge obviously also arise when discussing rail cargo transport instead of HSR passenger transport. However, as freight is usually not as time-constrained as passenger transport, a break-of-gauge is significantly less of a burden. Indeed, dry ports, like the one built in Khorgas at the Chinese-Kazakh border, are even a welcomed opportunity by logistics managers to redistribute rail freight (Wu 2018). The break-of-gauge problem is especially visible in South-East-Asia, where Thailand gained enormous blockage power on Chinese rail development in the region, if it decides to not continue the Laotian HSR line all the way to Bangkok, see chapter 6.2.1 (Janssen 2017).

9.8 Summary

It has been shown that China's approaches to IPRs has had a large influence on its capability to develop individual HSR technology standards. This development has been supported by the formerly introduced industrial policy strategies like *Made in China 2025* and infrastructure development initiatives like the BRI. Chinese HSR projects overseas are an important element for exporting such IPR approaches to other countries, with the motivation to create a stronger global alliance pushing for a global IP paradigm change. This could especially be observed in Laos, Indonesia, Iran, and Hungary/Serbia, where the involvement of the local economy and workforce is normalizing the Chinese approach of inexpensive IPRs. Additionally, it has been found that such projects also contribute in internationalizing Chinese technology standards, following the dual-track approach by Seaman. Here, little strong evidence has been found for the cooperative approach, where indications remain rather weak and speculative, as no disproportionate engagement of China in the relevant SSOs could be identified. Still, large emerging countries like Indonesia, Mexico, Russia, Iran, Turkey, or Thailand have chosen Chinese HSR standards for their national networks, meaning they could choose to lobby[43] for them on an international level in SSOs. On the other hand, almost all studied Chinese HSR projects have found to trigger strong technological lock-in mechanisms, eventually creating *de-facto standards*, see The HSR projects in Laos, Russia, Iran, Hungary/Serbia, Turkey, and Thailand are all key sections of any further regional development. If Chinese technology standards are used on these sections, a path dependency is likely to lead into a technological lock-in situation. Once this is established, further expansions of regional networks are also likely to be contracted to Chinese companies, as opportunity costs of switching technologies would be too high. This mechanism bypasses international processes for standardization and instead setting them *de facto*.

[43] For the sake of the argument, this would ignore other political constraints through relationships with China

Table 1. The HSR projects in Laos, Russia, Iran, Hungary/Serbia, Turkey, and Thailand are all key sections of any further regional development. If Chinese technology standards are used on these sections, a path dependency is likely to lead into a technological lock-in situation. Once this is established, further expansions of regional networks are also likely to be contracted to Chinese companies, as opportunity costs of switching technologies would be too high. This mechanism bypasses international processes for standardization and instead setting them *de facto*.

Table 1: Influence of Chinese HSR Projects Overseas

Project	IPR Policy Export	Influence SSO	De-Facto Standards
ASEAN 1 (Laos/Myanmar)	+	-	+
ASEAN 2 (Thailand/ Malaysia/Vietnam)	-	=	-
Indonesia	+	+	+
Mexico	**o**	+	+
Russia	**o**	+	+
Iran	+	+	+
Hungary/Serbia	+	=	+
Turkey	=	+	-
Libya/Venezuela	=	-	-
Saudi Arabia	=	-	-
+ strong influence	= medium influence	- no influence	**o** missing information

10 Review

10.1 Biases and Limitations

As any research, the results of this thesis are affected by biases and limitations. This section unfolds some of them and indicates their likely effects on the findings. First, and possibly most significant, the quantitative part of this research suffers under an extreme data selection bias. Information on the BRI in English is relatively fragmented and incomplete, and only selected official documents are translated from Chinese, being written in a propagandistic style or are not even publicly available at all. This was especially a problem for countries with strong ideological ties to China and weak to the Western world, e.g. in Laos. Real-time information on most HSR projects is hard to gather, and some sources may be inaccurate or outdated. Even though several databases from other scholars have been used, see chapter 6.1, they are far from congruent, suggesting that other projects may have not been reported at all or some of the analyzed projects have not progressed as far as assumed. However, as the data selection was followed up by an extreme slim-down of cases to those being relevant, it can be assumed that no projects which would have passed these selection criteria would have remained undetected. Additionally, during the first months of this research, new project announcements and status updates have been troubling to describe an up-to-date picture.

Here, the global standstill caused by the Covid19 pandemic has proved helpful to keep informed about the current situation. On the other side, the resulting economic crisis has most likely also led many problems within the analyzed projects and might have even affected the overall Chinese strategy regarding the BRI and the HSR sector. As of today, these impacts on the present research are hardly predictable. Second, the case selection and hypotheses development suffer under the blurred boundary between conventional railroads and HSR lines. As discussed, the definition of *high speed* is disputable and has been adapted for this research. Still, it is hard to assess if HSR lines are indeed meant for *high-speed* passenger transport, the purpose for which they are technologically built, or if they may be heavily misused for cargo transport at lower speeds[44]. If overseas HSR lines are being used for cargo transport instead of passenger transport, the use case for China changes completely, and explanations for such investments can be better found when looking at other hypotheses, as described in chapter 3.5. Concluding, it can be assumed that some HSR projects will most likely more be used as conventional lines for freight transport (like the one in Laos), while others remain purely reserved for passenger transport (like the one in Indonesia).

10.2 Suitability of Used Literature

The research by Breznitz and Murphree (2013) and Seaman (2020) have been supportive to adequately structure the analysis of the investigated hypothesis. Also, other literature on the BRI, *Made in China 2025*, and HSR systems has been helpful to explain China's increased motivation to invest in infrastructure overseas. The research by Mattli and Büthe (2003) could also have been used to analyze the present case but compared to former two it is the most outdated without any focus on China. To reduce the complexity of the analysis, I have therefore decided against explicitly using their work on standard-setting for the present case. Still, their research offered a good starting point and the theory of a realism approach versus a world society approach could have certainly been valuable for discussing the case of Chinese-initiated standard-setting within the HSR sector, leaving room for further research. A shortcoming of most contemporary research has been the extreme focus on the ICT industry. As this is one of most prevalent industries in which Chinese innovations are dominating the global market, this focus is only reasonable. However, the special dynamics in the field of infrastructure and the high relevance of path dependency and technological lock-ins is making this field in no way less relevant when discussing the impact of Chinese technologies in

[44] The term *misuse* is of course not entirely appropriate here, as cargo transport also benefit from the direct routes and technical systems of HSR lines. Still, they are usually not as time-constrained as passenger transport, and the extra costs of designing and building railway lines for speeds above 200 km/h (cargo trains usually run 160 km/h maximum, even on such lines) are not justifiable if tracks are mostly occupied by freight transport.

the world, especially when looking at standard-setting. The strong scientific focus on the ICT industry and the case of 5G/*Huawei* might distract scholars of considering other fields as well. The lower level of awareness gives reason to suggest that China will be more successful in internationalizing their standards in the infrastructure sector than in ICT: First, because they face less equivalent competition on the global market, and second, because overseas engagement in roads and railways seem to create far less public outcry abroad.

11 Conclusion & Outlook

This thesis has analyzed why China invests in HSR projects overseas. Former research on the topic have led to three strings of explanations, proposing geopolitical, economic-strategic, and domestic-economic motivations. These have been translated into hypotheses of which the economic-strategic was chosen for an in-depth analysis, focusing on the role of technology standards and IPR approaches for China's HSR investment decisions. It has been found **China is today the by far most dominant player on the HSR market**, with leading companies, innovations, and technology standards across the entire sector. This large ecosystem receives strong political support through heavily subsidized domestic demand and extensive funds for undercutting market prices on international projects. By connecting research on the industrial policy strategy *Made in China 2025*, the BRI, global IPR regimes and international standard-setting, this thesis has **revealed a mechanism which allowed the Chinese HSR industry to create well-elaborated and competitive technology standards**. With its engagement in overseas projects, they are now trying to internationalize these standards. Here, China is making use of its first-mover advantage in the sector, providing it with the power and ability to set global standards and consolidate its dominance on the global market. However, a detailed investigation on 109 Chinese railway projects overseas, bringing together data from various sources, discovered that only very few HSR projects experience real credible commitment by Chinese stakeholders. These projects have then been used to provide empirical material for validifying the theories on standard-setting by John Seaman (2020), and on China's IPR approach by Breznitz and Murphree (2013). The results have shown that the **HSR sector is a good example for showing how China's policies are triggering long-term changes in the global IP paradigm**, favoring inexpensive licensing models over viewing IP as part of the value-added chain. It has been found that the several of the selected **projects are able to create path dependencies by setting de-facto standards** in certain regions. This technological lock-in situation is making Chinese companies the most favorable choice for future expansions as it improves regional compatibility and interoperability. Centrally located key projects or first-mover projects in formerly undeveloped networks are the main driver of this process, as they have the largest potential for setting path dependencies. On the other hand, Seaman's **cooperative approach**, which assumes China is increasing its influence in international organizations in order to set global standards, has been analyzed and **found to be largely insignificant** for the case of HSR, as it lacks sufficient evidence and is ineffective in the dispersed global power regime of the railway sector. Concluding, the hypothesis introduced in the beginning can be approved. **China is using investments in overseas HSR projects to internationalize its domestic technology standards**, mostly by engaging in projects with a high potential for setting de-facto standards, while the institutional pathway could not be substantiated sufficiently. The proposed industrial policies and China's approach of inexpensive IPR models have paved the way to successfully develop these standards. If overseas HSR projects serve to export these models as well could not be finally clarified within this research, leaving room for further research. As suggested in other BRI research (cf. Zheng 2019), no evidence could be found that Beijing is indeed prioritizing projects which would contribute more to these goals over others which do not. In fact, the projects in Venezuela and Libya even seem to have extremely little influence on any of these indicators – however, they might be explainable using one of the other hypotheses. Also, investment decisions have not seemed entirely consequent over the course of the last years. The cancelled tender of the Indonesian HSR project resulted in a renegotiation at very favorable terms for the host country, a process likely to be repeated in Thailand. This could not be observed in Mexico, which provides a similarly isolated market at the same size, where de-facto standard-setting can be assumed to have the same prospects as on Java islands. Such inconsistencies suggest that either the introduced hypothesis cannot alone explain investment decisions or that China is not pushing for it at any price. This work has contributed to existing research in three main aspects. First, by organizing existing literature in three main hypothesis schemes and prioritizing their research interest and suitability for finding relevant results for the case of HSR. This part can be used by other scholars to analyze geopolitical or domestic-economic aspects of China's HSR investments, as well as using the hypotheses scheme for analyzing other BRI projects. Second, the present work provides *one* comprehensive dataset for Chinese-run overseas HSR projects, collected from several different data sources. Such information has not yet been made available for international scholars and is therefore a valuable source when studying the BRI, Chinese overseas investments, and possible developments in the HSR sector. Third, it has been proved that standard-setting in the HSR sector is high on the agenda of Beijing's policymakers and a relevant issue for investment decisions. Existent industrial policies have been well used to establish a strong domestic innovation ecosystem and competitive technology standards. The methods of this thesis could have also been used well to study China's overseas investments in the ICT industry, in which the Chinese high-tech firm *Huawei* has already been banned from tendering in many countries around the globe out of fears over wiretapping and governmental intervention in foreign communications (Tominey 2020; EC 2020; Cilluffo and Cardash 2018; Kaska et al. 2019). The discussion about Huawei's involvement in 5G telecommunications infrastructure gave Western societies a grasp of what can be expected in the next decades regarding industrial competition from China. Currently the railway and HSR sector is not seeing the same level of awareness and research interest, but first signs of conflict have already emerged. The infringement cases in Serbia/Hungary and Mexico, as well as the interest by the UK to have China involved in the construction of its new HSR project *HS2*, have fueled discussions about the already well-advanced Chinese dominance in the railway industry. If the Chinese HSR ecosystem manages to further expand its worldwide market share, the fear of ending up in a monopoly-controlled market with few competitors available for large projects is not entirely ill-founded. China's engagement in HSR projects enclosed in the BRI may serve as a little-noticed accelerator on this pathway (cf. Al-Sayed and Yang 2018). Without a doubt, China will play a more significant role in the decades to come in all imaginable areas, including development policies and involvement in international organizations, e.g. for standard-setting. The challenge for western nations will be how to handle their relationship with China and balance economic interests with democratic and value-based principles. It remains to be seen if under the outlined conditions, Chinese railway companies are indeed as successful in developing infrastructure abroad as they have been domestically, also because they cannot access similar apparatus of bureaucracy as in China and face a more challenging political culture, similar to the ICT industry. HSR companies might face similar opposition if they keep pushing too aggressively on global markets. Meanwhile, China's political engagement in international organizations and its increased influence on technology standard-setting is causing significant consequences in various policy areas, such as geopolitics & security, trade economics, and technology & innovation leadership. Altogether, the shifts in these areas can be viewed as preliminary steps for permanent changes in the world order. If the Chinese foreign and industrial policy strategies prove to be successful, they can strongly amplify China's leverage on world politics, laying a foundation for a Chinese dominated 21st century.

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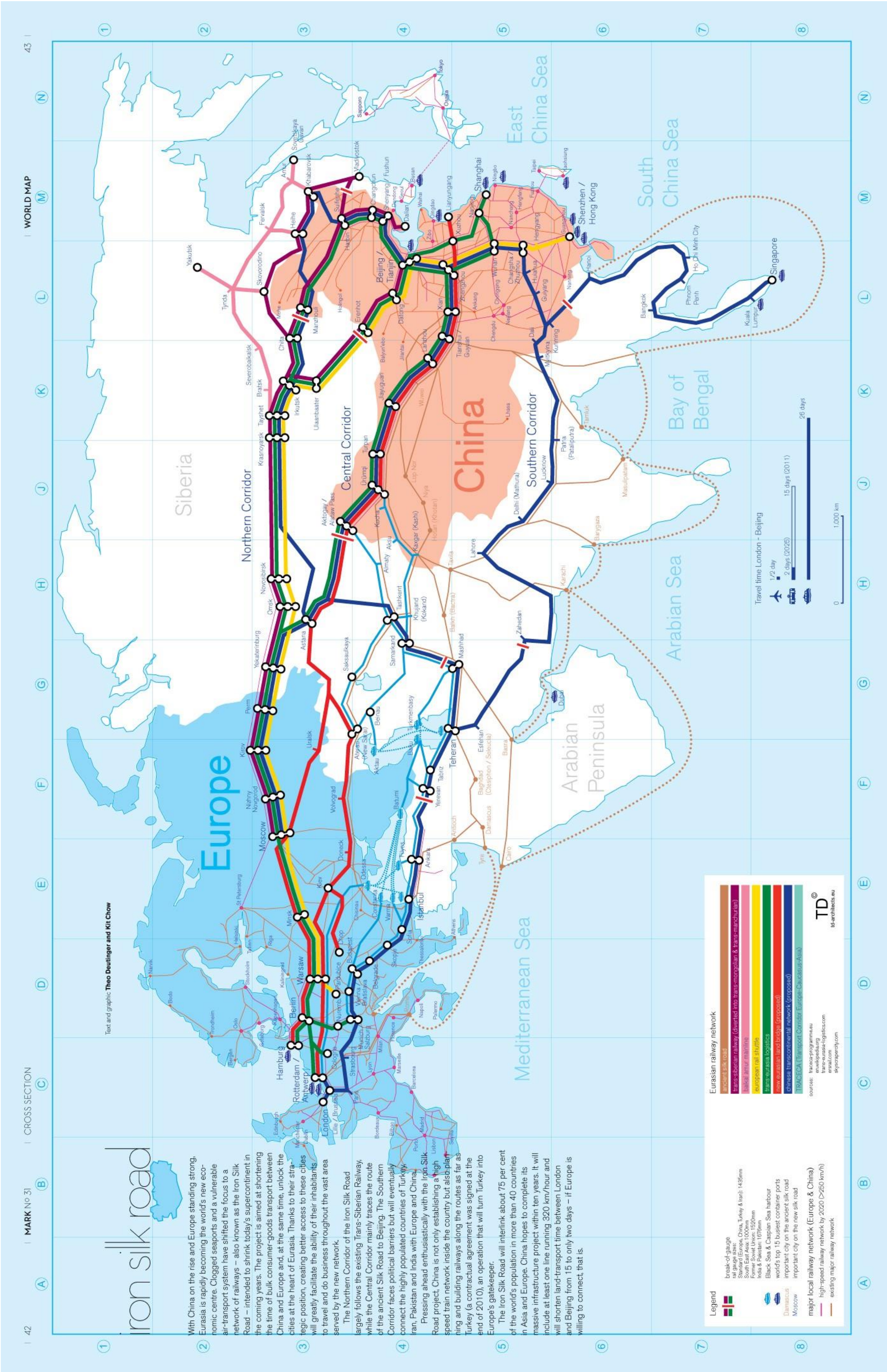
Annex A1 – Excel File on 109 Chinese Rail Projects

The attached file is a spreadsheet with information on 109 Chinese rail projects, as outlined in chapter 6.1. The analysis is largely incomplete due to missing information. Sources can be found at the end of the file

https://1drv.ms/x/s!Anoh6mk_fa8Cg7Ex8n5He6QV9v192w?e=ybdVps

Annex A2 – The Iron Silk Road



Source and High-Resolution Graphic: http://geopolitics.co/wp-content/uploads/2016/06/iron_silk_road.jpg, accessed on 26/07/2020