Benchmarking the sustainability reporting of high-speed railways (HSRs)

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1. Introduction

Railways are often bracketed with sustainability in studies of the transport sector (Schiller and Kenworthy, 2017). High-speed railways (HSRs) as a transportation mode for modern society have the potential and capability to meet many of the individuals' and societies' mobility needs in a safe and efficient manner (Leboeuf, 2018). HSRs provide a reliable transportation mode, which boosts economic activity as well as providing an acceptable level of accessibility for different segments of society (Albalate et al., 2012). Also, HSRs minimize negative impacts on the environment (Cornet et al., 2018), alongside enhancing the liveability of local communities with fewer emissions, noise, congestion, and accidents (Loo and Comtois, 2015). HSRs' effects spread far beyond meeting individuals' mobility needs; from the USA to China, HSRs as strategic megaprojects are capable of changing humans' perception of distance and time, connecting places and shrinking spaces (Banister et al., 2013). HSRs reinforce the economic development and the wealth of regions and support sustainable urban growth (Henríquez and Deakin, 2017).

Seeking a modern, efficient, and clean transportation system, several countries around the world have built their own HSR systems while others are planning and constructing new lines in Africa, the Middle East, South East Asia, North America, Europe, and the Far East. However, despite the growing popularity of HSRs, their cost plus their social, economic, and environmental performance put them under the lenses of continuous debate and criticism (Albalate et al., 2012, Henríquez and Deakin, 2017). As the wider environmental, economic, and social effects of HSRs have often been utilized to justify the system further, debates and arguments have developed challenging the validity and the creditability of these effects (Loo and Comtois, 2015, Henríquez and Deakin, 2017).

HSR operators communicate their economic, social, and environmental performance through a wide range of publications such as annual, sustainability, and corporate social responsibility (CSR) reports. Sustainability reporting has many benefits and motivations (Del Mar Alonso‐Almeida et al., 2014). Organizations report on their sustainability performance for several reasons, such as encouraging continuous improvement, supporting the decision-making process by providing necessary data,

monitoring compliance with regulations and policies in the environmental sector (Burritt and Schaltegger, 2010). However, sustainability reporting varies significantly across industries and organizations, and equally, among HSR operators. Several researchers point to the lack of standardization in sustainability reporting (Roca and Searcy, 2012). Steurer et al. (2005) and Van Marrewijk (2003) stress that sustainability reporting approaches should be tailored to suit company-specific circumstances. However, if external stakeholders are to be able to compare companies or sectors to identify best practice a minimum form of standardization is needed.

The first research gap is that there is no one unified sustainability reporting framework that combines HSR issues together under the three pillars of sustainability's cover. Instead, HSR sustainability issues have been tackled separately by scholars in different publications. Traditional topics such as emissions, energy, and employment are partly covered in some HSR operators' reports (JREast, 2018b, SNCF, 2017a), while other relatively-new topics are not adequately addressed and, in some cases, they rarely feature in operators' reports (DB, 2017, Renfe, 2015).

Despite the large volume of academic work on sustainability, no previous studies have specifically examined sustainability reporting practices of HSR operators, which constitute the second research gap to be tackled in this paper. Of the studies reviewed, the closest to this goal are the limited studies that look at reporting practices of organizations across several sectors together. For instance, studies of Andreas et al. (2012) and G&AI (2014) examined the adoption of international guidelines within companies' reports, such as those provided by the Global Reporting Initiative (GRI), without necessarily focussing on industry-specific factors. Kolk (2008) looked at how corporate governance aspects are covered in the information disclosure of Fortune Global 250 companies. Also, Daub (2007) looked at the adoption of the GRI guidelines in reporting practices of Swiss companies, without focusing on a specific sector.

To fill these research gaps, this paper sets out to characterize and benchmark the availability of a selection of sustainability factors, representing all three pillars of sustainability concerning the sustainable performance of HSR systems. This paper

has two objectives; to select and to validate social, economic, and environmental factors that are representative of the sustainable performance of HSRs and to examine the availability of the selected factors in HSR operators' reported publications. The task forms part of a larger project to build an HSR sustainability benchmarking and reporting framework, and this paper will not seek to evaluate the sustainability performance of HSRs operators. Such evaluation will be developed in further research by the authors.

The focus of this study is HSR sustainability factors which are being discussed in the current literature, and the extent to which these factors are covered in reporting practices of HSR operators.

Section 2 starts with an introduction to the literature on sustainability reporting and then considers the three pillars of sustainability, discussing a wide range of social, economic, and environmental factors that govern HSRs' performance. Section 3 explains the adopted methodology while section 4 presents results of the exploration of HSRs organizations' reports. Section 5 discusses findings and potential improvements and offers recommendations and limitations. Conclusions are drawn in the final section.

2. Literature Review

2.1 Sustainability reporting in the railway sector

Sustainability reports can be defined as publications that include a set of indicators that can be used to assess organizations' performance; communicate with external and internal stakeholders, and to disseminate information, thus allowing the public to evaluate performance (Del Mar Alonso‐Almeida et al., 2014, GRI, 2018a). Reporting on sustainability issues and challenges that relate to the long-term social, environmental, and economic performance of HSRs inspires accountability and provides operators with valuable internal and external benefits, such as those presented in Table 1.

Table 1: internal and external benefits of reporting on sustainability issues and challenges.

Benefits	Reference
Internal benefits	
Asserting the relationship between financial and non-financial performance	(Del Mar Alonso-Almeida et al., 2014)

Influencing long term strategies and plans that comply with national and international environmental goals and visions	(Sprinkle and Maines, 2010)
Identifying and managing risks while taking advantages of opportunities	(Sprinkle and Maines, 2010)
Boosting efficiency, diminishing costs and streamlining processes	(Chong and Tan, 2010)
Providing early warnings regarding future mismanagements	(Andreas et al., 2012)
Avoiding the engagement in publicized economic, social and environmental failures	(Del Mar Alonso-Almeida et al., 2014)
Benchmarking sustainability internally and with other operators	(GRI, 2018a)
External benefits	
Enhancing reputation, loyalty and the culture of HSRs	(Andreas et al., 2012)
Demonstrating companies' commitment to sustainable development, which might attract international aid and funds	(Andreas et al., 2012, GRI, 2018a)
Helping stakeholders to understand the real value of the company, its tangible and intangible assets	(Chong and Tan, 2010)
Reinforcing relations between operators and local communities by explaining operators' contributions to these communities	(GRI, 2018a)
Alleviating and reversing negative social, economic and environmental impacts	(Del Mar Alonso-Almeida et al., 2014)

Source: author's elaboration on different sources.

Del Mar Alonso-Almeida et al. (2014) comment that financial services and the energy sector took the lead in sustainability reporting within the GRI community. In contrast, and due to the low adoption of GRI standards, the representation of the rail sector is small, occupying - with toys and tobacco industries- the bottom of the GRI report ranking. Table 2 shows that within the GRI community, out of 13454 organizations, only 38 are related to the rail sector and of which only 10 organizations operate HSR services. Three operators are from Japan and one from each of China, South Korea, Russia, Taiwan, Italy, France, and Spain. HSR operators within the GRI community manage almost 19 per cent of the total HSR activity around the world, measured by track KMs (Leboeuf, 2018), while the rest of 81 per cent are not covered in GRI reporting.

Table 2: The representation of the rail industry in the GRI community.

	Total in the GRI community	Rail sector	Rail sector (% of total)	Rail sector operating HS services	Rail sector operating HS services (% of total)	Rail sector operating HS services (% of the rail sector)	Percentage of total HSR lines that are operated by HSR organisations under the GRI banner
Organizations	13454	38	0.28 %	10	0.075 %	26.32 %	19 %
Reports	53058	170	0.32 %	60	0.011 %	35.3 %	

Source: author's elaboration on (GRI, 2019) and (Leboeuf, 2018).

2.2 The economic pillar

This section discusses different factors that govern the economic sustainability of HSRs and presents some indicators that can be used for reporting on them.

A punctual and reliable HSR service attracts more passengers while meeting their needs in a safe and cost-effective manner. Additional customers bring higher revenue and build a good reputation (DB, 2017, Renfe, 2015). HSR operators pay specific attention to punctuality and reliability and some operators promote their HSR service -such as the Japanese Shinkansen- as a system that stands for a punctual and reliable transport mode (Schumann, 2017). JRCentral (2018) states that computer-aided traffic control, which integrates data and information from different sources, reporting on trains and facilities utilization's status can support a reliable and punctual system.

Costs include purchasing equipment, operation, and maintenance expenses including staff's salaries (Leboeuf, 2018). Additional costs include investing in new technologies (JRCentral, 2018); research activities and sponsorship (SNCF, 2017a); and, human resource development initiatives such as training and skills development programs (DB, 2017). Revenues comprise train operation revenues plus incomes from other business activities (JRCentral, 2018). These activities include real estate and property management, such as managing hotels, offices and residential projects (JREast, 2018b). Managing stations and merchandises that comprise department stores and chains for selling goods and food constitute another source of income (van Hagen and van Oort, 2018). The diversification of income sources is necessary for economically sustaining the railway business in the long term (Suzuki, 2017). While direct costs and revenues are typically reported from the operators' perspective, the cost-benefit ratio can be discussed from planners', policymakers' and governments' perspective. In this regard, costs incorporate construction, operation, maintenance, and recycling costs, while benefits focus on time savings, revenues, and comfort (De Rus, 2012). The cost-benefit ratio in its basic form could be enhanced by considering wider -indirect- economic impacts, which may take a considerable period to appear (Nash, 2017).

HSRs are not usually fully justified on direct users' benefits, and wider economic impacts are required to provide overall justification (Vickerman and Ulied, 2006, Nash, 2017). These impacts reflect on agglomeration effects besides job creation and employment opportunities. Another wider impact is the changes in land prices

and property values. While the overall economic impact of HSR might look positive at the national level, there might be social and economic inequalities arising from the distribution of effects across regions and local centers (Albalate et al., 2012, Nash, 2017).

The efficiency of railway operations attracts significant attention in the literature. Some studies have looked at energy efficiency (Li et al., 2012), while others have considered social efficiency (Fukuyama et al., 2011). From the economic perspective, cost-efficiency studies have looked at methods and factors that influence costs of operating railways, aiming to reduce these costs, and a wide range of indicators have been utilized in this regard such as staff per train-km and train-km per track-km (Merkert et al., 2010).

Competition and cooperation with air transport is also an important factor that governs the long-term sustainability of HSRs (Albalate et al., 2015). In most scenarios, the introduction of new HSR lines and improvements in existing lines have increased HSR demand while reducing air transport demand (Clewlow et al., 2014, Givoni and Dobruszkes, 2013). Such changes in transport demands create economic benefits for HSRs while reducing the negative environmental impacts of air transport (Jiménez and Betancor, 2012). However, HSR effects on air transport vary among regions and countries depending on corridors' characteristics, demand distribution and the overall development of the transport system (Sun et al., 2017).

Integration of HSRs with other transportation modes could be facilitated through hub stations, which provide seamless and easy transfers between modes, especially through information provision and advanced integrated ticketing systems (Leboeuf, 2018). A successful integration considers several points, such as accessibility between the city center and HSR stations, connectivity between HSR stations, and nearby airports (Cheng, 2010) and facilities to promote walking and cycling around stations. Such integration can create economic benefits for HSR operators through cost reduction and generating revenues while saving travellers' time and money (UKParliament, 2011). Other benefits include environmental and social benefits (Cheng et al., 2015, Garcia, 2015).

Introducing HSRs has impacts on local and international tourism, both in terms of tourism revenue figures and the number of local and international arrivals. Exploring

the literature suggests that these effects are controversial, and while they are generally positive in some countries (Chen and Haynes, 2012), they are negligible in others (Albalate et al., 2017). Even within the same country, the effects on tourism vary among cities and regions. Some HSR operators report on the relationship between HSR and tourism, explain their efforts to promote tourism while securing potential economic benefits through selling tourist passes and other tourism products (JRCentral, 2018, JREast, 2018b).

International involvement in the HSR context is considered as a form of diplomacy since deals and agreements usually include financing offers and plans besides continuous support (Hu, 2017). HSR operators engage internationally in businesses and projects for different purposes; building a reputation (Hu, 2017), spreading the HSR culture of a country (Huang, 2017); and most importantly, securing sustainable funding by increasing sales and external revenues (Grey, 2017). External revenues can compensate operators' losses on the national level (SNCF, 2017a).

The international agencies such as the GRI, the International Union of Railways (UIC) and the World Bank offer a variety of reporting guidelines, which comprise economic, social and environmental indicators. Table 3 presents some parameters that can be used for reporting on economic performance.

Table 3: indicators that could be used for reporting on economic factors.

Indicator	The factor on which the indicator is used to report	Reference
Total operation costs	Costs	(WorldBank, 2017)
Average operation costs (costs/ p.km)	Costs	(WorldBank, 2017)
The average fare (revenues/ p.km)	Revenues	(WorldBank, 2017)
Infrastructure access charge (€/ track km)	Costs	(Leboeuf, 2018)
The construction costs of HSR projects (€ million/ route km)	Costs	(Leboeuf, 2018)
The energy consumed per vehicle activity (MJ/train.km)	Efficiency	(UIC&IEA, 2015)
HSR operating revenues per train km (€/ p.km)	Efficiency	(Beck et al., 2013)
HSR operating expense per train km (€/ train.km)	Efficiency	(Beck et al., 2013)
Utilization of railway infrastructure (million train.km/ track.km)	Efficiency	(Beck et al., 2013)
The cost-to-benefit ratio of the HSR project	Costs-to-benefits ratio	(Nash, 2017)
Quantitative and qualitative explanation of wider impacts of the HSR project (avoided emissions, job opportunities, agglomeration)	Wider economic impacts	(Nash, 2017)
Changes in the domestic tourism demand after connecting an area with the HSR network (%)	Effects of HSR on tourism	(Albalate et al., 2017)
Changes in the international tourism demand after connecting an area with the HSR network (%)	Effects of HSR on tourism	(Albalate et al., 2017)
Daily ridership of both HSR and airlines along a specific corridor (thousand passengers daily)	Competition between HSR and airlines	(Leboeuf, 2018)
Specific CO_2 emissions of HSR vs airlines (g CO_2/pkm)	Competition between HSR and airlines	(Leboeuf, 2018)

Numbers of metro stations/bus stations that can be reached without transfer from the HSR station	Integration of HSR with other transport modes	(Leboeuf, 2018)
Number of electric car parking spaces at the HSR station (space/1000 daily passenger)	Integration of HSR with other transport modes	(Leboeuf, 2018)
Parking fare at the HSR station (€/24 hours)	Integration of HSR with other transport modes	(Leboeuf, 2018)
Numbers of metro lines/commuter lines/ bus lines at the HSR station	Integration of HSR with other transport modes	(Leboeuf, 2018)

Source: author's elaboration on different sources.

The previously discussed economic factors and associated indicators of Table 3 point towards the richness of topics that concern the economic sustainability of HSRs. However, little is known regarding the extent to which different economic factors and related indicators are covered in HSRs operators' sustainability reports and publications.

2.3 The Social pillar

This section examines different a combination of factors that might have positive and negative impacts within the social scope of sustainability of HSRs.

The rapid urbanization and newly-introduced mobility and motorization trends are resulting in different forms of social inequities among diverse citizens, informal settlements, changes in lifestyle, and less accessibility to jobs for the lower-income citizens (Ortuño-Padilla et al., 2017). The HSRs' experience presents several social problems especially in terms of rapid expropriation of rural lands and social segregation. For instance, Chen and Wei (2013) discuss social segregation explaining that while HSR stations present China's modern face facilitating technological breakthroughs, they are mostly occupied by medium- to high-income users who can afford it. On the contrary, conventional rail stations which are often located at the heart of the city centers are usually considered as less prestigious, facilitating gathering places for poor immigrant workers. Chen and Wei (2013) point out that rapid expropriation refers to the acquisition of land, and in several scenarios, HSR stations are located outside the city center in the suburbs, increasing land prices in an unprecedented manner. Rapid changes in land prices have created uneven development, converting rural farming areas to modern high-rise building zones while local governments allowed high-density solutions to bring more revenues (Ayten and Çay, 2017). Farmers who have been displaced did not necessarily get fair compensation for their land and being pushed to live in cities

where they do not have enough skills to work and make a living (Chen and Wei, 2013).

Social exclusion is another factor linked to HSRs, and users could be excluded from using the system for different reasons, which can be classified into seven categories; physical, economic, time-based, fear-based, space exclusion, geographical, and exclusion from facilities (Pagliara et al., 2016). These reasons vary among countries and users; some people could be geographically excluded as they live in rural areas and it is hard for them to reach the HSR station, while others might not be able to access stations due to a disability and hence they are physically excluded (Pagliara and Biggiero, 2017).

Accessibility expressed by door-to-door (DTD) travel time is essential in the case of HSR, considering the provision of the end-to-end seamless journey that saves time where possible (Leboeuf, 2018). It comprises two components; external accessibility which refers to the time spent in the train while traveling between two cities; and, internal accessibility which considers the time required to reach the HSR station from the origin point and to reach the final destination after leaving the HSR station in the destination city. Moreover, internal accessibility considers the time spent inside train stations (Chen and Wei, 2013, Wang et al., 2016).

The affordability of HSR is also socially relevant, and ticket prices are the principal factor. The price of the ticket is perceived as the most crucial factor that affects travelers' mode choice. Moreover, reductions in tickets' prices are proven to be more effective in encouraging travelers to use HSRs than reductions in other factors such as stations' access/egress time (Biggiero et al., 2017). To make HSR more affordable, some operators launch cheaper services with a new business model (Delaplace and Dobruszkes, 2015). For instance, SNCF -the French HSR operator- launched the 'OUIGO'; as an affordable HSR service.

Railways are closely connected with local communities primarily through stations (Bertolini, 1996), and HSR operators tend to engage in different activities and initiatives that contribute to the economic development of communities while creating social benefits and leaving a positive environmental footprint. Various projects could be considered in this regard such as educational campaigns, tree planting, operating medical facilities and cultural fairs, and exhibitions. For example, Japanese HSR

operators promote local products in HSR stations (JRCentral, 2018). Another essential form of engagement is facilitated by the involvement of locals in the decision-support and decision-making processes (Cascetta and Pagliara, 2013).

Employment practices within HSR operator organizations are relevant within the social scope. These include the total number of new employees hired, their gender and age, benefits provided to full-time staff, and the number of employees who were entitled to parental leave by gender (Marimon et al., 2012). Another aspect of employment is training and continuous development programs that are provided by HSR operators to improve the theoretical and practical skills of staff (GRI, 2016e).

Safety of people around railways is a key priority since safe railway systems attract more passengers generating higher revenues and reducing the costs of fatalities and injuries. Such costs impose a heavy burden on both the economy and society (Profillidis, 2014). The safety and risk factor comprises the safety of people who work in railways, travelers, and the public, reflecting on fatalities, major and minor injuries in stations, worksites and along tracks (ORR, 2018). Moreover, the safety and risk factor reflects on organizational safety culture adopted by HSR operators, considering safety practices, educational campaigns and training (Farrington-Darby et al., 2005).

Finally, customers satisfaction has its importance within the social pillar, since positive customer experiences encourage travelers to use the HSR service instead of other modes and via versa. Made and Hagen (2018) discuss that people have three emotional needs while traveling by trains namely; having the freedom to use their traveling time as they wish; being in control to easily access necessary traveling information without relying on others; and, being appreciated and welcomed by railway staff.

There is a wide range of parameters that could be used for reporting on the social sustainability factors of HSRs. Table 4 presents some of these indicators which are offered by the international reporting guidelines and other studies.

Table 4: indicators that could be used for reporting on social factors.

Indicator	The factor on which the indicator is used to report	Reference

The number and rate of work-related fatalities and injuries caused to staff	Safety	(GRI, 2018b)
Total number of fatalities/injuries caused to railway passengers	Safety	(UIC, 2018b)
Total number of fatalities/injuries caused to third-party people due to railway activities	Safety	(UIC, 2018b)
Total number and rate of new staff hired by gender, age, and region	Employment	(GRI, 2016e)
Quantitative and qualitative explanation of benefits provided to employees	Employment	(GRI, 2016e)
The return to work and retention rates (%)	Employment	(GRI, 2016e)
The total door-to-door journey time	Door-to-door journey	(Chen and Wei, 2013)
Results of a survey which measures customers satisfaction	Customer satisfaction	(GRI, 2016a)
Percentage of operations with implemented local communities' engagement (%)	Engaging with local communities	(GRI, 2016f)
Quantitative and qualitative explanation of potential positive and negative impacts to local communities	Engaging with local communities	(GRI, 2016f)
Results of a survey which identify those who are excluded from using the HSR service	Social exclusion	(Pagliara and Biggiero, 2017)
Total number of properties to be demolished along HSR corridors	Rapid expropriation	(Arcadis, 2018)
Quantitative and qualitative explanation of compensation provided to land and property owners	Rapid expropriation	(Arcadis, 2018)

Source: author's elaboration on different sources.

The previous discussion presented social factors and issues affecting the social sustainability of HSRs, plus some related indicators. Despite the importance of topics such as safety, and employment, the social performance of HSRs is not limited to these factors. Scholars have discussed several social issues such as social exclusion, social segregation, and rapid expropriation pointing to their importance. Little is known regarding the extent to which all previously presented social problems are tackled and considered in HSRs operators' sustainability publications.

2.4 The Environmental pillar

This section offers and discusses different factors within the environmental scope of the sustainability of HSRs. It will also reflect on operators' reporting practices.

CO2 is the main man-created greenhouse gas that is contributing to global warming, which constitutes a major environmental challenge in the 21st century (Baron et al., 2011). Generating traction electricity might result in emitting different greenhouse gases besides several pollutants such as particles and NO2 (Bergendorff et al., 2008). HSR projects produce carbon emissions at different stages; design and construction; operation and maintenance; and, recycling (IEA, 2017). During the operation stage, the majority of carbon emissions are generated by operating trains; using electricity for traction, which will have different carbon components depending on the primary energy source and the technology used (Lin et al., 2019). Other

carbon emission sources include station operations, printing and distributing tickets (JREast, 2018b). Considering reporting practices, HSR operators report on their carbon emission performance using different indicators and measurement methods; some report only on carbon emissions created in the generation of traction electricity; other operators expand to include emissions produced while burning crude oil to generate and to distribute electricity. Moreover, only a minority of operators use 'well-to-wheel' methods (FSItaliane, 2017).

Energy consumption is an environmental factor that correlates with the economic theme as the scarcity of non-renewable energy sources could create economic pressures (IEA, 2019). In the HSR context, the final energy consumption refers to electricity used for traction, while primary energy consumption considers -including the final consumption- all energy that has been used to generate the final energy to become available for rail operators. Primary energy includes energy lost in distribution networks and energy consumed by energy production machines in production factories (Bergendorff et al., 2008). The source of energy is also crucial as using renewable energy and nuclear power results in fewer emissions compared to burning fossil fuels (DB, 2017, SNCF, 2017a).

Noise is another important environmental sustainability factor. HSR systems generate noise affecting the quality of living in residential zones alongside tracks, imposing considerable health risks that vary in their severity, besides possible negative impacts on livestock and other animals (DeVos, 2016). HSR noise levels vary depending on different variables, such as the speed and the length of the train and the distance between the track and the property. Some of these levels exceed national limits and regulations and hence, railway operators have to employ noise reduction methods, which also vary in their cost and effectiveness (Ivanov et al., 2017).

The land-use sustainability factor refers to vegetation and herbicide management from railway companies' perspective (UIC, 2018a). Impacts of vegetation management vary depending on the location and type of surfaces; sealed and unsealed. Railway companies use different methods and techniques for herbicide and vegetation management to guarantee the safety and reliability of railway operations (Nolte et al., 2018). Generally speaking, railways use a smaller amount of

herbicides compared to agriculture. However, rail companies' performance regarding vegetation and herbicides management varies among operators and countries (UIC, 2018a). This variation is reflected when considering a set of criteria comprising environmental hazards, cost efficiency, the amount of water, energy and emissions and frequency of application (Nolte et al., 2018).

Another important environmental factor is biodiversity. HSRs impose different risks on the wildlife along their tracks, especially when they cross national parks, forests and protected areas. The most apparent impact is direct mortality, which happens due to different reasons; wire strikes, collision with trains, electrocution and rail entrapment. Other effects are imposed on flora, plants, and trees. Considering monitoring and mitigation, HSR companies' efforts vary in this regard (Borda-de-Água et al., 2017, Carvalho et al., 2017). Carvalho et al. (2017) discuss that HSRs might have higher negative impacts on the wildlife than conventional rail as they have higher speeds, higher noise levels, and different fencing practices, emphasizing methods to monitor and mitigate HSRs' impacts on the wildlife.

Recycling is another environmental factor. Silva and Kaewunruen (2017) in their study discuss possible economic and environmental benefits of rolling stock recycling, noting that passenger trains might be more challenging to recycle compared with freight trains as they facilitate more variation and diversity in materials. HSR operators have different attitudes and methods for recycling, waste and chemical substances management, which happen on two levels; components level and materials level (Grossrieder, 2011).

The final factor within the environmental scope of sustainability is materials and resources, which reflects mainly on sustainable performance regarding the consumption of wood and water, depending on their sources. For example, HSR operators use water for different industrial and non-industrial purposes, while some operators make efforts to gradually cut their consumption. The collection and transportation of materials are also important for the cost-effective management of materials and resources (DB, 2017, FSItaliane, 2017).

The richness of the discussed environmental factors and challenges is also accompanied by diverse reporting mechanisms, which offer plenty of reporting

parameters. Table 5 presents some indicators that could be used for reporting on the discussed environmental sustainability factors.

Table 5: indicators that could be used for reporting on environmental factors.

Indicator	The factor on which the indicator is used to report	Reference
Specific CO_2 emissions of rail transport (g CO_2/pkm)	Emissions	(UIC, 2016)
The well-to-wheel CO_2 emissions of rail transport (g CO_2/pkm)	Emissions	(Leboeuf, 2018)
The total amounts of CO_2 emissions associated with the life cycle - planning, construction, operation, and recycling- of the HSR project tonnes)	Emissions	(Leboeuf, 2018)
Amounts of NOX, SOX A and other air emissions (tonnes)	Emissions	(UIC, 2016)
Total energy consumption within the organization	Energy consumption	(UIC, 2016)
Primary energy consumption of rail transport (kj/pkm)	Energy consumption	(UIC, 2016)
Final energy consumption of rail transport (kj/pkm)	Energy consumption	(UIC, 2016)
The share of renewable electric energy in the total energy consumed (%)	Energy consumption	(Bergendorff et al., 2008)
Noise levels at a distance of 25m from the rail axis and a height of 3.5m above the rail track (dBA)	Noise	(Ivanov et al., 2017)
The pass-by noise levels of electric locomotives with a speed of 250km/h or more (dBA)	Noise	(EURLEX, 2014)
The amount of herbicides used for vegetation control (kg/ track km)	Land use	(UIC, 2018a)
The cost of herbicides used for vegetation control (€/ track km)	Land use	(UIC, 2018a)
Quantitative and qualitative explanation of biodiversity values and features of areas near companies' activities	Biodiversity	(GRI, 2016c)
Quantitative and qualitative explanation of companies' activities impact on biodiversity	Biodiversity	(GRI, 2016c)
Quantitative and qualitative explanation of companies' efforts in protecting biodiversity	Biodiversity	(GRI, 2016c)
Total weight of renewable/ non-renewable materials used (tonnes)	Resources and materials	(GRI, 2016b)
The percentage of recycled input materials consumed (%)	Recycling	(GRI, 2016b)
The percentage of reclaimed materials (%)	Recycling	(GRI, 2016b)
Total weight of hazardous/non-hazardous waste generated by type and disposal method (tonnes)	Resources and materials	(GRI, 2016d)
Quantitative and qualitative explanation of remarkable spills	Resources and materials	(GRI, 2016d)
Total weight of hazardous waste transported by type (tonnes)	Resources and materials	(GRI, 2016d)

Source: author's elaboration on different sources.

Carbon emission, energy consumption, materials, land use, noise, and biodiversity are all environmental factors that affect the environmental performance of HSRs. Scholars and publications have discussed these environmental topics, and a wide range of parameters are available to express most of them. However, HSRs operators might be interested in specific environmental factors while paying less attention to other issues, and little is known regarding the representation of previously presented environmental factors in HSRs operators' reports.

The presented literature on the sustainability of HSRs showed the richness of topics and factors that can be managed, measured and, covered in companies'

sustainability disclosure. Also, it listed some key economic, social, and environmental indicators offered by reporting guidelines.

After a thorough exploration, the study has identified a combination of 26 economic, social, and environmental factors that govern the sustainability performance of HSR. Table 6 summarizes these factors and points towards some related studies in the literature. The next part of this paper will discuss the availability of the 26 factors in operators' publications and potential improvement areas.

Table 6: The Identified 26 sustainability factors of HSR

Economic sustainability factors	**Related studies and references**
Punctuality and reliability	(Schumann, 2017)
Costs	(Ollivier et al., 2014), (WorldBank, 2017)
Revenues	(WorldBank, 2017), (van Hagen and van Oort, 2018)
Efficiency	(Merkert et al., 2010), (Beck et al., 2013)
Cost-benefit ratio	(Nash, 2017), (Tao et al., 2011)
Wider economic impacts	(Cheng et al., 2015), (Vickerman and Ulied, 2006)
Effects on tourism	(Albalate et al., 2017), (Albalate and Fageda, 2016), (Chen and Haynes, 2012)
Competition with air transport	(Fukuyama et al., 2011), (Delaplace and Dobruszkes, 2015)
Integration with other modes	(Leboeuf, 2018), (UIC, 2019a)
International involvement	(Huang, 2017), (Hu, 2017), (Grey, 2017)
Social sustainability factors	**Related studies and references**
Safety and risks	(Profillidis, 2014), (UIC, 2018b)
Accessibility expressed by door-to-door journey time	(Leboeuf, 2018), (UIC, 2019a), (Chen and Wei, 2013), (Wang et al., 2016)
Social segregation	(Chen and Wei, 2013)
Rapid expropriation	(Chen and Wei, 2013), (Arcadis, 2018)
Social exclusion	(Pagliara et al., 2017), (Pagliara et al., 2017)
Engaging with local communities	(Cascetta and Pagliara, 2013)
Customer satisfaction	(Sahin Dölarslan, 2014)
Employment	(Marimon et al., 2012), (WorldBank, 2017)
Affordability and operators' initiatives	(Biggiero et al., 2017), (Delaplace and Dobruszkes, 2015)
Environmental sustainability factors	**Related studies and references**
Carbon emissions	(Lin et al., 2019), (IEA, 2017), (Wang et al., 2019), (Cornet et al., 2018)
Energy consumption and sources	(IEA, 2017), (IEA, 2019), (Li et al., 2012)
Land use	(Nolte et al., 2018)
Resources and materials	(Renfe, 2015), (SNCF, 2017a), (FSItaliane, 2017)
Biodiversity	(Carvalho et al., 2017), (Borda-de-Água et al., 2017)
Recycling	(Silva and Kaewunruen, 2017), (Grossrieder, 2011)
Noise	(Ivanov et al., 2017), (DeVos, 2016)

Source: author's elaboration on different sources.

3. Methodology

3.1 The flowchart of conducting the research

This study comprises two main steps; first, selecting and validating social, economic, and environmental factors that are representative of the sustainable performance of HSRs; second, examining the availability of these factors in operators' reported

publications. Figure 1 illustrates the step-by-step process of conducting the research. Steps one and two have been already completed since exploring the literature has led to identifying 26 sustainability factors and some associated indicators, as presented in Tables 6, 3, 4, and 5, respectively.

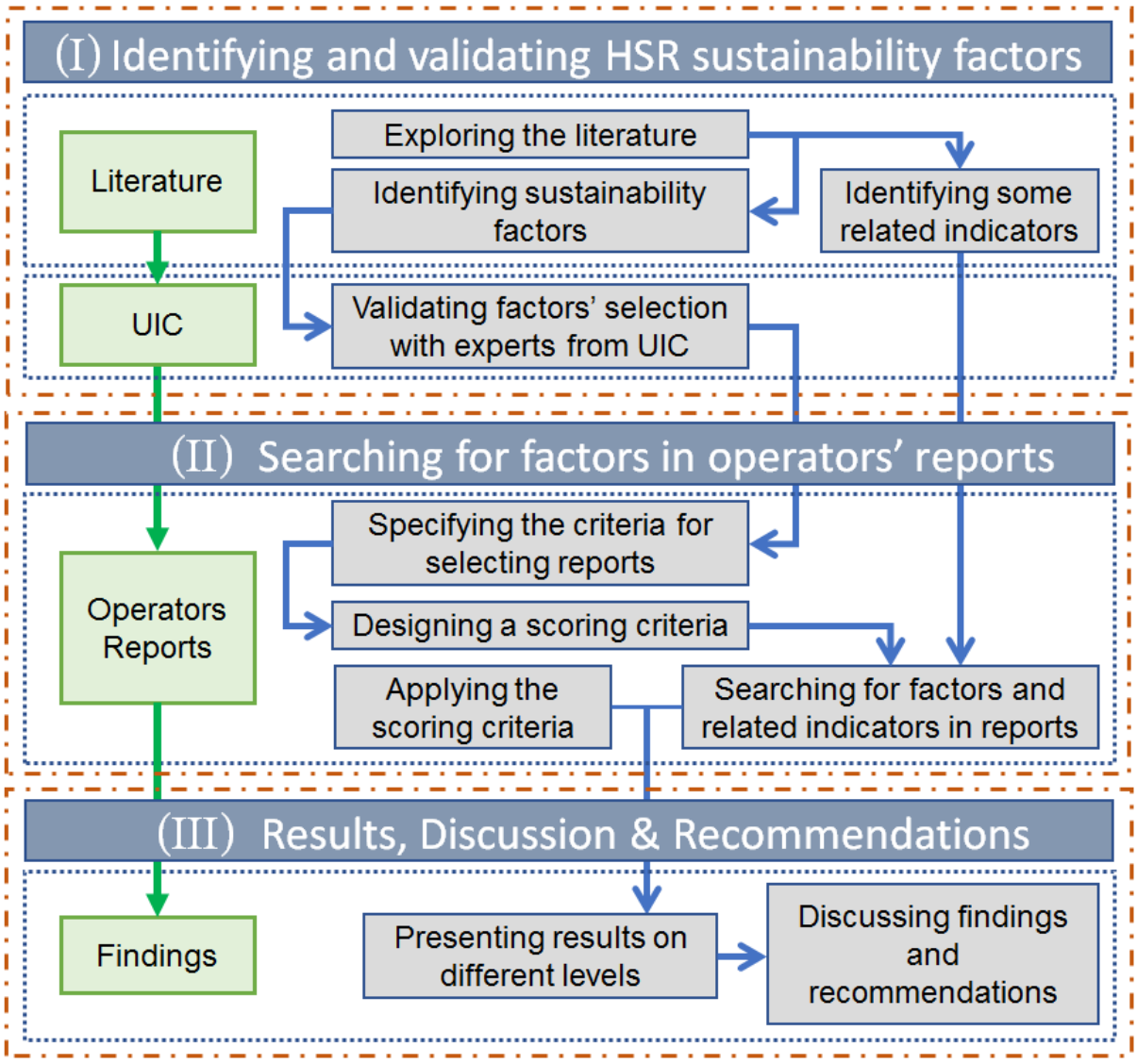

Figure 1: A step-by-step process for conducting the study

3.2 Validating factors' selection with experts of the UIC

For validating the author's selection of factors, the list of 26 factors was presented to experts of the International Union of Railways (UIC). In February 2019, the author conducted three face-to-face meetings with the head of the sustainable development unit, the director of the passenger department, and a senior adviser in the HSR unit. After being briefed on the research project, the experts were asked to weight the importance of the selected factors by giving a score out of 10 for each factor

according to its relevance to the sustainability of HSR and to the need to report on it using the following criteria:

- Score 0: the factor is not relevant to the sustainability of HSR and on which there is no need to report
- Score 1-4: the factor is slightly relevant but there is no need to report on it
- Score 5-7: the factor is relevant, and it is useful to report on it
- Score 8-10: the factor is very relevant with a vital need to report on it

Table 7 presents the results of the consultation with UIC's experts. It shows that all 26 factors fall in the third and fourth categories, affirming the authors' assessment of their relevance and importance to the sustainability of HSR. Also, the consultation helped the author to conclude that none of the identified 26 factors should be excluded from the review of reporting. The experts' scores indicated that they consider more than half (14) of the factors to be very relevant with a vital need to report on them, while the other 12 factors are relevant, and it is useful to report on them.

Table 7: Results of consultation with UIC's experts

Sustainability pillars	Sustainability factor	Expert 1	Expert 2	Expert 3	Average Score
The economic pillar	Punctuality and reliability	10	10	8	9.33
	Costs	6	5	7	6
	Revenues	6	5	10	7
	Efficiency	7	5	8	6.67
	Cost-benefit ratios	6	10	6	7.33
	Wider economic impacts	7	5	5	5.67
	Effects on tourism	6	10	8	8
	Competition with air transport	8	5	8	7
	Integration with transportation modes	8	10	8	8.67
	International involvement	8	8	8	8
The social pillar	Safety and risk	10	10	8	9.33
	Accessibility expressed by door-to-door journey time	9	10	8	9
	Social segregation	8	5	6	6.33
	Rapid expropriation	8	10	5	7.67
	Social exclusion	8	10	6	8
	Engaging with local communities	6	10	8	8
	Customer satisfaction	6	10	8	8
	Employment	6	10	5	7
	Affordability and operators' initiatives	7	5	6	6
The environmental pillar	Carbon emissions	10	10	8	9.33
	Energy consumption	10	10	8	9.33
	Land use	7	10	5	7.33
	Resources and materials	9	10	5	8
	Biodiversity	9	10	4	7.67
	Recycling	8	10	3	7
	Noise	7	10	3	6.67

Source: author's elaboration on meetings with the UIC experts

3.3 Criteria for selecting reports

This study looks at published reports of eight HSR operators namely; JR Central, JR East, and JR West, all from Japan, Renfe in Spain, SNCF in France, DB in Germany, FS Italiane in Italy, and Guangshen Railway in China. These specific operators have been selected for several reasons. First, they are collectively responsible for managing and operating more than half of the total HSR passenger services around the world (Leboeuf, 2018). Second, they offer a reasonable mix combining companies from both Europe and Asia with extensive experience in operating mature HSR systems. Third, all selected operators collaborate –on different levels- with international railway agencies such as the UIC (UIC, 2019b). Finally, these operators offer a wide range of publications via their websites. An additional two HSR systems in their construction stages were also included. These two systems are the HS2 in the UK and California High-Speed Rail in the USA. The reason for including these systems is that since they are in the construction stage, their reports might disclose some lifecycle sustainability information.

The criteria for selecting reports are based on five key points; the publisher, the type, the publishing date, the language, and the availability of reports. Table 8 explains the criteria for selecting reports reflecting on these five points.

Table 8: the criteria for selecting reports

	Criterion
The publisher	HSR operators that report on their sustainability performance in a consistent manner.
The type	Reports in which HSR companies disclose sustainability information, including annual, sustainability, and corporate social responsibility reports plus sustainability statements.
The publishing date	Newest reports, mostly published between 2015 and 2018
The language	Only reports in their English version. However, only in the Chinese operator case, a report published in its Chinese version was used and translated using Google Translate, due to the lack of any report in English.
The availability	Only reports that are publicly available via HSR companies' websites.

Source: author's criteria

The selected operators offer plenty of publications in different languages. However, taking into consideration the criteria presented in Table 8, a total of 15 publications were considered, including annual reports, sustainability reports, corporate social

responsibility reports (CSR), responsible business reports, sustainability statements, and integrated reports.

The reason for the variety of publications is that some operators do not publish explicit and independent CSR or sustainability reports. Instead, they include detailed information regarding their social and environmental performance in their financial and integrated reports (Wolniak and Hąbek, 2016). Other operators such as JR East, SNCF, and FS Italiane publish separate documents for reporting on social and environmental performances. Via their websites, these operators offer more than one sustainability document, so, at least two documents for each one of these three operators have been considered. This finding itself reveals the differences in reporting practices and highlights the difficulty facing the stakeholder who wishes to benchmark HSRs' sustainability for any reason.

It is worthy of mentioning that the study has sought to include more publications of some remarkable Chinese HSR operators such as Beijing Bureau Railway Group and Shanghai Bureau Railway Group. However, there were no publicly available performance reports for these operators.

3.4 Scoring criteria for reviewing HSR Companies' reports

Having validated all factors and selected all reports, the author created a rating scale of 0-1-2-3 to document the richness of each sustainability factor in HSRs reports. Similar criteria have been presented in (Daub, 2007), and these criteria were used by the author as follows:

- 0 = no meaningful information is presented regarding the specific factor.
- 1 = patchy information is presented without providing enough clarification and with limited use of charts and visuals.
- 2 = good information regarding the factor is presented. Proper use of charts and visuals. However, not all areas of the factor are well covered and addressed.
- 3 = the reporting provides full information regarding the factor; a mix of quantitative and qualitative indicators is presented with extensive use of charts and examples comparing the performance over different years.

As stated earlier, there are 15 documents for ten companies and some companies have more than one report. In such a case, only the maximum score of each factor

from the company's reports is considered. For example, JR East has two documents in which the score varies between 1 and 3 points for particular factors. In such case, 3 points are recorded for JR East for that factor, and other scores were neglected, see Figure 2. Applying the previously discussed scoring criteria means that:

- The maximum score a company can get is 3 (points)* 26 (sustainability factors) =78 points.
- The maximum score a sustainability factor can get is 3 (points)* 10 (companies) =30 points.

Figure 2: explaining the adopted scoring criteria

3.5 Searching for sustainability factors in companies' report

Having designed the scoring criteria, the author searched for evidence of the identified and validated 26 sustainability factors in selected operators' reports. The search process looked for quantitative and qualitative information that relates to the 26 factors, including but not limited to parameters listed in Tables 3,4 and 5, plus any information that could lead to their calculations. The author used visual observation in searching for evidence within reports, which have been thoroughly checked at least twice. All parts of each publication have been examined including the table of content, facts sheet, performance highlights, the main body, consolidated and unconsolidated data, and appendices. Inspecting for sustainability factors aimed to reveal reporting variations at different levels, as in Table 9.

Table 9: levels of variations the search process sought to reveal

Variation level	Explanation
26 factors level	To identify the most and least covered factors in operators' reports
Companies level	To reveal companies that covered most factors and those who reported on fewer factors
Indicators level	To distinguish between quantitative and qualitative parameters used for reporting on sustainability factors

4. Results

4.1 Sustainability factors' results

Table 10 shows the presence of and the author's evaluation of the reporting of each company on each sustainability factor in different reports, using the approach summarised in sections 3.4 and 3.5 above.

Within the economic pillar, Figure 3 shows that the costs and revenues factor ranked the first with 23 points respectively, followed by punctuality and reliability, efficiency and international involvement with 21, 19 and 17 points respectively, all out of a maximum of 30. Integration with other modes, effects on tourism, the wider impacts, and competition with air obtained less than half of the maximum possible score. The cost-benefit ratio scored only one point, showing the lowest level of reporting among all economic factors.

Reporting on the social factors pillar, summarised in Figure 4 illustrates that employment and safety gained almost the maximum score with 28 and 27 points respectively. Accessibility, social exclusion, social segregation, and affordability gained relatively low scores of 8, 7,6 and 6 respectively. Rapid expropriation was the lowest among social factors with a reporting score of 3 points.

In the environmental factors pillar, Figure 5 shows that carbon emissions obtained a full score of 30, while energy consumption, materials, and recycling scored 24 points each. Noise and biodiversity gained around half of the maximum score while reporting on the land-use factor was the weakest, obtaining only 6 points.

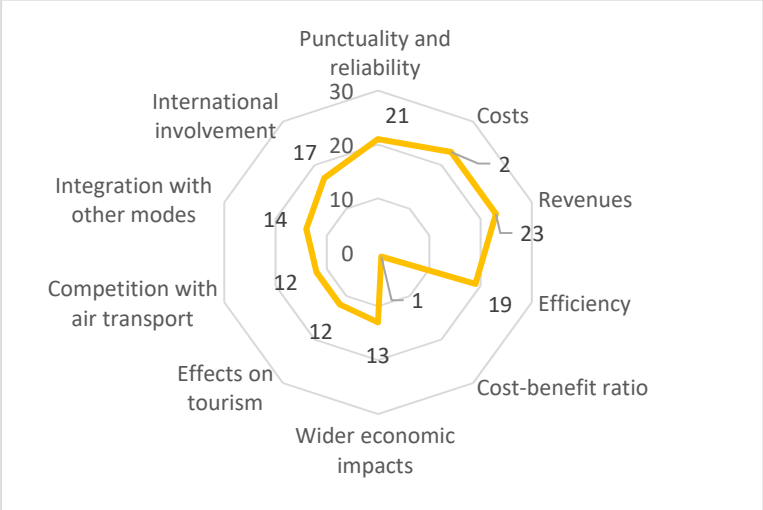

Figure 3: Economic factor' scores

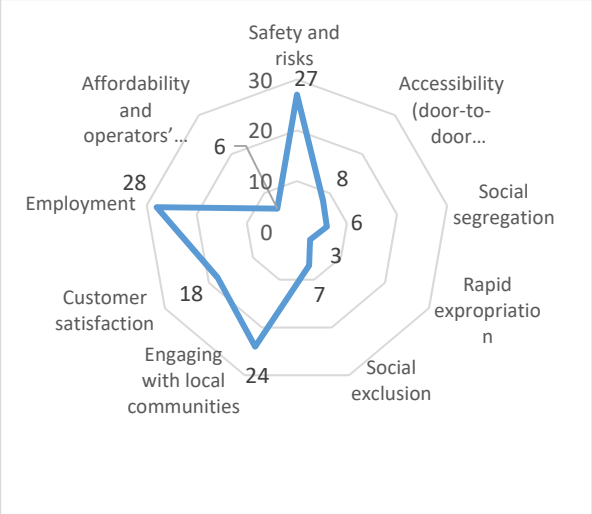

Figure 4: Social factor' scores

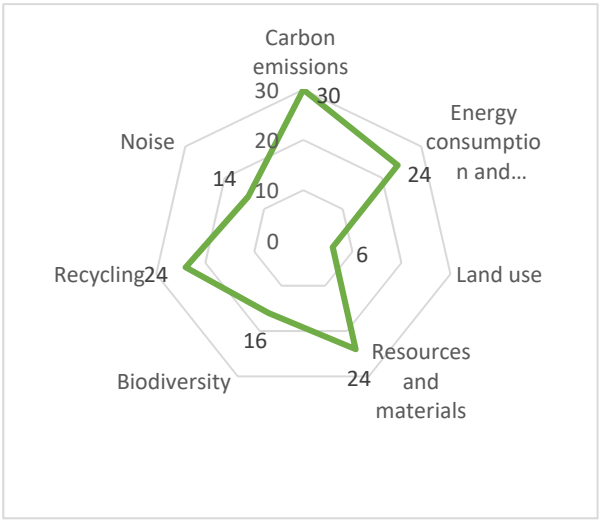

Figure 5: Environmental factor' scores

Taking all factors together, Figure 6 shows that 10 of 26 factors scored below 14points, and carbon emissions obtained the first rank among all factors, followed by employment and safety. The cost-benefit ratio obtained the lowest score among all factors followed by rapid expropriation. Moreover, economic factors' scores are relatively close to each other, compared with social factors' scores which vary greatly between high and low reporting scores. Furthermore, Figure 7 shows that environmental factors gained the biggest representation in companies' reports, being covered on average with a score of around 66 per cent of the maximum possible score, followed by economic factors and social factors with almost 52 per cent and 47 per cent respectively.

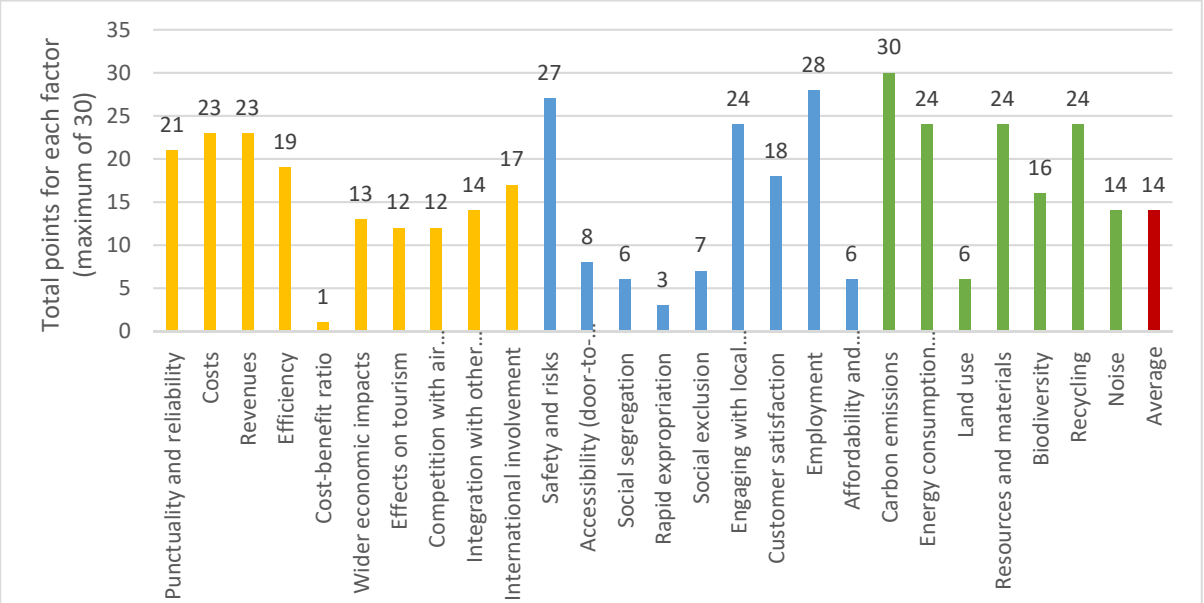

Figure 6: Sustainability factor scores' comparison

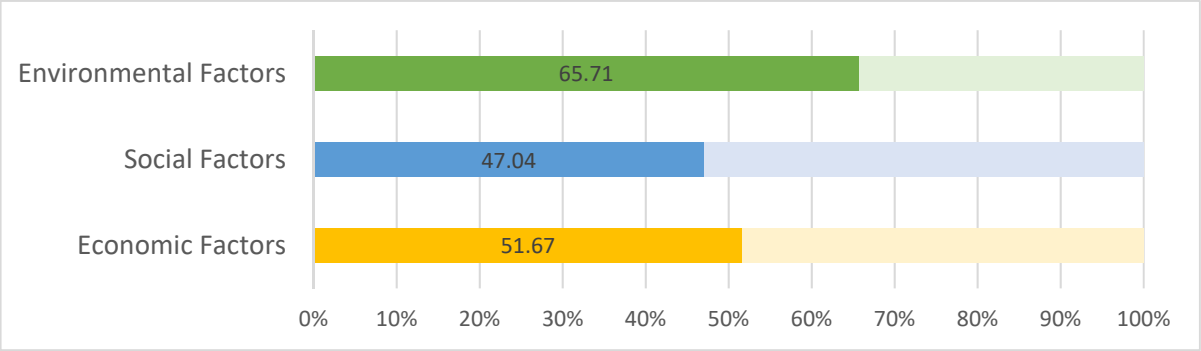

Figure 7: percentage of economic, social and environmental factors being reported on average

4.2 Companies reporting quality's results

Figure 8 shows the different operators' reporting practices on the selected economic, social and environmental factors. 60 per cent of HSR organizations had reporting scores above the average of 53.85 per cent, and majority of these scores are relatively close to the average value. European HSR obtained the top three scores, with SNCF ranked the first with 70.5 per cent followed by FS Italiane and Renfe with scores of 66.6 and 65.4 respectively. In contrast, Guangshen railway gained the lowest score, reporting on only around 36 per cent of sustainability factors.

Moreover, Figure 8 illustrates that some operators presented a relatively identical performance while reporting on the economic, social and environmental factors. For example, FS Italiane's economic, social and environmental reporting scores are 57 per cent, 59 per cent and 59 per cent respectively. On the other hand, some operators showed a variation in scores while reporting on sustainability pillars. For example, DB obtained a score of 57 per cent on economic factors, 51 per cent for environmental and 41 per cent for social factors. SNCF's showed the highest performance while reporting on social factors, achieving almost 78 per cent over all social factors.

On the other hand, Renfe ranked first in reporting on environmental factors, reporting on around 66 per cent of all environmental factors. CHSR and HS2 showed very similar performance while reporting on environmental factors, covering almost 55 per cent of factors. However, CHSR obtained the lowest score with reporting on economic factors covering only 20 per cent of factors, although there may be a justification for this as the line is not yet operational.

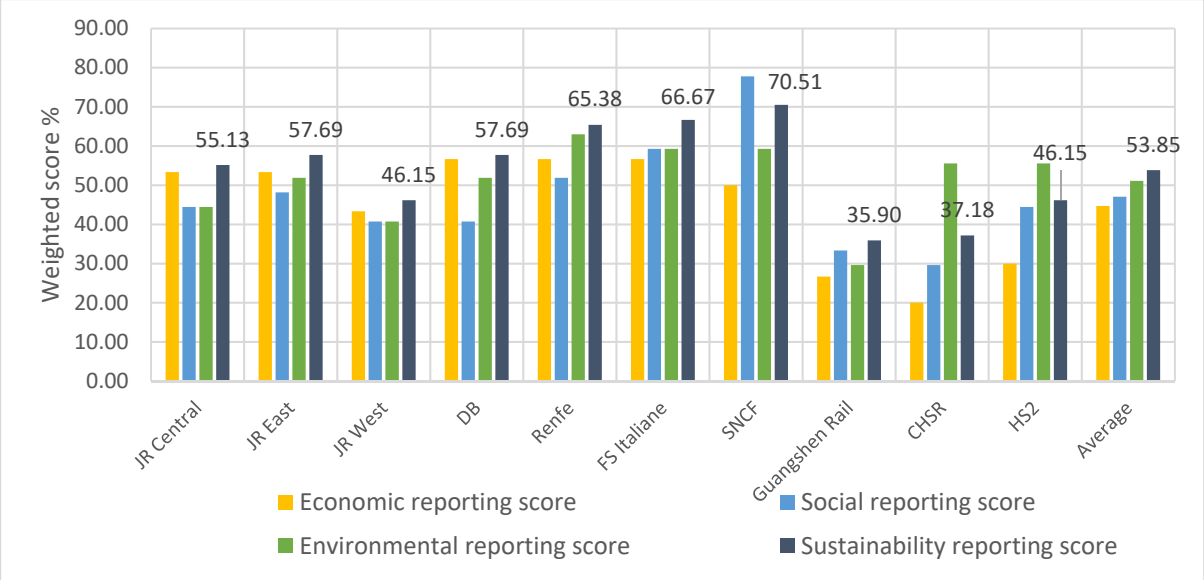

Figure 8: Companies score while reporting on sustainability's pillars

4.3 Indicators' results

Companies used both quantitative and qualitative indicators to report on their performance. Table 11 presents the results of comparing 15 different publications of all companies. Figure 9 illustrates a balance in the use of both quantitative and qualitative indicators in all reports, with a slight bias towards using qualitative disclosure.

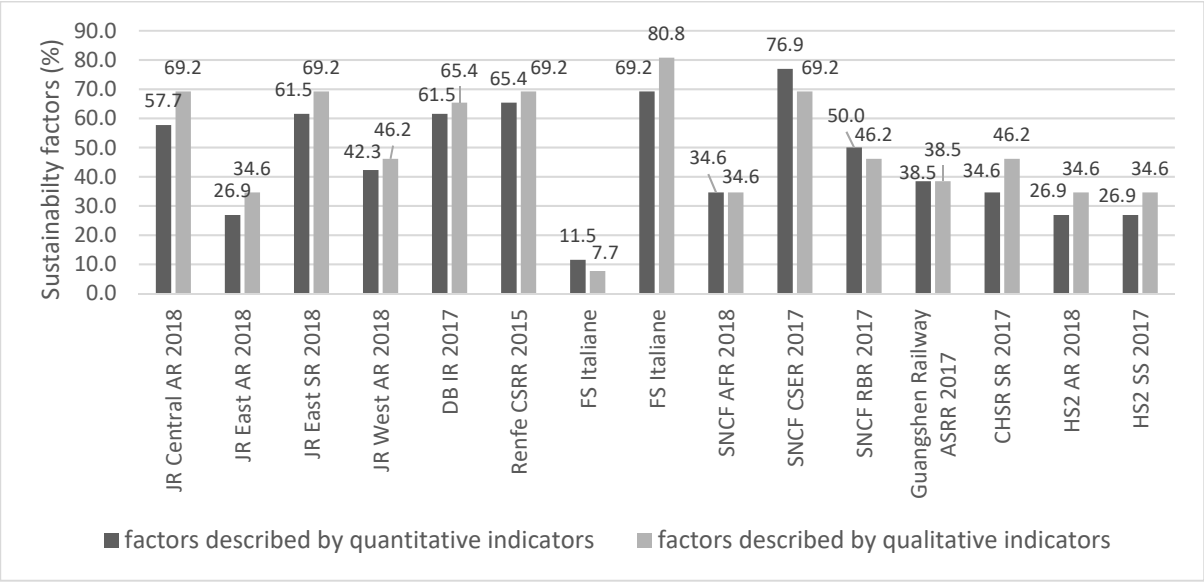

Figure 9: Representing sustainability factors using quantitative and qualitative indicators

Figure 10 shows that factors such as employment, safety, energy, and emissions were described in almost 13 out of 15 reports using both quantitative and qualitative

indicators. Factors such as door-to-door journeys and integration with other modes were mostly described by qualitative indicators, while materials and resources and wider economic impacts were represented mostly by quantitative parameters. However, most of the factors showed a balance in quantitative and qualitative indicators' use.

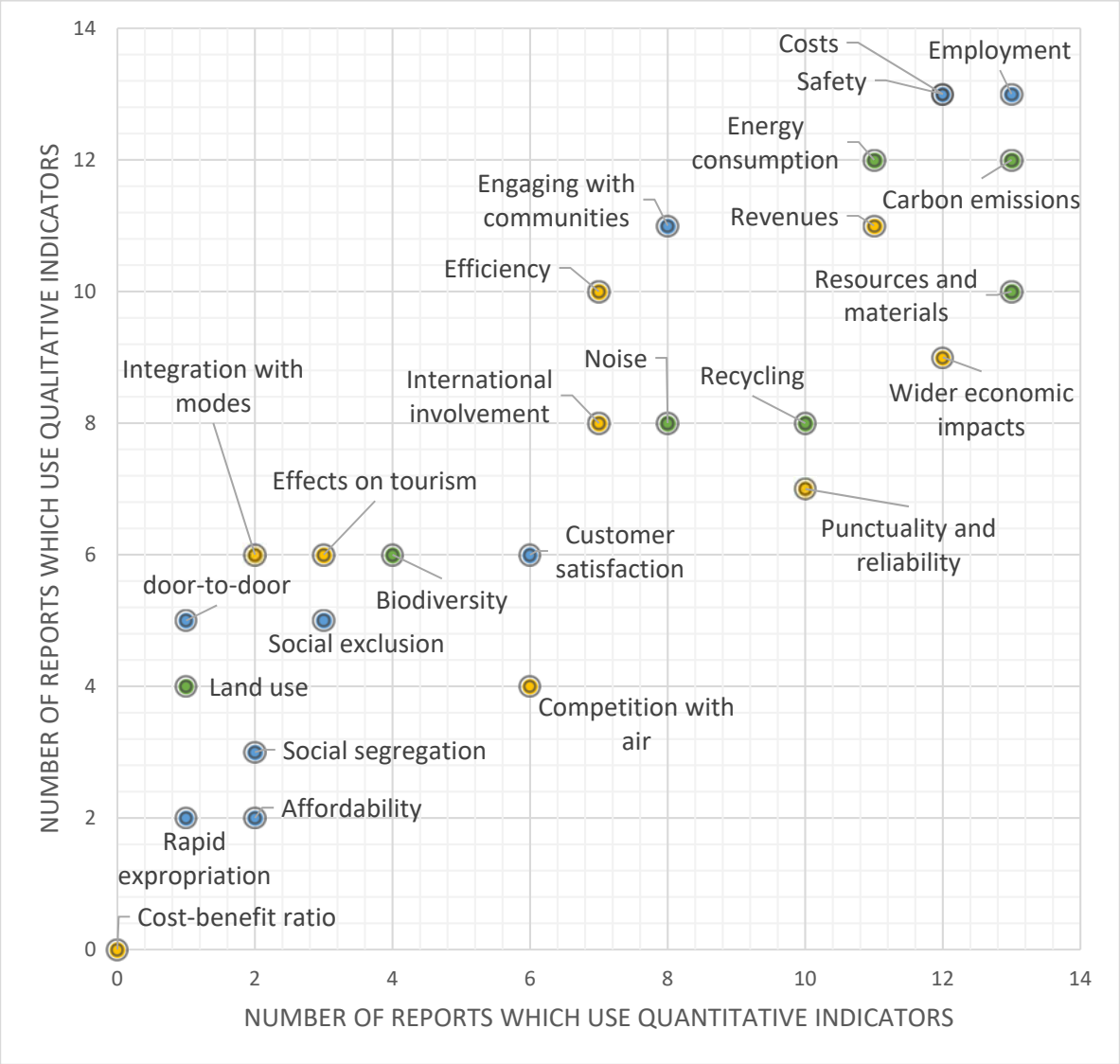

Figure 10: Representing sustainability factors in all 15 companies' reports using quantitative and qualitative indicators

5. Discussion of current reporting practices and potential improvements

The Benchmarking exercise has revealed variations in sustainability reporting, and these will be discussed at the following levels; three sustainability pillars, the 26 chosen sustainability factors, 10 HSR companies; and, the extent of quantification.

5.1 Reporting variation at the sustainability pillars' level

The first level of reporting variation is found among three sustainability pillars, and Table 12 summarizes these variations plus reflecting on areas of improvement.

Table 12: findings and potential reporting improvements at the sustainability pillars' level

	Current reporting situation	Areas of required and potential improvements
The economic pillar	- obtained mixed reporting performance - almost 52 per cent of economic sustainability factors were covered in operators' reports	- reporting on the economic pillar could be enhanced by disclosing more information about; wider economic impacts, effects of HSR on tourism; and, the competition with air transport in terms of the per km pricing
The social pillar	- obtained the weakest reporting performance - only 47 per cent of social sustainability factors were considered in operators' reports	- international reporting guidelines especially those offered by the UIC and the GRI could develop a set of railway-specific indicators to help operators in reporting on more social factors in their publications - new parameters are required for facilitating the reporting process on factors of social exclusion, social segregation, rapid expropriation and affordability
The environmental pillar	- obtained the highest reporting performance among sustainability pillars - around 65 per cent of environmental sustainability factors were covered in operators' reports	- reporting on the environmental pillar failed to cover almost 35 per cent of the identified environmental factors - more reporting is required on factors of biodiversity, land use and noise

The highest environmental reporting performance could be explained by the fact that environmental topics have been tackled by many scholars and organizations while governments and agencies have pushed towards the adoption of such topics (Andreas et al., 2012, G&AI, 2014). The result of these multiple and accumulative efforts is translated in the availability of several frameworks, assessment methods and many key performance indicators especially in topics related to carbon emissions and energy consumption.

In contrast to the environmental pillar, findings of this study show that some newly discussed social issues in the field of HSR are not as yet covered in sustainability reporting practices, pointing towards the need to develop an appropriate reporting mechanism to boost social reporting performance.

5.2 Reporting variation at the 26 sustainability factors' level

The second level of reporting variation is revealed among the 26 sustainability factors, and Table 13 summarizes the findings regarding the current reporting situation and areas of potential improvements at the 26 sustainability factors level.

Table 13: findings and potential reporting improvements at the 26 factors' level

		Current reporting situation	Areas of required and potential improvements
Factors with good reporting performance	**Economic**	- Factors: punctuality and reliability, costs, revenues and efficiency - A wide range of indicators are used such as percentage of trains arrived within 5 minutes, total operating revenues, operating expenses, net profits, total equity, equity ratio, earnings per share, financial efficiency	- When reporting, operators should distinguish between HSR and other services, by providing specific economic data that only relates to HSR, especially regarding costs and revenues. - HSR operators could report on the per passenger.km costs, revenues and net profits - reporting on costs associated with purchasing energy
	Social	- Factors: safety, engaging with local communities, employment, customer satisfaction - reporting focuses on numbers and types of rail accidents such as numbers of derailments, collisions, fires, and level-crossing accidents. - reporting focus on total numbers of employees by contract type, gender, and age	- reporting on numbers of fatalities/injuries caused to passengers/staff/third-party people due to HSR activities. - reporting on numbers of training hours offered to staff - reporting on lost working days due to work-related accidents - more focus on negative impacts caused to local communities, and efforts to alleviate the such effects - reporting on numbers of jobs offered to locals
	Environmental	- Factors: carbon emissions, energy consumption, resources and materials, recycling - a variety of indicators are used such as the final energy consumption (MJ), the total amount of CO2 produces (tonnes), recycling rate (%), amounts of materials and resources used (tonnes) - most reporting practices focus on total quantities associated with all services managed by the operators, while less attention is paid to differentiating between these services	-HSR should report on the per passenger.km energy consumption and carbon CO_2 emissions - reporting on amounts of other pollutants such as NOx and So_x and particles - Reporting on the source of materials, especially whether or not these sources are sustainable - explaining efforts to reduce the consumption of water, sand, paper, concrete, and metals. - reporting on amounts of hazardous/non-hazardous wastes produced/transported - differentiating between impacts of HSR and other services; for instance, reporting on emissions resulted from the HSR activity, rather than those of all services
Factors with average and weak reporting performance	**Economic**	- Factors: costs-to-benefits ratio, broader economic impacts, effects on tourism, integration with other modes, international involvements, competition with air transport - operators reflect on numbers of jobs created - operators list international projects in which they are involved	- more attention to reporting on lifecycle costs and benefits of each HS Project - reporting on revenues generated from engaging in different projects internationally - disclosing information about the comparison between HSR and air transport in terms of per km pricing and per passenger CO_2 emissions
	Social	- Factors: door-to-door journey time, social exclusion, social segregation, rapid expropriation, affordability and operators' initiative - most available information focuses on providing facilities for disabled people - some operators reflect on smart ticketing - some operators reflect on numbers of properties demolished due to constructing new HSR lines	- disclosing information about the coordination between HSR and other transport modes for providing seamless journeys that result in fewer emissions - presenting results of surveys that examines reasons behind excluding specific people from using HSR services - reporting on compensations offered to landowners plus rehabilitation programs provided to farmers who left their lands - disclosing information about offers and discounts available to students, seniors, and disabled people
	Environmental	- Factors: land use, noise, biodiversity - no specific indicators are used, and international reporting guidelines of UIC and GRI are rarely adopted - patchy information about operators' efforts to reduce HSR noise levels - scarce reporting on vegetation control methods and amounts and costs of herbicides used - irregular and rare information about initiatives to protect biodiversity	- disclosing information about the length of noise-absorbing walls erected along different HSR corridors - reporting on technological approaches to reduce noise - publishing information about costs and amounts of herbicides used per track km, plus efforts to reduce the usage of chemicals and active materials - reporting on biodiversity should provide information about; the natural site; HSR activities' positive and negative impacts; and, efforts to protect biodiversity - reporting on numbers of trees planted to offset some adverse environmental impacts

Several potential reasons might be behind the variation in reporting on the 26 sustainability factors level. First, the availability of several performance measurement frameworks and indicators plus international efforts and regulations might explain the advanced reporting level on some factors (Andreas et al., 2012, G&AI, 2014). Moreover, there is a possibility that operators tend to report on factors on which they perform well while avoiding reporting on factors where they have low performance (Lei et al., 2015). Another possibility is that HSR operators are interested in factors that are related to their operations while reporting on factors such as social exclusion and rapid expropriation could be seen to be the responsibility of other regional/national organizations and governments.

5.3 Reporting variation at the HSR companies' level

The third level of reporting variation was among HSR companies, and this variation is translated into different scores and different covered topics. Table 14 summarizes the main findings related to this variation and potential areas for improvement.

Table 14: findings and potential reporting improvements at the HSR companies' level

	Current reporting situation	Areas of required and potential improvements
Companies with good reporting performances	- SNCF, Renfe and FS Italiane achieved highest reporting performances - SNCF offers an extensive reporting on social sustainability factors, using a wide range of indicators such as numbers and amount of grants offered to employees, purchasing from small local businesses as a percentage from total purchasing, the number of charities assisted - FS Italiane often distinguish between HSR and other services when reporting	- more reporting on the competition between HSR and air transport, especially in terms of pricing (per km) and CO_2 emissions - Renfe needs to disclose more quantitative and qualitative information about their social performance, especially regarding social exclusion and social segregation - SNCF and Renfe need to distinguish between HSR and other transport services in their reporting - FS Italiane explain offered and discounts offered to different categories in the society
Companies with average reporting performances	- JR East, JR Central, and DB achieved mediocre reporting performances -both JR Central and JR East focus in their reports on areas in which they deliver superior performance, such as zero fatalities as a result of operations, and the per seat.km CO_2 emissions - DB offers a well-structured report reflecting on several performance indicators plus providing a chronical comparison	- using the (g CO_2 per seat.km) could be replaced by using (g CO_2 per passenger.km) unit, as this provides more realistic CO_2 values, especially when the load factor of trains is often lower than 100 per cent - JR Central could disclose information about the integration between HSR and other modes, explicitly reporting on numbers of buses, subway lines and car parking spaces available at the station - DB's safety disclosure could be enhanced by reporting on numbers of fatalities and injuries caused to passengers and third-party people
Companies with a weak reporting performance	- JR West, Guangshen Railways, HS2 and CHSR achieved lowest reporting performance - Guangshen Railways' reporting performance is limited to providing key financial and employment figures, such as number of employees, total revenues and costs	- Guangshen Railways could expand their reporting practices by reflecting on key performance indicators such as energy consumption and CO_2 emissions per passenger-km, numbers of rail accidents, fatalities and injuries - JR West could reflect more on the integration with other transport modes and effects of tourism - both the HS2 and CHSR could reflect more on lifecycle emissions associated with their projects, plus their efforts to alleviate these emissions and other negative impacts

Lei et al. (2015) explored corporate responses of five Chinese railway companies after a major train accident in China, concluding that none of these companies have provided detailed information about the accident in their report. Moreover, Lei et al. (2015) expanded in their findings pointing out that for every aspect, Chinese companies tend to use their CSR reports only for disclosing achievements, rewards, and honors obtained while not providing practical information and avoiding the provision of negative information. Our findings partly match with findings in (Lei et al., 2015); Chinese operators focus on rewards and achievements in their report. However, there is evidence to dispute (Lei et al., 2015)'s claim that Chinese reports do not include practical information. This study found that the Chinese HSR operator has included key practical information regarding several sustainability factors such as costs, revenues, and key employment figures.

5.4 Reporting variation at the types of Indicators' level

The fourth variation level relates to the degree of quantitative and qualitative reporting, and Table 15 summarizes key findings and recommendations at this level.

Table 15: findings and potential reporting improvements at the types of indicator's level

	Current reporting situation	Areas of required and potential improvements
The use of qualitative indicators	- factors of biodiversity, land use, door-to-door journey time and integration with other modes were mostly described by qualitative explanation	- reporting on biodiversity could be enhanced by providing quantitative information about the total expenditure on the environmental conservation - disclosing information about the per.km costs and amounts of herbicides used - reporting on the integration with other modes could be enhanced by providing numbers of metro stations and bus lines at the HSR station, plus numbers of stops and stations that can be reached without transfer.
The use of quantitative indicators	- quantitative indicators mostly described factors of punctuality and reliability and wider economic impacts	-reporting on punctuality and reliability could be enhanced by providing a qualitative explanation about compensations offered to passengers who experience delays and service cancelations - reporting on the wider economic impacts is not limited to numbers of jobs created, and operators could discuss changes in land and property prices, agglomeration effects and externalities such as the amount of CO_2 prevented by shifting from air transport and cars to HSR
The use of both types of indicators	- Most factors showed a balance in the use of quantitative and qualitative indicators - most reports showed a balance in using both quantitative and qualitative indicators - factors such as affordability, cost-benefit ratio, and rapid expropriation showed a weak representation by both quantitative and qualitative indicators	- there is a vital need for using quantitative and qualitative parameters suggested by international guidelines as this allows conducting benchmarking exercise for comparing the performance of different operators - there is a need for developing new quantitative and qualitative indicators for expressing factors with low representation in operators' reports.

5.5 General Discussion

Findings from all levels revealed the variation in reporting among HSR companies, highlighting the fact that there is no common set of factors that HSR companies report on today, and further, that even on the factors where there is a high level of reporting, the exact nature of the reporting often differs. Therefore, it is currently impossible to use benchmarking data from HSR companies to compare their sustainability. These findings highlight the potential for the development of a common reporting framework for HSR sustainability reporting. It is beyond the scope of this paper to suggest what such a framework would look like, but from the research undertaken the authors can suggest the following considerations for its development:

1. The framework could comprise the identified and validated 26 sustainability factors.
2. Some indicators should be sector-specific focused on HSRs.
3. The framework should utilize a combination of quantitative and qualitative indicators, depending on the nature of the factors.
4. Wherever possible it should include currently used indicators although there may be a need for some standardization or normalisation.
5. Any factors that are currently the subject of statutory reporting requirements - such as profit and loss and carbon emissions in some countries- should be used, but care must be taken to ensure consistency when comparing different countries. Ioannou and Serafeim (2017) discuss that even in the absence of regulations that mandate the adoption of reporting guidelines, companies and organizations look up to qualitative properties of creditability and compatibility, and hence there is a great potential for the framework to be adopted.
6. These is a need to develop new indicators for measuring the underrepresented sustainability factors.
7. These new indicators should be acceptable to HSR operators and seen as a useful addition to their reporting packages.

It is important to mention that the weaker reporting performance does not necessarily mean weaker sustainability performance of an HSR system. Hahn and Kühnen (2013) discuss that sustainability reporting does not necessarily convey a fair and

true view of companies' actual sustainable performance. A weak reporting performance could be explained by the fact that an operator might be simply reluctant to share their data in their annual and sustainability reports. Another reason could be the immature sustainability reporting culture within an organization, reflecting on the need for more leadership and training in this regard. The third reason could be either the absence of governmental pressure towards information disclosure or even governmental censorship and instructions which prevent reporting on specific areas (Azizul Islam and Deegan, 2008).

The authors of this study believe that HSR operators should consider disclosing and reporting on factors and areas in which they have relatively weak performance, as this could act as a mitigation tool and also promote interventions that address the issues revealed. Reimsbach and Hahn (2015) explain that self-reporting of negative information and weak performance does not affect stakeholders' perceptions and decisions about the company, while the judgment of a third external party such as the media could do. Instead, self-reporting of negative information and weak performance might have positive effects, possibly reducing its apparent stigma. Moreover, a well-balanced report that combines both positive and negative information is likely to have a greater influence on stakeholders and audiences, compared to a report which focuses only on praising the organizations while ignoring its shortcomings (Isaksson and Steimle, 2009, Guthrie and Farneti, 2008).

5.6 Pathways to impact

The insights from this study can be used by international organizations' -such as the GRI and the UIC- in updating and modernizing their current reporting guidelines, making it more specific and increasing its applicability in the field of HSRs. The organizational adoption and the sponsorship of the framework will enhance both the sustainability reporting and the sustainability performance of HSR operators around the world, allowing the best performers to fill gaps in their reporting practices by adding new factors while weak performers will expand and update their current limited disclosure. Ioannou and Serafeim (2017) explain that ongoing governmental and international efforts and regulations to enhance organizations' CSR reporting practices are generally successful in improving the revelation of quantitative and qualitative performance information.

Moreover, a framework with standardised factors and indicators would facilitate international benchmarking exercises among HSR operators worldwide, allowing them to identify strengths and weaknesses in their sustainability performance. Utilizing the framework for benchmarking will endorse the sharing of ideas, disseminating lessons, and learning from best practices, while the overall result will be improving HSR systems' performance as a sustainable transportation mode. Finally, long-term effects of the suggested framework will underpin UN's efforts in addressing sustainable development goals in a balanced manner that consider all three sustainability pillars.

5.7 Limitations of this study

While the study has gained a reasonably comprehensive view of the types of sustainability reporting carried out by HSR operators, in the scrutiny of operators' reports was conducted by the author using visual observation. So, results might be slightly biased and subjective. However, to eliminate potential impacts of bias and subjectivity on findings and conclusions and to guarantee their validity, all documents have been thoroughly checked at least twice. The search process considered all parts of each report, including facts sheet, highlights, summaries, the main body and tables of contents.

5.8 Further research opportunities

This paper points to opportunities for further research into the field of HSR sustainability reporting, measurement and benchmarking. Follow-up studies could tackle the development of a set of key performance indicators to express sustainability factors that are weakly covered in current reporting practices, such as social exclusion, social segregation, social expropriation, and land use. Other studies could examine standardisation of indicators which are currently common among HSR operators, including the potential to apply weightings to each of the factors to allow for their different levels of importance. Moreover, future research could conduct in-depth case studies examining and comparing the reporting culture of HSR operators in different countries, focusing on operators in countries that show limited reporting performance.

6. Conclusion

This research has identified two research gaps; there is no one unified sustainability reporting framework that combines HSR issues under the three pillars of sustainability's cover; and, no previous studies have individually examined sustainability reporting practices of HSR operators. To fill these gaps, the study looked at sustainability reporting practices of some HSR companies around the world. The novelty of the research and the contribution to academia and the industry are summarized in the following key findings and recommendations:

1. The study identified and validated a framework of 26 economic, social, and environmental factors that are representative of the sustainable performance of HSR. These factors combine operators' traditional reporting interests and the most recent studies and publications in the field of sustainability of HSR.
2. The 26 factors framework could be used for updating reporting practices and publications of HSR operators, offering them a set of factors that matters from the sustainability perspective and on which they can disclose information. Another potential use of the framework is upgrading reporting guidelines of international organizations such as the UIC and the GRI.
3. The study looked at the extent to which the 26 factors are covered in operators' reports, and it found variations in reporting at different levels; sustainability pillars' level, factors' level, companies' level, and the extent of quantification's level.
4. At the three pillars' level, the research found that around 48 per cent, 53 per cent and 34 per cent of the identified economic, social and environmental factors respectively have not been covered in operators' reporting practices. Hence, there is a great potential for improvements in reporting against all pillars, by properly covering all identified sustainability factors. An appropriate reporting and comprehensive measurement will result in better management, and the outcome will be economic, socially acceptable, clean and environmental-friendly HSR services.
5. At the 26 factors' level and within the environmental pillar, the study found that factors of land use, biodiversity, and noise were poorly covered in publications. Reporting on energy consumption and carbon emissions was relatively good; however, there are standardization and normalization issues.

6. Within the social pillar, social exclusion, social segregation, and rapid expropriation took minimum attention in sustainability reports. Reporting on safety and employment was relatively acceptable.
7. Within the economic pillar, reporting on the competition with air transport, integration with other modes, the costs-to-benefits, and the wider economic impacts was inadequate. In contrast, operators showed a good reporting performance on costs, revenues, and efficiency.
8. Reporting on all factors could be improved. For example, operators could distinguish in their information disclosure between HSR and other transport services they operate. Providing total operation values for all services hinders any potential of conducting benchmarking exercises. Moreover, normalization is required when reporting, as this allows internal and external comparisons.
9. Some operators showed a better reporting performance than others. However, all companies have the potential to enhance their reporting practices. Operators with good performances could upgrade their reporting by diversifying factors and related indicators. Operators with average and weak performances should at least report on critical factors and gradually consider other advanced areas and parameters.
10. Operators tend to report on areas in which they have excellent performance. However, it is essential to report on both positive and negative aspects of the performance, as this will result in better management.
11. The study suggested some parameters that can be used for reporting on different factors. For instance, within the environmental scope, HSR operators could reflect on the per passenger.km energy consumption and emissions. Also, the costs and amounts of herbicides used for vegetation management should be provided. Moreover, operators should reflect on the source of materials and resources used plus their efforts to reduce the total consumption. Improving reporting on environmental factors will result in better measurement and management, and the outcome will be a clean and environmental-friendly HSRs.
12. There is a need for developing indicators for reporting on poorly covered factors. The international reporting guidelines mostly reflect on general topics that apply to different fields. Topics such as social exclusion, social segregation, and wider economic impacts have their importance in HSR's current literature. So, reporting

guidelines could also develop new parameters for measuring and managing these factors.

13. Qualitative reporting is necessary for explaining operators' efforts in a specific topic, while the quantitative disclosure is vital for conducting benchmarking exercises and comparisons. To fulfil both purposes, a balance between quantitative and qualitative indicators is required.

Reporting variation at all levels discussed in this paper suggests that there is a great potential to enhance and fill gaps in sustainability reporting practices of HSRs companies. A unified sustainability reporting framework comprising all 26 sustainability factors with an appropriate set of quantitative and qualitative indicators could fill these gaps. Moreover, the suggested common framework could facilitate sustainability benchmarking exercises among HSRs companies and enable external stakeholders to compare their sustainability performance.

Acknowledgment

This paper follows from a PhD project at the University of Birmingham, examining the possibility of building HSR sustainability reporting and benchmarking framework. The project includes several stages of which this paper is a part. Other stages will look at the development of key performance indicators to measure and report on sustainability factors that are poorly represented in current reporting practices. The project is funded by the University of Birmingham's Postgraduate Research Scholarship (2016-2019); the Council for At-Risk Academics' Grant (2016-2019).

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Table 10: Assessment of the availability of sustainability factors in companies' reports.

	Company	JR Central	JR East	JR East	JR East	JR West	DB	Renfe	FS Italiane	FS Italiane	FS Italiane	SNCF	SNCF	SNCF	SNCF	Guangshen Railway	CHSR	HS2	HS2	HS2	Total Maximum of 30
	Country	Japan	Japan	Japan	Japan	Japan	Germany	Spain	Italy	Italy	Italy	France	France	France	France	China	USA	UK	UK	UK	
	Document type	AR	AR	SR	Final*	AR	IR	CSRR	AR	SR	Final*	AFR	CSER	RBR	Final*	ASRR	SR	AR	SS	Final*	
	Year	2018	2018	2018	Final*	2018	2017	2015	2018	2017	Final*	2018	2017	2017	Final*	2017	2017	2018	2016	Final*	
Symbol	Reference	(JRCentral, 2018)	(JREast, 2018a)	(JREast, 2018b)	Final*	(JRWest, 2018)	(DB, 2017)	(Renfe, 2015)	(FSItaliane, 2018)	(FSItaliane, 2017)	Final*	(SNCF, 2018)	(SNCF, 2017a)	(SNCF, 2017b)	Final*	(Guangshen, 2018)	(CHSR, 2017)	(HS2, 2018)	(Templ e-RSK, 2016)	Final*	
EC-1	Punctuality and reliability	3	1	2	2	1	3	3	0	3	3	1	3	1	3	3	0	0	0	0	21
EC-2	Costs	2	3	1	3	3	3	3	2	2	2	2	2	2	2	2	1	2	0	2	23
EC-3	Revenues	3	3	3	3	3	3	3	3	3	3	3	3	0	3	2	0	0	0	0	23
EC-4	Efficiency	2	1	1	1	2	2	2	0	2	2	1	2	2	2	2	2	0	2	2	19
EC-5	Cost-benefit ratio	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
EC-6	Wider economic impacts	1	1	1	1	1	2	1	0	2	2	2	1	2	2	1	3**	0	2	2	13
EC-7	Effects on tourism	2	2	2	2	2	1	2	0	2	2	0	0	1	1	0	0	0	0	0	12
EC-8	Competition with air transport	3	0	1	1	1	2	1	0	0	0	0	1	0	1	0	2	0	1	1	12
EC-9	Integration with other modes	1	1	2	2	1	1	2	0	3	3	1	1	0	1	0	1	0	2	2	14
EC-10	International involvement	2	3	3	3	0	2	3	1	3	3	2	3	1	3	1	0	0	0	0	17
SO-1	Safety and risks	3	3	3	3	3	2	3	0	3	3	2	3	3	3	2	3	2	1	2	27
SO-2	Accessibility (door-to-door journey)	0	0	1	1	1	1	0	0	2	2	2	2	1	2	0	0	1	0	1	8
SO-3	Social segregation	0	0	0	0	0	2	0	0	2	2	0	0	2	2	0	0	0	0	0	6
SO-4	Rapid expropriation	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3
SO-5	Social exclusion	0	0	1	1	0	0	1	0	1	1	0	2	1	2	0	0	2	2	2	7
SO-6	Engaging with local communities	3	2	3	3	2	0	3	0	2	2	1	3	3	3	3	2	3	2	3	24
SO-7	Customer satisfaction	1	1	2	2	2	3	3	0	3	3	1	3	1	3	1	0	0	0	0	18
SO-8	Employment	2	2	3	3	3	3	3	0	3	3	2	3	3	3	3	3	2	1	2	28
SO-9	Affordability and operators' initiatives	2	0	0	0	0	0	1	0	0	0	0	3	0	3	0	0	0	0	0	6
EN-1	Carbon emissions	3	1	3	3	3	3	3	0	3	3	1	3	2	3	3	3	2	3	3	30
EN-2	Energy consumption and sources	2	2	3	3	2	3	3	0	3	3	1	3	3	3	2	2	1	1	1	24
EN-3	Land use	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2	0	2	2	6
EN-4	Resources and materials	2	0	2	2	3	2	3	0	3	3	1	2	1	2	2	3	1	2	2	24
EN-5	Biodiversity	0	0	2	2	1	1	3	0	1	1	1	3	2	3	0	2	0	3	3	16
EN-6	Recycling	3	0	2	2	2	3	3	0	3	3	1	3	2	3	1	3	0	1	1	24
EN-7	Noise	1	0	2	2	0	2	2	0	2	2	0	2	1	2	0	0	1	3	3	14
	Total (maximum of 78)	43	26	43	45	36	45	51	6	52	52	25	51	34	55	28	29	19	30	36	

AR= annual report SR=sustainability report IR= integrated report CSRR=corporate social responsibility report AFR= annual financial report CSER=corporate social engagement report RBR= responsible business report ASRR=annual social responsibility report SS= sustainability statement *the higher value in all documents for a specific operator is adopted ** the value is obtained from the (Inverting in California Economy Report) available via the operator's website

- 0 = no meaningful information is presented regarding the specific factor
- 1 = patchy information is presented without providing enough clarification and with limited use of charts and visuals
- 2 = good information regarding the factor is presented. Good use of charts and visuals. However, not all areas of the factor are well covered and addressed.
- 3 = the reporting provides full information regarding the factor; a mix of quantitative and qualitative indicators is presented with an extensive use of charts and examples comparing the performance of different years

Source: Author's elaboration on HSR companies' reports

Table 11: Assessment of the availability of quantitative and qualitative indicators in companies' reports.

	Company	JR Central		JR East		JR East		JR West		DB		Renfe		FS Italiane		FS Italiane		SNCF		SNCF		SNCF		Guangshen Railway		CHSR		HS2		HS2		Total Maximum of 15	
	Country	Japan		Japan		Japan		Japan		Germany		Spain		Italy		Italy		France		France		France		China		USA		UK		UK			
	Document type	AR		AR		SR		AR		IR		CSRR		AR		SR		AFR		CSER		RBR		ASRR		SR		AR		SS			
	Year	2018		2018		2018		2018		2017		2015		2018		2017		2018		2017		2017		2017		2017		2018		2016			
	Reference	(JRCentral, 2018)		(JREast, 2018a)		(JREast, 2018b)		(JRWest, 2018)		(DB, 2017)		(Renfe, 2015)		(FSItaliane, 2018)		(FSItaliane, 2017)		(SNCF, 2018)		(SNCF, 2017a)		(SNCF, 2017b)		(Guangshen, 2018)		(CHSR, 2017)		(HS2, 2018)		(Templ e-RSK, 2016)			
Symbol	Type and availability of indicators	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L
EC-1	Punctuality and reliability	●	*	●		●	*	●		●	*	●	*			●	*			●	*	●		●	*							10	7
EC-2	Costs	●	*	●	*		*	●	*	●	*	●	*	●	*	●	*	●	*	●	*	●	*	●	*			●	*			12	13
EC-3	Revenues	●	*	●	*	●	*	●	*	●	*	●	*	●	*	●	*	●	*	●	*			●	*							11	11
EC-4	Efficiency	●	*						*	●	*		*			●	*			●	*	●	*	●	*	●	*				*	7	10
EC-5	Cost-benefit ratio																															0	0
EC-6	Wider economic impacts	●	*	●		●	*	●	*	●	*	●				●	*	●	*	●		●	*			●	*			●	*	12	9
EC-7	Effects on tourism		*		*		*	●	*	●			*			●	*															3	6
EC-8	Competition with air transport	●	*			●			*	●	*	●								●						●	*					6	4
EC-9	Integration with other modes		*		*	●	*				*		*			●	*															2	6
EC-10	International involvement		*	●	*	●	*				*	●	*	●		●	*	●	*	●	*											7	8
SO-1	Safety and risks	●	*	●	*	●	*	●	*	●	*	●	*			●	*		*	●	*	●	*	●	*	●	*	●	*			12	13
SO-2	Accessibility (door-to-door journey)						*										*		*	●	*		*									1	5
SO-3	Social segregation									●	*					●	*						*									2	3
SO-4	Rapid expropriation																													*	●	*	1	2
SO-5	Social exclusion											●	*				*			●	*							●	*		*	3	5
SO-6	Engaging with local communities	●	*		*	●	*		*			●	*			●	*			●	*	●	*	●	*		*	●	*			8	11
SO-7	Customer satisfaction					●	*		*	●	*	●	*			●	*			●	*	●										6	6
SO-8	Employment	●	*	●	*	●	*	●	*	●	*	●	*			●	*	●	*	●	*	●	*	●	*	●	*	●	*			13	13
SO-9	Affordability and operators' initiatives	●	*																	●	*											2	2
EN-1	Carbon emissions	●	*			●	*	●	*	●	*	●	*			●	*	●		●	*	●	*	●	*	●	*	●	*	●	*	13	12
EN-2	Energy consumption and sources	●	*		*	●	*	●	*	●	*	●	*			●	*	●		●	*	●	*	●	*	●	*		*			11	12
EN-3	Land use		*														*										*			●	*	1	4
EN-4	Resources and materials	●	*			●	*	●		●	*	●	*			●	*	●	*	●	*	●		●	*	●	*	●		●	*	13	10
EN-5	Biodiversity					●	*					●	*							●	*		*				*			●	*	4	6
EN-6	Recycling	●	*			●	*	●		●	*	●	*			●	*	●	*	●	*	●				●	*					10	8
EN-7	Noise	●				●	*			●	*	●	*			●	*			●	*	●	*						*	●	*	8	8
	Total (maximum of 26)	15	18	7	9	16	18	11	12	16	17	17	18	3	2	18	21	9	9	20	18	13	12	10	10	9	12	7	9	7	9		

AR= annual report SR=sustainability report IR= integrated report CSRR=corporate social responsibility report AFR= annual financial report CSER=corporate social engagement report
RBR= responsible business report ASRR=annual social responsibility report SS= sustainability statement N= quantitative indicators L= qualitative indicators
● Existence of quantitative indicators * existence of qualitative indicators

Source: Author's elaboration on HSR companies' reports