Previous research on Eurasian Continental Bridge mainly focused on regional collaboration in infrastructural development. Transport flexibility has been identified as an important aspect of overall supply chain flexibility. Flexibility encompasses infrastructure, physical movement of goods and communication. Flexibility of transport along railway line like the Eurasian Continental Bridge is vital in addressing uncertainties in the supply chains depending on it.

The Russian section of the Eurasian Continental Bridge runs from Vladivostok and Nakhodka through Chita, Oms and Moscow. Figure 1 shows the Eurasian Continental Bridge; blue line in the map shows Moscow – Vladivostok line. The Eurasian Continental Bridge connects Moscow to Vladivostok, a distance of 9,289 km with track gauge of 1.520 m. The Trans-Manchurian line connects Moscow to Beijing through Manzhouli border station which is 6,638 km from Moscow. The continental bridge also consists of Trans-Mongolian line to Beijing through Russia/Mongolian border station at Sükhbaatar, a distance of 5,921 from Moscow.

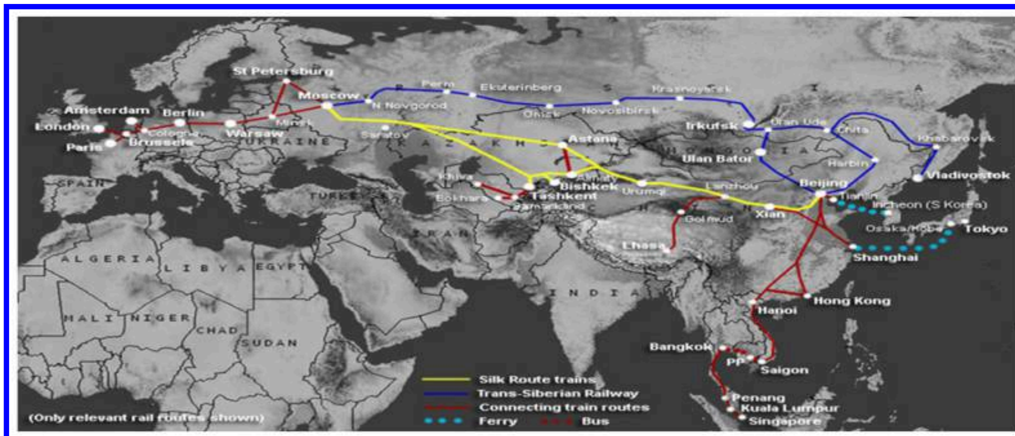

Figure 1. Eurasian continental bridge

This paper aims to address the concerns of La-Roche of attaining efficiency and flexibility in the land bridge as a step towards making the land bridge become cornerstone of reconstruction of world economy. It attempts to fill research gaps in the areas of railway efficiency and flexibility by adopting an integrative approach combining two. The research evaluates the current efficiency level of the Russian section of the land bridge as recommended by Ilie (2010) and Rodrigue (2012) among other researchers.

2 Literature Review

Several researchers have studied efficiency and flexibility of in transport systems. Performance based aspects of efficiency like cost efficiency, cost and service effectiveness (Tennenbaum, 2001; Fielding, Babitsky & Brenner, 1985; Rodrigue, 2012). Other researchers focused capacity and volume aspects of efficiency (Schiller Institute, 2001; Ilie, 2010).

Efficiency has been the main focus of previous railway research (Padila & Eguia, 2010). Zhu (2001) used simulation approach to analyze carrying capacity utilization of railway (European Commission, 2006; Vrugt & Robinson, 2007; Zitzler & Thiele, 1999). Some researchers used survey methods (Bussieck, Winter & Zimmermann, 1997; Cordeu, Toth & Vigo, 1998) but were not specific to Eurasian Continental Bridge. A number of researchers studied economic efficiency of railway transport (McCullough, 2005; Oum & Yu, 1994). Economic efficiency is divided into productive and allocative efficiencies (Oum & Yu, 1994). Determinants of railway efficiency have also been identified in literature. US Department of Defense (2005) noted that efficiency is impacted on by train characteristics, transit time, labor relations and time to clear customs. Federal Railway Administration Research Board (2006) identified key determinants of railway efficiency as human resource, information systems and railway logistics processes.

Research on flexibility has dwelt on both internal and external transport flexibilities. Gosling, Purvis and Naim (2009) classified internal transport flexibility into three: physical movement of goods, infrastructure related flexibility and capacity associated categories. Flexibility of physical movement of good encompasses mode, fleet and vehicle flexibility (Christopher & Juttner, 2000). Infrastructure related transport flexibility includes node, link and temporal flexibility (Gosling, Purvis & Naim, 2009; Christopher & Juttner, 2000). Node flexibility in international railway transport refers to ability of the concerned governments and other stakeholders to plan, approve, implement or remove transport nodes in a railway network. Link flexibility is the ability to establish or remove transport links between nodes. Temporal flexibility is defined as the ability to sequence transport infrastructural investments and the extent to which its use requires user coordination (Noteboom, Keters & Debruyne, 2013; Peppers & Rogers, 1996).

3 Research Methods

3.1 Objectives

There are two objectives:

To analyze efficiency and flexibility characteristics of the Eurasian Continental Bridge; To propose a model of flexibility and efficiency of the Eurasian Continental Bridge.

3.2 Methodology

This research adopted a survey approach to evaluate the efficiency and flexibility levels of the Eurasian Continental Bridge. It used multistage stratified random sampling method to sample respondents from the government ministry of transport, freight companies and Russian Railways. Table 1 shows sample of respondents.

Data collection was done using structured closed ended questionnaires. Determinants of flexibility were identified as: physical movement of goods;

infrastructure; capacity; speed; mobility; service delivery and ownership. Tables 2 and 3 summarize attributes of efficiency and flexibility, respectively. All the characteristics of efficiency and flexibility were rated using Likert Scale with 1= strongly disagree; 2=disagree; 3=agree; 4=strongly agree; 5=very strongly agree.

Table 1. Sample of Respondents

	Target Respondents	Number of participants	Percentage
Ministry of Transport	30	21	70%
Russian Railways	50	43	86%
Freight Companies (15 companies)	150	122	81.3%
Total	**230**	**186**	**80.87%**

Table 2. Efficiency attributes of the continental bridge

Question 1: To what extent do you agree that the following characteristics contribute to efficiency of the Eurasian Continental Bridge?

Code	Category	Characteristics	Code	Rating
TC	Train characteristics	Train energy efficiency	TC1	
		Reliability of trains and wagons	TC2	
		Train capacity	TC3	
		Train speeds	TC4	
TF	Time factor	Transit speed and gauge characteristics	TF1	
		Automated fast train driving	TF2	
		Timely scheduling and planning	TF3	
		Time to clear customs	TF4	
HR	Human resource	Nature of Human Resource Utilization	HR1	
		Labor relations	HR2	
		Human Resource development	HR3	
IS	Information systems	Level and nature of data collection	IS1	
		Level of transport decision support system	IS2	
		Efficiency of wayside and onboard detection systems	IS3	
		Improved visibility of goods in transit	IS4	
		Data accuracy and timeliness	IS5	
LP	Railway logistics processes	Reliability of railway infrastructure	LP1	
		Ability to improve railway hardware management system	LP2	
		Reliability of railway physical infrastructure	LP3	
		Ability to increase throughput	LP4	
		Ability to reduce train idling	LP5	

Table 3. Flexibility attributes of the continental bridge

Question 2: To what extent do you agree that the following characteristics contribute to flexibility of the Eurasian Continental Bridge?				
Code	Determinant Category	Characteristics ability to:	Code	Rating
PD	Physical Distribution	1.Plan, approve, implement or remove transport nodes by concerned governments and other stakeholders	PD1	
		2.Adjust transport speeds in response to customer demand	PD2	
		3.Redeploy transport asset	PD3	
		4.Avoid under-utilization of organizational transport resources	PD4	
IN	Infrastructure	1.Improve railway infrastructure	IN1	
		2.Effect nodal (station) improvements	IN2	
		3.Have adequate warehousing facilities	IN3	
CP	Capacity	1.Have various transit options	CP1	
		2.Manage different types of information by transport service provider	CP2	
		3.Accommodate different routes	CP3	
		4.Improve carriage capacity to meet traffic demands	CP4	
SD	Service delivery	1.Implement quick response	SD1	
		2.Empower workforce	SD2	
		3.Have flexible planning system	SD3	
		4.Deliver quickly and effectively	SD4	
		5.Have an effective motivation system	SD5	
		6.Tailor service to customer demands	SD6	

Reliability and regression analysis was used in this research. Reliability analysis was done using SPSS software to obtain Cronbach's alpha. Regression analysis involved calculation of coefficient of determination R^2 between groups of correlated characteristics as shown in Tables 4 and 5. Test for multi-collinearity was done using Variance Inflation Factor (VIF) statistics of which VIF values of less than 10 indicate that there is no multi-collinearity (Hair, et al, 2009).

Table 4. Regression analysis of efficiency characteristics

Latent variable	R-square	Dependent variable	A-nova	Independent variable	Beta Coeff.	VIF
TC	0.561	IS	F=815.16, p=0.00	TC1	0.552	2.14
				TC2	0.613	2.14

				TC3	0.715	2.14
				TC4	0.846	2.14
TF				TF1	0.697	2.14
				TF2	0.584	2.14
				TF3	0.610	2.14
				TF4	0.732	2.14
HR				HR1	0.634	2.14
				HR2	0.695	2.14
				HR3	0.727	2.14
IS	0.627	LP	F=624.45, p=0.000	IS1	0.525	2.28
				IS2	0.653	2.28
				IS3	0.703	2.28
				IS4	0.741	2.28
				IS5	0.551	2.28

Table 5. Regression analysis of flexibility characteristics

Latent variable	R-square	Dependent variable	Anova	Independent variable	Beta Coeff.	VIF
PD	0.643	SD	F=716.15, p=0.000	PD1	0.651	1.39
				PD2	0.516	1.39
				PD3	0.675	1.39
				PD4	0.743	1.39
IN	0.745	PD	F=607.23, p=0.000	IN1	0.598	2.33
				IN2	0.774	2.33
				IN3	0.641	2.33
CP				CP1	0.655	2.33
				CP2	0.593	2.33
				CP3	0.677	2.33
				CP4	0.626	2.33

3.3 Research Hypotheses

H1: The characteristic studied is significant to efficiency of the Eurasian Continental Bridge. H2: The characteristic studied is significant to flexibility of the Eurasian Continental Bridge.

4 Discussions of Results

4.1 Results of Reliability Analysis

Tables 6 and 7 show calculated Cronbach Alphas for all the characteristics of efficiency and flexibility of Eurasian Continental Bridge are well ahead of the cut off rate of 0.70 which proves good reliability. It means that all the factors used to evaluate the efficiency and flexibility of the land bridge were found to be reliable so factors would produce consistent results irrespective of time period.

Table 6. Reliability and regression analysis results of efficiency characteristics

Latent variable	Independent variable	Cronbach's Alpha	Dependent variable	Independent variable	Cronbach's Alpha
TC	TC1	0.85	IS	IS1	0.72
	TC2	0.71		IS2	0.77
	TC3	0.81		IS3	0.80
	TC4	0.87		IS4	0.74
TF	TF1	0.79		IS5	0.75
	TF2	0.88	LP	LP1	0.70
	TF3	0.95		LP2	0.78
	TF4	0.70		LP3	0.71
HR	HR1	0.83		LP4	0.70
	HR2	0.91		LP5	0.83
	HR3	0.82			

4.2 Results of Regression Analysis

Infrastructure and capacity characteristics create significant positive impact on physical distribution of the land bridge as regression coefficients are significant (IN β – 0.928 and CP β – 0.725). The value of R2 shows 74.5% variations in physical distribution. The Variance Inflation Factor (VIF) statistics shows the value of 2.33 for both independent factors, which is very far from cut off rate of 10. Therefore there is no concern of multi-collinearity among independent factors. Physical distribution creates significant positive impact on service delivery (PD β – 0.724).

Table 7. Reliability and regression analysis results of flexibilitiy characteristics

Latent variable	Independent variable	Cronbach's Alpha	Dependent variable	Independent variable	Cronbach's Alpha
PD	PD1	0.76	CP	CP1	0.70
	PD2	0.70		CP2	0.90
	PD3	0.81		CP3	0.73
	PD4	0.75		CP4	0.77
IN	IN1	0.86	SD	SD1	0.81
	IN2	0.88		SD3	0.76
	IN3	0.79		SD4	0.72
				SD5	0.89
				SD6	0.82

The value of R2 shows 64.3% variations in Service Delivery. Train Characteristics, Time Factor and Human Resource factors create significant positive impact on Information System (TC β – 0.683, TF β – 0.749 and HR β – 0.786, respectively). The value of R2 shows 56.1% variations in Information Systems. Information System create significant positive impact on Logistics Processes as regression coefficients are significant (IS β – 0.941). The value of R2 shows 62.7% variations in Logistics Processes. The VIF statistics shows the value of 2.28 for both independent factors, which is very far from cut off rate of 10. So there is no concern of multi-collinearity among independent factors.

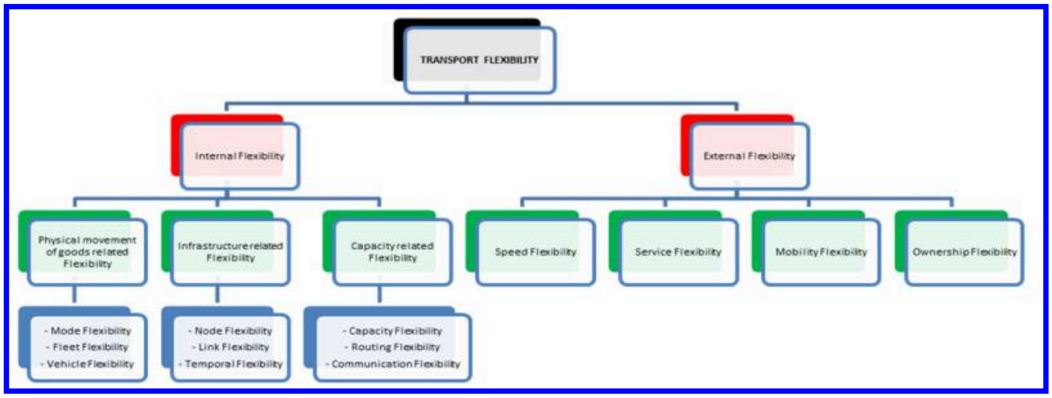

Figure 2. Transport flexibility

4.3 Implications of Research Findings

Infrastructure and capacity are key factors in flexibility of Eurasian Continental Bridge. Key factors influencing efficiency are train characteristics, time factor and human resource. However, physical distribution flexibility and service delivery flexibility cannot be achieved also without flexibility in infrastructural and capacity development. The role of physical distribution flexibility and service flexibility are very important in case of urgently required or fast transit goods. It requires timely and cost effective distribution of varieties goods to distant lands in Middle East and Europe across Russia.

Efficient logistics processes are important in meeting strict lead times. In order order to satisfy varieties of customer transport requirements in the Eurasian Continental Bridge bound supply chains, customized and timely transport and logistics services should be offered through effective and flexible service delivery and efficient logistics processes (Figure 3).

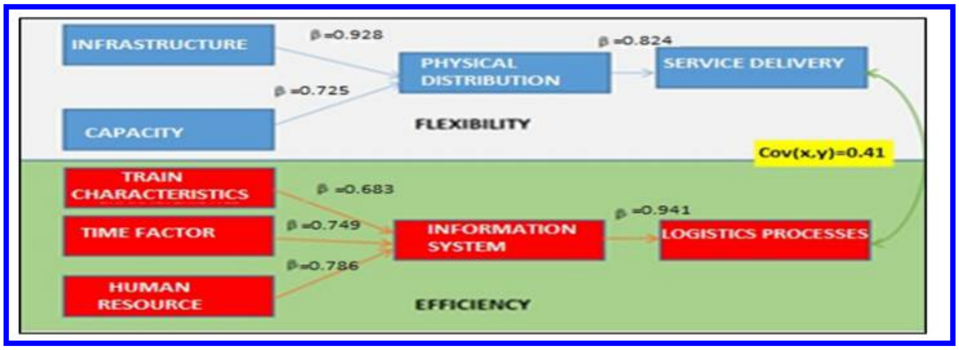

Figure 3. Relationship between efficiency and flexibility characteristics

5 Conclusions

The following conclusions can be drawn from the findings of this research:

(1) Main characteristics influencing efficiency and flexibility of the Eurasian Continental Bridge are train characteristics, time factor and human resource;

(2) Infrastructure and capacity characteristics create significant positive impact on physical distribution along the land bridge. This implies that improvement of infrastructure and capacity can positively improve physical distribution thereby increasing efficiency and flexibility.

(3) Train characteristics, time factor and human resource factors have significant positive impact on the use of railway information system. Trains should be made such as to allow for proper installation and use of onboard railway information system. Improvement of human resource capacity and train speeds (time factor) of the land bridge can lead to efficiency and flexibility improvement.

(4) Railway information systems have positive significant impacts on logistics processes of the land bridge. Most modern logistics processes need information system to ensure fast information processing to boost both flexibility and efficiency.

It is concluded that to improve efficiency and flexibility levels practitioners and policy makers should focus on the characteristics studied in this research.

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