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RESEARCH ARTICLE

Innovative Development of Railway Corporations in Asian Region: Estimating the Impact of Environment Using Comparative Analysis of Korean and Chinese Companies

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Abstract:

Background:

Currently, the issue of the company's innovative development is relevant in all areas of activity. Railway transport, which has one of the development vectors such as an innovative component, poses for itself the task of achieving high competitiveness through active innovative developments and implementations. This direction is influenced by external and internal factors, which should be taken into account while developing and implementing the company's innovative development strategy.

Nowadays, there is increase in the development of global competition and in the transfer of innovations in all areas of service industries, including the railway sector. In recent years, the countries of the Asian region have adopted a strategy for developing the competitiveness of the transport sector through innovative development and the transfer of technology.

Objective:

The study aims at investigating environmental factors which influence innovative development of transport company and evaluating their interdependence using correlation-regression analysis.

Methods:

The correlation-regression analysis and comparative approach were used to develop the model.

Results:

Two Rail corporations from Asian region were investigated. External and internal factors influencing innovative development of these corporations were found; significant in explaining the factors' interdependence was discussed.

Conclusion:

Different groups of factors influence innovative development of transport companies in Asia. These findings can be used as information for managers to develop strategic programs to improve innovative development process in Asian transport companies.

Keywords: Innovative development, Railway transport, Correlation-regression analysis, External and internal environmental factors, Modeling, Innovation, Asian region.

1. INTRODUCTION

Innovative development of the company is the basis for increasing the efficiency of its activities. Tougher

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competition, business conditions, the impact of external and internal factors requires the formation and implementation of an innovative development strategy.

Railway transport is one of the most actively developing on the innovative base of industries in global market. One of the vectors for the Korean and Chinese rail industry development is innovation, namely, the creation of new and improvement of existing goods and services.

The Asia Pacific transportation market is anticipated to grow at the highest rate of 6.8% over the forecast period owing to increasing spending by the governments on construction of new railroads and dependency of population on rail for transportation. In addition, growth in the imports and exports of Asian countries expected to bolster the market growth. According to OECD [1], the number of freight cars in Asia Pacific region has increased by 28,000 units between 2013 and 2015. Construction of dedicated freight corridors in India and increasing usage of speed trains in China & Japan can be the other factors which are expected to boost the Asia Pacific railroads market in the recent years (Fig. **1**).

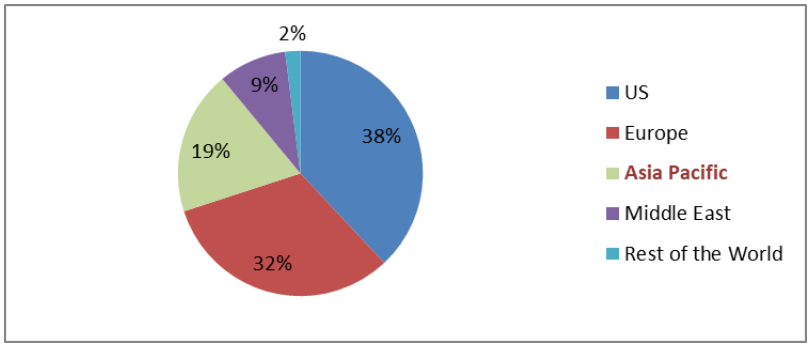

Fig. (1). Rail global market by 4 Regions in 2016.
Source: OECD report, 2017 URL: https://data.oecd.org/ (last access 12.02.2018).

The travel market in Asia Pacific is growing and evolving rapidly. Rail travel is keeping pace with this growth and has huge potential to play an even greater role in supplementing and complementing the wider travel industry to the benefit of the traveler [2].

Railways need to understand this decision making process. Their customers take destination, cost, and proximity to the weekend when deciding to extend a trip. Knowing and understanding these travelers' need can help railways make better offers; at the present stage of economic relations' development in all countries, the creation and transfer of technology is important, because this will increase knowledge [3 - 6].

The volume of the passenger transportation market, including rail transport, represents a rapid growth worldwide. This is due to the introduction of digital technologies and urbanization, which are the engines of the railway industry development; the recent trends are:

- The Asia-Pacific region and Western Europe are the largest regional markets for rail transport, accounting for 58% of the global railway market,
- Direct trains and services provided to travelers constitute the two largest market segments, which is 72 percent of the industrial market,
- The new high-tech services and production used in these regions force all manufacturers and the carrier to compete with each other and use digital technologies [7, 8].

The railway infrastructure was growing in the period 2013-2015, for example, 26,000 kilometers of new roads were built for urban development; it increased speed and comfort of transportation. Thus, the total network of road roads increased by 1.6 million kilometers (+ 2% per annum) during this period. The Asia-Pacific region has developed most rapidly in recent years; for example, over the past two years, China has invested heavily in its railway infrastructure and has paved 6,200 kilometers of new high-speed trails [9].

2. PROBLEM STATEMENT

With the right approach, rail in Asia Pacific could either be the driving force behind door-to-door travel or leapfrog air travel altogether for a convenient city-center-to-city-center experience. And, in any case, it should be an attractive option for experience-hungry inbound travelers.

Asian transportation system is growing too fast in the recent years. Therefore attention to the railways in the Asia - Pacific region is growing. The reason for this is the need to develop transit traffic and increasing speed and comfort. China and South Korea have adopted a new direction in the development of high-tech industries in industrial policy. South Korea first acquired and licensed from foreign companies advanced technology and uses them in the national railway company Korea Rail Express (KTX); then this country quickly localized the production of advanced technologies with the help of technology transfer. For example, the first shipment of trains used by KTX was manufactured by Alstom, the next 34 were produced in South Korea by Hyundai using 58 percent of domestic technology. By 2008, Hyundai introduced KTX-II, the result of ten years of R&D research supported at the state level; this product was already produced using 87% of domestic technologies [10, 11].

In 2004, the Government of China approved a new plan for the development of railways until 2020. The implementation of the plan began swiftly, and in recent years, the development and application of technology in rail transport has accelerated more than 17% [12].

So, China and South Korea try to develop rail industry very fast nowadays using high-tech services and customer-oriented approach. The problem is recognition of factors which influence the innovative development of industry. It seems important to investigate the strategies for innovative development of the railway industry in South Korea and China using the comparative analysis; it is necessary to compare the influence of factors from internal and external environment on the formation of the company's innovative development strategy. Proceeding from this premise, this study presents a set of external and internal factors; their impact on the company's strategy is assessed, and conclusions on the research results are presented.

This study is based on two research questions:

1. How do external and internal factors affect the innovative development of Railway Corporation?
2. How do factors interdepend themselves?

3. APPROACHES TO TRANSPORTATION INDUSTRY DEVELOPMENT: LITERATURE REVIEW

Modern economies are characterized by a high degree of openness, globalization, knowledge and innovation. Therefore, different types of innovations play a diverse role in the development of social and economic potentials of different countries.

In recent years, the most intensive transformation of economies is in the Asian countries, which have chosen a strategy for the domestic technologies production based on the available experience from advanced countries [13]. Thus, the economy of the Asian region is innovative and has its own problems. For example, the production and transfer of innovations are always expensive, while the technologies quickly become obsolete and may not pay back in the future. In this regard, along with innovative technologies, countries need innovative knowledge to compete successfully in the international arena. Companies are trying to diversify their technologies into different industries, making them interchangeable [14].

At the current stage of innovation development, it is possible to determine the main characteristics and drivers of the transportation industry:

3.1. Globalization

This is one of the development laws in the modern world. This concept applies not only to the economic sphere of society. For the economy as a whole, this process is superior to the integration process. Globalization involves interaction between people, companies, and states of different countries by means of world trade and investment, where information technologies are also based. To date, there has been an increase in the scale and pace of capital movements, which creates a single space for economic activity. Strict price and non-price competition is observed, which gives a strong impetus to the development of innovations in the country [15]. Thus, it is possible to single out the main aspects of the influence of the process of globalization on innovative development:

3.2. Acceleration of the Pace of New Technologies Production

Due to the severe competition and the continuous release of new products (technologies, inventions, services, and various consumer goods), a short period of time remains for the creation and realization of new ideas. This development is also based on information and communication technologies. As a result, the "life" of each service and product has significantly decreased, because something is constantly being created [16].

3.3. Cooperation with Centers of Knowledge Production

It implies close cooperation with state laboratories, research universities, and centers of applied and academic science. Increase in the share of services and the role of knowledge transfer. This process encourages transport companies to use outsourcing as a new way of organizing economic activity, which allows them to achieve certain savings. Also, this affects the change in existing business models, since the implementation of interaction between companies requires a higher level of organization.

3.4. High Level of Intellectual Capital Importance

This characterizes the fact that there is an increase in the importance of value added from the intangible assets of the enterprise and the intellectual capital. One of the first authors who paid attention to this trend was J. Tobin, who said that this leads to a significant excess of the value of their capitalization over the level of the value of tangible assets [17]. This means that the level of intellectual capital and technologies is the most important for the shareholders of transport companies.

3.5. Increase in Entrepreneurial and Market-Oriented Activity

This characteristic means the increased activity of small entrepreneurs, moreover, in most developed countries; the creation of favorable conditions for the "existence" of small entrepreneurs is a priority task of the state strike. So, in the USA for the last 20 years 90% of jobs were created by small entrepreneurs, whereas the number of jobs of large corporations has decreased on the contrary [18]. It is not so easy to follow this way in Asia Pacific region, but it is trend. The increase in entrepreneurial activity in recent years is characteristic of all developed countries. Transport companies from Asia try to achieve global level of competitiveness; global competitiveness index helps to understand which indicators should be developed in innovative strategy of transport company (Fig. **2**).

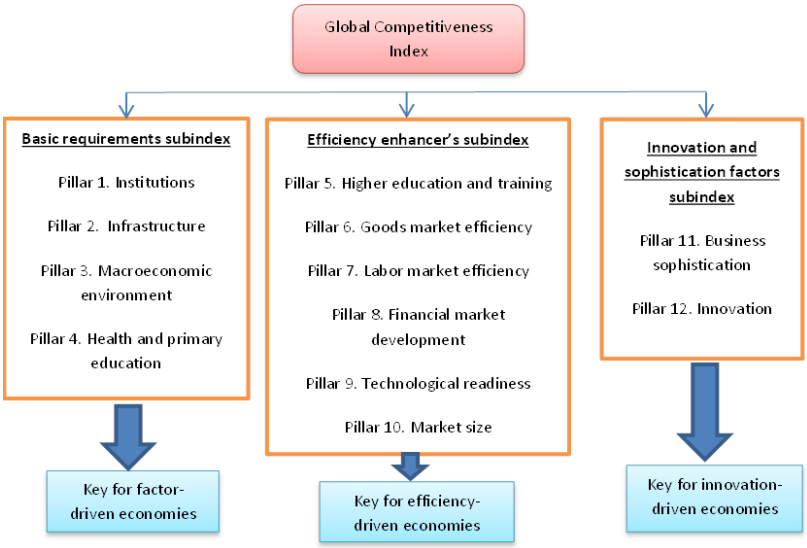

Fig. (2). Factors affecting the degree of global corporations' development.

3.6. Permanent Increase in the Rate of Economic Growth

This process has a long enough character, since the 1970s there has been a long increase, not counting economic

crises, which also subsequently gave impetus for further recovery after the economic recovery. The reason for this trend is the increased level of technology development and increase in the level of profitability, as well as the active injection of large amounts of investment cross over the world. The increase in the rates of economic growth is accompanied by the strengthening of the state and the development role in a clear and stable macro policy by the majority of developed and developing countries. Moreover, most of the state budget is directed to the development of human capital, which indicates the desire to raise the level of production. For example, this trend exists in Korean and Chinese rail industries.

It is not so much interesting a strategy of Asian companies, but it is very interesting the pace of industry changes. The speed of change is not convenient for large corporations-monopolists, but it is inevitable; therefore, large companies-leaders tend to support start-ups and develop co-operation with small business. Small companies can make fast R&D (within the Corporation support) and provide transferring of innovations.

Nowadays there are seven different modern technologies in railway transportation industry:

3.7. The Internet of Things (IoT)

The Internet of Things (IoT) enables passenger and freight services to use sensors, Machine2Machine learning, 'Big Data' analytics, cloud computing and other tech to gather and analyze information from a wide variety of sources and data streams. The use of various Internet technologies allows railway company to keep an account the most important indicators (costs, speed of transportation, the volume of passenger flows, the degree of customer satisfaction, *etc.*). These technologies simplify transport services, make them faster and cheaper.

3.8. Augmented Reality (AR) and Virtual Reality (VR) both Get Real

These technologies help preliminary build a three-dimensional model of a new railway or train, test it and calculate all the risks. For example, industry giant Bombardier develops its ‘virtual manufacturing’ technology [19].

3.9. Intelligent Applications

These are virtual personal assistants, which improve customer service, help with the scheduling and booking of tickets.

3.10. More Cyber-Security Breaches

These technologies help companies maintain information, correct it, or improve information management systems and a database. Transportation companies and their customers feel more secure using these technologies.

3.11. Digital Twins

These technologies participate in R&D and help to improve the functioning of the developed physical or management model. Their task is to catch alarm signals of any violations and provide recommendations for correcting problems.

3.12. Disruptive Innovations

These innovations help rail companies to reduce costs and be more competitive with other markets. For example, high profile companies like Uber, Lyft, Ola, Gett reduced successfully their costs in short period [20].

3.13. Technology Alliances (Partnership)

Strategic partnership and cooperation increase opportunities for development and cost reduction. Knowledge exchange is gaining momentum, risks are being reduced, new risks are opening up, and technology transfer and protection in the global market are facilitated. For example, State railway group China Railway Corp and Hong Kong-based international transport operator MTR Corp signed a letter of intent in 2016 to explore strategic co-operation ‘within and outside of’ China aiming to support the Chinese rail industry’s ‘Go-Global’ strategy [21]. The partnership will aim to work across sectors including high speed, rail operations, transport-related integrated property development and staff training.

Innovative development of the company is impossible without technology implementation. Technology influences the formation and choice of the directions of the company's innovation activity. The transport company risks losing its existing market share if it does not adjust in time for technological changes in the industry.

The scarcity or availability of resources directly influences the formation of an innovation development strategy: the company either limits itself, given the lack of resources and maneuvering with existing reserves, or expands its horizons in the market.

The impact of the financial stability of the company, as well as a sufficient number of resources, allows managers to discover new directions for the company's development. Financial instability adversely affects the organizational climate; qualitative selection and training of personnel are competitive advantages in the market of innovative products.

4. METHODOLOGY

To assess the impact of external and internal factors on the strategy of company's innovative development I use the model of multiple regressions, representing a set of factors (x) that affect the score (y). At the same time, it is necessary to consider that factors can be dependent among themselves, therefore, an analysis is carried out for the presence of multicollinearity factors, which allows determining the factors excluded from the model.

The methodology concept consists of several steps and they are shown in Fig. (**3**).

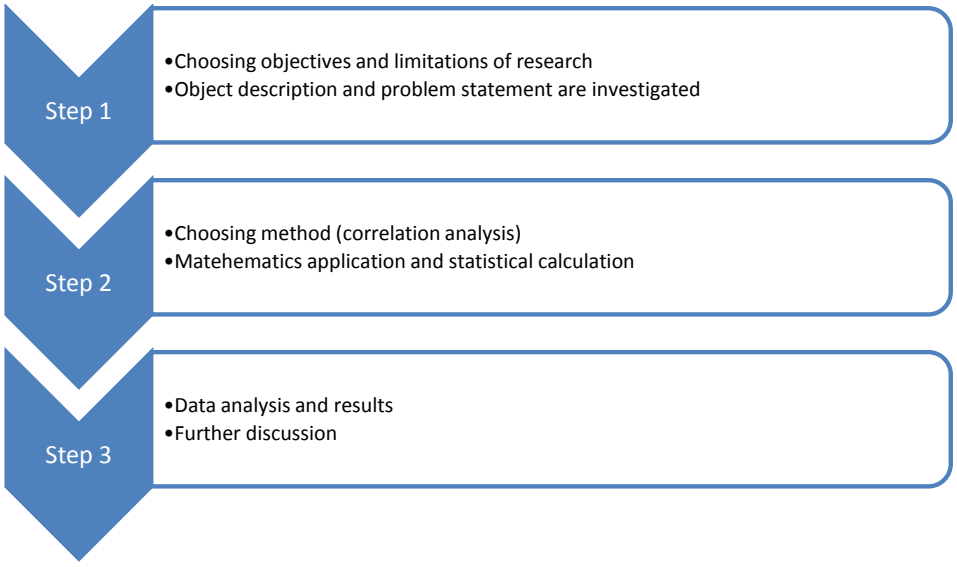

Fig. (3). Methodology framework.

For the study, the resultant indicator was chosen as the percentage of passengers transported on innovative trains. The following factors were presented alternatively:

- the percentage of personnel engaged in research activities (the "personnel" factor),
- the turnover ratio of the advanced capital (the "assets" factor),
- the availability of innovative trains (the "technology" factor),
- the passenger turnover of railway transport in the country (the "competition" factor),
- the financial stability factor (the "financial" factor),
- the volume of public investment in innovation (the "economic conditions" factor).

Model building begins with data collection and further processing. We consider that the factors have different units of measurement, so, it is necessary to bring them to a single scale: for each indicator we calculate its growth rate (unit of measure is percent).

To build the model, the Microsoft Excel analysis package "Regression" and "Correlation" is applied. It is assumed that there is a linear relationship between the factors of the model and the resultant characteristic. We can build multiple linear regression model (Eq. 1).

$$y = a+b_1*x_1+b_2*x_2+\cdots+b_n*x_n+\cdot, \quad \textbf{(1)}$$

where

x_1, x_2, …, x_n - model factors,

y - resultant indicator,

b_1, b_2, b_n - model parameters,

ε - model error.

The model parameters show the average change in y as a result of a change in one of the factors in the model, it means that other factors are not subject to change. To analyze the parameters of the model, the least squares method is used. On the basis of the least squares method we estimate the model parameters: the sum of the squares of the effective characteristic deviation (y) from the calculated values of the variables (ŷxi) will be minimal. It should also be noted that the parameters of the model a, b_1, b_2, b_n are random variables; therefore, to obtain more accurate results for the least squares, we submit the Gauss-Markov conditions [22]. These conditions tell that

1. the mathematical expectation of a random deviation should be 0 for any observation,
2. the variance of random deviations is constant (check for homo- and heteroscedasticity),
3. there should be no autocorrelation in the model.

The next step is to analyze the regression statistics, which reflects the four indicators of R. R2 is additional indicator for model's evaluation. It has 4 types:

1. R2 (reflects the quality of the model),
2. multiple R2 (shows the degree of dependence between the effective indicator and the factors of the model),
3. normalized R2 (R2, adjusted for the sample size),
4. standard error (reflects the spread of data in the sample).

To test the equation for statistical significance, Fisher's F-criterion is used. We can compare the values of sample variances of two independent samples (the calculated and tabulated values are compared and then the conclusion is made about the reliability of the constructed equation). The calculated value of the F-test of Fisher is found (Eq. 2):

$$F\_count=(r\_xy\text{^}2)/(1-r\_xy\text{^}2\ )*(n-2), \quad \textbf{(2)}$$

Where

r_xy^2 - the determination coefficient;

n - the number of observations in the study.

If the table value of Fisher's F-test is greater than the calculated one, then the model is considered insignificant, and the constructed equation is unreliable.

For further model's evaluation, the author use analysis of the determination and correlation coefficients. Previously, it was noted that the factors of the model can be dependent among themselves; therefore, it becomes necessary to analyze the pair correlation coefficients. Two factors of the model have a linear dependence if the coefficient of pair correlation exceeds the value 0.7. To assess the practical significance of the multiple regression equation, the coefficient of multiple correlation and determination is used. The coefficient of multiple correlations varies from 0 to 1: a less close relationship is reflected at a value close to 0. As for the multiple determination coefficients, the author uses it for regression quality analysis: if the coefficient value is close to 0, a conclusion is drawn about the low quality of the regression.

A deeper analysis of the interdependence of the factors in the model can be carried out by checking for the presence of multicollinearity factors ($\chi 2$ criterion). If there is multicollinearity between the factors, this negatively affects the quality of the model and makes it difficult to assess the influence of factors on the outcome. To determine the value of the $\chi 2$ criterion, a matrix consisting of paired coefficients and model factors correlation suspected of having multicollinearity is used. The next step is the calculation of the matrix determinant and the criteria's value, after which the obtained value is compared with the table value: if the tabulated value exceeds the calculated one, it means absence of a connection between the model factors.

If result of the analysis requires us to correct the model, variables that negatively affect its quality are excluded from it. After that, the partial coefficients of elasticity and correlation are calculated. Partial coefficients of elasticity show

which growth of the effective characteristic can be expected with an increase in the individual factor of the model by 1%. The partial correlation coefficients are used to determine the influence of each individual factor without taking into account the influence of other model factors. The range of this coefficient is from -1 to 1: if the value of the module coefficient is close to 1, a stronger dependence of the effective characteristic on this factor is observed. If the coefficient takes a negative value, there is an inverse relationship between the indicators.

5. DATA ANALYSIS AND RESULTS

The construction of correlation-regression models for rail companies "Korean Railway Corporation" (KoRail) and "China Railway Corporation" (CRC) was started with sampling according to annual, statistical and financial reports in open access [23, 24].

Variable models were coded as follows:

x_1 - the percentage of personnel engaged in research activities,
x_2 - the volume of public investment,
x_3 - the passenger turnover of railway transport in the country,
x_4 - the financial stability factor,
x_5 - the turnover ratio of the advanced capital,
x_6 - the availability of innovative compounds,
y - the percentage of passengers transported on innovative trains.

The percentage of personnel engaged in research activities was defined as the ratio of the employees' number engaged in R&D in the company to the employees' total number of the company. The volumes of state investments in innovative activities of companies were presented in the amount, where they are defined in investment programs in 2015-2016. Passenger turnover of railway transport in the country (D_{pass}) (this indicator was submitted within the fact that KoRail and China Railway Corporation are monopoly companies in the railway transport sector in South Korea and China, respectively) was determined (Eq. 3)

$$D_{pass} = \frac{Pass_{rw}}{Pass_{total}} * 100\%, \quad \textbf{(3)}$$

$Pass_{rw}$ - passenger turnover on the railway transport, $Pass_{total}$ - the passenger turnover in the country by all modes of transport.

The coefficient of financial stability (K_{fs}) was calculated (Eq. 4):

$$K_{fs} = \frac{C+D}{A}, \quad \textbf{(4)}$$

where C - company's equity, D - company's debt obligations, A - company's assets.

The coefficient of resource productivity (K_{res}) of these companies is calculated (Eq. 5):

$$K_{res} = \frac{B}{A_{av,annual}}, \quad \textbf{(5)}$$

where B - the revenue of the company, $A_{av,annual}$ - the average annual value of the company's assets.

The presence of innovative compositions is considerd as the number of trains on the enterprise's balance at the end of each month in 2015-2016.

KoRail innovative trains are the trains of type Z (developing speed is up to 250 km / h), C and D 250-300 km / h), G (more than 300 km / h).

Thus, the processed data for the construction of correlation-regression models of companies are presented in Table **1** and **2**.

Table 1. Initial data for building a model. Korean Railway Corporation (KoRail).

x_1, %	x_2, %	x_3, %	x_4, %	x_5, %	x_6, %	y, %
145,16	116,67	105,04	123,16	96,28	133,33	158,93
138,89	125,86	104,25	123,16	99,61	133,33	154,74

(Table 1) contd.....

x_1, %	x_2, %	x_3, %	x_4, %	x_5, %	x_6, %	y, %
158,82	116,13	108,53	102,55	94,09	200,00	174,92
161,76	120,34	113,41	102,55	97,02	150,00	169,60
163,64	129,63	105,02	102,55	96,28	150,00	162,72
161,76	114,29	105,43	100,45	97,45	150,00	149,76
160,61	118,33	105,86	100,45	94,79	180,00	158,92
158,82	120,34	104,62	123,16	90,09	200,00	162,37
158,82	118,64	104,63	100,45	96,28	220,00	164,01
154,29	120,00	105,43	100,45	99,68	137,50	144,83
158,82	112,90	105,02	100,45	97,34	137,50	164,93
158,82	120,63	105,02	88,07	97,40	122,22	141,41

Table 2. The initial data for building the model. China Railway Corporation (CRC).

x_1, %	x_2, %	x_3, %	x_4, %	x_5, %	x_6, %	y, %
133,33	79,93	102,92	137,92	83,93	214,29	105,26
133,33	322,70	100,00	137,92	82,73	187,50	95,24
133,33	322,70	101,87	133,64	83,15	214,29	95,45
133,33	322,70	102,91	133,64	84,82	200,00	110,53
133,33	322,70	104,38	99,95	80,60	180,00	110,00
133,33	322,70	103,57	95,41	81,38	180,00	104,76
133,33	322,70	104,17	98,96	84,06	190,00	110,00
133,33	322,70	104,38	104,71	84,78	158,33	114,50
133,33	322,70	104,38	106,13	82,18	146,15	113,93
133,33	322,70	104,80	106,13	88,14	146,15	115,50
133,33	322,70	104,79	106,13	85,34	142,86	114,93
133,33	322,70	104,79	99,63	87,83	140,00	115,00

Following the developed method, the author checks the statistical significance of the model and does the analysis of regression statistics. According to the results of the analysis, it was revealed that the models of both companies reflect a high dependence of the effective indicator on the model factors.

The coefficient of multiple correlation for the KoRail is 0.79, for CRC - 0.96, it means in this case, that there is an almost linear dependence.

Regarding the coefficient of determination, in the case of KoRail (Model 1), 63% of the variation is due to the selected factors of the model, in the case of CRC (Model 2), 91% of the variation is predetermined by the model variables. The standard error in the Model 1 is quite high (8.9), which indicate a low quality of this model. In other hand, Model 2 has a relatively low standard error of 2.87, which indicates a higher quality of this model.

Thus, based on the results of the regression analysis, multiple regression equations for both companies were constructed (Eq. 6 and Eq. 7).

$$y = -159,3 + 0,29x_1 – 0,2x_2 + 1,85x_3 + 0,4x_4 + 0,25x_5 + 0,15x_6 \quad \textbf{(6)}$$

$$y = -424,19 + 0,01x_2 + 5,03x_3 + 0,17x_4 + 0,06x_5 - 0,08x_6 \quad \textbf{(7)}$$

We get the results after assessing the quality of the regression models using the Fisher F-test. We found that for KoRail the calculated value was 1.41 with a tabular value of 4.95. Since the tabular value exceeds the calculated value, the Model 1 is considered statistically insignificant. For the CRC the tabular value is the same (4.95) because of an equal number of observations, and the calculated value of the criterion is 12.75, which is much higher than the tabulated value, therefore, the Model 2 is significant and reliable.

Since the Model 1 was found to be unreliable, it is necessary to make its adjustment. This result indicates that the model includes factors that have little effect on the company's innovative development. To determine the factors to be excluded from the model, it is necessary to analyze the correlation coefficients (Table **3**).

Table 3. Correlation coefficients of the model of the Chinese Company.

	x_1	x_2	x_3	x_4	x_5	x_6	y
x_1	1	-	-	-	-	-	-
x_2	-0,15181	1	-	-	-	-	-
x_3	0,31946	-0,09440	1	-	-	-	-
x4	-0,67534	0,17756	-0,19920	1	-	-	-
x5	-0,37142	0,11928	-0,02638	-0,27355	1	-	-
x6	0,35192	-0,14191	0,05150	0,06001	-0,67927	1	-
y	0,21398	-0,10595	0,48922	0,21665	-0,28447	0,57061	1

Table **3** shows that the most significant effect on the percentage of passengers transported on innovative trains is provided by the factor "availability of innovative compounds" (correlation coefficient is 0.57). In Model 1, factors x_1, x_2, x_4 and x_5 are excluded due to their least or negative impact on the result. Thus, the new equation has the following form (Eq. 8):

$$y = -54{,}86 + 1{,}76x_3 + 0{,}17x_6 \quad \textbf{(8)}$$

When the Fisher criterion value is recalculated for the new equation, the actual value is 5.23, which is higher than the table value and indicates the significance of the Model 1.

To analyze the correlation coefficients in the Model 2, the data are presented in Table **4**.

Table 4. Correlation coefficients of the model of the Chinese company.

	x_1	x_2	x_3	x_4	x_5	x_6	y
x_1	1	-	-	-	-	-	-
x_2	-0,08704	1	-	-	-	-	
x_3	-0,25128	0,14331	1	-	-	-	-
x_4	0,24415	-0,45670	-0,80464	1	-	-	-
x_5	-0,48877	0,01991	0,36031	-0,06389	1	-	-
x_6	0,38279	-0,44964	-0,66855	0,67729	-0,45325	1	-
y	-0,25999	0,15206	0,91458	-0,65275	0,49744	-0,74605	1

Table **4** shows that the factor x_3 (passenger turnover of railway transport in the country) has the greatest effect on the percentage of passengers transported by innovative compounds, the correlation coefficient is 0.91. It is necessary to pay attention on the paired coefficients between the factors x_3, x_4, x_6, since multicollinearity is possible. To check for this phenomenon, the criterion $\chi 2$ is used. Based on the results of calculations, the value of this criterion was 12.4 with a tabular value equal to 9.48. Since the calculated value exceeds the tabulated value, we can make a conclusion that there is a presence of multicollinearity factors in the model 2. The elimination of the factors x_4, x_6 allowed the transformation of the multiple regression equation (Eq. 9).

$$y = -6{,}82 + 5{,}12x_1 + 0{,}01x_2 + 4{,}21x_3 + 0{,}71x_5 \quad \textbf{(9)}$$

Verification of the model for Fisher's adequacy also showed that the model 2 is statistically significant.

In order to determine to what extent the resultant is dependent on a particular model factor, the author uses the partial correlation coefficients calculation (Eq. 10).

$$r_{xy-z} = \frac{r_{xy} - r_{xz} * r_{yz}}{\sqrt{(1 - r_{xz}^2) * (1 - r_{yz}^2)}} \quad \textbf{(10)}$$

Based on the results of the calculations, it was revealed that the innovation development of KoRail is more affected by the presence of innovative trains that represent the "technology" factor (the coefficient of the private correlation is 0.63). In the case of the CRC, the indicator "share of passenger turnover of the railway transport", which represents the "competition" factor, has the greatest influence (the value of the coefficient of the private correlation is 0.92).

CONCLUSION AND RRECOMMENDATIONS

The conducted research proved the significant influence of environmental factors on the innovative development of transport companies. The correlation dependence between the factors influencing the innovative development of transport companies was also established.

The results of the conducted research confirmed the development trends of the transport industry in the Asian region. Therefore, a comparative analysis of transport companies of China and South Korea became especially interesting for studying.

1. As conclusions and economic interpretation of the modeling study results for KoRail it is necessary to note the possibility of additional purchase of innovative compounds for their direct commissioning, since the connection of this factor and innovation development is direct; therefore, the increase in technology will positively affect the development of the company. However, the company's expected profit should be noticed: in 2018, the expected profit of KoRail is 3 billion won; in 2019 the forecast values are 9 billion won. The average cost of innovative compounds is 600 million won (the price varies depending on the number of technologies in the composition). Consequently, the allocation of 15% of net profit for the purchase of innovative compounds will give an opportunity to produce at least 17 trains in 2018-2019 [25 - 28]. The purchase of innovative compounds and technology development will also reduce operating costs; increase the mileage between locomotive repairs, switch to cheaper exploitation, and increase capacity through the introduction of high-speed trains.
2. As for the Chinese Railway Company, when adjusting its strategy of innovative development, it is necessary to understand such a highly influential factor as “passenger turnover of railway transport”. It enhances the mobility of the ever-growing population of China, thus increasing the volume of passenger traffic will positively influence the development of the whole company. So, it means that marketing factor is very important for innovative development of this corporation.

These results can be used to make managerial decisions in the process of forming the transport company's innovative development strategy.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The author declares no conflict of interest, financial or otherwise.

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REFERENCES

[1] *Breakthrough Institute and Information Technology an Innovation Foundation, Rising tigers, sleeping giants.,* Oakland, Washington, 2009, pp. 78-98.

[2] J. Scales, and P. Amos, "Railways for development", *An overview of China’s Railway development program. World Bank Transport Forum,* 2009.

[3] Y. Freemark, *High- Speed Rail in China ,* 2009.

[4] K.O.T.I. Knowledge Sharing, *New Intermodal Transport Systems in Korea (Report Issue 23).,* The Korea Transport Institute, 2017, pp. 78-98.

[5] M.J. Gallivan, "Organizational adoption and assimilation of complex technological innovations: Development and application of a new framework", *Data Base Adv. Inf. Syst.,* vol. 32, no. 3, pp. 51-85, 2011. [http://dx.doi.org/10.1145/506724.506729]

[6] *Propharma Group, Approach to Technology Transfer [Website]. Available from:,* 2018. http://www.slideshare.net/ProPharmaGroup/approach-to-technology-transfer-bob- beall-19009502?from_search=3

[7] *J.A. Schumpeter, Theory of Economic Development.,* Transaction Publishers, 1982, pp. 78-99.

[8] B.T. Hayati, *BPTT 3133 Technology Transfer in Business [Website].,* 2018. Available from: http://www.slideshare.net/nabilahnajah/

[9] *China Railway Corporation [Website].,* 2018. Available from: http://www.china-railway.com.cn/en/

[10] *Korea Railway Corporation [Website].,* 2018. Available from: http://www.letskorail.com/

[11] H. Marcus, "Patent management in entrepreneurial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motive", *R & D Manag.,* vol. 43, no. 1, pp. 21-36, 2012.

[12] W.I.P.O. Statistics Database, *WIPO Statistics Database: Statistics on Patents [Website]. ,* 2018. Available from: http://www.wipo.int/ipstats/en/statistics/patents/

[13] *H. Tetsuro, Z. Shengchuan, J. T. Castro, H. Yu-Kai, Building Sustainable Urban Logistics Systems in East Asia.,* The Korea Transport Institute, 2016, pp. 67-98.

[14] G.K. Fogel, *Business environment in China: economic, political and cultural factors. - MBAA Proceedings,* 2010

[15] F. Relations, *Relations with Neighboring Countries.*. Available from: http://www.china.org.cn/english/en-shuzi2004/dwgx/dw-zb.htm

[16] D. Pojani, and D. Stead, "Sustainable Urban Transport in the Developing World: Beyond Megacities", *Sustainability,* vol. 7, pp. 7784-7805, 2015.
[http://dx.doi.org/10.3390/su7067784]

[17] J. Tobin, *Can We Grow Faster?,* 2018. Available from: http://cowles.yale.edu/sites/default/files/files/pub/d11/d1149.pdf

[18] E. Vasconcellos, *Urban Transport, Environment, and Equity: The Case for Developing Countries.,* 2nd ed Earthscan: New York, NY, USA, 2013.

[19] H. Dimitriou, and R. Gakenheimer, *Urban Transport in the Developing World: A Handbook of Policy and Practice.,* Edward Elgar Publishing: London, UK, 2011.
[http://dx.doi.org/10.4337/9781849808392]

[20] H. Haghshenas, and M. Vaziri, "Urban Sustainable Transportation Indicators for Global Comparison. -", *Ecol. Indic.,* vol. 15, pp. 115-121, 2012.
[http://dx.doi.org/10.1016/j.ecolind.2011.09.010]

[21] B. Cohen, "Urbanization in Developing Countries: Current Trends, Future Projections, and Key Challenges for Sustainability", *Technol. Soc.,* vol. 28, pp. 63-80, 2006.
[http://dx.doi.org/10.1016/j.techsoc.2005.10.005]

[22] *Policy Instruments for Achieving Environmentally Sustainable Transport.,* Organization for Economic Co-Operation and Development: Paris, France, 2012.

[23] M. Noland, and H. Pack, *Industrial Policy in an Era of Globalization: Lessons from Asia.,* Institute of International Economics: Washington, DC, 2013.

[24] Z. Qi, and J. Yang, *China implements radical railway reform. - International Rail Journal 2013.,* 2018. Available from: http://www.railjournal.com/index.php/policy/china-implements-radical-railway-reform.html?channel=000

[25] *World Bank. PPP Arrangements / Types of Public-Private Partnership Agreements. PPP in Infrastructure Resource Center for Contracts, Laws and Regulation,* 2018. Available from: http://ppp.worldbank.org/public-private-partnership/agreements

[26] *OECD report China,* 2017. Available from: https://data.oecd.org/china-people-s-republic-of.htm

[27] *OECD report Rep. of Korea,* 2017. Available from: https://data.oecd.org/

[28] *OECD report,* 2017. Available from: https://data.oecd.org/