DEFINING OF MATRICES FOR ASSESSMENT OF DEVELOPMENT AND EVALUATION OF RAILWAY TRANSPORT BY IDENTIFYING TECHNOLOGICAL AND ECONOMIC FACTORS

Assist.Prof. Vinko Jenić, D.Sc., Faculty of Transport and Traffic Sciences, vinko.jenic@fpz.hr

Marjana Petrović, B.Eng., Faculty of Transport and Traffic Sciences, marjana.petrovic@fpz.hr

Draženko Fabijanić, B.Eng., HŽ Cargo, drazenko.fabijanic@hznet.hr

ABSTRACT

Over the recent fifteen years there has been intense discussion in the Republic of Croatia about the need to develop railway transport based on the White Paper – European Transport Policy and EU Directives directing the activities towards separation of the railway transport from the railway infrastructure, opening of the railway transport market, financial consolidation of railway lines, construction of inter-operational Trans-European network of railway lines and raising of transport safety and ecological standards.
Apart from huge efforts and changes, the restructuring of the railway companies is progressing relatively slowly and without any major development shifts in comparison to the competitive road transport. The main reasons for such a condition may include the need for high investments into the interoperability of the railway lines network, different legal regulations among member countries (especially noticed in the aspect of transport security, engine staff licensing requirements, needs for the formation of regulatory bodies, raising of the quality of service), shortage of modern qualified management of railway companies, etc.
The reason for this is because in small-size European rail companies the majority of national operators in cargo transport fail to qualify for the market competition thus getting even weaker in relation to road competition and becoming “easy prey” for big international rail operators. Big European rail carriers are primarily interested in operating on the Trans-European network of railway lines thus additionally reducing the operation on local railway lines which has direct negative consequences on the decrease of railway and the increase and development of road transport beyond the Corridor routes, reduction of safety in transport, increase of harmful impacts on environmental protection, increase in the number of

unemployed, physical destruction and prevention of regional development of European countries.
The railways in Croatia – *Hrvatske željeznice* have been for a number of years going through the restructuring process and modernisation in order to become competitive on the market. In the area of cargo transport one of the biggest problems occurs in searching for the selection between: profitable transports and transports of public interest which are often non-profitable, which is best seen for transport in cases of carrying low-value mass cargo, transport of cargo on unprofitable and local railway lines with low operation and transport of cargo on technically demanding and difficult railway lines (e.g. railway lines Ogulin/Oštarije – Knin – Split).
The division of the Croatian Railways into four new enterprises out of which HŽ Cargo is formed as the rail carrier in cargo transport, has meant the end to the possibility of financing unprofitable transports. Therefore, it is extremely important to find a development business model in the future period. The HŽ Cargo development strategies can be started by finding and defining suitable, optimal matrices of development, evaluation and research of railway transport whose methodological forms for the evaluation of the technological and financial attractiveness, the user accessibility and in general the competition in transport supply in this paper are based on the GE matrix and ADL matrix.

Keywords: railways, attractiveness, availability, competitiveness, transport, development, assessment, GE and ADL matrices, technological and economic factors

INTRODUCTION

The matrix for assessment of development and rail transport evaluation serves to determine the development strategies in the rail transport of cargo which are obtained on the basis of evaluating the overall building blocks and factors of competitiveness which results from:

- assessment of technological attractiveness, suitability, availability of transport
- assessment of financial attractiveness, suitability, availability of transport
- volumes of transport and share of cargo transport in overall surface transport.

Matrix for assessment of development and rail transport evaluation is designed according to:

- positioning of business units (transport mode) on the matrix of rail transport development
- presentations of business units values (transport modes) with proportional relation to competitive road transport, and
- selection of development strategies i.e. development strategies for each single business unit (transport mode).

MATRIX FOR ASSESSMENT OF DEVELOPMENT AND RAIL TRANSPORT EVALUATION

Positioning and Structuring of Business Units (Transport Mode) on the Matrix

The business units positioning can be carried out after the analytic assessment of the technological and financial attractiveness of transport which are performed by the following methodological forms:

1. identification of relevant factors
2. determining of relative significance of factors
3. structural assessment of all factors
4. overall assessment of attractiveness, suitability, availability and competitiveness of transport.

Identification of Relevant Factors of Technological and Financial Attractiveness of Transport

In order to achieve a relation of maximum quality between the technological and financial elements of transport the selection of the most important relevant factors is of great importance. Table 1 shows some of the relevant factors that affect the attractiveness of transport and which here mean influence on attractiveness, popularisation, suitability i.e. acceptability, transport accessibility and the similar, which eventually have overall influence on creating and on the position of overall transport competitiveness. The mentioned proposal of elements and factors is subject to changes depending on numerous influencing, partly internal and mostly external parameters regarding the type and need to organise transport, geo-traffic influences, catchment areas, types of industrial activities, seasonal activities, catering activities, demand/supply production of the generally existing and potential users / transport consignees.

Table I - Relevant factors of technological and financial attractiveness of transport company

Technological attractiveness of transport	Financial attractiveness of transport
1. Transport volume (transport/year)	10. Cost-efficiency of transport
2. Use of rail transport capacities (throughput capacity)	11. Money flow 12. Price competitiveness
3. Transport relation (length)	13. Price sensitivity and stability
4. Duration (speed) of transport	14. Financial power of transport service users
5. Availability and use of wagon rolling stock	15. Financial stability of company
6. Value of goods	16. Industrial growth
7. Transport safety level	17. Productivity
8. Environmental protection	18. Virtual coefficient of transport kilometre

9. Location accessibility of carriers (δ)	
Total level of quality of provided transport service	

Determining Relative Significance of Factors

Since each of the mentioned factors has no equal and comparable influence on the attractiveness of transport, it is necessary to assess which of the factors has greater, and which has minor significance i.e. weight, force, power and impact in rendering a business unit more attractive, more popular, more suitable /acceptable, more accessible, i.e. eventually more competitive. The assessment based on relative indicators of factors which are relevant can be done for each single case, but it is also possible with the in-advance defined factors of technological and financial attractiveness to define immediately also their relevance as presented in Table 2, which is also just a proposal and may be subject to changes.

Table II - Relative significance and influence of parameters of technological and financial attractiveness of companies expressed in value indicator (coefficient)

Technological attractiveness of transport	Value coefficient	Financial attractiveness of transport	Value coefficient
1. Transport volume (transport/year)	0.10	10. Cost-efficiency of transport	0.20
2. Use of rail transport capacities	0.15	11. Money flow	0.20
3. Transport relation (length)	0.10	12. Price competitiveness	0.10
4. Duration (speed) of transport	0.10	13. Price sensitivity and stability	0.10
5. Availability and use of wagon rolling stock	0.05	14. Financial power of users	0.15
6. Value of goods	0.10	15. Financial stability of company	0.10
7. Transport safety level	0.15	16. Industrial growth	0.05
8. Environmental protection	0.10	17. Productivity	0.05
9. Location accessibility of carriers (δ)	0.15	18. Virtual coefficient of transport kilometre	0.05
Total level of transport service quality	1.00	Total level of transport service quality	1.00

The total significance of the selected factors in the analysis is set at level 1.00. Thus higher or lower values are assigned to each factor proportionally to individual significance and value of influence on the integral quality level in providing the transport service, not neglecting the evaluation either from the position of the carrier or from the position of the transport service user who are equal in this case.

Assessment of Factors of Technological Attractiveness of Transport

The transport attractiveness is assessed on the basis of all the isolated factors. Each factor is assigned a grade for attractiveness on a scale of five (1-5) answers. The assessment of the factors of technological and financial attractiveness can be done on the basis of assessing by approximation using mathematical interpolation or based on the previously determined professional analyses which could provide clear instruction for the assessment of factors of the technological attractiveness. Further in the paper, assessments have been provided for the evaluation of single factors that may be the basis for further more detailed expert analysis.
The basis for the assessment of factors regarding **volume of transport** in the first phase is on the estimate of the number of trips during the year, according to the measurability in the following way:

1. for fewer than 52 trips annually i.e. fewer than 1 trip weekly
2. for 53 to 155 trips annually i.e. fewer than 2 trips weekly
3. for 156 to 207 trips annually i.e. fewer than 3 trips weekly
4. for 208 to 259 trips annually, i.e. fewer than 4 trips weekly
5. for 260 and more trips annually, i.e. fewer than 5 trips weekly.

The basis for measurability of the assessment of factors of **the usage level of train transport capacities** depends on the type (categorisation, ranking) of the train that is used for the transport of a certain type of goods that is transported by a single train:

1. for less than 50% of train capacity occupancy
2. for occupancy of train transport capacities from 50 to 59%
3. for occupancy of train transport capacities from 60 to 69%
4. for occupancy of train transport capacities from 70 to 79%
5. for occupancy of train transport capacities from 80% and more and for all transports that use forwarding trains.

The basis for the measurability of the assessment of factors of **the relation (length) of transport** is based on the optimal characteristic of the distance of train running. In a general case (when total transport relations are processed) it is possible to use the following measurability for assessment:

1. for train running relation lengths shorter than 100km (usage of circular - manipulative train routes)
2. for train running relation distances from 100 to 199km

3. for train running relation distances from 200 to 299km

4. for train running relation distances from 300 to 399km

5. for train running relation distances of 400 kilometres and more.

During this assessment the average distances of train relations in other European countries need to be taken into consideration and to be built into the assessment measurements (e.g. the recommendation is not to perform shunting and processing of trains on relations shorter than 500km). In case of studying only a certain transport route (e.g. Corridor Vb), then the assessment should be adapted to the total length of that route.
When speaking about the measurability of assessing the influence of factors of **the time duration of cargo transport**[1] regarding the average commercial speed of transport then the values in case of this factor are divided in the following manner:

1. for transport duration of 5 hours on distances of up to 100km

2. for transport duration from 5 to 10 hours on distances from 100 to 199km

3. for transport duration from 10 to 20 hours on distances from 200 to 399km

4. for transport duration from 20 to 30 hours on distances from 400 to 600km

5. for transport duration of more than 30 hours on distances exceeding 600km.

The basis for measurability and assessment of factors of **availability and use of wagon rolling stock** is based on the type of wagons used, wagon ownership and wagon demand. This reduces to a great extent the possibility of analytical approach to this factor and the acceptance of free evaluation in assessment (open issue of many rail carriers is whether to invest in their own wagon rolling stock, its renewal and expansion i.e. enlargement, or whether it is sufficiently organisationally well to use the existing wagon rolling stock available on the market):

1. for non-provision of the necessary wagon rolling stock

2. for the use of foreign classical wagon rolling stock

3. for the use of one's own classical wagon rolling stock

4. for the use of foreign modern wagon rolling stock

5. for the use of one's own modern wagon rolling stock.

The basis for measurability and assessment of factors of the **value of goods** is significant both in the technological (cargo insurance in transport) and in the financial part of the

[1] The duration of transport includes the total duration of all the initial and end operations from the initial commercial operations/activities regarding preparation and receiving of cargo for transport from the sender, duration of the train trip will all the en-route operations/activities, to final operations/activities, and the moment of delivery i.e. taking over of the cargo by the receiver of the shipment.

attractiveness (pricing of transport) and the measurability of assessment in the first step i.e. phase can be done according to the following assessment based on tariff classes:

1. for low value goods
2. for low value goods in combined transport
3. for medium-value goods
4. for medium-value goods in combined transport
5. for all high-value goods.

The basis for measurability in assessing the factors of **safety level of transport flow** as one of the most important factors in assessing the technological attractiveness can be based on the analysis of safety elements (environment – railway line and rail tracks objects with all the accompanying elements, traffic means, human factor – humans) in the following manner:

1. for non-compliance with minimal standards of not a single safety element
2. for compliance with minimal standards of one of the safety elements
3. for compliance with minimal standards of two or more safety elements
4. for compliance with minimal standards of all the safety elements
5. for compliance with minimal standards of all the safety elements and existence of a developed and efficient Safety Management System.

The basis for measurability of assessing **environmental protection** as a factor, considering all the advantages of rail transport, primarily refers to the system of environmental protection management which is used to follow and develop its basic elements (physical planning, impact on pollution, energy saving and noise, vibration transfer), i.e. the assessment is defined in the following manner:

1. for compliance with the standards of only one element of the environmental protection management system
2. for compliance with the standards of two elements of the environmental protection management system
3. for compliance with the standards of three elements of the environmental protection management system
4. for compliance with the standards of four elements of the environmental protection management system
5. for the introduced system of environmental protection management.

The evaluation for measurability of assessing **location accessibility of rail carrier** more narrowly considering primarily refers to the possibility of delivering wagons to the loading/unloading points:

1. for cargo transport which has no approach tracks either at the point of loading or unloading
2. for cargo transport in surface transit (no loading or unloading)
3. for cargo transport that has approach tracks either at the point of loading or at the point of unloading
4. for cargo transport that has approach tracks in international transport or at the point of loading or at the point of unloading
5. for cargo transport that has approach tracks both at the point of loading and at the point of unloading.

However, in considerations, in a deeper and more detailed analyses and research the results show that this element as a factor is placed first, affecting to the highest extent the competitiveness of the carrier, and being the main stimulator for attracting potential and keeping the existing rail transport users, mainly when considering mass transport of cargo i.e. the so-called large rail transport users / rail cargo transport consignees. Therefore, this factor is to be presented and explained in more detail.

In studying the influence and significance of this factor, a formal mathematical model of its definition has been developed, thus developing the expression for the rail carrier accessibility coefficient (δ) to users, which is then used to very simply determine the classification of accessibility. After that, the considerations and research have been expanded to the accessibility regarding the catchment area of rail plants for cargo transport, problems that occur related to accessibility as well as guidelines for their solution and elimination.

Regarding the indicators and routers in the considerations in developing the analyses of the respective technological factors that pointed to very high initial value of location accessibility as technological factor, the intention was to determine maximally precisely its measurability which would result in precise and accurate indicator of its influence in creation, development and defining of assessment matrix of development and evaluation of rail transport by means of identification of influencing value, significance of organisational, technological and economic i.e. economic and financial parameters, i.e. factors.

Thus the development and research of this factor and its components, elements has been approached in the below described manner.

Generally, the accessibility of an object can be understood as a kind of *measure of time* necessary to reach this same object from the origin. Therefore, the intention is to express the accessibility precisely as a function of that time. This function has to reflect the inverse proportion of accessibility and time, i.e. the shorter the mentioned time, the greater the accessibility and vice versa. It should be immediately noted that due to inverse proportionality this function cannot be linear, but the tendency is to make it (at least in form) as simple as possible.

For the integrity of study, at the beginning an arbitrary origin or industrial complex is fixed, a production factor in the catchment area - zone, depending on which type of transport is targeted, and as the destination the railway station or several railway stations are taken that are closest to that origin. It is considered intuitively acceptable to assume that the distance from the origin to destination can be travelled by one of several types of transport means or combination thereof. Consequently, time *'T'* from departure from origin (*A*) to departure of train from the observed railway station (*B*) for which the accessibility coefficient is determined, can be (analytically) divided into time T_{dol} – necessary to arrive to the destination (i.e. station) and time $T_{\check{c}ek}$ – waiting (at the railway station) to departure of train (which can include also e.g. the activities of cargo loading). This yields the equation:

$$T = T_{dol} + T_{\check{c}ek} \qquad [1]$$

Time T_{dol} is a variable and it is studied further in the text in more detail. It should be noted that time $T_{\check{c}ek}$ is a relatively variable value depending on the frequency of trains. Ideally, $T_{\check{c}ek}$ would be a fixed value, but this would require adjustment of the train schedule, possibly introduction of extra compositions i.e. wagons etc., which is not always (easy) to realise and requires additional engagement i.e. complicates the technology and organisation of operation.

Time T_{dol} from equation (1) can be analytically divided into time T_{dost} spent on the delivery of goods (tavel time, i.e. delivery of goods from point A to point B with the railway station for which *δ* is calculated) and T_{prkc} i.e. time of transhipment or only unloading when referring to cargo traffic i.e. cargo transport. Therefore, the following equations are valid:

$T_{dol} = T_{dost} + T_{prkc}$ – cargo transport, time necessary for arrival i.e. delivery of goods [2]

If equation (2) is inserted in equation (1), it yields:

$$T = T_{dost} + T_{prkc} + T_{\check{c}ek} \qquad [3]$$

Since time T cannot equal zero – not even in the ideal case, then *acceptable values* of time T are considered here. Formally, for arbitrary, but fixed $T_1 \in R,\ T_1 > 0,$ *a set of acceptable values V* is defined as a semi-opened interval $V := < 0, T_1\ ]$. Thus, if the total time from the start to end of process is within interval V, it may be considered that the process was performed at satisfactory speed, and the additional improvements are not necessary. The largest element T_1 of this interval can be called *maximum acceptable time*.

The question is: Which value should be selected for T_1? Generally we can take T_1=1 hour (=60 minutes). However, here no concrete values of T_1 will be used, but rather generally the maximal acceptable time T_{max} and accordingly for the set of acceptable values the interval V=< T_{max}].

Using equation [3] and the considerations until now, the following function can be defined:

<u>*Definition 1*</u>: Function δ: $< 0, +\infty >^3 \rightarrow < 0, +\infty >$ defined with δ ($T_{dost} + T_{prkc} + T_{\check{c}ek}$) : = T_{max}/T [4]

for cargo transport, where T is the value determined by relation [3] and is called the *function of accessibility*.

The function of accessibility δ is theoretically a function of three variables and can assume an infinite number of values. However, this is practically not correct since the function definition field is in fact the Cartesian product of three finite sets. The entire process, namely, is performed in real time, i.e. it is of finite length. Also, all the three variables that appear in [3] are practically integers (integers of minutes) since seconds, tenth of seconds etc. can be neglected. Therefore, each of the sets that form the Cartesian product is finite, and their product – the accessibility function domain δ – a finite set. Direct consequence of this fact is the finiteness of the set which contains precisely all values of function δ[2]. This set is called *image of function*[3] *δ*.

In mathematics, with mathematical expressions, it is known that every finite subset of the set of real numbers R has its smallest and largest element (i.e. minimum and maximum) in relation to the standard instrument $\leq$ in set R of real numbers. Since the image of function δ is a finite subset of R, the following definition has sense:

<u>*Definition 2*</u>: Maximum δ_{max} of function δ determined by relation [4] is called coefficient of accessibility.

Further in the paper, the coefficient of accessibility is denoted as δ (as well as the function defined by [4]).

Immediately the question is asked: why precisely the maximum has been selected and whether this selection is completely acceptable? The maximum has been selected in order to first of all consider the best possible case. If it really is the best possible case (according to criteria that will be analysed later) and is insufficiently good, then it is clear that all the other cases are even worse. In other sciences as well (physics, chemistry, electrical engineering, etc.) first of all the ideal models are studied and such approach has been used here as well.

What are the properties of coefficient δ? From [4] it can be seen that for $T \in V$ holds $\delta \geq 1$, whereas for all other T holds $\delta \in$ *<0, 1>.* This can be interpreted also like this: The lower the coefficient δ, the less accessible the destination, and the greater the coefficient δ, the more accessible the destination. For the sake of simplicity, $\delta \in$ *<0, 1]*, i.e. the highest possible value of coefficient of accessibility equals 1[4].

Closely connected with the *accessibility coefficient* would also be the *coefficient of inaccessibility* η defined by relation

$$\eta = 1-\delta. \qquad [5]$$

It is easy to see that $\eta \in$ *[0, 1>*, and one may say that the destination is less accessible the greater the coefficient η, i.e. it is more accessible the lower the coefficient η (inversely than δ).

The question should also be discussed: Which values of coefficient of (in)/accessibility are "good" (i.e. do not require improvements in organisation of transport), and which are "bad" (i.e. require finding of better solutions)? One of the possible criteria is the following: Accessibility can be considered bad if $\delta \leq \frac{1}{2}$ (then the process takes at least twice as long as the maximally acceptable time), medium if $\frac{1}{2} < \delta \leq \frac{2}{3}$, good if $\frac{2}{3} < \delta \leq \frac{3}{4}$, very good if $\frac{3}{4} < \delta \leq 1$ and finally excellent if δ=1.

---

[2] Here, the considerations, theoretically, might only complicate the possibility of existence of infinitely many lines (delivery) of truck and routes (operating trains) of rail cargo transport that can be used as well as infinitely many trains the departure of which must (can) be waited for. However, such possibilities do not actually exist.

[3] Formally, *image of function* $f : A \rightarrow B$ is a set $Im\, f := \{y \in B : \exists x \in A, y = f(x)\}$.

[4] Formally, thus, δ=1 is defined for $T \in V$, regardless of the actual δ_{max} calculated according to definition 2.

It is interesting to observe the difference $T-T_{max}$ in order to see the extent of deviation from the maximally acceptable time, i.e. ratio of *p* mentioned difference and time T_{max} (i.e. how many times longer does the process take than acceptable). Using [4] and [5] the following equation is obtained:

$$p = \frac{T - T_{max}}{T_{max}} = \frac{1-\delta}{\delta} = \frac{\eta}{\delta} \qquad [6]$$

Ideal case is when $p = 0$ and this occurs when $T \in V$. However, for different origins it is not only greater than zero, but also greater than 1. This case occurs when the accessibility of railway station is bad (according to the above criteria). If $p \geq 2$, the railway station can be considered to be practically inaccessible (the process takes at least three times as much as acceptable), and in practice this represents a serious problem in organising traffic from a certain respective railway station (since then it is very difficult to attract customers, users - consignees, goods).

This provides theoretical bases for further considerations regarding the coefficient of accessibility. Furthermore some problems related to accessibility will be mentioned, in solving of which the coefficients of in/accessibility can be used.

Finally thus, it is clear and one can deduce that the coefficient of accessibility of a railway station is a more recent and in the past practice, in professional and scientific circles not used indicator. However, it can be a valid indicator for the data about the extent to which a certain railway station is more or less accessible to a certain industrial group from a certain region (usually local), production factors, plants, a company, i.e. how much it or the railway find the delivery of goods and its rail transport justified, cost-effective, economical, optimal or not. In this way it can be relatively easily determined which terminal, railway station, cargo-transport centre (as origin) are best for easiest / fastest delivery of goods for loading and for having the goods dispatched from there by rail, or vice versa, from which traffic place of work (as destination) it is possible to take over the goods in the simplest / fastest way to transport it to the user / consignee of the rail cargo transport.

As part of the research, the function of this model has been tested, expressed in coefficients of in/accessibility (δ and η) using examples of actual systems in practice in real space and time. In the majority of "bad" indicators, when referring to the connection between the railway station and the user of industrial tracks, the reason can be found mainly in long waiting time to be included in a train and delivered from railway station ($T_{ček}$). This shows that the indicators of accessibility are far worse to the users of the same traffic place of work for acceptance and dispatch of the goods, terminals, cargo-transport centre or the railway station itself, which are dislocated and not connected to the industrial working tracks i.e. railway line.

The majority of representative examples is based on the connection of the railway station by industrial tracks with the users. According to the results of the indicators one may observe the flexibility of the model and extremely good behaviour in the actual system i.e. environment. All the distance and time indicators have been obtained by direct measurements and by recording the situation in the field[5].

The basis for measurability in assessing and evaluating the final one from the group of technological factors, i.e. **total level of quality of available and provided transport**

[5] Field distances are obtained by precise recording using a measuring instrument – laser Range-Master lrf-1200 and GPS device and times by direct measuring or mathematical approximation of mean times obtained by interpolation.

service needs to be additionally analysed and studied in more detail, including all the previously mentioned factors, and the starting elements for assessment have been set and defined in the following manner:

1. for poorly performed core activity in transport (delays in transport, cargo damage, etc.)
2. for poorly performed additional activities
3. for poorly performed core activity in transport
4. for poorly performed core activity according to COTIF
5. for well performed core and additional activities.

Assessment of factors of financial attractiveness of transport

The basis in measurability of assessing **cost-efficiency of transport** refers primarily to the correlation of revenues and expenditures per transport so that the assessment has been expressed as follows:

1. for transport which yield lower revenues than expenditures
2. for transport which yield equal revenues and expenditures
3. for transport which yield 5% higher revenues than expenditures
4. for transport which yield 10% higher revenues than expenditures
5. for transport which yield 15% and more revenues higher than expenditures.

The evaluation for measurability of assessing **the money flow** refers primarily to monitoring of the relations of transport payment terms by the users and transport cost payment terms by the rail carrier, which yields that:

1. if payment for transport is 30 days and more after the payment for transport costs
2. if payment for transport is from 1 to 30 days later than the payment of transport costs
3. if payment for transport is on the same day as the payment of transport costs
4. if payment for transport is from 1 to 30 days before the payment of transport costs
5. if payment for transport is from 30 days and more prior to the payment of transport costs.

In considerations and analysis of relevant parameters for the assessment and evaluation of the **price competitiveness of transport** several economic forms of theories have been considered and compared from several aspects characteristic for the traffic branches in general, and their appearance and behaviour in practice. However, among them special consideration was paid to factors that directly or indirectly affect the productivity, amount of costs and economy, and consequently also the price of transport service. Thus, mainly, from the position of the following forms in which they appear these have been included: value prices, production prices, normative, revenue, competitive and sales prices. In determining the value of this factor the focus has been placed on the range of transport prices that can be accepted by the market, and which are considered competitive, to those selling prices at which the transport services are really marketed and sold. Since in different market conditions and relations the competitive price is different from the selling price, sometimes lower, sometimes higher than the selling one and vice versa, all categories have been included, regardless of when and whether these relations suit the rail carrier or not.

Therefore, regarding the inclusion into the pricing and the correlation of transport revenues, the profit-making and tariff for cargo rail transport in the following financial factors, all the subfactors that affect the design of transport service value have been included. This has been further included into the consideration and analysis of factors of **price sensitivity and stability of the company, financial power of the users, financial stability of the company, industrial growth, productivity and virtual coefficient of the transport kilometre.** Thus, here, the following subfactors realised during one calendar year have been included: distances of realised trips, weight (mass) and volume of carried cargo, types of cargo, relations of gross-transport and net-transport work, levels of usage (steady and mobile) of transport capacities, levels of transport lack of uniformity, transport conditions, quality of the provided transport services, density and development of the railway line network and transport volume.

The mentioned discussions and analyses and the obtained research results of the included subfactors based on exact indicators deduced from the statistics through the realised studied operation in 2007 and 2008 in the Republic of Croatia have resulted in the formation of a theoretical assessment of the technological and financial attractiveness of rail cargo transport regarding the attractiveness, popularity, suitability i.e. acceptability, accessibility of cargo transport by rail, which includes also the overall position of the level of its competitiveness.

The deduced and obtained results have been rounded to integers and presented in Table 3.

Table III - Assessment of factors of technological and financial attractiveness of transport

Technological attractiveness of transport	Grade	Financial attractiveness of transport	Grade
1. Transport volume (transport/year)	3.00	10. Cost-efficiency of transport	4.00
2. Use of rail transport capacities	4.00	11. Money flow	2.00
3. Transport relation (length)	5.00	12. Price competitiveness	3.00
4. Duration (speed) of transport	5.00	13. Price sensitivity and stability	4.00
5. Availability and use of wagon rolling stock	3.00	14. Financial power of users	4.00
6. Value of goods	2.00	15. Financial stability of company	2.00
7. Transport safety level	5.00	16. Industrial growth	2.00

8. Environmental protection	3.00	17. Productivity	2.00
9. Location accessibility of carriers (δ)	5.00	18. Virtual coefficient of transport kilometre	4.00

The indicators presented in the Table show clearly that there are some instances of illogicality from the aspect of the law of economic sciences, and the reason lies in the "constant" or better, long-term and regular users of cargo rail transport who traditionally favour rail transport. Similarly, it may be seen that the traditional preference of large users for rail transport services are not disrupted by minor shifts on the competitive transport market but rather possibly only by major disturbances.

This is a good indicator for rail carriers, since even when there is disturbance on the market and weakening i.e. decline in its competitiveness in relation to other transport branches, those larger and large users of rail transport services do not easily change the carrier, since that would result in substantial difficulties, which shows their traditional connection to the railways. This goes in favour of rail companies since they are given thus the opportunity to adapt over some time to the changes on the market and start initiatives to increase and/or maintain their competitiveness in order not to lose the minor users of their services as well, and thus prepare for possible new or stronger disturbances on the transport market within the frame of their domain.

Overall grade of technological and financial attractiveness of rail transport

The final step in positioning the technological and financial attractiveness of transport is a relatively simpler task. The weighted grades (according to significance) of transport attractiveness are simply added together per each factor. Thus obtained value is used in order to locate each strategic business unit (type of transport) of HŽ Cargo, which can be seen in the proposals according to Tables 4 and 5. In this way the position of the transport attractiveness of railway and of its business power in the matrix is determined based on the grades of individual business units.

Table IV - Overall grade of technological attractiveness of transport

Technological attractiveness of transport	Significance	Grade	Weighted grade
Transport volume (transport/year)	0.10	3.00	0.30
Use of rail transport capacities	0.10	4.00	0.40
Transport relation (length)	0.10	5.00	0.50
Duration (speed) of transport	0.10	5.00	0.50
Availability and use of wagon rolling stock	0.05	3.00	0.15
Value of goods	0.10	2.00	0.20
Transport safety	0.15	5.00	0.75
Environmental protection	0.10	3.00	0.30
Quality of service	0.05	2.00	0.10
Location accessibility of carriers	0.15	5.00	0.75
Total grade	1.00		3.95

Table V - Overall grade of financial attractiveness of transport

Financial attractiveness of transport	Significance	Grade	Weighted grade
Cost-efficiency of transport	0.20	4.00	0.80
Money flow	0.20	2.00	0.40
Price competitiveness	0.10	3.00	0.30
Price sensitivity and stability	0.10	4.00	0.40
Financial power of users	0.15	4.00	0.60
Financial stability of company	0.10	2.00	0.20
Industrial growth	0.05	2.00	0.10
Productivity	0.05	2.00	0.10
Virtual coefficient of transport kilometre	0.05	4.00	0.20
Total grade	1.00		3.10

Positioning of strategic business units on the matrix

The matrix for assessment of development and evaluation of rail transport after having identified the technological and financial factors (Figure 1) consists of:

- coordinates of the technological attractiveness of transport
- coordinates of financial attractiveness of transport
- total volume of transport and share of rail transport
- nine strategic options.

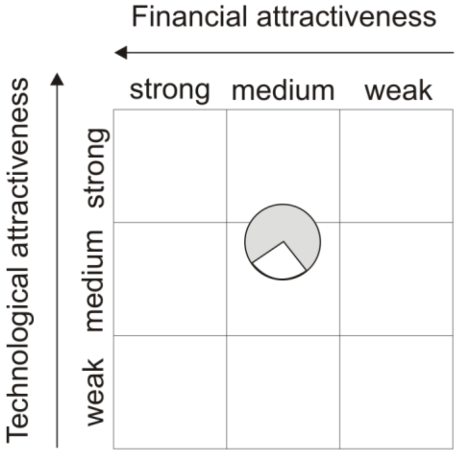

Figure 1 - Matrix for assessment of development and evaluation of rail transport

Position point of every strategic business unit on the matrix is presented as the centre of a circle, with the size proportional to the total size of surface transport, and the section shows the market share of the strategic business unit of HŽ Cargo.

BASIC STRATEGIC OPTIONS AND THEIR SELECTION

Model obtained on the basis of the matrix for the assessment of development and evaluation of the rail cargo transport provides different strategic recommendations depending on the situation that has been defined for individual business unit, and the basic strategic options available are:

- Development – substantial investments into strategic business units are necessary in order to permanently build up competitive advantages;
- Selective development – strategic business units that have medium power in very attractive industries or high power in medium attractive industries;
- Selective operation – strategic business units that operate in medium attractive industries and have medium attractive power;
- Maintaining of position – strategy for leaders in slow-growing industries;
- Focusing – poor competitive position in attractive industry – fast decision-making;
- Giving up – if the strategic business unit has no future prospects in industry.

The basic strategic options have been presented in Figure 2.

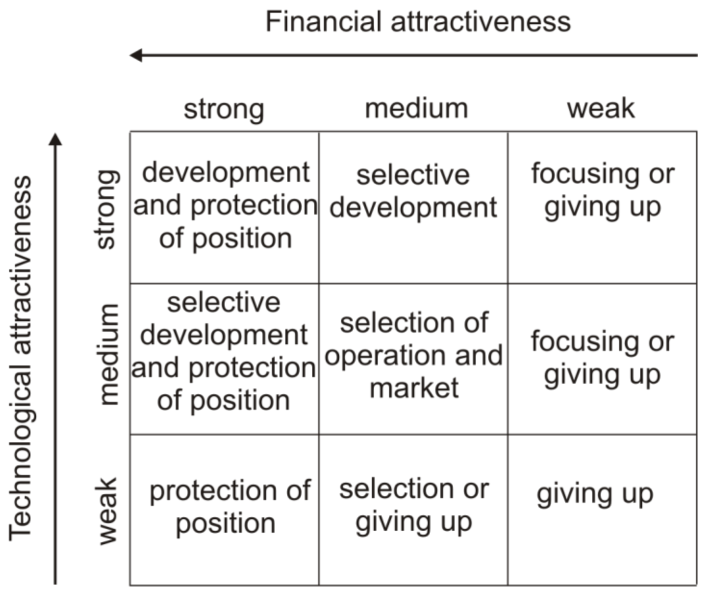

Figure 2 - Possible strategic options for their selection

The mentioned presentation is based on the GE matrix which means that the selection of strategic options has to be additionally processed and the strategic options redefined based on the combination of the technological and financial attractiveness of transport

CONCLUSION

Since railway companies in Croatia have initiated the process of restructuring and modernization in order to become more competitive on the freight transport market, a major issue has risen in freight transport: opting for a profitable transport or one more in line with public interest which in turn is often not profitable. The said becomes most obvious when it comes to low value bulk freight transport, freight transport on non remunerative and less active local railways as well as on technically more demanding railways with a large tariff transportation coefficient and a virtual kilometre coefficient i.e. expenses.

Division of Croatian Railways into four new companies, one of which is Croatian Railway-Cargo (HŽ-Cargo) – a railway freight transport operator, the possibility of financing non profitable means of transport has been considerably reduced thus making it imperative to find a new development business model in the forthcoming period. It is possible to initiate development strategies of HŽ-Cargo by determining and defining a suitable, optimal development, evaluation and research matrix of railway transport (DR&R - Development Railway & Research) whose methodological patterns for technological and financial lucrativeness, availability to users and competitiveness in freight transport given its technical, technological, economical (financial), throughput and transport capacities have been carried out, in this work, based on portfolio matrix theories of industrial attractiveness and business strength, (General Electric) matrix and ADL (Arthur D. Little) matrix, respectively.

Through elaboration and implementation of the GE and the ADL matrices, research of attractiveness evaluation measurability of railway transport has been performed based on certain technological and financial factors. Employing the specific set criteria, hierarchical evaluations of impact and importance of individual factors on attractiveness and overall competitiveness of railway freight transport on the transport market have been obtained. In doing that, the initial financial factor of transport profitability as well as technological factor of transport operator i.e. transport availability have been singled out as highly influential, followed by analyses of transportation safety level and financial strength of railway transport users. After these specific factors have been taken into consideration, others from both groups follow, in the order of proportionately assigned evaluations, value coefficient and finally pondered evaluation.

As a conclusion, the results indicate that creating a railway development matrix has a number of positive characteristics, as follows:

- It seeks solutions in an expert way and through technological-financial analysis of railway freight transport factors
- It positions business units (types of transport) in railway freight transport in a systematic way
- It enables positioning and selection of strategic choices based on transport routes (e.g. corridors) for each business unit
- It unifies everyday workers' tasks, production and sales of transport services in HŽ-Cargo in a professional way
- whereas
- Matrix can be extended and used for strategic determination of road transport operators.

LITERATURE

Hamel, Gari i Prahalad C.K. (1994). *Competing for Future*, Harvard Business School Press, Boston, SAD

Wilson, Ian (1992). *Realizing the Power of Strategic Vision*, Long Range Planning, Vol.25, No 5,

Tipurić, Darko, *Strategija razvoja poslovnih sustava*, skripta za poslijediplomski sudij, Varaždin

Porter, Michael E. (1985), „Competitive Advantage“, Free Press, New York

Prahalad C.K. i Hamel G. (1990). The core compentences of the corporation, Harvard Business Review

Tipurić D., Markulin G., (2002). *Strateški savezi*, Sinergija, Zagreb

Badanjak D., Bogović B., Jenić V. (2006). Organizacija željezničkog prometa, Sveučilišni udžbenik Sveučilišta u Zagrebu, Fakultet prometnih znanosti, Zagreb.

Jenić V. (2007). Modeliranje tehnološke strukture željeznice u funkciji gospodarskog sustava (Railway Technological Structure Modelling int he Function of the Economic System), Doctoral Dissertation, University of Zagreb, Faculty of Transport and Traffic Sciences, Zagreb.

Bogović B. (2006). Prijevozi u željezničkom prometu, ekonomika-marketing-tehnologija, Sveučilišni udžbenik Sveučilišta u Zagrebu, Fakultet prometnih znanosti, Zagreb.

Uremović D. (2004). Analiza strateških elemenata informatičke tvrtke, Ispitni zadatak iz kolegija „Strategija razvoja poslovnih sustava",Sveučilište u Zagrebu, Fakultet organizacije i informatike Varaždin, Varaždin.