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Low-cost Business Model in Railway Passenger Transportation

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Declaration on the word of honor:

I proclaim that I have composed this master thesis by myself and only used the materials stated in the references.

In Prague, August 21, 2011 Ivo Toman

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1 Introduction

Transportation is an integral part of society. Its position in the society is as established as the food industry, but while there are many kinds of foods available, transportation has evolved to only few means – road, rails, air, and water and by ourselves. Railway might have been the first truly mass-transportation means for long land distances, but since then it has lost its dominant position to cars and airplanes.

Despite the loss of much of its glory, railway industry and the railway passenger transportation still play major in both developed and developing societies. Anywhere in the world, the railway infrastructure is well considered as the wealth of a nation and it plays a significant role in the development potential.

One of the most unique specifics of the railway industry is the lack of diverse business models and its traditional operations with lower number of major innovations. This is a very different situation from, what we could see in automotive or aviation industry. The railway industry is missing low-cost operators in the passenger transportation – a dominant phenomenon of the aviation industry. Even though the airlines have been around much shorter time than passenger railway transportation companies, they have innovated the business model significantly and airline companies developed several distinguished business models.

As surprising as it might sounds, there is no great body of knowledge in the area of low-cost business models in the railway transportation (neither freight nor passenger). Therefore, this thesis is dedicated to an initial exploration of the area of low-cost business models in passenger transportation and the ultimate objective is to confirm the hypothesis whether there is a potential for low-cost business models in railway passenger transportation.

The goals of this thesis is to 1) identify the fundaments of the low-cost business model in the railway transportation, 2) investigate the key techniques used by companies excelling with a low-cost business models, 3) come up with recommendations for low-cost railway companies and 4) testing the economic viability of the specifics and tangible recommendations.

I plan to achieve the objectives by 1) dedicating my efforts to understanding the historical development of railway industry, 2) analyzing and understanding the cost of travelling and its fundamental elements, 3) finding and analyzing analogies in other industries and 4) run simulations and develop scenarios documenting the financial effect of the recommendations.

There are countless elements and techniques used by various low-cost companies and therefore I clearly want to state my intention to dedicate my effort and research only to those most significant techniques with high value potential in the railway industry and to those which I consider to be a key differentiator in the future. I will also use a criterion of relevance to the railway in the choice of the techniques. Moreover, I do

not want to come up with “out-of-blue” number, which are nothing less than wishful thinking.

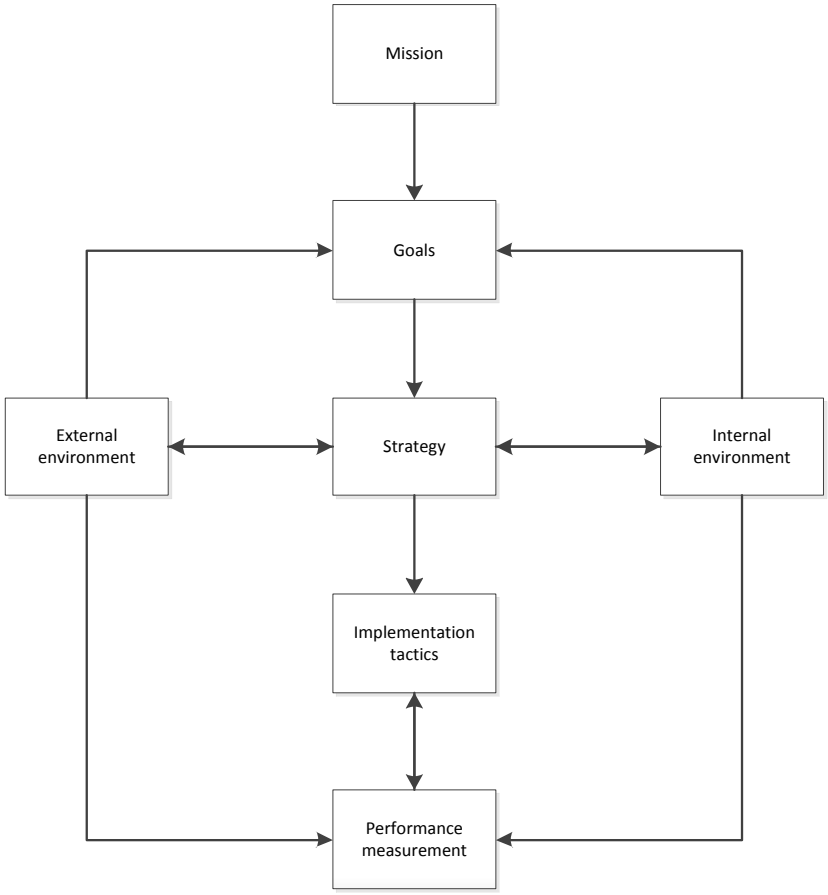
2 Strategy

The first step in defining the low-cost business model in passenger railway transportation is to understand what a strategy is, what a business-model means, how companies use it and why it is important.

The word strategy originates from the ancient Greek word "strategos", which is described as "*the general's plan for arraying and maneuvering his forces with the goal of defeating an enemy army*" (Editor, 2005). Strategies have been long used in the art of war. Right up till today, many strategic management thinkers come back to books like "The Art of War" by Chinese general Sun Tzu, "The Prince" by Niccolò Machiavelli, "The Book of Five Rings" by a famous Japanese samurai and swordsman Miyamoto Musashi or "On War" by Carl von Clausewitz. It is not uncommon to find these books at prestigious universities. Sun Tzu is one of the best examples of a strategic thinker who builds on the outside factors such as the wind, time of day or year. In particular, he analyzes his opponent's weaknesses and exploits them Another example is Musashi who not only focused on exploiting his opponent's weaknesses like Sun Tzu but also focused on working on his own strengths and weaknesses

The transition of the war-oriented strategy toward the business one began to emerge during the latter half of the twentieth century. One of the first authors who explicitly talks about the corporate strategy was Kenneth Andrews and his book "The concept of Corporate Strategy" (Collins & Montgomery, 1995). Probably the most famous strategy author of our era is Michal Porter, who described strategy as "*a broad formula for how a business is going to compete*" (Porter, 1980).

Diagram 1 - Context of Strategy



Source: (Editor, 2005), adjusted by Ivo Toman

Diagram 1 represents the context of the strategy in today's corporations. A good strategy cannot exist in isolation. At the beginning of any strategy formulation are the corporate values. This is represented by the company mission. The mission enters as one element into the corporate strategic, long-term goals, which represent the position of the company in the future. The strategy then represents a set of means to achieve these goals and it is tightly influenced by both the external and internal environment.

In turn, the external environment is represented by the parties who can potentially affect the competitive situation. The external environment can either be structured in the opportunities or threats proposed by SWOT analysis or it can also be viewed from the perspective of the Porter's Five Forces.

Here, the Porter's approach provides a way of looking at the potential profitability of the industry or market and trying to see the underlying drivers. Porter's Five Forces analyze customers, suppliers, competitors, substitutes and potential new entrants. Nonetheless, the Porter's Five Forces cannot be a solid fundament of any strategy without analyzing the internal environment. The internal environment can be seen as the company's resources and capabilities, which can also be looked upon as weaknesses and strengths in the sense of SWOT. The output of the internal analysis

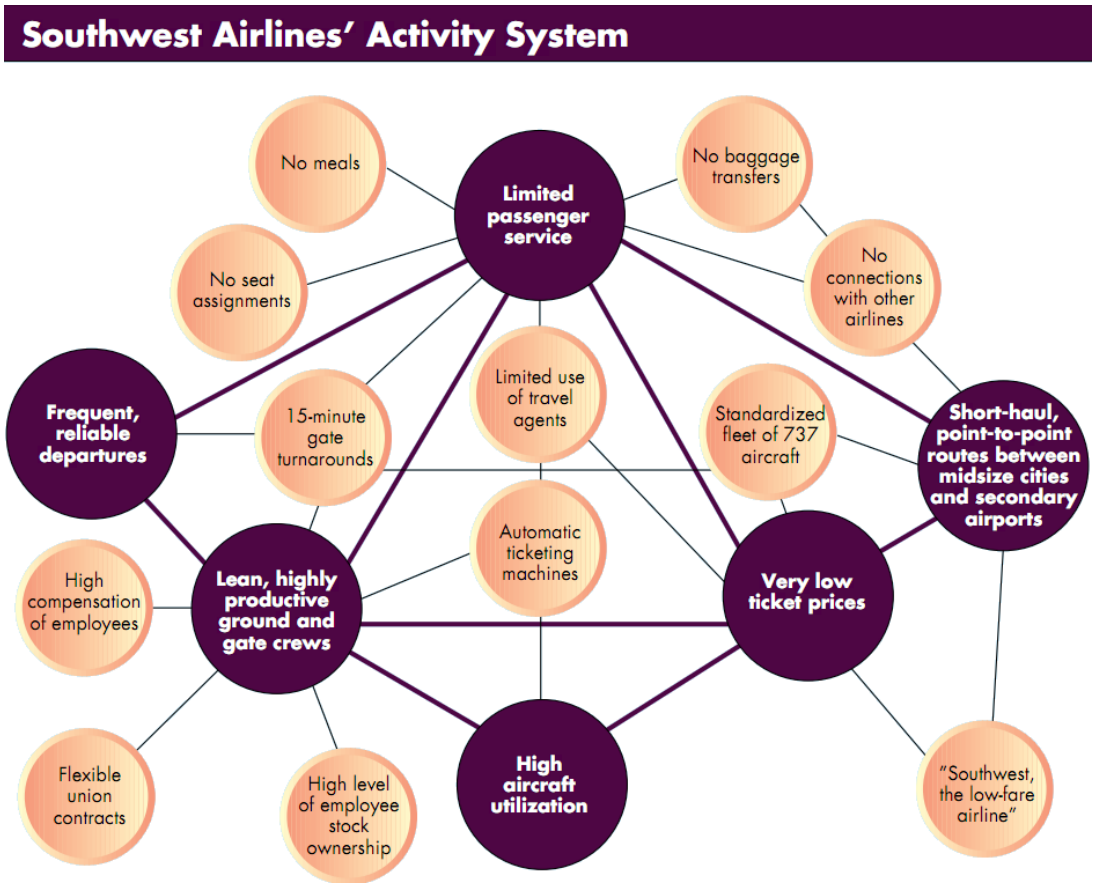
can be understood as key strengths or core competences, those are then combined with the outside factors and the competitive advantages are identifies.

Once the strategy is formulated based on the inputs from goals, internal and external environment, the implementation plan or tactics is developed. This represents a break-down of the strategy for the needs of operational management, divisions or functions. It represents a day-to-day manual which is also affected and adapted according to outputs delivered by performance measures. One of the most crucial parts of the strategy translation to the implementation plan is the communication between the top-management, which is generally responsible for strategy formation, and the operational middle-, lower-management as well as the general employees of the company. Without a functional mutli-directional communication, the company is atgreat risk of misalignment and loss of the potential identified in the strategy.

There are three major channels of communication:

1. The top-down communication represents the communication from the top-management to everyone else within the company about the strategy. This includes it's rationale, roles of individual department , goals, means of achieving goals, time-frame, measurements of success, motivation for achieving the strategic goals to name a few.
2. The bottom-up communication is mostly the feedback loop for the top-management about issues arising and potential areas of further improvements. This communication might represent a serious problem in companies with very high power distances between people. In such organizations subordinates might even be afraid to point out a problem because they feel they could get punished or they believe in the "unquestionable truth" of their bosses.
3. The inter-departmental, horizontal communication focuses on the alignment of all the departments. This is done through the development of new interactions in situations wherever necessary . This is to ensure that the company is moving as a cohesive body, without "leaving anyone behind" Horizontal communication is especially important if the company formulates its strategy through a series of well designed processes which depend on each other. This creates extra pressure on the management to synchronize all the activities into an "activity system" (Porter, What is Strategy?, 1996). Such a strategy is crucial in sustaining the company's competitive advantage because it builds on the principles of inimitability, durability, appropriability, sustainability and superiority (Collins & Montgomery, 1995).
4. An example of such an activity system is shown diagram 2. The circles are the key pillars and activities of the Southwest low-cost leadership strategy and we can see how well interconnected they are. Even if a competitor manages to replicate the company's strategy, it does not necessarily achieve the corporate strategy effectiveness as intended. This is because the Southwest Airline activity system works in tight relation of one another.

5. **Diagram 2: Activity system of Southwest Airlines**



Source: (Porter, What is Strategy?, 1996)

2.1 Generic strategies

In order to understand the low-cost leadership strategy (low-cost strategy), it is important to understand what other generic strategies companies can choose to pursue.

The business strategy literature offers many classifications of the generic strategies, such as low-cost leadership, product differentiation, creation of strong customer relations, merger and acquisition strategy, supply chain integration, technological & product leadership, strategies of scope and many others. I would like to describe four basic strategies, which have become a basis for many other strategies such as differentiation, customer relationship, network and low-cost leadership strategy.

2.1.1 Differentiation strategy

This strategy builds on the qualitative features of the product offering that customers value. These features are identified through market research, focus group or customer polls. The strategy might apply to product or service as well as to any industry. In a sense, even the low-cost strategy can be viewed as a form of the differentiation strategy, because the company pursuing the low-cost strategy is setting itself apart in a way that customers can appreciate – by the price of the product. The fact, that customers can appreciate the differentiating feature stands at the core and financial viability of the strategy. Basically, customer appreciation can be

seen as the willingness to pay for the product which in turn, might lead to buying more of the product or even combination of the two.

2.1.2 Customer relationship strategy

This strategy builds on long term relationships with the customer. It is well represented by small specialist stores, which are able to survive in a market dominated by multinational chains of stores. Customers are willing to patronize small stores for several reasons such as simplifying customers' lives or work, ongoing benefits, personalized service, customized solutions, personal contact and/or continuous learning (Editor, 2005). An additional factor for establishing the customer relationship strategy is the presence of close symbiotic product ecosystem, such as the case of Apple, Inc. This shows that the strategy not only applies to small niche businesses, but also to large companies with network of branches. However, it must be noted that with large businesses, the company needs to build on the improved customer experience while keeping the cost in reasonable limits.

2.1.3 Network strategy

Network strategy is founded on the so called “network effect”. In business sense, this means that the value to each user of a network increases with every additional user. A popular application of this effect is also known as the Metcalfe’s law, which is often applied to devices or users of internet services. Among many famous companies, which have built up an empire based on the network strategy are Microsoft, Facebook, eBay, YouTube, and Wikipedia to name a few. With increasing user traffic other parties (such as advertisers or companies) were joining the service. In the case of YouTube, customers constantly uploaded and resent large numbers of videos to the friends and the public daily. This viral cycle continued to spread to a point where older media sites like metacafe and vimeo are on the verge of being phased out. This is an example of a winner takes all situation, but we might find some exceptions, such as the fight between Facebook and MySpace. Even though MySpace was the first and most popular social network, Facebook managed to turn the situation around.

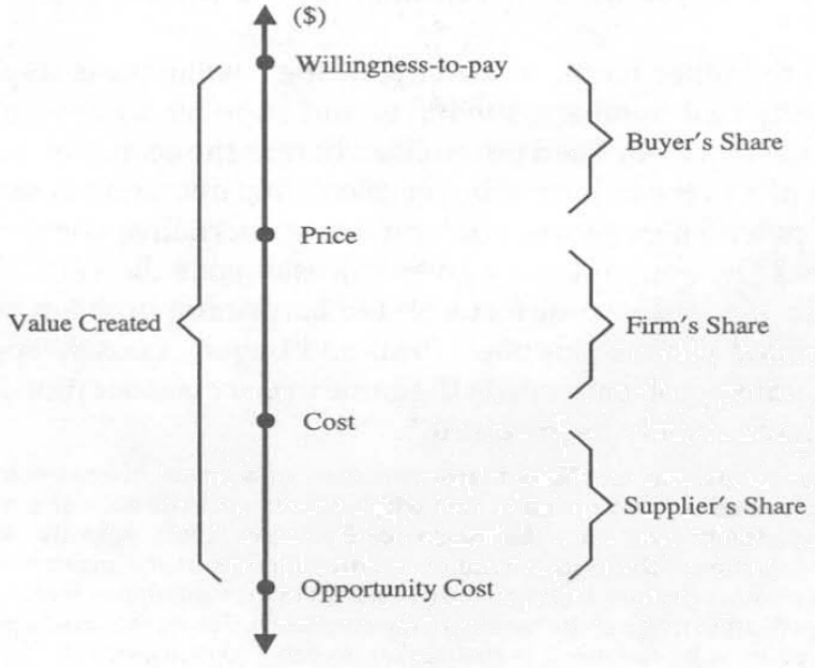
2.1.4 Low-cost leadership

As the name of this strategy implies, the key driver of this strategy is the determination of the company to achieve the lowest costs possible. More precisely, the goals of the company should be to have the lowest cost of all its competitors. This strategy is often used in situation when the company does not have its own product, but resells reselling other companies’ products (retailers, agents, etc.) or in situation when it is very difficult to achieve any product differentiation, which would deliver a high enough value for the customer to make him/her pay more or buy more of it.

In order to understand the motives for pursuing the low-cost leadership, we can have a look at diagram 3 below. It describes the value generated by product (or service) for its consumers – the value is the difference between the willingness of people to pay for the product and the opportunities of the resources used up in bringing the product to the final consumer. The top level, the willingness and the price, are dictated by forces beyond the company’s control, therefore we will assume them to be

constant and unchangeable. If the company wants to improve its financial position, all it can do is to push the cost base lower.

Diagram 3: Value appropriation



Source: (Brandenburger & Harborne, 1996)

There are several ways that this can be achieved- continuous improvement in operating efficiency, business process reengineering, exploitation of the experience curve, an unbeatable supply chain and product redesign (Editor, 2005).

The continuous improvement in operating efficiency or even business process reengineering are two most common approaches used by companies to improve the operational excellence and drive the cost down. The continuous improvement is best represented by the Japanese technique kaizen, which has found its invaluable place in many manufacturing industries and it represented an evolutionary progress. On the other hand, business process reengineering is a revolution-like process often initiated and introduced by consulting companies. Compared to continuous process improvement, it has a major risk arising from the complexity, because it requires planning of all major process at once.

Exploitation of the experience curve is an application of the learning curve. Production processes that are labor extensive should experience the gradual improvement in operation efficiency as a result of either increased output as the workers develop and share best practices.

In addition, an unbeatable supply chain can also be represented in diagram 3 as well as the decrease of the "cost" point down closer to the opportunity cost. Low-cost companies often push for lower costs down to the supply chain and they might create

strong partnerships to achieve the cost/price leadership. The establishment of the unbeatable supply chain might take form of closer cooperation on a product development or the introduction of the kaizen strategy and other cost saving measures. Another unbeatable supply chain example can be seen in retailing, where dominant players in the market, such as Wal-Mart in the United States of America (USA), aggressively squeeze companies in the lower parts of the supply chain in order to obtain the best prices.

Many companies had to undergo a radical product redesign once they started to face low cost production (mostly coming from developing countries). Xerox's introduction of product stewardship is a great example of the product innovation and redesign. When Xerox started to face much cheaper, but equally good in quality production from Japanese companies, it redesigned its new products in a way that some used parts from old printers could be used in new models without any further processing.

As implied earlier, there is almost no such case whereby a company would only employ either pure low-cost strategy or pure network strategy. It is almost always a combination of the 4 generic strategies described above, though in varying degrees of application.

3 Business model

There are many definitions of a business model. For example it can be explained as the internal workings of a company, or as mechanisms that generate value or cash. Since the truth lies probably somewhere in the middle, the definition by Joan Magretta seems to be the most appropriate for the purpose of this work: "*Business models are variations on the generic value chain underlying all businesses. Broadly speaking, this chain has two parts. Part one includes all the activities associated with making something: designing it, purchasing raw materials, manufacturing, and so on. Part two includes all the activities associated with selling something: finding and reaching customers, transacting a sale, distributing product or delivering the service.*" (Magretta, 202)

This definition includes the aspect of value-generation, represented by referring to the value chains embedded in every firm. It also includes the system and process behind the value generation. We can also argue that this definition is customer oriented in a sense, that customers define what value is and is not.

The relationship between a business model and a strategy is that the business model should be an integral part of a corporate strategy. It is included in both the high level strategy and the implementation plan. The term business model became popular during the boom of the internet business, when companies like Google, Amazon and eBay redefined the ways of how business can be done. These companies defined new ways of generating customer value and monetizing their products. In particular, the business models of companies such as Google or Mozilla represented a small revolution, because they began to deliver their products to users for free and they still

managed to generate incredible amounts of profit. Today, the buzzword is the Web 2.0, which also includes a new way of generating customer value by allowing users to use a platform to generate content or services by themselves. The best example for such a business model is, of course, Facebook.

3.1 Low cost business model

The low cost business model needs to then be understood as being both strategic and operational. The strategic part represents the efforts of the company to achieve the lowest costs of delivering value and the lowest price (which can be also understood as cost) for the final consumer. The operational part is the means and activities that the company undertakes to achieve the strategic goals. When looking at the low-cost business models of companies such as IKEA or Southwest Airlines, we need to realize that the key to their success is not only the lowest cost, but also high value for the customer.

$$value - for - money = \frac{value\ delivered\ to\ customer}{price\ of\ product\ or\ costs\ for\ customer}$$

The equation of the value-for-money indicator implies a danger for the low-cost business model. If companies cut prices, they might also decrease the value to the customer. If a 1% decrease in price is offset by a 1% decrease in value, the low-cost business model will not succeed. The companies have to decrease the price by more than the decrease of the value. The best measures, companies can undertake, are those that decrease price while increasing the value for client. A good example is represented by the current sustainability movement and lean production in the business. Companies take steps to recycle inputs and to eliminate waste and the burden to the environment. Consumer trends imply that such corporate behavior can be well appreciated by buyers who gain additional value by feeling better about the product because they feel they protect the environment. It also provides value for the company because it represents a point of differentiation from their competitors. On the cost-side, the company saves a lot of money on the purchasing of new materials and this creates a basis for price cuts. This kind of sustainability awareness proves fertile ground for both differentiation and low-cost strategies.

The example of IKEA well confirms that a company needs to act in the sense of value-for-money maximization. IKEA would never become the global market leader if these budget furniture offered had significantly shorter life cycle. IKEA delivers approximately the same value as the more expensive competitors, but with lower prices. In terms of its fight against low-cost competition, IKEA focuses on product innovation, additional features and higher product range (i.e. higher value), while offering it at the same or lower price.

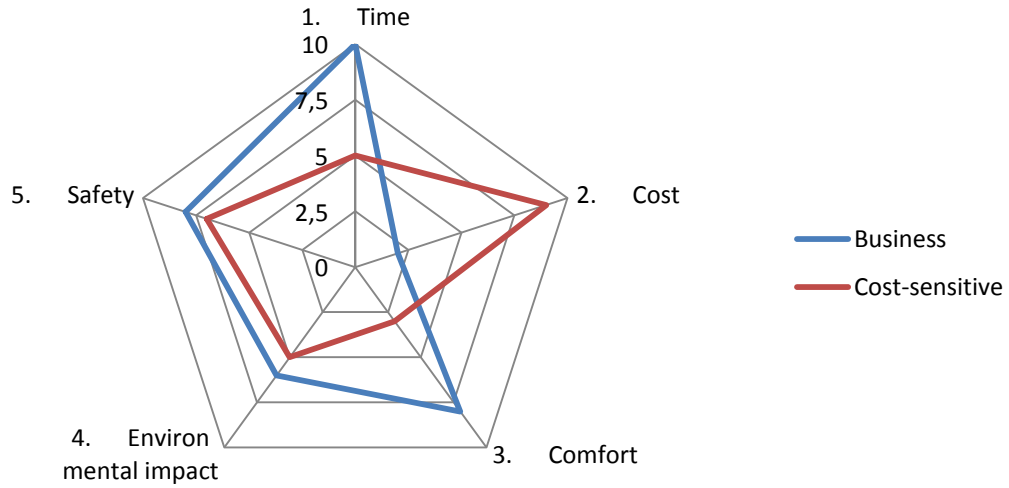
4 Traveling

We can identify 5 fundamental dimensions that define and influence people's choices on the means of travelling

1. Time
2. Cost
3. Comfort
4. Environmental impact
5. Safety

These 5 dimensions might also serve for market segmentations as the consumer preferences are within these criteria. Based on a market study or using intuition we can define some customer types. The Business travelers are most probably inclined to look at time and comfort, while price tends to play a less important role in their decision making. On the other hand, the price will be a major decision making factor for cost-sensitive passengers who are willing to sacrifice some comfort for a good price and they are also more willing to travel during off peak periods.

Diagram 4 examples of customer types



Source: Ivo Toman

4.1 Time

When looking at the total time required for a travel, we can identify three major stages and eight key activities as since in diagram 5.

Diagram 5: Structure of time requirements

Pre-travel		Travel					Post-travel
Finding the best connection	Buying ticket	Check-in	Boarding	En route	Baggage claim	Exit	Trouble shooting

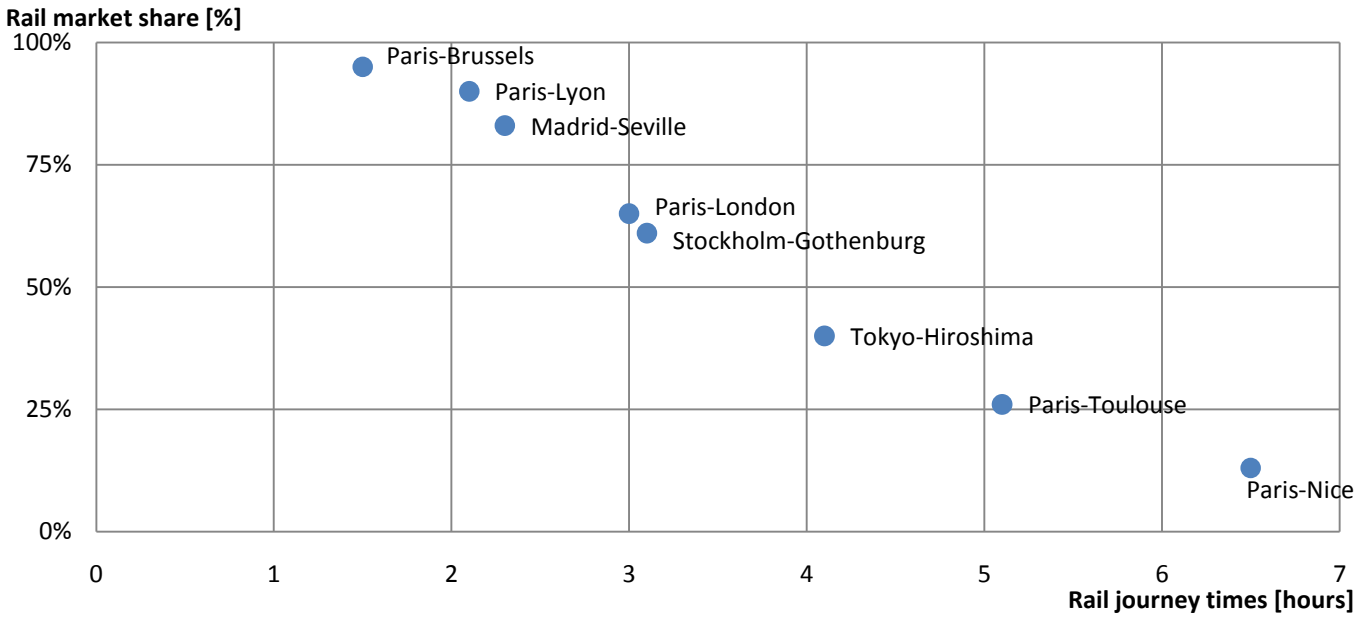
Source: Ivo Toman

It is important to take into account the length of time required for travelling. It is clear that the middle part accounts for the bulk of the time required, however, we must not forget the other two stages. Especially the initial pre-travel stage which might account for an indispensable part of the total time required as it happens for almost every journey. The final post-travel stage might be very time consuming, but it does not occur often.

It is also important to realize that travelling by bus and train do represent only a part of the travel and the traveler might iterate the middle stage (as the passenger needs to dedicate time to reach bus terminal for departure and later after the bus/train journey is finished, he/she needs time to reach home from the destination bus terminal).

The importance of the total time requirements in customer decision making is illustrated best by comparing the market shares of trains and airlines on various distances.

Diagram 6: Market share of rail for selected journeys of 300-600 km (market for air and rail transport only)



Source: UIC, High-speed Congress, March 2008, via (Streichfuss, 2010)

Diagram 6 above shows that consumers' preferences to train travels decrease with longer travel times (the actual time spent on journey, i.e. excluding the times in the pre-travel, post-travel stage and the times needed for check-in, boarding, baggage claim and exit). This can be explained by the fact that traveling by air requires more time in for activities outside of the actual travel. All passengers need to dedicate some time to look up the best flight connection and mainly they are required to be at the airport quite a long time ahead of departure to pass check-in, security clearance and boarding. Even when they have boarded, it takes some time get the airplane ready for take-off. After landing at the destination airport, the procedure of alighting takes up to 10-15 minutes. On top of that, the passenger then needs to wait for some additional 15 minutes for the baggage. Therefore, if a passenger arrives to the airport one and half hour before the departure, the actual time of travel accounts less than 1/3 of the total time requirements. Since the check-in, boarding and baggage claim procedures require approximately constant time requirements for any flight durations, we can see that for 6 hours flight, the actual time en route accounts already for ¾ of the total time requirements.

4.2 Cost

Costs of traveling by train should also be understood as the total costs connected to the travel. These costs can be separated into two main categories:

1. Explicit
2. Implicit

The explicit cost of traveling by train is represented by the cost of the train ticket and by the cost of connecting travels to and from the railway stations. The costs of connecting travels are not significant for the travels by train because the density of railway stations is quite high and usually the railway stations are located not far away from the town centers. Nevertheless these costs are comparatively higher for train travels than they are for travels done by buses or by cars. For the purpose of this thesis, I want to look into the options of the low-cost business model beyond the boundaries of the core business.

The implicit cost of traveling can be represented by the opportunity costs that are closely related to the time of traveling. This is since the passenger can dedicate this time to some "productive" activities. Having said that, I would like to justify why this thesis will deal not only with measures affecting the price of the train ticket, but also why it will also look often into measures affecting the time total travel requirements.

4.3 Comfort

Comfort also has to be understood in all its breadth. We can distinguish comfort in all the stages during the length of travel. In the pre-travel stage, comfort is represented by accessibility, easy to use system for choosing the right train at a right time and purchasing the ticket. During the second stage, comfort can be separated into 3

segments, namely 1) the check-in and boarding procedure, 2) the actual transport/travel and 3) the baggage claim. We must not forget about the post-travel stage, where the consumer comfort from the previous stages could be easily destroyed by inadequate customer service and trouble-shooting. In the post-travel stage, we can think of one additional comfort-oriented activity, the customer relationship management. This might primarily represent personalization of the special offers, inclusion to various loyalty programs and personalized communication and services.

4.4 Environmental impact

How environmentally and eco friendly the mode of transport represents a trend that is increasingly apparent in the customer's consideration of transport choice. Even some governments make economic and legislative decisions to promote environmentally-friendly means of transportation. This is especially valid for railway transport as it is regarded as one of the most ecological means of transport (Kim & Van Wee, 2008), (Streichfuss, 2010).

4.5 Safety

Safety is always an important decision-making factor, but it is not so relevant in the European Union due to the very strict safety rules for transportation. For the purpose of this thesis, I will assume that other means of transport offer the comparable safety standards and that customers are indifferent to the safety among the different means of transportation.

5 Railway industry

In order to understand the present state of the railway industry, it is important to better understand the historical role and development of railways in different geographical regions. The railway industry has undergone tremendous booms and falls and it has greatly shaped human activity and economic development.

5.1 Origins of railways

The very first rail-based transportation probably came from ancient Greece, where around 600 BC, people started building a rail transportation network that stretched for a couple of kilometers. Other wagon/rail based transportation could be observed in the medieval times in Europe in the form of wooden carts pulled by horse or men.

The origins of modern railway transportation can be traced back to the 19th century, where the first applications of steam engines found their way to railway transportation. The construction boom of railway tracks started in the 1830s, especially in the USA and in Britain. In the USA, the total length of the railway tracks increased from zero to more than 163 thousand kilometers by 1890 (U.S. Census Bureau, 1890). This represented a tremendous growth and railways soon become a driver in inhabiting vast areas in the west of northern America. In the USA the development of railway track has been done mainly by private subject and companies and this trend has survived till the present times.

Till the beginning of the twentieth century, the development of railway infrastructure in Europe was not different from the USA – the development was also carried out by the private sector. Later in the twentieth century, when the railway industry become too important and strategic for the country's national security and economic development, the governments around Europe stepped in with strong regulation and they began to limit market competition. The consequence of the government interference was a deterioration of the railways in terms of development, traffic and financial conditions. This was followed by large nationalizations of the railway industry. By mid twentieth century, a vast majority of European railway companies were controlled and owned by the state. This situation is still present in many countries in Europe.

The situation in twentieth century USA was different and similar to Europe at the same time. Many private railways companies went public in the nineteenth and twentieth century and have never been nationalized. Nevertheless, even the USA was imposing tighter and tighter control mechanisms on the railway industry through regulation and taxation. In the 1970s the railways experienced a decline in the transportation volumes and they were not in such a financial situation to maintain healthy investments into the infrastructure or rolling stock. This caused the majority of railway companies (especially in the North-East of the USA) to file for bankruptcy (Streichfuss, 2010).

One of the most significant innovation in the railway industry occurred in 1960s, when the first high speed trains, or bullet trains were introduced. The First bullet

train, better known as the *Shinkansen*, was introduced in 1964 in Japan (Central Japan Railway Company), soon after that, the TGV trains were introduced in France. This innovation came during the time where air transportation increased in popularity. The introduction of the bullet trains helped railway transport to slow down the decreasing traffic and in some cases it helped railway companies to win some markets share.

5.2 Transformation of railway industry

The transformation of railways around the world was driven by two major trends: liberalization and privatization. These two trends are not only specific to railway industry; we can also observe both trends in the past transformation of other network industries such as telecommunications, public television and radio or in the energy sector.

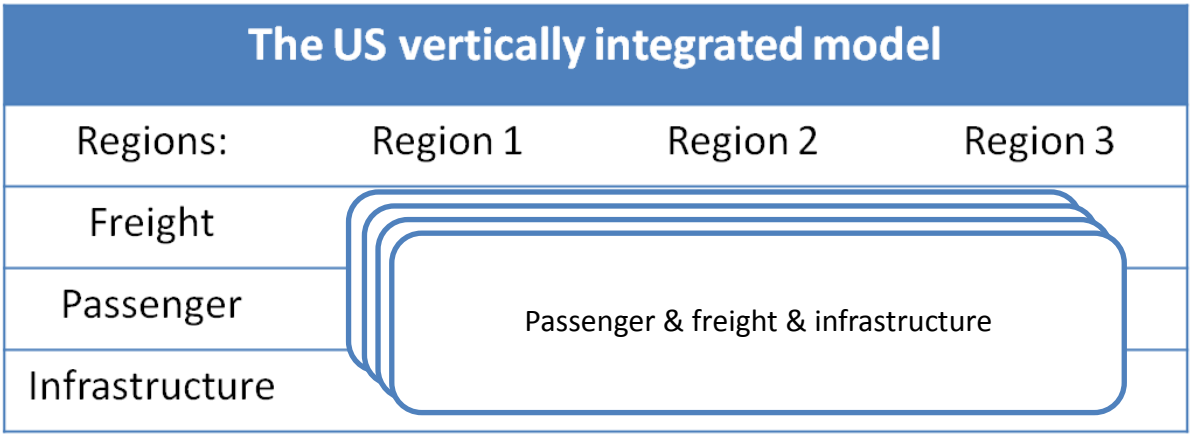
5.2.1 Liberalization

Liberalization is a megatrend which comes hand-in-hand with increasing globalization. We might also see this trend relating with increased globalization and westernization. The trend is also prevalent in major economic schools of thought, such as monetarism or laissez-faire. There are many rationales behind the liberalization of the railway industry. Probably the main factors are the government's focus on increasing competitiveness of the country and its infrastructure, focus on reducing governmental spending, improving employment, attracting foreign direct investments and encouraging the spill-over effects from the private investments to the railway companies and infrastructure.

The different historical development of railway industries in different geographical regions and the different process of liberalization led to 3 distinct models of railway industry organization – first, the model in the South and North America, best represented by the USA, second the specific model of industry organization in Japan and third the model currently pursued by the countries of European Union.

The US model of railway industry organization results from the historical origins of railway industry in the US. As described earlier, the individual private railway companies in the USA were responsible for the in construction and operation of these railway lines. This has survived till today and the major railway companies in the USA are vertically integrated companies with their own infrastructure. The infrastructure also becomes the factor of differentiation and a competitive advantage. Due to the enormous cost of building these infrastructures, this model fits best for one or very few companies on the market. Companies can achieve reasonable scale in infrastructure development, they have absolute control over it and it also helps to rationalize the infrastructure development. Further economies of scale result from the integration of the freight and passenger transport. This further improves the company's financial stability against market fluctuations.

Diagram 7: The US model of railway industry organization



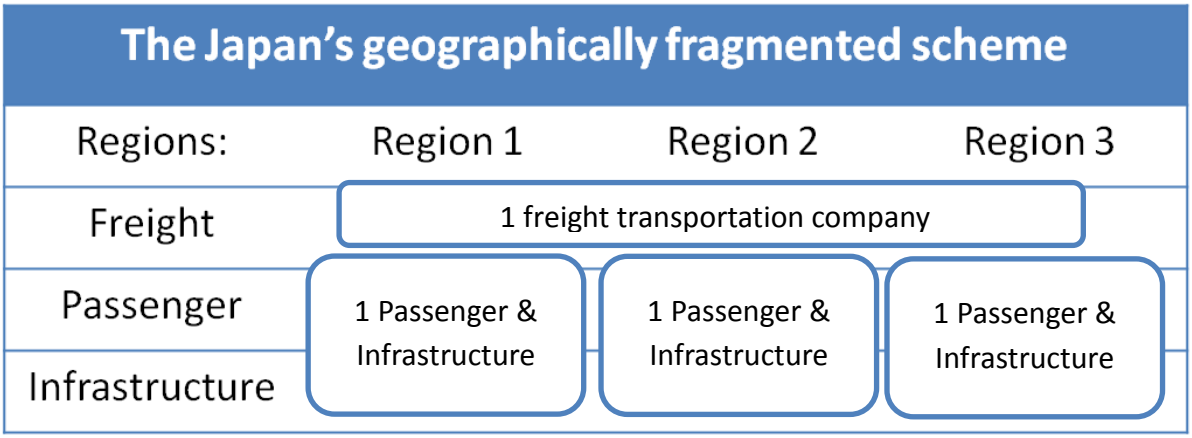
Source: Ivo Toman

The Japanese railway industry organization model has also been strongly affected by historical development. The rail tracks have been dismantled during the World War II (WWII) in order to obtain more steel for war activities and it was only after WWII was there a renaissance in the railway infrastructure development. As mentioned earlier, Japan was the first country to introduce bullet trains into the market which later allowed them to build a larger network capable of very high speed train operations.

However, the problem with this development was in the expenses. By 1987, Japan National Railways (the national railway monopoly train and infrastructure operator) accumulate ¥27 trillion worth of debt. That year, Japan's government separated the Japan National Railways into 6 independent passenger companies and one freight company. The passenger companies were active in particular regions: West, Central, East, Hokkaido, Kyushu and Shikoku (Central Japan Railway Company). These companies, with some exceptions, formed locally active monopolies on both passenger transport and infrastructure management. Only one rail freight company is still in state ownership and it still has access to the infrastructure of all the regions without limitations. In 1987, the six passenger transportation companies were privatized.

This arrangement made it difficult for companies to leverage economies of scale in investments and operations and it also limited the competition severely through high barriers to entry. On the other hand, such an arrangement represented a good base for market/customer oriented decision making in the areas of infrastructure development.

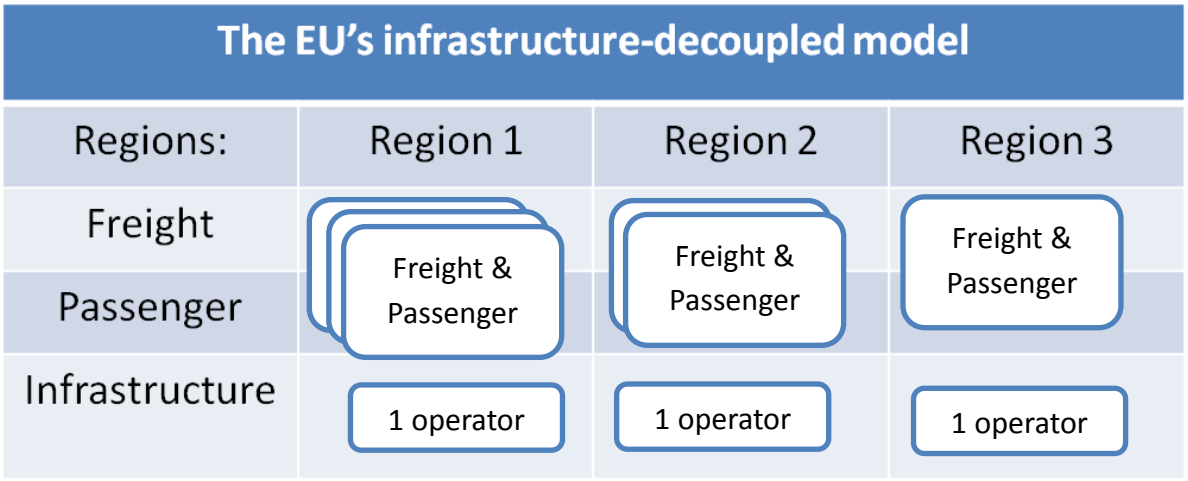
Diagram 8: Japan's railway industry organization model



Source: Ivo Toman

The European railway industry organization model is being developed and coordinated by the European Commission and Parliament. The structure of the industry resembles the structure imposed on other network industries. It highly resembles the industrial organization in the energy market, where the European Union requires the transmission infrastructure to be independent and accessible for every company without differences. In addition, the railway infrastructure (the tracks and potential stations) is required to be operated by independent local companies who are in charge of operation and development. Such organization of the industry should ensure maximum competition among railway companies and should raise barriers to entry. Moreover, this solution is a good base for international standardization as the infrastructure operators have, increasing competition from other transportation companies. On the other hand, this organization might create an issue/problem in resources allocation for infrastructure development, mainly because these companies do not have direct contact to final customers and might not understand the current trends in customer mobility requirements.

Diagram 9: The European model of railway industry organization



Source: Ivo Toman

5.2.2 Privatization

Privatization is the second trend in the process of railway industry transformation. We can observe this trend all around the world, but currently the efforts of privatizations are prevailing in Europe, where privatization has become a preferred means of achieving the EU's strategy to create competitive railway transportation.

According to experts from Roland Berger Strategy Consultants, the blueprint for transportation has three fundamental steps (Streichfuss, 2010):

> "*Step 1: Clarify the interface with the state and create a sustainable organizational structure*"
>
> "*Step 2: Restructure and achieve competitiveness*"
>
> "*Step 3: Privatize*"

Even though the process might look intuitive and easy to achieve, the reality is far more difficult and complex. New Zealand and Great Britain can serve as good evidence to the difficulties of railway privatization.

In 1993, the government of New Zealand privatized the integrated railway company (including both transportation and infrastructure unit), but due to financial problems and low return on investments, the government decided to step in and bail out the company by buying back the fixed assets of the company, i.e. the infrastructure and related long-term investments. Despite the efforts, the privatized company could not reach a stable financial position and in 2008, merely 15 years after privatization, the government decided to nationalize/repurchase the rest of the original railway transportation company (Clark, 2010).

A similar, but more successful story occurred in Great Britain, which has been the first European country to fully privatize its railway industry. The process of privatization was different from the case in New Zealand in the sense that the government of the Great Britain has split the railway industry into 100 separate transportation companies, out of which 6 were freight companies. Even though the transportation companies are competitive today, the infrastructure management company had to be bought back by the government in 2002 (Streichfuss, 2010).

In addition, the case of Deutsche Bahn, Germany's incumbent company shows how long the process of privatization can take. The German government started its efforts to transform Deutsche Bahn in beginning of the 1990s and it was almost about to launch and IPO in 2008, but then the financial crises hit. The IPO has been postponed and as of end of March 2011, there is no date set for the company to go public (Deutsche Bahn, 2011).

5.3 The current situation

The booms time in the construction of new railway tracks have long been gone. The total length of the railway tracks in EU27 (except Malta and Cyprus) has increased from 215 thousand kilometers in 1990 to only 217 thousand kilometers in 2007 (Eurostat, 2011). A change can be seen in the structure of the railway tracks as many countries are building new dedicated tracks or upgrading existing tracks for high-speed trains. Such projects have taken place mostly in developed countries in Western Europe. The development of the very-high speed trains has been on a smaller scale in the new EU member and the average speed is also much lower than the speeds achieved in the West.

The most important implication from the historical development of the railways is the fact that the limited commercial freedom from the 20th century has vastly limited business innovations. We still see many incumbent railway operators under the control of the government where they are subjected to an environment with little freedom. What is important for this paper is the comparison of the railway and the airline industry in terms of emergence of low-cost carriers. The history of low-cost carriers dates back to 1971, when the Southwest Airlines began operations on their first flights within Texas, United States (Southwest Airlines, 2011). Since then the low cost airlines have won the dominant market position in many countries and continents. The Southwest airlines are the largest airlines in the US and Ryanair belongs among top 3 airlines in Europe (IATA , 2011).

The situation in the railway industry is much different. When searching for railway operators listed as low cost, you cannot find any (Author's internet scan). There have been some attempts by established companies to spin-off a part of their operations, such as the case of SNCF or Trenitalia. According to internet and academic research, no independent low-cost railway operator has achieved a significant size comparable with the largest railway companies. In many regions, this situation is most probably caused by the strong regulation and the limits on competition. The case of the European Union might well document this underlying hurdle. In almost all central and eastern European countries, we can observe national monopolies operating and often even owning the infrastructure and the conducting of transportation operations. It was only after accession to the European Union that these countries were allowed other companies to operate on the incumbent's territory.

Even though the liberalization of the railways has progressed significantly and many of the governmental regulations have been eased, several hurdles are still in place. These hurdles include tax disadvantages, internalization of external costs into the cost base and inadequate state financial contribution for public services offered by railway companies.

While road and railways tend to pay similar taxes, the tax disadvantage of railways is most true in comparison to the air transportation. Airlines are exempt from paying VAT on the international flights and thus become more price-competitive against railway or road transportation.

The internalization disadvantage stems from the structure of user access charges. Road transportation in general does not pay for all the costs of operating, maintaining and developing of the road network. The other factor in internalization of the external costs comes from the fact that a significant portion of the railway traffic is carried out on the electric tracks. The internalized external cost is reflected in the participation of energy sector in EU emission trading system. The cost of emissions is naturally reflected in the electricity price and it directly affects the cost base of railway transportation companies.

The state's inadequate financial contribution for public services is caused both by the integration of many incumbent railway companies into the governmental body and the state's order to operate low-traffic routes. The problem exacerbated during the financial and economic crises in the past few years as well as during the current debt crises of many countries. During that period, government and voters pushed for a reduction in governmental spending and these negatively affected railways, which do not always enjoy a positive public opinion.

5.4 Future of the railways and its renaissance

In order to understand the future prospect of railways, we need to understand the current market position of railways and the significant trends in the markets.

5.4.1 Competitive situation of railways

The table below helps in putting the railways key strengths in the context to the other means of transportation – the road and air transportation. The sea transportation is not taken into account, due to the fact that the competition between sea and railway transportation is rather low in freight and minimal in the passenger transportation.

	Average external cost [€/pass.km]	Sustainability	Flexibility	Speed	Cost	Compactness
Rail	23	High	Medium	Medium	Low	Medium
Air	53	Low	Low	High	Medium	High
Road	76	Medium	High	Medium	High	Low

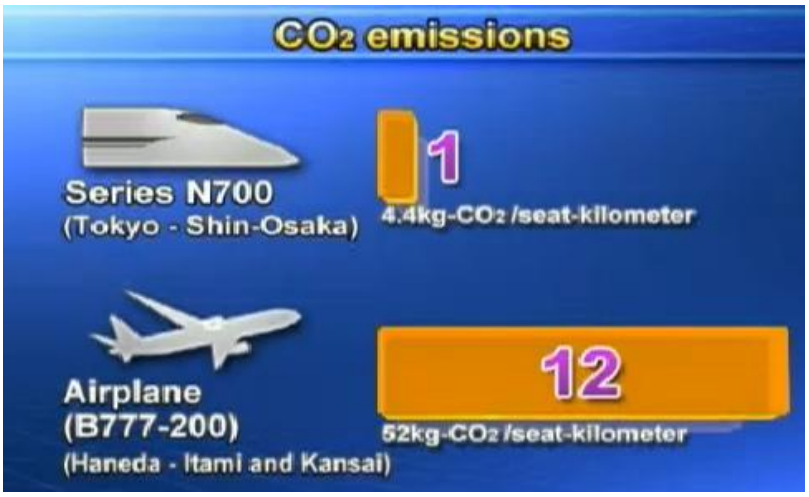
Source: (Schreyer, Schneider, Maibach, Rothengatter, Doll, & Schmedding, 2004) via (Zwinger, Budinsky, Oliveira, & Toman, 2010)

According to the first column, we can clearly see that the railway transportation does produce much less external cost – 2.3times less then air transport and 3.3times less than road transportation. These costs represent the externalities that the particular

means of transportation produces – the air pollution, the noise pollution, accidents or other costs incurred by society at large. The cars externalities might decrease by adoption of electric cars, but adoption is expected to be rather slow. Railways can further decrease the external cost by adopting new technologies in train traction, such as Electric Multiple Unit (EMU = train equivalent of all-wheels drive). Trains built with EMU technology offer reduced noise and improve the energy efficiency and they also have lower axle load, which help to reduce the track maintenance costs and improve the life span. If the governments around the world crease a fair market conditions in terms of internalization of external costs, the railway transportation will gain an even stronger position.

Environmental friendliness of the particular means of transportation does closely connected to the external costs, but it is cleaned from the effects such as congestions, accidents or urban effects. The environmental friendliness or eco-friendliness is a very important trend in the developed countries especially. People turn away from their previous habits and rituals in order to mitigate their negative impact on the environment. This trend has also gained a significant foothold among the consumer oriented companies, especially in the fast-moving consumer goods industry. Companies, such as Unilever and Procter & Gamble, compete one each other, who can introduce a washing powder suitable for 40, 30 or 20 degrees Celsius washing temperatures in order to decrease the energy consumption during the washing process. The trend in bio production has also hit traditional retailers in the United States or even the cosmetics producers and retailers (a good example is The Body Shop retail concept). Railway transportation perfectly fits to this trend with the environmental related costs of less than 13.1 EUR / 1000 passenger kilometers, compared to 29.7, resp. 48.6 EUR / 1000 passenger kilometers in the road transportation, resp. air transportation (Schreyer, Schneider, Maibach, Rothengatter, Doll, & Schmedding, 2004). If we compare the Shinkansen train Series N700, which is being widely adopted in the JR Central (Central Japan Railway Company) with the conventional airplane, we can see that the N700 series produces only 1/12 of the CO2 emissions of the Boeing 777-200, measured per a seat kilometer – see the figure below.

Figure 1: CO2 emissions comparison



Source: (Central Japan Railway Company)

It is important to highlight that the industries around air transportation are also going on the market trend for lower environmental impact and higher product sustainability. Both Boeing and Airbus bringing major innovations their airplanes by introducing with advanced materials to make airplanes lighter and more efficient engines to make them run more efficiently. The innovations in the automotive industry also focus on bringing electric and hybrid vehicles to the market in order to mitigate the ecological footprint of the industry. Nevertheless, the railway industry does innovate too. Moreover, the railway industry should consider its marketing communication to improve the general awareness of it eco-friendliness and win a hearth-share on consumers.

Flexibility of transportation is surely a key strength of the road transportation as the infrastructure and personal car mobility is the pinnacle of transportation evolution. Airplanes, on the other hand, are very limited to major cities and as such they can serve for only special-purpose trip on the long distance. People spend a lot of time travelling to the major airports to catch a flight. Trains offer a middle way. Train stations are located in almost every local town (at least in Europe) and they are also connected to the local public transportation network. The competitive position of railways is very well situated in competition to air transportation and the competitive situation against cars is not looking gloom at all.

In terms of speed, it is also difficult to make one judgment about who is best and who is not. We can clearly state that currently the commercial speeds of airplanes are much higher than speeds of any other means of transportation. Cars are limited on the speed by political will and the availability of highways. This is not the case of airplanes, where the limitation is based on the current level of technology. The situation around trains is more difficult. Trains can achieve speeds close to the airplanes – maglev trains hold the speed record of 581 km/h on a special electro-magnetic track and the fastest TGV train made by Alstom has achieve the top speed of 574 km/h (Unknown, 2007), (Unknown, Japanese Maglev, 581km/h, 2006). The

cruising speed of the top-speed TGV and Maglev can be at about 500 km/h, which is about 2/3 of the cruising speed of Boeing 737. The problem with the speed of railways transportation is more in the infrastructure, which often limits the speeds far below the top speed of the trains – an example can also be the Pendolino train employed by Ceske Drahy, which can achieve speed of 220km/h, but the tracks limit the commercial speed to 160km/h. Still, the speeds of currently employed trains are comparable or even much faster (in the case of very-high-speed trains) than the car transportation.

Compactness of the network is very important in the urban areas and when connected to the macro trend of extending the urban areas around the major towns, we can assume that this factor will play an even larger role in the future. Roads offer the worst compactness of all means of transportation and the non-organization of the road traffic is the base for great inefficiencies. If we talk of the distant future, the technology of driverless cars has the potential of increasing the capacity or throughput of the highways by the factor of two to three (Thrun, 2011). Nevertheless, this improvement does not help the compactness much, as the roads are spreading everywhere and generally have multiple lines. The air transport is much more compact and the traffic on one airport can be up to almost 2700 flights a day (Airports Council International, 2010). In terms of passenger, daily more than 241 thousand people can go through an airport (Airports Council International, 2010). This represents a huge throughput through a small piece of land at every major city. Railways are surely less compact than airports because they require one route for areas with less traffic or two or even more routes for high and very traffic areas. The key strength of the railways resides in the throughput. The busiest railway track in the world, the Tokaido Shinkansen connecting Tokyo and Osaka, transports 378 thousand passengers everyday on only 2 railway tracks (Central Japan Railway Company). This represents almost 57% higher throughput than the airlines while still keeping a compact size, especially compared to multiple lane highways. To put the throughput numbers in the context also with the road transportation. The busiest highway in the north America, the Ontario Highway 401, has the average annual daily traffic of 500 thousand cars a day, but the highway has somewhere between 12-18 lanes in both directions and it take much more space than the Shinkansen route (U.S. Department of Transportation, Federal Highway Administration, 2007).

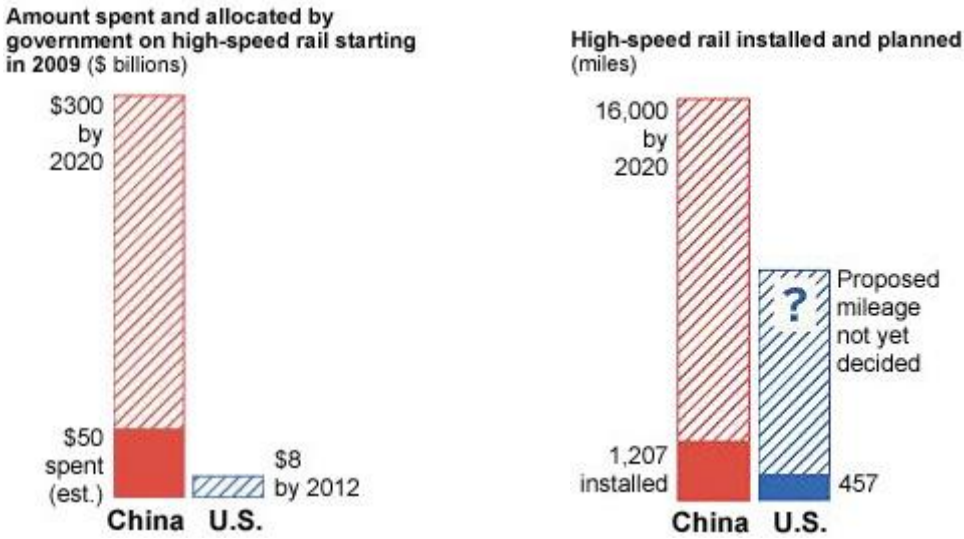
One more trend we can observe in the railway industry is the increasing involvement of the supply chain in the innovations. Historically, railway industry has been highly vertically consolidated where the railway transportation companies were responsible for majority the progress. Companies producing trains and equipment used to have little or no product portfolio on hand, they were generally waiting for a tender of a major transportation operator and then they built a product (train, equipment, track system, or other) from scratch for the customer. Such a dysfunctional system has survived even to the 1990s in Europe. An example of this legacy supply chain structure is development of the ICE 1 train. These trains were built by Siemens, but they were initiated by and developed according to plans of Deutsche Bahn. In the past

20 years, the industry has begun to transform and it is already possible to see major changes. The ICE 3 was already developed fully by Siemens. A similar story has been also in France, where Alstom has underwent the development of the latest generation of high-speed trains from its own initiative, without havening any concrete orders placed. The higher involvement of the supply chain is a necessary base for innovation and improved competitiveness of the industry. As in many industries, today there are not companies fighting one another, but rather supply chains and eco-systems of companies fighting other supply chains and eco-systems.

5.4.2 Investments

When analyzing the market movements and governmental spending and plans we can see the increasing shift in transportation towards railways. A sign of trust for the railway industry in the North American and beyond was the acquisition of Burlington Northern Santa Fe by Warren Buffett's Berkshire Hathaway in the 2009 for more than USD 44 bn. It was bold step and a bet on the characteristics of railway such as environmental friendliness, price advantage and efficiency of the transport (FOX Channel, 2009). One other benefit Warren Buffett implied in the interview on FOX Channel is that the railway industry has a strong spill-over effect on the economy as well as other industries (in his case the shippers). The spill-over effect has also been documented FUNDING project, which found that when investing into railway infrastructure, the spill-over effect might account for as much as 50% of all the benefits (Proost et al, 2007).

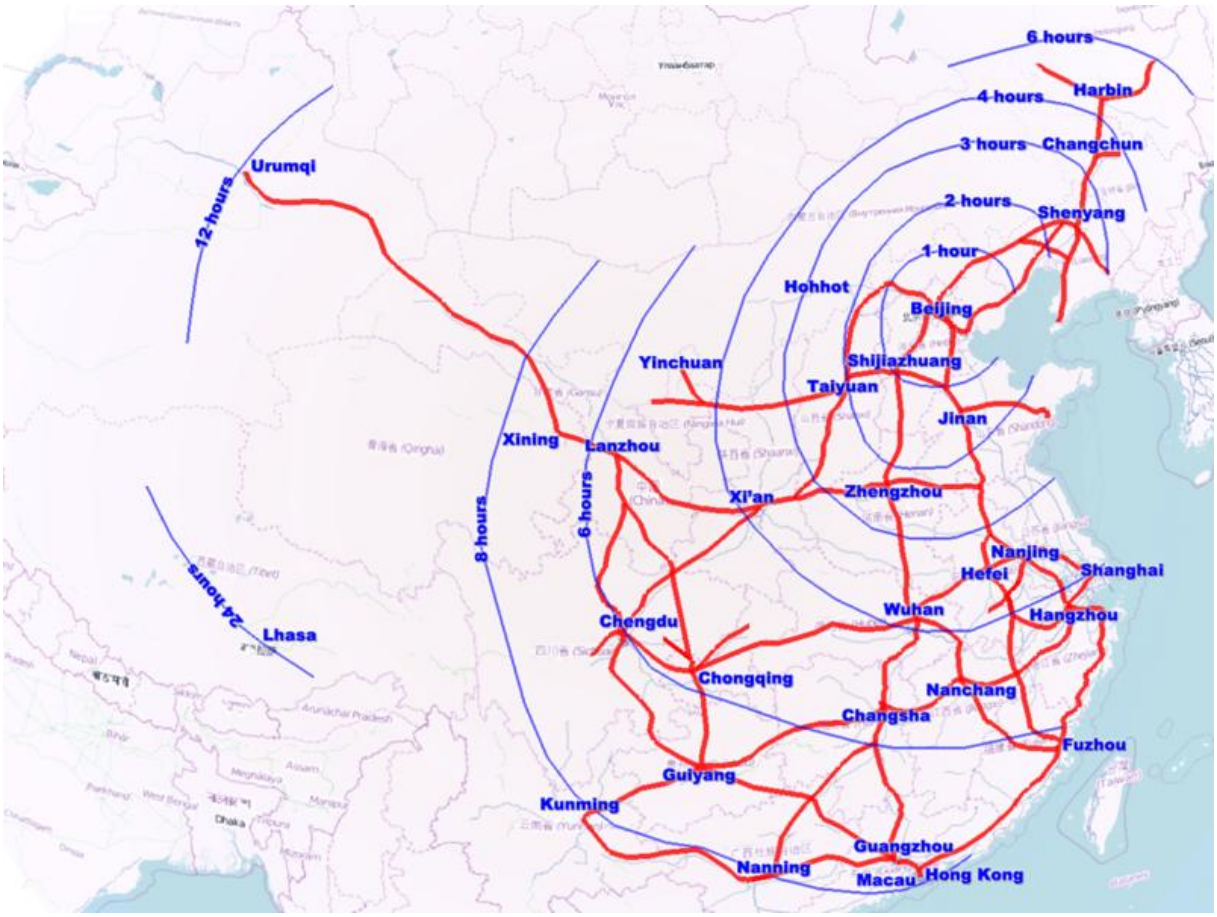
Governments do realize many benefits of the railway too and the case of China underlines the importance of railways for the future. The huge boom in infrastructure build-out started in China only in 2005, but the magnitude of the investments has exceeded the investments size of any other country in the world. At brisk of the global economic and financial crisis, the Chinese government intensified its efforts in the demand-driven economic growth incentives and it poured approximately USD 50 bn in the railway build-out alone (Powell, China's amazing new bullet train, 2009).



Source: (Powell, 2009)

China is currently working on connecting major cities with very-high-speed train lines, which, once finished, will be the largest and among the most sophisticated in the world. By 2020, the Chinese government will have invested about USD 300 bn. These funds should produce as much as 26 000 kilometers of high-speed railway tracks spanning across the vast land area of China.

Picture 1: Proposed high-speed railway tracks by 2020



Source: (Wikimedia, 2010)

The great Chinese efforts in building the massive railway network has also brought about some major technological innovations. China has for example managed to build one of the fastest production trains in the world – the CRH380A. IBM has won a contract to provide part of the software backbone solution to the high-speed railway system in the China and it also founded its global bullet train R&D center in Beijing (Powell, Video: China Bullet Train, 2009).

The situation in the Czech Republic is more similar to the situation in the USA. Czech Republic dispose of a developed network of railway track, but the problem it faces is in the average maximum speed and the lack of the high-speed railway tracks.

There have been several signs of renaissance of the Czech railways. 2 Czech private companies announced its plans to enter the railway business. RegioJet, the company of Radek Vancura and a sister company of Student Agency, has plans to begin operations on the track between Prague and Ostrava in September 2011 (iHNed, 2011). RegioJet plans initially bring older wagons, but with a guarantee of superior quality and service. Later is the business development it is reasonable to expect that Jancura's company will purchase new trains, wagons and/or locomotives as it has done in the case of the bus transportation company Student Agency. LeoExpress, the company run by son of a Czech billionaire, has announced its plans to enter on the

same track between Prague and Ostrava later in 2012. LeoExpress has chosen a different strategy from the RegioJet and it plans to purchase new trains from Swiss company Stadler (iHNed.cz, 2011). These trains will be specifically redesigned from regional tracks to long-distance tracks (iHNed.cz, 2011).

The Czech incumbent company, Ceske Drahy, has reacted to the efforts of the competition by rolling stock upgrades. It plans to invest approximately CZK 1 billion into the rolling stock refurbishments and approximately CZK 4.8 billion in the purchase of new high-speed trains from Siemens (Šitner, 2011). Ceske Drahy also applied for and received debt rating from Moody's (Malý, 2011). This will enable Ceske Drahy to issue Euro bonds on the international financial market. These funds will become the crucial vehicle for the rolling stock modernization and additional operations improvements.

5.5 Chapter conclusion

To conclude the section on competitive position of the railways, we need to point out that railway holds a very good competitive position for achieving future growth in volume. This growth should also bring about the necessary investments into the infrastructure so that the areas of speed can also match and outmatch the rival means of transportation. The technology is also moving forward at a speed which is not far too different from airline or automotive industry.

Even though the technology, the underlying regulation and the consumer behavior are shifting towards in a competitive position of railways, I believe that there is one necessary innovation which could also bring great volumes and trigger further popularization and re-development of railways – the business innovation. Railways companies need to rethink the ancient business model of theirs. Companies need to redesign their operations and fundamental axioms of the industry to win over consumers.

In the practical part of this thesis I will further develop the concept focused on the decreasing of all costs related to traveling in the logic describe earlier.

6 Distribution channels

I would like to focus on the various possibilities how the railway transport companies can rethink the distribution channels for the sale of tickets and thus achieve significant saving, improve the ease of traveling, and increase customer satisfaction.

6.1 The legacy distribution

In general, the railway companies are famous for having very much the same distribution system as they had many decades ago. The core of the ticket sales has been always centralized in the railway stations and in some regions directly in the trains. This system was working well in the 19th and the first half of 20th century because that time railway station were very much the economic center. The locations of the main railway stations were also close to the town centers and it allowed for higher footfall. Nevertheless, the railways lost its economic importance and as the towns expanded, fewer and fewer people found it comfortable to visit the railway stations and the footfall dropped significantly. In a situation where the road, air and/or railway transportation offers equal transportation opportunities and value, the location of the ticket-offices are at the core of the decision-making. The traditional ticket sale at the railway stations had a negative effect on the transportation volumes. When we look at the ticket sale today, there are many railway companies still dependent on the traditional ticket sale model.

The fact that the distribution channel is mainly at the train station causes one more major problem – it is expensive. There are a great number of stations and each tends to have staff dedicated to ticket sales. This fact, combined with lower popularity of railways and low footfall around the train stations makes the staff productivity very low, therefore very expensive. Then, it comes as no surprise that the distribution cost of the railway operators account for as many as 15% of the total costs.

Few companies developed online ticket sale on the internet and few companies opted in for ticket vending machines. SNCF, the French national railway operator, sells tickets through bucket shops – shops who serve as agent and they sell tickets for pre-defined prices. The main purpose of these shops is to sell tickets, which would otherwise not be sold. Though, this “sales channel innovation” is a mere copy of what airlines network carriers do and the problem with this channel is that it is very expensive and the value is rather questionable – especially for the low-cost companies.

6.2 On-line ticket sale

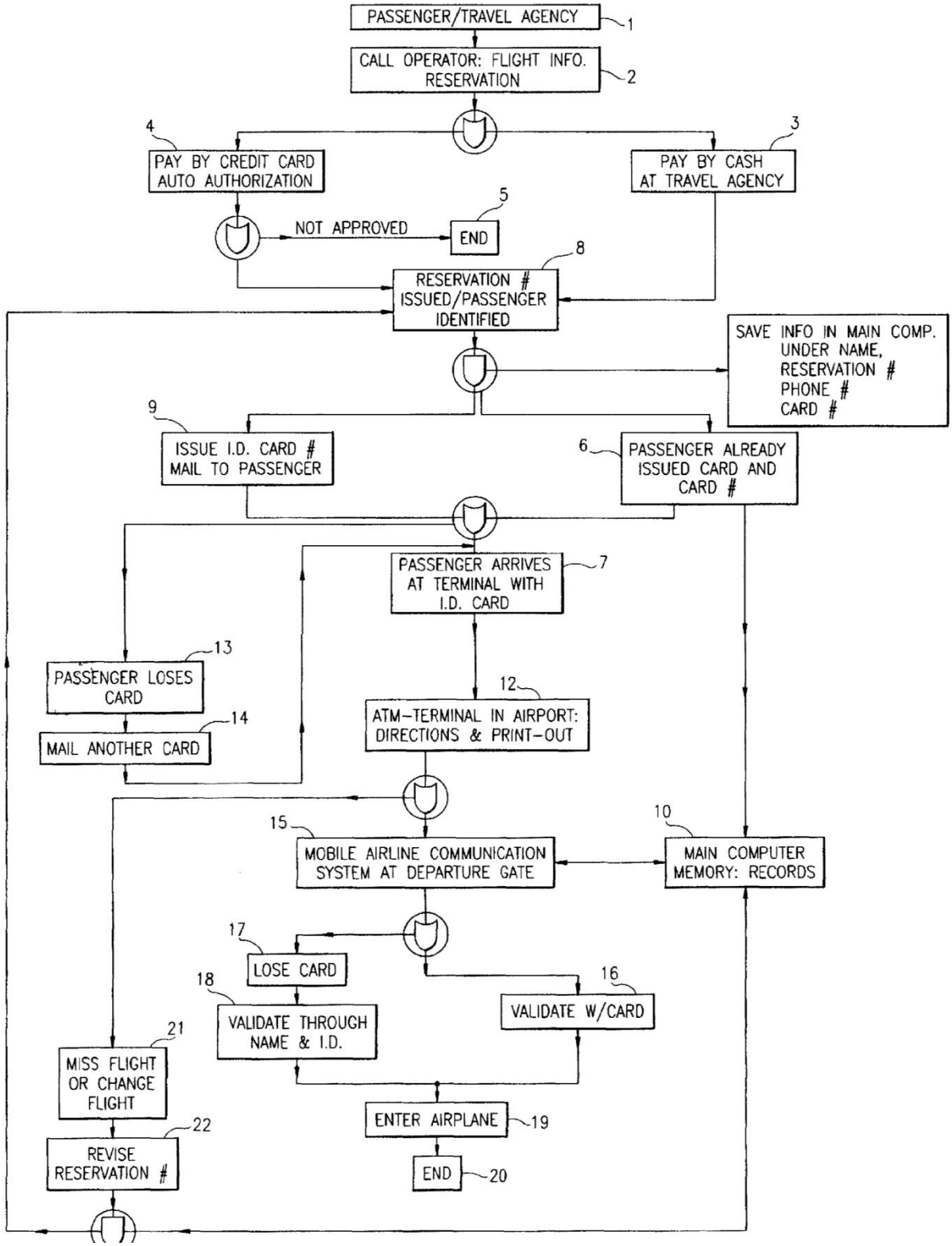
Internet has revolutionized many areas of human activity and it has established itself as one of the most used communication channel in the world. According to the statistics of the internet world stats, internet is available for approximately 2.1 billion people worldwide, representing a penetration of about 30.2% (Internet World Stats, 2011). However, we can still observe large qualitative differences between the regions. While North America and Europe reach the penetration rate of almost 80% resp. 60%, Africa and Asia are below 12%, resp. 24% penetration rate (Internet World

Stats, 2011). These qualitative differences might represent a major driver in potential savings for the railway operators, especially if we assume that people from lower income groups do not have access to internet and at the same time have higher representation among the train travelers as they cannot afford travelling by car. If we assume that the distribution of travelers does exactly correspond to the availability of internet access then we can assume that the maximum potential for the online sales channel exactly matches the internet penetration rate.

6.2.1 Electronic ticketing

The online ticket sale has its origins in the U.S. Patent No. 5,724,520, dated on March 3, 1998 (filed on November 21, 1994) registered to Joel R. Goheen (see the Picture 2: Electronic ticket patent scheme below). Since the original introduction in the airline industry, the electronic ticketing has been evolved and innovated to be more flexible and automated, but the core idea remain unchanged. The electronic ticketing has also found its application in other means of public transportation or for example in entertainment business.

The process of the electronic ticket issue is adaptive to the customer's needs and automated by the web application. I will use the example of the airline electronic ticket sales/issue for the purpose of process description. The process starts by opening the web application and looking up suitable flights and choosing one flight. After the flight is chosen, customer might decide whether he/she only want to reserve the flight ticket or whether he/she wants to purchase the flight ticket. The purchasing could be done either electronically/remotely or in person at a dealer or company location. The latter option has been in time abandoned by many companies for both cost reasons as well as for the customer convenience. After purchase of the ticket, the unique electronic ticket ID is stored in company systems and the flight ticket is assigned to the flight. The ticketing system are also designed alter any details of the ticket as well as reissue the ticket in case of loss or damage, eventually the system can cancel the ticket and refund the original purchaser. The electronic ticket is later used for check in of the passenger (either electronically or in person at the airport). The flights assigned to a particular flight are then used for boarding the airplane as well as for verification whether there are any passengers missing from the flight (eventually who from passengers is missing).



Picture 2: Electronic ticket patent scheme

Source: (Google)

6.2.2 Implications for the railway transportation

The railway transportation generally used for shorter distances than the airplanes and as such, customers might not feel comfortable with planning the trip in advance

and purchasing the tickets online. Tradition and habits of travelers play a significant role in usability and penetration of the online ticketing. The difficulty in achieving high penetration and use of online booking can be best documented by the situation in Germany, where Deutsche Bahn intended to implement a system requiring passengers to book a ticket in advance. The system failed to become the equivalent of the airline ticketing system, because German passengers have a strong habit to buy tickets on board of trains or at the train station. Deutsche Bahn later had to use a hybrid system, which would allow passengers to purchase tickets both onboard for a price premium and discounted tickets online. This customer oriented solution represents increased costs for Deutsche Bahn not only due to the use of more expensive purchasing channels (onboard and ticketing windows at the train stations), but also because of need for additional high-tech software to forecast the customer demand to improve the transportation capacities. Furthermore, this solution does not correspond to the principles of the low-cost business model. The key challenge is to change people thinking and habits, but it is a long process and it might represent both significant investments and a loss of customers.

A special value of the online ticketing and of the use of electronic tickets resides in a better control and better forecasts possibilities of the demand and possible adjustment of the available capacities. More to this topic is explained in section for revenue management and optimization of transportation capacities.

The potential savings of the higher use of the online distribution channel can truly be significant. The current cost of distribution for railway companies is as many as 15% of the total costs. This number is quite comparable to the distribution costs of the network carriers in the aviation industry, where it accounts for come 12-13%. The progressive (and price aggressive) the companies such as Ryanair or EasyJet are able to shrink the cost of ticket sale down to 5.8%, and the maximum potential lies even below 5%. If all tickets are to be sold online, there is a potential to reduce the ticket price by as many as 10% of the current price, while keeping the same profitability.

Another problem occurs due to the fact that the stations and infrastructure is separated from the transportation company. This is a problem especially with the ticket sale, when employees at the station are not employees of the transportation company. This brings about the loss of control of the process and the loss of contact with the customer.

One area of the electronic ticketing that needs to be adapted for the needs of the railway transportation is the check-in and boarding process. For airlines, the check-in is a very established step preceding travelling, when customers choose a seat, hand in baggage and obtain a boarding pass. Boarding then a formal step used to verify that a customer boards the correct airplane. In the context of railway transportation, the check in and boarding might be superfluous in many cases. The practice of hard-low-cost airlines such as Ryanair shows that the check-in is as simple as possible and it also discourages people from travelling with large pieces of luggage, by charging high luggage fees. The competitive advantage of railways is that there is generally a lot of

space for luggage above-head compartments or at the seats, moreover the additional weight of the luggage does not have a significant impact on variable costs of transportation, because the structure of track-access charges and because of the transportation characteristics of railway transport (either electric or diesel). The check-in process of Ryanair also discourages from booking a particular seats (by charging seat-reservation fee) in order to cut the time required to passengers to board the airplane. This is also relevant for the railway transportation because streamlining the time of travel represents implicit cost savings for passenger and cost saving for the transportation company in the form of higher capital turnover. The example of Spanish very high speed trains shows that the railway companies can develop system of check-in and boarding similar to the airline companies, where the train station has an open area available for everyone and a closed area only for people with train tickets. The entrance to the closed area is very similar to the check-in and then the entrance to the train is managed by conductors is resembles the boarding process. Nevertheless, this system represents higher time requirements for travel as well as additional construction and personnel cost. Moreover this system requires a train station to be "isolated" and only the major train station in the major towns can fulfill this requirement. A more practical approach would be to use the electronic ticket without assigned seat (but with guarantee of having a seat) and with either a barcode, 2D barcode or for common contactless approach communication (see examples on the pictures below). Electronic tickets in such a form could then be checked by conductor either at boarding, or even onboard of the train. The latter option would save a few minutes boarding at every station while also providing good countermeasure against free riders.

Picture 3: example of NFC data exchange for check-in

Source: engadgets.com

Picture 4: 2D barcode used

Source: Brussels Airlines

6.2.3 Mobile ticket sale as an extension to the on-line ticket sale

Electronic tickets purchased and/or presented on a handheld are a natural evolution of the electronic ticketing and it has already found its way to the airline sales channels. There is basically one fundamental difference between the mobile electronic ticket and the normal electronic ticket – the mobile electronic ticket is not expected to be printed and it can be easily presented on the screen of the mobile phone. The mobile electronic ticketing does not represent any major additional cost of the railway company, but it helps to save time and money to the consumer and as such it has to be viewed as an opportunity for the low-cost railway operator.

6.3 "Common Contactless Approach"

The Common Contactless Approach represents a major shift in the ticket distribution. The ticket sale had remained unchanged for more than hundred years, since the foundation of first railway transport companies in the beginning of 19th century in the Great Britain – i.e. all the processes connected to selling the tickets were done manually at the stations or at specialized agents or tickets sale offices. Also the processes of ticket control had to be done manually by member of the train staff. We can see first major attempts to reform the tickets sale, as recently as in 1970s/1980s in Japan. That time it was not with the common contactless method, but using technology of magnetic stripes embedded in tickets. The process of reforming the ticket sale through "common approaches" has progressed since then and I would like to describe the current state of affairs in the paragraphs following.

6.3.1 Introduction – what is common contactless approach

The common contactless approach is an approach which allows its users to use one means of payments for transaction at various vendors or service providers. The first major commercial system built on the principles of common contactless approach has been the Octopus card, introduced in Hong Kong in 1997 (Truong). This system is important for the purpose of this thesis because it has been founded primarily to ease the payments for the public transportation.

The word "common" in the name implies the characteristics of the card to be used repeatedly in various places, at various vendors or service providers. The "common" also characteristics implies that the such a system is not generally developed by a single company, but that such a system can only exist if there is a board of companies taking part in the system. Often government is involved in the system. The role of government includes both the legislative support and supervision and guarantee. The legislation support is necessary in the case, when there are no laws setting rules for electronics means of payments and the possibility of using the means of electronic payments outside of one company. This is especially important, because the usage of the electronic means of payments across companies represents creation of some kind of money or currency. Government has to control any such a kind of electronic money for tax reasons as well as for the ensuring the consistency in the monetary policy. The supervision role of the government is important for the system to be compliant with strategic goals of the local government of the national government in case of wide application of the approach. The general application of common contactless approach would have major impact on economy as well as the monetary policy and the government is an important stakeholder. The involvement of the government in the system also represents an important factor of trust and guarantee to the system. The presence of the government in formation of the rules and structure of the system should be a clear signal to the business subjects and to the individuals that they can trust the system and should not be rejecting its acceptance.

The word "contactless" in the name implies the technical solution of the system. A common system is also the usage of payment cards or paper money. The specific of

this system is the usage of so called “smart cards” and devices for reading the data from the smart cards. These two objects are the core for the electronic exchange of money. The smart card is any type of medium (typically in the shape of a card) which has a tiny microchip or integrated circuits embedded into it. The integrated circuits contains a basic component for processing the transaction, a rewritable memory component used for storing the value and the information about the card, an antenna for contactless transmission of information and often a security component which serves the goal of protecting the electronic money and encrypting the information stored (it forms a RFID chip with rewritable memory). The smart cards are generally plastic (both rigid and flexible). The other part of the system, which allows the contactless transactions, is the smart card reader. The smart card reader is able to receive information from the smart cards, process it and transmit information back to the smart card in order to update the current status/balance on the smart cards. The smart cards and the readers are of course only a small part of the whole system, but they are the basis for the contactless characteristics.

The whole system can be separated into five levels (Streichfuss, 2010):

1. The smart cards as the fare mediums
2. Front-end smartcards processors
3. Local data processor
4. Service provider central computers
5. Clearing house

The technical aspects of the level 1 (of the smart cards) have been explained above.

The level two contains the smart card readers but also additional supporting infrastructure. There are two key components of the support infrastructure. First, the machines used for recharging the funds and issuing new tickets. And second, the fare gates controlling the entry of a person and charging a fare. The gates are basically an extension of the readers and while the readers are used onboard of the transport vehicles or at the retailers, the gates are used at the hubs and stations.

The level three represent the communication infrastructure equipment handing the communication from the readers to the central computers and transaction systems.

The level four of the system are the transaction system of each particular service provider. These systems might be storing operator-specific data about the smart card or about the person holding the card.

The highest level in the system is the clearing house system, which helps to reconcile the transactions and information flows among all parties participating in the system. It also gathers all data, generates and provides reports. Such reports are valuable especially for the government, but all parties in the system have the same right to access such reports. This level five of the infrastructure should also have a disaster recovery site, which needs to ensure the smooth and reliable operations in case of a critical failure or other major problems. Without such a robust infrastructure the

system would not achieve the necessary reliability and companies would hesitate to participate.

6.3.2 Application

Building the system of common contactless payments from scratch requires significant investments into infrastructure and one company would not be able to achieve positive return on investment if it was about to fund the whole project by itself. The system gains significant economies of scale and therefore the commercial application of the common contactless approach involve many parties and companies in order to distribute the cost of building up the backbone infrastructure and designing and implementing the information system and related software applications. The more companies/parties are involved the better is the chance of achieving critical mass and making the system fully profitable. If more competing companies enter the system, the first mover will lose the initial advantage, but as the literature says, the key point of the common contactless system is not to compete on cost of distribution but to achieve efficiency of the ticket sale.

6.3.3 Business case: Octopus in Hong Kong

The Octopus card was historically one of the first major implementation of the common contactless approach in the public transportation. The efforts started in 1994 when five major transport operators in Hong Kong joined to form Creative Star Limited, in 2002 renamed to Octopus Card Limited (Octopus Holdings Limited, 2009). This company was responsible for development of building the infrastructure and setting the rules for the future Octopus card. The ultimate goal of the implementation of the Octopus card is best described by the mission of the company – “Making everyday life easier” (Octopus Holdings Limited, 2009). Even though this motto was primarily aimed at the customers, we can imagine that the companies collaboratively aimed at simplification of their in-house processes as well.

The key challenge for the Octopus was designing and establishing a user friendly and rapid front-line infrastructure, which would fulfill the promise of simplicity without congesting the massive through flow people. There are approximately 7.1 million people living in Hong Kong (Census and Statistics Department, 2011) and in order to make the system work, the tickets issuing and recharging infrastructure had to be very intuitive with very few steps needed in order to issue or recharge the card. Also the construction of the gates had to ensure safe and smooth flow of passengers in both directions (in and out).

The start of the operations of the Octopus cards was marked in September 1997 (Octopus Holdings Limited, 2009). There had been issued three million Octopus cards within the first three months of the Octopus operations (Octopus Holdings Limited, 2009), which is the best proof that the system managed to reduce the complexity of the system and provided a card, which really makes the everyday life easier.

In the following stages of Octopus operations, more parties have been joining the system. In the years since the inception of the Octopus cards, retail shops have opted in the system offering recharging of the cards and accepting small payments by the cards. Also various local banks have opted in and offered various services such as Automatic Add Value Service, which enabled an automatic recharge of the Octopus card with a pre-set amount and it further improved the consumer experience. Other companies started to use Octopus cards as access cards to residential areas and condominiums. In time more and more companies entered the system and nowadays the people in Hong Kong can use the cards for transportation, restaurants and fast foods, entertainment, photocopying, sport events, parking meters, apparel clothing stores, and other.

6.3.4 Benefits

Time

By using one contact less means of payment, the customer does not need to queue for tickets sale. This effect is especially important when the passenger is catching connecting train. Additional time can be in the commuter trains where people can faster because they don't have to purchase tickets while boarding the train (or more frequently bus). This effect has also a positive effect on the assets turnover for the operator.

Costs for operator

Operator saves a lot on the cash handing. There is lower need for armored vehicle cash transport and additional security services. This is especially true for the new technologies such as NFC, which could be integrated with the bank account, phone bill or payment card.

Some implementations of the common contactless approach use gates for reading the contactless mediums (smart cards, NFC chips, electronica wallets) and these gates can help the fight against the free riders. Such a solution can be implemented without causing any bottleneck in the flow of passenger in or out the terminals.

This helps to decrease the need for infrastructure used for selling tickets, e.g. points of ticket sale at the train stations, ticket vending machines, agents, or other. If the smart cards or electronic wallets are to be rechargeable on internet or via wire transfers, the railway operator will also achieve additional saving in the area of cash collection services. The operator will no longer need armored vehicles transporting daily revenues from stations or other points of sale to the bank. The operator should also realize small fees charged by banks for processing/transferring the daily cash revenues to the bank accounts.

Costs for passenger

The customer can use one medium without the need of purchasing many of them. This can also have the effect of freeing up some cash to the customer.

Nevertheless this effect is going to be only marginal.

Thanks to the flexibility of the system, a various pricing schemes might also be adopted. For example in Singapore, the local public transportation company SMRT uses the electronic wallets for all buses, metros, or the light trains. People are obliged to enter any vehicles with the smart card and they "check-in" while boarding the vehicle and they also "check-out" when leaving the vehicle. This system well reflects the costs of transportation because the passenger pays (in Singapore) only for the kilometers he or she has actually travelled. The "check-in" is monitored by the driver (as boarding a bus is allowed only at the front door). The "check-out" is not monitored by anyone and if the passenger forgets to "check-out" he or she is charged the maximum fee (calculated from the station he or she entered the vehicle to the end station).

Comfort — The customer can use one credible medium for the transport and the procedure of buying tickets is much simpler. It also easies the customer in planning a journey within one operator.

Environment — The railway company can save a lot of paper and other disposable material (e.g. plastic cards with magnetic strip) from its operations. If the common contactless approach is well implemented, customers can use on medium of payments for many years. Therefore, the transition from the paper based tickets to the common contactless approach can be communicated as being environment-friendly.

Other — Reducing the amount of cash present at the railway stations also reduces the risks of robbery.

The common contactless approach generally counts on the integration of the park-and-ride parking places into the system. This, together with promotions, has positive effect on the higher use of public transportation. This might also represent an incentive for people to travel by trains, because it reduces the "complexity" of having a connection travel to the train station. The system can also offer feeder bus-to-rail incentives (Streichfuss, 2010).

The participation is lowering switching costs for people already having a "smart card" or other electronic wallet, this effect is especially true for companies which are in the position of market challenger or in a market niche. The dominant player might prefer to raise any switching cost possible.

The company and the public authorities might gain access to valuable customer data. It can be especially helpful in analyzing the behavioral patterns, customer types and in forecasting the demand.

The common contact approach also offers the possibility of joint marketing and promotional activities with other companies taking part in the system. It provides improved customer information and offers better consumer experience (through ease of using and interoperability with other companies and services). Many of the data and information gathered through the common contactless approach (electronic wallets) can also provide invaluable

data for decision making in a timely fashion.

6.3.5 Challenges

One problem resides in the fact that the first mover/adopter usually bears additional risk of consumer acceptance and risks included in implementing new technology and new processes (operation risks). The later adopters can decide only after having a proof of concept done by the first mover and they can also replicate the processes and practices developed by the first mover – either by hiring consultants or by headhunting key personnel from the first mover.

6.3.6 Relevance for the future

The main argument for including the common contactless approach into this thesis is the current development around the NFC. NFC (standing for near-field communication) is a technological combination of RFID chips (with many characteristics of the common contactless approach) and smartphones. This technology will allow users of smartphones to make payments at the shop or even among themselves by simply moving two devices close to each other. The payments is far from the only possible usage of the NFC, generally speaking, NFC can replace all transactions which involve exchange of information – such as loyalty cards, exchange of files, business cards and many, many other activities.

The enablers to the current development and future deployment possibility are the joint effort telecommunication companies, phone manufacturers and smartphone operating system developers. One of the main proponents of the technology is Google, which has announced in 2011 new service Google Wallet and a far reaching technological pilot program in the USA. On the side of the phone manufacturers, we can see many new devices being released with the support of NFC, mainly Nokia has done a major step to include NFC to many of its new smartphones, Samsung is producing the Google branded Nexus S and RIM (the manufacturer of BlackBerry smartphones) is both developing its own NFC based payment system and planning to release NFC enabled smartphones (Ziegler, 2011).

7 Revenue management

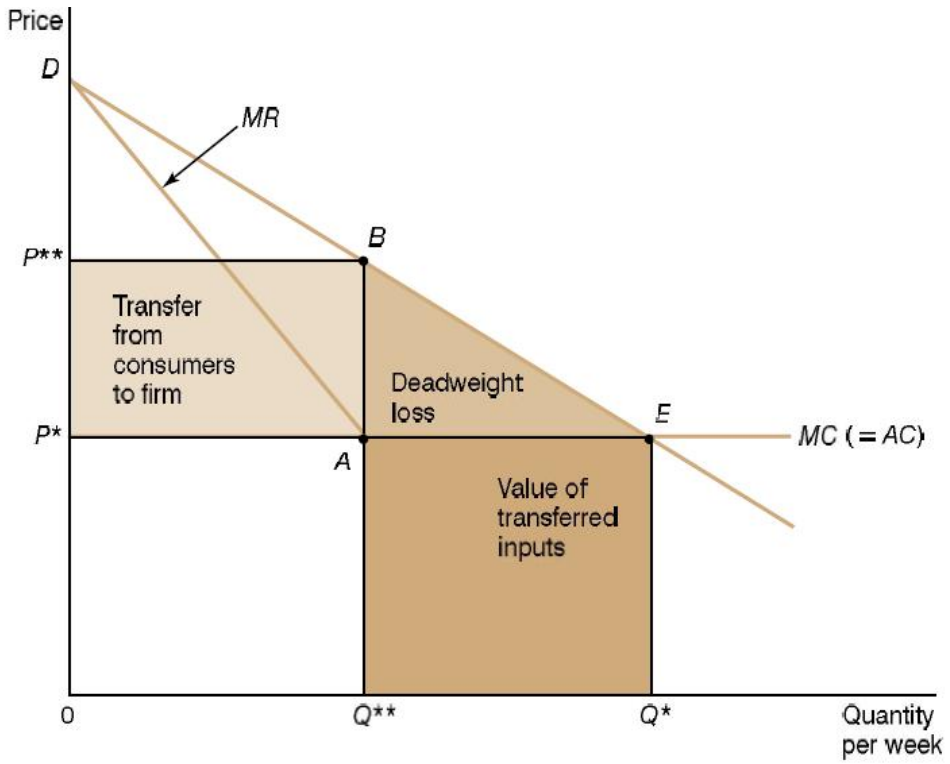
Revenue management is a phenomenon of the late 20th century and it is, by some, considered to be one of the most important pricing and management innovation in the late 20th century.

7.1 Fundaments in microeconomics theory

The revenue management has it fundaments also in microeconomics in the theory of monopoly, more specifically in the price discrimination. The price discrimination applies in microeconomics to situation of a monopoly on the market. The monopoly is rationally behaving economic entity and as such, it determines the price of it production and the production quantity by the Golden rule principle. By this principle the company produces until marginal cost of producing one additional unit of output equals the marginal revenue from the additional unit of production, a.k.a. MC = MR. By using this rule, the monopoly will produce the quantity Q** and sell the entire production at the market price P**. This will have three major impacts on the market and wealth distribution:

1) Monopoly will exploit a part of the consumer surplus, marked on the picture below by the “Transfer from consumers to firm”
2) The owners of the input will lose a part of their factor income marked by “Value of transferred inputs” because these inputs will not be employed in the most profitable market (this market), but they will be transferred to the market with second best returns.
3) This transaction will cause the market participants to lose the so called “deadweight loss”. No one from the participants will gain this amount, which is caused by the monopoly power to affect the price of it production.

Chart 1: profit maximization decision of a monopoly



Source: (Nicholson, Snyder, Luke, & Wood, 2008)

The microeconomics theory speaks about the price discrimination as a tool or practice of the monopoly which it can use, under certain conditions, to fully exploit the consumers' surplus and the deadweight costs. The price discrimination will also not cause the owner of the inputs to lose some of its value, as it is the case of the normal market transaction described earlier. The exploitation of the consumers' surplus and the deadweight loss is transformed into monopoly profits.

The microeconomics theory knows many types of price discrimination, but the three most widely used are:

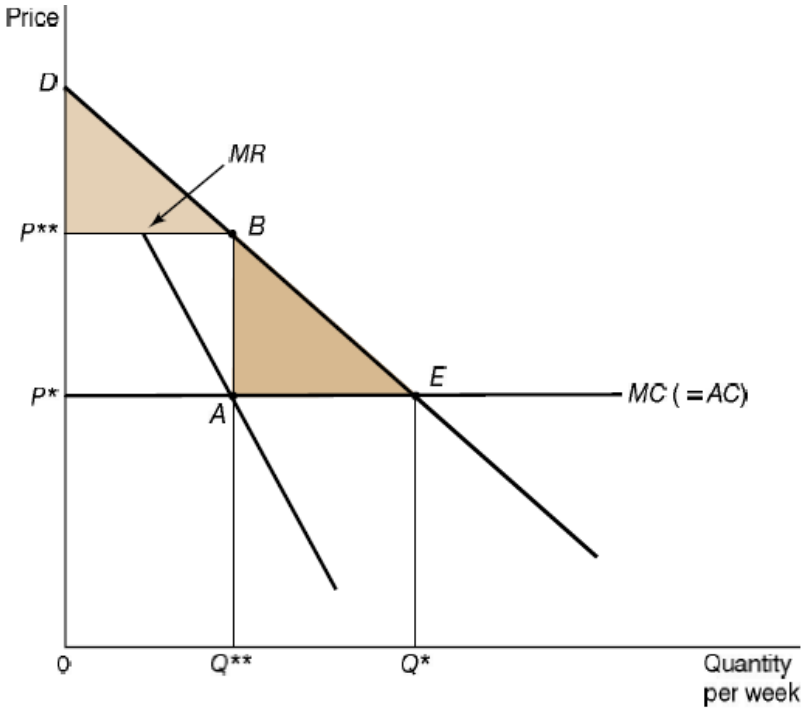
1) Perfect price discrimination
2) Quantity discounts
3) Two-part tariffs

All price discrimination techniques are built on the assumption that the buyers of the products under price discrimination are not permitted to resell (further transactions are not possible). Second assumption is the existence of differing consumers' willingness to pay for the same product as well as perfect information about it.

The perfect price discrimination exists in situations where the company is able to sell a product to each consumer for the maximal price he/she is willing to pay. The perfect price discrimination does not create single equilibrium on the market; it sets a single equilibrium for each one consumer. The demand curve therefore takes the

shape of a negatively sloped line or a curve (the line intersecting points B and E on the chart below).

Chart 2: Perfect price discrimination

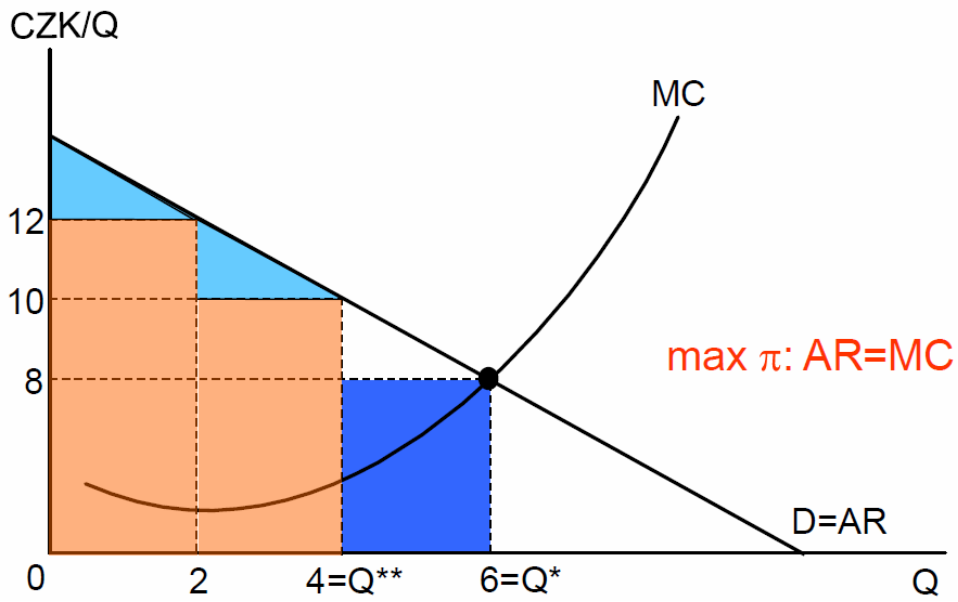


Source: (Nicholson, Snyder, Luke, & Wood, 2008)

The perfect price discrimination allows for the perfect exploitation of the consumers' surplus and the deadweight loss. At the same time the quantity produced is maximized.

The quantity discounts price discrimination can easily be documented on the example when person comes to a pizzeria and is offered one free pizza to every pizza purchase. Due to the fact that not everyone is going to order 1+1 pizza for the price of one pizza, it helps to segment the consumers and as such it creates price discrimination – it offers different price for a pizza for different consumers. This sale technique helps to cover fixed costs as long as the average sale price of the second pizza is above the marginal cost of producing it. On the chart below, the quantity discounts price discrimination is show by the orange area (for example, those who buy only one pizza or those who purchase 2 pizzas and ask only for 1 free pizza) and the blue area, which is represented by those who buy for the lowest price possible (1+1 pizza for the price of a pizza).

Chart 3: quantity discounts



Source: (Hořejší, 2010)

Two part tariffs is a price discrimination technique built upon the existence of consume segmentation criteria, which creates distinctive consumer groups who differ by their willingness to pay (they have different demand curve on the market). Then the company might create a distinguished product offering for each group and so exploit the different willingness to pay.

7.2 Techniques used in airline industry

Airline industry has been one of the most progressive and innovative when it comes to application of price discrimination techniques. Over the last fifty years, airlines have learned how to segment markets, how to develop dynamic pricing schemes and how to offer various frequent flyer programs. All these techniques have their base in price discrimination, but the airlines managed to find further use of it.

7.2.1 Yield management

Yield management, which is a sub-category of revenue management, is very well established in the airline industry and it has spread quickly since it original introduction in the mid-1980. Yield management is a process or system used to achieve the maximal yields from perishable goods – airline seats in the case of airline industry. Though, it is not generating demand for the service (Streichfuss, 2010). The yield management is an attempt to implement the perfect price discrimination in the commercial activity. The necessary enabler of the yield management correspond to the price discrimination assumptions and extend it by one more – the consumer must be willing to book seats in advance. This condition is very important because unlike in economics theory, the company does not have perfect information about the consumers' willingness to pay for one seat. The booking in advance helps a company to estimate the demand for its airplanes. The demand estimation is facilitated by extensive statistical models built on consumer behavior analysis. Companies have to

collect data about the consumption trends, from which they build a demand forecast. When the customers then book seats in advance, the actual occupancy rate is then compared to the forecasted demand. It is the core for dynamic price scheme – if the actual demand is exceeding the forecast, the price for ticket might rise or if the actual demand falls behind the forecast, the price of air tickets does not rise according to the forecast and the price might even fall.

The additional function of yield management systems lies in the demand forecasts and actual demand monitoring. The airlines companies might well adjust their transportation capacities when they see that the demand levels are not corresponding to the current capacity available. In the case of airlines, this can mean that a company will employ a larger/smaller airplane, an airplane with different share of business class on the total capacity or it might employ one more airplane. Basically, this also has an impact on the cost efficiency of the airlines, because it ensure maximal capacity utilization and eliminates cost such as flying a jumbo-sized airplane for a number of customers, who would have otherwise fit into a smaller, less fuel guzzling type of airplane.

7.2.2 Frequent flyer program

The principles of the quantity discounts price discrimination are well established in the frequent flyer programs. The flyers might opt in for the frequent flyer program and they collect miles with every flight they make. They can turn these miles into price discounts for the purchase of another flight. This creates a consumer segmentation, which allows for different pricing for different consumer and it enables the company to generate larger volumes and offer lower price for the loyal customers. Frequent flyer programs also have one major benefit for airline companies – the switching costs. Because the miles can be turned into money available for flight purchase, the consumer would suffer a financial loss if it stopped using an airline while having many miles on his/her account and it also strongly discourages from the flying a different airline anytime he/she travels.

7.2.3 Offering various classes

The two-tariff (or multiple tariff) price discrimination used in airline industry is hidden behind the airplane and traveler segmentation into the various classes. The most common segmentation is probably the split into the First, Business and Economy class, but there might be more detailed segmentation. KLM, the Royal Dutch airline company is for example offering Economy Comfort seats, which differ from the Economy class only by the larger leg space. Ryanair has been trying to implement a sub-economy class, where the passenger would be half sitting and half standing.

Another segmentation approach can be observed in the fee structures of many airlines. Ryanair is, for example, charging additional fees for seat reservation or for priority boarding. The baggage fees might also be considered as an attempt to create multiple tariff price discrimination, but the effect of these fees is rather questionable.

7.3 Usability of the airline techniques in the railway industry

As mentioned earlier, the innovation of business models in the railway industry has been very limited. There have been some attempts to introduce new techniques, but the wide spread adoption and innovations still need to take place if the railway industry wants to achieve a major improvement in its competitive position and enjoy a railway renaissance.

7.3.1 Yield management

Historically two distinctive models of yield management have been developed for the purpose of railway transportation. The first yield management model was a closed system, which has been rolled out by SNCF, the France's national railway operator. The second model is partly open system, which has been developed by Deutsche Bahn, the Germany's national railway operator.

The closed system of yield management can be described as a copy of the yield management system developed and employed by airline companies. It requires all tickets to be sold before the train departure, in order to plan the capacities and to adjust the pricing of a ticket. The customer was required to choose a particular train and the flexibility of the ticket was very limited (especially for the economy class tickets). This system benefits from the wagon flexibility, trains can offer. A railway company can simply add a wagon or remove a wagon from the train in order to optimize the seat utilization and the cost efficiency (more information to this cost efficiency can be found in the section dedicated to the track-access charges optimization).

The introduction of partially open system had a much more dramatic story. Deutsche Bahn tried to implement a closed system in the 1990s, but they have encountered a tough customer resistance to the closed system, because customers were historically used to enormous flexibility of purchasing a train ticket for a certain route and then using it anytime within a certain time period. The company was forced to rethink the yield management technique and they decided to create a hybrid of the closed system and the former traditional model, which assumed frequent purchase of a ticket at the train station right before train departure or onboard of the train. Deutsche Bahn developed a system, which had to balance the share of the train capacity dedicated for tickets sold onboard and the tickets sold in advance in dynamic pricing scheme. Deutsche Bahn has encouraged the ticket purchase in advance by providing better prices, but it also had to plan the capacities for the customers who board the train without a ticket. The openness of the system put extra pressure on generating the demand forecasts and as such this partially open system is much more difficult to manage towards high capacity utilizations. Another issue that arises from the partially open system is the complexity of the seats availability and pricing. This is especially sensitive issue for communication to the customer.

The sad truth of the yield management on the railways is that only very few companies have adopted the yield management systems for their operations. The two pioneering companies, SNCF and Deutsche Bahn, are enjoying one of the best

economic performances among railway companies. On the other hand, the companies, which have not adopted the yield management systems, have also suffered from a much worse economics situations.

7.3.2 Frequent flyer programs

Frequent flyer programs have been implemented by many incumbent railway companies, but in a different way than in the airline companies. The railway companies offer a frequent travel card for a lump sum, and then this card allows the traveler to travel on any route with a discount. Some frequent traveler cards allow even for 100% discount on any route without limitation.

7.3.3 Offering multiple classes

The airline industry has managed to establish a simple class-structure, where the customer can easily navigate. The railway industry has created a more complicated structure which differs among particular trains (EC, IC, express train, passenger train, commuters etc.) and companies also name the sections within the train by their specific names. Additional level of difficulty for the customer is also the availability of seat reservation and dinning wagon. Even though a more detailed segmentation might offer better possibilities for price discrimination, it also has a negative effect on the precision of demand forecasts and on wagon marshalling. If a company segments the passenger into 3 segments, it has to marshal a train with at least 3 wagons. The experience of the Czech incumbent railway company Ceske Drahy shows that the average occupancy rate is as low as approximately [redacted].

The detailed segmentation also creates extra complexity for the travelers – and it is by the definition in the beginning of this paper a cost for the traveler.

7.4 Application for low-cost railway operators

The yield management is a must-have for any company which strives to be a low-cost railway operator. The question whether to use the closed or partially open system is harder to answer, mainly due to the varying consumer responses to it. Basically, the closed system should be pushed as hard as only possible for its high cost efficiency potential, which is can help the companies to depart exactly the number of seats/wagons demanded. This creates savings in terms of higher assets turnover, lower energy consumption per seat-km, lower track access charges and potentially even lower personnel costs.

From the revenue perspective, the yield management is a great way how to offer the consumer the lowest prices possible, because a small number of seats might be allocated for very low prices. These prices might even fall below the costs, because building the awareness of offering the lowest prices pays back in the form or larger demand. Nevertheless, the dynamic price scheme, should have very few and clear-cut price steps in order to minimize the customer costs associated with looking up information about prices and availability.

The frequent traveler programs are much harder to judge because the economic viability is much more difficult to evaluate. Even when looking at the low cost airlines, some do offer the frequent flyer programs (such as Southwest) and some do not (Ryanair, AirAsia). The decision criteria for deployment of frequent traveler program on the rails should be based on the criteria such as the existence of such a program among competing companies both on rails and in other modes. Second factor in decision making should be based on the customer response to it. If the railway operator will increase the loyalty and attract new customers, it is of course a valuable tool. A good practice of the frequent flyer programs is the cooperation with partners. Companies are issuing co-branded payment cards and then every payment provides small revenue share for the airline company. The other example of the involvement of the partners might come in on-board sales, when a customer is earning points for the number/value of sales he/she does.

Lastly, offering of multiple classes should be abandoned in the low-cost railway operators. The main reason is the inflexibility of the wagons to offer the number of seats corresponding to the actual demand level. The usage of single class also has cost saving factors as the unified train class and potentially even the unified wagon setting promises lower maintenance cost. Secondly, the multiple classes also create a more difficult communication and as such additional cost for the customer, who needs to dedicate more time to understand the system and to decide. Third, offering the business or first class simply does not come hand-in-hand with the principles of low-cost transportation. The reference low-cost airlines companies also do not offer two-class transportation.

8 Other recommendations

8.1 Point-to-point transportation

The point-to-point transportation is one of the characteristics of the low-cost airlines and it is also a major differentiator from the traditional network carriers. The point-to-point transport is characterized by eliminating any stop or transfer during the journey. The network carriers are built around the concept of hub-and-spoke, which brings customer from spokes to the hub, where customer either wait in the airplane or transfer to another airplane. Then they fly to another spoke. First, the hub-and-spoke system is both increasing the costs through lower assets turnover, but also though extra baggage handling and airport fees (Brancatelli, 2008). Second, the hub-and-spoke system is also imposing additional costs on the customer in the form of opportunity costs, waste of time and decreasing the comfort. Third, the hub-and-spoke is much less fuel efficient because customers fly in triangles instead of lines and also the take-offs and landings might imply extra fuel consumption.

Railway companies need to take one lesson from the low-cost airlines. They should evade the hub-and-spoke system mainly due to the extra cost incurred by the customer in the form of wasting time and decreasing comfort. The ideal place for low-cost railway operators to start is a busy route between two cities. If the operator provides a point-to-point transportation, the journey might become faster than buses, it would be more comfortable and it had the best base to leveraging economies of scale. These are the factors that bring about the scale and scale is the fundamental element of low-cost companies enabling them to make large profits on small margin. The question whether the companies should make one stop in a major town on the route depends on the established migration flows and on the time it would have to spend idle at the station.

8.2 Ancillary revenues

In 2010, Ryanair generated EUR 663.6m from ancillary revenues, while the total operating revenues reached 2988.1. This means that Ryanair is able to generate more than 22% of its revenues from outside the flight ticket sales (Ryanair Holdings plc, 2011). Ryanair managed to develop a system of onboard sales; it pushed the “no-frills” attitude so far that it even wanted to charge for toilets. Ryanair is also famous for having fees for any extra service – bags, check-in, priority boarding, seats or even payments. Many people seem not to like it, but these revenues help Ryanair to be one of the cheapest low-cost carriers in the world and at the same time one of the richest airline companies in the world.

But companies should think twice before imposing a new fee on the customer. The fees might be a low-hanging fruit, which almost every single company is picking, but it might hurt the brand in the long term (DuBois, 2011). Southwest Airlines is one of very few low-cost companies, which are not imposing as many fees as it only can think of. It has a strategy, where it is trying to understand clients’ perception of what is an integral part of flying and what it identifies as integral, that is not being a

subject of any fees. Southwest forgoes a part of the potential revenues on fees, but it is gaining market share on unsatisfied customers from other companies.

The implications for the railway companies are in a very similar tone as is the strategy of Southwest airlines. Companies must identify, what a low-cost train travel means and then it needs to build up "nice-to-have" value adding services and products, which might be a subject of fees. Vending machines with basic grocery and soft-drinks on board might be especially interesting for the low-cost railway operators.

8.3 Single airplane model

Single airplane model is one of the most typical features of the low-cost airlines and it it something that can easily be applied to the railway companies. Ryanair, the largest European low-cost airline, and a company with one of the lowest cost base, went so far with the "single airplane model", that it flies only one specific product from Boeing – the 737-800 (Ryanair, 2011). We can observe a similar story at companies such as Southwest (Southwest Airlines, 2011), Volaris (Volaris, 2010) or Wizz Air (Wizz Air, 2010) and the list goes on.

The lower maintenance costs are one of the most frequently noted factor. Southwest manages to save millions of dollars every year on the maintenance costs thanks to the economies of scale (Brancatelli, 2008). When we look at the cost base of Ryanair, we can see that the maintenance costs account for only 3.3% of the total operating costs in 2010 (Ryanair Holdings plc, 2011). In 2010, the maintenance costs accounted for 4.4% of the total operating costs of Ceske Drahy, the Czech incumbent railway operator (České dráhy, a.s., 2011). It is not clear whether the comparison among these two industries is appropriate.

A company with single airplane model can achieve further cost benefits through its work-force. If all work-force is skilled in one airplane, it makes it much easier to improve utilization, flexibility and effectiveness. The same principle applies for the railway companies. This highly specialized workforce makes it much easier and faster for a railway company to find a person capable of doing a control, maintenance and repairs of a train. Furthermore, this also provides the railway company with labor flexibility in terms of headcount rationalization.

The purchasing costs also play a major role in cost benefits of the single. Both the purchase of airplanes and parts belong to the benefits of the single airplane model. Large purchases of airplanes are assumed to have large discounts, but the companies are very secretive about the discounted prices (Maxon, 2011). A similar situation prevails also in the railway industry. The large deals enjoy significant discounts. Austrian Railways made one of the largest purchases of trains in last decades and they had also purchased an option for additional trains. Now they cannot use the option and they offered it to Ceske Drahy, which could purchase 16 modern high-speed trains sets for a price of approximately CZK 5 bn. For this price, Ceske Drahy bought only 5 train-sets Pendolino less than a decade ago (iHNed.cz, 2011). The economies of scale in purchase do also apply for spare parts and Service-level

agreements with third-party providers. Leo Express, the new entrant to the Czech Railway market, which hopes that such a SLA with the train manufacturer will save a significant portion of maintenance costs (Šitner, Bitva o železnice začíná. První ostrý souboj proběhne na trati Praha - Ostrava, 2011).

A significant benefit railway companies might enjoy is the modularity of certain types of trains. The railway companies might decide to purchase locomotives and wagons separately. This enables them to flexibly marshal wagons behind a train in case of demand fluctuation. In an opposite case, the company would have to wait for a larger train to arrive or it would have to operate with large portion of unutilized seats. This flexibility also applies for scheduling, which might otherwise require significant investments with uncertain returns.

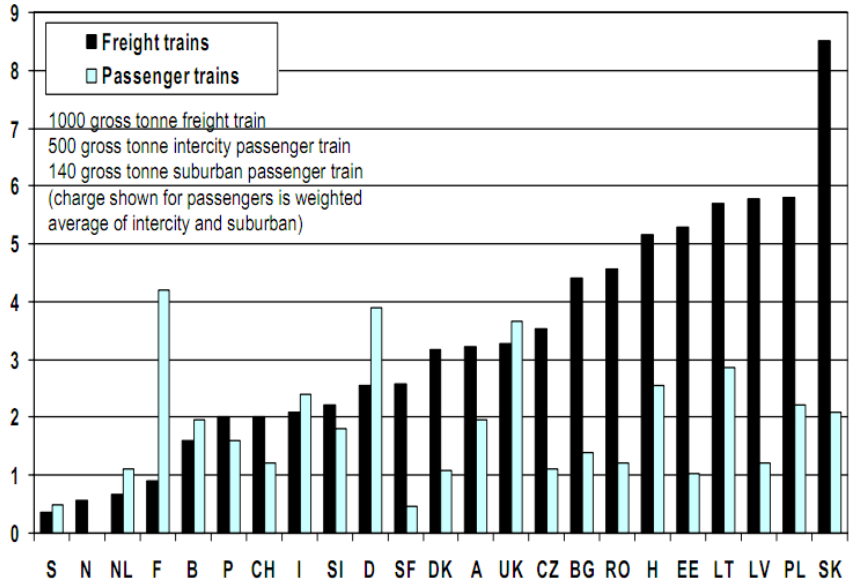
The purchase and operation of one-type vehicle represents a risk as well. If the company chooses inappropriate vehicles, it might have large problems later in the future and it would have little flexibility in dealing with such a situation. A recent problem of Southwest Airlines with material fatigue at one of their Boeing 737 caused that the company had to ground a significant portion of its fleet (HARRIS, 2011). A recent purchase of 180 new airplanes Airbus A320Neo by AirAsia also represents a risk inherited in the single-airplane model (Bryan & Jones, 2011). First of all this new airplane is a small revolution for the A320 series and might not be well proven yet. Second, this airplane is expected to have a long live span and even though it is one of the most fuel economic airplanes today, this might easily change within the live span of the airplane.

8.4 Track access fees optimization

8.4.1 Introduction to the track access charges

The track access charges are the railway equivalent to the tolls on the road and they can play a meaningful role in the company's cost structure, especially in case of low-cost railway operators. At the moment, the track access charges and even the accounting schemes used for calculations differ significantly among the EU countries. Secondly, the track access charges also differ between the passenger and freight trains (see figure below).

Figure 2: Track access charges in the EU



Source: (Developing European Railways Committee, 2005)

The figure above implies one major risk. The governments or European Parliament might one day decide to reverse the positive discrimination of passenger railway transportation and the track access fees for passenger trains might surge several fold.

8.4.2 Case of the Czech Republic

The track access charges in the Czech Republic are set by the SŽDC (railway infrastructure administration), which is a state-owned company. The state is trying to liberalize the railway transportation and therefore the risk of raising the track access charges on the passenger transport is imminent.

The calculations of the track access charges is included in this thesis because there is an entrant on the Czech railway market, which track access charges as a key competitive advantage (Šitner, Bitva o železnice začíná. První ostrý souboj proběhne na trati Praha - Ostrava, 2011).

The formula used to calculate the track access charges for any passenger train is following (Správa železniční dopravní cesty, státní organizace, 2010):

$$C_m = C_1 + C_2$$

$$C_1 = S_{1E} * L_E + S_{1C} * L_C + S_{1R} * L_R$$

$$C_2 = \frac{Q}{1000} * (S_{2E} * L_E + S_{2C} * L_C + S_{2R} * L_R) * n$$

Where:

C_m = maximum track access charge

C_1 = track access charge component related to traffic management

C_2 = track access charge component related to infrastructure maintenance

S_1 = price per 1 train-kilometer related to the traffic management

- S_{1E} = for the track, which are part of the European Rail System
- S_{1C} = for the tracks, which have nation-wide character
- S_{1R} = for the tracks, which have regional character

S_2 = Price per 1000 gross hauled ton-kilometers

- S_{2E} = for the track, which are part of the European Rail System
- S_{2C} = for the tracks, which have nation-wide character
- S_{2R} = for the tracks, which have regional character

L = the distance travelled in kilometers

- L_E = on the track, which are part of the European Rail System
- L_C = on the tracks, which have nation-wide character
- L_R = on the tracks, which have regional character

Q = gross train weight in tons. For a passenger train, it represents the total weight of the any locomotive and wagon in the trains as well as the weight of the transported goods and passengers in tons. The weight of passengers is calculated according to a formula

n = coefficient related to the use of train tilting [1 = non-tilting, 1.25 = tilting]

e = coefficient related to the use of locomotives with internal combustion on tracks with electric traction

In order to present the track access charge recommendations in an easier to understand form, I will assume in all the simulations below that we are using an electric non-tilting train, which runs on a 100km long track, which is part of the Trans-European Transport Network. This case has been chosen intentionally, because such tracks represent one of the best opportunities for the low-cost railway operator, as the highest volumes can be reached.

The simulator is using the official data from SZDC (Správa železniční dopravní cesty, státní organizace , 2010).

The input data in the table below are held constant throughout the simulations and therefore there are repeated in the output-tables from the simulations.

Table 1: Constant input data for the simulations

C_1 [Kč]	739
L_E [km]	100
S_{1E} [Kč/1 train-km]	7,39
S_{2E} [Kč/1000 GhT-km]	42,37
n	1
Train ticket price [Kč/100km]	129
e	1

Source: Ivo Toman

The C1 is held constant due to the nature of the recommendations. The C1 component is dependent on the train kilometers, which are held constant. The C1 component would play an important role in simulations of route-efficiencies, where the use of alternative routes with different lengths would be analyzed, but this analysis can be conducted only on a route-specific scenario and it does not fit the purpose of this thesis.

Base scenario

	Base scenario	
C_m [Kč]	2.510	
change in C_m [Kč]	0	
C_2 [Kč]	1.771	
Q [tons]	418	
# of seats/wagon	66	
# of wagons	6	
weight of a wagon [tons]	49,6	
weight of locomotive [tons]	87,6	
utilization rate		
total # of passengers	118	base case
TAC / passenger	21,3 Kč	adjustments to base case
Change against base case	- Kč	impact of adjustments

Source: Ivo Toman

The base scenario uses the input data above and it extends it with additional data needed to produce a complete simulation. Among the newly added data belong that the train has 6 wagons with capacity of 60 seats each, weight 44 tons (parostroj.net, 2004), the locomotive weights 87.6 tons (ŠKODA TRANSPORTATION a.s., 2008). The utilization rate is corresponding to approximate seat utilization rate of the Ceske Drahy. The rest of the data is already being calculated.

Scenario 1: Wagon rationalization

	Base scenario	rolling stock optimization	
C_m [Kč]	2.510	1.578	
change in C_m [Kč]	0	-932	
C_2 [Kč]	1.771	839	
Q [tons]	418	198	
# of seats/wagon	66	66	
# of wagons	6	2	
weight of a wagon [tons]	49,6	49,6	
weight of locomotive [tons]	87,6	87,6	
utilization rate	[redacted]	89%	
total # of passengers	118	118	base case
TAC / passenger	21,3 Kč	13,4 Kč	adjustments to base case
Change against base case	- Kč	-7,9 Kč	impact of adjustments

Source: Ivo Toman

In this scenario, only one input data has been changed – the # of wagons. The rest of the input data remain unchanged. The major impact of this change is the improved seats utilization rate, which surged from [redacted]% to 90%. The savings on the track access charges are represented by the lower weight of the train unit. If these saving on track access charges are reflected in the price of the ticket, it does not bring much savings for individual customer as the customer's savings are mere 7.8 Kč, or 6% of ticket price/100km). Customer might not consider this change important especially due to the fact that a bus might cost as few as 100Kč on a 100 km route (CHAPS spol. s r.o., 2011). Nevertheless these savings of 932 Kč per 100 train kilometers might represent a significant source of profit for the railway operator.

It is important to mention that these savings are probably going to be much larger. Ceske Drahy could use fewer wagons and that would remove a large part of depreciation and maintenance cost off their books. Additional driver of the saving might be in deployment of energy efficient locomotives, which would be dragging only 149 tons (including its own weight) instead of 418 tons.

Scenario 2: Low weight train sets

The role of supply chain might be very important in several industries and the railway industry is no exceptions. The impact of the supply chain on the track access charges might have two components – the weight of the trains and the seat capacity per wagon.

	Base scenario	SC: weight	
C_m [Kč]	2.510	1.976	
change in C_m [Kč]	0	-534	
C_2 [Kč]	1.771	1.237	
Q [tons]	418	292	
# of seats/wagon	66	66	
# of wagons	6	6	
weight of a wagon [tons]	49,6	30	
weight of locomotive [tons]	87,6	80	
utilization rate		30%	
total # of passengers	118	118	base case
TAC / passenger	21,3 Kč	16,7 Kč	adjustments to base case
Change against base case	- Kč	-4,5 Kč	impact of adjustments

Source: Ivo Toman

In the table above we can observe that the decrease in weight (of locomotive by 7.6tons and the decrease of wagon weight by almost 20 tons each) would bring savings of 534 Kč per 100 train kilometers. This builds on the assumption that all other factors remain unchanged from the base scenario, which also means that the train is still running with very low occupancy rate. This case best documents the benefits of the light-weight trains. If we assume that this train will run a track of 150km, 8times a day, 250 days a year for 15 years and it saves 534 Kč on 100 km, the total savings amount for 24 m Kč only in track access charges (assumed unchanged for the whole period).

Scenario 3: Low-weight trains & wagon space efficiency

A train has almost double the dimensions and the floor space of a bus, but the seats available are approximately the same (Autoline, Ltd., 2011) (parostroj.net, 2004). Therefore, the higher density of seats/m² is a savings driver.

	Base scenario	SC: weight + seats	
C_m [Kč]	2.510	2.112	
change in C_m [Kč]	0	-398	
C_2 [Kč]	1.771	1.373	
Q [tons]	418	324	
# of seats/wagon	66	132	
# of wagons	6	6	
weight of a wagon [tons]	49,6	30	
weight of locomotive [tons]	87,6	80	
utilization rate			
total # of passengers	118	237	base case
TAC / passenger	21,3 Kč	8,9 Kč	adjustments to base case
Change against base case	- Kč	-12,4 Kč	impact of adjustments

Source: Ivo Toman

In the scenario above, it is assumed that the supply chain can produce much lighter train sets and it can also optimize the wagon space. It is also assumed that the higher seat capacity does not affect the occupancy rate and more customers are attracted. The savings per train are smaller than in previous scenarios, but since the track access charges are almost fixed[1] and the track access charges are spread among much larger group of customer, each customer pays 12.4Kč (or 9,6%) less.

Scenario 4: Low-weight trains, wagon space efficiency & rationalization

	Base scenario	SC: weight, seats & eff.	
C_m [Kč]	2.510	1.252	
change in C_m [Kč]	0	-1.258	
C_2 [Kč]	1.771	513	
Q [tons]	418	121	
# of seats/wagon	66	132	
# of wagons	6	1	
weight of a wagon [tons]	49,6	30	
weight of locomotive [tons]	87,6	80	
utilization rate		89%	
total # of passengers	118	118	base case
TAC / passenger	21,3 Kč	10,6 Kč	adjustments to base case
Change against base case	- Kč	-10,7 Kč	impact of adjustments

Source: Ivo Toman

In this scenario, it is assumed that the number of customer remains unchanged and that the supply chain is able to deliver lighter trains with higher seat density in

[1] the only variable part is the weight of the passengers and it accounts for less than 6% of the total weight

wagons. The last drive in this scenario is the efficiency of the number of wagons deployed. This brings about high capacity utilization and the lowest weight from all the scenarios. Through these changes, the weight-bound component of the track access charges dropped by 71%. The total track access charge dropped by more than 50% and the savings per 100 train kilometers are 1,258 Kč.

Best case scenario

	Base scenario	Base + utilization	Best case	
C_m [Kč]	2.510	2.510	2.112	
change in C_m [Kč]	0	0	-398	
C_2 [Kč]	1.771	1.771	1.373	
Q [tons]	418	418	324	
# of seats/wagon	66	66	132	
# of wagons	6	6	6	
weight of a wagon [tons]	49,6	49,6	30	
weight of locomotive [tons]	87,6	87,6	80	
utilization rate	[redacted]	92%	92%	
total # of passengers	118	364	728	
TAC / passenger	21,3 Kč	6,9 Kč	2,9 Kč	
Change against base case	- Kč	-14,4 Kč	-18,4 Kč	
Price/100km/passenger	129 Kč	129 Kč	129 Kč	
Revenues	15.222 Kč	46.956 Kč	93.912 Kč	
revenues - TAX	12.712 Kč	44.446 Kč	91.800 Kč	
Price/100km/passenger	129 Kč	**42 Kč**	**20 Kč**	base case
Revenues	15.222 Kč	15.222 Kč	14.824 Kč	adjustments to base case
revenues - TAC	12.712 Kč	12.712 Kč	12.712 Kč	impact of adjustments

Source: Ivo Toman

The fact that the fixed costs tend to account for a large part of the total costs in the railway industry create a good basis for low-cost business model, because the reduction in price tends to drop significantly with the increasing number of passengers.

In the table above, we can see that the increase in seats utilization from [redacted]% to 92% has the potential to reduce the price of the train ticket from 129 Kč to 42 Kč, while keeping the revenues after deduction of track access charges unchanged. The best scenario leverages the train space capacity and assumes the same seat capacity utilization. Based on this scenario, there is a total potential of price reduction of 109 Kč on a 100km long journey. This represents a potential 90% ticket price decrease while keeping the total revenues after deducting track access charges.

The best scenario well documents that the effect of train weight reduction on track access charges plays a meaningful role in case of low traffic, but it decreases with increasing traffic volumes (as it tends to be a fixed amount for a train).

Conclusion

Writing this thesis has proved to be even more difficult than I originally assumed, but it was well compensated by a vast amount of knowledge assimilated.

In terms of low-cost business model, one of the most non-traditional insights brought about in this thesis is the understanding of costs for customers in the sense of total cost of transportation, instead of only the cost of transportation ticket. The techniques and recommendation from the thesis strictly followed this customer-centric principle. This is especially important for a railways low-cost business in order to succeed in the inter-modal competition. This logic results from the facts that the competing means of transportation (air or car) are strong in terms of flexibility or speed, which indirectly translates to the customers' costs of travelling.

The analysis of historic and concurrent market environment in the railway industry revealed that industry could not be as innovative as the automotive or airline industry mainly due to the strict governmental control and consequently due to a lack of the competition. Some technological innovations could have emerged due to some nation's focus on hi-tech, but the governmental control or even ownership caused the business innovations to die away. Despite bankruptcies, the miserable governance and financial position of many railways all around the world, the last decade has shown a great deal of hopes for a renaissance in the railway industry. This is mainly driven by 1) increasing liberalization of the industry and markets, 2) by gradual elimination of discriminative burdens from the transportation market environment, 3) by more active role of supply chain in the innovations and progress, 4) growing volume of investments into the railways 5) and by improving the financial situation of the railway companies.

The historical development and current situation and existing trends brought me to the conclusion that time for major business innovations has not been better and that the question of low-cost business models in the railway passenger transportation is very relevant for today and the close future.

In line with the previous findings, the key cost-oriented techniques and recommendations for low-cost railway operators are 1) the focus on cheap distribution channels, which allow for very high throughput of passengers, 2) focusing on high assets turnover and 3) optimizing track access charges. On the revenue side, companies should 4) introduce yield management systems and 5) building a strong stream of ancillary revenues.

The cheap distribution channels, mainly represented by online, have a great savings potential of more than 10% of total cost for some companies. Since low-cost companies build on offering their products or services to masses, the use of common contactless approach has a significant potential in improving the throughput of passengers through railway platforms or gates. Moreover, it also allows passengers to

handle ticket purchase in much faster way; therefore it is saving costs to the customers.

The point-to-point transportation without many stops is a key to achieve higher assets turnover and it also decreases the indirect costs for the passenger (in the form of time unproductive time). Importance of high assets turnover is further emphasized by the fact that the railway industry is specific for being very capital intensive.

The optimization of track access charges (through better assets utilization, optimization of transportation capacities and weight reduction) might have a meaningful effect on the cost of transportation, especially in the lower volumes. Even though the effect of increasing number of customer overweighs the previous measures easily, these optimizations might be a key competitive differentiator and they surely belong to low-cost strategy thanks to their positive effect on the price.

The yield management system is a crucial tool that low-cost railway companies need to implement, because it has great potential in differentiating the prices for various customers. It also helps to level the load for particular trains through dynamic pricing and it helps the company to optimize the assets through detailed and (ideally) precise information about the total seat sold and occupancy rates.

The ancillary revenues are a dominant profitability driver of many low-cost companies, especially in airline industry. The railway companies need to balance the focus on ancillary revenues with the cost of the travelling. It means, the low-cost railway company needs to build a revenue stream in areas, which complement to rather than clash with people's needs for transportation.

To conclude this thesis, the low-cost business model has a great potential in the railway industry and the adoption of the recommended techniques might lead to revolutionary prices – in an ideal case up to 90% lower prices for a ticket without hurting the current profitability. If the effects of all recommendations could be quantified, it is most probable that the measures could bring a decrease in price of as much as 90% while even improving the profitability significantly.

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10 Appendices

10.1 Appendix 1: External costs of transportation

AVERAGE COSTS IN 2000 BY COST CATEGORY & TRANSPORT MODE														
	Average Cost Passenger							Average Cost Freight						
	Road				Rail	Avia-tion	Over-all	Road			Rail	Avia-tion	Water-borne	Over-all
	Car	Bus	MC	Pass. total				LDV	HDV	Total				
	[Euro / 1000 pkm]							[Euro / 1000 tkm]						
Accidents	30.9	2.4	188.6	32.4	0.8	0.4	22.3	35.0	4.8	7.6	0.0	0.0	0.0	6.5
Noise [1]	5.2	1.3	16.0	5.1	3.9	1.8	4.2	32.4	4.9	7.4	3.2	8.9	0.0	7.1
Air Pollution	12.7	20.7	3.8	13.2	6.9	2.4	10.0	86.9	38.3	42.8	8.3	15.6	14.1	38.5
Climate Change High	17.6	8.3	11.7	16.5	6.2	46.2	23.7	57.4	12.8	16.9	3.2	235.7	4.3	16.9
Climate Change Low [2]	*(2.5)*	*(1.2)*	*(1.7)*	*(2.4)*	*(0.9)*	*(6.6)*	*(3.4)*	*(8.2)*	*(1.8)*	*(2.4)*	*(0.5)*	*(33.7)*	*(0.6)*	*(2.4)*
Nature & Landscape	2.9	0.7	2.1	2.6	0.6	0.8	2.0	10.9	2.0	2.9	0.3	3.8	0.8	2.6
Up-/Down-stream [3]	5.2	3.9	3.0	5.0	3.4	1.0	3.9	22.4	7.4	8.8	2.4	7.4	3.3	8.0
Urban Effects	1.6	0.4	1.1	1.5	1.3	0.0	1.1	5.2	1.1	1.5	0.5	0.0	0.0	1.3
Total EU 17 [4]	76.0	37.7	226.3	76.4	22.9	52.5	67.2	250.2	71.2	87.8	17.9	271.3	22.5	80.9

Table 3 Average external costs of transport in the EU17 countries

Remarks:

1) The modal differences in noise costs are directly related to the national noise exposure databases used and thus might be subject to different ways of noise exposure measurement.
2) Average climate change costs for the low scenario (for information only, values not used to calculate total costs))
3) Climate change costs of up- and downstream processes are calculated with the shadow value of the 'Climate Change High Scenario'
4) Total average costs calculated with the climate change high scenario.
5) Noise costs for freight trains might be under-estimated as the simplified traffic allocation procedure applied did allocate most freight trains to daytime traffic.

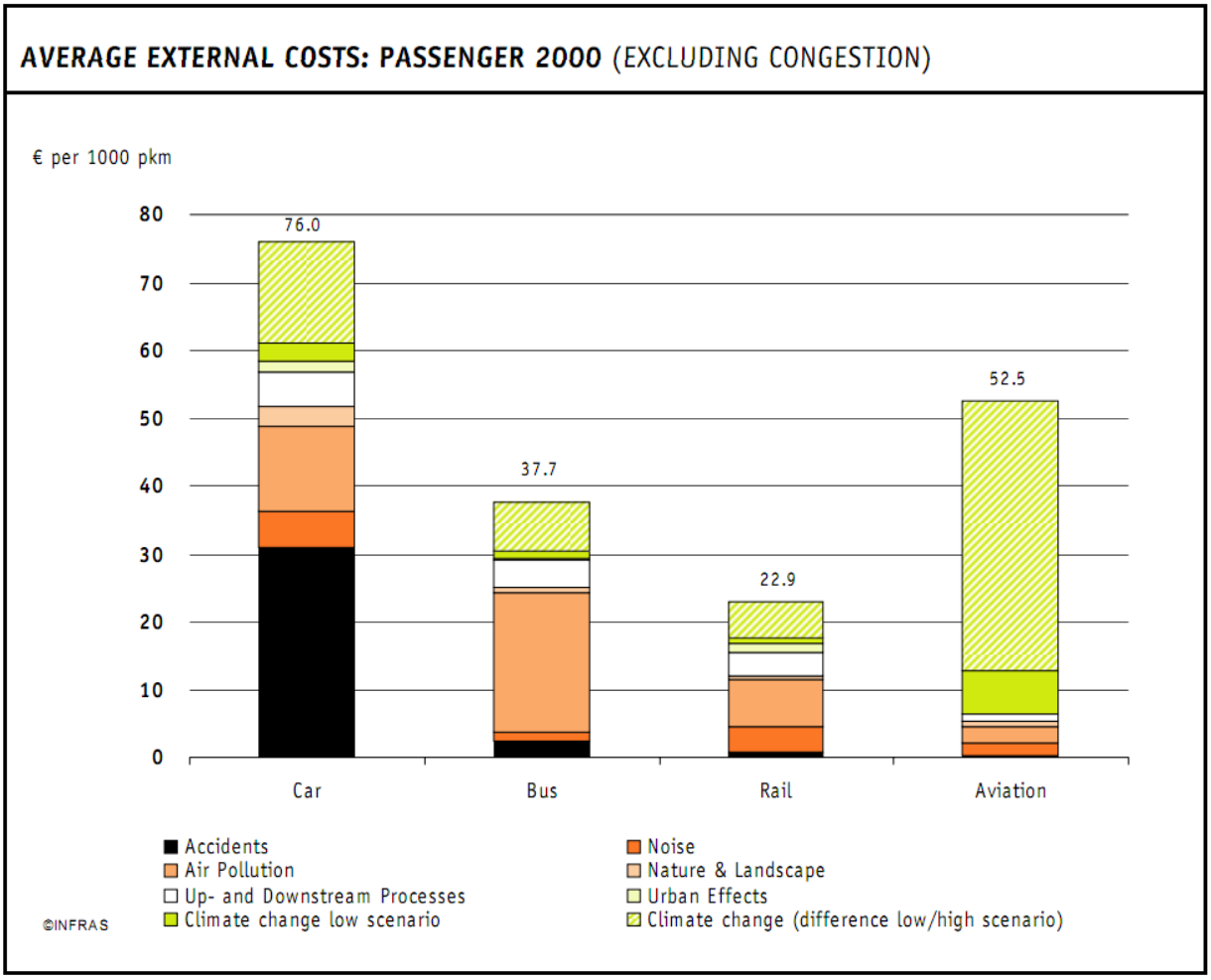

Figure 2 Average external costs 2000 (EU 17) by means of transport and cost category: Passenger transport. The high value of climate change costs in aviation is due to the higher global warming effect of aviation's CO_2 emissions at high altitude during flight (factor 2.5 used compared to the impacts of CO_2 emissions on the earth surface, based on IPCC 1999).

(Schreyer, Schneider, Maibach, Rothengatter, Doll, & Schmedding, 2004)