System Dynamics and Product-Market Matrix for Strategic Planning

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Abstract:

A rail road company has been losing market share to road transportation in spite of the fact that it had some clear competitive advantages over road. The company wanted to solve the puzzle and needed a new strategy to change the trend of losing its market. To design the strategy, system dynamics is used along with a market-product segmentation matrix. While the matrix is used to identify priorities of each segment, system dynamics with a marginal productivity analysis is used to design strategies for each segment to regain company's market share. The paper shows how system dynamics strengths and merits can be combined with the strengths of other tolls and techniques to create a clear and convincing strategy that top management can appreciate and get committed to implement.

Introduction

This paper intends to introduce a method for strategic planning that combines the insights gained from a system perspective[1] and a traditional marginal analysis[2] and product-service segmentation[3]. The approach is being used in a project for a railroad company that is facing some strategic challenges. In the future, I hope to report the full implementation of it in the company. But here comes the challenges the approach to formulate strategy to face them.

Railroad is a main alternative for land transportation usually competing with road transportation. Especially for long distances railroad enjoys obvious cost and safety advantages. But a railroad company in Iran, a large country, where main origin-destinations distances are more than 500 miles has been loosing its market share. Figure 1 shows the change in market share from 1994 to 2000.

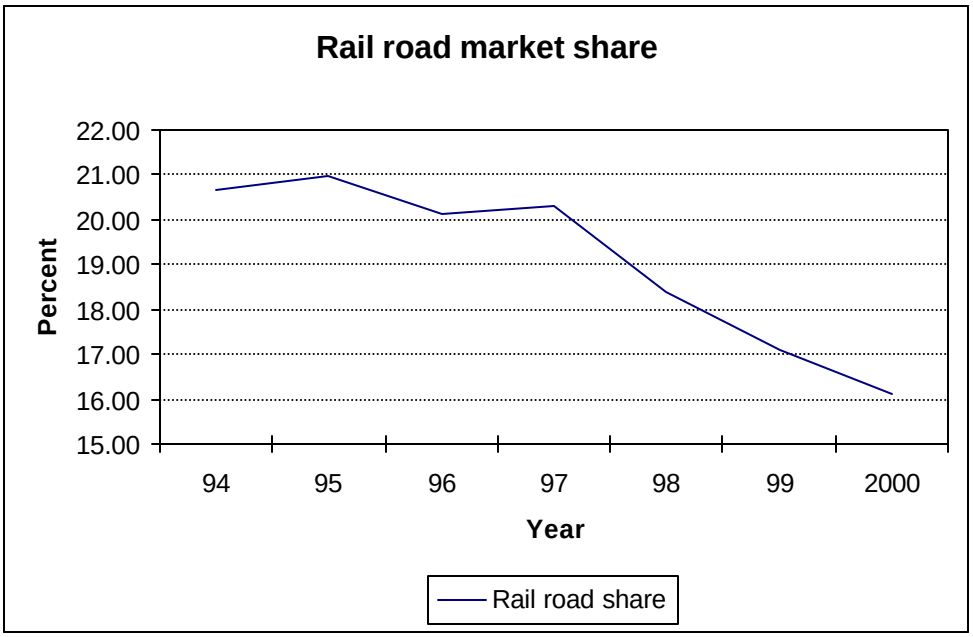

Figure 1: Rail road market share in cargo transportation.

The challenge of the top management was to understand the reasons for the decline and formulate strategy to reverse the direction of change in the market share.

Approach

Teaching: Top management, including the chairman and board members, got involved in the project from the beginning. They participated in a series of system thinking lectures, problem formulation, methodology selection, and strategy formation. System dynamics framework is used in two ways.

System Dynamics: First system dynamics framework is used to understand past performance of the company and mechanisms causing the lost of market share. Second, system dynamics and system thinking are used to formulate policies and strategies to promote the company's market share in selected segments.

Market-Service Segmentation: A market-service segmentation matrix is used to identify the most promising areas to focus first and generate surplus to strengthen the less promising segments of the matrix. In each segment then a system dynamics maps and judgments of top management were used to formulate segment's strategy.

Marginal Analysis: Marginal analysis is used to see how resources should be allocated to activate the most strong positive feedback loops. The marginal impact of resources allocated to fuel each reinforcing loop is determined by using the best possible estimation by managers based on the projects that should be proposed from different division in charge of major causal links in different positive loops.

This paper presents a work in process. It reports the use of system dynamics to provide an explanation for the lost of market share. The paper also presents the market-service segmentation matrix used in the analysis in order to identify the segments that the company can focus on.

Finally, a system dynamics for the analysis of strategy formulation in each segment is discussed based on marginal analysis.

Feedback loops governing change in market share

Rail road has been losing market share to road transportation since 1994, Figure 1. The first challenge was to provide an explanation for this behavior.

Attractiveness of rail roads relative to road was proposed as the major driver of the market share. Attractiveness of each transportation alternative is driven by several factors shown in Figure 2. These factors include availability, quality, transportation time, and price.

Examination of cost structure of transportation by rail and road shows some major differences. Figure 3 shows the major elements of transportation unit cost in each sector. As is shown in Figure 3, there were two major elements of cost in rail that do not exist for road; those are rail road maintenance cost and depreciation of rail roads. For road, the owner of trucks did not have to pay neither for the maintenance of roads nor to count for depreciation of road. In addition, there was a difference in tax rates. There was a tax for railroad transportation that was supposed to be collected for the expansion of rail roads in the country. But there was not such tax for the road transportation. As a result, maintenance cost of rails, rail depreciation, and rail expansion taxes increased rail road prices above what it otherwise could be.

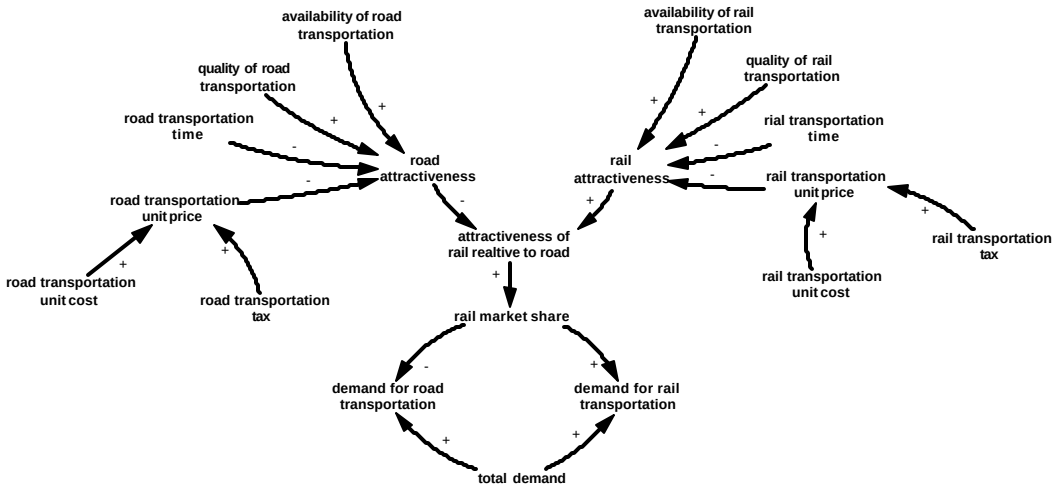

Figure 2: Attractiveness drivers.

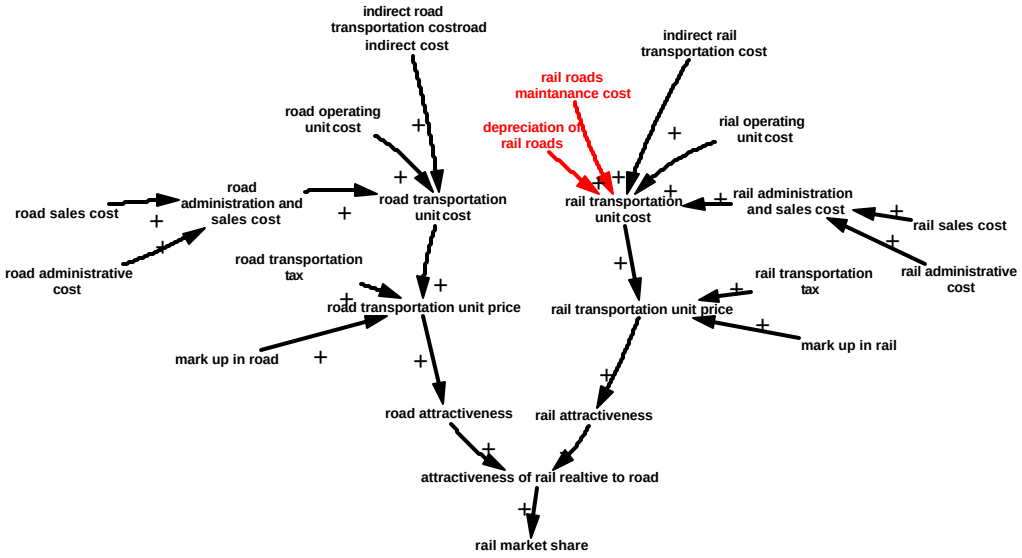

Figure 3: Elements of cost structure of road and rail.

Cost, tax, and price differences create a dynamic and change market share. Figures 4-1 and 4-2 show the related feedback loops that explain part of what has been happening in the market place for the rail road company to loose their market chare.

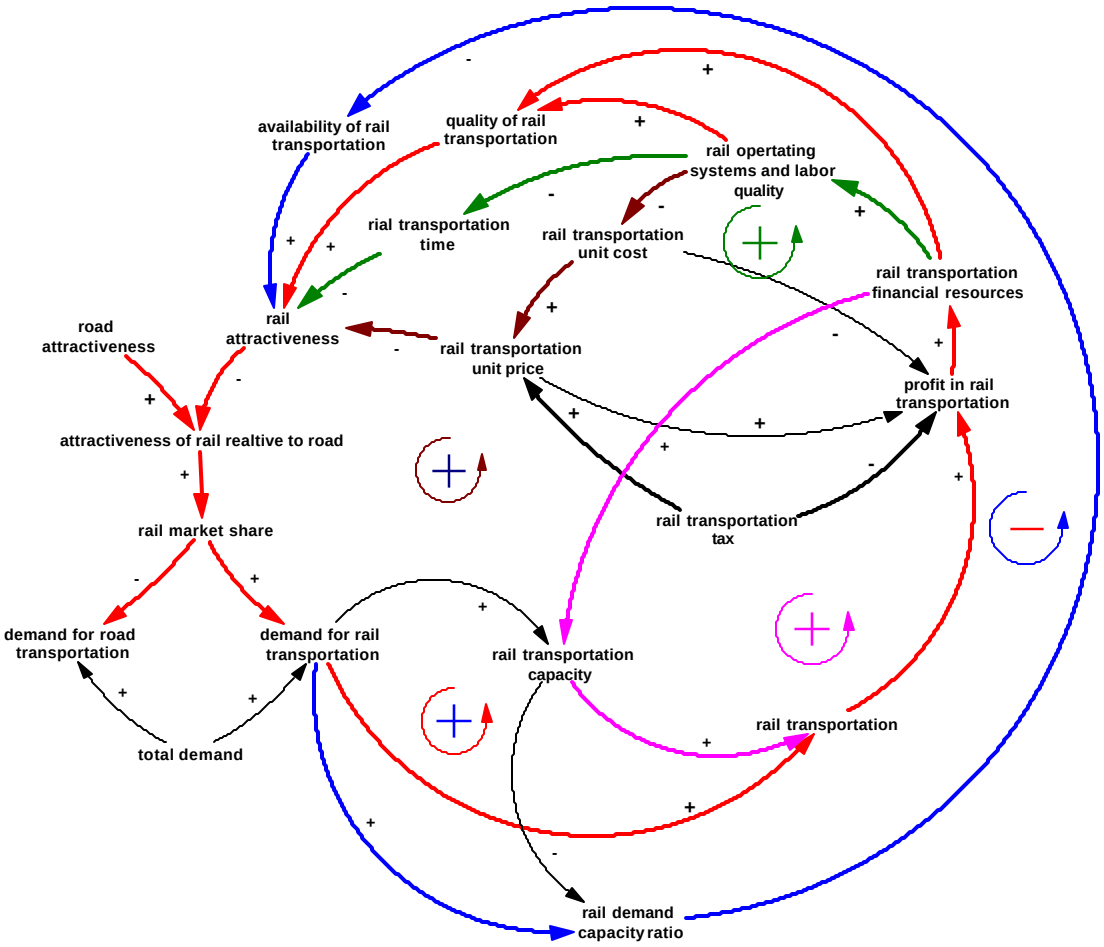

Figure 4-1: Feedback loops governing market share through profit as is influenced by tax and unit cost.

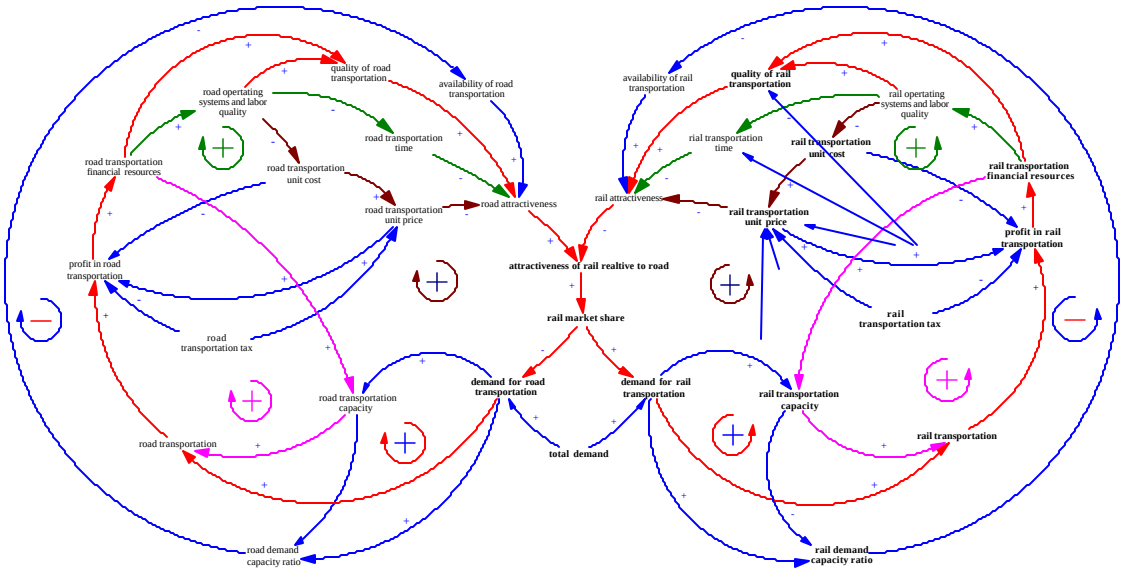

Figure 4-2: Feedback loops working in road and rail sectors to set the market share.

As Figure 4 shows, higher tax and higher unit cost in the rail road, decreases the attractiveness of rail road relative to road transportation. Lower attractiveness of rail decreases rail market share. Lower market share leads to lower demand and lower rail transportation. Lower rail transportation leads to lower profit and financial resources in the rail. As financial resources drop, Rail Road Company's ability to build capacity and to improve quality of services and the adequacy of its operating systems and labor quality declines. Inadequate operating systems and labor quality result in lower quality of services and higher transportation cost and longer transportation time. All these factors lead to lower attractiveness for the rail road and push the market share even lower.

From the above analysis it became clear that a tax on rail transportation can trigger a decaying process in the rail road sector. This analysis itself supported rail road management effort to bbby for either elimination of the tax or setting an equal tax for the road transportation. In addition the analysis strengthens an argument to separate the rail road expansion and maintenance from the rail road company and put it in the government budget similar to the way that the government treats road.

Market-service segmentation matrix

One of the main elements of the approach was a market-service segmentation matrix. This matrix was designed to identify the areas that railroad has greatest potential advantages over road. The segments with greatest advantages would be the first to focus and win the market share back from the road. Then by resources generated from the best segment, was to be used in the next best segment to improve the performance and gain the market share. The process would continue till it covers all segments that railroad has potential advantages over road.

Market segmentation

The rail network was divided into 5 major axes as the main market segments of the company. Each axis presents an origin destination. Four axes come from the origins in north-east, north-west, south, and south-west to a largest city in the center of the country. Another major axis connects major iron ores to steel plants complexes. Given the distance between origin and destination, topography of the axis, and the type and amount of transportation demand characterized each segment in a way different from the others.

Service segmentation

The railroad company provides two kinds of services: cargo and passenger transportation. This study focused on cargo transportation. There are three major types of cargos: bulk, liquid, and miscellaneous. Transportation of each cargo is taken as a service.

Market-service segmentation matrix

Based on market and product segments presented above, a market-service segmentation matrix was created. Figure 2 shows the matrix. In each segment of the matrix some basic factors was identified to set the priority of that segment. The major factors included: total demand, market share, price of rail relative to road, unit cost of transportation, rail transportation time relative to road, and profitability. Collection of the information to complete each cell is in process.

Table 1: Product-service segmentation matrix to set segments priorities

			Market									
Products	Descriptions		Axis 1		Axis 2		Axis 3		Axis 4		Axis 5	
Bulk	Total demand											
	Rail market share		.		28.8		3.53		63.7		3.16	
	Unit cost (Rls/Ton-Km)											
	Road fair	Rail fair	85	139	85	111	85	148		144.8	85	136
	Profit per unit of service		-33		-78		-7		27		-85	
	Road time (hours)	Rail time (hours)										
Fluid	Total demand		695		61		872		41		238	
	Rail market share		49.35		13.11		92		34.15		68.91	
	Unit cost (Rls/Ton-Km)		118		163		92		58		170	
	Road fair	Rail fair	85	62.21	85	83.36	85	120.65	85	187.7	85	108.2
	Profit per unit of service		-33		-78		-7		+27		-85	
	Road time (hours)	Rail time (hours)										
Miscellaneous	Total demand		5035		1201		4112		1555		3332	
	Rail market share		27.35		2		20.4		14.34		9.54	
	Unit cost (Rls/Ton-Km)		118		163		92		58		170	
	Road fair	Rail fair	80	164	80	157.9	80	207.0	80	176.4	80	168.3
	Profit per unit of service		-38		-83		-12		22		-90	
	Road time (hours)	Rail time (hours)										

Strategic importance of each segment

Based on the information in the matrix, managers were asked to rank the cells of the matrix based on their priorities and importance. The priority was given based on the following considerations:

Transportation demand: higher demand leads to higher priority
Unit cost: lower unit cost relative to road implies higher priority
Transportation time: lower transportation time implies higher priority.

The matrix also shows that in many cells while fair for the rail road is lower than the road, the market share of the rail is lower. This observation indicated that transportation time and the quality of services (including the contractual procedures and door-to-door services provided by road transportation) overcame the price advantages of the rail road and were crucial in gaining the market share for the road.

As a result, while price advantage is a positive factor for the rail company, but the company should focus more on the quality of services to compete with the road.

Strategic Implication of the market service segmentation matrix

Based on the information in the cells, the company decided to concentrate on the cells that have greater potential and more advantages in order to gain back the market share from road. Then by becoming profitable in those cells, the surpluses generated in profitable cells can be used to invest in less advantageous cells to bring them up to the level to be able to compete with the road and re-gain the market share.

System maps to formulate strategy in each segment

Strategy formulation in each cell focused on resource allocation. Financial resources of the rail company is from their profit (plus non cash expenses), government budget, and loans. Resources should be allocated to different production factors. Three main production factors are considered in the model: human resource and their motivation, business processes and systems, and capital equipment. Figure 5 shows the causal links for resource allocation. More total resources lead to more resources allocated to each production factor. But one important question is how the company allocates resources to different factors.

Resources allocated to each factor would increase that factor and could lead to the growth of transportation services. Figure 6 shows how resource allocated to human resources can triggers different growth mechanisms and also a balancing loop that checks the growth if human resources go out of balance with other factors. Resources allocated

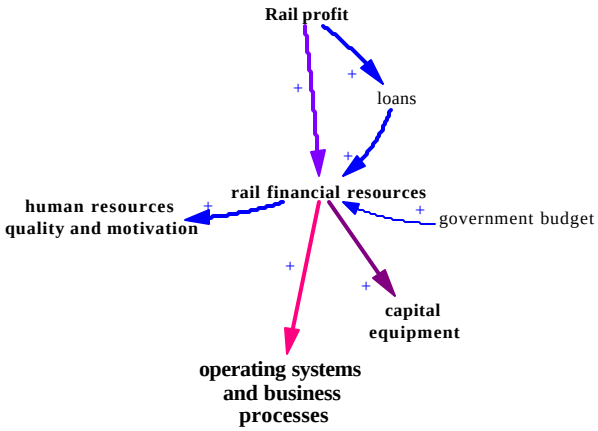

Figure 5: Resources allocation to different production factors.

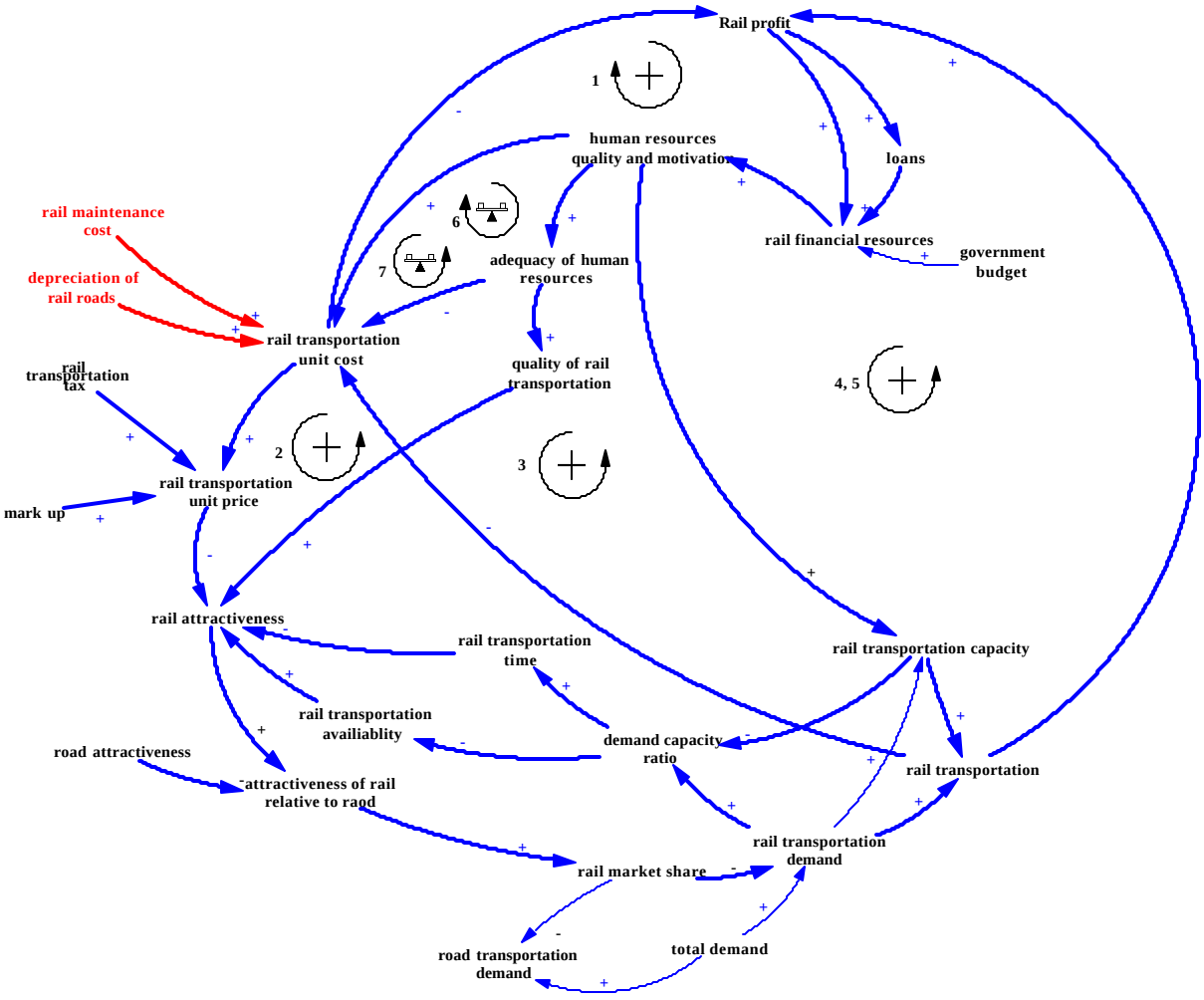

Figure 6: Reinforcing and balancing loops activated by allocation of resources to human resources.

to human resources, used wisely to improve the quality and motivation of people working in the company, would increase adequacy of human resources that decreases unit cost of services. Lower unit cost leads to more profit and generates more resources to be allocated and the first reinforcing loop becomes active. Lower unit cost, on the other hand, could lead to lower price and higher attractiveness of rails relative to road transportation. Higher rail transportation attractiveness leads to more demand and higher services. Higher transportation services cause higher profit and more resources to be allocated. The second reinforcing loop for the growth becomes active.

Better human resources with better motivation would also improve the quality of the rail roads transportation services that leads to more attractiveness for rail roads. More attractiveness generates more resources and the third reinforcing loop is activated.

More human resources with better motivation also increase the capacity of the rail roads to deliver transportation services. Higher capacity would make the rail roads service more available hence increases the attractiveness of the rail road services and creates more demand and higher revenues and more resources, the fourth reinforcing loop. In addition, higher production capacity, due to more human resources, delivers more services and creates more revenues and more resources, fifth reinforcing loop.

Resources allocated to human resources can also activate a balancing loop that controls the growth. Resource allocated to the human resources if not in balance with other production factors, could increase the unit cost of services as can not be used effectively due to shortage of other factors. That is when marginal productivity of resources allocated to human resources is less that the resources allocated, allocation would increase unit cost. Higher unit cost would decrease profit and also would decrease price and attractiveness. Both would lead to lower profit and lower resources. In fact reinforcing loops 1 and 2 are replaced with two negative or balancing loops, loops 6 and 7. Therefore depending on the adequacy of other production factors that determine the marginal productivity of human resources, allocation of resources to the human resources can activate reinforcing or balancing loops.

The same mechanisms are at work for the allocation of resources to the other two production factors. Figures 7 and 8 show similar feedback loops for allocation resources to capital equipment and business processes and systems.

One important strategic issue is the allocation of resources to those growth loops with maximum gain. Scarce resource will serve the growth of the company when are allocated to activate loops with most growth power. Since reinforcing loops go either through attractiveness and/or unit cost, managers should see the marginal impact of resources allocated to each production factor on determinants of the attractiveness and the unit cost of services. The marginal impact should be averaged by proper weight to determine the overall impact resulted from allocation of resources to each production factors. The average impact of resources allocated to each production factor can be used to set the priority and share of each factor from allocated resources to maximize growth. Table 2 is designed to implement this procedure. This table should be filled out by the managers based on plans and projects suggested from different division of the organization.

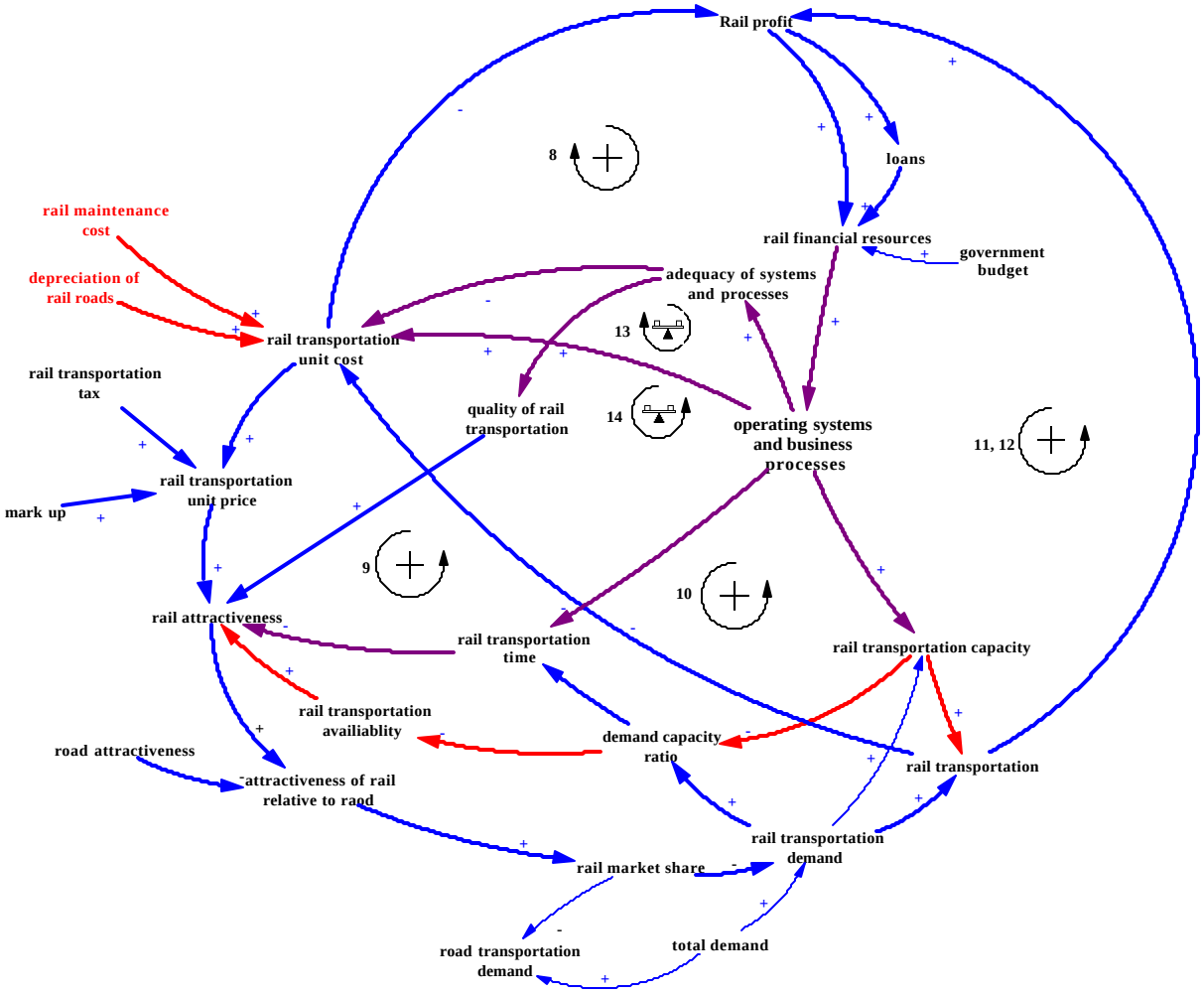

Figure 7: Reinforcing and balancing loops activated by allocation of resources to business processes and systems.

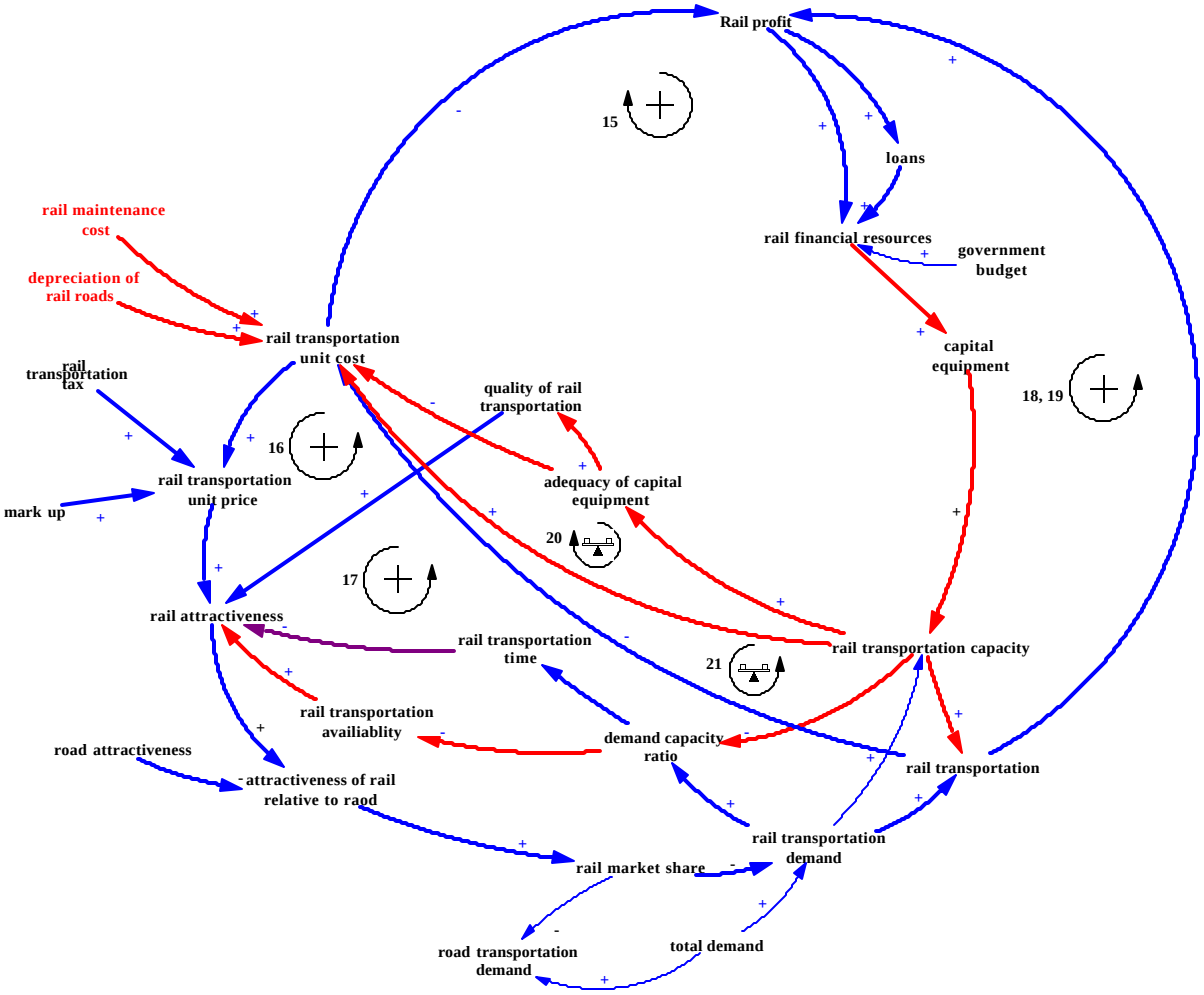

Figure 8: Reinforcing and balancing loops activated by allocation of resources to capital equipment.

Table 2: Impact of one unit of resources ($1000) to each production factors on attractiveness

Attractiveness determinants	Description	Production factors		
		Human resources	Business processes and systems	Capital equipment
Unit cost	$/unit			
	Points			
	Weight			
Quality	Quality measure			
	Points			
	Weight			
Service time	Hours			
	Points			
	Weight			
Service availability	Availability index			
	Points			
	Weight			
Total weighted impact on attractiveness				

To calculate the impact of resources allocated to each production factor, some more detailed analysis can be done. Figure 9 shows the allocation of resources to different alternatives in expanding capital equipment of the company. Resources allocated to capital equipment can be used to expand the capacity of locomotives, wagons, rails, or maintenance facilities. With the same process explained above, the company can determine which alternative will results in more production capacity given the other non-capital equipment factors are available. Table 3 can be used to determine the marginal production capacity of investment in different capital equipment. Table 3 should be filled out based on the best investment project available for each category of capital equipment given that other factors remain constant. In the last row of Table 3, the alternative investment with the best marginal production capacity is chosen. The best investment alternative is used as an input to Table 2.

A similar marginal analysis can be done for the resources allocated to business processes and systems. Resources can be used to improve different business processes and operating systems. Table 4 can be used to determine the marginal gain of investment in different processes and systems. Proposal investment in processes and systems improvement can be evaluated based on their marginal impact on unit cost of rail transportation services, transportation time, quality of services, and customer conveniences. Then the weighted average of gains of investment in each process and systems are compared to select the best ones as input to Table 2.

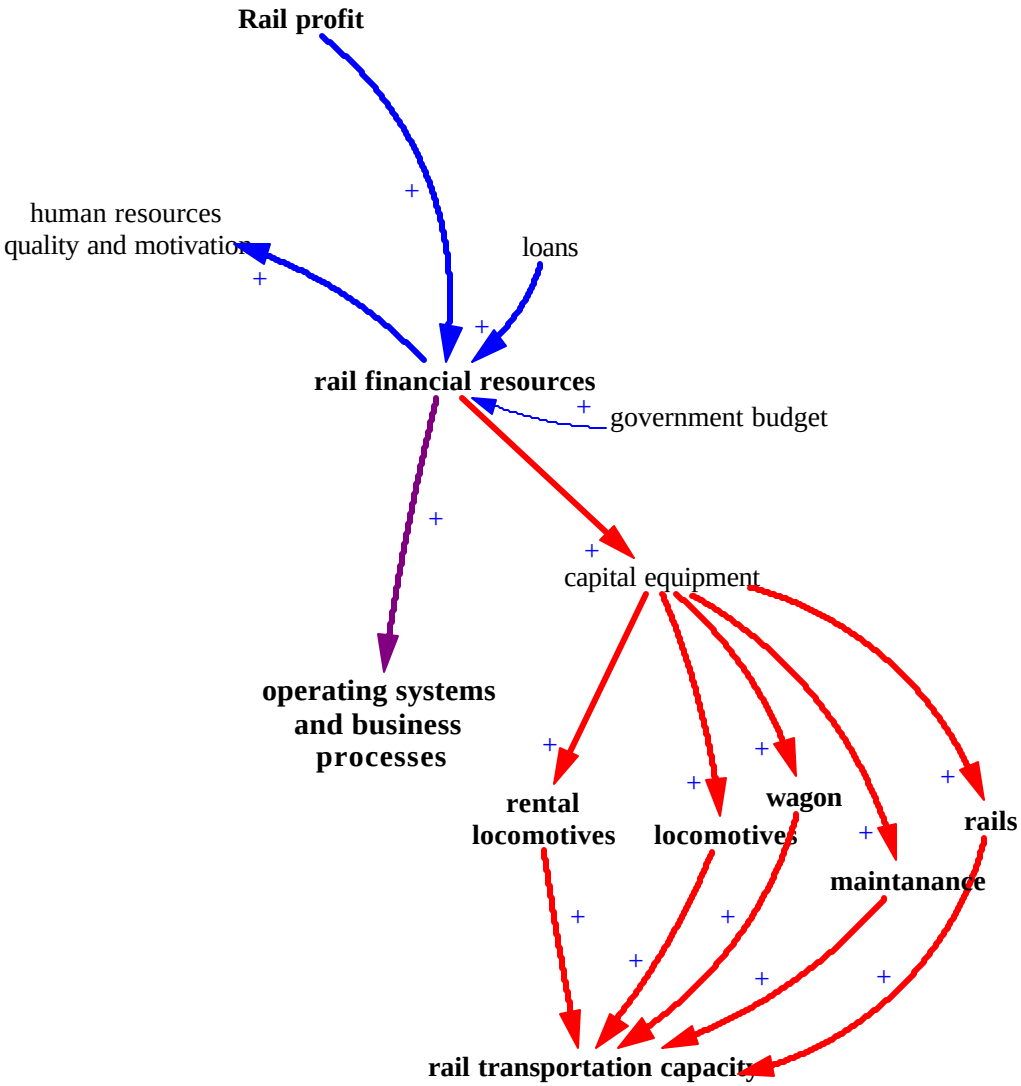

Figure 9: Allocation of resources to different capital equipment for capacity expansion

Table 3: Marginal production capacity of investment in different capital equipment

Attractiveness determinants	Required optimal investment	Capacity addition	Capacity per $ investmjent	Comments
	$	Tons-Km/Yr	$/Tons-Km	
Rails				
Locomotives				
Wagon				
Maintenance facilities				
Best marginal impact (Min $/Ton-Km)				

Table 4: Marginal

Attractiveness determinants	Description	Processes and Systems				
		Process 1	Process 2	System 1	System 2	System 3
Investment ($)						
Unit cost	$/unit reduction					
	$ inv/unit red/$					
	Points					
	Weight					
Quality	Quality imp					
	$ inv/Quality imp					
	Points					
	Weight					
Service time	Hours reduction					
	$ inv/Hours red					
	Points					
	Weight					
Service availability	Availability imp					
	$ inv/Avail. Imp					
	Points					
	Weight					
Total weighted points						

Summary and Conclusion:

Systems dynamics along with other marginal analysis for resource allocation and product-matrix segmentation can be used to formulate strategy for a multi product multi market company. System dynamics and even soft system thinking can be used to provide a dynamic theory for the past performance. Product-market segmentation can be used to identify the areas that have potential growth and needs focus attention by priorities. From system dynamics, one can identify reinforcing loops that generate growth and negative loops that resist growth. Marginal analysis along with reinforcing loops can be used to formulate strategic resource allocation to activate loops with the highest gain deactivate balancing loops with the highest resistance to growth. Marginal gain of resources allocated to alternative activities can be obtained by evaluating project proposals for each alternative.
This methodology is planned to be used in a rail road company. I hope to report the results in the future conferences.

Refrences:

1. Sterman John, Business Dynamics, System Thinking and Modeling for a Complex World, McGraw-Hill, 2000.
2. Robert S. Pindyck and Daniel L. Rubinfeld, Microeconomics, Prentice Hall, 2001.
3.

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