Influence of Traffic Congestions on Safety Stock in Company

Juraj Dubovec(✉), Jana Makyšová, and Milan Kubina

Faculty of Management Science, University of Žilina,
Univerzitná 8215/1, 010 26 Žilina, Slovakia
{juraj.dubovec, jana.makysova,
milan.kubina}@fri.uniza.sk

Abstract. Traffic intensification in Slovakia is an effect of economic development of the country. Traffic development in limited capacities of road infrastructure produces delays in traffic congestions. Congestions are becoming the problem mostly for companies which has to deal with its serious impact on established supply rules due to the extension of delivery time. This article points to effects of congestions on safety stock level change which is necessary for stabilization of assembling systems.

Keywords: Congestion · Delivery time · Production system stability · Safety stock · Logistics

1 Introduction

Accompaniment of development in Slovakia, as it is in developed countries is an intensification of traffic on the roads which has not only positive effects on mobility, but has also negative influence on environment, on worsening traffic flow, increasing number of car accidents or on road traffic inefficiency.

We would like to concentrate in our article on problem of traffic flow worsening leading to a sharp increase of congestions number on the roads and its influence on safety stock.

In road traffic network which is on the edge of its capacity, even small deviations in traffic volume produce a cascade effect [6].

More non-linearity is striking, more the thing (car) and a function of this thing (transport) are diverging. If traffic is linear, there would be no big difference between situations when stretch of a road is passed by 20.000, 25.000 or 23.000 cars. In case when cars are driving. The difference between the thing and its function will increase depending on uncertainty rate which is present in it. The driving time does not depend on intensity average, but on positive deviation from this state.

2 Traffic Congestions

In the frame of the traffic problem, congestions are conceived as an impassability or a blockage of driving corridor in road traffic [7]. Main reasons of congestions creation on the roads are:

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– intensity of road traffic,
– insufficient capacity of road network.

There are also additional reasons of congestions creations on roads. They are different, starting by car accidents, technical faults on means of transport, natural phenomenon, maintenance activities etc. When different events producing congestions occur in the same time, there is a synergic effect and congestions are even broader. Also the probability of congestion creation on different stretches of road varies [1].

Consequences of congestions are delays caused by getting stuck in blockage or by use of alternative route which usually has worse parameters than the route disabled by congestion. The dependence between road network loading and the time loss in congestions is presented in Fig. 1.

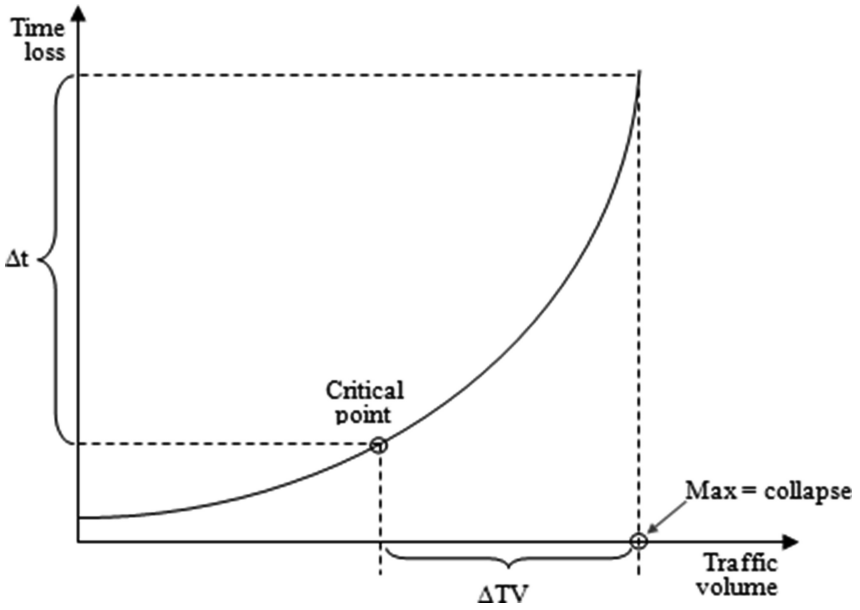

Fig. 1. The graph demonstrating the dependence between traffic volume in the road network and a loss of a time created by congestions on loaded even overloaded road network. Value of Δt presents an addition of delay time due to traffic volume increase by ΔTV. Traffic intensification has an exponential character. On this curve is located a critical point from which even a small addition on traffic volume generates a multiplication of delay in congestions. The point represented on a curve is only illustrative.

Analysis and prognosis of Slovak road administration [2] are not optimist at all in this problem, it is even reversely. In cooperation with Strategic plan of road network development of Slovak republic till the year 2020 [3] it turns out that motor vehicles increase is quicker than the increase of new express roads and highways which aim is to bring the intensity down to an acceptable level. The total number of motor vehicles listed in Slovakia is presented on Fig. 2. It is important to notice, that congestions on roads are not

caused only by vehicles registered in Slovakia, but Slovakia is also a country of destination and of transit and so foreign vehicles significantly participate in traffic, mostly vehicles from Czech Republic and from Poland, but also from other countries.

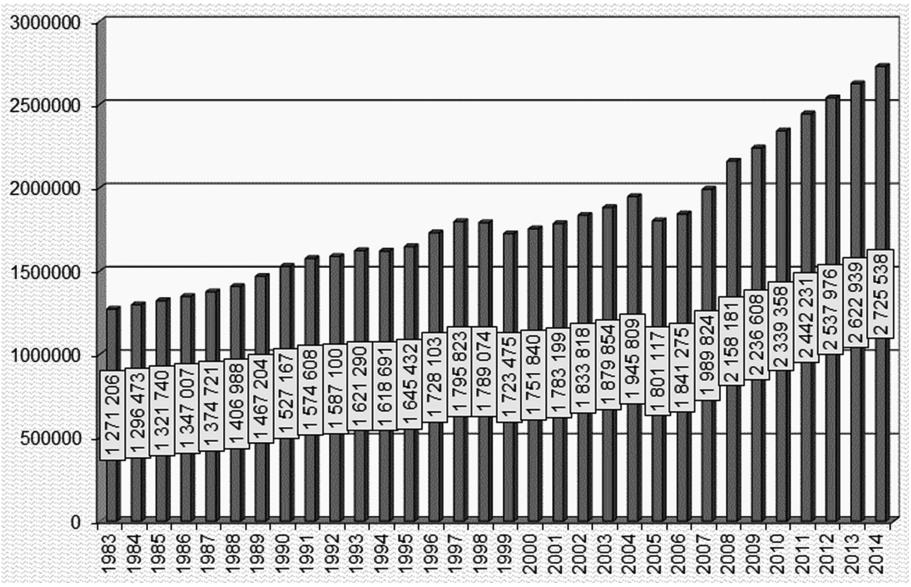

Fig. 2. The graph representing the total number of motor vehicles registered in Slovakia from the year 1983 till the year 2014 [4].

Slovak road administration measures all five years the intensity of road traffic. It is possible to get details of survey methodology is possible on their web pages [2]. Due to realized measurements the highest traffic volume was detected on the bypass of Bratislava directed to Senec where pass more than 100,000 vehicles per day and on the bridge Lafranconi directed to Wien with more than 88,000 vehicles per day. Any other road section in Slovakia did not reach the number 50,000 vehicles per day. The highest increase of traffic volume – 78 % – achieved the road section from Martin to Žilina. Also, this is a road section with very frequent congestions. Executors of this survey say that main roads in Slovakia are congested. And the intensity is increasing each year. Measurement of this year will show how the traffic intensity would change. Figure 2 indicates, that situation in years 2010–2015 got even more complicated and traffic got denser.

It is possible to find an analogy in queueing theory with multiple queueing nodes, while all nodes are not equal. In comparison with road network it is important to consider the fact that there is one optimal queueing node and others are offering solution where at least one parameter is worse. In case that there is a congestion on optimal queueing node, driver can chose another queueing node but he has to take into account more passed kilometers, traffic restrictions (bridges – reduced height, reduced carrier; road quality, sharp turns…) on other queueing node.

Queueing theory provides also an explanation for queue creation, its behavior, and advance in queue.

3 Supply Logistics on Overloaded Road Network

Worsening road network permeability presents complications for companies depending on regularity and punctuality of inventory delivery. Irregularity and non-punctuality causes problems for companies, such as marginal costs increase that company has to expend for its production.

When supply situation related to cost increase occurs, company has two possibilities, how to solve it:

- Time reserve and cost shifting to suppliers (carriers),
- Safety stock increase.

3.1 Time Reserve and Cost Shifting to Suppliers (Carriers)

The simplest solution on the first view is to prepare the shipment earlier that it can hit the road in advance so that potential congestions would not have an influence the deadline of delivery to destination.

But this solution anticipates the increase of costs necessary for material delivery in fixed dates. This includes necessity to procure new motor vehicles, new drivers for motor vehicles, more fuel is used, to procure manipulation technic for loading material on vehicles etc.

Car factories already adopted a kind of supplying principle which allowed them to cut their stocks by 20 % approximately. So they have shifted a part of their costs on suppliers. Car companies will shift their costs related to congestions and potential delays to their suppliers or they will take a part of risk by increasing the level of safety stock.

3.2 Safety Stock Increase

The purpose of safety stock is to increase the stability of system when uncertainty really exists in particular environment. Safety stock should cover random deviations in delivery time. Costs of deficit for productive or assembling stock can have as a consequence the interruption of production or assembling. Sometimes, non-satisfaction of demand is joined to financial sanctions. The size of safety stock is mostly influenced by variability between the supplier and the company which can have two forms. It is a late delivery or a poor quality delivery.

If delivery time is longer due to congestions, companies will have to reevaluate their actual supplying system. Because if the shipment is late because of impassability of the road, company can be obliged to stop the production, and that will produce big financial loss.

Car factories are rare companies in Slovakia functioning under the mode of production stability. That means that they have in their plants only a minimal level of stock (safety stock) and the majority of material is delivered in system Just in Time.

The level of safety stock is set in the way that new material will come in a moment when all material delivered in previous shipment is used. The time from the moment when is reached the level of safety stock giving impulse for ordering new stock to the moment of delivery of ordered stock to the company is exactly calculated and is defined as delivery time (DT). Figure 3 is a graphical presentation of consumption, ordering and delivery process.

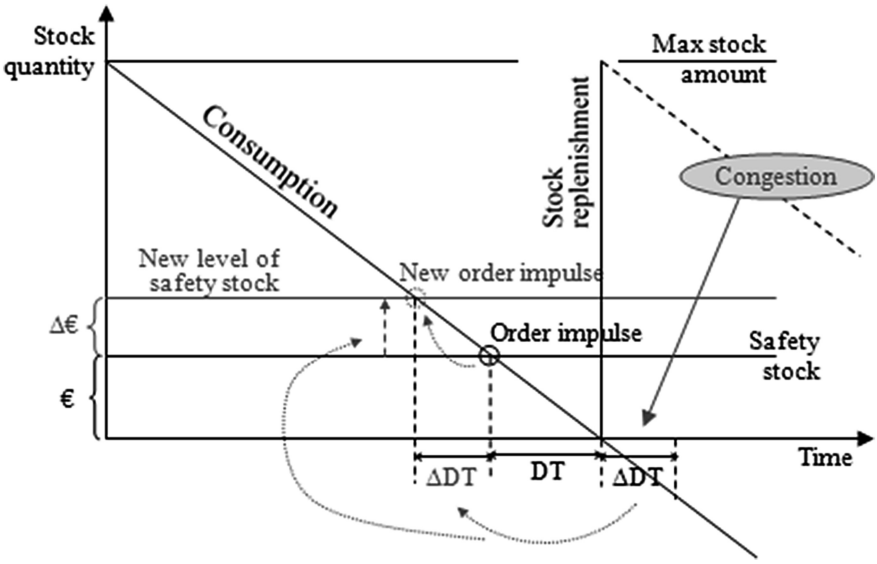

Fig. 3. Model of consumption and stock replenishment in company.

It is obvious that the amount of safety stock is defined in a way to cover the consumption from the moment of ordering to delivery of new shipment. But if the delivery time is longer due to congestion, company will find itself in stock deficit and have no material for production. To eliminate this situation, it is necessary to add the time extending delivery to standard delivery time. This would ensure new delivery at least or before the moment when the safety stock is spent. That means that the impulse for ordering must come early enough to ensure sufficient time for delivery. This leads to safety stock level increase. Having safety stock level increased means that company has to have more sources fixed in its safety stock as it has previously and this would increase marginal costs invested to stabilize the system.

4 Conclusion

Slovakia as one of top car producers in the world faces actually the strengthening of traffic volume. This causes problems to companies which have their production system stabilized like car factories. It is very arduous to reach this state preceded by numerous

analysis and optimizations. Paradoxically problems based on road transport intensification are partially caused by car factories them-selves.

Also a Slovak road administration seeks to mitigate the impact of increasing traffic volume through the project *National system of transport information* [5]. This should solve basic problems in the field of security and fluency of traffic on roads of Slovak republic. In accordance with main factual and political aims of European Union and with main missions of Slovak republic, the project creates an environment for a significant reduction of transport accidents and extenuation of its effects on lives, health and property of citizens, at once it participate to diminution of congestion creation and high traffic intensity on most loaded roads [2].

With the current trend of road traffic development many companies will have to reevaluate their exert rules for inventory management which are dependent on reliability of shipments from the time's point of view.

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