

Green logistics and supply chain volatility: Is there a 'green bullwhip effect' to be feared in supply chains?

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Abstract

Sustainable and green logistics concepts are a major trend in global supply chains. An important research question in this context is the topic of a possible interdependence between green logistics measures and overall volatility in supply chains, discussed in logistics literature e.g. as 'bullwhip effect'. This research paper therefore tries to give an overview about existing knowledge regarding bullwhip effect and green logistics in order to proceed to a volatility impact analysis of specific and relevant green logistics instruments to the whole supply chain. By this first and estimation-based input a draft for the definition of a green logistics bullwhip effect is described.

1 Introduction

Sustainable and Green Logistics concepts are a major trend in global supply chains – recently highlighted by the DHL study 'delivering tomorrow'. This study shows that an increasing number and share of customers are demanding green logistics services and therefore product development and sales concepts with logistics service providers will have to react to this trend.

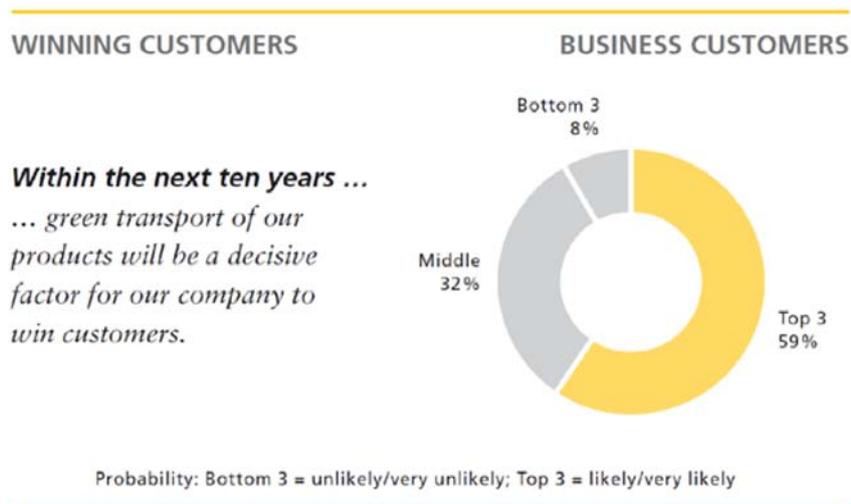


Figure 1. Green Logistics Demand (DHL, 2010, 43).

Several literature concepts and discussions address this sustainability trend (e.g. Polonski, 2001; Sommer, 2007; Aronsson/Huge-Brodin/Kohn, 2008; Günther, 2008; Kranke, 2008, Middendorf, 2008; MEPC, 2009; Sundarakani/Souza/Goh, 2010).

An important element of sustainability concepts is the new setup of actors, adding politics and regulations from the political arena to the traditional market schemes with companies and customers as actors. Due to this effect, many changes are enforced in companies and also in customer behavior recently unknown in standard rational market settings. The following figure 2 gives an impression of this new triangular positioning of the field of green logistics.

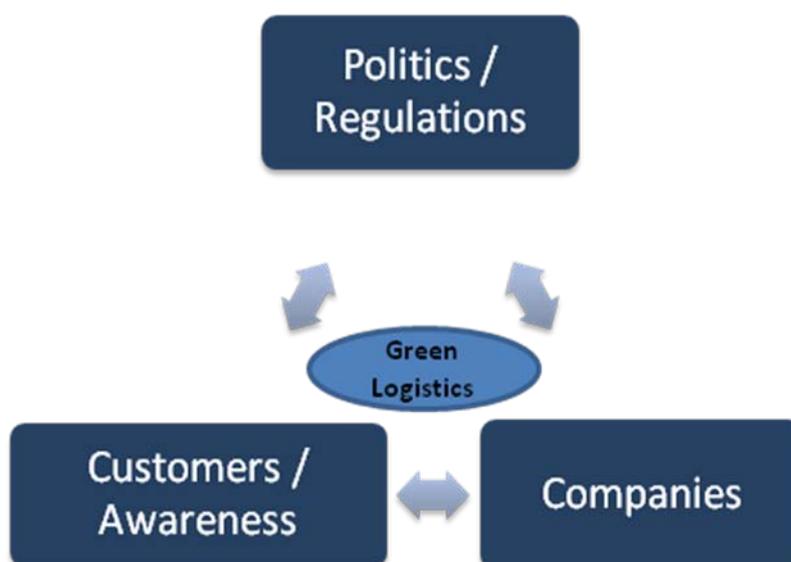


Figure 2. Total Sustainability Management Draft.

2 Bullwhip Effect

Second the knowledge about the *bullwhip effect* regarding increasing safety stock and order levels upstream induced by a (minor) change in end customer demand is widely discussed and explained in logistics literature (see for example Lee/Padmanabhan/Whang, 1997; Metters, 1997; Taylor, 1999; Chen/Ryan/Simchi-Levi, 2000; Helbing, 2003; Chatfield et al., 2004; Hwarng et al., 2005; Carranza Torres/Villegas Moran, 2006; Paik/Bagchi, 2007; Jaksic/Rusjan, 2008; Kelepouris/Miliotis/Pramatari, 2008; Wright/Yuan, 2008 Agrawal/Sengupta/Shanker, 2009).

The following picture describes this general setting of 'distorted' supply chain delivery levels due to information shortages, missing transparency and uncoordinated behavior of supply chain companies. Usually this effect leads to increased costs in transport and warehousing throughout the whole supply chain and therefore supply chain management in general tries to reduce this effect.

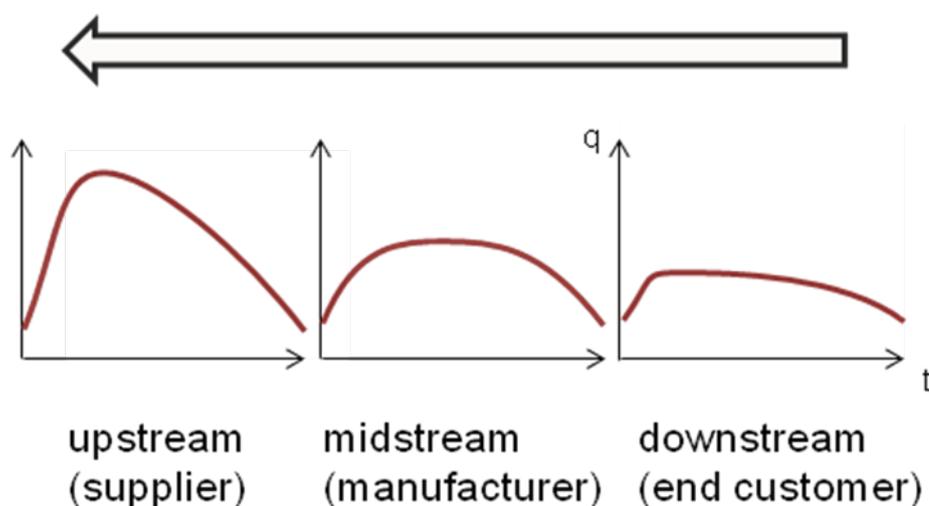


Figure 3. Standard Bullwhip Effect.

3 Green Logistics Instruments

If supply chain wide green logistics concepts are introduced as e.g. suggested by the following overview regarding a 'Total Sustainability Management' approach for logistics, the consequences regarding the known bullwhip effect might be of interest - therefore an important research question is the topic of the interdependence between green logistics measures and overall volatility in supply chains.

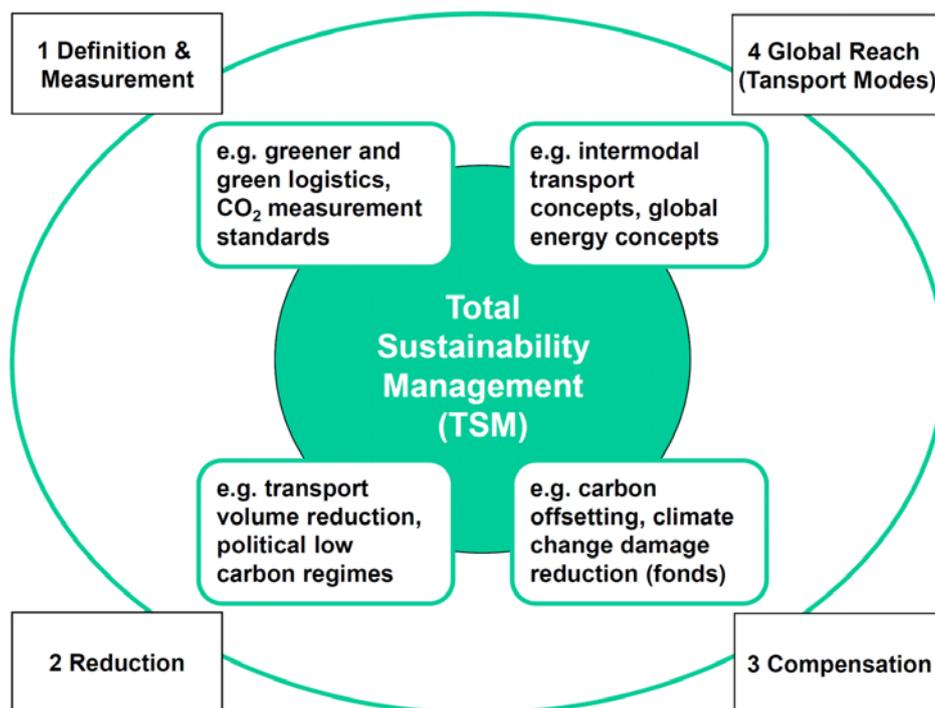


Figure 4. Total Sustainability Management Draft.

An important and recent example for green logistics instruments is the inclusion of airlines into the carbon dioxide emissions certificate trading system of the European Union – major facts are displayed in the following table.

Objective / Topic	Information
Reduction targets 2012 and 2013-2020	- 3 % (2012) and - 5 % (from 2013) compared to the average of 2004-2006 (baseline), i. e. the cap is at 97 % and 95 %, respectively
Aviation emissions trading participants	Over 4.000 international aircraft operators from more than 150 countries. Germany accounts for 355 of these.
Allocation free of charge	82 % of the allowances
Reserve	3 % of the allowances
Auction ratio	15 % of the allowances
Allocation	Based on a Europe-wide uniform benchmark, which the EU Commission will calculate in 2011

Table 1. Airline Emissions Trading Regime Characteristics
(German Emissions Trading Authority, 2010, 3).

Other instruments may include electric trucks, reduction of empty or partially empty trucks and other vessels, slow steaming with ships (and maybe also planes as 'slow flying') as well as the use of biofuel in trucks and planes. Such instruments are discussed in the following chapter in regard to their specific influence towards supply chain volatility.

4 Volatility Assessment of Green Logistics Instruments

The following table gives a first draft overview regarding green logistics measures, the transmission character and the result on flexibility and volatility in supply chains. This is outlined with specific green logistics instrument examples in the following research analysis.

(a) For *electric-driven trucks* a characteristic restriction is the range restriction due to battery capacity.¹ This leads typically to a negative influence to operational *flexibility* as reactions to short-notice changes are limited due to this range limitation. This implies that the average *volatility* regarding bullwhip effect incidents may increase as persons within the supply chain companies anticipate this restricted flexibility and range.

(b) A *reduction of empty tours* (truck but also other transport modes) leads on average to a reduction of shipment intervals and therefore implies a negative influence on supply chain flexibility as longer spacings between shipment intervals mean longer reaction times. This in general leads to an increasing volatility too, as actors in the supply chain may rationally order larger quantities due to feared shortages facing these longer shipment intervals.

(c) With *slow steaming* at ship transports will lead to longer travel periods and transition times and therefore a negative development of overall supply chain flexibility. This again will have an increasing effect on general volatility in supply chains as actors try to battle longer lead times with higher security stock levels and order volumes, especially in the (small) order volume increases causing the bullwhip effect.

(d) The *use of biofuel* for example in planes may as an opposite example have exceptionally positive effects on supply chain flexibility as speed and range of such planes using biofuel increase due to first research results. This would vice

¹ As first step for all instruments a 'transmission character' is discussed describing the operational influence on logistics and transport processes.

versa lead to decreasing supply chain volatility as actors factor the decreasing lead times into their rationale in lot size and order size decisions.

(e) And *carbon dioxide emissions trading* for example for planes as in the European Union since 2011 will probably lead to a reduction of flight intervals and therefore to a decrease in flexibility due to longer transport intervals and overall capacity reductions. Again this would lead to an increasing volatility in supply chains as relevant actors will increase their order sizes in demand change situations stronger than before the introduction of such a regime. This last case is also the first option to scientifically measure the proposed effects as the emissions trading regime was introduced to the complete airline industry in 2011 and therefore a comparison of order quantities between 2010 (before the regime) and 2011 (with the regime) should reveal the effect of such a proposed green bullwhip effect.

Table 2 provides an overview about the discussed green logistics instruments and their assumed transmission and volatility effect on supply chains.

Green Logistics Instrument	Transmission Character	Influence on Flexibility	Influence on Volatility V
(a) Electric-driven trucks	Restriction of transport range	<i>Negative</i> influence due to shorter range	<i>Increasing</i> V due to feared shortages
(b) Reduction of empty tours (trucks)	Reduction of shipment intervals	<i>Negative</i> influence due to longer spacing	<i>Increasing</i> V due to feared shortages
(c) Slow steaming (ships)	Longer travel period & more ships needed	Negative influence - increased travel time	<i>Increasing</i> V due to feared shortages
(d) Use of biofuel (planes)	Change of speed and range	Positive influence due to higher range	<i>Decreasing</i> V due to less shortage fear
(e) Carbon dioxide emissions trading (airlines)	Reduction of flight intervals	Negative influence due to decrease in capacity	<i>Increasing</i> V due to restricted capacity and rising prices

Table 2. Green Logistics Instruments and Their Volatility Impact.

5 Concluding Remarks

The presented results have established a first idea about the possibility of a green logistics bullwhip effect in logistics. The presented methodology was very rudimentary and has to be enhanced in further research efforts – which should be definitely undertaken as severe consequences for the whole economy can be expected, until today mainly without any ‘problem-awareness’.

(a) For example specific industries as e.g. fashion and electronics industries with short lead and delivery times should reassess their supply chains and stock levels in order to avoid shortages and panic orders once green logistics instruments are going to be put in place.

(b) Second an overall strategy concept and analysis for green logistics instruments should be implemented in order to assume better understanding of supply chain-wide consequences of green logistics instruments.

These examples highlight the need for further research in this field of green logistics bullwhip effects.

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