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Green Bullwhip Effect Simulation Concept

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ABSTRACT

Sustainable and green logistics concepts pose an important trend in global supply chains. An interesting research question in this field is the topic of a possible interdependence between green logistics concepts and overall and upstream progressive volatility in supply chains, discussed in logistics literature e.g. as 'bullwhip effect'.
This research paper describes existing knowledge regarding the bullwhip effect and green logistics in order to proceed to a volatility simulation analysis of specific and relevant green logistics instruments to the whole supply chain. By this concept draft for a green bullwhip effect first glances on the possible quantitative effects in supply chains are possible.

INTRODUCTION

In logistics management and research one important objective is an understanding as well as the reduction of increasing order lot sizes through the supply chain (upstream) - the *bullwhip effect* (Agrawal et al. 2009; Beamon 1999; Campuzano and Mula 2011; Carranza Torres and Villegas Moran 2006; Chatfield 2004; Coppini et al. 2010; Corsten 2004; Helbing 2003; Hwarng et al. 2005; Kelepouris et al. 2008; Lee et al. 1997; Metters 1997; Özelkan and Lim 2008; Paik and Bagchi 2007; Pati et al. 2010; Taylor 1999).
A standard bullwhip effect is shown in the following picture with a small increase in customer orders (right hand side) and increasing order lot sizes at the manufacturing and suppliers stage.

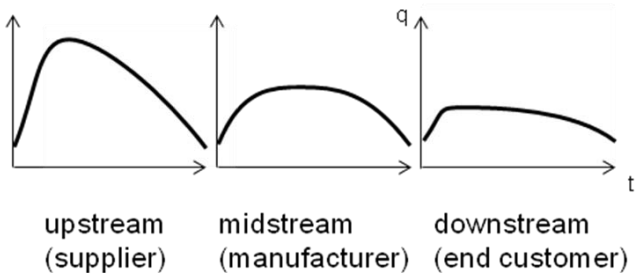

Figure 1: Standard Bullwhip Effect

The *reasons* for this effect are information gaps, psychological biases (security) and insufficient co-ordination and planning among the supply chain partners (Chen 2000; Cho and Lee 2011; Jaksic and Rusjan 2008). Therefore *countermeasures* are directed towards enhanced information exchange and transparency as well as co-ordination and integrated planning approaches in the supply chain (Wright and Yuan 2008).

GREEN LOGISTICS CONCEPTS

Green logistics concepts are discussed in a manifold of literature contributions (Aronsson et al. 2008; DHL 2010; Murphy and Poist 2000; Murphy et al. 1996; Polonski 2001; Sommer 2007; Sundarakani et al. 2010; Trunik 2006; Wilson 2009) and entail a plethora of instruments and measures in order to reduce energy consumption and emissions by logistics processes.
The following figure 2 by the author gives an example of an integrated concept: Four implementation areas of *definition and measurement* (e.g. PCF, carbon emission calculation in logistics, global standards as e.g. GHG or BSI), *reduction* of energy input and emissions output in logistics, *compensation* as management area in terms of carbon compensation programs as well as the fourth perspective of *global reach* with the request of globally integrated transport concepts e.g. in sustainable multi-modal transports.

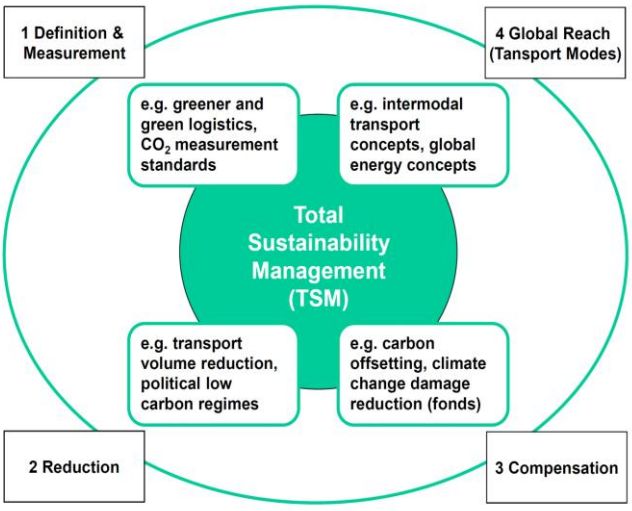

Figure 2: Integrated Green Logistics Concept

But as current state of logistics research it has to be recognozed that though many concepts are devised a lack of simulative analysis of unintended effects exists. The following conceptual description of a green bullwhip effects wants to contribute to that specific lack by describing one specific possible consequence of green logistics measures to the supply chain in general.

GREEN BULLWHIP EFFECT

Combining the two described theory fields leads to the question which impact green logistics concepts and instruments will have on traditional dynamics in supply chains, for example the specific research question addressed herein: "Will volatility and bullwhip effect amplitudes *increase* due to green logistics instruments?"

This hypothesis can be depicted in the following figure 3 by the author where the - excess - increase in order lot sizes for each step of the supply chain is expressed in colored fields.

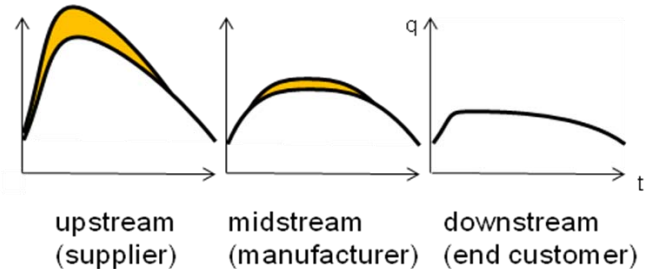

Figure 3: Green Bullwhip Effect

CASE STUDY PREPARATION

In preparation for a case study simulation not yet implemeted the following thoughts have been established as conceptual framework – and have to be combined with new variables and assumptions regarding lead times and lot sizes in supply chain order processes in respect towards green logistics measures.
The following table gives an impression of these impacts of different green logistics instruments.

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

Table 1: Green Logistics Instruments Impact on Supply Chain Volatility

Altogether it can be recognized that most green logistics instruments will cause an increase in volatility and therefore *ceteris paribus* to *increasing* order lot size levels. This could trigger quite significant increases in costs throughout the supply chain as known from quantitative standard bullwhip analyses and simulations.
The described case study is planned to be implemented in a simulation at the beginning of 2012 with first data from the EU airline carbon emissions trading system which started in 2011. Further modeling e.g. with GAMS is planned.

CONCLUSIONS

The presented results have established a first idea about the shape of a green logistics bullwhip effect in logistics. But such simulations and thereafter piloting tests in business practice are very much needed as many legislatory steps as e.g. the carbon emissions trading costs for airlines are decided upon today but will reward changes in transport times, volatility and total supply chain costs in the far future. This could also enhance the overall evaluation of such instruments prior to legislative action and introduction in order to avoid unnecessary economic burdens in the future. Further thoughts about the green bullwhip effect would include for example:

- Specific, time-sensitive 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. Maybe even specified simulation models regarding the quantitative effects of a green bullwhip effect should be conducted specifically for such industries.
- Second an overall strategy concept and simulation analysis for green logistics instruments should be implemented in order to assume better understanding of supply chain-wide consequences of green logistics instruments.
- Third further case studies and simulations are necessary in specific fields and industries in order to prove the existence of the described green bullwhip effect in business practice.

These examples and thoughts emphasize the important need for further research in this field of a green logistics bullwhip effect.

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BIOGRAPHY

MATTHIAS KLUMPP studied economics and business administration after a vocational degree in logistics (Speditionskaufmann IHK Fulda) at University of Leipzig and IECS Strasbourg from 1995 to 1998 (Diplom-Kaufmann, Diplom-Volkswirt). Parallel to his professional consultant career in strategy management, logistics and education (zeb/, conoscope) he obtained a PhD at University of Leipzig in 2007 and started as a professor at FOM University of Applied Sciences Essen.

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