SUSTAINABILITY AND TECHNOLOGY INNOVATION IN LOGISTICS – FRIENDS OR FOES?

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Abstract

In logistics sustainability concepts such as CO_2 footprint measurement, green logistics or empty transport reduction are developed and used in relative isolation from important future technology trends such as RFID, GPS or process automation. This research contribution seeks for an integrated view of the relation between new technologies and sustainability in logistics – and therefore will contribute to the question if the two topics are friends (synergetic relation) or foes (competitive relation). This will help logistics service providers and other supply chain companies to understand the question of sustainability better and improve their future investment and business development planning.

Keywords: Sustainability in Logistics, Sustainability and Technology Innovation

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1. Introduction

In logistics sustainability concepts such as CO_2 footprint measurement, green logistics or empty transport reduction are developed and used in relative isolation from important future technology trends such as RFID, GPS or process automation. This research contribution seeks for an *integrated view* of the relation between new technologies and sustainability in logistics – and therefore will contribute to the question if the two topics are friends (synergetic relation) or foes (competitive relation). This could help logistics service providers and other supply chain companies to understand the question of sustainability better and improve their future investment and business development planning.

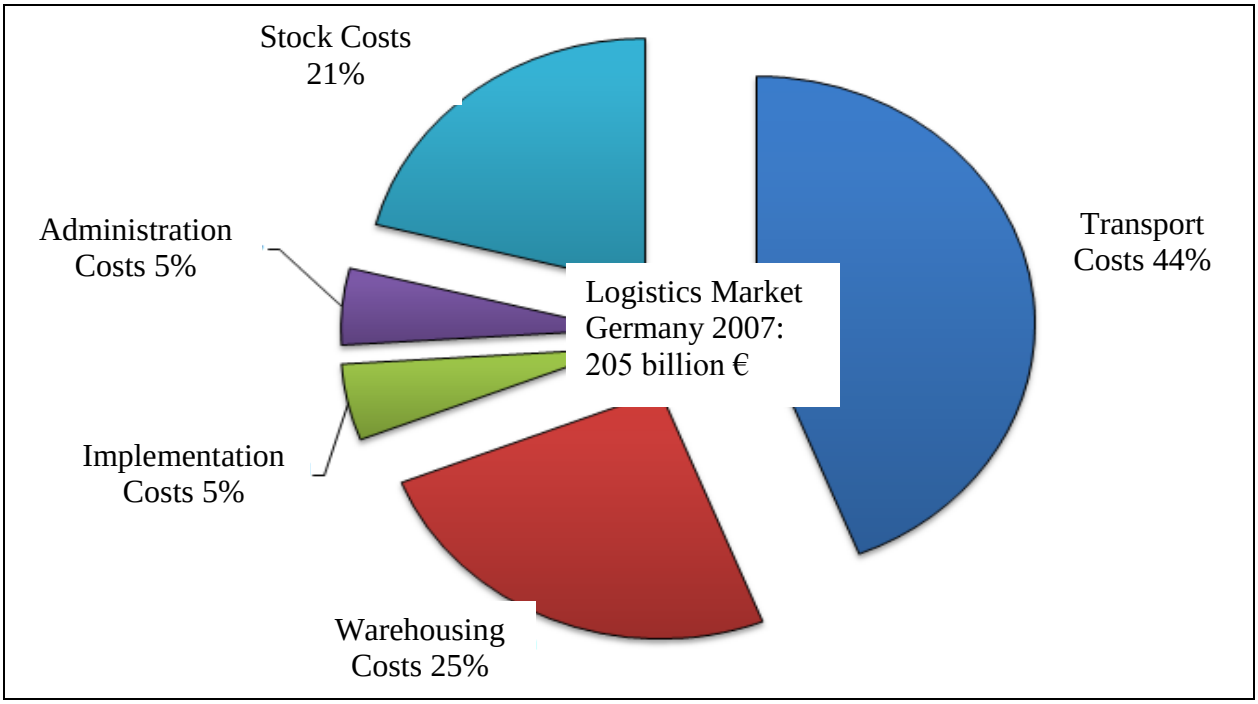

Figure 1: Logistics Market and Functional Segments (Klaus, P., Kille, C. (2008), p. 3)

In 2004 the logistics market in Germany alone amounted to 170 billion Euro.[1] Numbers of FRAUNHOFER for 2007 report a logistics market volume of 205 billion Euro in Germany and 900 billion in the whole of Europe[2] in this sector – therefore this market is growing stronger than the

[1] Cp. Klaus, P., Kille, C. (2006), p. 43, p. 70, p. 80.
[2] Cp. Fraunhofer Institut (2008), p. 1.

general GDP and is positioned on number three after the automotive industry (337 billion Euro) and the machinery industry (219 billion Euro).[3]

Simply the indicated 44 percent transport costs in logistics amount to about 90 billion Euro. The *strategic position of logistics* in any sustainability concept is also highlighted by the fact that e.g. for Germany the export rates drives the logistics market additionally. For Germany this export share of GDP has risen from 16 % in 1995 to 23 % in 2006.[4] But logistics is also fueled by the connected procurement inflows of goods, as most export products (and also services) need the import of raw and module parts, usually from Eastern Europe or Asia. An increasing competition is putting pressure on profit margins and disturbing future outlooks in different areas: Trade companies are facing a logistics cost share 2008 of on average 15,9 % of total costs (compare to industry companies: 7,0 %).[5]

Important driving factors are: Rising fuel prices, road charges, ecological taxes as well as the standardization of logistics services.[6] The German Logistics Association (BVL) is drawing the same bottom line and reporting: "… logistics costs [are] … basically driven by rising energy, fuel, transport and personnel costs."[7] In this context BVL is naming the four most important trends for the future with 'Globalization', 'Sustainability', 'Security' and 'Innovation'.[8] This is highlighted by the following citation from the study:

„Additionally to globalization the logistics industry is harassed by increasing sustainability requirements, increasing security regulations and technology innovation expectations. For the companies asked in the study more and more security and stability questions are posed regarding their supply chains. Besides procurement and marketing risks there are mainly risks regarding natural catastrophes, strikes, terror incidents or supply chain partners going out of business. Expected technology innovations are additionally said to influence their cost situation. And long-term views stress the importance of sustainable logistics concepts."[9]

Moreover the improvement of service quality (e.g. flexibiliy, reliability, reactivity) as logistics objective is ranked before cost reduction objectives – though most of the times a real cost transparency is not a given in logistics systems.[10]

In general definitions of logistics are referring to business administration terms and concepts. But nowadays more and more the reference framework for logistics concepts has to be enlarged towards ecological problems as logistics and transport processes contribute to energy consumption, pollutant and noise emission.[11] Moreover there are specific risks in transporting e.g. dangerous goods.[12] Interdisciplinary views of logistics concepts have therefore to integrate economic and ecologic perspectives as outlined below.[13]

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[3] Cp. Klaus, P., Kille, C. (2008), p. 2.
[4] Cp. Die Bundesregierung (2008), p. 9.
[5] Cp. Straube, F., Pfohl, H. (2008), p. 4.
[6] Cp. Göpfert, I., Hillbrand, T. (2005), p. 48.
[7] Straube, F., Pfohl, H. (2008), p. 3.
[8] Cp. Straube, F., Pfohl, H. (2008), p. 1.
[9] Straube, F., Pfohl, H. (2008), p. 1.
[10] Cp. Straube, F., Pfohl, H. (2008), p. 2.
[11] Cp. e.g. Eickmann, C. (2002); Eisenkopf, A. (2006); Zelewski, S., Saur, A., Klumpp, M. (2008).
[12] Cp. Klaus, P., Krieger, W. (2004), p. 547.
[13] Cp. Muchner, C. (1997), p. 41.

Logistics and innovation are a ‚natural pairing' as shown by the basic optimization orientation of logistics by definition as well as the following citation:

„There is no question if the logistics industry is innovative or not – but we lack the specific and empirically grounded knowledge about causes, success factors, hurdles and internal as well as external requirements for innovation competence, innovation actions and successful innovation management in industry and retail companies with core logistics functions (about 55% share) as well as logistics service providers (about 45% share).“[14]

Innovations are not restricted to single companies in supply chains: The running German central government is aiming at improving the leading frontline position of logistics in Germany. This is underpinned and detailed in the concept 'Master Plan Logistics Germany of 2008' and is rich with technology and innovation policies.[15]

Logistics is an interesting field for studying the *interaction* of sustainability and technology innovation as most companies due to a PriceWaterhouseCoopers survey invest in new technologies (e.g. new transport equipment, new handling equipment) in order to improve their ecological impact and at the same time their cost situation as depicted in figure 2.

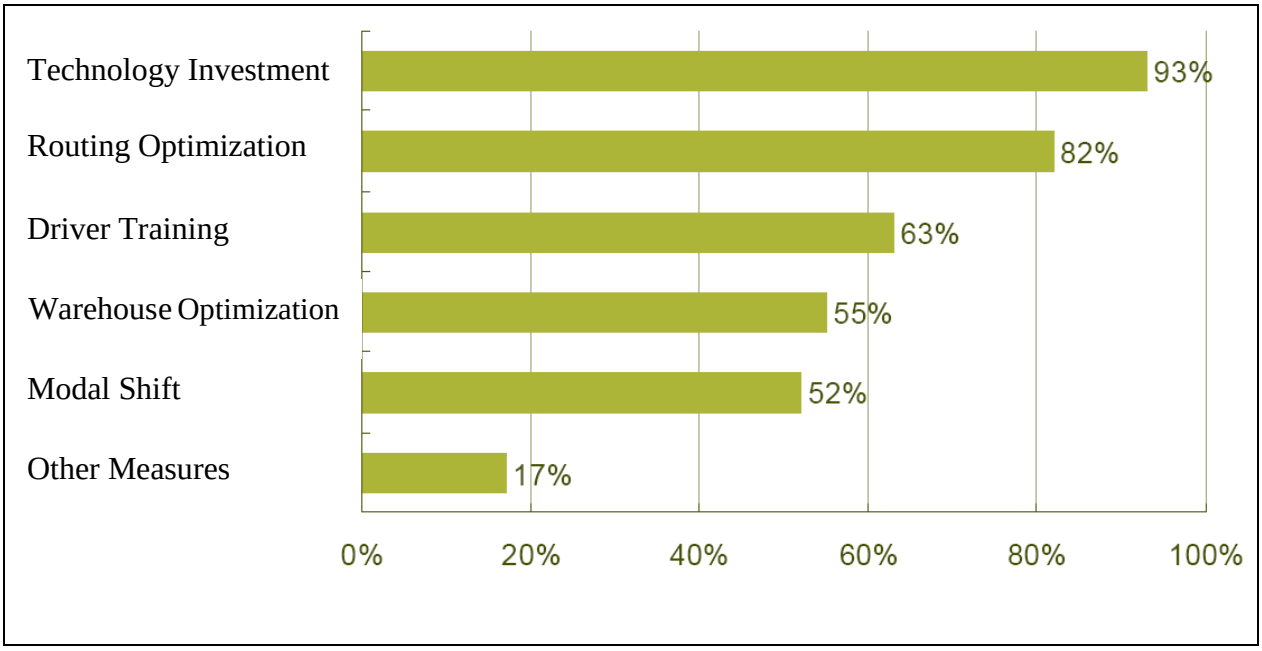

Figure 2: Sustainable Investments in Logistics (PWC 2009, p. 9)

At the same time the *potential* in improving sustainable solutions is still high in the logistics sector: For example *carbon footprint measurement* is today expected only by 28% of the customers of logistics service providers in Germany in the PWC study, but 48% of the customers

[14] Voß, R. (2008), p. 5.
[15] Cp. Die Bundesregierung (2008), p 9.

of logistics service providers who act globally.[16] Therefore a growing interest and also *impact potential* for technology innovation in the context of green logistics solutions can be expected and should foster the research interest in this field. Especially the *synergies* or *conflicts* of logistics technology investments regarding the sustainability should be discussed.

2. Economic Perspective

In the logistics industry advertising and a common brand name may support a logistics service provider to be successful – but profits are not resulting from this external activities but from internal economic or business administration concepts and measurements. A study of CapGemini with 300 participating companies from the sector shows that stock keeping optimization or procurement price reduction has more impact on short-term profits than long-term supply chain management projects.“[17]

2.1. Warehouse Concepts

Many companies for example follow *warehouse centralization* concepts - to be distinguished in *vertical* and *horizontal* centralization, with vertical defining the number of stock keeping levels and horizontal denominating the number of warehouses per level. Therefore in the horizontal dimension the number of warehouses defines c.p. the *throughput* in each single warehouse per stock keeping level – with centralization concepts enlarging this throughput significantly. Each warehouse has to handle a significantly higher number of goods in the same time period – enabling the company to use economies of scale in throughput handling as well as in transport delivering from this warehouse (but accepting higher transport cost caused by longer distances in the distribution area attached to one single warehouse).

In addition safety stock levels can be lowered. And most important for technology innovations: The number of affected places when introducing new technologies as e.g. RFID is diminished – reducing *introduction costs* significantly. In this case innovation and sustainability may be *foes* as a lower innovation barrier on the one hand is resulting in significantly longer transport routes on the other hand (concept B). Assuming a constant throughput for concept A and B (figure 3) of 500 tons and an equal distribution of this throughput among warehouses it is clear that concept A means 100 tons throughput per warehouse and a small distribution area.

In concept B one has to face longer transport distances but can operate with only two warehouses with 250 tons throughput each. Therefore a typical and modern logistics concept of warehouse centralization has got the following effects on innovation and sustainability, showing that a final decision is not possible in general, but each and every effect has to be measured in individual cases:

(a) Fixed cost reduction and better economies of scale,

(b) Lower innovation hurdles through lower number of logistics assets,

[16] Cp. PriceWaterhouseCoopers (2009), p. 11.
[17] Cp. http://www.logistik-inside.de/cms/829264, date: 03. April 2009.

(c) Potentially *lower* ecological impact (energy, pollution, noise) through larger transport volumes (bundling effects),

(d) Potentially *higher* ecological impact through longer transport distances.

Stock keeping strategies usually are depending on production and procurement strategies as well as distribution strategies – with higher lot sizes in production and procurement indicating more centralized warehouse structures than smaller lot sizes and more points of origin (suppliers) and points of destination (customers). In addition first-rate communication, handling and transport technologies have to be implemented in order to operate successful central warehousing concepts.[18]

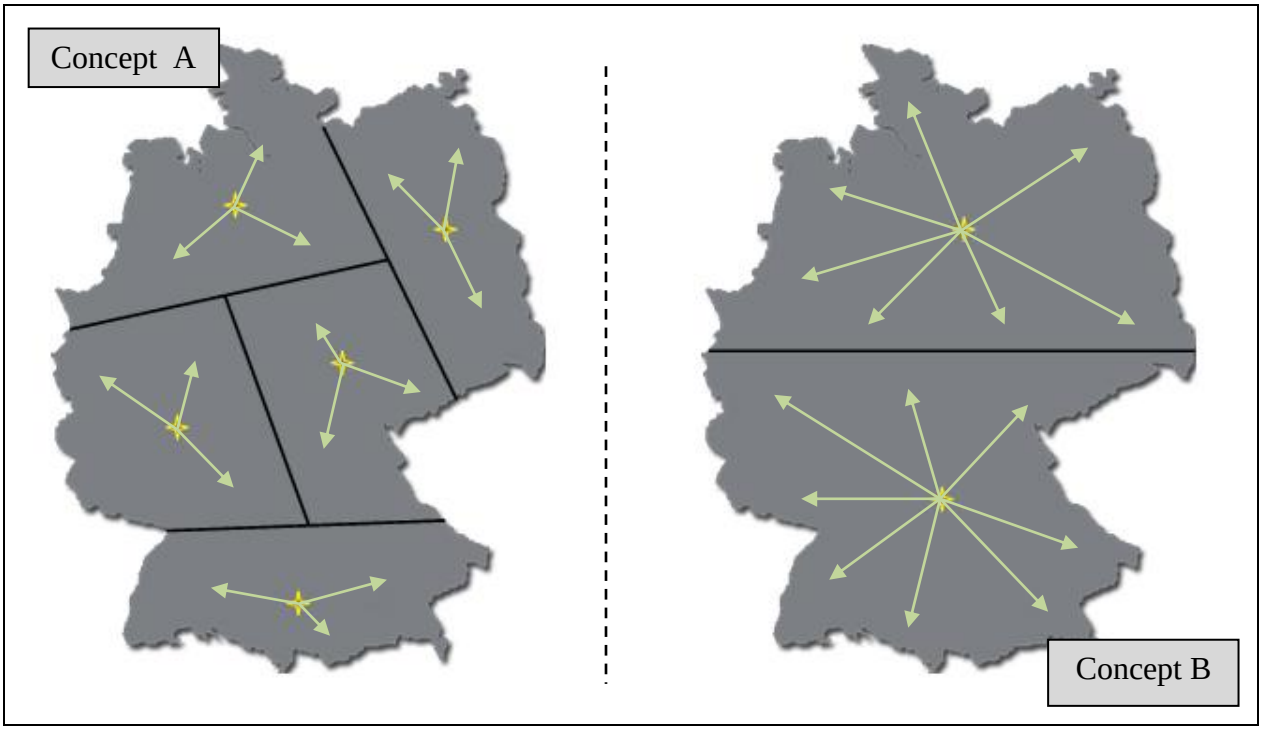

Figure 3: Stock Keeping Centralization (Germany)

2.2. Logistics Service Levels

In order to control such concepts KPI as e.g. stock keeping unit (SKU) availability or distribution service level are measured in order to manage stock efficiently. Also this service level can be influenced by new technologies and has distinctive impacts on sustainability: A low service level leads to missing stock costs (production or earnings failures) but allows for smaller warehouses and transport lot sizes and therefore a lower ecological impact. But a very high service level also implies high stock keeping costs as well as sustainability failures through (too) high stock levels

[18] Cp. Delfmann, W. (2004), p. 520.

and transport demands. Therefore an optimization in this area leads to possible synergies in both areas, economic and ecologic.

The logistics companies speak the same language: The 10 most important SCM projects today are driven in 48% by stock keeping measurements, 45% by strategic supply chain measurements and 44% by improvement of long term planning.[19]

This proves that technology innovations can contribute to both areas in terms of improving stock keeping as well as handling efficiency – the leading to economic as well as ecologic beneficial results. For example warehouse automation is greatly welcomed by all participants in logistics in order to reduce missing SKU in rolling in and rolling out processes in a warehouse.

Besides the physical effects of such new technologies the information (IT) area is highly important to such concepts – as enabler as well as an instrument to further improve the planning and steering process in order to reach higher efficiency levels.[20] It has to be controlled accordingly that investment and change-over costs have to be earned economically by cost reduction effects of these concepts.

2.3. Logistics Outsourcing

A further discussion point in logistics could be the ongoing improvement through insourcing or outsourcing concepts: On the first view this has not much in common with technology development or innovation. But in the details of logistics processes and outsourcing it can be recognized that most companies do implement new technologies as core business advantage when tackling outsourcing.

	Strategic Competitive Advantage	**Operative Cost / Quality Advantage**
Outsourcing	Economies of scale and external synergies by bundling similar logistics services for several customers	Reduction of factor costs by structural or opportunistic causes, integration of external logistics know-how
Insourcing	Economies of scale and internal synergies by bundling different services of one single customer	Profiteering of sales and profits of third companies by insourcing, supporting and extending internal know-how

Figure 4: Results of Insourcing versus Outsourcing (Klaus, P., Krieger, W. (2004), p. 256)

[19] Cp. http://www.logistik-inside.de/cms/829264, date: 03. April 2009.
[20] Cp. ten Hompel, M. (2008), p. 16.

These logistics descriptions can also be understood as technologies changes. The economic efficient use of technologies follows similar routes as described for logistics outsourcing above. And moreover outsourcing brings in new technologies ("external know-how") which highlights the important role of producers and logistics service providers as change agents in logistics outsourcing projects. This could lead to operative cost and quality advantages – sometimes also to improved resource efficiency in terms of energy consumption or other. This depends to a great extend on the right point of time for investing in such new technologies – often this point of time is defined through The optimization of interfaces has traditionally been one of the core logistics topics and has now an increased importance due to global supply chains. Therein the efficient information use and transmission is a very important subtask in order to steer stock levels and transport flows.[21]

This should lead to the reduction of out-of-stock situations, requiring modern information architectures and systems in order to avoid negative effects on stocks and transports flows respective levels of the so called bullwhip-effect. This effect is also called Forrester-, Whiplash- or whipsaw-effect and describes the empirical measured effect of rising lot and stock sizes along a supply chain due to lacking information. As described in the stock keeping concepts this could lead to inefficiencies economically as well as ecologically due to higher than necessary transport lows and warehouse sizes with stock levels.[22]

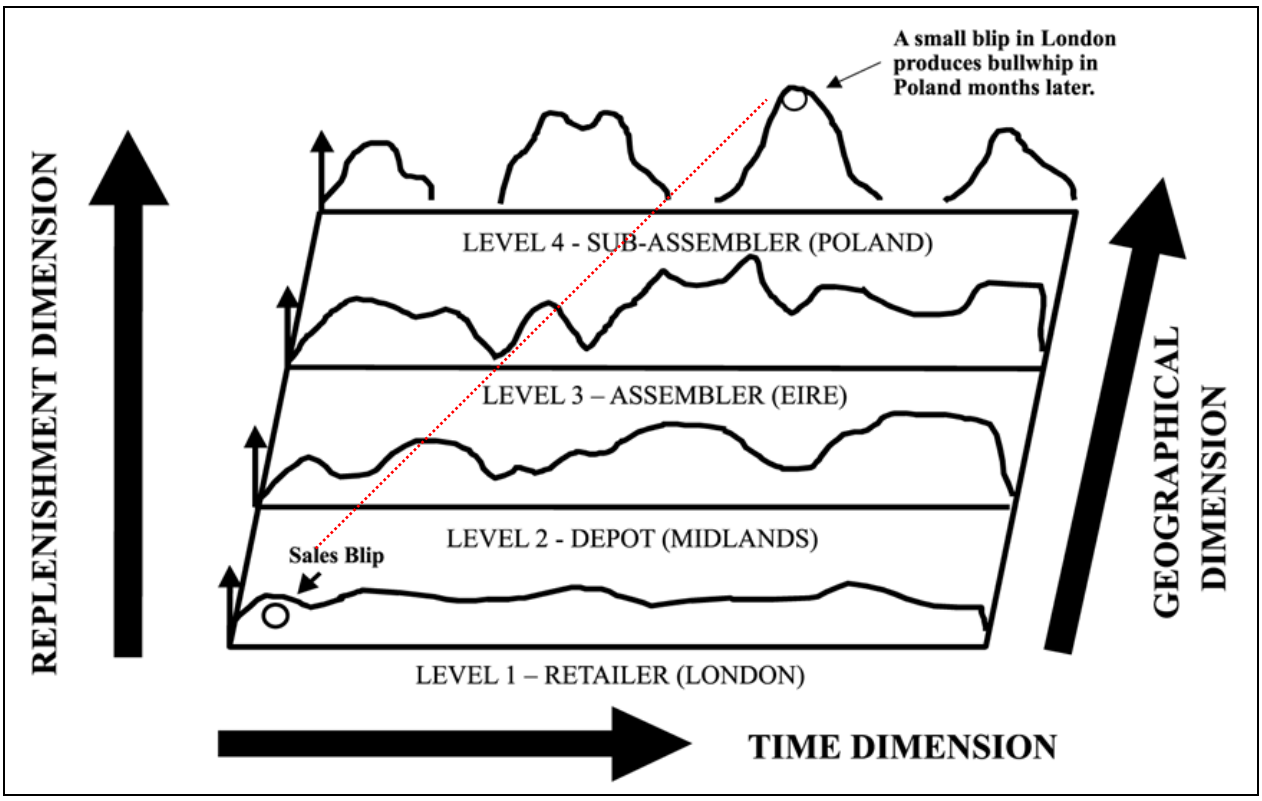

Figure 5: Bullwhip Effect (McCullen, P., Towill, D. (2001), p. 533)

[21] Cp. Klaus, P., Krieger, W. (2004), p. 455.
[22] Cp. Klaus, P., Krieger, W. (2004), p. 155.

The figure above shows also the locally distributed nature of such bullwhip-effects (London-Poland), affecting several countries and therefore consuming a lot of energy and costs. One measurement against these effects is called baton passing: This describes overlapping frontiers between two activities, meaning one has not to be finished completely in order to start the second activity e.g. transporting the goods to the sales house.[23]

Another option is the so called vendor managed inventory: In this case the supplier receives constant information about the changes in stock and transport status of all goods in the supply chain. According to this information the supplier is steering the supply of goods in the supply chain and can therefore possibly reduce stock levels and transport flows.[24]

All these concepts rely on best possible technologies for information recognition (automated) and analysis by computers. The better and faster this can be achieved through technologies (Barcode, IT, RFID, GPS), the better can steering impulses and therefore efficiencies be achieved.

3. Ecological Perspective

As early as December 1993 the sentence was coined that „environmental issues are one of the most important of our time.“ [25] The general importance of sustainability concepts has more likely risen than fallen in the last 16 years since then. The public conscience in terms of such issues is mainly addressed by big incidents such as Seveso 1976, Tschernobyl 1986 or Exxon Valdez 1989. These examples are more or less tragic incidents which could have been avoided in each and every case – though there is a general statistical probability in total for such events to happen.

Logistics has to face another significant ecological threat: The effects and causes of ‚creeping' emission in the context of logistics and transport processes. For example the specific pollutants CO_2 and NO_x are emitted in road transport and travel. Therein CO_2 accounts for roughly 9-26 %[26] of the global greenhouse effect and NO supports ozone layer destruction. In a long-term perspective the greenhouse and ozone displacement effect are named in an interdependent concept – though they are basically in terms of causes as well as reduction concepts two different phenomenons.

For the ozone layer hazardous FCKW and also ozone (O_3) itself belong to the greenhouse gases. They are nevertheless because of their small volume not causing huge negative effects or harm. The Max-Planck-Institute for meteorology in Hamburg despite this warns that an increasing greenhouse effect may accelerate the ozone layer destruction.[27] Since 1994 the ozone leak is starting to close back in – leaving scientists in doubt about the forecast of near recompletion. NASA for example estimates that about the year 2068 will bring a near-original status of the ozone layer. [28]

[23] Cp. Klaus, P., Krieger, W. (2004), p. 36.
[24] Cp. ten Hompel, M. (2008), p. 237.
[25] Ventzke, R. (1993), Vorwort, o. S.
[26] Cp. Kiehl, J. T., Trenberth, K. (1997), p. 197.
[27] Cp. www.mpimet.mpg.de, date: 18. März 2009.
[28] Cp. www.earthobservatory.nasa.gov, date: 18. März 2009.

This will require totally new technology concepts in order to reduce such causes and pollution. This can happen by the way of different concepts based in different technologies to be described as follows:

- Reduction of direct emissions by road transport for example by more efficient motors, energy recycling systems, hybrid driving systems and others.
- An optimization of equipment used by implementing state-of-the-art information technologies in order to reduce for example empty transport legs in different transport systems as e.g. road, rail, sea or air.
- A contribution to a reduction of waste could be reusable packaging. This would bring a closed loop systems to many supply chains from the logistics point of view. Optimized packaging could help to reach more economic and also ecologic transport processes and poses therefore a perfect synergy potential for these areas – though many of those could not necessarily be termed 'high-tec'.[29]
- The secure handling of goods transport especially in the areas of recycling and dangerous goods is an important end environmentally crucial task in logistics. The relevant German legislation (GGBefG) defines not only the transport but also the handling processes (loading, unloading, storage) as relevant act under this regulation. Also in this area new technologies in terms of avoiding, handling and storing such waste and dangerous goods can improve the sustainability concept in logistics. For example environmental 'hot spots' are the final storage points for radioactive material in Asse II' (Wolfenbüttel) and ‚Gorleben' in Germany.
- A reduction of traffic and pollution especially in inner city logistics by cooperative city logistics concepts can be supported by matching information technology concepts. This requires the cooperation of several logistics companies and aims at efficient transport flows in highly populated areas (inner cities) with their traffic restrictions.[30]

As green logistics concepts gains importance and publicity many logistics service providers and also industry companies offer such concepts and projects regarding sustainability: For example Procter & Gamble promises to rise the share of rail transports from 10 to 30 percent until 2015 in order to reduce road traffic with all its emission and negative external effects. The products of this company travel 200 million kilometers alone in Western Europe annually. The announced modal change towards rail transportation would potentially save up to 67.500 tons of CO_2 per annum.[31]

The German logistics service provider DHL / Deutsche Post is offering business customers to post their surface mail ‚climate change neutrally' as ‚GO GREEN' products – with a promised complete analysis of all emitted CO_2 amounts during the transport and the later remission by e.g. renaturalization of wood areas in order to bring back the emitted CO_2.[32]

Moreover many concepts are implemented today in Germany and the European Union in order to reduce the emission of respirable dust by lorries and cars in order to improve living quality and

[29] Cp. Ullrich, R. (1996), p. 3.
[30] Cp. Klaus, P., Krieger, W. (2004), p. 85.
[31] Cp. http://www.logistik-inside.de/cms/827984, date: 02. April 2009.
[32] Cp. http://www.logistik-inside.de/cms/827984, date: 02. April 2009.

also public health in cities. Studies show that such reductions can increase living quality and also living expectation significantly by 15 percent. [33] Further topics for the interaction of technology and innovation in sustainable concepts are for example:

- land use,
- energy consumption,
- air pollution,
- resource consumption,
- residues,
- water consumption and water pollution

and other ecological effects.

4. Logistics and Sustainability in Business Cycles

The ongoing world finance crisis can have two different impacts on technology investments: On the one hand technologies and investments are introduced slower than planned. On the other hand there are also companies increasing their investments (*antonym movement*): According to a PWC study 42% of logistics companies are postponing technology and sustainability investments due to the actual crisis – whereas 33% are increasing their investment in order to cut costs.[34]

Also in sea shipping logistics similar investment reductions are reported. For example Hapag-Lloyd is reacting to the economic crisis with cost reductions worth about 400 million Euro.[35] „Every investment possible is postponed"[36] says the CEO Michael Behrendt. The Hamburg Port Authority HHLA is planning to cut investment projects due to work and turnover shortages.[37]

But in the logistics sector there are also companies with increasing investment plans: For example the German company ‚Voigt Logistik' is not postponing investments in new warehouses and lorries.[38] But especially road and bridge building projects are profiting from the business crisis. According to PriceWaterhouseCoopers (PWC) is posing a mighty chance to the German traffic infrastructure – the German government plans to invest 14 billion Euro in this sector.[39] In a CapGemini study two out of three supply chain managers said, the crisis is the most important factor for their actual decisions. As second important factor customer requirements were named and place three was referred to as the quest for sustainability.[40] In general it can be said that technology enhancements are necessary from an economic as well as an ecological perspective – and this is independent from business cycles.

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[33] „A reduction of respirable dust emissions of ten microgram per cubic meter air has increased the life expectancy by 0.6 years on average write epidemiologists around C.A. Pope of Brigham-Young-University in Provo (Utah) in the journal `New England Journal of Medicine` (Vol. 360, p. 376)"; http://www.logistik-inside.de/us-studie-weniger-feinstaub-erhoeht-die-lebenserwartung-800564, date: 03. April 2009.
[34] Cp. PriceWaterhouseCoopers (2009), p. 12.
[35] http://www.logistik-inside.de/cms/826856, date: 02. April 2009.
[36] Cp. http://www.abendblatt.de/daten/ 2009/03/25/1098026.html, date: 02. April 2009.
[37] Cp. http://www.logistik-inside.de/cms/828626, date: 02. April 2009.
[38] Cp. http://www.kn-online.de/schleswig_holstein/wirtschaft/68753_Fest_verwurzelt_und_nicht_bange.html, date: 02. April 2009.
[39] Cp. www.pricewaterhousecoopers.de (2009), date: 02. April 2009.
[40] Cp. http://www.logistik-inside.de/cms/829264, date: 03. April 2009.

5. Integrated Development Perspective

An integrated perspective with a joint analysis of technology innovation and sustainability improvements should help especially in the logistics sector

a) to improve technologies and therefore *efficiency* and also

b) to provide an *economic* cost reduction in order to

c) enhance *ecological* efficiency at the same time.

The following analysis scorecard may contribute as a first suggestion to this concept improvement in managing logistics innovation and sustainability in logistics (figure 6).[41]

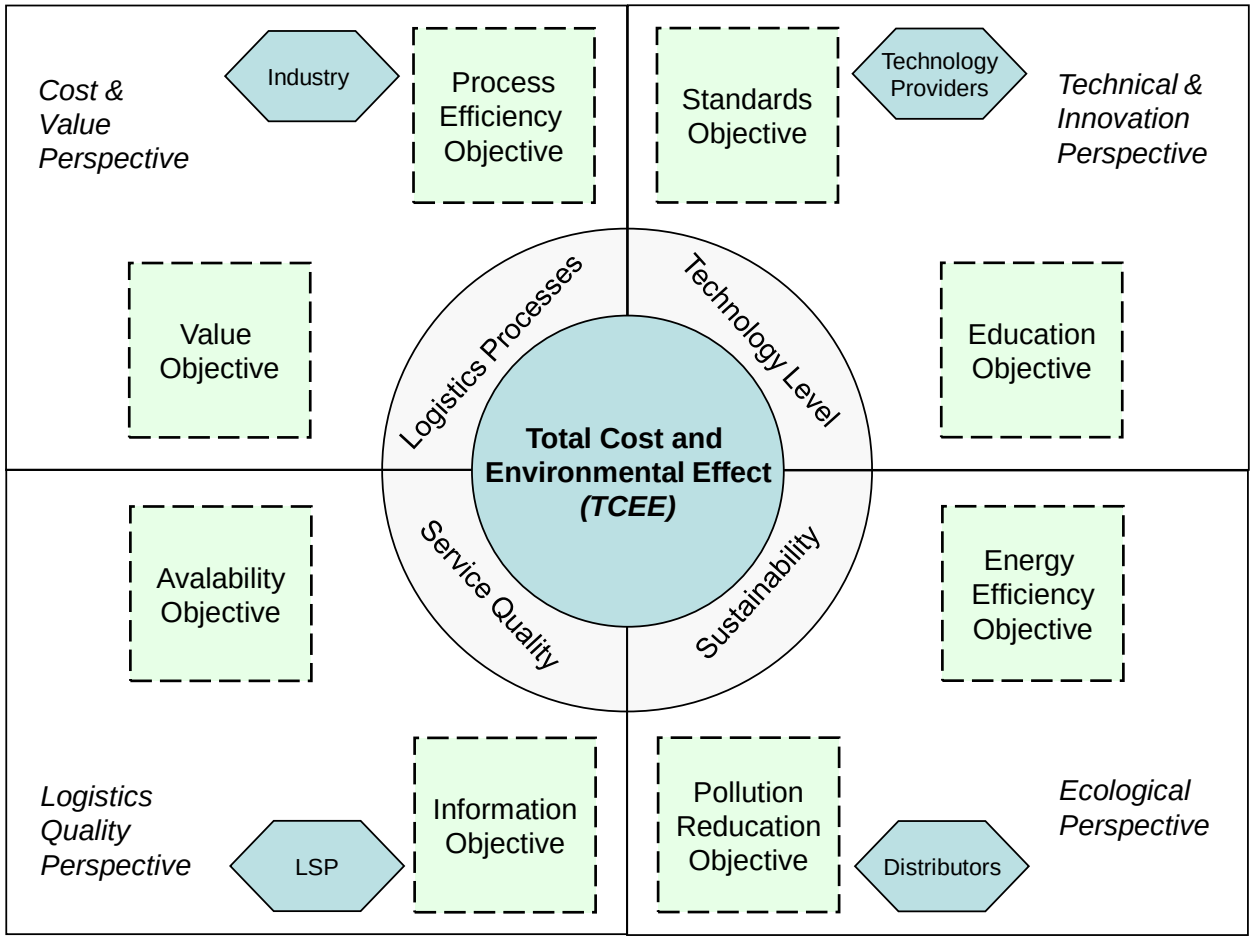

Figure 6: Technology Innovation and Sustainability Assessment in Logistics (*TISAL*)

Future contributions may improve this first draft in terms of empirical piloting and testing as well as concept amendments.

[41] Cp. Klumpp, M., Ostertag, M. (2008); Jasper, A., Klumpp, M. (2008).

6. Conclusion

As shown by this research contribution for research as well as for practitioners the question of technology innovation and sustainability in logistics is not an easy to answer one. Therefore more emphasis has to be put on further research and empirical evaluation. But even so some *major pointers* can be given ahead in the direction of practical logistics implementation and projects:

a) First of all *both objectives* of technology innovation and sustainability should be included in any planning and concept outlining activities in logistics by all partners in supply chains.

b) Second *awareness* has to be enhanced that there are some crucial concept decisions as e.g. shown for warehousing structures which define the interaction of techn0ology innovation and sustainability on a long-term basis. Therefore such decisions should be reviewed more comprehensively and in-depth including also the two named objectives as decision criteria.

c) And third a "positive hunt" for *best practice examples* should be established in companies searching for and communicating positive examples for concepts integrating technology innovation and sustainability in logistics and therefore providing synergies between these two crucial objectives.

This can enhance the chances to find technology and sustainability on the same side as friends instead of foes - which would benefit all partners in modern supply chains.

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