ABSTRACT
With the ever increasing focus on cost reduction, product leadership and customer intimacy, the need for Supply Chain Management practices rises across many industries. Over the last two decades Logistics Service Providers have become important players in many chains and industries. New challenges arise due to the emergence of technologies. Data and information can be found anywhere, however, to make the proper decisions we need to have an insight in how decisions should be made, and what is important for the company and what not. In order to do so we solicited the Key Performance Indicator (KPI) literature -focussing on the areas of general management, supply chain management, logistics service provision and warehousing. In our earlier work we proposed a KPI framework that we here revisit and validate in the Warehousing domain – through the means of expert interviews.

Keywords: Performance Measurement, Logistics Service Provision, Warehouse Management

INTRODUCTION
The increasing importance of efficiency and a focus on core competencies opened up many business opportunities for logistics service providers (Christopher, 1998). Customers increasingly expect shorter delivery times and more accurate services. As a result control of logistics service providers increases in complexity. Performance indicators can support the management of complex systems. The increasing use of information and communication technology – also in small and medium sized companies – facilitates data collection on a broader scale and could lead to more extensive performance measurement (Melnyk et al., 2004). This literature study constitutes the fundament of a broader research, in which we examine performance measurement of logistics service providers. With this literature review we want to answer the questions: What performance indicators for logistics service providers are proposed in literature? And how does industry rate the usefulness of found performance indicators?

In order to find the performance indicators for logistics service providers, we conducted a literature review in several fields: literature on performance measurement in general, literature on logistics and
supply chain management, and literature especially undertaken in logistics service provision industry and warehouse management. Based on this literature review and our experience in industry we established a framework of performance indicators and empirically evaluated its usefulness. We end with conclusions and further research directions. This work is based on previous research (Krauth et al., 2005a, Krauth et al., 2005b). We extend our earlier work for performance indicators for warehouse management. This is reflected in the literature review, the list of key performance indicators and we also empirically validated our findings with an expert in logistics service provision including warehousing.

LOGISTICS SERVICE PROVIDERS - DEFINITION
We follow the approach of Krauth et al. (2004) to describe and classify different forms of logistics service providers. Third party logistics providers (3PL) are typically addressed in the context of long-term outsourcing of logistics activities by a manufacturer (Sink et al., 1996; Razzaque, 1998). Carriers and shippers are labels for providers and buyers of transportation (Gibson et al., 2002). Freight forwarders are referred to as international trade specialists, offering a variety of services to facilitate the movement of international shipments (Murphy et al., 1992; Murphy and Daley, 2001). Shipping lines and shipping companies are conducting activities of transport and can be further distinguished into e.g. ocean freight shipping liners or ocean liner shipping (Durvsula et al., 2002; Fusillo, 2003). We define logistics service providers as companies, which perform logistics activities of a customer either completely or only in part (Delfmann et al., 2003; Lai, 2004). These functions can include traditional activities such as transporting, warehousing, packaging, etc. but also less conventional activities as those related to custom clearance, billing as well as tracking and tracing.

Regarding warehousing activities one can distinguish dedicated and public warehouses. Dedicated warehouses are typically based on a long term contract and are built in cooperation with the shipper. This allows to organize processes and design information systems, such that they smoothly integrate with the shipper. The level of automation is very high, allowing an efficient handling of goods (e.g. bus systems). The logistics service provider might even act as a call center for the shipper. Public warehouses on the other hand, serve on average around five customers. The warehouse is developed independently from the customers of the logistics service provider. The relationship can often be characterised as short term, level of process integration and automation are significantly lower than in dedicated warehousing. The relationship of a logistics service provider with his client can also be distinguished according to whether an open book or closed book approach is taken. In closed book arrangements the price is negotiated on a yearly basis and typically does not change during that time. In an open book environment on the other hand, the logistics service provider and his customer examine every month the cost situation. If it turns out that e.g. late shipper notifications led to an increase in costs, the price can be adapted accordingly.

LITERATURE REVIEW PERFORMANCE MEASUREMENT
We review the literature starting from general management perspective and then zooming in to supply chain management, logistics service provision as a special case of a supply chain and finally warehouse management as a specific activity within logistics service provision.

General management
Three purposes of metrics can be identified as (Melnyk et al., 2004): control, communication and improvement. According to Melnyk et al. (2004) literature has until now mainly focused on the use of
metrics, but less on generating metrics and putting them into execution. They mention several reasons for an increased interest in performance measurement: (1) ever changing and ever increasing demands of customers, (2) the moving focus from internal operations to a chain of collaborating companies (3) decreasing product life cycles, (4) increased amount of data (not necessarily data quality) and (5) growing number of options a company can choose from. Metrics need to move from static measurement to a more proactive style. Metrics will contribute to creating competitive advantages if they also allow on the spot recognizing of business opportunities as well as business threats.

The balanced scorecard is a framework that measures a company’s performance in an integrated manner. It provides a formalized mechanism to achieve a balance between non-financial and financial results across short-term and long-term horizons and is based on the notion that companies have to aim at a true integration of marketing, production, purchasing, sales and logistics (Brewer and Speh, 2000). The balanced scorecard distinguishes four main perspectives (Kaplan et al., 1992): customer, internal, financial, and innovation & learning. The customer perspective deals with how the company performs from an external standpoint. Kleijnen and Smits (2003) propose the use of the balanced scorecard in order to deal with multiple performance metrics in SCM. Knemeyer et al. (2003) examined the perspective of a logistics service provider’s customer. If the customer perceives that the logistic service provider focuses on the interaction between the companies and is concerned with winning and keeping the customer, the relationship can be strengthened. Stank et al. (2003) conducted a survey, which addressed a logistics service provider’s performance and how it related to market, customer satisfaction and loyalty. The model distinguishes between three different kinds of performances: relational performance, operational performance and cost performance.

The internal business perspective translates the customer perspective into what the company must do in order to meet its customer’s expectations. Continuous change is required. For a logistics service provider these innovations can mean to change business strategies such as a change from short to long distance transport, adding additional activities, new countries, new modes of transport, new communication systems such as RFID or WebServices (Chapman, et al. 2003, Lemoine and Dagnaes., 2003). Financial performance indicators measure whether the company’s strategy, implementation, and execution are contributing to bottom-line improvement.

Performance measurement in supply chain management
Supply chains can typically be categorized into either efficient or responsive supply chains (Fisher, 1997). Christopher and Towill (2002) make a similar distinction into lean and agile. Logistics service providers must be aligned with the supply chain they serve; measuring flexibility, efficiency and responsibility levels is a first step. Weber (2002) is using a hierarchical model to measure supply chain agility. The SCOR model further provides insight into metrics and indicators of supply chains (SCOR - Supply Chain Council, 2003; Stewart, 1995) However, the SCOR model was originally developed for manufacturing processes and therefore it might not be directly applicable to logistics service provision (Lai et al. 2004).

Strong partnerships form the basis of supply chain management. Partnership evaluation criteria are (Gunasekaran et al., 2001): level and degree of information sharing (Mason-Jones and Towill, 1997), buyer-vendor cost saving initiatives (Thomas and Griffin, 1996), extent of mutual co-operation leading to improved quality (Graham et al., 1994), entity and stage at which supplier is involved (Toni et al., 1994) and extent of mutual assistance in problem solving efforts (Maloni and Benton, 1997). However, Kemppainen and Vepsaelaeinen (2003) suggest, that it is neither feasible nor profitable to have strong
collaboration with all supply chain partners. Logistics service providers should select key customers and focus on strengthening these relationships.

Another important point regarding supply chain management is the use of information systems (Sanders and Premus, 2002). Information systems support the integration of inter-organizational processes (Hammer, 2001). Ross (2002) shows that IT investment can have a positive impact on market performance as a result of better coordination in the value chain. However, putting such a high level of collaboration into practice is not easy. Both information quality and relationship commitment play an important role (Moberg and Speh, 2002).

Performance measurement for logistics service provider
Logistics service providers offer services in a wide variety of areas (Sink et al., 1996) – see Table 1: transportation, warehousing, inventory management, order processing and value added services. Lieb and Kendrick (2003) report that third party logistics service providers also offer services such as contract manufacturing, assisting customers with purchasing and offering financial services (e.g. insurances, real estate, et cetera). Engaging in e-commerce was perceived as the single most important business opportunity for the surveyed companies. Logistics service providers are further trying to expand their activities outside their home country (Lemoine and Dagnaes, 2003).

<table>
<thead>
<tr>
<th>Table 1: Activities of logistics service providers (based on Sink et al., 1996)</th>
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<tbody>
<tr>
<td><strong>Transportation</strong></td>
</tr>
<tr>
<td>Shipping, Forwarding, (De)consolidation, Contract delivery, Freight bill payment / audit, Cross-Docking, Brokering</td>
</tr>
<tr>
<td><strong>Warehousing</strong></td>
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<tr>
<td>Storage, Receiving,(Re-) Assembly, Return goods,</td>
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<tr>
<td><strong>Inventory Management</strong></td>
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<tr>
<td>Forecasting, Cocation analysis, Consulting</td>
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<tr>
<td><strong>Order processing</strong></td>
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<tr>
<td>Order entry/fulfilment, Consignee management, Call centre</td>
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<tr>
<td><strong>Information Systems</strong></td>
</tr>
<tr>
<td>EDI, Routing/scheduling, Artificial Intelligence, Expert systems, Barcoding, RFID, Web-based connectivity, Tracking and Tracing</td>
</tr>
<tr>
<td><strong>Value-added activities</strong></td>
</tr>
<tr>
<td>Design and Recycling of packaging, marking/labelling, billing, call center activities.</td>
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</table>

The literature has examined a variety of measures to measure general or specific performance of logistics service providers regarding transport activities (Van Donselaar et al., 1998), timeliness and accuracy (Bromley, 2001; Johnson, 2001), delivery performance (Stewart, 1995), personnel scheduling and safety measures (Crum and Morrow, 2002; Mejza et al., 2003). See Fowkes et al. (2004) for a discussion on how reliability and predictability is valued in industry. Mentzer and Konrad (1991) define performance measures in five sub-areas of logistics: transportation, warehousing, inventory control, order processing and logistics administration. Logistics service providers can also be distinguished based on characteristics of customer relationships (Knemeyer et al., 2003), customer satisfaction and loyalty (Stank et al., 2003). Findings of Lai et al. (2004) suggest that perceptions of shippers and consignees differ. For a more in-depth examination of logistics service provision literature we refer to (Krauth et al. 2005a, Krauth et al. 2005b).

Performance measurement of warehouse management
Faber et al. (2002) examine information systems for warehouse management. In their exploratory study they examine complexity of warehouses and control structure. Complexity of warehouse management is indicated among others by amount and heterogeneity of handled products, the extent of overlap between them, amount and type of technology as well as characteristics of associated processes. Their
findings suggest that warehouses with a high daily amount of processed orderlines and amount of stock keeping units will be best supported by customized software.

Moberg and Speh (2004) study the process of selecting logistics service providers in order to outsource warehousing. Their empirical evidence is based on a survey in the US to customers of logistics service providers that offer warehousing activities. According to their findings, the most important indicators for choosing a particular logistics service provider are related to responding to service requests, general management and ethical issues. Criteria that seem to be less important are the risk affinity of logistics service providers, information technology, company size and coverage.

Colson and Dorigo (2004) present a software tool which allows to select public warehouses. Their extensive list of decision criteria includes: storage surface and volume, dangerous items, possibility for temperature control, separation of storage areas, control for temperature humidity, ventilation, offices on site, geographical distance to highway connection, train, waterways, certification (ISO 9001/9002, SQAS, HACCP), opening hours, assistance with customs, use of technology such as RFID/Barcoding, modem connection, handling equipment (electric, gas and diesel/petrol forklifts) number and characteristics of docks.

Also personnel of warehousing departments has been addressed in literature (Autry and Daugherty, 2003). They studied the fit between the warehouse and its employess, worker satisfaction and how warehousing employees cope with stress.

Rogers et al. (1996) examined whether the use of information technology affects performance of warehouses. They conducted a survey including both public and dedicated warehouses. Their findings suggest that the use of information technology is related to several positive outcomes, such as improvement of quality, cycle times might be reduced as well as an increase in productivity. The Fraunhofer Institut für Materialfluss und Logistik examined a wide range of warehouse management systems (Fraunhofer Institut für Materialfluss und Logistik, 2005). They use more than 2500 criteria to examine whether a warehouse management system fits to the respective company. They assess among others indicators such as: product range, user environment and system characteristics, basic functions such as order processing, inventory management, means of transport and typology of storage.

OUR FRAMEWORK
The literature overview presented in the previous section supports the view that a new framework for performance indicators can be beneficial in the area of logistics service provision. For further explanation of our framework we refer to earlier studies (Krauth et al., 2005a, Krauth et al., 2005b). Based on the literature review we classify performance indicators according to the perspective of different stakeholders: manager, employee, customer and society. We further refine the managerial perspective into: effectiveness, efficiency, satisfaction as well as IT & innovation. We compiled a list of more than 130 key performance indicators, which we classified in our framework (Table 2). Indicators which are marked with an Asterisk (*) are especially relevant for warehousing operations.

FRAMEWORK EVALUATION
In order to evaluate the framework developed we went through several steps. First we consulted an industry expert in order to cross-validate our model with feedback from industry. In the next step we visited the planning department of a logistics service provider, to see whether we could actually find proof for the validity of our framework in their daily operations. In the third step we conducted an
interview with an expert of warehouses and focused on the customer perspective of logistics service providers. We briefly describe the evaluation for the first two evaluation steps and cover the third in more detail in Section 6.

Table 2 - Performance indicators for logistics service provision

| Internal perspective - Management point of view | Total number of orders | Long term plans availability / development | Revenue ↑ |
| Capacity utilization ↑ | Number of customers ↑ | Market share ↑ | Profit margins ↑ |
| Km per day ↑ | Number of regular customers ↑ | Number of markets that have been penetrated ↑ | Labour productivity ↑ | Number of profitable customers ↑ | Successful contacts – % of successful deals out of the initial offers ↑ | Price ↑ | Continuous improvement, rate ↑ | Effectiveness of distribution planning schedule ↑ | Turnover per km ↑ | Product range ↑ | % of orders scheduled to customer request ↑ | Number of deliveries ↑ | Plan fulfilment ↑ | % of supplier contracts negotiated meeting target terms and conditions for quality, delivery, flexibility and cost ↑ | Benefit per delivery ↑ | Total loading capacity (for trucks) ↑ | |
| Perfect order fulfilment ↑ | *Product variety ↑ | Certification (ISO 9001/9002, SQAS, HACCP) ↑ | *Storage volume ↑ | *Amount of products* ↑ | *Dangerous item storage possibilities ↑ | *Storage racks ↑ | *Handling equipment (electric, gas and diesel/petrol forklifts)↑ | *Temperature control ↑ | *Number and characteristics of docks ↑ | *Ventilation control ↑ | *Distance to highway ↓ | | |
| Total distribution cost ↓ | Average fuel use per km ↓ | Overhead/management/administrative costs ↓ | Labour utilization ↑ | Average delivery re-planning time ↓ | Quality of delivery documentation per truck/driver ↑ | Overhead percentage ↓ | Marketing costs ↓ | Effectiveness of delivery invoice methods ↑ | Overtime hours ↓ | Failure costs ↓ | % orders / lines received with correct shipping documents ↑ | % Absent employees ↓ | Prevention costs ↓ | % product transferred without transaction errors ↑ | Salaries and benefits ↓ | Appraisal/Inspection costs ↓ | Item/Product/Grade changeover time ↓ | Controllable expenses ↓ | % of failed orders ↓ | Order management costs ↓ | Non-controllable expenses ↓ | % of realized km out of planned km ↑ | Supply chain finance costs ↓ | Total distribution cost ↓ | System cost ↑ | Total time in repair (for trucks) ↓ | Customer service costs ↓ | Performance measurements costs ↓ | Total supply chain costs ↓ | Total distribution cost ↓ | Performance cost ↑ | Ratio of realized orders vs. requested orders ↑ | Order management costs ↓ | *Pallets/ m2 ↑ |
| Inventory costs ↓ | Variable asset costs ↓ | Average delivery planning time ↓ | Inventory costs ↓ | Fixed asset costs ↓ | Average delivery planning time ↓ | Total delivery costs ↓ | Information system costs ↓ | *Pallets per hour↑ |
| Satisfaction | |
| Attrition of drivers ↓ | On-time delivery performance ↑ | % of orders scheduled to customer request ↑ | Morale, motivation of personnel ↑ | Number of customer complaints ↑ | Overall employees satisfaction ↑ |
| IT and innovation | Overall customer satisfaction ↑ | Overall society satisfaction ↑ |
| Information system costs ↓ | Number of new products in the range ↑ | % of information management assets used / production assets ↑ | Up-to-date performance information availability ↑ | % of information exchange through IT ↑ | % of invoice receipts and payments generated via EDI ↑ | Utilization of IT equipment ↑ | Availability of IT equipment ↑ | Average time for new products development ↓ | IT training costs ↑ | Use of RFID/Barcoding ↑ | Average costs for new product development ↓ |
| Internal perspective – Employee’s point of view | Weight to (un)load per labour hour ↓ | Salaries and benefits ↑ | Km per trip ↓ | Cost to (un)load per trip ↓ |
| Working conditions ↑ | |
| External perspective – Customer’s point of view | Transparency for a customer ↑ | Services variety ↑ | Transportation price ↓ | Possible types of communication ↑ | Order configuration flexibility ↑ | Insurance price ↓ | Available types of insurance ↑ | Possibility to change order details ↑ | Primary services price ↓ | Available types of goods insurance ↑ | Additional services price (priority transportation) ↓ | Goods safety ↑ | Order size flexibility ↑ | Contact points (number of people to contact) ↓ | Product variety ↑ | Timeliness of goods delivery ↓ | *Assistance with customs ↑ | Response time ↓ | *Duration pickup until information is available to shipper ↓ |
| *On site offices *↑ | updated inventory information is available to shipper ↓ |
| External perspective – Society’s point of view | Solid particles emission ↓ | Competition level among similar companies ↑ | Level of CO2 emission ↓ | Taxes to the national treasury ↑ | Care for animals/children around ↑ | Society satisfaction ↑ | Participation in charitable actions ↑ | Use of innovation technologies ↑ | Wasting resources ↓ | Reputation of a company ↑ | Development of innovation technologies ↑ | Recycling level ↓ | Road maintenance costs ↓ | Cooperation with other companies ↑ | Employees satisfaction ↑ | Number of available work places ↑ |
During our expert interview we received feedback regarding different aspects of our framework. Our framework includes a broad range of indicators, reflecting the different aspects that have to be taken into account for decision making within logistics service providers. The expert further mentioned that advantages of our framework are that we do not solely measure costs and the broad range of given indicators. The advantage of the framework is that it could easily be translated into a software system to support coordination in logistics service provision. For a more in-depth description of the first evaluation we refer to (Krauth et al., 2005a).

The second phase of evaluation consists in a comparison of our framework with industry visits with the planning team of the container unit of a Netherlands based medium sized logistics service provider. The manual assignment uses simple heuristics such as total amount of empty kilometres. Also performance indicators from the satisfaction dimension are used. The planners ensure that truck drivers are assigned routes they are content with. In general planners do use a set of performance indicators for their planning, however they are poorly documented. For a more detailed description of our second evaluation see (Krauth et al., 2005b).

**Expert interview on customer perspective of warehousing**

We conducted an interview (~ one hour) with an expert from industry, who has over 15 years of experience in warehouse management, of both dedicated as well as public warehouse. He has designed dedicated warehouses for well-known international companies in the sector of fast moving commodity goods. In these sectors warehousing does play a crucial role. Delivery has to be fast and reliable since stock outs are often lost sales. At the same time the price has to be on a highly competitive level. In our interview we focused mainly on the customer perspective of our framework. The first comment was that the framework is very extensive, “There is hardly anything else that you could measure”. However, from the perspective of the customer only three performance indicators do really matter: costs, performance and flexibility (to accommodate increases and decreases in the flow of goods). Costs are measure as costs per stored unit. Performance is measured as On-Time and In-Full (OTIF) and the expected OTIF level might be as high as 99,5 %. The fact that the shipper is only interested in these three performance measures is related to the reasons why manufacturers outsource in the first place: (1) decrease costs, (2) logistics service provider is specialist and can bundle (different clients, attracting return orders) (3) the tariff agreements are sometimes more attractive for logistics service industry than e.g. automotive industry, (4) less management attention needed.

If the client would know that much about logistics service provision [to compile such a long list of performance indicators] the client could conduct the respective activities without assistance. However, the list of performance indicators can be very useful for open book relationships. In an open book relationship the logistics service provider has to justify an increase in costs.

Performance indicators that are important in the routine work for logistics service providers are those concerned with personnel. Labor costs can be as high as 60%. Since environmental friendliness becomes more and more important for manufacturing companies, also logistics service providers have to start measuring them. Clients could also ask for handling of dangerous goods. The performance indicator of marketing costs does not apply to logistics service provider; there are typically no marketing activities to speak of. Pallets per hour are an example of performance indicators that are difficult to measure. The amount of pallets can be obtained from the warehouse management system.
The respective time it took to handle the pallets is captured in the personnel system. Finding the data, and calculating respective performance indicators is usually done with spreadsheets and can be a very time consuming process.

CONCLUSION

In this paper we build upon our earlier work on performance measurement and control in logistics service providing. We focussed especially on the logistical sub-domain of warehousing / warehouse management – which is different from the transportation focus we had in our earlier work.

The paper starts with a description of key literature, and introduces our framework that clusters the different streams in performance measurement. It is a generic classification, which could be used, together with an in-depth company analysis as a basis to map one company’s specific operations. Our analysis showed that it is not only capable of mapping transportation firms, but also is suitable in the related LSP function of warehousing. Note that the list as such might be an interesting element in company analysis. It helps in structuring thoughts and although it is not complete – simply because such lists can never be complete – it is quite extensive. Based on our empirical validation we suggest that our list of key performance indicators could be an instrument to let industry executives rethink their operations, and let them move away from a sole focus on cost minimization. Not surprisingly, there is a trend in the industry towards the utilization of more performance criteria in daily operations, and more strategic behaviour.

For the nearby future we consider several directions to extend our framework. From a theoretical perspective we are interested in how separate indicators relate and interact with one another. Empirically we plan to research how applicable the framework and list of (130+) indicators is in practice, and how this could be used as a (management) instrument. What performance indicators need to be given to local decision making units in order to achieve company’s wide goals such as profit, customer satisfaction or flexibility? Is it beneficial to give different and maybe contradictory sets of performance indicators to different departments within the logistics service provider? Last but not least, we perceive this work as a first step within our larger effort towards the design and definition of a new inter-organizational information system for planning and implementation of logistical service provision. We consider an agent-based architecture, in which the agents steer their decisions based upon the proper decision criteria – that should come from the proper performance indicators.

ACKNOWLEDGEMENTS

This work is part of DEAL (Distributed Engine for Advanced Logistics) supported as project EETK01141 under the Dutch government funded EET programme. For this particular paper we are very grateful for the contributions of Jan T. Verschoor.

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A performance indicator or key performance indicator (KPI) is a type of performance measurement. KPIs evaluate the success of an organization or of a particular activity (such as projects, programs, products and other initiatives) in which it engages. Often success is simply the repeated, periodic achievement of some levels of operational goal (e.g. zero defects, 10/10 customer satisfaction), and sometimes success is defined in terms of making progress toward strategic goals. Accordingly, choosing the