Urban Consolidation Centre: Evaluation of supportive police measures with agent based modelling

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The urban consolidation centre (UCC) is a promising concept, where the load of entering trucks is transferred to new trucks to increase the load factor and allow for easier time-windowed operation (e.g. by avoiding traffic jams) (Quak & de Koster, 2009).

The main benefits of UCC's are (Huschebeck and Allen, 2005): reductions in the number of vehicle trips, reductions in the number of vehicle kilometres, and better utilization rates for vehicles. A higher load factor in the city can decrease harmful effects associated with city logistics. The main concern is the financial viability of the centre. In practice the UCC concept has failed due to stakeholder behaviour as freight transport itself is under high pressure with strong competition and Just-In-Time delivery systems (Germain & Droge, 1996). Unsuccessful business cases behind many UCC's led to unhealthy financial outcomes where the continuity of operations depended on government subsidies or heavy regulatory measures (van Duin et al., 2010). Despite that many ex ante evaluations, indicated that UCC's would be financially feasible (e.g. Marcucci and Danielis, 2008) only 15 out of 200 centres evaluated ex post were still running after 5 years (Browne et al., 2005). Additional value added services can potentially boost the income of the UCC, but collaboration between all involved actors is necessary to secure demand, which make operations complex. Business cases behind UCCs, investigated based on Cost Benefit Analysis (van Duin et al., 2008; van Duin et al., 2010), showed all very low financial viability, with a strong need for governmental subsidy. It can be concluded that modeling approaches do not seem to predict well with respect to the feasibility of urban distribution centres. The potential supportive role of these policies will be analysed in more detail in this research by obtaining more insight into the dynamic behavioral interaction between freight carriers, retailers, UCC operators and municipalities. Former research (Holguin-Veras, 2006) (Quak, 2008) has shown its value with respect to the understanding the behavioral reactions between freight carriers and municipalities. In our research the behavioural interaction is implemented in a multi-agent model (Weiss, 1999; Wooldridge, 2009).

Our main research question addressed here is as follows:

What is the impact on urban distribution center usage of changing traffic conditions, dynamic pricing strategies and/or variations in operating schemes?

The unsuccessful implementation of any urban distribution centre makes self-sufficient operation impossible (van Duin et al., 2008). In theoretical business case analysis the urban distribution centre appeared to be successful in many cases (Marcucci and Danielis, 2008). This difference between theory and practice could be caused by the fact that static representations use average

values for calculation and thereby do not take statistical effects and individual choices into account. More precise understanding of the dynamics of local conditions in the inner cities and the interactive dynamics in the behavioral attitudes between the freight carriers, urban distribution center and the municipality is needed. The introduction of more dynamic mechanisms in this study encompasses variable traffic conditions and dynamic demand locations. Dynamic UCC usage was tested by various delivery schemes and dynamic fee settings during the day.

As first attempt to introduce and understand the dynamics a multi-agent model with vehicle routing (solvation based on the genetic algorithms) was developed. Simulation-experiments were setup with 3 freight carrier terminals, 1 UCC, 12 - 18 trucks, 240 retailers and a road network (including 300 roads, 114 streets and 60 node agents). Conclusions are based on these experiments:

- An increase of a UCC usage corresponds to decrease of NOx emissions and kilometers in the inner-city. The NOx emission decreases with 19.0% with standard deviation of 13.7 % and the km count decreases with 18.8% with standard deviation of 12.9% in comparison without a UCC.
- Different delivery schemes or toll rates do not have a significant impact on NOx emission decrease or km count reduction. There is however a significant difference between the low and high congestion rate of 1 standard deviation for NOx emission.
- Subsidy providence doesn't impact NOx emission or km count, only for UCC financial viability. The only positive business case for the UCC is with a subsidy rate of 50%, which indicates the complexity of generating a positive business case for an UCC and in line with the research findings (Browne et al., 2005; van Duin et al., 2008).
- To enhance UCC financial performance the dynamic UCC fee was tested. The fee varies during the different hours of the day. Five cases were tested by increasing the general dynamic fee curve. Significant differences between various dynamic fee settings are present. The fact that the UCC income is almost significantly higher than similar situations for fixed fee is encouraging.
- As a last experiment the traffic conditions have changed to highly congested. Comparing the scenarios there is no significant difference between the NOx emission or km count reduction and the freight carriers' costs.

From this research it becomes that generating a positive business for a UCC is highly challenging. For a UCC to be profitable, it seems to be necessary to receive subsidy permanently or/and to find other value added activities like for example pre-retail activities to increase profitability. When collaboration in the form of subsidy is needed, other incentives are required for the municipality to participate.

To our opinion multi-agent modelling has shown its value for understanding the dynamic multi-stakeholder behavior, i.e. the stakeholder interactions between freight carrier, shopkeeper, urban distribution center and municipality. Further development of multi-agent modelling will be continued in several city logistics case studies in order to develop an ontology to formalise city logistics problems and to setup a laboratory in which policy experiments can be executed (Anand et al., 2010).