

# Preface

This dissertation<sup>1</sup> is based on four papers written during my term of employment at Bielefeld University. The following abstracts summarize the problems investigated, the solution methodologies, and the most important findings.

- **Integrated machine scheduling and vehicle routing with time windows<sup>2</sup>**

This paper integrates production and outbound distribution scheduling in order to minimize total tardiness. The overall problem consists of two subproblems. The first addresses scheduling a set of jobs on parallel machines with machine-dependent ready times. The second focusses on the delivery of completed jobs with a fleet of vehicles which may differ in their loading capacities and ready times. Job-dependent processing times, delivery time windows, service times, and destinations are taken into account. A genetic algorithm approach is introduced to solve the integrated problem as a whole. Two main questions are examined. Are the results of integrating machine scheduling and vehicle routing significantly better than those of classic decomposition approaches which break down the overall problem, solve the two subproblems successively, and merge the subsolutions to form a solution to the overall problem? And if so, is it possible to capitalize on these potentials despite the complexity of the integrated problem? Both questions are tackled by means of a numerical study. The genetic algorithm outperforms the classic decomposition approaches in the case of small-size instances and is able to generate relatively good solutions for instances with up to 50 jobs, 5 machines, and 10 vehicles.

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<sup>1</sup>Examiners: Prof. Dr. Hermann Jahnke, Prof. Dr. Reinhold Decker, and Prof. Dr. Christian Stummer (Bielefeld University, Faculty of Business Administration and Economics)

<sup>2</sup>Published in *European Journal of Operational Research*, Volume 227, Issue 1, May 2013, pages 152-165. Chapter 3 contains this paper in a revised and supplemented version.

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- **The cost-cutting potential of Supply Chain Scheduling**

*Co-authored by Dr. Jan Herrmann*

Supply Chain Scheduling deals with the coordination of the machine and delivery schedules of two or more supply chain stages. The objective is to improve the supply chain's competitiveness measured in total logistics costs or the supply chain makespan, for example. However, the potential for improvement has never been properly quantified. If performance improvements did not suffice to compensate for the cost of coordination, Supply Chain Scheduling would be unprofitable and thus expendable. This paper aims to assess the cost-cutting potential of Supply Chain Scheduling. The investigation focusses on a supplier and a manufacturer, both of whom face a machine and delivery scheduling problem. The sum of tardiness, inventory holding, and transportation costs that result if the companies schedule on their own is compared to the total costs incurred if they schedule jointly. On average, Supply Chain Scheduling cut costs by up to 35%.

Since the complexity of the examined scheduling problems can lead to extremely long computation times, only small-size instances are solvable using a commercial optimization software. Hence, a Microsoft Excel-based heuristic approach is developed that enables us to handle real-world-size instances as well. To the best of our knowledge there is currently no appropriate spreadsheet approach to scheduling problems that does not rely on expensive add-on software packages. This paper's heuristic can be easily transferred to a large number of batching, sequencing, routing, and scheduling problems. Since Excel is an omnipresent software and such problems occur almost everywhere, the proposed approach provides enormous opportunities for practitioners. (co-authored by Dr. Jan Herrmann)

- **Supply Chain Scheduling: Makespan reduction potential<sup>3</sup>**

This paper also addresses the optimization potential of Supply Chain Scheduling. Focusing on the overall makespan of a four-stage supply chain, eight scheduling scenarios are compared by means of a numerical study. The simplest scenario is characterized by separate scheduling of all stages. The most promising scenario is a joint scheduling approach that treats the supply chain as a flow shop. In the other six scenarios, different subsets of stages coordinate their schedules. Joint Supply Chain Scheduling of all stages significantly outperforms the other

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<sup>3</sup>Published in *International Journal of Logistics Research and Applications*, Volume 15, Issue 5, October 2012, pages 323-336. Chapter 5 contains this paper in a revised and supplemented version.

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seven scenarios. This result holds for the case with a single machine as well as for two identical parallel machines at each stage. Owing to the complexity of some scheduling problems, the numerical investigation of the four-stage supply chain scenario is limited to small-size instances which are still solvable using a commercial optimization software. However, a second study deals with a simpler two-stage supply chain structure that allows for the investigation of real-world-size instances. Since the shortest processing time priority applied at the first stage leads to permutation schedules which on average result in near-optimum makespans, a joint Supply Chain Scheduling approach based on Johnson's algorithm turns out to be unreasonable.

- **How to benefit from an R&D investment sharing contract with a supplier**

*Co-authored by Dipl.-Kffr. Rabab Mitri*

Despite a tendency to concentrate on one's core business, especially companies that are known for their innovative products are often found to have an exceptionally high in-house production depth. Focusing on such a company, we model various factors that influence the make-or-buy decision for a component required for a new product. As many innovating companies aim to produce high-quality goods on principle, the component's quality plays an important role in the model. Investment in R&D is another important factor since these sunk costs can weaken the innovating company's position when negotiating with a potential supplier on the component price. Consistent with the observation that innovative companies tend to produce specific components on their own, we identify cases in which in-house production is advantageous. However, in-house production as well as a classic wholesale price contract with a specialized supplier often turn out to be inefficient. This paper demonstrates that, under certain conditions, both the innovative company and the supplier can benefit from sharing the associated R&D investment.

Issues in Supply Chain Scheduling and Contracting

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