FACULTEIT ECONOMIE EN BEDRIJFSKUNDE

UNIVERSITEIT GENT

Invitation

You are cordially invited to the public defense to obtain the academic degree of

DOCTOR OF BUSINESS ECONOMICS

by Ebenezer Olatunde Adenipekun

Facility logistics modeling and optimization in mixed-model assembly lines

Supervisors:
Prof. dr. Veronique Limère - Prof. dr. Nico André Schmid

Monday, 30 September 2024 at 16h30
In the Faculty Board Room, Campus Tweekerken, Tweekerkenstraat 2, 9000 Ghent
Please confirm your attendance no later than 18 September by email to ebenezerolatunde.adenipekun@ugent.be

EXAMINATION BOARD

Prof. dr. Geert Poels
Chair - Ghent University

Prof. dr. Veronique Limère
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Abstract

Assembly line feeding has gained significant attention recently due to the rise of mass customization in industries such as automotive manufacturing and machine building, where there is a growing consumer demand for personalized end products. A critical challenge posed by this trend is managing the space at the border of line (BoL), the area designed for part storage at each assembly station. As the demand for a wider variety of parts required increases, the available space at the BoL remains constant, intensifying the difficulty of efficient space utilization. This thesis addresses this challenge by integrating facility logistics such as vehicle types, supermarket types, placement, and sizing with assembly line feeding decisions, achieved through developing and implementing mixed-integer linear programming (MILP) models.

Study 1 concerns developing a MILP model that combines assembly line feeding and vehicle type decisions, becoming the first study in the literature to combine these decisions. The model assigns each part to an appropriate feeding policy and vehicle type, aiming to minimize total feeding costs while effectively managing space at the BoL and preventing part shortages that could result in line stoppages. Feeding policies refer to distinct ways of presenting parts at the BoL. To accurately quantify the costs, the model selects specific routes and determines the fleet size of every vehicle type used. These routes may be between the warehouse or supermarket and a sequence of consecutive assembly stations. The model is complemented by some valid inequalities during the solving procedure and validated by solving artificial problem instances. The results demonstrate that the optimal selection of vehicle types significantly outperforms heuristic approaches commonly used in the literature and practice. **Study 2** builds on the optimization model from Study 1 by tailoring it to the specific case of a machinery manufacturing company, thereby validating the model's practical applicability. The adaptation involves expanding the five basic feeding policies to twelve, modeling the preparation process at the preparation area in a parts-to-picker manner rather than the conventional picker-to-parts approach, and incorporating multiple warehouses, each with its corresponding preparation area. The results indicate that, compared to the current assignment, the optimal assignment and various restrictive solutions, characterized by practically relevant constraints, yield significant cost savings. Additionally, the optimal solution streamlines the feeding process.

Study 3 addresses the routing challenges encountered when navigating the shop floor within a high-variety mass customization context. The problem concerns the traversal along varying supermarkets or work cells for collection before traversing a sequence of consecutive assembly stations for delivery. Heuristics, such as nearest neighbor, S-shape, modified S-shape, and combined heuristics, introduced to address the problem are characterized by practical implementability, offering practitioners defined guided rules to navigate the shop floor. The study compares the results from the heuristic methods to the exact solution as a benchmark. **Study 4** proposes a MILP model designed to simultaneously assign parts to appropriate feeding policies and suitable cell types to every part requiring preprocessing. These cell types are preparation areas located next to each assembly station (line-integrated) or between the warehouse and the assembly line (regular), where preprocessed parts are repackaged. Precise cell placement facilitates efficient transportation between preparation areas and assembly lines, thereby reducing transportation costs, while optimal sizing minimizes spatial costs. Within a callback procedure, the model ensures navigating regular cells sharing the same delivery frequency and assembly station sequence by the dedicated vehicle type. The study introduces valid inequalities and symmetry-breaking constraints to enhance the model's efficiency. The results show that optimal cell selection is significantly cost-effective compared to exclusively using one of the cell types.

Curriculum vitae

Ebenezer Olatunde Adenipekun, born in Ilesha, Nigeria, holds an Erasmus Mundus joint Master of Science degree in Mathematical Modeling in Engineering from three European universities. He joined the Faculty of Economics and Business Administration at Ghent University in 2019, where he serves as a research and teaching assistant for courses in Production & Logistics Management and Logistics & Supply Chain Management. Study 1 is published in OMEGA the *International Journal of Management Science* and as a peer-reviewed conference proceeding (C1) in the *Proceedings for the Annual European Simulation and Modeling Conference*. Study 2 is accepted for publication in the *INFORMS Journal on Applied Analytics*. Study 3 is published as a peer-reviewed conference proceeding (P1) in the *Proceedings of Advances in Production Management Systems*. Study 4 is being prepared for submission to a reputable journal. Ebenezer has presented his research at numerous international conferences, including the *European Conference on Operational Research* (Virtual, 2021; Espoo, 2022) and the *Annual Conference of the Belgian Operations Research Society* (Lille, 2020; Ghent, 2022; Liège, 2023).