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## Case Article

## HCell and E-Waste Collection: An Analytics Case for Business Decision Making

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**Abstract.** Prescriptive analytics has emerged as a powerful tool in decision-making processes across various industries. We present a detailed case study that explores a specific decision-making problem encountered by a cell phone manufacturer. The objective of this study is to demonstrate how case-based learning can enhance relatability and effectiveness in problem-solving, particularly in the realm of prescriptive analytics. The case utilizes prescriptive analytics methodologies and involves modeling and solving the problem using Excel, General Algebraic Modeling Language, or Python. The case study has been successfully integrated into graduate-level courses and has received positive student reviews. Feedback indicates that the case enhances students' understanding of prescriptive analytics and its real-world applications, fostering improved engagement and learning outcomes.



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**Supplemental Material:** The Teaching Note and Excel/GAMS/Python files are available at <https://www.informs.org/Publications/Subscribe/Access-Restricted-Materials>.

**Keywords:** Python • sensitivity analysis • social innovation • sustainable development goals

## 1. Introduction

The demand for business analysts and data scientists has increased significantly in the last five years. Currently, most firms' business intelligence and advanced analytics tools focus on descriptive, diagnostic, and predictive analytics. Only a small percentage of companies are taking advantage of prescriptive analytics; however, this number is expected to increase 21.2% by 2030.<sup>1</sup> Prescriptive analytics is considered a complex and valuable type of analytical approach used for decision support and automation across a variety of business functionalities (from marketing/sales to logistics/strategy) in many industries. Although interest in prescriptive analytics is expected to grow, there are only a few classroom case studies focusing on contemporary topics using modern tools. This case will provide students the opportunity to apply scientific and mathematical methods to real-world situations by placing students in the role of analysts as well as allowing the instructor flexibility in their approach to teaching as suggested by Drake (2019). The problem,

in this case, challenges students with a strategic decision of a company facing environmental regulation. Similar to the challenges put forward by Chau and Benson (2025) on optimizing locations, students will need to make decisions on the location of both manufacturing facilities as well as collection centers. The case requires the students to formulate a mathematical model of the management decision that the firm is facing and solve it using Excel Solver, General Algebraic Modeling Language (GAMS), or Python.

The case also offers numerous opportunities to discuss optimization topics. Based on a real-life application, it resonates with students, who appreciate the chance to work on something practical and grounded in real-world scenarios. Suitable for both master of business administration (MBA) and master of science (MS; e.g., analytics or data science) students, the difficulty can be adjusted by selecting the tool—Excel, GAMS, or Python—most appropriate for the audience. The case introduces students to strategic decision making, a concept often overlooked in analytics

courses that tend to focus more heavily on methodological applications. It highlights the importance of sensitivity analysis and demonstrates the value of planning for uncertainties. Furthermore, if the instructor chooses to use Excel, the case is complex enough to require students to adjust solver settings to reduce computation time, providing them with a rare opportunity to practice optimizing solver configurations, a skill that is typically discussed but seldom applied in analytics courses.

## 2. Literature Review

The integration of project-based learning into analytics education has proven to be a powerful tool for preparing students to navigate complex, real-world challenges. This approach helps students develop essential skills, such as problem formulation, analytical reasoning, and decision making in ambiguous scenarios (Armacost and Lowe 2003, Behara and Davis 2010, Hillon et al. 2012, Konrad et al. 2018, Sanders Jones et al. 2021, Pachamano et al. 2022). However, existing frameworks often struggle with inherent limitations, including insufficiently structured projects, constrained access to reliable data, and misalignment between student capabilities and project demands (Konrad et al. 2018). Structured simulations, which mimic real-world decision-making processes in a controlled environment, have emerged as a promising alternative (Joshi et al. 2005, Pachamano et al. 2015). By allowing students to engage with realistic business problems while providing the necessary scaffolding, these simulations offer a balanced approach to building analytical expertise while minimizing common logistical challenges.

In addition to including more realistic problems, instructors have increasingly sought to move beyond Excel tools, incorporating modern programming languages, such as Python, and optimization platforms, like GAMS, into their analytics curricula (Diamant 2024, Isken 2025). These innovations not only support the development of modeling and data-wrangling skills but also enable students to tackle more complex, real-world problems that mirror industry demands.

Despite progress in analytics education, there is still a notable lack of case studies that focus on the intersection of analytics and sustainability, leaving this critical area underrepresented in classroom discussions (Cole and Snider 2020, Dong and Boute 2020, Guthrie 2024). For instance, although reverse logistics processes—such as managing returns, refurbishing products, and recovering value—have been widely practiced across industries, these topics are seldom examined through an analytical lens in educational settings. Recent contributions, however, are beginning to address this gap. Chandra and Vatsa (2021) offer a case on sustainable multimodal logistics and green

distribution strategies, whereas Mutha et al. (2023) introduce students to the operational complexities of closed-loop remanufacturing under uncertainty. These cases provide timely opportunities for students to engage analytically with contemporary sustainability and circular economy challenges, reflecting a growing commitment to integrating such topics into the analytics curriculum.

Addressing this gap, this case study highlights the intersection of analytics and sustainability by focusing on reverse channel design within the context of operational and environmental objectives. As Chollette and Roeder (2012) suggest, embedding sustainability within core analytics courses can bridge the divide between quantitative and qualitative decision-making approaches, enabling students to evaluate trade-offs and propose actionable improvements. Additionally, instructors have the flexibility to choose the tool that best fits their course (i.e., Excel Solver, GAMS, or Python (with Pyomo package)). This case serves as a structured yet flexible tool to familiarize students with reverse supply chain challenges, fostering critical thinking about how analytics can drive sustainability efforts in diverse industries.

## 3. Learning Objectives

Primarily, the case has been developed for coverage in sustainable supply chains and prescriptive analytics courses to highlight the application of optimization models in more contemporary problems and the importance of sensitivity analysis. From this standpoint, the case enables students to

1. differentiate between descriptive, predictive, and prescriptive analytics in addressing reverse supply chain decisions;
2. build and implement optimization models for forward and reverse supply chain design using provided data;
3. identify and address data gaps;
4. analyze potential shortcomings of the implemented models and propose strategies to overcome these challenges;
5. evaluate the impact of changes in parameters on the distribution plan and costs; and
6. interpret the outcomes of analytics-driven models and provide actionable recommendations for reverse supply chain network design.

## 4. Target Courses and Potential Obstacles

In our graduate analytics program, the case study was presented in various formats, including Excel, GAMS, and Python versions, as a part of a methods-focused course as well as a sustainability course. Distinct discussion formats

were employed for the on-site and online courses to suit their respective learning environments.

Excel provides an accessible starting point for students with minimal programming experience, offering familiarity and the opportunity to explore advanced features of a widely used business tool. GAMS, designed specifically for optimization, is more user friendly than Python, and although it is more complex, it is favored by MS in business analytics students because of its flexibility, customization capabilities, strong industry relevance, and seamless integration with widely used data science libraries, such as Pandas and NumPy. This compatibility enables students to preprocess and manipulate data in familiar formats before formulating and solving optimization models in Pyomo, making it especially well suited to the data science curriculum. The strengths and limitations of each tool are highlighted further in Table 1.

#### 4.1. In-Person Analytics Course

In the in-person analytics course, the case was distributed to students a week prior to the scheduled discussion. During class, the discussion begins with the forward supply chain model before transitioning to the retrofitting and collection center components. Once the retrofitting and collection center models are introduced and discussed, students recognize that reverse supply chain design is essentially a supply chain problem incorporating reverse flows. Although most students successfully developed the base model for forward supply chain design before the discussion, they did have difficulty modeling the retrofitting and collection center decisions. Therefore, the instructor may want to plan on spending additional time during the discussion on the decisions surrounding the retrofitting and collection center.

Upon discovering the optimal solutions, students often encounter a critical realization: that slight alterations in parameter values can lead to shifts in the optimal solution. Although arriving at the correct conclusions becomes straightforward at this stage, students may not inherently grasp the implications of

parameter changes. This juncture offers a prime opportunity to segue into broader discussions on sensitivity analysis—the systematic approach to understanding how changes in input parameters affect a model’s outputs and conclusions. Sensitivity analysis, although important for most quantitative analyses, is often underemphasized in analytics courses. Executives typically want to understand how results change under different scenarios not captured in the original model. To make the process more engaging, students are asked to guess the answers to sensitivity analysis questions before performing the analysis. Distributing sensitivity analysis questions among students, with each question assigned to at least two individuals, helps manage time constraints. To further motivate participation, offering extra credit for students whose predictions align with their findings adds an element of competition, making the class more exciting and encouraging students to engage more with the material.

When discussing the sensitivity analysis, the dominant facility concept where a single facility with the lowest cost usually serves a market, as described in Verter and Dincer (1995), can be introduced alongside the trade-off between fixed and variable costs, which frequently arises in supply chain design and models with fixed costs. These insights provide a broader understanding of the economic principles underlying supply chain network decisions. The timeline for the case discussion, outlining each activity and the time allocated to it, is summarized in Table 2.

#### 4.2. In-Person Sustainability Course for Analytics Students

In the sustainability course, which spans only eight weeks, this case is offered as an extra credit opportunity for analytics students because of time constraints. Although not mandatory, some students chose to complete it, demonstrating their interest in applying optimization concepts. It also helps students recognize that analytics can be applied in sustainability contexts, an application many are not aware of before

**Table 1.** Strengths and Limitations of Various Optimization Tools Used in the Case

Tool	Strengths	Limitations	Ideal student level
Excel	Intuitive, accessible, familiar to most students	Limited problem sizes	Undergraduate or MBA students with minimal coding background
GAMS	Optimized for modeling, generates structured outputs automatically	Limited customization, not widely applicable beyond optimization	Students with some technical background and interest in real-life-sized optimization models
Python (Pyomo)	Highly versatile, integrates seamlessly with pandas and NumPy (core data science libraries) customizable outputs, industry relevant	Requires programming skills	Students with strong technical and mathematical background

**Table 2.** Timeline of Case Activities

Activity	Time allocation
Discussion of base model, retrofitting, collection center models	1–1.5 hours
Students guess the responses to the sensitivity analysis questions	15 minutes
Students complete sensitivity analysis	30 minutes
Discussion of sensitivity analysis	30 minutes

encountering this case. Additionally, it could be easily integrated into a semester-long course.

### 4.3. Online Analytics Course for MBAs

In the online analytics course for MBAs, the case is assigned as a two-week assignment. Most students successfully complete the forward supply chain design but like their peers in other formats, encounter difficulties with the retrofit and collection center models. After providing solutions to these models, we recommend either hosting an online session to explain the solutions or posting a recorded video with a detailed explanation.

In the following week, assign each student a parametric sensitivity analysis question. This can be randomized using the university's learning management system. Ask students to post their guesses for their assigned questions on the discussion forum, with a suggested deadline of midweek. Subsequently, students perform sensitivity analysis, share their findings on the discussion forum, and engage with their peers by commenting on at least one other student's post.

## 5. Student Experience

The case study has been implemented with graduate-level business analytics and MBA students, many of whom possess diverse professional backgrounds spanning business, engineering, and supply chain management. Students typically work individually or in pairs to develop their models, with the majority utilizing Excel Solver, whereas a smaller subset employed Python's optimization libraries.

Throughout the exercise, students have demonstrated a high level of engagement, particularly valuing the autonomy to construct models without reliance on predefined templates. Students also felt more confident in building prescriptive models after the case study, with many noting how applicable the skills were to their professional roles. Notably, students were particularly surprised to discover through sensitivity analyses that fixed warehouse costs would need to increase by approximately 800% before observing any change in the optimal network configuration. This realization reshaped their understanding of solution stability in supply chain design, transforming their

perception of sensitivity analysis from a mere technical evaluation to a critical strategic decision-making tool.

Moreover, students also reported that the case study effectively bridged theoretical concepts with practical applications, particularly in understanding the trade-offs between fixed infrastructure and variable transportation costs. From an instructional standpoint, the case study requires minimal setup yet delivers significant educational value.

## 6. Conclusion

In this case, we present a prescriptive analytics problem for strategic data-driven decision making for a firm, HCell, looking to expand in the European Union. This case helps students in developing analytical thinking by formulating a mathematical model for the decisions faced by the firm. In addition, students will also learn to program the mathematical model in a software/programming language (Excel/GAMS/Python) of the instructor's choosing based on the level and type of degree of the students. The case has received positive testimonials in the classes taught, especially in placing the students in the shoes of decision makers at large corporations.

### Endnote

<sup>1</sup> See <https://www.globenewswire.com/news-release/2022/07/05/2473900/0/en/Prescriptive-Analytics-Market-Share-Estimated-to-Garner-USD-16-23-Billion-by-2030-with-a-CAGR-of-21-2-Report-by-Market-Research-Future-MRFR.html>.

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