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Unmasking Mathematical Fallacies in Operations Management: Two Mini-Case Studies Using Misdirection

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Abstract. This paper presents two mini-cases, "The Accused Driver" and "The Billing Problem", to expose students to mathematical misdirection situations which can occur in operations management contexts but have yet to receive sufficient attention in undergraduate and graduate education. These two cases help students to identify mathematical misdirection and recognize the potential cognitive biases underlying the technique. By demonstrating decision-making tools that can help avoid or mitigate these cognitive biases, we aim to equip students with the critical thinking and analytical reasoning skills needed to make informed decisions and become effective leaders in the field of operations management.

Keywords: mathematical fallacies, operations management teaching, procurement, double counting.

1. Introduction

In his *Visual Explanations* book, data visualization legend Edward Tufte (1997) analyzed instruction manuals used by magicians to better understand how distraction and misdirection are foundational to what he termed "disinformation design" in data visuals. Regarding the magician's craft, Tufte noted, "In conjuring, strategies of *disguise* and *attention control* work to regulate the optical information available to the spectator" (p. 64). Similarly in 2007, historians (Melton & Wallace 2009) discovered a long-lost copy of a Central Intelligence Agency training manual written by a professional magician for the United States government. The manual included such topics as "Surreptitious Removal of Objects" and "Working as a Team" but all with a focus on training agents in how to recognize and deploy misdirection and evidence tampering techniques. Both magicians and spies utilize visual misdirection when they wish their mark (i.e., intended victim) to believe one thing when the reality is quite another.

Mathematical misdirection (Read 1933) is a well-documented phenomenon most often appearing in mathematical games or diversions.

Recently, Netz (2022) found that a significant part of mathematical education in ancient Babylon and Greece was composed of "clever games accompanying the education of bureaucrats" (p. 11). Singmaster (2004) details the more recent history of recreational mathematics. This article adapts two of his examples – adding remainders and mixing payments and refunds – to an operational context. The authors believe that most mathematical errors inside organizations are unintentional. However, one's ability to recognize mathematical misdirection can save you and your firm from both unintended errors and intentional targeting.

Operational data includes both outcomes and complex processes justifying those outcomes. As such, it is subject to misdirection and evidence tampering. This paper details two mini-cases (Orchard 2019, Ni *et al.* 2019, Dunne & Brooks 2004) grounded in mathematical misdirection that can be used in operations management courses. We define a mini-case as a one that can be introduced, read, analyzed, and summarized in less than 50 minutes. (Both mini-cases are included in Appendix A following our Reference section.) Mathematical misdirection focuses the novice reader on the outcome more than the process. Readers who assume too much symmetry between the two often get fooled. That is, the reader is given a series of calculations leading to a desired outcome even though the outcome is erroneous.

Mathematical misdirection is a considerable challenge in operations management, as many cognitive biases cause misdirection during the decision-making process. For instance, decision-makers may base their judgments on initial numbers, metrics, or calculations, triggering misdirection through the anchoring effect (Kahneman & Tversky 1974). Moreover, confirmation bias can also contribute to mathematical misdirection because decision-makers may focus on data that support preconceived notions and ignore contradictory evidence or alternative perspectives (Nickerson 1998). Additionally, decision-makers can be swayed by how information or data are framed (Tokar *et al.* 2016), such as how they are presented graphically or numerically, leading to misdirected outcomes. Another pertinent example of mathematical misdirection can be observed in the context of total cost of ownership assessments. Decision-makers often fall into the trap of focusing solely on the initial purchase price of a product while neglecting to consider the full range of long-term costs associated with the product, such as maintenance, repair, operational expenses, and eventual disposal costs. This narrow perspective can lead to a gross underestimation of the true cost, affecting budgeting and financial planning. Given these potential biases in decision-making, it is essential for educators to train students to be skeptical of claims and assumptions. By fostering critical thinking and analytical reasoning skills through short case studies that specifically focus on mathematical misdirection, students can learn to recognize and mitigate mathematical misdirection and make more informed decisions.