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2015/07/01 - 2016/06/30

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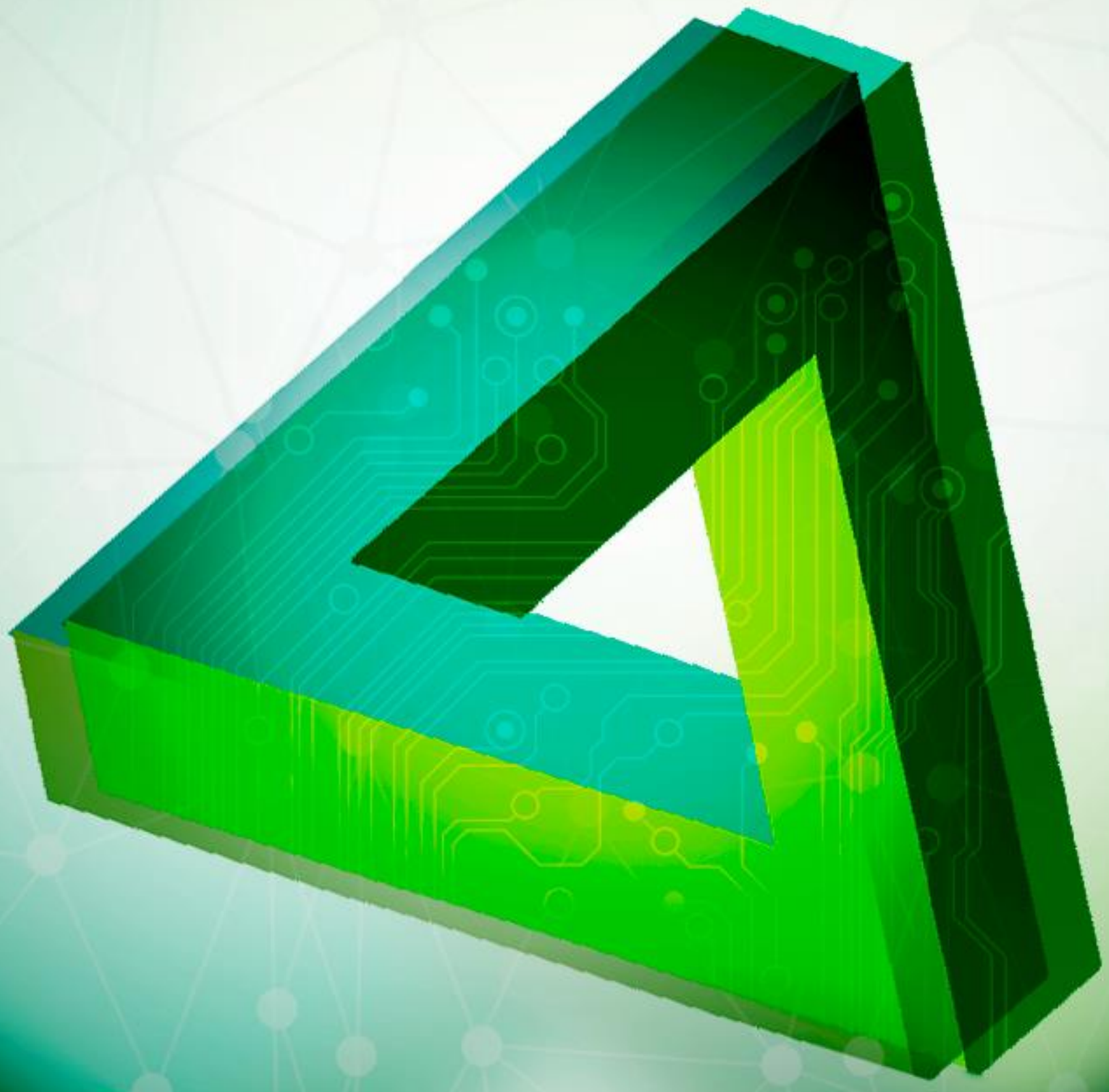

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Última actualización: 2016/09/12

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Productos Reconocidos

Ordenado por fecha de aparición en línea:

1. Gomez, A; Marino, R; Akhavan-Tabatabaei, R., Medaglia, AL; Mendoza, J. On Modeling Stochastic Travel and Service Times in Vehicle Routing. Transportation Science. 50 (2): 627 – 641. Doi: 10.1287/trsc.2015.0601

2. Villalobos, J; Munoz, V; Rogan, J; Zarama, R; Penagos, JF; Toledo, B; Valdivia, JA. Modeling a bus through a sequence of traffic lights. Chaos. 25 (7). Doi: 10.1063/1.4926669

3. Lopez-Santana, E; Akhavan-Tabatabaei, R; Dieulle, L; Labadie, N; Medaglia, AL. On the Combined Maintenance and Routing Optimization Problem. Reliability Engineering and System Safety. 145: 199 – 214. Doi: 10.1016/j.ress.2015.09.016

4. Gonzalez, AD; Duenas-Osorio, L; Sanchez-Silva, M; Medaglia, AL. The Interdependent Network Design Problem for Optimal Infrastructure System Restoration. Computer-aided Civil and Infrastructure Engineering. 31 (5): 334-350. Doi: 10.1111/mice.12171

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On Modeling Stochastic Travel and Service Times in Vehicle Routing

14/07/2015

Andrés Gómez
Ricardo Mariño
Raha Akhavan-Tabatabaei
Andrés L. Medaglia
Jorge E. Mendoza

DOI: 10.1287/trsc.2015.0601

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03

TRANSPORTATION SCIENCE
Vol. 50, No. 2, May 2016, pp. 627–641
ISSN 0041-1655 (print) | ISSN 1526-5447 (online)

http://dx.doi.org/10.1287/trsc.2015.0601

On Modeling Stochastic Travel and Service Times in Vehicle Routing

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Vehicle routing problems with stochastic travel and service times (VRPSTT) consist of designing transportation routes of minimal expected cost over a network where travel and service times are represented by random variables. Most of the existing approaches for VRPSTT are conceived to exploit the properties of the distributions assumed for the random variables. Therefore, these methods are tied to a given family of distributions and subject to strong modeling assumptions. We propose an alternative way to model travel and service times in VRPSTT without making many assumptions regarding such distributions. To illustrate our approach, we embed it into a state-of-the-art routing engine and use it to conduct experiments on instances with different travel and service time distributions.

Keywords: vehicle routing; stochastic travel times; stochastic service times; Phase-type distributions
History: Received: May 2013; revisions received: March 2014, October 2014; accepted: January 2015. Published online in *Articles in Advance* July 14, 2015.

1. Introduction

Vehicle routing problems (VRPs) are concerned with the design of efficient routes that deliver goods and services from (to) central depots to (from) customer locations, satisfying specific business constraints. Since the 1960s, a vast amount of research has been devoted to solve different VRP variants. Most of the solution methods for VRPs are based on the premise that problem parameters such as travel, service times, and customer demands are known in advance. However, in a practical setting, more often than not, the problem parameters (customers, demands, or travel times) are uncertain, and neglecting their stochastic nature may lead to poor routing decisions. Each uncertain component poses unique challenges that result in different solution approaches (Gendreau, Jabali, and Rei 2014). In this research we address the family of problems that has received less attention in the literature: the VRPs with stochastic travel and service times (VRPSTTs).

The family of VRPSTTs is defined on a complete graph $G = (\mathcal{V}, \mathcal{E})$, where $\mathcal{V} = \{0, v_1, v_2, \ldots, v_n\}$ is the vertex set and $\mathcal{E} = \{e = (v_i, v_j)\colon v_i, v_j \in \mathcal{V}, v_i \neq v_j\}$ is the edge set. Vertices $v_i \in \mathcal{V}\backslash\{0\}$ represent the customers and vertex 0 represents the depot. An edge weight $\tilde{t}_e$, associated with edge $e = (v_i, v_j)$, represents the random travel time along edge e. Each customer $v_i \in V\backslash\{0\}$ has a random service time $\tilde{s}_{v_i}$ and a known demand d_{v_i} for a given product. Both travel and service times are assumed to follow known distributions. Customers are served by an unlimited fleet of homogeneous vehicles located at the depot, each with a maximum capacity Q.

The objective is to design a route set $\mathcal{R}$ of minimum total expected duration $E[\tilde{T}(\mathcal{R})] = \sum_{r\in\mathcal{R}} E[\tilde{T}_r]$, where $\tilde{T}(\mathcal{R})$ is the total (random) duration of the route set, $\tilde{T}_r$ is the (random) duration of route r, and $E[\cdot]$ denotes the expected value. Each route $r \in \mathcal{R}$ is a tuple $r = (0, v_{(1)}, \ldots, v_{(i)}, \ldots, v_{(n_r)}, 0)$, where $v_{(i)} \in \mathcal{V}\backslash\{0\}$ is the ith customer visited in the route, n_r is the number of customers serviced by the route, and $(v_{(i)}, v_{(i+1)}) \in \mathcal{E}$ (with $v_{(0)} = v_{(n_r+1)} = 0$). We will refer to route r, depending on the context, either as the sequence of vertices or edges in the route. Aside from the classical capacity constraint, each route $r \in \mathcal{R}$ satisfies a set of constraints $\mathcal{C}$ that involve the route duration. For instance, set $\mathcal{C}$ may include not exceeding a time limit T or violating customer time windows.

Search algorithms for VRPSTT can be decoupled into two components: the *optimization engine* and the *route evaluator*. The optimization engine is responsible for exploring the solution space, unveiling new routes to make up a solution. The vehicle routing literature comprises a number of efficient search algorithms that, with mild adaptations, can play the role of

Modeling a bus through a sequence of traffic lights

21/07/2015

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Juan Alejandro

DOI: 10.1063/1.4926669

CHAOS **25**, 073117 (2015)

Modeling a bus through a sequence of traffic lights

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(Received 24 April 2015; accepted 2 July 2015; published online 21 July 2015)

We propose a model of a bus traveling through a sequence of traffic lights, which is required to stop between the traffic signals to pick up passengers. A two dimensional model, of velocity and traveled time at each traffic light, is constructed, which shows non-trivial and chaotic behaviors for realistic city traffic parameters. We restrict the parameter values where these non-trivial and chaotic behaviors occur, by following analytically and numerically the fixed points and period 2 orbits. We define conditions where chaos may arise by determining regions in parameter space where the maximum Lyapunov exponent is positive. Chaos seems to occur as long as the ratio of the braking and accelerating capacities are greater than about ∼3. © *2015 AIP Publishing LLC*.
[http://dx.doi.org/10.1063/1.4926669]

Traffic research is almost as old as automotive vehicles themselves; however, it is just lately that its full complexity has been recognized. Many kinds of models, going from cellular automata to systems of coupled differential equations, attest for its non-triviality. In spite of such efforts, it keeps providing interesting results. In this paper, we present and analyze the consequences of a discrete map describing the exact evolution of a bus under ideal city conditions. The buses display chaotic behavior very near (in parametric sense) of an optimal flow setting, which makes it difficult to simultaneously optimize travel time and maintain a predictable schedule. The chaotic and nontrivial dynamics are due to the finite braking and accelerating capacities of the buses. New results are related to a more complete understanding of the bus dynamics, derivation of the analytical expressions for the bounds of the nontrivial and chaotic behaviors in the bifurcation diagrams with respect to various parameters of the system, many of which can be controlled by traffic controllers. These bounds can be use to estimate the relevance of the nontrivial and chaotic dynamics of the bus trajectories. For example, we have found that chaos occurs when the ratio of the braking and accelerating capacities are greater than about ∼3.

I. INTRODUCTION

The dynamics of city traffic has become an active area of research not only because of its social and economical relevance,[1] but also and because it displays many interesting features[2–11] such as complex dynamics and emergent phenomena.[12–14] This complex behavior has been studied using many different approaches, going from statistical and cellular automaton, to hydrodynamical and mean field models.[15–18] Some approaches have even included the topological complexity of the traffic networks.[19] In spite of much effort in trying to understand traffic networks, there remain many interesting problems, such as emergent phenomena,[20] chaotic behavior,[2,11] stochastic like resonances,[21] self-organization,[22] etc.

One of the main components of city traffic involves buses and their dynamics. For example, there are a number of publications that study problems related to school buses (see Refs. 23 and 24 and references therein), while others analyze environmental issues associated with bus transportation systems.[24,25] There are also a number of publications that investigate on the position of bus-stops.[26] For example, Jia *et al.*[27] and Ding *et al.*[28] use a cellular automaton model to study the impact of bus-stops on the dynamics of traffic flow; while Tang *et al.*[29] analyze the same problem using a traffic flow model. Optimization models were also used by Ibeas *et al.*[30] The interaction of the bus with traffic lights is discussed by Estrada *et al.*,[31] where a simulation optimization model is used to minimize the travel time of bus users in an urban network. There are also a number of publications that investigate the traffic light timing to optimize vehicle flow. For example, Liao and Davis[32] used Global Positioning Systems (GPS) and automated vehicle location systems on the buses in Minneapolis, to develop an adaptive signal priority strategy. Also a bus priority method for traffic light control based on two modes of operation was proposed by Koehler and Kraus.[33] Some studies combine traffic light and stop position using nonlinear map models, as was done by Mei *et al.*[34] (their interest lies in T junctions) and Hounsell *et al.*,[35] where the issue is how to tackle the challenge posed by locational error associated with GPS, where a traffic signal is located close to a bus stop in London.

Hence, the majority of the researches on buses have dealt with the problem of how traffic flow is affected by buses and vice versa (see Refs. 36–48, for examples).

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On the Combined Maintenance and Routing Optimization Problem

03/10/2015

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DOI: 10.1016/j.ress.2015.09.016

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07

Reliability Engineering and System Safety

Reliability Engineering and System Safety 145 (2016) 199–214

Contents lists available at ScienceDirect

Reliability Engineering and System Safety

journal homepage: www.elsevier.com/locate/ress

On the combined maintenance and routing optimization problem

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ARTICLE INFO

Article history:
Received 3 November 2014
Received in revised form
26 June 2015
Accepted 23 September 2015
Available online 3 October 2015

Keywords:
Maintenance planning
Vehicle routing
Time windows
Waiting time

ABSTRACT

This work focuses on the problem of planning and scheduling maintenance operations for a set of geographically distributed machines, subject to non-deterministic failures with a set of technicians that perform preventive maintenance and repair operations on the machines at the customer sites within a specific time window. This study presents a two-step iterative approach. In the first step, a maintenance model determines the optimal time until the next preventive maintenance operation, its frequency, and the time window for each customer, while minimizing the total expected maintenance costs. In the second step, a routing model assigns and schedules maintenance operations to each technician over the planning horizon within the workday. This two-step iterative process balances the maintenance cost, the failure probabilities, and waiting times at each customer. The novelty of this work lies in the integration of maintenance scheduling and a routing model that considers several machines.

1. Introduction

It is well known that thoughtful planning and scheduling of maintenance operations leads to significant improvements in the reliability of an industrial installation or a distribution network [16]. Maintenance planning determines the set of operations, time intervals, and resources (staff, supplies, and spare parts) necessary to conduct maintenance operations [6]. Companies often delegate maintenance planning to staff with experience, trusting in their intuition and knowledge. When they are faced with scheduling maintenance operations manually, even the most experienced planners can only consider a limited number of possibilities. Moreover, it is often the case that to manually generate a feasible schedule, they need to invest a significant amount of time.

When the machines are geographically distributed, the problem becomes even more complex because in addition to allocating maintenance operations to the workforce (e.g., crews) it is necessary to sequence their visits. The combinatorial optimization problem of finding the best set of routes (sequence of visits) for a workforce crew is known as the *vehicle routing problem* [21]. In a broad sense, this problem determines the best set of routes to be performed by a set of vehicles (crews) in order to serve a set of geographically-spread customers (machines) subject to some operational constraints. Among several variants of this problem, the vehicle routing problem with time windows (VRPTW) is closely related to planning and scheduling maintenance operations. In the VRPTW, the crews have a limited capacity (e.g., workday) to serve customers for whom maintenance operations must be started within given time windows.

Several applications for the combined maintenance and routing problem arise naturally in the oil and gas industry, telecoms, public utilities, health care, and the financial sector. For example, daily operations in an upstream oil and gas company involve managing a network of interconnected pumping stations. Because of the prohibitive costs of stopping the operation, the company incurs in an overly expensive maintenance policy that ensures the highest service levels at the intermediate stations. However, this policy translates into excessive technician visits to the stations, spread throughout a vast region. This type of company would be interested in other options that explore the tradeoff between service level and operational costs. Another application arises in maintenance operations of security hardware (e.g., video cameras) in a network of automatic teller machines (ATM). Most banks outsource these maintenance operations to a third party, who commits to perform periodical preventive maintenance within certain time windows. Upon occurrence of failures or accidents (e.g., vandalism), the technicians must go to the ATMs on a tighter

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http://dx.doi.org/10.1016/j.ress.2015.09.016
0951-8320/

The Interdependent Network Design Problem for Optimal Infrastructure System Restoration

04/12/2015

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DOI: 10.1111/mice.12171

COMPUTER-AIDED CIVIL AND INFRASTRUCTURE ENGINEERING

Computer-Aided Civil and Infrastructure Engineering **31** (2016) 334–350

The Interdependent Network Design Problem for Optimal Infrastructure System Restoration

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Abstract: *This study introduces the Interdependent Network Design Problem (INDP), concerned with defining the minimum-cost reconstruction strategy of a partially destroyed system of infrastructure networks, subject to budget, resources, and operational constraints, while considering interdependencies between them. To solve the INDP, the authors develop an efficient Mixed Integer Programming (MIP) model, which considers different types of interdependency while exploiting efficiencies from joint restoration due to colocation for the first time. The authors also propose heuristic methodologies based on simulation and the iterative use of the INDP model, to enable studying problems with additional complexity, such as accounting for uncertainty from possible disaster scenarios, or determining not only what to reconstruct but the order of reconstruction. Such methodologies enable the analysis of expected costs and performance associated to reconstruction of the system of networks, providing an effective tool for infrastructure decision makers. To exemplify the capabilities of the presented INDP-based methodologies, the authors study the process of restoration of a set of interdependent networks after hypothetical earthquakes in Shelby County, TN, United States. Results show that the INDP-based approaches that account for time-dependent recovery converge to quasi-optimal solutions in all 16 configurations studied, considering four different resource levels and four different earthquake magnitudes. Similarly, as desired in emergency response scenarios, the rate of performance recovery is high in the early reconstruction stages, recovering more than 85% of performance in the first stage in a worst-case scenario.*

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DOI: 10.1111/mice.12171

1 INTRODUCTION

It is well known that extreme natural events such as earthquakes and hurricanes have significant social and economic impact, partly due to their negative effects over infrastructure systems. Natural hazards kill more than 75,000 people and affect more than 200 million people around the globe every year (Van Wassenhove,

Micro-Level Adaptation, Macro-Level Selection, and the Dynamics of Market Partitioning

14/12/2015

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DOI:10.1371/journal.pone.0144574

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RESEARCH ARTICLE

Micro-Level Adaptation, Macro-Level Selection, and the Dynamics of Market Partitioning

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OPEN ACCESS

Citation: García-Díaz C, van Witteloostuijn A, Péli G (2015) Micro-Level Adaptation, Macro-Level Selection, and the Dynamics of Market Partitioning. PLoS ONE 10(12): e0144574. doi:10.1371/journal.pone.0144574

Editor: Wei-Xing Zhou, East China University of Science and Technology, CHINA

Received: February 13, 2015

Accepted: November 22, 2015

Published: December 14, 2015

Data Availability Statement: Our work is a computer simulation study, which does not contain real data. All the computer codes (a set of Matlab files) and estimated data can be found in the following public repository: (https://www.openabm.org/model/4746/version/2).

Funding: This work was supported by Fonds Wetenschappelijk Onderzoek (FWO, http://www.fwo.be/), Odysseus program (http://www.fwo.be/en/fellowships-funding/research-projects/odysseusprogramme/), and P.I. AvW.

Abstract

This paper provides a micro-foundation for dual market structure formation through partitioning processes in marketplaces by developing a computational model of interacting economic agents. We propose an agent-based modeling approach, where firms are adaptive and profit-seeking agents entering into and exiting from the market according to their (lack of) profitability. Our firms are characterized by large and small sunk costs, respectively. They locate their offerings along a unimodal demand distribution over a one-dimensional product variety, with the distribution peak constituting the center and the tails standing for the peripheries. We found that large firms may first advance toward the most abundant demand spot, the market center, and release peripheral positions as predicted by extant dual market explanations. However, we also observed that large firms may then move back toward the market fringes to reduce competitive niche overlap in the center, triggering non-linear resource occupation behavior. Novel results indicate that resource release dynamics depend on firm-level adaptive capabilities, and that a minimum scale of production for low sunk cost firms is key to the formation of the dual structure.

Introduction

Many industries feature dual market structures, with a few large companies dominating the market's center and many smaller enterprises surviving in the market's periphery. Such dual market structures are associated with high concentration and high firm density (i.e., number of firms). In industrial organization and organization theory, the question as to how dual market structures of two dominant firm types evolve has been studied since a long time [1, 2, 3]. However, to date, alternative explanations circulate in the literature that have not yet been integrated [4], implying that the evolution of dual market structures still are not fully understood [5]. In this paper, we develop an agent-based simulation model to explore different dual market structure explanations, revealing how they can or cannot be integrated, and what additional mechanisms may well play a role.

A Markov regime-switching framework to forecast El Niño Southern Oscillation patterns

18/12/2015

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DOI: 10.1007/s11069-015-2106-y

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Nat Hazards
DOI 10.1007/s11069-015-2106-y

ORIGINAL PAPER

A Markov regime-switching framework to forecast El Niño Southern Oscillation patterns

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Received: 26 March 2015 / Accepted: 30 November 2015

Abstract The El Niño Southern Oscillation (ENSO) is an ocean–atmosphere phenomenon involving sustained sea surface temperature fluctuations in the Pacific Ocean, causing disruptions in the behavior of the ocean and atmosphere. We develop a Markov-switching autoregressive model to describe the Southern Oscillation Index (SOI), a variable that explains ENSO, using two autoregressive processes to describe the time evolution of SOI, each of which associated with a specific phase of ENSO. The switching between these two models is governed by a discrete-time Markov chain, with time-varying transition probabilities. Then, we extend the model using sinusoidal functions to forecast future values of SOI. The results can be used as a decision-making tool in the process of risk mitigation against weather- and climate-related disasters.

Keywords ENSO · Markov-switching · Autoregressive processes · Forecasting · Regimes

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Published online: 18 December 2015

TransMilenio, a Scalable Bus Rapid Transit System for Promoting Physical Activity

16/02/2016

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DOI 10.1007/s11524-015-0019-4

Journal of Urban Health: Bulletin of the New York Academy of Medicine
doi:10.1007/s11524-015-0019-4

TransMilenio, a Scalable Bus Rapid Transit System for Promoting Physical Activity

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ABSTRACT *Transport systems can play an important role in increasing physical activity (PA). Bogotá has been recognized for its bus rapid transit (BRT) system, TransMilenio (TM). To date, BRTs have been implemented in over 160 cities worldwide. The aim of this study was to assess the association between PA and the use of TM among adults in Bogotá. The study consists of a cross-sectional study conducted from 2010 to 2011 with 1000 adults. PA was measured using the International Physical Activity Questionnaire. In a subsample of 250 adults, PA was objectively measured using ActiGraph accelerometers. Analyses were conducted using multilevel logistic regression models. The use of TM was associated with meeting moderate-to-vigorous PA (MVPA). TM users were more likely to complete an average of >22 min a day of MVPA (odds ratio [OR] = 3.1, confidence interval [CI] = 95 % 1.4–7.1) and to walk for transportation for ≥150 min per week (OR = 1.5; CI = 95 % 1.1–2.0). The use of TM was associated with 12 or more minutes of MVPA (95 % CI 4.5–19.4, $p < 0.0001$). Associations between meeting PA recommendations and use of TM did not differ by socioeconomic status (p value = 0.106) or sex (p value = 0.288). The use of TM is a promising strategy for enhancing public health efforts to reduce physical inactivity through walking for transport. Given the expansion of BRTs, these results could inform the development of transport PA programs in low- to high-income countries.*

KEYWORDS *Physical activity, Walking, Transportation, Bus rapid transit*

INTRODUCTION

Physical inactivity (PI) is associated with at least 5.3 million deaths per year. If PI were decreased by 25 %, over 1.3 million deaths could be prevented every year[1] in mostly low- and middle-income countries.[2] Governments and health professionals are therefore being encouraged to promote physical activity (PA) and prevent noncommunicable diseases (NCDs).[3]

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Published online: 16 February 2016

Using agent based modeling to assess the effect of increased Bus Rapid Transit system infrastructure on walking for transportation

21/03/2016

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DOI: 10.1016/j.ypmed.2016.03.015

Preventive Medicine

Preventive Medicine 88 (2016) 39–45

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Using agent based modeling to assess the effect of increased Bus Rapid Transit system infrastructure on walking for transportation

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ARTICLE INFO

Article history:
Received 5 November 2015
Received in revised form 24 February 2016
Accepted 17 March 2016
Available online 21 March 2016

Keywords:
Physical activity
Agent based model
Bus Rapid Transit

ABSTRACT

The effect of transport infrastructure on walking is of interest to researchers because it provides an opportunity, from the public policy point of view, to increase physical activity (PA). We use an agent based model (ABM) to examine the effect of transport infrastructure on walking. Particular relevance is given to assess the effect of the growth of the Bus Rapid Transit (BRT) system in Bogotá on walking.

In the ABM agents are assigned a home, work location, and socioeconomic status (SES) based on which they are assigned income for transportation. Individuals must decide between the available modes of transport (i.e., car, taxi, bus, BRT, and walking) as the means of reaching their destination, based on resources and needed travel time. We calibrated the model based on Bogota's 2011 mobility survey.

The ABM results are consistent with previous empirical findings, increasing BRT access does indeed increase the number of minutes that individuals walk for transportation, although this effect also depends on the availability of other transport modes. The model indicates a saturation process: as more BRT lanes are added, the increment in minutes walking becomes smaller, and eventually the walking time decreases. Our findings on the potential contribution of the expansion of the BRT system to walking for transportation suggest that ABMs may prove helpful in designing policies to continue promoting walking.

1. Introduction

A 25% decrease in physical inactivity (PI) could prevent over 1.3 million deaths every year (Lee et al., 2012) from non-communicable diseases (NCDs). Hence, walking for transportation may be an important contributor in meeting physical activity (PA) recommendations to prevent NCDs (WHO, 2007; Gordon-Larsen et al., 2009). Walking is associated with reductions in the risk of cardiovascular disease (Gordon-Larsen et al., 2009), type 2 diabetes, obesity, cancer, and improvement in overall fitness (Hamer and Chida, 2008). Studies on public transportation have shown that walking is the most natural and important mode for accessing public transport (Daniels and Mulley, 2013; Cervero, 2001).

Nevertheless, the findings on the association between the use of and access to public transit systems and walking for transportation are mixed (Ding et al., 2013), implying an urgent need to understand the relation between transport infrastructure and PA promotion.

Several studies exploring this relation have identified a positive association between walking and access to Bus Rapid Transit (BRT) systems (Cervero et al., 2009; Hino et al., 2011; Lemoine et al., 2016).

Specifically, by applying statistical models to estimate the association between built environment characteristics and walking for transportation, these studies have shown that BRT users are more likely to meet PA recommendations. This finding is highly relevant given that during the last four decades BRTs have been implemented in over 180 cities with an increasing ridership that already numbers over 30 million passengers per day (Hidalgo and Gutiérrez, 2013). Therefore, BRT systems are an important part of the built environment and a growing trend around the globe.

Evidence is still lacking, however, on whether a substantial increases in BRT access can lead to an increase in walking for transport (Saelens et al., 2014). To assess the shape of this trend we must account for

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http://dx.doi.org/10.1016/j.ypmed.2016.03.015
0091-7435/

On the preventive management of sediment-related sewer blockages: a combined maintenance and routing optimization approach

28/03/2016

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DOI: 10.2166/wst.2016.160

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Water Science & Technology

On the preventive management of sediment-related sewer blockages: a combined maintenance and routing optimization approach

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ABSTRACT

In this work we tackle the problem of planning and scheduling preventive maintenance (PM) of sediment-related sewer blockages in a set of geographically distributed sites that are subject to non-deterministic failures. To solve the problem, we extend a combined maintenance and routing (CMR) optimization approach which is a procedure based on two components: (a) first a maintenance model is used to determine the optimal time to perform PM operations for each site and second (b) a mixed integer program-based split procedure is proposed to route a set of crews (e.g., sewer cleaners, vehicles equipped with winches or rods and dump trucks) in order to perform PM operations at a near-optimal minimum expected cost. We applied the proposed CMR optimization approach to two (out of five) operative zones in the city of Bogotá (Colombia), where more than 100 maintenance operations per zone must be scheduled on a weekly basis. Comparing the CMR against the current maintenance plan, we obtained more than 50% of cost savings in 90% of the sites.

Key words | non-deterministic failures, sediment-related sewer blockages, sewer system maintenance planning, vehicle routing

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INTRODUCTION

Maintenance operations have an important role for the reliability improvement in industrial facilities and infrastructure systems (Remy *et al.* 2013; López-Santana *et al.* 2016). The purpose of preventive maintenance (PM) operations is to extend the lifetime (or the time to the next failure) of equipment or infrastructures, taking into account that replacement or reparation might be more expensive. It is expected that effective maintenance policies reduce the frequency of service disruptions and their undesirable consequences (Endrenyi *et al.* 2001). A well-defined plan for maintenance includes a set of tasks, time intervals, and resources that are required to perform a series of maintenance operations (Duffuaa 2000). In practice, some companies and utilities delegate PM planning to experienced employees. Based on their intuition and knowledge of the system, employees determine schedules of maintenance operations; however, an employee only considers a limited number of possibilities in the time available for such planning (López-Santana *et al.* 2016).

Particularly, urban water utilities are responsible for complex infrastructure systems and equipment. These systems are subject to non-deterministic failures and require maintenance. When equipment or infrastructure fails, different side effects such as service disruptions, bad publicity, public health issues, or unsafe conditions for users (among others) might arise (Korving *et al.* 2006; Rodríguez *et al.* 2012; Hickcox 2013). Although these undesired situations can be mitigated through corrective maintenance (CM) operations, costs and challenges involved are the main concerns for utilities.

Planning maintenance operations for water utilities involves an additional hurdle due to the underground nature of the system: system elements are difficult to observe and therefore to maintain (Yang & Su 2007). In this sense, sewer system sediment-related blockages are one of the main challenges faced by these utilities (Arthur *et al.* 2009). It is well known that this type of failures can cause flooding and sewer overflows (Korving *et al.* 2006) and it

doi: 10.2166/wst.2016.160

A new methodology for the optimal design of series of pipes in sewer systems

02/04/2016

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DOI: 10.2166/hydro.2016.105

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Geotechnical Engineering and Engineering Geology (Q2)

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Journal Citation Reports®
Engineering, Civil (Q2)

Journal of Hydroinformatics

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A new methodology for the optimal design of series of pipes in sewer systems

Natalia Duque, Daniel Duque and Juan Saldarriaga

ABSTRACT

The sewer network design problem consists of determining both the layout and the hydraulic design of the system. This paper aims to find an optimal hydraulic design for a specific layout consisting of a series of pipes. An optimal hydraulic design of a series of pipes is that which satisfies all the hydraulic, commercial, and construction constraints, while minimizing the construction costs. The present paper proposes a graph modeling framework in which the result of a shortest path problem coincides with the hydraulic design, and the underlying graph models the diameter and slope of each pipe in the series. To assess the performance of the methodology, several numerical examples are presented varying the pipe material, the topography, and the number of pipes in the series.

Key words | design of series of pipes, graph modeling, optimization, sewer systems, shortest path problem

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INTRODUCTION

The sewer network design problem consists of determining both the layout and the hydraulic design of the system. The layout of the network is defined by the initial pipes and the flow direction of each pipe. The hydraulic design determines the diameter and the slope of the pipe to be installed at each link of the sewer network, and a link refers to the span between two manholes. Moreover, pipe diameters are chosen from a discrete set of commercial diameters and the slope of a pipe is related to the elevation gap of its extremes. In this paper, the layout is assumed to be a series of pipes that might belong to a complete sewer network. The challenge is to find a minimum-cost design that accomplishes all hydraulic and construction constraints established by the corresponding national legislation. In the following, it is assumed that the design flow rate for each pipe is known beforehand. The design flow rate for a pipe corresponds to the inflow at the upstream manhole of the pipe plus the flow rate coming from the upstream pipes. The input information of the problem includes topographic information (horizontal length of the links and ground elevation of the manholes), commercial characteristics (available pipe materials and diameters), physical characteristics of the fluid (water density and viscosity), and hydraulic characteristics (flow resistance formula and pipe's internal roughness). In this work, the hydraulic constraints that must be fulfilled are: a minimum pipe diameter, a maximum filling ratio, a minimum wall shear stress, a minimum and maximum velocity, and a minimum and maximum slope.

Sewer network design involves two different problems (the layout definition and the hydraulic design), and due to their complexity it is not common practice to solve them simultaneously. Available solution strategies in the literature propose solving both problems sequentially, but the hydraulic design problem has received more attention through both exact and heuristic methodologies.

Several exact approaches have been proposed for both problems. Haith (1966) used dynamic programing (DP) to obtain an optimal design of a series of pipes by considering a single pipeline divided into different segments, each with constant inflow and cost parameters. Decision variables in the model include the invert elevation at the end of each pipe and its diameter. However, this methodology had

doi: 10.2166/hydro.2016.105

Cows, agency, and the significance of operational thinking

14/04/2016

Camilo Olaya

DOI: 10.1002/sdr.1547

Cows, agency, and the significance of operational thinking†

Camilo Olaya*

Abstract

The reverence for data as the source of knowledge seems to be the rule in academic activities. In this respect, system dynamics has much to offer. One of its trademarks is "operational thinking", a distinct attitude that, unlike scientific practices that seek to understand the world by means of data analysis, seeks to transform systems in terms of operations. Operational thinking means to recognize agency as the driving force through which systems actually work: free decision-makers invent their own future through actions that shape and create systems; they do not obey laws to be discovered by observing the past. System dynamics models provide intelligible explanations that meet such agency. Redesigning and improving human systems require then the capacity to realize and transform operational arrangements, that is, to understand and change decision processes and purposeful actions. Copyright © 2016 System Dynamics Society

Syst. Dyn. Rev. **31**, 183–219 (2016)

Introduction

> A popular economic journal published the research of a noted economist who had developed a very sophisticated econometric model designed to predict milk production in the United States. The model contained a raft of macroeconomic variables woven together in a set of complex equations. But nowhere in that model did cows appear. If one asks how milk is actually generated, one discovers that cows are absolutely essential to the process. (Richmond, 1993, p. 128)

Barry Richmond used the previous statement to show what he labeled as "operational thinking", which he described as thinking in terms of "*how things really work*", as opposed to "how things would theoretically work, or how one might fashion a bit of algebra capable of generating realistic-looking output" (Richmond, 1993, p. 127). Richmond associated such operational thinking with the identification of key material arrangements of the modeled system, "getting down to the physics … the core stock-and-flow infrastructure that lies at the heart of a system" (Richmond, 1994, p. 141). My impression is that the value of this way of thinking is unrecognized or underestimated. Indeed, Richmond felt that operational thinking, as a thinking skill, remained underappreciated in the field of system dynamics (SD). The reason for this, according to him, is that such a skill "is so much a natural part of the way

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† A preliminary version of this paper was presented at the 30th International Conference of the System Dynamics Society

Accepted by Laura J. Black, *Received 27 February 2015*; *Revised 12 February 2016*; *Accepted 17 February 2016*

System Dynamics Review
System Dynamics Review vol 31, No 4 (October 2015): 183–219
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/sdr.1547

An engineering perspective for policy design: self-organizing crime as an evolutionary social system

16/06/2016

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DOI 10.1007/s12117-016-9282-3

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Trends Organ Crim
DOI 10.1007/s12117-016-9282-3

An engineering perspective for policy design: self-organizing crime as an evolutionary social system

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Abstract Here we introduce methodological guidelines for designing policies against organized crime. We employ the evolutionary ontology proposed by Kurt Dopfer for conceiving organized crime as the outcome of social, intelligent agents whose strategies evolve through time. To illustrate the use of this ontology we explore the case of corruption in public procurement processes in Colombia in which criminal organizations—groups of corrupt agents—converge spontaneously. The ontology leads to conceive corruption as a knowledge process that adapts according to the evolution of problem-solving rules that are created, used and discarded by agents that seek to attain personal gains by means of public resources. We also use an engineering perspective that favors model-aided design. We built a simulation model that illustrates how the dynamics of such evolving-rules systems can be conceptualized for exploring potential policies. The application of the evolutionary ontology shows why corruption exhibits self-organization: system-level patterns develop from spontaneous interactions that use only local information. Rule dynamics form a changing structure of rule-populations that adapt to novel environmental conditions and generate meta-stable adaptions that explain why corruption persists despite continuous challenges from the environment. This engineering approach forms the ground for proposing policies that instead of addressing the operant level of a social system (according to observed operations and data), should meet the dynamics of rules that govern those operations. Hence, the role of regulators shifts from "controllers" to inventors of selectionist environments that facilitate suitable change through the introduction or promotion of counter-crime rules, the design of selective pressures that favor the evolution of desirable rules and the attention to coordination gaps at the macro-structure. The recognition of

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Published online: 16 June 2016

Linear solution schemes for mean-semivariance project portfolio selection problems: An application in the oil and gas industry

17/06/2016

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DOI: 10.1016/j.omega.2016.05.007

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Management Science and Operation Research (Q1)
Strategy and Management (Q1)

Omega

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Contents lists available at ScienceDirect

Omega

journal homepage: www.elsevier.com/locate/omega

Linear solution schemes for Mean-SemiVariance Project portfolio selection problems: An application in the oil and gas industry ☆

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ARTICLE INFO

Article history:
Received 18 August 2014
Accepted 31 May 2016

Keywords:
Semivariance
Project selection
Project portfolio optimization
Benders decomposition
Mean-SemiVariance
Risk
Petroleum industry

ABSTRACT

We study the Mean-SemiVariance Project (MSVP) portfolio selection problem, where the objective is to obtain the optimal risk-reward portfolio of *non-divisible* projects when the risk is measured by the semivariance of the portfolio's Net-Present Value (NPV) and the reward is measured by the portfolio's expected NPV. Similar to the well-known Mean-Variance portfolio selection problem, when integer variables are present (e.g., due to transaction costs, cardinality constraints, or asset illiquidity), the MSVP problem can be solved using Mixed-Integer Quadratic Programming (MIQP) techniques. However, conventional MIQP solvers may be unable to solve large-scale MSVP problem instances in a reasonable amount of time. In this paper, we propose two *linear* solution schemes to solve the MSVP problem; that is, the proposed schemes avoid the use of MIQP solvers and only require the use of Mixed-Integer Linear Programming (MILP) techniques. In particular, we show that the solution of a class of real-world MSVP problems, in which project returns are positively correlated, can be accurately approximated by solving a single MILP problem. In general, we show that the MSVP problem can be effectively solved by a sequence of MILP problems, which allow us to solve large-scale MSVP problem instances faster than using MIQP solvers. We illustrate our solution schemes by solving a real MSVP problem arising in a Latin American oil and gas company. Also, we solve instances of the MSVP problem that are constructed using data from the PSPLIB library of project scheduling problems.

1. Introduction

The selection of the best investment projects within a set of alternatives is crucial to any firm facing competition. Moreover, the ability to build portfolios that efficiently allocate scarce resources contributes to the achievement of corporate goals in the long run. Typically, a portfolio's expected profit is considered the single most important corporate goal to be maximized; however, it is not the only one: the fitness of a firm's portfolio should also involve a measure of the portfolio's volatility or risk. For instance, a portfolio with very attractive expected profits might expose the company to a large loss with high probability, whereas a low-risk portfolio might secure the company lower but more certain profits. For these reasons, the problem of selecting projects to create an optimal risk-reward portfolio has been actively considered in the literature (cf., [10,36,38]).

A keystone economic sector where the problem of selecting an appropriate portfolio of project investments arises is the upstream oil and gas industry. In this sector, the project investment's returns are subject to high uncertainty, mainly driven by factors like geology, equipment costs, oil selling price, well production levels, and oil quality, among others. In a typical project, the profit's probability distribution is usually asymmetrical (skewed), exhibiting a high probability of low profits and a low probability of high profits [37]. Moreover, given the significant amount of investment required to carry out a project, managers and investors in this industry have a strong bias against underperforming portfolios [26,30,34,35], leaning towards downside-risk measures to quantify the risk of investment [33].

Although different downside-risk measures are available in the literature (cf., [6,16,25,31]), in this paper we focus on the semivariance risk measure. Through this measure, projects with a high probability of having returns lower than a critical value (e.g., the expected value or any other value specified by the decision maker)

☆This manuscript was processed by Associate Editor Strusevich.

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http://dx.doi.org/10.1016/j.omega.2016.05.007
0305-0483/

Universidad de los Andes | Vigilada Mineducación
Reconocimiento como Universidad: Decreto 1297 del 30 de mayo de 1964.
Reconocimiento personería jurídica: Resolución 28 del 23 de febrero de 1949 Minjusticia