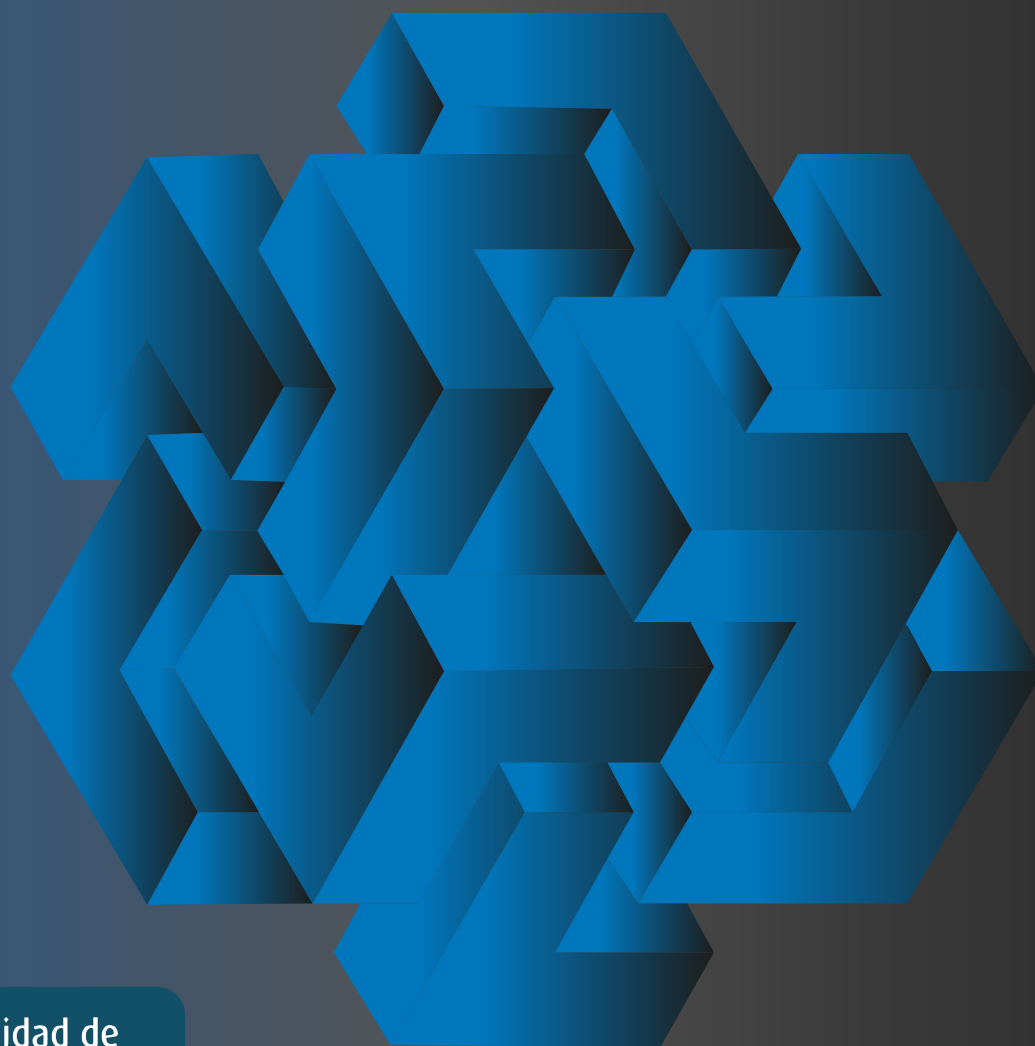


01/01/2025 - 31/12/2025

Publicaciones de alto impacto

Departamento de Ingeniería Industrial

Número 12



Publicaciones de **ALTO IMPACTO**

El Departamento de Ingeniería Industrial considera de vital importancia compartir con el público los resultados de investigación de excelencia alcanzados por nuestros docentes. Estos logros representan un motivo de gran satisfacción para nuestra comunidad académica. En esta décima edición, se presentan las publicaciones correspondientes al año 2025, las cuales reflejan la amplitud, relevancia e impacto de la Ingeniería Industrial. Para su inclusión en esta revista, es necesario que dichas publicaciones cumplan con los rigurosos criterios establecidos por Minciencias para ser reconocidas como de "alto impacto" en la producción académica y que se resumen a continuación:

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Cálculo de muertes evitables por la pandemia: Un análisis para Bogotá bajo un contexto del efecto en el diseño de la red logística y el control de inventarios en la vacunación Covid-19 en Colombia:

1 de enero de 2025
Publicado en: Medicina



Nelson Mariño
Ciro Alberto Amaya

ÍNDICE:

Análisis retrospectivo del impacto de la vacunación contra el COVID-19 en Bogotá, evaluando la disponibilidad de vacunas, población priorizada y efectividad. El estudio estima que una distribución más ágil y oportuna de las vacunas disponibles podría haber evitado hasta 3.300 muertes adicionales, evidenciando que las barreras logísticas y administrativas limitaron la eficiencia del proceso de vacunación.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

SCImago Journal: Q2

ARTÍCULO DE INVESTIGACIÓN

Cálculo de muertes evitables por la pandemia: Un análisis para Bogotá bajo un contexto del efecto en el diseño de la red logística y el control de inventarios en la vacunación Covid-19 en Colombia

Computation of avoidable deaths in the pandemic: An analysis on Covid-19 vaccination in Bogotá (Colombia) under the logistics network design effect and the inventory control context

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Resumen

Objetivo: Hacer un análisis retrospectivo, basado en los datos disponibles sobre las personas fallecidas por la COVID-19 y la disponibilidad de vacunas para Bogotá, para estimar el número de personas que se contagiaron y murieron y que potencialmente no hubiesen fallecido si estuviesen vacunadas, bajo el supuesto que para ese momento con las vacunas ya disponibles se hubiesen podido aplicar, con un modelo logístico más rápido y directo sin tantos eslabones. **Metodología:** Se realiza un análisis numérico retrospectivo que considera la cantidad de vacunas disponibles, el número de personas priorizadas para ese momento y la efectividad de las vacunas reportada en los estudios científicos. **Resultados:** La vacunación fue una forma efectiva de combatir la pandemia SARS-CoV2 y según estimaciones del Ministerio de Salud y Protección Social - MSPS se logró disminuir muertes de alrededor de 22.000 personas a nivel nacional. No obstante, de acuerdo con esta investigación y según las vacunas disponibles, en solo Bogotá se hubiese podido aumentar ese número hasta en unas 3.300 personas, si el inventario disponible, aunque escaso, se hubiese administrado eficiente y oportunamente. **Conclusiones:** En Colombia el planteamiento del Plan Nacional de Vacunación se basó en el Programa Ampliado de Inmunización (PNV). No obstante, la red logística implementada, el control y asignación de inventario y las barreras

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An Exact Method for Reliable Shortest Path Problems With Correlation:

18 de enero de 2026
Publicado en: Networks - An International Journal



Esteban Leiva
Santiago Morales
Daniel Yamín
Andrés L. Medaglia

ÍNDICE:

Este artículo presenta un método exacto para encontrar la ruta más corta y confiable en redes de transporte con tiempos de viaje inciertos y correlacionados. Mediante la integración de un algoritmo basado en pulse y estrategias de poda, la propuesta maximiza la probabilidad de llegar a tiempo mientras reduce drásticamente los tiempos de cálculo, optimizando la toma de decisiones en movilidad y logística.

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Journal Citation Reports: Q3

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RESEARCH ARTICLE OPEN ACCESS

An Exact Method for Reliable Shortest Path Problems With Correlation

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Keywords: correlation | optimal paths | pulse algorithm | reliable paths | shortest paths | transportation networks

ABSTRACT

Shortest path problems often arise in contexts where travel times are uncertain. In these settings, reliable paths are often valued more than paths with lower expected travel times. This has led to several variants of reliable shortest path problems (RSPP) that handle travel time reliability differently. We propose an algorithmic framework for solving RSPPs with non-negatively correlated travel times and resource constraints. By building upon the flexibility of the pulse algorithm, our unified and exact algorithmic framework solves multiple variants of the RSPP: the α -reliable shortest path (α -RSP), the maximum probability of on-time arrival (MPOAP) problem, and the shortest α -reliable path (S- α RP). We derive a bound on the reliability of path travel times and incorporate three pruning strategies: bounds, infeasibility, and dominance, leveraging properties of the normal distribution and non-negative correlation structures. Computational experiments on large-scale transportation networks (with up to 33 113 nodes and 75 379 arcs) demonstrate that the framework achieves a ten-fold speed improvement over state-of-the-art methods, highlighting its potential real-world applications and extensions to related problems.

1 | Introduction

Finding optimal paths in a network is crucial for applications arising in different domains, ranging from telecommunications to transportation [1, 2]. In many contexts, optimal path applications arise in an inherently uncertain environment. For instance, in road networks, travel time is uncertain due to factors like congestion, traffic accidents, and extreme weather conditions. Hence, optimizing routes while considering uncertain travel times is of utmost importance in routing applications. Along this line, various stochastic path problems have been introduced to address randomness in travel times under different objectives and constraints.

The Least Expected Travel Time (LET) path has been a common approach to solve stochastic shortest path problems. However, LET paths fall short for most travelers, as reliable paths are valued more than LET paths [3]. This preference stems from the fact that while LET paths might offer the shortest expected travel time, they often come with high variability and uncertainty, making them less dependable [4]. Recent empirical studies have shown the importance of reliability in routing decisions [5–7]. Consequently, several researchers have proposed different variants of Reliable Shortest Path (RSP) problems that account for reliability guarantees while considering different metrics and constraints that model uncertainty and reduce the likelihood of significant delays.

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Optimal hybrid backup systems for substation auxiliary services during outages through stochastic programming

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Publicado en: Electric Power Systems Research.



Matheus Holzbach
Norberto A. Martínez
Lucas T. Faria
Alejandra Tabares
José F. Resende
John F. Franco

ÍNDICE:

El artículo propone un modelo de optimización para diseñar sistemas de respaldo con paneles solares y baterías, buscando garantizar el suministro eléctrico durante cortes de energía y reducir costos de inversión y dependencia de generadores.

ENLACE AL ARTÍCULO:

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Optimal hybrid backup systems for substation auxiliary services during outages through stochastic programming

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Auxiliary services
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ABSTRACT

Auxiliary services are fundamental to ensure the uninterrupted operation, control, and surveillance of critical infrastructure. Traditional dependency on diesel generators as backup power sources during service disruptions is increasingly challenged by their non-renewable nature, operational costs, and environmental impacts. Addressing these concerns, this paper introduces a novel stochastic programming method for the optimal design of a hybrid backup system (HBS), integrating photovoltaic (PV) panels, battery storage, and bidirectional inverters, specifically tailored for substation auxiliary services (SAS). The proposed model represents the uncertainties associated with solar irradiance and power outages (occurrence and duration) through a scenario-based analysis, ensuring a required level of robustness. The proposed model is applied to a case study and a sensitivity analysis of the most important parameters was executed. It was identified that the optimal investment corresponds to an HBS formed by 6 batteries and 22 PV panels (18 kWh/8.58 kWp), providing a robustness level of 99.526 %, which reduces the unavailable hours of the SAS by 61 %. The findings underscore the pivotal contribution of battery systems to support SAS under outages, facilitating the attainment of requisite reliability thresholds. Nonetheless, achieving higher levels of robustness is intrinsically linked to increased financial investment in the backup system infrastructure.

1. Introduction

Substation auxiliary services (SAS) are essential tasks for the normal distribution network operation. They perform functions associated with monitoring, measuring, communicating, and operating of numerous electrical equipment such as potential and current transformers, automatic switches, sensors, protection relays, supervisory systems, and others. Furthermore, SAS include essential loads such as lighting, heating-cooling, motors, and circuit breakers [1–3].

Due to their importance to the electric distribution system, SAS must be operated without interruption, even under outage. Generally, SAS are supplied by a low-voltage bus connected to a distribution feeder in normal operating conditions. Still, to act during an outage, substations are equipped with backup systems to provide power for SAS during the outage period in the distribution feeder.

The most common backup system is the diesel generator. However, it has some disadvantages: (i) diesel is a non-renewable and highly

polluting energy source, (ii) diesel generators have high operation and maintenance costs, and (iii) there are frequent reports of diesel generator malfunctions. Additionally, some regulations recommend the presence of more than one backup system. For instance, Brazilian regulation requires at least two independent sources to supply SAS [1,4].

Environmental concerns have become an increasingly sensitive issue in recent decades. Recently, the Secretary-General of the United Nations announced that the “era of global warming” has ended and the “era of global boiling” has arrived, marking an unprecedented level of heating in human history [5]. This fact reinforces the importance of renewable energy generation, which has emerged as a focal point in modern research, reflecting a vital and strategic investment in response to evolving environmental, social, and economic challenges. For instance, PV panels, wind turbines, and energy storage systems (ESSs) are distributed energy resources (DER) often integrated into modern power systems [6]. The large-scale inclusion of renewable DERs: (i) increases the energy sources to meet time-varying consumer demands, (ii) reduces the electrical system dependence on fossil fuels, and (iii) postpones

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Machine Vision-Assisted Design of End Effector Pose in Robotic Mixed Depalletizing of Heterogeneous Cargo:

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Publicado en: Revista científica Sensors



Sebastián Valero
Juan C. Martínez
Ana M. Montes
Cesar Marín
Rubén Bolaños
David Álvarez

ÍNDICE:

El artículo propone un sistema en tiempo real para la despaletización robótica de carga heterogénea (cajas de distintos tamaños y posiciones). Usando visión artificial con deep learning, identifica con precisión la ubicación de las cajas y planifica trayectorias libres de colisiones para el brazo robótico, optimizando la eficiencia y adaptabilidad en la logística de almacenes.

ENLACE AL ARTÍCULO:

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Journal Citation Reports: Q2

SCImago Journal: Q1



Article

Machine Vision-Assisted Design of End Effector Pose in Robotic Mixed Depalletizing of Heterogeneous Cargo

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Abstract: Automated depalletizing systems aim to offer continuous and efficient operation in warehouse logistics, reducing cycle times and contributing to worker safety. However, most commercially available depalletizing solutions are designed primarily for highly homogeneous cargo arranged in orthogonal configurations. This paper presents a real-time approach for depalletizing heterogeneous pallets with boxes of varying sizes and arbitrary orientations, including configurations where the topmost surfaces of boxes are not necessarily parallel to each other. To accomplish this, we propose an algorithm that leverages deep learning-based machine vision to determine the size, position, and orientation of boxes relative to the horizontal plane of a robot arm from sparse depth data. Using this information, we implement a path planning method that generates collision-free trajectories to enable precise box grasping and placement onto a production line. Validation through both simulated and real-world experiments demonstrates the feasibility and accuracy of this approach in complex industrial settings, highlighting potential improvements in the efficiency and adaptability of automated depalletizing systems.

Keywords: segmentation; hand-eye calibration; robotic depalletizing; heterogeneous cargo handling; deep learning in robotics; sparse stereo vision; 3D object detection; non-orthogonal pallet configurations; pick-and-place robotics



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1. Introduction

Automated depalletizing solutions consist of systematically removing goods or materials from a pallet to place them on a production line [1]. They can operate continuously, significantly reducing cycle times compared to manual methods and enhancing production rates. By performing repetitive tasks with high accuracy and consistency, these systems minimize human error and can handle hazardous or heavy materials, reducing the risk of workplace injuries. Furthermore, these systems can be reprogrammed to adapt to changes in production lines or to handle new products without the need for extensive structural reconfiguration [2].

Most existing depalletizing systems, such as the one demonstrated by Etde [3], perform well with homogeneous and consistently orthogonal pallet configurations, but exhibit increased error rates when these conditions are not fully met. This paper explores the design and implementation of an automated depalletizing system tailored for heterogeneous pallets, starting by presenting the general depalletizing scheme, which outlines the system configuration and operational workflow. Subsequently, we present a deep learning-based

A Hybrid Approach for the Container Loading Problem for Enhancing the Dynamic Stability Representation

1 de marzo de 2025

Publicado en: Mathematics, de la editorial MDP



Ana M. Montes Franco
Juan Camilo Martínez Franco
Alejandra Tabares
David Álvarez

ÍNDICE:

El artículo propone un método híbrido para optimizar el cargue de contenedores, buscando aprovechar mejor el espacio y garantizar la estabilidad y seguridad de la carga durante el transporte. Combina técnicas de optimización con modelos de estabilidad dinámica para evaluar la distribución de los

ENLACE AL ARTÍCULO:

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Journal Citation Reports: Q1

SCImago Journal: Q2



Article

A Hybrid Approach for the Container Loading Problem for Enhancing the Dynamic Stability Representation

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Abstract: In the container loading problem (CLP), the construction of packing patterns is driven by the maximization of the volume occupied, and comprises several constraints such as loading feasibility, weight balance, cargo stability, operational safety, material handling, and the prevention of cargo damage during container shipping. Previous works introduced dynamic stability indicators using simulation or statistical approaches. However, this firstly exponentially increases the computational burden, and secondly misrepresents the essential kinetic mechanical aspects. This paper presents a hybrid scheme to solve the CLP by embedding a mechanical model into a reactive GRASP algorithm, leading to two main novelties; namely, the substitution of the physics simulation engine to find the dynamic stability of the packing patterns, and a modified structure of the metaheuristic, guaranteeing specified minimum stability while achieving efficient packing patterns. The mechanical model dynamically analyzes the forces and accelerations acting on the cargo to predict loss of support, overturning, or critical velocity deltas that would damage it. At the same time, the reactive GRASP algorithm considers the dynamic stability indicators in the improvement steps. The stability indicators are obtained from the mechanical model, allowing the user to know the percentage of damaged boxes in a packing pattern. The effectiveness of the proposed approach is tested using a set of classical benchmark instances, obtaining adequately accurate solutions within a short computational time. The resulting scheme integrates real-world problem conditions and achieves dynamic stability solutions at an acceptable computational cost; it is programmed in C++ instead of relying on proprietary simulation tools.

Keywords: container loading problem; dynamic stability; GRASP; metaheuristic

MSC: 05B40

1. Introduction

Transportation, loading, and unloading of cargo are essential activities of the supply chain, as companies cannot operate without moving their raw materials or finished products [1]. Ensuring the product arrives undamaged is necessary for customer satisfaction, saving costs, and avoiding repeated work. The number of packages shipped in 2019 was 100 billion and is expected to reach 200 billion globally by 2025 [2]. As a consequence, in the specialized literature economic incentives have been a driving force behind the study of packaging problems where the issue of packing a set of small objects (e.g., boxes) into large objects (e.g., containers) needs to be solved. Consequently, there is a genuine interest



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Scaling of cardiovascular risk factors in 230 Latin American cities:

1 de marzo de 2025
Publicado en: Revista científica Scientific Reports



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ÍNDICE:

El artículo analiza cómo el tamaño y la urbanización influyen en cuatro factores de riesgo cardiovascular en 230 ciudades latinoamericanas. Los resultados muestran que la diabetes y la hipertensión aumentan en las ciudades más grandes, mientras que el tabaquismo disminuye, aportando evidencia clave para las políticas de salud pública urbana en la región.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q1

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scientific reports

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OPEN Scaling of cardiovascular risk factors in 230 Latin American cities

Aureliano S. S. Paiva¹, Usama Bilal², Roberto F. S. Andrade^{1,3}, Claudiano C. Cruz Neto^{1,4}, J. Firmino de Sousa Filho^{1,5}, Gervásio F. Santos^{1,5}, Maurício L. Barreto¹, Daniel A. Rodríguez⁶, Pricila Mullachery², Brisa Sanchez², Ana V. Diez-Roux², Felipe Montes⁷, Andrés Trotta⁸, Tania Alfaro⁹, J. Jaime Miranda^{10,11} & Tonatiuh Barrientos-Gutiérrez¹²

Urbanization results in increased numbers of people living in cities and poses challenges and opportunities to public health policies. Studies of urban scaling have unveiled how cities' socio-economic and infrastructural attributes vary systematically with city size. Previous studies have explored the scaling properties of health outcomes across metropolitan areas in different countries, but chronic diseases have been infrequently examined. This paper examines scaling behaviors of 4 cardiovascular risk factors: hypertension, diabetes, tobacco smoking, and obesity across 230 cities in six countries of Latin America. In analyses pooled across countries, diabetes and hypertension showed weakly superlinear scaling (higher prevalence in larger cities). In comparison, obesity showed linear scaling, and tobacco showed weakly sublinear scaling (lower prevalence in larger cities), although most coefficients did not differ significantly from the null. In country-specific analyses, hypertension and diabetes tended to show a superlinear pattern across most countries, obesity tended to show a sublinear pattern in most countries, and tobacco tended to be superlinear (in contrast to the analysis pooled across countries where it was sublinear). Results suggest the need to examine further the drivers of this varying scaling of risk factors.

Keywords Urban health, Cardiovascular disease, Urban scaling, Proportion, Latin America

More than half of the world's population currently lives in cities. By 2050, this proportion is expected to reach 70%¹. This concentration of people living in dense areas poses several challenges and opportunities on a global scale. For this reason, urban conditions are important components of the 2030 Sustainable Development Goals, as reflected in Goal 11: to make cities and human settlements inclusive, safe, resilient, and sustainable. In addition to its impact on social and economic interactions², urban areas are often characterized by high incidence of chronic health conditions like cancer, cardiovascular, and chronic respiratory diseases, which coexist with infectious diseases such as HIV/AIDS and arboviruses^{3,4}. There is an urgent need to understand the health consequences of this rapid urbanization process and how it can be managed to improve population health. Indeed, the linkages between urbanization and health are especially relevant in Latin America, where more than 80% of the population lives in cities, with Argentina having the highest urbanization rate at 92% and Peru the lowest at 78%, and where levels of social inequality are amongst the highest in the world¹.

Urbanization can have specific impacts on numerous health outcomes, both beneficial and adverse. Urban living can affect health through many mechanisms, including environmental exposure, lifestyle, and access to healthcare. Understanding cities as "living organisms of different sizes" subject to the effects of scaling can lead to insights regarding how the functioning of urban systems shapes population health⁵. Prior studies on scaling have shown that features of cities, such as electric grids, streets, and social networks, display fractal structures

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Mediation analysis investigating the mechanisms of two school-based smoking prevention interventions in adolescents from Northern Ireland and Bogotá:

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ÍNDICE:

El artículo investiga mediante un análisis de mediación cómo funcionan los mecanismos internos de dos programas escolares para prevenir el tabaquismo en adolescentes. Evalúa y compara de forma intercultural los resultados en Irlanda del Norte y Bogotá para identificar qué factores psicológicos y sociales determinan el éxito de estas intervenciones.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

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Mediation analysis investigating the mechanisms of two school-based smoking prevention interventions in adolescents from Northern Ireland and Bogotá.

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Dynamic effect of climate change on flood damage cost in the Andean region of colombia using an ARDL-ECM model and climate change projections:

5 de abril de 2025
Publicado en: Sustainable Cities and Society



Camilo A. Rodríguez Espinosa
Carlos F. Valencia
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ÍNDICE:

El estudio utiliza un modelo estadístico (ARDL-ECM) y datos históricos (2006-2023) para demostrar cómo el cambio climático afecta económicamente los costos por inundaciones en la región andina de Colombia. Al proyectar un incremento inminente de estos daños, el artículo aporta evidencia clave para diseñar políticas públicas de prevención y mitigación en el país.

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Sustainable Cities and Society 125 (2025) 106309

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Dynamic effect of climate change on flood damage cost in the Andean region of Colombia using an ARDL-ECM model and climate change projections

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ARTICLE INFO

Keywords:
Flood events
Climate related natural disasters
Meteorological variables
Climate change
ARDL-ECM
Statistical downscaling

ABSTRACT

Natural disasters in Colombia related with climate fluctuations have high economic and social impacts, including the loss of human lives, infrastructure, agricultural production and livestock. Areal and riverine floods are the most common natural disasters in the country given its topography and heavy rainfall seasons. Flooding occurrences have increased during the last decades due the climate change and climate variability with prolonged periods with precipitation also affected by global phenomena as El Niño and La Niña. This research uses an Autoregressive Distributed Lag-Error Correction Model (ARDL-ECM) to describe the dynamics of meteorological variables, such as precipitation, relative humidity and air temperature, and their effects on floods in the Colombian Andean region by using monthly flood damage costs during the period from October 2006 to December 2023. The ARDL-ECM cointegration test indicates a statistically significant relationship among the meteorological variables analyzed and flood damage cost. With the estimated parameters for long and short-run effects, flood cost is projected for future decades using two climate change scenarios for meteorological variables. These simulations provide a perspective of the future impact of floods in the study region and allow discussion of current flood prevention and action policies to mitigate these results. The imminent increase of flood events under climate change found in this study provides even more evidence on the necessity of strengthening current efforts to reduce emissions and deforestation in Colombia.

1. Introduction

Climate change has become one of the most important challenges for humanity in the last decades due to its negative impacts on physical, economic, and social systems (Vatankhah et al., 2020; Yang et al., 2020). It is expected that the occurrence of extreme weather events, such as droughts and floods, will be more frequent and intense during the next decades (Ayala García et al., 2023). World Meteorological Organization (2021) reports that between 1970 and 2019 more than 4800 cases of floods were reported globally generating 1.12 trillion US dollars (USD) and more than 300 thousand deaths. In South America, more than 500 cases of floods were reported generating costs for 59.53 billion USD and more than 40 thousand deaths. Although precipitation levels are increasing, this is not the only factor to consider when analyzing floods (Sharma et al., 2018), so it is important to increase the evidence on the complex relations among natural disasters and the current trends in meteorological variables.

In Colombia, Climate Change Knowledge Portal (2021) reports that floods represent 45.29% of the annual occurrence of natural disasters between 1980 and 2020. According to Hoyos et al. (2013), La Niña phenomenon affected four million Colombians in 2010–2011 and generated economic losses of approximately 7.8 billion USD, related to destruction of infrastructure, damaging of agricultural lands and payment of government subsidies. Several studies on floods and the El Niño/La Niña phenomenon in Colombia have also shown evidence on the effect of climate change such as: the changing trends of some precipitation indices in the regions during El Niño/La Niña events (Ávila et al., 2019; Giraldo-Osorio et al., 2022), the potential changes in precipitation during the current century (Chaulagain et al., 2023), and the effects in terms of discharge and flood in Magdalena's basin, which is the main river in Colombia (Munar et al., 2023).

Considering the economic and social consequences of floods in tropical developing countries, it is important to relate these events with climate to better understand this complex phenomenon and generate

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2210-6707/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

Investigating variation in adherence to classroom norms for smoking and vaping according to individual norms sensitivities for adolescents in Northern Ireland and Bogotá:

7 de abril de 2025

Publicado en: Social Science Research Network



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ÍNDICE:

El artículo estudia cómo varía la adherencia de los adolescentes a las normas escolares contra el tabaco y el vapeo según su sensibilidad individual a las reglas. Mediante una comparación entre estudiantes de Irlanda del Norte y Bogotá, busca entender qué factores influyen en el cumplimiento de estas normas para mejorar las estrategias de prevención escolar en diferentes culturas.

ENLACE AL ARTÍCULO:

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1 Title: Investigating variation in adherence to classroom
2 norms for smoking and vaping according to individual
3 norms sensitivities for adolescents in Northern Ireland and
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Trajectory Planning for Robotic Manipulators in Automated Palletizing: A Comprehensive Review:

26 de abril de 2025

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ÍNDICE:

El artículo es una revisión que analiza los algoritmos recientes para la planificación de trayectorias y colocación óptima de manipuladores robóticos en el paletizado automatizado. Evalúa cómo construir celdas robóticas eficientes y libres de colisiones para organizar cajas heterogéneas, ofreciendo una visión clara del estado del arte en la logística de empaque industrial.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q2



Review

Trajectory Planning for Robotic Manipulators in Automated Palletizing: A Comprehensive Review

Samuel Romero ¹, Jorge Valero ¹, Andrea Valentina García ², Carlos F. Rodríguez ³, Ana Maria Montes ¹ , Cesar Marín ² , Ruben Bolaños ² and David Álvarez-Martínez ^{1,*}

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Abstract: Recent industrial production paradigms have seen the promotion of the outsourcing of low-value-added operations to robotic cells as a service, particularly end-of-line packaging. As a result, various types of research have emerged, offering different approaches to the trajectory design optimization of robotic manipulators and their applications. Over time, numerous improvements and updates have been made to the proposed methodologies, addressing the limitations and restrictions of earlier work. This survey-type article compiles research articles published in recent years that focus on the main algorithms proposed for addressing placement and minimum-time path planning for a manipulator responsible for performing pick-and-place tasks. Specifically, the research examines the construction of an automated robotic cell for the palletizing of regular heterogeneous boxes on a collision-free mixed pallet. By reviewing and synthesizing the most recent research, this article sheds light on the state-of-the-art manipulator planning algorithms for pick-and-place tasks in palletizing applications.

Keywords: robotic manipulators; collision; trajectory planning; palletizing; inverse kinematic; B-spline



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1. Introduction

Industrial robots are increasingly used for manufacturing and packaging operations, including end-of-line palletizing. In modern production, companies often outsource such low-value-added tasks to specialized robotized cells that provide packing ‘as a service’. A typical palletizing cell consists of a conveyor feeding products, a palletizing station, and a robotic manipulator that transfers products from the infeed to the pallet [1]. A possible schematic of a robotic packaging cell is shown in Figure 1.

Planning efficient trajectories for the manipulator in this context is critical to ensure high throughput and collision-free operation. Robotic trajectory planning generally involves computing a path and time schedule for a robot to move from a start to a goal configuration while satisfying kinematic and dynamic constraints. Classic objectives include minimizing motion time, distance, or energy and avoiding collisions. Over the past decades, a wide variety of algorithms has been developed to address these objectives, from early optimal control approaches in the 1980s to modern sampling-based planners and machine learning techniques. Despite significant progress, several open challenges remain.

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<https://doi.org/10.3390/robotics14050055>

Advancing MG Energy Management: A Rolling Horizon Optimization Framework for Three-Phase Unbalanced Networks Integrating Convex Formulations

24 de marzo de 2025
Publicado en: preprint en arXiv



Pablo Cortés
Alejandra Tabares
John F. Franco

ÍNDICE:

El artículo propone un modelo para la gestión eficiente de microredes eléctricas. Considera redes trifásicas con desequilibrios en su funcionamiento. Utiliza un enfoque de optimización de horizonte rodante. El modelo incorpora cambios en la generación renovable y la demanda. Busca reducir los costos operativos y mejorar la estabilidad de la red. Los resultados muestran mejoras en la eficiencia de la gestión energética.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Advancing MG Energy Management: A Rolling Horizon Optimization Framework for Three-Phase Unbalanced Networks Integrating Convex Formulations.

Pablo Cortés, Alejandra Tabares, Jhon Franco

Abstract

Real-world three-phase microgrids face two interconnected challenges: (1) time-varying uncertainty from renewable generation and demand, and (2) persistent phase imbalances caused by uneven distributed energy resources (DERs), load asymmetries, and grid faults. Conventional energy management systems fail to address these challenges holistically and static optimization methods (e.g., day-ahead scheduling) lack adaptability to real-time fluctuations, while balanced three-phase models ignore critical asymmetries that degrade voltage stability and efficiency. This work introduces a dynamic rolling horizon optimization framework specifically designed for unbalanced three-phase microgrids. Unlike traditional two-stage stochastic approaches that fix decisions for the entire horizon, the rolling horizon algorithm iteratively updates decisions in response to real-time data (e.g., updated solar forecasts, load measurements). By solving a sequence of shorter optimization windows—each incorporating the latest system state and forecasts—the method achieves three key advantages: Adaptive Uncertainty Handling by continuously "re-plans" operations to mitigate forecast errors (e.g., sudden cloud cover reducing solar output). Phase Imbalance Correction by dynamically adjusts power flows across phases to minimize voltage deviations and losses caused by asymmetries, and computational Tractability, i.e., shorter optimization windows, combined with the mathematical mmodel, enable better decision-making holding accuracy. For comparison purposes, we derive three optimization models: a nonlinear nonconvex model for high-fidelity offline planning, a convex quadratic approximation for day-ahead scheduling, and a linearized model to important for theoretical reasons such as decomposition algorithms. Simulations on a 34-bus unbalanced microgrid demonstrate that the rolling horizon strategy reduces expected operational costs by 17% compared to two-stage stochastic methods. Crucially, the quadratic model achieves solutions in under 2 seconds per optimization window, critical for real-time deployment. Furthermore, the linear model achieves a similar performance, maintaining a 99.28% of the quadratic convex model's accuracy.

Keywords: MG Energy Management, Rolling Horizon Optimization, Three-Phase Unbalanced Networks, Integer Linear Models, Convex Quadratic Optimization, Renewable Energy Integration.

Decision Support System to Solve Single-Container Loading Problem Considering Practical Constraints:

19 de mayo de 2025
Publicado en: Revista científica Mathematics



Natalia Romero Olarte
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John W. Escobar
David Álvarez

ÍNDICE:

El artículo presenta una herramienta de código abierto en MS Excel para optimizar la carga de contenedores considerando restricciones reales (peso, estabilidad y entregas múltiples). Mediante un algoritmo heurístico eficiente, genera patrones de empaque visualizables paso a paso, facilitando la gestión logística de forma accesible para los profesionales.

ENLACE DE ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: **Q1**

SCImago Journal: **Q2**



Article

Decision Support System to Solve Single-Container Loading Problem Considering Practical Constraints

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Abstract: The container loading problem (CLP) has a broad spectrum of applications in industry and has been studied for over 60 years due to its high complexity. This paper addresses a realistic single-container loading scenario with practical constraints, including orientation limitations, maximum stacking weight, static stability, overall container weight limit, and fractional loading for multiple drop-off points (multidrop). We propose an open-source decision support system (DSS) implemented on a widely used platform (MS Excel®), which employs a heuristic algorithm to find efficient loading solutions under these constraints. The DSS uses a multi-start randomized constructive algorithm based on a maximal residual space representation. The constructive phase builds the loading pattern in vertical layers (columns or walls), while respecting all practical constraints. The performance of the proposed heuristic is validated through extensive computational experiments on classical benchmark instances, comparing its results against the recent state-of-the-art methods. We also analyze the impact of multi-drop constraints on utilization metrics. The DSS features an interactive interface for creating/loading instances, visualizing step-by-step packing patterns, and displaying key statistics, thus providing a user-friendly decision tool for practitioners.

Keywords: container loading problem; decision support system; heuristics; multi-drop loading; packing; stability

MSC: 90C27; 90C59



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1. Introduction

In 2020 and 2021, the COVID-19 pandemic posed great challenges for logistics operators worldwide due to the surge in online retail, home deliveries, and the global distribution of vaccines. Many companies in the logistics and delivery sector were pushed to their limits [1]. According to the Pitney Bowes Parcel Shipping Index (2022), global parcel volume in 2021 increased by 21% compared to the previous year, reaching 159 billion parcels—about 5000 parcels every second (or 436 million per day) [2]. This rapid growth is projected to continue, with annual parcel shipments possibly reaching 200–250 billion by the mid-2020s. Such trends underscore the importance of optimizing loading processes; efficiently utilizing container space and adhering to safe loading practices can help logistics providers handle more goods while controlling costs and maintaining service quality.

Within this context, the efficient loading of shipping containers (or truck trailers) has gained renewed attention. The three-dimensional container loading problem (CLP)

Simultaneous Color Registration and Depth Completion of Point Clouds with Curriculum Learning:

26 de mayo de 2025

Publicado en: Revista científica Sensors



Juan C. Martínez
Ana M. Montes
Cesar Marín
David Álvarez

ÍNDICE:

El artículo propone una red neuronal que realiza simultáneamente la alineación de imágenes a color y el completado de mapas de profundidad en 3D. Utilizando un entrenamiento progresivo (curriculum learning), el modelo supera a los métodos tradicionales logrando una alta precisión con menos parámetros y una inferencia más rápida, ideal para su uso en robótica y conducción autónoma.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q2



Article

Simultaneous Color Registration and Depth Completion of Point Clouds with Curriculum Learning

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Abstract: Dense depth completion is critical for 3D computer vision but remains challenging when depth data are sparse and misaligned with color images due to sensor offsets. We propose a fully convolutional neural network architecture that simultaneously performs depth completion and color image registration, effectively addressing the problem of sparse depth maps and misaligned RGB inputs. Our model is trained with a novel synthetic depth generation strategy that mimics real time-of-flight (ToF) sensor noise and occlusion artifacts, helping to bridge the simulation-to-real gap. In addition, we adopt a staged curriculum learning paradigm that progressively increases task complexity over three training phases, from easy alignment scenarios to full-depth completion with simulated sensor noise. By leveraging shared features between the depth and color tasks, the joint model outperforms separate single-task approaches. At the KITTI Depth Completion benchmark, the proposed approach achieves competitive accuracy while using significantly fewer parameters and achieving faster inference than existing methods, demonstrating its effectiveness and efficiency.

Keywords: depth completion; spatial transformer networks; multimodal image registration



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1. Introduction

High-quality depth information is essential for accurate spatial understanding and object localization in robotics, autonomous driving, and augmented reality applications. However, obtaining dense and accurate depth maps remains challenging due to hardware limitations, occlusions, and sensor noise. Traditional depth completion methods often rely on interpolation techniques, hand-crafted features, or optimization-based formulations to infer missing depth values [1]. These classical approaches can be efficient, but they struggle to capture complex structures in highly sparse data. More recent methods leverage deep learning models—particularly convolutional neural networks (CNNs) and Transformers—to learn depth priors from large-scale datasets, achieving substantial improvements in accuracy [2]. Deep learning approaches have demonstrated the ability to handle very sparse inputs by learning from context, although they typically require extensive training data and careful network design.

A less-explored but important challenge in RGB-D sensing is the misalignment between depth sensors and color cameras. Depth sensors (such as LiDAR or stereo cameras) provide sparse point cloud data that must be projected into the camera frame, often resulting in depth maps that are not perfectly aligned with the color images due to slight differences in sensor pose or field of view. Even with calibrated intrinsic and extrinsic parameters, unmodeled distortions or baseline offsets can cause residual misalignment.

Sensors **2025**, *25*, 3328

<https://doi.org/10.3390/s25113328>

Performance assessment and dynamic fault detection in photovoltaic systems using artificial intelligence:

28 de mayo de 2025

Publicado en: Revista científica Energy



Nelson Salazar Peña

Alejandra Tabares

Andrés González Mancera

ÍNDICE:

El estudio desarrolla un modelo computacional basado en inteligencia artificial para evaluar el rendimiento de sistemas fotovoltaicos y detectar fallas. Utiliza una red neuronal artificial (ANN) para estimar la producción eléctrica esperada y analizar pérdidas meteorológicas, operativas y técnicas. El modelo, validado en el sistema fotovoltaico de la Universidad de los Andes, logró 93,8 % de precisión en la detección de fallas y 98,8 % de recall, demostrando su utilidad para optimizar el monitoreo y desempeño de estos sistemas.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q1

SCImago Journal: Q1

Introduction

The increasing global adoption of photovoltaic (PV) solar energy is met with inherent challenges, primarily its intermittent nature due to variable weather conditions (e.g., solar irradiance, geographical factors, daily weather patterns, cloud cover, fog, mist, turbidity) and its susceptibility to various losses and failures (e.g., soiling, shading, degradation). Losses in a PV system refer to reduced energy generation due to external factors that disturb the nominal behavior of electrical components within a known range without compromising their integrity. Research estimates that such power losses can range from 10% to 70%, representing an average decrease of 25% in energy production [1]. Key loss factors highlighted by Ref. [2] include air pollution, soiling, shading, angle of incidence, PV panel temperature, PV panel mismatch, degradation, inverter performance, maximum power point tracking performance, transformer performance, DC and AC cables, auxiliary power sources, blackouts, and grid availability. Unlike losses, failures in a PV system compromise the integrity of the electrical components. Detecting these failures is crucial for enhancing the efficiency, reliability, and lifespan of the PV system [3]. While research has estimated the extent to which failures have historically reduced energy generation, system blackouts are common due to potential dangers such as electric discharges or fires [4]. The main failures documented in the literature [[3], [4], [5]] include line-to-line, line-to-ground, bypass diode, open circuit, electric arc, hot spot, delamination, discoloration, and microcracks.

Precise knowledge of these losses and failures is relevant for various stakeholders [2]. Investors require it to assess project viability and predict average annual energy production for financing, thereby estimating project revenue over the PV system's typical 30-year lifespan. Owners need this information to evaluate PV system performance and condition using metrics like performance ratio, fill factor, and capacity factor. For academia, this knowledge helps establish a reference framework for research through simulation studies, production data analysis, and evaluation of meteorological and spatial conditions. Therefore, accurate characterization of losses and effective fault detection are crucial for reliable performance evaluation of PV systems. This information guides decision making to achieve the expected efficiency of the PV system [6], making it increasingly important to

Index insurance for simultaneous flooding and drought risks with insufficient data: a two-step approach. Stochastic Environmental Research and Risk Assessment:

7 de junio de 2025

Publicado en: Stochastic Environmental Research and Risk Assessment.



Adriana Abrego
Tjeerd M. Boonman
Carlos F. Valencia

ÍNDICE:
El artículo propone un modelo de seguros agrícolas indexados al clima que protege simultáneamente frente a sequías e inundaciones, incluso cuando existe poca información histórica disponible. Utiliza datos satelitales, pronósticos climáticos, copulas y regresión por cuantiles para diseñar un seguro más preciso y económico para productores de café en Colombia.

ENLACE AL ARTÍCULO:
CLIC AQUÍ

Journal Citation Reports: Q2
SCImago Journal: Q1



Index insurance for simultaneous flooding and drought risks with insufficient data: a two-step approach

Adriana L. Abrego-Pérez¹ · Tjeerd M. Boonman² · Carlos Felipe Valencia Arboleda¹

Accepted: 16 March 2025
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Abstract

Agricultural producers face increasing challenges with climate change, as floods and droughts affect crop yields. Index insurance based on weather derivatives has grown rapidly in the past decades, but challenges remain. The existing models are designed to provide protection against either flooding or droughts, but rarely for both. Additionally, remote areas in emerging economies lack data that are needed for a more precise and thus fair-priced insurance index. We propose a two-step approach to manage flooding and drought risks through weather index insurance. In the first step, a weather index is constructed and forecasted. In the second step, we use a bivariate copula model with dynamic quantiles. We apply this approach to optimize the hedging strategy for coffee producers in the province of Samana in Colombia for the period 2007–2019, and forecasts for 2020–2028. We find that the optimal index insurance model is based on a copula structure with dynamic quantiles. This model can reduce basis risk, as measured by the improvement of hedging effectiveness, compared to benchmark models: We find hedging effectiveness of 60% while other studies find up to 43%. Compared to current programs for coffee crops, the insurance premiums based on our approach are up to five times cheaper. Our results can be useful for policy makers and agricultural producers, as higher hedging effectiveness and more affordable index insurance contracts allow more producers to use index insurance. Our approach can be replicated in other low-income regions where data is challenging to obtain from weather stations.

Keywords Weather derivatives · Index Insurance · Bivariate copula · Quantile regression · Flooding

JEL Classification C22 · G22 · Q14 · Q18 · Q54

1 Introduction

Climate change rises perils and the need from farmers and policymakers to find better insurance solutions to cope with both drought and flood risks (Begueria et al. 2014; Tellman et al. 2022). A relatively new approach is weather index

insurance. The insurance pays out to the policy holder on the basis of a predetermined index (for example rainfall level) for losses resulting from weather and catastrophic events (GIIF 2021). Weather index insurance represents a useful hedging tool for farmers to cope with weather risks (Skees et al. 1997; Bucheli et al. 2020). Because weather index insurance does not necessarily require the traditional services of insurance claims assessors, it allows for the claims settlement processes to be quicker and more objective. Other advantages when compared to conventional insurance are lower adverse selection, moral hazard, systemic risks and administrative costs (GIIF 2021).

For developing countries, index insurance plays a relevant role because of the weak institutional support mechanisms and the high dependence on low-technology agriculture that is more vulnerable for extreme climate events. Index insurance helps to reduce production risks, as it improves the adaptative capacity of agricultural systems to climate

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Optimization of Bus Dispatching in Public Transportation Through a Heuristic Approach Based on Passenger Demand Forecasting:

1 de julio de 2025

Publicado en: Smart Cities, de la editorial MDPI (Multidisciplinary Digital Publishing Institute).



Javier E. Barrera Hernández
Luis Enrique Tarazona Torres
Alejandra Tabares
David Álvarez

ÍNDICE:

El artículo propone un método para optimizar el despacho de buses según la demanda de pasajeros. Combina pronósticos de demanda mediante inteligencia artificial con un modelo heurístico que permite decidir cuándo y cuántos buses enviar, buscando reducir costos y tiempos de espera y mejorar el nivel de servicio. El método fue probado con datos reales del transporte público de Montería, Colombia, logrando resultados cercanos a los modelos de optimización exacta, pero con tiempos de cálculo hasta 98 %.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q1

SCImago Journal: Q1



Article

Optimization of Bus Dispatching in Public Transportation Through a Heuristic Approach Based on Passenger Demand Forecasting

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Highlights

What are the main findings?

- The adaptive heuristic achieves on average a 95% match to the MILP benchmark’s operational utility with a mean optimality gap below 5%, while preserving high service levels (>90%) across diverse demand profiles.
- Computational times are reduced by up to 98% compared to the exact MILP model, enabling near real-time dispatch decisions on a standard computing platform.

What is the implication of the main finding?

- The framework offers a scalable, implementable dispatching solution for mid-sized urban transport operators, balancing service quality and cost efficiency under uncertain demand.
- By integrating machine-learning forecasts with a lightweight heuristic, the approach bridges the gap between theoretical optimization and practical, data-driven real-time operations.



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Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: Accurate and adaptive bus dispatching is vital for medium-sized urban centers, where static schedules often fail to accommodate fluctuating passenger demand. In this work, we propose a dynamic heuristic that integrates machine learning-based demand forecasts into a discrete-time planning horizon, thereby enabling real-time adjustments to dispatch decisions. Additionally, we introduce a tailored mathematical model—grounded in mixed-integer linear programming and space-time flows—that serves as a benchmark to evaluate our heuristic’s performance under the operational constraints typical of traditional public transportation systems in Colombian mid-sized cities. A key contribution of this research lies in combining predictive modeling (using Prophet for passenger demand) with operational optimization, ensuring that dispatch frequencies adapt promptly to varying ridership levels. We validated our approach using a real-world case study in Montería (Colombia), covering eight representative routes over a full day (5:00–21:00). Numerical experiments show that: 1. Our heuristic matches or surpasses 95% of the optimal solution’s operational utility on most routes, with an average gap of 4.7%, relative to the benchmark mathematical model. 2. It maintains high service levels—above 90% demand coverage on demanding corridors—and robust bus utilization, without incurring excessive operating costs. 3. It reduces computation times by up to 98% compared to the optimization model, making it practically viable for daily scheduling where solving large-scale models

Smart Cities **2025**, *8*, 87

<https://doi.org/10.3390/smartcities8030087>

Codesign of water - saving prototypes in rural areas of colombi: An aalysis of student participation with social impact through poCIO framework:

1 de julio de 2025

Publicado en: Journal of Engineering Education Transformations



Catalina Ramírez

Luisa Payán-Durán

Janeth Árias-Hernández

Edier Ernesto Espinosa Díaz

Diana Duarte

Andrés Torres

ÍNDICE:

El artículo analiza el uso del modelo poCDIO en proyectos de ingeniería con comunidades rurales de Colombia. A través de la participación de estudiantes, profesores y habitantes, se desarrollaron soluciones para el ahorro de agua. El estudio concluye que la participación comunitaria y el co-diseño permiten llevar la ingeniería más allá del aula y generar soluciones con impacto social.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

SCImago Journal: Q3

Battle of Water demand forecasting

18 de julio de 2025
Publicado en: Journal of Water Resources Planning and Management.



Alvisi S.
Franchini M.
Marsili V.
Mazzoni F.
Salomons E.
Housh M.
Abokifa A.
Arsova K.
Ayyash F.
Bae H.
Alejandra Tabares

ÍNDICE:
El artículo analiza cómo rediseñar y optimizar una red de distribución de agua en E-Town, Colombia, dividiéndola en áreas de medición (DMAs). Busca reducir fugas, controlar las presiones, mejorar la calidad del agua y garantizar un suministro eficiente, utilizando un enfoque de optimización multiobjetivo y un proceso de diseño por etapas vulputate velit esse molestie consequat.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q1

SCImago Journal: Q1



Battle of Water Demand Forecasting

S. Alvisi, Ph.D.¹; M. Franchini²; V. Marsili, Ph.D.³; F. Mazzoni, Ph.D.⁴; E. Salomons, Ph.D.⁵; M. Housh, Ph.D.⁶; A. Abokifa, Ph.D.⁷; K. Arsova⁸; F. Ayyash⁹; H. Bae, Ph.D.¹⁰; R. Barreira, Ph.D.¹¹; L. Basto¹²; S. Bayer, Ph.D.¹³; E. Z. Berglund, Ph.D.¹⁴; D. Biondi, Ph.D.¹⁵; F. Boloukasli Ahmadgourabi¹⁶; B. Brentan, Ph.D.¹⁷; J. Caetano¹⁸; F. Campos¹⁹; H. Cao, Ph.D.²⁰; S. Cardona²¹; E. P. Carreño Alvarado, Ph.D.²²; N. Carriço, Ph.D.²³; G.-A. Chatzistefanou²⁴; Y. Coy²⁵; E. Creaco, Ph.D.²⁶; S. Cuomo, Ph.D.²⁷; A. de Klerk²⁸; A. Di Nardo, Ph.D.²⁹; M. DiCarlo, Ph.D.³⁰; U. Dittmer, Ph.D.³¹; R. Dziedzic, Ph.D.³²; A. Ebrahim Bakhshipour, Ph.D.³³; D. Eliades, Ph.D.³⁴; R. Farmani, Ph.D.³⁵; B. Ferreira, Ph.D.³⁶; A. Gabriele, Ph.D.³⁷; M. M. Gamboa-Medina, Ph.D.³⁸; F. Gao³⁹; J. Gao, Ph.D.⁴⁰; R. Gargano, Ph.D.⁴¹; M. Geranmehr, Ph.D.⁴²; C. Giudicianni, Ph.D.⁴³; K. Glynis⁴⁴; S. Gómez⁴⁵; L. González⁴⁶; M. Groß⁴⁷; H. Guo⁴⁸; M. N. Habibi⁴⁹; A. Haghighi, Ph.D.⁵⁰; B. Hammer, Ph.D.⁵¹; L. Hans⁵²; M. Hayslep⁵³; Y. He⁵⁴; L. Hermes⁵⁵; M. Herrera, Ph.D.⁵⁶; F. Hinder⁵⁷; B. Hou, Ph.D.⁵⁸; A. Iglesias-Rey⁵⁹; P. L. Iglesias-Rey, Ph.D.⁶⁰; I.-S. Jang, Ph.D.⁶¹; J. Izquierdo, Ph.D.⁶²; M. S. Jahangir, Ph.D.⁶³; C. Jara-Arriagada⁶⁴; B. Jenks⁶⁵; G. Johnen⁶⁶; M. Kalami Heris, Ph.D.⁶⁷; M. Kalumba, Ph.D.⁶⁸; M.-S. Kang, Ph.D.⁶⁹; M. Khashei Varnamkhasti⁷⁰; K.-J. Kim, Ph.D.⁷¹; J. Kley-Holsteg⁷²; T. Ko⁷³; A. Koochali, Ph.D.⁷⁴; P. Kossieris, Ph.D.⁷⁵; P. Koundouri, Ph.D.⁷⁶; C. Kühnert, Ph.D.⁷⁷; A. Kulaczowski⁷⁸; J. Lee, Ph.D.⁷⁹; P.E. Li⁸⁰; Y. Li⁸¹; H. Liu, Ph.D.⁸²; Y. Liu⁸³; C. A. López-Hojas⁸⁴; A. Maier, Ph.D.⁸⁵; C. Makropoulos, Ph.D.⁸⁶; F. J. Martínez-Solano, Ph.D.⁸⁷; N. H. Marzouny⁸⁸; A. Menapace, Ph.D.⁸⁹; C. Michalopoulos⁹⁰; G. Moraitis⁹¹; H. Mousa⁹²; H. Namdari⁹³; D. Nikolopoulos, Ph.D.⁹⁴; M. Oberascher, Ph.D.⁹⁵; A. Ostfeld, Ph.D.⁹⁶; M. Pagano⁹⁷; F. Pasha, Ph.D.⁹⁸; J. Perafán⁹⁹; G. Perelman¹⁰⁰; J. Pesantez, Ph.D.¹⁰¹; M. Polycarpou, Ph.D.¹⁰²; M. G. Quarta¹⁰³; Q. Que¹⁰⁴; J. Quilty, Ph.D.¹⁰⁵; C. Quintiliani, Ph.D.¹⁰⁶; A. Ramachandran¹⁰⁷; G. Reynoso Meza, Ph.D.¹⁰⁸; V. Rodríguez¹⁰⁹; Y. Romano, Ph.D.¹¹⁰; J. Saldarriaga, Ph.D.¹¹¹; A. K. Salem¹¹²; P. Samartzis, Ph.D.¹¹³; G. F. Santonastaso, Ph.D.¹¹⁴; D. Savic, Ph.D.¹¹⁵; V. Schiano Di Cola, Ph.D.¹¹⁶; D. Schol, Ph.D.¹¹⁷; A. G. Seyoum, Ph.D.¹¹⁸; R. Shen¹¹⁹; K. Simukonda, Ph.D.¹²⁰; A. Sinske, Ph.D.¹²¹; R. Sitzenfrei, Ph.D.¹²²; B. Sonnenschein¹²³; I. Stoianov, Ph.D.¹²⁴; A. Tabares, Ph.D.¹²⁵; E. Todini, Ph.D.¹²⁶; L. Tsiami¹²⁷; I. Tsoukalas, Ph.D.¹²⁸; A.-J. Ulusoy, Ph.D.¹²⁹; L. Vamvakieridou-Lyroudia, Ph.D.¹³⁰; A. van Heerden¹³¹; J. Vaquet¹³²; V. Vaquet¹³³; S. Wallner¹³⁴; M. Walraad¹³⁵; D. Wang¹³⁶; S. Wu, Ph.D.¹³⁷; W. Wu, Ph.D.¹³⁸; A. Wunsch, Ph.D.¹³⁹; Y. Yao¹⁴⁰; J. Yu¹⁴¹; A. Zanfei, Ph.D.¹⁴²; D. Zanutto¹⁴³; H. Zhang¹⁴⁴; M. Ziebarth, Ph.D.¹⁴⁵; F. Ziel, Ph.D.¹⁴⁶; and J. Zou¹⁴⁷

Abstract: As part of the Battle of Water Networks competition series, the Battle of Water Demand Forecasting (BWDF) was organized in the context of the 3rd Water Distribution Systems Analysis and Computing and Control in the Water Industry (WDSA-CCWI) joint conference held in Ferrara (Italy) in 2024. In line with the previous editions of the Battle of Water Networks—the main objective of which was to address a specific problem related to the design and operation of water distribution networks—the BWDF aims to compare the effectiveness of methods for the short-term forecast of urban water demand in a set of real district metered areas. During the conference, 31 teams across the world participated in the BWDF and presented their approaches. The results obtained demonstrate the importance of (1) considering integrated approaches for short-term water demand forecasting; and (2) evaluating their performance in relation to more than one metric, case study, and period. DOI: 10.1061/JWRMD5.WRENG-6887. This work is made available under the terms of the Creative Commons Attribution 4.0 International license, <https://creativecommons.org/licenses/by/4.0/>.

Author keywords: Water demand; Forecasting; Water distribution network; Field data; Time series analysis; Artificial intelligence.

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Note. This manuscript was submitted on October 18, 2024; approved on April 1, 2025; published online on July 18, 2025. Discussion period open until December 18, 2025; separate discussions must be submitted for individual papers. This paper is part of the *Journal of Water Resources Planning and Management*, © ASCE, ISSN 0733-9496.

Integrating and Comparing Radiality Constraints for Optimized Distribution System Reconfiguration

23 de julio de 2025
Publicado en: preprint en arXiv



Pablo Cortes
Alejandra Tabares
Fredy Franco

ÍNDICE:

El artículo analiza diferentes restricciones matemáticas de radialidad para optimizar la reconfiguración de redes de distribución eléctrica. Compara su eficiencia computacional en redes de distintos tamaños, buscando identificar qué formulaciones permiten resolver los problemas de optimización más rápidamente y reducir las pérdidas de energía.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Integrating and Comparing Radiality Constraints for Optimized Distribution System Reconfiguration

Pablo Cortés, Alejandra Tabares, Fredy Franco

Abstract

The reconfiguration of electrical power distribution systems is a crucial optimization problem aimed at minimizing power losses by altering the system’s topology through the operation of interconnection switches. This problem, typically modelled as a mixed-integer nonlinear program (MINLP) demands high computational resources for large-scale networks and requires specialized radiality constraints for maintaining the tree-like structure of distribution networks. This paper presents a comprehensive analysis that integrates and compares the computational burden associated with different radiality constraint formulations proposed in the specialized literature for the reconfiguration of distribution systems (RDS). By using consistent hardware and software setups, we evaluate the performance of these constraints across several well-known test cases, including systems with 14, 33, 84, 136, and 417 buses. Our findings reveal significant differences in computational efficiency depending on the chosen set of radiality constraints, providing valuable insights for optimizing reconfiguration strategies in practical distribution networks.

Keywords: Electrical distribution systems, mixed-integer non-linear programming, reconfiguration.

An iterated local search based approach for a real rich vehicle routing problem with time windows:

30 de julio de 2025

Publicado en: Computers & Industrial Engineering, de la editorial Elsevier.



Andrés F. Romero Silva
Alejandra Tabares
David Álvarez
John Willmer Escobar

ÍNDICE:

El artículo propone un método híbrido para optimizar rutas de vehículos, considerando restricciones reales como capacidad, tipos de vehículos y horarios de entrega. Busca reducir costos y mejorar la eficiencia logística mediante técnicas de búsqueda y optimización. Además, fue probado con datos reales de una empresa y se implementó para apoyar sus operaciones diarias.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q1

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An iterated local search based approach for a real rich vehicle routing problem with time windows

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ARTICLE INFO

Keywords:
Hybrid algorithm
Decision support systems
Iterative local search
Rich vehicle routing problem
Set partitioning

ABSTRACT

The vehicle routing problem with multiple real constraints is one of the leading logistics challenges for technology-based companies. Despite being a classic and well-studied real-world routing problem, only a few companies have implemented algorithms to solve it entirely and automatically. Based on a real case study of a technology-based company, this paper proposes a solution to an asymmetric close-open mixed vehicle routing problem that considers capacity constraints, heterogeneous fleet, time windows, and computational and operational implementation constraints. A hybrid algorithm is proposed, which combines an iterative local search strategy with a set-partitioning problem strategy, utilizing a computing architecture that meets all the constraints to solve the considered problem. Benchmarking was conducted using classic instances from the literature and actual instances from the company to demonstrate the performance of the proposed methodology. The solutions for the company's instances have an average gap of 9% compared with the upper bound obtained via the related knapsack problem. In contrast, the results for classical instances have an average gap of 8% compared with the best-found solution in the literature. Moreover, the algorithm and the architecture created are already used in the company's day-to-day operations, validating the efficiency and effectiveness of the proposed work.

1. Introduction

In the rapidly evolving landscape of modern logistics, the vehicle routing problem (VRP) remains a critical lever for cost optimization. Transportation costs account for more than 50 % of total logistics costs in regions such as Latin America (12–14 % of GDP) and developed economies (7–8 % of GDP) (Dan, 2021; Departamento Nacional de Planeación, 2021). While traditional VRP formulations focus on simplified scenarios, industrial applications demand solutions that consider asymmetric close-open mixed routes, heterogeneous fleets, capacity limits, time windows, and computational feasibility. These solutions are real challenges where academic advancements often diverge from operational realities. This gap persists despite decades of research, leaving many technology-driven firms reliant on fragmented, manual planning or generic SaaS tools that sacrifice quality for speed. Drawing from a real-world case study, this work bridges theory and practice by proposing a hybrid metaheuristic—combining iterative local search (ILS) with set-partitioning optimization—embedded within a scalable computational architecture. Our approach addresses multifaceted routing constraints and integrates critical implementation factors such as horizontal scalability and software compatibility within a decision support system validated in daily operations. Benchmarking against classical instances and company-specific data reveals competitive gaps of 6–8 % versus theoretical bounds. Moreover, the deployed system now drives measurable cost reductions, demonstrating that rigorous algorithms can be effectively transitioned into industrial tools without compromising their real-world applicability.

The VRP, in its canonical form, seeks to minimize transportation costs by designing routes for a given fleet of vehicles serving geographically dispersed customers. However, real-world logistics operations—particularly in technology-centric enterprises—require extensions based on combinations of different problems, such as capacitated Vehicle Routing Problem (CVRP) (Bernal et al., 2018; Linfati and Escobar, 2018), Vehicle Routing Problem with Time Windows (VRPTW)

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0360-8352/© 2025 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Transportation infrastructure maintenance planning: An exact column enumeration approach

25 de agosto de 2025

Publicado en: Computers & Operations Research, de la editorial Elsevier.



Daniel Yamin

Andrés L. Medaglia

Juan F. Correal

ÍNDICE:

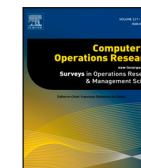
El artículo propone un modelo de optimización para planificar el mantenimiento de infraestructura de transporte, buscando asignar un presupuesto limitado de la manera más eficiente para mantener carreteras, puentes y otros activos en buenas condiciones durante un período de 10 años.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: **Q2**

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Transportation infrastructure maintenance planning: An exact column enumeration approach

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ARTICLE INFO

Keywords:
Infrastructure maintenance planning
Transportation assets
Knapsack problem
Column enumeration
Column-and-cut generation
Cover inequalities

ABSTRACT

Transportation infrastructure assets deteriorate over time due to natural hazards, heavy traffic, and aging, increasing their risk of failure. National transportation agencies must strategically invest in maintenance to avoid significant social and economic impacts. We address the infrastructure maintenance planning problem, in which a maintenance plan must be designed for each asset within a budget limit to maximize the weighted average asset condition over a planning horizon. We derive a knapsack-type mathematical formulation and propose an exact column enumeration algorithm to solve it. First, a column-and-cut generation algorithm computes a (dual) upper bound on the optimal value. The master problem selects a maintenance plan for each asset and is strengthened with extended q -cover inequalities. By representing maintenance plans as paths over a directed acyclic multigraph that captures asset deterioration and maintenance decisions, the pricing problems unveil feasible plans through a specialized labeling algorithm. Second, a relaxation-enforced neighborhood search finds a (primal) lower bound. Finally, using these bounds, we enumerate sufficient columns to find an optimal solution via a commercial MILP solver. Computational results on generated instances spanning a 10-year planning horizon demonstrate that our algorithm delivers optimal solutions for instances with up to 50 assets and near-optimal solutions (gap < 0.18%) for instances with up to 100 assets within five hours.

1. Introduction

Transportation networks are essential for economic growth because they enable the efficient movement of goods, people, and services. Key infrastructure assets, such as airports, ports, tunnels, bridges, and roads, play a crucial role in ensuring timely and reliable transportation. Therefore, preserving these assets throughout their lifespan is a priority for national transportation agencies. However, these assets deteriorate over time due to various factors, including natural hazards (e.g., earthquakes, floods, and landslides), heavy traffic loads, and aging, which can lead to significant structural damage. Consequently, inadequate maintenance of transportation infrastructure yields severe consequences, ranging from service disruptions to catastrophic failures that may even result in the loss of life.

The aging of transportation infrastructure, along with the increasing frequency of extreme natural events and the shrinking budgets for maintenance planning, has made the condition of these assets a global concern. In 2023, the US spent over USD 44 billion on infrastructure, with more than USD 210 million allocated to repair and rebuild infrastructure following natural disasters. Despite these efforts, only 44%

and 68% of the nation's bridges and urban roads are in good condition (U.S.A. Facts, 2024). The poor condition of bridges best illustrates this widespread problem. Approximately 42% of bridges in the US are at least 50 years old, with about 7.5% rated as structurally deficient (ASCE, 2021). Europe faces a similar challenge. For example, in France, a third of road bridges required repairs in 2018, with 841 bridges posing a potential risk. In Italy, 300 bridges were at risk of failure (The Guardian, 2018). This problem is equally (if not more) severe in developing countries. Limited resources and insufficient institutional support often result in a lack of systematic inspections and maintenance procedures. For example, approximately 30% of the bridges in Colombia managed by the national transportation agency are in critical condition (La República, 2023).

In this context, national transportation agencies are facing increased traffic volume and load and the adverse effects of climate change. This situation is aggravated by limited budgets to maintain and rehabilitate aging and deteriorating infrastructure. Finding innovative methods to address these challenges and determining an optimal maintenance plan for each asset in a portfolio is crucial to extending its lifespan and

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Incremental healthcare costs associated to Chronic Obstructive Pulmonary Disease in Colombia using administrative healthcare data:

25 de octubre de 2025

Publicado en: Value in Health Regional Issues



Carlos F. Valencia

Juan F. Martínez.

ÍNDICE:

El estudio calcula el costo económico directo de la EPOC en Colombia usando bases de datos del sistema de salud y un método causal avanzado. Determina que el costo incremental por paciente es de \$1349 dólares, elevándose hasta \$2935 si hay complicaciones como cáncer de pulmón, lo que demuestra la crítica carga financiera que esta enfermedad

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q3

SCImago Journal: Q1



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Economic Evaluation

Incremental Direct Cost of Chronic Obstructive Pulmonary Disease in Colombia Using Doubly Robust Methods on Administrative Data

Carlos F. Valencia, PhD, Juan F. Martínez, MSc

ABSTRACT

Objectives: To estimate incremental healthcare costs associated with chronic obstructive pulmonary disease (COPD) using administrative healthcare data in Colombia.

Methods: We conducted a retrospective cohort analysis using administrative health databases from Colombia's population covered by the contributory health insurance scheme. Patients with COPD were identified using a specific operative definition, and the control group was randomly selected from the remaining individuals. To estimate the incremental cost of COPD, we applied a causal approach using a doubly robust model, integrating propensity scores and outcome regression models. This ensured accurate estimation by addressing potential confounding, being robust for misspecification both in the propensity score and in the mean outcome. Confidence intervals were obtained using bootstrapping. In addition, we analyzed the incremental effect of common COPD complications, such as cardiovascular diseases and pulmonary infections.

Results: Our group of patients with COPD was comprised 251 060 people, whereas our control group comprised 967 081 people. The estimated incremental cost of a person with COPD was US dollars \$1349. The incremental cost of a person with COPD and some type of complication ranged from \$1405 to \$2935. The most expensive complication was lung cancer, and the least expensive complication was any type of muscular weakness.

Conclusions: The incremental costs of COPD in Colombia align with the average values typically reported for middle-income countries. However, these estimates fall on the lower end of global cost estimations. There was a greater incremental cost found for patients with complications such as lung cancer, cardiovascular diseases, and pulmonary infections.

Keywords: administrative databases, causal inference, COPD, doubly robust methods, incremental cost, medical cost estimation.

VALUE HEALTH REG ISSUES. 2026; 53:101513

Introduction

Chronic obstructive pulmonary disease (COPD) is characterized by restricted pulmonary airflow and respiratory obstruction, caused mainly by smoking, smoke and tobacco inhalation, or air pollution exposure. COPD is the fourth leading cause of death globally.^{1,2} By 2021, it is estimated that >3.5 million deaths were caused by COPD and that by 2030, it will be the third leading cause of death worldwide.³ By 2050 it is projected that the global cases of COPD will increase in 23% with respect to 2020 approaching approximately 600 million cases. For low- and middle-income countries, this increment is estimated to be >30%, augmented the gap in COPD prevalence between developed countries and the rest of the world.⁴ The health burden caused by COPD is larger in developing countries, with about 90% of the global COPD deaths.⁵

COPD is an irreversible condition, and although there several treatments that improve the quality of life of patients such as oxygen therapy, pulmonary rehabilitation, or medicines to treat

complications, there is also a respective high cost associated with the economic burden on healthcare systems.⁶ Various studies have estimated the medical costs of patients with COPD globally, often leveraging diverse methodological approaches. However, there is still a lack of information on the economic burden of COPD in several low and middle-income countries, which causes lack of attention from governmental and health institutions to further developing actions that mitigate the risk of the disease or the incorrect estimation of resources needed to treat this chronic condition.⁷

This study aims to quantify the annual direct incremental cost of COPD in Colombia using a national administrative health database that contains claims of all patients on the contributory regime (private health providers). Some studies have estimated economic burden and direct cost of COPD cost in Colombia before, most of these studies have primarily been descriptive in their statistical approach. For example, Pérez et al⁸ estimated the direct cost of COPD and lung cancer attributable to tobacco consumption using microcosting techniques by characterizing

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Collaborative Scenario Experimentation for Strategy Formulation to Shape Desirable Futures:

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Publicado en: Research-Technology Management



Paula Wuth

Ricardo J. Hernández

Leonel Merino

Sebastián Negrete

Ignacio Pavez

ÍNDICE:

El artículo aborda la experimentación colaborativa de escenarios como una herramienta metodológica clave para la formulación de estrategias organizacionales. El enfoque busca estructurar procesos dinámicos que permitan a los equipos de trabajo diseñar, simular y evaluar de forma conjunta diferentes alternativas futuras, facilitando la toma de decisiones proactivas para moldear y alcanzar escenarios futuros deseables.

ENLACE AL ARTÍCULO:

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Collaborative Scenario Experimentation for Strategy Formulation to Shape Desirable Futures

Paula Wuth, Ricardo J. Hernández, Leonel Merino, Sebastian Negrete & Ignacio Pavez

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Moderators of peer influence effects for adolescents' smoking and vaping norms and outcomes in high and middle-income settings:

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Jennifer M. Murray

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Ruth F Hunter

ÍNDICE:

El estudio analiza cómo factores como la personalidad, el género y el nivel socioeconómico moderan la influencia de los amigos en el tabaquismo y vapeo de 1,344 adolescentes en Irlanda del Norte y Bogotá. Los resultados muestran que esta presión es mayor en mujeres y en colegios de bajos recursos, lo que aporta datos clave para mejorar los programas de prevención escolar.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

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Moderators of peer influence effects for adolescents' smoking and vaping norms and outcomes in high and middle-income settings

Jennifer M. Murray^{1*}, Sharon C. Sánchez-Franco²,
Olga L. Sarmiento², Erik O. Kimbrough³, Christopher Tate¹,
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Background: Peer influence is central to adolescent smoking initiation, yet its impact varies depending on individual and contextual factors. Understanding which moderators (personality, contextual, cultural, and environmental traits) shape these processes can inform more effective prevention strategies. We investigated hypothesized moderators of peer influence for adolescent smoking/vaping norms and other smoking-related outcomes in high and low-middle-income countries (LMICs): Northern Ireland and Bogotá.

Methods: Across 12 schools ($n = 1,344$, age 12–13 years), participants completed novel behavioral economics experiments measuring social norms, and self-report surveys, before and after school-based prevention interventions (ASSIST and Dead Cool). We examined how peer influence effects were moderated by setting, intervention type, gender, school socio-economic status (SES), personality traits, social network positions, and self-efficacy. Moderation was examined using regressions with interactions between peer-group means (friends, school classes, school year groups) of the outcome variables and moderators ($p \leq 0.01$).

Results: Peer influence was moderated by study setting, intervention, gender, school SES, personality characteristics (pro-sociality, fear of negative evaluation, extraversion), and social network structure. Effects were stronger among girls and in schools with lower SES. ASSIST schools showed greater peer influence effects than Dead Cool, reflecting the programs' distinct mechanisms, as

Frontiers in Psychology

01

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Climate risk, policy, and insurance: a forecast-based model for weather index design in vulnerable economies.

01 de diciembre de 2025

Publicado en: Internacional Economics and Economic Policy



Adriana Abrego

José A. Nuñez Mora

ÍNDICE:

El artículo propone un modelo que combina pronósticos climáticos, inteligencia artificial y variables económicas para diseñar seguros agrícolas más eficientes, orientados a reducir el impacto del cambio climático sobre pequeños productores de café y fortalecer su capacidad de gestión del riesgo.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: Q2

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RESEARCH



Climate risk, policy, and insurance: a forecast-based model for weather index design in vulnerable economies

Adriana L. Abrego-Perez¹ · José A. Nuñez-Mora²

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Abstract

Climate volatility poses significant risks to agricultural livelihoods, particularly in emerging economies where access to formal risk management instruments is limited. Weather index insurance has been promoted as a scalable solution, yet adoption rates remain modest due to inadequate targeting and limited policy support. This study proposes a two-stage methodology to assess both the technical design of indices and the economic drivers of adoption among smallholder coffee farmers. In the first stage, we adapt a low-basis-risk insurance model using forecast-based weather variables to approximate yield losses in contexts with minimal historical records. In the second stage, we embed these pricing results into an influence diagram framework that links weather volatility with income variability, crop prices, and subsidies, thereby modeling farmers' decision-making under uncertainty. Results show that although the insurance is actuarially sound and provides positive expected pay-offs (about 40 USD/month), adoption is highly context-dependent. Uptake remains low (16%) under moderate weather but increases to 48% under stressed climate scenarios defined by higher variance in the weather index and shifts in crop prices, particularly when subsidies exceed 50%. These findings emphasize the importance of adaptive subsidy schemes and context-appropriate index design, offering practical guidance for strengthening climate resilience in rural economies facing growing weather volatility.

Keywords Direct acyclic graphs · Influence diagram decision model network · Index insurance forecasting · Hedging effectiveness · Bivariate copulas

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Lean Six Sigma implementation model in manufacturing SMEs in a developing country: a latent variable modelling approach:

2 de diciembre de 2025

Publicado en: International Journal of Lean Six Sigma



Martha C. Corredor Rojas

David Álvarez

José Fidel Torres

ÍNDICE:

El estudio valida un modelo para implementar Lean Six Sigma en PYMEs manufactureras de Colombia utilizando un enfoque de variables latentes y datos de 352 empresas. El resultado es un marco de trabajo práctico y adaptado a la realidad de los países en desarrollo para guiar decisiones organizacionales eficientes.

ENLACE AL ARTÍCULO:

CLIC AQUÍ

Journal Citation Reports: **Q2**

SCImago Journal: **Q1**

Lean Six Sigma implementation model in manufacturing SMEs in a developing country: a latent variable modelling approach

Martha Concepcion Corredor-Rojas, David Alvarez-Martinez and Jose Fidel Torres
Department of Industrial Engineering, Universidad de los Andes, Bogotá, Colombia

Abstract

Purpose – Research on Lean Six Sigma (LSS) in manufacturing small- and medium-sized enterprises (SMEs) in developing countries is scarce. This study aims to establish an LSS implementation model tailored to these companies in Colombia, using a hierarchical structure of the critical success factors (CSFs) identified and validated through a latent variable modelling approach.

Design/methodology/approach – A comprehensive literature review was conducted, and data were collected via online surveys of manufacturing SMEs. The surveys characterised the level of LSS implementation and identified CSFs (latent variables). These factors were then validated using psychometric tests and confirmatory factor analysis (CFA).

Findings – Among 352 surveyed SMEs, 22.7% have implemented Lean, Six Sigma or LSS. Eight latent variables out of 13 initial factors were corroborated through validation. Alignments between statistical estimator values and the constructs' conceptual meanings facilitated objective comparisons, substitutions and exclusions of variables and factors. This guided evidence-based decisions to refine the model, uncovering relationships between variables applicable to SMEs' reality. The result is an LSS implementation model that considers these context-specific relationships.

Research limitations/implications – This study relied on quantitative surveys and statistical analysis; future work could complement it with qualitative methods like case studies. The latent variable modelling approach demonstrated can be used to analyse and validate variables affecting organisational strategies implementation.

Originality/value – This research offers a novel structured approach for deploying LSS in SMEs, derived from CSFs validated through the latent variable modelling approach and organised hierarchically according to their average scores. It advances practical and theoretical understanding of LSS implementation in developing countries – particularly Colombia – and provides an evidence-based implementation framework for practitioners in similar contexts.

Keywords SMEs, Lean Six Sigma, Latent variables, Critical success factors, Validation, Factorial analysis, Implementation structure

Paper type Research paper

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Exact and Heuristic Algorithms for Convex Polygon Decomposition:

18 de diciembre de 2025
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Johana M. Martínez Contreras
Germán Fernando Pantoja
Astrid X. Rodríguez
John Willmer Escobar
David Álvarez

ÍNDICE:

El artículo propone un modelo exacto y un algoritmo heurístico para descomponer polígonos (simples o con agujeros) en el menor número de partes convexas. Mientras que el método exacto garantiza soluciones óptimas en casos pequeños y medianos, la heurística ofrece resultados casi óptimos reduciendo drásticamente el tiempo de cómputo, facilitando tareas como la robótica y el reconocimiento de patrones.

ENLACE AL ARTÍCULO:

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Article

Exact and Heuristic Algorithms for Convex Polygon Decomposition

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Abstract

Convex decomposition plays a central role in computational geometry and is a key preprocessing step in applications such as robotic motion planning, 2D packing, pattern recognition, and manufacturing. This work revisits the minimum convex decomposition problem and proposes both an exact mathematical model and an efficient heuristic algorithm capable of handling simple polygons as well as polygons with holes. The methodology incorporates a visibility-preserving bridge transformation that converts holed polygons into equivalent simple instances, enabling the extension of classical decomposition schemes to more general topologies. In addition, a convex-union post-processing phase is implemented to reduce the number of convex parts obtained by either method. The performance of the proposed approach is evaluated on benchmark instances from the literature and on a new dataset of polygons with holes introduced in this work. The exact model consistently produces optimal decompositions for small and medium instances, while the heuristic achieves near-optimal solutions with significantly reduced computation times. The union phase further decreases the number of resulting convex pieces in most cases. All codes, datasets, and results are publicly released to facilitate reproducibility and comparison with future methods.

Keywords: polygon convex decomposition; heuristic approaches; exact algorithms

MSC: 68U05

1. Introduction

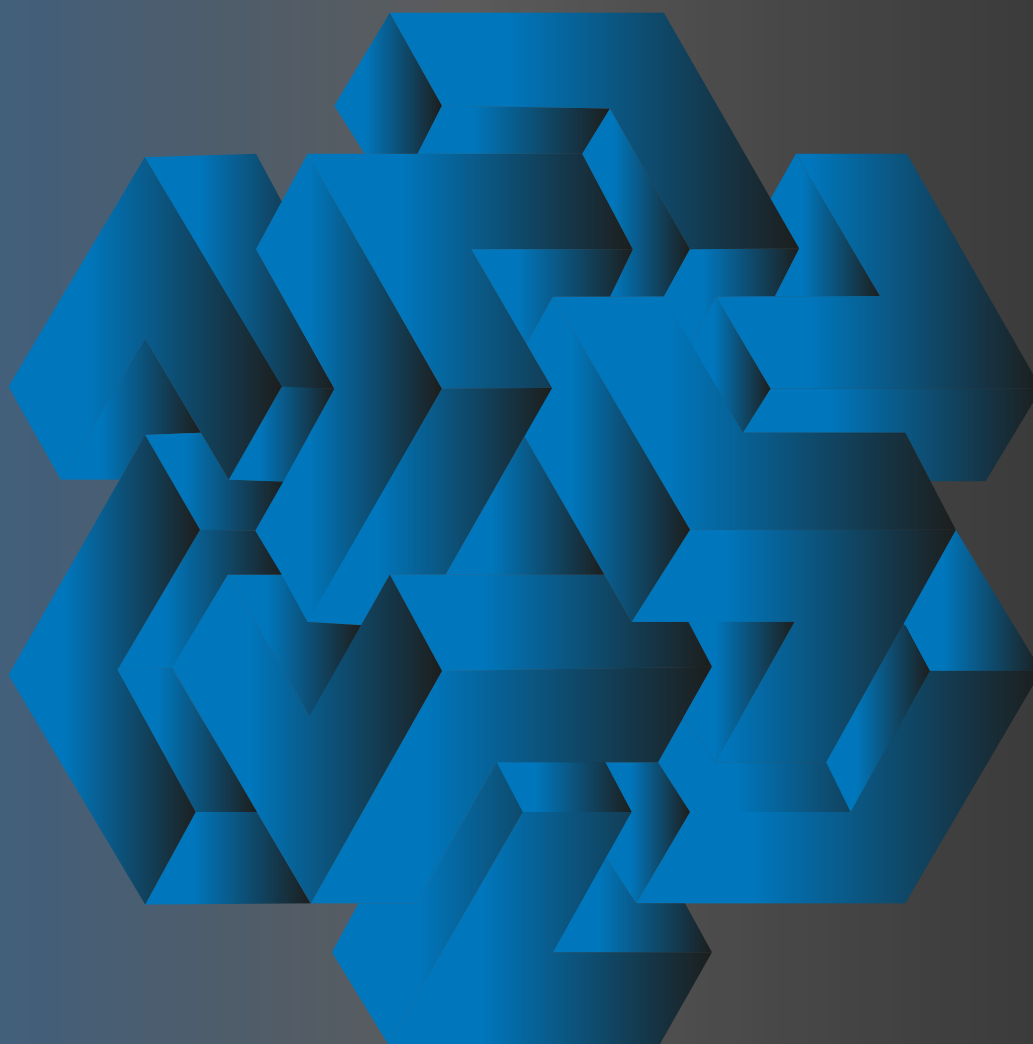
Polygons are fundamental two-dimensional geometric structures widely used to represent objects in computer graphics, pattern recognition, robotics, and computational geometry [1]. In addition, they are a simple way to understand objects and situations in real life [2]. A polygon is a two-dimensional object with at least three sides and three angles. A polygon is convex when every diagonal lies entirely inside the region or, equivalently, when every pair of points can be connected by a segment fully contained in the polygon. Otherwise, the polygon is non-convex, exhibiting one or more reflex (concave) vertices [3–5]. Convex shapes are computationally attractive because they enable simpler geometric operations, faster rendering, and more reliable reasoning in optimization and algorithmic tasks. Consequently,



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