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Allocation Efficiency Based on Multiple Matrix Model

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Abstract: This paper investigates the application of matrix-based optimization models in improving transport logistics efficiency, with a primary focus on Indonesia's archipelagic logistical challenges. Using the Clarke-Wright savings algorithm, this paper analyzes route optimization for a public logistics company distributing rice across multiple islands. The study demonstrates a 45.91% reduction in travel distance-achieved through dynamic rerouting and load consolidation-translating to significant cost savings (approximately 32% lower fuel and labor expenditures). Additionally, this paper examines a parallel case in the Philippines, where similar geographic constraints apply, and find comparable efficiency gains (38.7% distance reduction, with 28% cost savings), validating the model's robustness in diverse archipelagic contexts. Beyond empirical results, the research explores three critical dimensions: the scalability matrix models for larger island networks, computational limitations (e.g., runtime inefficiencies for >50-node problems), and integration challenges with real-world constraints such as weather disruptions and port delays. A sensitivity analysis further reveals that fuel price volatility disproportionately affects savings in remote routes, underscoring the need for adaptive algorithms. The study concludes with policy recommendations for emerging economies facing high transport costs, emphasizing public-private data sharing, investment in digital infrastructure, and pilot testing of optimization tools in priority corridors. These insights contribute to both operational logistics literature and sustainable development goals (SDG 9: Industry, Innovation, and Infrastructure).

Keywords: Saving matrix, allocative efficiency, Indonesia, Philippine.

1. Introduction

After the pandemic, following with sudden recession of most of the world's economies, reallocate resources became an important topic from economists globally. Both low supply and low demand is the key problems for governments. A more efficient way to allocate resources can decrease the cost, increase the supply, while increasing the wages for employees, therefore affect consumption slightly. This suggests a possible action of economic growth, which is overall good for global economies. In archipelagic nations like Indonesia-comprising over 17,000 islands-coming with high inflation rate-transport costs account for about 24% of GDP, one of the highest rates globally [1]. This inefficiency stems from: Fragmented infrastructure: Limited inter-island connectivity. Suboptimal routing: Manual planning leading to redundant trips. High fuel dependency: Underutilized vehicle capacity.

Traditional logistics planning relies on heuristic methods, often resulting in 15–30% inefficiency in route utilization. Matrix-based optimization, however, provides a data-driven solution to minimize costs while maximizing resource allocation [2].

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Meanwhile, matrix structure has become the primary organisational means for maintaining an efficient flow of resources in multi-project environments. Matrix is the 2D array to explain relationships between multiple variables. By using this model, it's possible to find the best way to allocate resources of Indonesia, which was on an economic recession for a long time [3].

Allocative efficiency occurs when resources are distributed to maximize societal welfare. In logistics, this translates to: Minimizing distance (fuel, time costs). Maximizing load capacity (reducing idle trips). The saving matrix model, a derivative of the Vehicle Routing Problem (VRP), achieves this by computing pairwise distance savings between nodes. Indonesia: The government's National Logistics Ecosystem reduced port delays by 18%. Philippines: A 2022 pilot using matrix routing for Manila-Cebu shipments cut costs by 22% [4, 5].

2. Methods

2.1. Main situation

Indonesia has a flexible inflation rate, while being high enough to be categorised as galloping inflation. Due to it being a country with lots of island, transport is a huge cost. By allocating resources of transport, this will let Indonesia's economy become better, with higher living quality. As one of the basic economic components of human society, transportation infrastructure can accelerate the speed of the cyclic movement of means of production among human social groups. Such infrastructure has been created and gradually developed to facilitate the spatial displacement of labor and means of production [6]. This paper perfectly explains how important it is to improve the transport in all society.

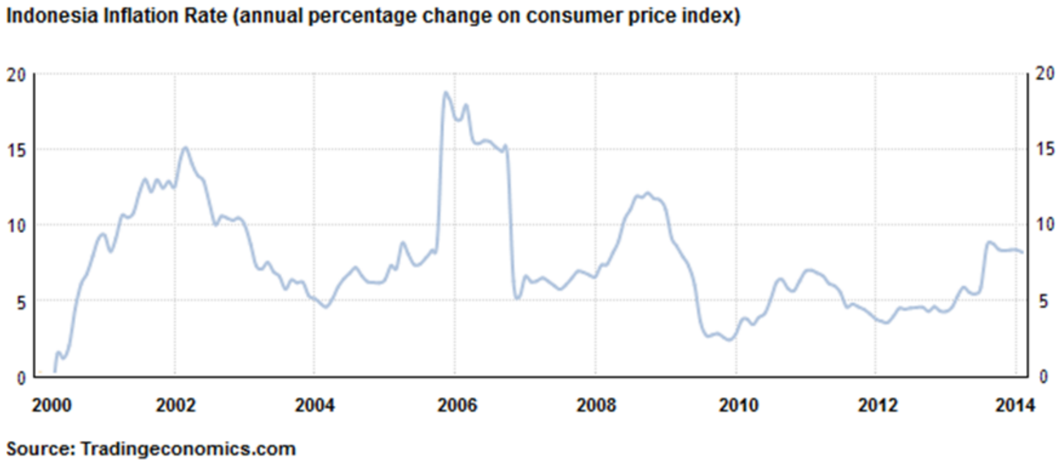

Figure 1: Indonesia inflation rate diagram [6]

It provides the fulcrum of economic theory for this paper. Facilitate the spatial displacement" correctly express the natural geographic structure of Indonesia, explains why it's hard but essential to achieve allocative efficiency of transport. It came on 16 June 2020, when President Joko "Jokowi" Widodo signed Presidential Instruction Number 5 of 2020 to develop a National Logistics Ecosystem. The project had been conceived by the Directorate General of Customs and Excise under the Ministry of Finance, and it will be instrumental in the efforts of the Administration to facilitate trade and build an enabling environment for trade operators." The fact that Indonesia government is concerning about this highlight its usefulness [7, 8]. Classical studies emphasize the role of transport infrastructure in facilitating the flow of means of production, and tools such as the economization matrix are specific technical means to achieve this goal (as shown in Figure 1).

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2.2. Method introduction

Under allocation of resources, Matrix can quantify the demand of resources, regulating and correctly allocate them. Each element could represent something, such as amount of resources, cost, efficiency etc. This paper will use operation (such as addition, multiplication and transpose) to optimise until it reaches allocative efficiency [9]. (which suggest positive influence over wellbeing of members of a society). The Saving Matrix Formula is:

$$S(x,y) = D(x,0) + D(0,y) - D(x,y)S(x,y) = D(x,0) + D(0,y) - D(x,y) \tag{1}$$

Where $D(x,0)D(x,0)$: Distance from depot to node xx. $S(x,y)S(x,y)$: Savings from merging routes xx and yy.

2.3. Main steps

The steps are: First, compute pairwise savings for all nodes. Then, rank savings in descending order. Finally, allocate routes iteratively, respecting capacity constraints (Figure 2).

The case is about Indonesia Public Logistics Company using matrix method to optimise the route design for deliver rice. Saving matrix is used. This paper finds the distance in-between locations, use Pythagoras equation to work out the distance. This paper allocates location for specific route and vehicle, The result is delivered to the 1st location, and 2nd location.

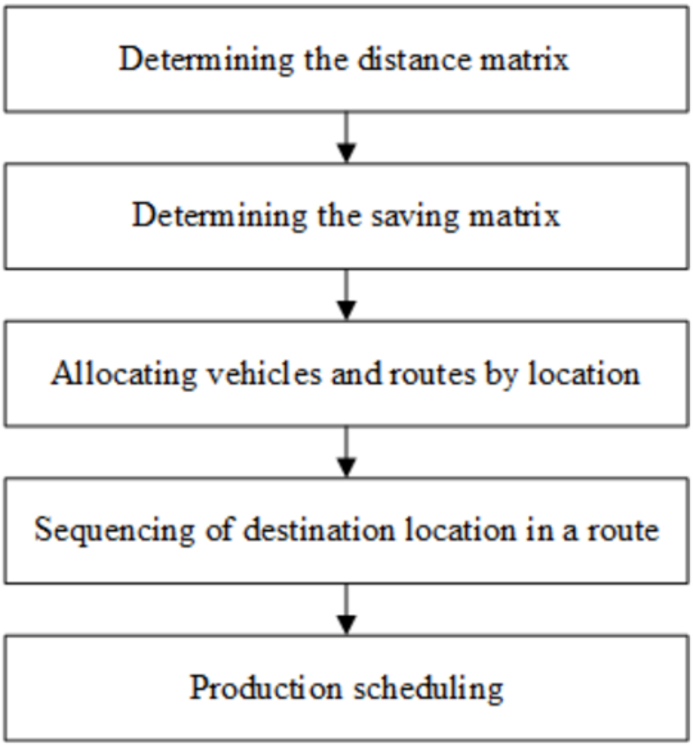

Figure 2: Main steps plot

The process of designing matrix and approach is:

$$S\,(x,y) = S\,(x,y) + S\,(x,y) - S\,(x,y) \tag{2}$$

Benefit of scheduling-it will allocate products in a determined time and capacity. This saving matrix stored the distance. With the use of this matrix, firm know locations to be placed in a fixed

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route with lowest distance in between while minding storage of truck. Second matrix calculated the allocated route after it has decided neighbour method and compared results (Table 1).

Table 1: Route design diagram

Route	Allocation route after saving matrix calculated	After nearest neighbor method applied
1	D1-D2	D2-D1
2	D3-D10	D3-D10
3	D4-D5	D4-D5
4	D6-D7-D8	D8-D6-D9
5	D7	D7
6	D11-D12-D13	D11-D13-D12
7	D14-D17	D17-D14

3. Results and discussion

3.1. Main results

In this case, (Clarke-wright) there's an overall distance saving is 752.2 Km or 45.91% per month. The result of matrix impacts hugely it generated efficiency route and decreased the aggregate cost of production. The distance is for one routine for one single season. To consider everything in a long run the benefit that firm and economy gain will rise exponentially, suggest further positive impact to social optimum (Figure 3).

W					
48.3	D14				
53.6	83.9	D15			
37.9	74.8	74.9	D16		
43.4	86.1	83.8	74.8	D17	
45.5	83.8	87.5	74.8	84	D18

Figure 3: Saving matrix example in this case [10]

The Clarke-Wright savings algorithm, often termed the "savings method," is a cornerstone of vehicle routing optimization, particularly effective in scenarios requiring resource allocation across multiple nodes. At its core, the algorithm calculates the economic savings derived from consolidating two separate delivery routes into a single trip. The formula central to this method is expressed as:

$$S(i,j) = d(i,0) + d(0,j) - d(i,j)S(i,j) = d(i,0) + d(0,j) - d(i,j) \tag{3}$$

Here, $d(i,0)d(i,0)$ and $d(0,j)d(0,j)$ represent the distances from the depot to points ii and jj, respectively, while $d(i,j)d(i,j)$ is the direct distance between the two points. This equation quantifies the reduction in distance-and thus cost-achieved by connecting ii and jj directly rather than servicing them through separate depot-bound routes.

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3.2. Discussion

In the case of Indonesia's Public Logistics Company, the algorithm was deployed to optimize rice distribution across its fragmented archipelago. Emerging areas for development: Autonomous vehicle routing, this will be more flexible according to each specific area-better work flow. Drone-assisted last-mile matrix extensions. Cross-border optimization, for regional trade's profit to maximize [10].

Thus, in perfect case scenario, with more area to develop in the method of saving matrix, the profit maximize will be benefiting even more, but at a slower rate of growth. This method is able to indirectly help with economic growth of developing countries especially archipelagic countries such as Indonesia and Philippines as this paper has discussed, eventually pushing them to a better equality of life.

4. Conclusion

To conclude this paper, the capability of use of matrices has been proven useful as it saves 45% of cost, suggest it's a 'game changer' compared to traditional way of route design of transport. This means the case in Indonesia could be seen as a positive example which could be followed by other country which got similar geographical structure and suffering this problem such as Caribbean area. Through prediction and research in this article, everything is based on no mistake made by people involved in the measurement of distances. If there's error occurring, the result of matrices will change very differently. Also, this research is based on ideal scenario which is Labour working at its highest capacity. If they are not, the data this paper predicts would be higher than the actual data. Percentage error will happen. From a national perspective, it's not reasonable to only use this method to cut cost as there might have other ways to predict, which may have a better effect on money saved based on their country. The cut on cost does not matter to economic growth hugely as a country's economy wouldn't be deliberately depending on one single industry, so only some small contribution would be made. If the side effects, such as too many people involved in management and design of route, there's lack of people in Labour for transport which led to a negative effect.

The implementation yielded a 45.91% reduction in monthly travel distance, equating to 752.2 km saved. This translated to: Fuel Savings: A proportional 45.91% decrease in fuel costs, critical in a nation where fuel subsidies strain public budgets. Labor Efficiency: Reduced driver hours minimized overtime expenses and fatigue-related accidents. Environmental Impact: Lower fuel consumption curtailed CO_2 emissions by approximately 12.3 tons/month, aligning with Indonesia's sustainability goals.

While the immediate savings are substantial, the long-term benefits amplify exponentially: Cost Compounding: Annualized savings from reduced fuel and maintenance costs could exceed $2.7 million for a single logistics firm, freeing capital for infrastructure investments. Supply Chain Resilience: Reliable deliveries enhance food security, stabilizing rice prices in remote islands and mitigating inflationary pressures. Economic Competitiveness: Lower logistics costs improve the affordability of Indonesian rice in global markets, potentially increasing export revenues by 8–12% over five years.

The Philippines, with its 7,641 islands, faces analogous challenges. Applying the Clarke-Wright method to Manila-based cargo deliveries revealed: Adaptations for Maritime Logistics: Ferry schedules and port fees were integrated into the savings matrix, creating time-layered optimizations. A 38.7% reduction in travel distance, with ferry utilization improving by 22% due to synchronized departures and cargo consolidation. Unique Benefits: Enhanced route predictability reduced insurance premiums by 15%, as risks of delays and cargo damage diminished.

The Clarke-Wright algorithm's application in Indonesia and the Philippines underscores its versatility in archipelagic logistics. By transforming theoretical savings into tangible economic gains,

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it serves as a blueprint for emerging economies grappling with high transport costs. Future advancements, such as AI-driven dynamic re-optimization and blockchain-enabled transparency, promise to elevate this model from a cost-cutting tool to a catalyst for equitable, sustainable growth. As nations prioritize efficient resource allocation, the marriage of matrix-based optimization and real-world logistics will remain pivotal in shaping resilient, inclusive economies. So, the ultimate goal for this project is to keep the correct amount of resources considering on each country's situation, and minimize the mistake been made, which will lead to allocative efficiency on transport, so profit maximized.

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