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Research paper



Day-of-Week Traffic Congestion and Productivity Losses: A Value-of-Time Analysis of a Major Intersection In Batangas City

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Abstract

Traffic congestion is increasingly recognized not only as a transportation issue but also as a significant source of economic inefficiency, particularly in developing and medium-sized cities. This study estimates congestion-related productivity losses at a major intersection in Batangas City, Philippines, with emphasis on variations across days of the week. Using a value-of-time (VOT) framework, congestion costs were estimated from observed travel time delays and additional fuel consumption during morning (AM) and afternoon (PM) peak hours over seven consecutive days. Traffic data were obtained from closed-circuit television (CCTV) footage provided by the Batangas City Transportation Development Regulatory Office (TDRO) and supplemented by a brief key-informant interview to contextualize the observed traffic conditions. Results show clear day-of-week variation in congestion costs, with weekdays, particularly Mondays, incurring the highest economic and productivity losses. Across all days, time-related productivity loss constituted the dominant share of total congestion cost. The findings highlight how routine traffic delays translate into measurable economic losses and underscore the importance of integrating economic and productivity considerations into local traffic management and policy decisions in growing urban areas.

Keywords: *Day of Week Variation; Economic Inefficiency; Productivity Loss; Traffic Congestion; Value of Time .*

1. Introduction

Traffic congestion is no longer confined to large metropolitan centers; it has become a recurring challenge in developing and medium-sized cities such as Batangas City. Rapid urban growth, increasing vehicle ownership, concentrated economic activities, and constrained road capacity contribute to recurrent congestion, especially during peak travel periods. These conditions reduce travel efficiency and generate economic costs that extend beyond inconvenience to road users.

From the perspective of transportation economics, traffic congestion represents a form of economic inefficiency arising from the suboptimal use of time and resources. Travel delays lengthen trip durations beyond efficient levels, resulting in lost productive time, higher fuel consumption, and increased vehicle operating costs. Among these impacts, productivity loss associated with travel time delay is often the most substantial, as time is a scarce resource that could otherwise be allocated to work, education, or leisure activities.

The value-of-time (VOT) concept provides a practical means of translating travel delays into monetary terms. By assigning a monetary value to time lost in traffic, congestion impacts can be evaluated in economic terms that are relevant for planning and policy analysis. Examining congestion costs by day of the week further allows for identification of temporal patterns linked to work schedules, school activities, and commercial operations.

This study applies a VOT-based approach to assess day-of-week variations in traffic congestion and productivity losses at a selected major intersection in Batangas City. By combining observed traffic volumes, estimated delays, and fuel consumption with economic valuation techniques, the research provides localized and policy-relevant estimates of congestion-related economic losses in a medium-sized urban setting.

1.1. Research Objectives

The general objective of this study is to evaluate the economic cost of traffic congestion and associated productivity losses across different days of the week at a major intersection in Batangas City using a VOT approach.

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Specifically, the study aims to:
1) estimate the daily economic cost of traffic congestion based on travel time delays and additional fuel consumption during AM and PM peak hours;
2) quantify productivity losses resulting from traffic delays by converting time lost into monetary values using the VOT method;
3) compare congestion costs and productivity losses between weekdays and weekends;
4) identify the day of the week with the highest combined economic and productivity loss due to traffic congestion; and
5) determine whether time-related productivity losses contribute more significantly to total congestion costs than fuel-related costs.

1.2. Theoretical Framework

This study is anchored in core principles of transportation economics, particularly opportunity cost, VOT, and economic efficiency. Opportunity cost theory posits that time spent in traffic congestion represents foregone productive or leisure opportunities and therefore constitutes an economic loss. The VOT concept operationalizes this theory by assigning a monetary value to each hour of travel delay experienced by road users.

In congested traffic conditions, economic losses arise through two primary channels: time-related productivity loss and increased vehicle operating costs, especially fuel consumption. Higher traffic volumes during peak periods increase delays, thereby raising the total time lost by commuters. When multiplied by the VOT, these delays translate directly into productivity losses. At the same time, stop-and-go traffic conditions increase fuel consumption, adding to overall congestion costs.

Day-of-week traffic patterns are shaped by institutional and behavioral factors such as work schedules, school operations, and commercial activities. These factors influence travel demand and congestion intensity, which in turn affect the magnitude of economic and productivity losses. The theoretical framework, therefore, links traffic volume and delay to economic cost through time valuation and fuel consumption, with day-of-week variation serving as a key comparative dimension.

1.3. Hypothesis

H_{01}: There is no significant difference in the mean economic cost of traffic congestion across different days of the week.
H_{02}: There is no significant difference in mean productivity losses between weekday traffic congestion and weekend traffic congestion.
H_{03}: Mondays do not have significantly higher mean combined economic and productivity losses compared to other days of the week.
H_{04}: Productivity loss due to time delays does not contribute a significantly greater proportion to total congestion cost than additional fuel consumption.

2. Review of Related Literature

Traffic congestion has been widely documented as a major source of economic inefficiency in urban transportation systems. Small and Verhoef (2007) emphasized that congestion increases travel time, reduces reliability, and raises vehicle operating costs, thereby diminishing overall economic welfare. These impacts are particularly pronounced during peak periods when travel demand exceeds available road capacity.

The valuation of travel time has long been central to transportation economics. Button (2010) highlighted that time savings often represent the largest benefit in transport project appraisal due to their direct link to productivity and quality of life. Similarly, Litman (2013) found that time-related costs typically account for the majority of congestion-related economic losses, exceeding fuel and maintenance costs.

Recent congestion cost research emphasizes the continued dominance of time costs over fuel costs in urban settings (World Bank, 2017; Asian Development Bank, 2020). Studies in Southeast Asian cities show that medium-sized cities experience congestion costs comparable to larger metros due to constrained road space and mixed traffic (Asian Development Bank, 2020).

Compared with metropolitan-focused congestion studies, this paper extends prior VOT-based research by localizing estimation to a single high-friction intersection, focusing on a medium-sized Philippine city, and disaggregating impacts by day of the week, which is rarely explored in local studies.

Several studies have applied VOT-based approaches in developing urban contexts. Cervero (2013) observed that medium-sized cities may experience severe congestion impacts despite having fewer vehicles than large metropolitan areas, largely due to limited infrastructure and concentrated activity centers. In the Philippine context, Regidor and Teodoro (2005) demonstrated that urban traffic congestion leads to significant productivity losses, particularly among workers and public transport operators.

Day-of-week variations in congestion have also been documented. Downs (2004) reported that peak congestion often occurs on Mondays and Fridays, reflecting work resumption and end-of-week travel behavior. While weekend congestion may arise from recreational travel, its economic cost is generally lower due to reduced productivity-related trips.

Fuel consumption under congested conditions has been examined by Barth and Boriboonsomsin (2009), who showed that stop-and-go traffic substantially increases fuel use and emissions. However, fuel costs are commonly secondary to time-related productivity losses in total congestion cost estimation. Collectively, these studies support the need for localized congestion cost assessments that integrate both time and fuel costs while accounting for temporal variation.

3. Research Methodology

This section outlines the research design, data collection procedures, and statistical techniques used to analyze day-of-week variations in traffic congestion and productivity losses using a VOT approach. Appropriate analytical tools were applied to ensure objective and reliable comparison of congestion-related economic costs across days of the week.

3.1. Research Design

The study employed a quantitative, descriptive-comparative research design combined with applied economic estimation techniques. Traffic conditions were observed during fixed peak-hour periods over seven consecutive days without manipulating traffic flow. This design enabled systematic comparison of congestion costs across days of the week using real-world traffic data.

3.2. Data Collection Procedure

Traffic data were obtained from CCTV footage provided by the Batangas City Transportation Development Regulatory Office (TDRO). Observations covered seven consecutive days, with two peak-hour periods recorded daily: 6:00–7:00 AM and 5:00–6:00 PM. For each period, total vehicle counts and estimated average delay per vehicle were recorded. Vehicle counts were verified through repeated review of the CCTV recordings. A brief key-informant interview with a TDRO representative was conducted to provide contextual information and support interpretation of the quantitative results.

3.3. Statistical Treatment of Data

All traffic and delay data were encoded and processed using Microsoft Excel. Descriptive statistics were used to summarize vehicle volumes, average delays, and estimated congestion costs for each day. The economic cost of congestion was estimated using a value of time of Php 100 per hour, consistent with local wage conditions and standard transport economics practice.

Productivity loss was calculated by multiplying the average delay per vehicle (in hours), the assumed VOT, and the number of vehicles observed during each peak-hour period. Fuel cost was estimated based on additional fuel consumption per delayed vehicle and prevailing fuel prices during the observation period. Daily congestion cost was obtained by aggregating AM and PM peak-hour costs.

To strengthen empirical rigor, exploratory inferential tests were conducted using the seven-day congestion cost dataset. A one-way ANOVA framework was specified to assess day-of-week differences; however, because only one observation was available per day, F-statistics and p-values could not be computed. The ANOVA table is therefore presented descriptively to illustrate between-day variance. Independent samples t-tests were used to compare weekday and weekend costs, and a one-sample t-test was used to compare Monday with other days.

Finally, Monday's mean cost was compared with the average of other days using a one-sample t-test. Percentage contribution analysis was used to assess the relative importance of time-related productivity loss and fuel-related costs.

3.4. Justification of the Value of Time (VOT)

The assumed VOT of Php 100 per hour is based on a conservative approximation of local wage conditions in Batangas City. This value approximates the lower bound of prevailing daily minimum wages in Batangas when converted to an hourly rate. The chosen value is intentionally conservative to avoid overstating congestion costs and to reflect a mixed user group, including students, service workers, and informal-sector commuters.

3.5. Sensitivity Analysis (±20%)

To test robustness, congestion costs were recalculated using:

a) Low VOT = Php 80/hour
b) Base VOT = Php 100/hour
c) High VOT = Php 120/hour

Table 1: Sensitivity Analysis of Study

Scenario	Monday Total Cost
VOT –20%	Php 6,192
Base VOT	Php 7,740
VOT +20%	Php 9,288

The relative ranking of days (with Monday consistently highest) and the dominance of time-related productivity costs over fuel costs remain unchanged across all scenarios, demonstrating that the main conclusions are robust to reasonable variation in VOT assumptions.

4. Results and Discussion

This section presents the results of the economic assessment of traffic congestion at a major intersection in Batangas City. The analysis focuses on day-of-week congestion cost patterns, differences between weekdays and weekends, and the relative contribution of productivity loss and fuel cost components.

Given the short observation period and the use of one aggregated congestion cost per day, inferential results are interpreted cautiously and treated as indicative rather than confirmatory. Formal statistical tests (one-way ANOVA and t-tests) are presented to demonstrate effect magnitude and direction, but findings primarily support exploratory inference.

Table 2: Summary of Daily Congestion Costs (PHP)

Day	AM Peak Cost	PM Peak Cost	Total Daily Cost
Monday	5,111.16	2,629.21	7,740.37
Tuesday	2,709.83	2,524.01	5,233.84
Wednesday	2,733.73	2,620.26	5,353.99
Thursday	2,783.82	2,756.73	5,540.55
Friday	2,838.77	2,650.29	5,489.06
Saturday	1,812.79	2,093.87	3,906.66
Sunday	1,842.02	1,828.07	3,670.09

The results indicate that traffic congestion imposes a substantial and recurring economic burden on road users. Congestion costs varied noticeably across the days of the week, with Monday recording the highest total daily congestion cost (Php 7,740.37). This elevated cost was primarily driven by severe AM peak-hour delays, reflecting the resumption of work, school, and commercial activities after the weekend.

In contrast, weekend congestion costs were considerably lower, with Sunday registering the lowest total daily cost. This pattern suggests reduced travel demand and fewer productivity-related trips during non-working days. Across the observation period, weekday congestion costs consistently exceeded weekend costs, highlighting the strong link between traffic congestion and routine economic activity.

The AM and PM peak periods exhibited distinct congestion patterns. The AM peak period showed pronounced variability, particularly on Monday, when congestion costs were more than double those observed on weekend mornings. This reflects concentrated departure times associated with work and school schedules.

In contrast, PM peak congestion costs were more evenly distributed across weekdays, suggesting sustained traffic demand caused by staggered dismissal times from schools, offices, and commercial establishments. This indicates that while morning congestion is more acute during specific days, afternoon congestion represents a persistent daily burden.

These findings support the view that congestion in Batangas City is systematic rather than random, driven largely by institutional schedules and daily travel behavior.

Table 3: Weekday vs Weekend Congestion Costs

Category	Mean Daily Cost (Php)	Standard Deviation
Weekdays	5,871.96	937.42
Weekends	3,788.38	167.29

Weekdays incurred substantially higher average congestion costs than weekends. In addition, weekday costs exhibited greater variability, reflecting fluctuating traffic conditions associated with work schedules, school dismissal times, and commercial activity. Weekend congestion costs were not only lower but also more stable, indicating more predictable and less intensive traffic demand.

Although inferential testing is statistically underpowered due to the short observation window and single observation per day, exploratory t-tests were conducted to assess weekday–weekend differences and Monday-specific effects. These results are interpreted cautiously and primarily demonstrate the magnitude and direction of observed differences.

Table 4: One-Way ANOVA: Day-of-Week Differences in Total Daily Congestion Cost

Source of Variation	Sum of Squares (SS)	df	Mean Square (MS)	F	p-value
Between Days	11,483,201.6	6	1,913,866.9	—*	—*

Notes: *F-statistic and p-value cannot be computed because each day has only one observation (n = 1 per group).

Although formal ANOVA could not be computed due to one observation per day, the large between-day variance indicates meaningful day-of-week differences, justifying future multi-week data collection for confirmatory testing.

Table 5: Independent Samples T-Test: Weekday vs Weekend Congestion Costs

Group	n	Mean (Php)	SD (Php)
Weekdays	5	5,871.96	937.42
Weekends	2	3,788.38	167.29

Statistic	Value
Mean Difference	2,083.58 Php
t-statistic	4.61
Degrees of Freedom	≈ 5
p-value	0.005 (indicative)
Effect Size (Cohen's d)	2.78 (very large)

Weekday congestion costs are substantially higher than weekend costs, with a very large effect size. Given the limited sample size, this difference is interpreted as indicative of a strong weekday–weekend contrast rather than as confirmatory statistical evidence.

Table 6: Monday vs Other Days: One-Sample T-Test

Comparison Group	n	Mean (Php)	SD (Php)
Other days (Tue–Sun)	6	4,865.03	768.51
Monday	1	7,740.38	—

Statistic	Value
Mean Difference	2,875.35 Php
t-statistic	9.17
Degrees of Freedom	5
p-value	< 0.001

Monday's congestion cost is markedly higher than the average of other days, indicating that congestion intensity peaks at the start of the workweek. This result is interpreted cautiously due to the single-observation-per-day design.

Table 7: Percentage Contribution of Congestion Cost Components

Day	Time Loss (%)	Fuel Cost (%)
Monday	90.3	9.7
Tuesday	88.9	11.1
Wednesday	88.7	11.3
Thursday	88.2	11.8
Friday	88.6	11.4
Saturday	86.1	13.9
Sunday	85.4	14.6

Across all days of observation, time-related productivity loss accounted for the dominant share of total congestion cost, exceeding 85% even during weekends. Fuel costs constituted a smaller but consistent portion of total congestion costs, with a slightly higher percentage observed on weekends due to relatively lower time delays.

This result confirms the central premise of transportation economics that the opportunity cost of time is the most significant economic consequence of traffic congestion. While increased fuel consumption contributes to congestion-related losses, its impact is secondary compared to productivity losses resulting from travel delays.

Hence, the inferential results provide indicative support for rejecting H_{02} and H_{03}, as weekday congestion costs and Monday congestion costs are substantially higher than those of the comparator groups. H_{01} is addressed descriptively due to ANOVA limitations, while H_{04} is supported by the consistently dominant share of time-related productivity losses across all days.

Overall, the findings demonstrate that traffic congestion at the study intersection results in meaningful daily economic losses, primarily driven by productivity loss from time delays. Congestion costs are unevenly distributed across the week, with Mondays consistently exhibiting the highest combined economic and productivity losses, followed by other weekdays. Weekends impose a lower economic burden, reflecting reduced productivity-oriented travel.

These patterns align with established transportation economics theory and empirical findings from both local and international studies, reinforcing the relevance of applying a value-of-time framework in assessing congestion impacts in medium-sized cities.

The results also suggest that congestion impacts are time-specific and day-specific, implying that targeted traffic management interventions, particularly during Monday morning peak hours, may yield disproportionately large economic benefits relative to their cost.

Findings are site-specific and reflect congestion dynamics at one major intersection in Batangas City only. Results should not be generalized to the entire road network of Batangas City without further multi-site validation.

5. Conclusion

This study assessed the economic cost of traffic congestion and associated productivity losses at a major intersection in Batangas City using a VOT approach. By translating observed peak-hour delays into monetary terms, the analysis demonstrated that routine traffic congestion generates measurable and recurring economic losses.

Clear day-of-week variation in congestion costs was observed. Weekdays consistently incurred higher economic and productivity losses than weekends, with Mondays registering the highest total congestion cost. Across all days, productivity loss due to time delays dominated total congestion costs, while fuel-related costs played a secondary role. These findings reinforce the view that traffic congestion should be addressed primarily as a productivity and efficiency issue.

Overall, congestion at the study intersection produces recurring economic losses driven primarily by time-related productivity costs. The concentration of losses during weekday peaks, particularly Monday mornings, suggests that targeted, low-cost traffic management can generate disproportionately large economic benefits. While localized, the findings demonstrate how even short, routine delays impose measurable economic burdens in medium-sized cities.

6. Policy Implications

The findings indicate that traffic congestion management in Batangas City should be time-specific and demand-responsive, rather than uniformly applied across all periods. Congestion costs were shown to be concentrated during particular high-impact periods, most notably weekday peak hours, suggesting that targeted interventions during these times can yield disproportionately large economic benefits. By focusing limited public resources on periods with the highest productivity losses, local authorities can improve the efficiency and cost-effectiveness of traffic management strategies.

Given that time-related productivity loss constitutes the dominant component of total congestion cost, policy measures should prioritize actions that directly reduce travel time and delay variability. Such measures may include strengthened traffic enforcement during peak hours, regulation of roadside loading and unloading activities, stricter control of illegal parking, improved lane discipline, and optimization of signal timing at critical intersections. These interventions are relatively low-cost compared to large infrastructure projects and can generate immediate economic benefits by reducing delay-related losses.

At a broader planning level, incorporating congestion cost estimation into routine traffic monitoring and evaluation can support more evidence-based decision-making. By quantifying congestion impacts in economic terms, local government units can better justify traffic management investments, prioritize interventions, and communicate the economic consequences of congestion to stakeholders and the public.

7. Limitations and Recommendations

Several limitations of the study should be acknowledged. First, the analysis was confined to a single intersection and a seven-day observation period, which may not fully capture citywide congestion dynamics or seasonal variations in traffic patterns. The seven-day observation window limits generalizability. The observed week was a regular school and work week with no holidays or major public events, as confirmed by TDRO, making it broadly typical of routine conditions. However, congestion patterns may vary during holidays, paydays, enrollment periods, rainy seasons, and local festivals. Seasonal travel behavior, weather conditions, and academic calendar effects may introduce bias.

Second, the application of a uniform VOT and average fuel consumption rate simplifies heterogeneous travel behavior and does not reflect differences in income levels, trip purposes, or vehicle types. These assumptions, while necessary for practical estimation, may lead to under- or over-estimation of actual congestion costs for specific user groups.

Even modest reductions in Monday AM peak delay (10-15%) could yield daily savings of Php 700–1,100 at this single intersection. Given that low-cost measures such as traffic enforcer deployment and loading/unloading enforcement have minimal budget requirements, the implied benefit–cost ratio is likely favorable. However, feasibility constraints include limited manpower, political acceptability of stricter enforcement, and coordination with schools and commercial establishments.

Future research should address these limitations by expanding the analysis to multiple intersections or corridors, extending the observation period to capture longer-term and seasonal trends, and applying differentiated values of time and vehicle-specific fuel consumption estimates. Incorporating disaggregated data by vehicle class and trip purpose would further improve the accuracy and policy relevance of congestion cost assessments. Such enhancements would strengthen the use of economic analysis as a decision-support tool for sustainable urban transport planning in medium-sized cities.

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