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Analyzing Impacts of Transportation Infrastructure and Policies on Traffic Flow in Metro Manila Using Advanced Tools and Techniques

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ABSTRACT

Various transportation infrastructure and policies have been implemented in the Philippines in order to ease traffic congestion and other transportation and traffic problems. Many of these are in Metro Manila, comprising a long list that includes grade separation devices, traffic control facilities, and vehicle restraint measures. These have been generally perceived to have positive impacts and have led to the construction of more infrastructures or the continued implementation of traffic schemes. Nevertheless, there are sectors that have not taken advantage of available impact assessment techniques and tools to systematically and properly evaluate the effects of infrastructure and policies on transporation and traffic. This paper presents the most popular methods and some tools for appraising effectiveness of infrastructure and policies. Several examples are discussed and results are used in formulating recomendations regarding best practices in impact assessment.

KEY WORDS: impact analysis, infrastructure, policies, traffic flow

1. INTRODUCTION

1.1. Background

Transportation and traffic problems have hounded major cities around the world, necessitating the provision of various infrastructures and the implementation of an assortment of policies geared towards solving these problems. Various results have been experienced with certain policies failing to control traffic, and infrastructure unable to address the demand for facilities. In many cases, implementation is successful leading to the notion that such success can be replicated in other cases. these assessments, however, have been based on haphazard approaches and in cerftain situations, simple observation with the perception of success or failure based on feel rather than fact.

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This paper presents widely accepted methods and tools used in impact assessment of infrastructures and policies. These are the instruments by which the effectiveness or non-effectiveness of infrastructures and policies can be gauged systematically, scientifically, and objectively. A number of infrastructures and policies are then examined, illustrating a suitable manner for assessment that can be adopted by decision-makers in planning for facilities and strategies to solve transportation and traffic problems.

1.2. Objectives

The paper has the following objectives:

1. Present methods and tools for evaluating impacts of transporation infrastructure and policies;
2. Illustrate the utility of these methods and tools by examining impacts of specific infrastructures and policies using the methods identified; and
3. Recommend these methods and tools for regular use in impact assessment.

In the process of demonstrating the advantages of systematic impact assessment, the paper identifies several cases that have had a perceived impact on transportation and traffic in Metro Manila. As such, the discussions would be able to show clearly the effectiveness of established assessment methodology.

2. CASES FOR EXAMINATION

Five cases are examined in this paper. These are classsified into their transportation infrastructure or policy. Infrastructure is further classified into grade separation and traffic signalization. Similarly, policy is categorized into travel demand management (TDM) and traffic systems management (TSM) schemes. The cases cite in this paper have been examined in other papers and reports including those by Regidor and Felias [5], Mauricio and Santos [3], Gomez, Oliveros and Dela Cruz [1], and Tiglao, Regidor and Teodoro [7].

2.1. Infrastructure

Traffic Signals Traffic signals or traffic lights are installed at intersections according to a set of criteria that include volume, pedestrian considerations and accident occurrence. These are used in lieu of signage (i.e., stop and yield) in order to manage conflicting flows at intersections. In particular, there is the need to eliminate crossing conflicts that could result in fatal collisions among vehicles. Separation of flows is done by means of phasing groups of movements (i.e., grouped are those movements that do not have critical conflicts among them).

This paper will look into the impacts traffic signals installed at major intersections in the Makati Central Business District (CBD). In particular, five intersections are consdiered. These are the Ayala Avenue-Makati Avenue, Ayala Avenue-Paseo De Roxas, Puyat Avenue-Makati Avenue, Puyat Avenue-Paseo De Roxas, and Makati Avenue-Paseo De Roxas intersections.

Interchanges Grade separation is considered as a final option to ease congestion at intersections. Flows are separated by means of constructing overpass (flyovers), underpasses (tunnels) or their combinations. At intersections of major highways, signals would not be sufficient in managing flows due particularly to the high traffic volumes at these locations. Thus, a configuration consisting of several flyovers comprise the interchange that we can observe in such locations as the intersection of EDSA and the South Expressway.

The overpass at the EDSA - Ayala Avenue intersection is one among many interchange projects implemented to reduce congestion at major intersections in Metro Manila. The overpas serves to promote uninterrupted flow for vehicles coming from the Makati CBD are (via Ayala Ave.) and generally bound for the north of Metro Manila (via EDSA). This flyover elimianted the need for the corresponding left turn movement in the phasing of the traffic signal at-grade. For the purpose of this paper as well as simplicity, only the impacts of the overpass would be discussed. Note that at present, there is also the udnerpass along EDSA that serves both northbound and southbound vehicles.

2.2. Policies

There are currently several major schemes currently being implemented in Metro Manila. Two may be classified as TDM measures - the Unified Vehicular Volume Reduction Program (UVVRP) and the Truck Ban. These schemes address the demand side of transportation, and involve the regulation of the number of vehicles using roads thereby reducing volumes and easing congestion. These measures are at best effective on the short and medium terms, although certain policies like Singapore's vehicle ownership restraints have worked over the long-term. A scheme that was implemented but lately abandoned is the Organized Bus Route along EDSA, which entailed the regulation of the number of buses dispatched from critial locations like Cubao in Quezon City and Crossing in Mandaluyong City. Other strategies mainly were intended to instill discipline on motorists and pedestrians. These included the controversial Wet Flas scheme and the Pink Fences set-up along EDSA. Both are unpopular yet were implemented to determine actual impacts. So far, the pink fences have been implemented to a certain degree of success.

Truck Ban The truck ban has been in place since 1978 and restrains large trucks from using most Metro Manila roads to give way to other road users. It has long been perceived as having detrimental effects on goods movement and, consequently, on the economy. Trucks are allowed only along designated roads and routes, specifically those near the Port of Manila as well as the industrial areas along the Pasig River. Typically, trucks are not allowed along all other roads from 6:00 A.M. to 6:00 P.M.

The scheme has been criticized for its negative impacts on the economy in general. This is due to the perception that the truck ban has impeded the flow of goods in the region leading to economic losses. It has been argued that freight giving way to passenger traffic is an outdated solution given the infrastructure development in Metro Manila, among other factors that would show the present irrelevance of the truck ban.

U-turn Scheme The U-turn scheme or the "Big Rotonda" scheme was implemented in 2002. Intersections were closed and traffic signals were turned off in favor of median openings constructed along major thoroughfares. At first, this scheme was implemented along the wider thoroughfares of Commonwealth Avenue in Quezon City and Marcos Highway in Pasig and Marikina Cities. Following these were the implementation of the scheme at various locations in Metro Manila including many major intersections along EDSA. Unlike the UVVRP and

Truck Ban, the U-turn Scheme was largely experimental and entailed many adjustments as negative traffic impacts became apparent. Thus, along thoroughfares like Quezon Avenue, several median openings had to be constructed and closed while the MMDA was in the process of determining suitable location of openings.

There have been mixed perceptions regarding the effectiveness of the U-turn scheme. One drawback of increased speeds and the median openings in lieu of intersections have been the promotion of aggressive driving and increased frequency of weaving. These have led to an increase in the number of vehicular accidents that have often been referred to as the price of speeding up traffic.

3. IMPACT ASSESSMENT

3.1. Background

Impact assessments of infrastructure and policies are necessary to determine their efficacy or ineffectiveness. However, this is not often used in the Philippines despite providing experts and decision makers with a powerful tool in evaluating benefits of infrastructure and policies. Two methodologies are presented in this paper. One is the use of simulation, with examples of microsimulation and macro simulation results. Another is the use of before and after studies. Both are widely accepted methodologies for impact assessment and their application is discussed in the succeeding sections.

3.2. Simulation

In the absence of historical data, scenarios of ”with” and ”without” infrastructure or policy can be developed. Caution must however be taken since the ”without” case may involve present data (e.g., traffic volume, origin-destination, geometry, etc.). There may be arguments regarding the appropriateness of using such data. As such, it should be clear from the outset that use of the same present data would be necessary due to the nature of comparison.

A good case for illustrating development of scenarios for the ”with” and ”without” cases concern intersections with signals or grade separation devices. Present or current data on a signalized intersection, for example, can be evaluated for the ”without” case by replacing signals with sufficient signage (e.g., stop and yield signs). The performance of the intersection could then be assessed under the condition. Similarly, an intersection with grade separation (e.g., flyover, underpass) can be modeled as a signalized intersection to determine the benefits of providing grade separation for a supposedly saturated intersection.

The approach mentioned above could be used in relation to current schemes being implemented like the UVVRP, the truck ban and U-turn. Before and after studies for such policies, while also effective, may not necessarily reflect the impact of a single improvement. In certain cases, it is difficult to isolate the effects of an improvement.

3.2.1. Ayala Avenue-EDSA Overpass and Makati CBD Signals The cases of the Ayala Avenue-EDSA overpass and the Makati CBD traffic signals required the development of a simulation model. Road geometric features and traffic characteristics are sourced from fieldwork (e.g., traffic surveys) and related agencies (e.g., Traffic Engineering Center). The link and node system for the model is first developed and characteristics are later inputted to

Traffic Flow Parameters:	
Duration of lane change maneuver	3.0 sec
Average driver reaction time	1.0 sec
Time for successive lane changes	2.0 sec
Deceleration at start of lane change manuever	2.0 m/sec^2
Panic deceleration rate of lead vehicle in car following	4.0 m/sec^2
Panic deceleration rate of follower vehicle in car following	4.0 m/sec^2
Urgency threshold	10.0 m/sec^2/m
Safety factor	8.0
Percent of cooperative drivers with lane changer	50%
Headway below which all drivers will attempt lane change	2.0 sec
Headway below which no drivers will attempt lane change	5.0 sec

Vehicle Parameters:

Type	Size(m)	Occupancy
Car	4.4	2
Truck	10.7	1.2
Jeepney/FX	5.0	10
Bus	12.2	50

Table I. Parameters relevant to simulation model calibration (from Regidor and Felias [5])

the system. For the models of the overpass and signals, a commercial simulation package was used - TRAF-NETSIM. This was developed by the Federal Highway Administration (FHWA) of the United States is one of the more popular software in use. The features of such software allowed for easier development of the simulation models.

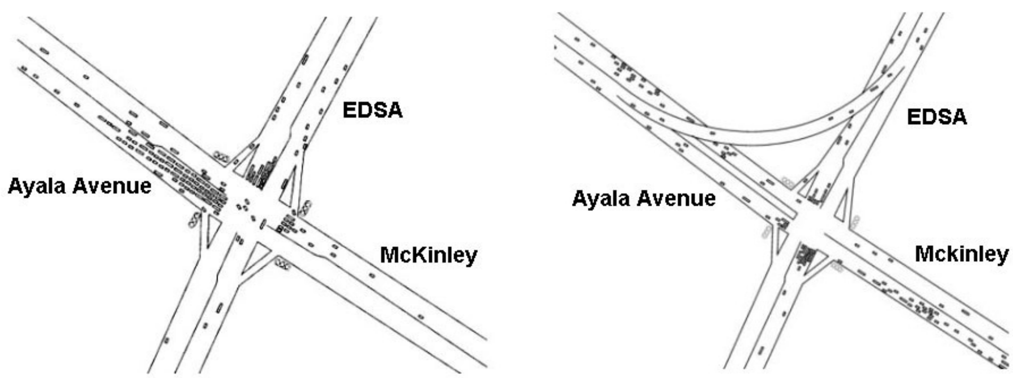
A basic requirement of model development is the calibration and validation stage. Calibration and validation entailed the adjustment of the parameters listed in Table 1 during several iterative runs of the models. Link flows at terminal nodes were compared to actual traffic count data. The models are deemed valid when terminal node discharges are all within 85% of actual traffic counts. That is, the models are presumed to approximate actual conditions for the "with" project cases. "Without" project cases assumed best conditions for intersections but with current traffic volumes. For the "without" overpass case, this meant optimum signal settings while for the "without" signals case, optimum lane allocations, and yield and stop sign controls were assumed.

Modeling public transportation operations are included in the features of TRAF-NETSIM. However, since the country of origin of the software only has bus operations, paratransit (e.g., jeepneys and FX) operation was approximated using modified buses (i.e., vehicle parameters) and operations. Detailed discussions of modeling public transportation operations, especially the consideration of jeepneys and FX may be found in Regidor and Felias [5].

Figure 1 shows the configurations of the Ayala Avenue-EDSA intersection with and witout the flyover. The intersection is signalized at ground level and the overpass basically eliminates left turning traffic from Ayala Avenue to EDSA. Note the queues along the left and middle

Scenario	Vehicle Restriction		
	UVVRP	Truck Ban	UVVRP for Trucks
Warm-wwo (base case/present situation)	√	√	
Warm-www	√	√	√
Warm-woo	√		
Warm-wow	√		√
Warm-owo		√	
Warm-oww		√	√
Warm-ooo			
Warm-oow			√

Table II. Scenarios developed for analysis of UVVRP and Truck Ban



(a) Without Flyover (b) With Flyover

Figure 1. Ayala Avenue-EDSA Flyover

lanes along Ayala in Figure 1a.

Figure 2 shows a screenshot of the Makati Avenue-Ayala intersection simulation. TRAF-NETSIM basically has two major components. These are the data editor component ITRAF, and the analysis and visualization component TSIS. The animation is done through the TRAFVU module of the TSIS component. Signal lights are indicated at the corners of the intersection.

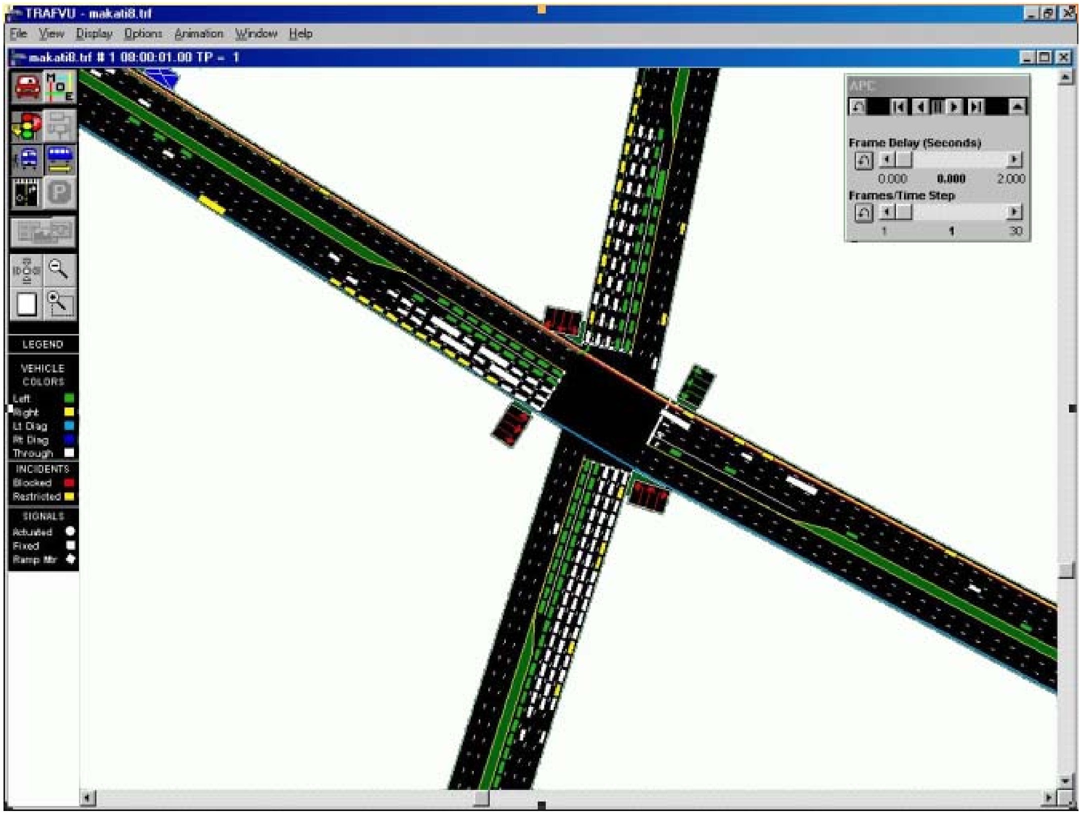
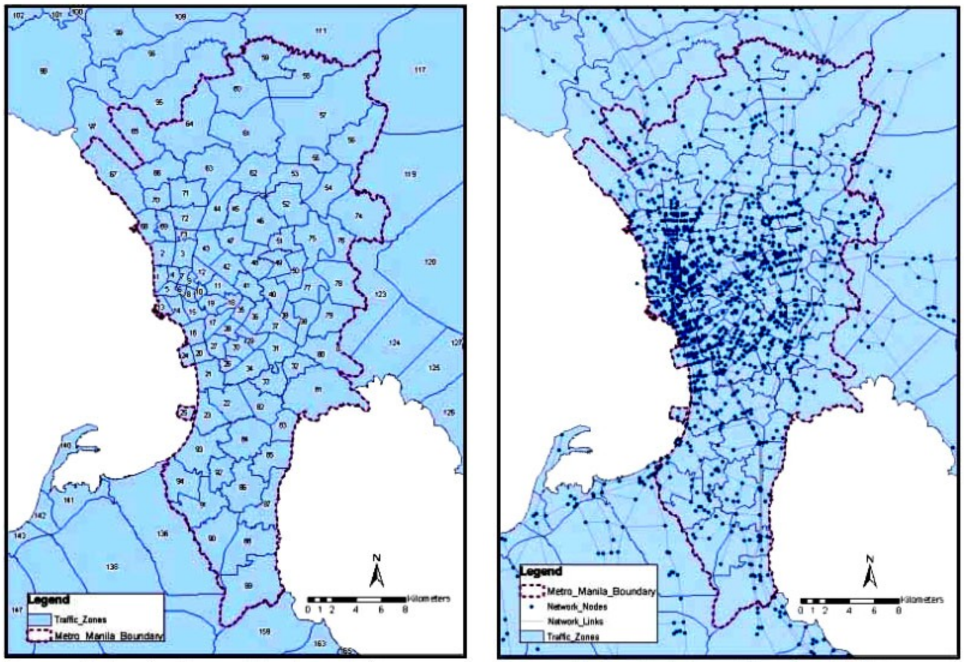


Figure 2. Ayala Avenue-EDSA Flyover

UVVRP and Truck Ban In the analysis of the effects of the two policies, Tiglao, Regidor and Teodoro[7] developed several scenarios involving combinations of the application of the schemes on Metro Manila traffic. These scenarios are given in Table reftable2. Macroscopic simulation was undertaken to evaluate the scenarios listed. This entailed use of the zoning, and link and node systems (primary roads only) developed from the Metro Manila Urban Transportation Integration Study [2], and the JICA STRADA (System for Traffic Demand Analysis) software. The zoning system, and the link and node system were updated to reflect changes since 1999 and are shown in Figure 3. Note that the systems include areas in the periphery of Metro Manila that is now termed as Mega Manila.

3.3. Before and After Studies

U-turn Scheme While it is possible to develop simulation models for U-turn schemes, a more practical approach is by way of before and after studies. It should be emphasized here that this methodology can be done only if data before a certain infrastructure or policy was implemented are available. As such, if traffic is deemed normalized after implementation (i.e., in certain cases this may take anywhere from a few weeks to a few months after implementation), data



(a) Zoning System (b) Link and Node System

Figure 3. Network considered for analyzing impacts of truck ban and UVVRP

collection should be undertaken and before and after studies engaged.

For the example in this paper, only corridor speeds were considered. Safety as well as weaving characteristics was not analyzed although these could easily be derived from a simulation model. Global Positioning System (GPS) units were utilized in the conduct of travel time and delay surveys. These devices recorded time and position allowed for tracing the routes taken by vehicles (public or private). Such data can easily be uploaded to a computer and be processed into spreadsheet and digital map formats. Figure 4 illustrates a typical GPS trace of the route taken by a test vehicle. In this case, the trace is that for Commonwealth Avenue from the U.P. Campus to the Sandiganbayan Complex. Two cases were considered for travel time and delay - Katipunan Avenue and Commonwealth Avenue. Commonwealth represented the first batch of roads along which the U-turn scheme was implemented. Katipunan represented roads where the scheme was applied to more recently, and which met with opposition.

4. ANALYSIS RESULTS

Utilizing the techniques and tools discussed in the preceding sections, the results are shown in the following TablesIII to VI. For Tables III and IV, the values presented were derived from the raw outputs of TRAF-NETSIM. Typical measures or parameters for traffic flow assessment where chosen including person measures of effectiveness, queue statistics, delay statistics, fuel

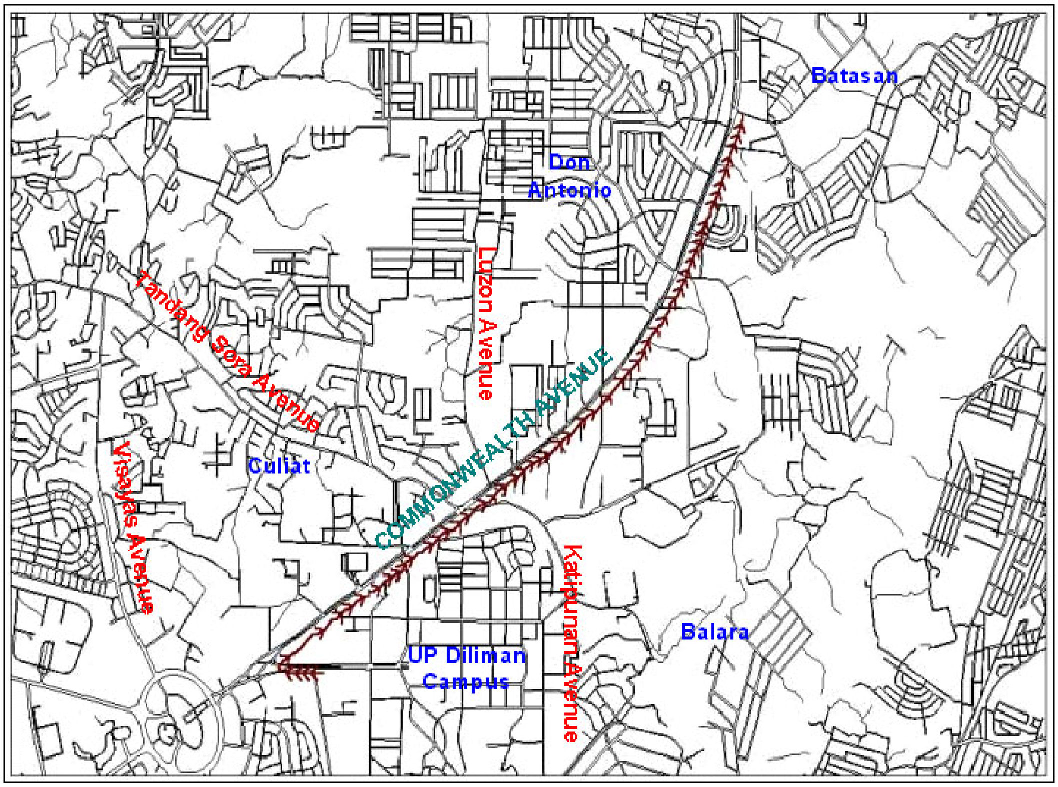


Figure 4. Example trace route of travel time and delay survey

consumption, and emissions. The values for the indicated scenarios and performance indicators in Table 5 were also derived from runs of the STRADA software that simulated flow over the entire network defined in Section 3.2 Values in Table VI are speed estimations from GPS travel time and delay surveys undertaken for the specified thoroughfares.

Tables III and IV show results of simulating traffic flow at the intersection of EDSA and Ayala Avenue for the "'with"' and "'without"' flyover cases, and at the Makati CBD for the "'with"' and "'without"' traffic signals cases, respectively. The percentage difference indicates improvement or deterioration of conditions due to the project. Thus, a positive difference for average speed and a negative value for delay indicated improvement of the situation due to the infrastructure.

The increase in fuel consumption is due mainly to the increase in the number of trips attributed to the improvement of traffic flow. Furthermore, the increase in travel time is consistent with the increase in the number of trips made. Such a result is supported by the decrease in emission levels that indicate vehicles burning fuel more efficiently. Note that CO, HC and NO levels would usually be high when there is congestion (i.e., when vehicles use low gear).

Four performance indicators were selected to reflect the results of macrosimulation for the

Evaluation for: Ayala Flyover	Without Project	With Project	%diff
1. Person Measure of Effectiveness			
-person-trips	26,219.4	30,617.0	+16.77
-delay (person-min)	21,434.2	5,166.7	-75.90
-travel time (person-min)	27,280.6	12,268.8	-55.02
-ave delay per person (min)	0.8	0.2	-79.36
-ave travel time per person (min)	1.0	0.4	-61.49
2. Queue Statistics			
-veh-min queued	16,825.2	3,195.6	-81.01
-veh-min stopped	16,128.3	3,109.9	-80.72
-ave lane occupancy (veh)	390.7	167.4	-57.15
-maximum queue	45	11	-75.56
-number of lane changes	5,435.0	5,043.0	-7.21
3. Delay Statistics			
-ave delay (sec/veh)	3.49	0.65	-81.38
-ave speed (kph)	10.47	28.01	+167.69
4. Fuel Consumption (km/li)	2.33	3.94	+68.94
5. Emissions (grams/km)			
-CO	333.70	295.37	-11.49
-HC	19.30	16.81	-12.93
-NO	42.92	39.88	-7.09

Table III. Comparison of "'with"' and "'without"' cases for EDSA-Ayala Flyover (from Regidor and Felias [5])

UVVRP and Truck Ban evaluation. PCU stands for passenger car unit and PCU-km and PCU-hour the number, lengths and duration of trips in the network. Higher values of PCU-km and PCU-hour indicate lengthier and longer trips (i.e., more delays). the parameter (v/c) is the volume to capacity ratio that shows the level of congestion along roads. Congested roads have high (v/c) with values greater than 1.0 suggesting saturated roads. In this case, only primary roads were included in macrosimulation. Speed here refers to travel speeds along the links representing primary roads throughout the network. Naturally, higher speeds indicate a more efficient system.

The results in Table V indicated that the best scenario is "'Warm-woo."' In this scenario, the UVVRP is implemented with exemptions for trucks. This suggests that the truck ban may be lifted without detrimental effects to traffic flow throughout the whole of Metro Manila. Exemption or exception of trucks from the UVVRP is also suggested. However, note that such results do not have any significant differences with all other results where the UVVRP is recommended. The first four scenarios included implementation of UVVRP while the latter four assumed that the scheme was lifted.

It can be deduced from the results in Table V that the UVVRP is the essential component for

Evaluation for: Ayala Flyover	**Without Project**	**With Project**	**%diff**
1. Person Measure of Effectiveness			
-person-km	10,688.2	46,853.9	+338.37
-person-trips)	27,144.8	120,563.6	+344.15
-delay(person-min)	60,645.1	115.926.9	+91.16
-travel time (person-min)	74,005.6	174,494.3	+135.79
-ave delay per person(min)	2.2	1.0	-56.96
-ave travel time per person (min)	2.7	1.4	-46.91
2. Queue Statistics			
-veh-min queued	101,759.5	16,556.5	-83.73
-veh-min stopped	101.434.8	16,134.8	-84.09
-ave lane occupancy (veh)	63.1	16.7	-73.53
-number of lane changes	3,551.0	9,779.0	+175.39
3. Delay Statistics			
-ave delay (sec/veh)	1246.3	59.5	-95.23
-ave speed (kph)	13.9	15.4	+10.79
4. Fuel Consumption (km/li)	1.50	8.02	+434.67
5. Emissions (grams/km)			
-CO	224.58	123.66	-44.94
-HC	15.09	7.43	-50.76
-NO	20.27	15.88	-21.66

Table IV. Comparison of "‘with"’ and "‘without"’ cases for traffic signals in Makati CBD (from Regidor and Felias [5])

		Performance Indicators		
Scenario	PCU-Km	PCU-Hour	Ave.(v/c)	Ave. Speed
Warm-wwo	103,235,823	5,772,545	1.37	17.9
Warm-www	109,320,939	6,321,806	1.45	17.3
Warm-woo	101,403,987	5,600,466	1.34	18.1
Warm-wow	107,214,900	6,111,919	1.42	17.5
Warm-owo	112,296,224	6,738,602	1.49	16.7
Warm-oww	118,415,082	7,285,708	1.57	16.3
Warm-ooo	110,551,363	6,529,308	1.47	16.9
Warm-oow	116,488,578	7,078,807	1.54	16.5

Table V. Traffic Assignment Modeling Results (from Tiglao, Regidor and Teodoro [7])

Running Speed (kph)		Travel Speed (kph)	
Before	**After**	**Before**	**After**
Katipunan Avenue (A.M. Peak)			
26.27	27.92	24.94	26.07
%Change = +6.28		%Change = +4.53	
Katipunan Avenue (Off Peak)			
24.80	48.17	21.83	47.81
%Change = +94.23		% Change = +119.01	
Commonwealth(A.M. Peak)			
25.73	37.25	17.00	36.06
% change = +44.77		% change = +112.12	

Table VI. Running and travel speeds along Katipunan and Commonwealth Avenues before and after implementation of U-turn scheme

better traffic flow. At the same time, the Truck Ban appears more as an irrelevant or outdated policy. Note that restrictions targeting only trucks (i.e., Warm-oww) present the worst results in terms of (v/c) and average speed over the Mega Manila network. Other scenarios that spare all other vehicles (except trucks) from restrictions did not fare better than all scenarios featuring the implementation of UVVRP.

The (v/c)'s in Table V reflects the overall conditions of major roads during a peak hour simulation of traffic. Minor streets were not included since trucks do not use these roads. Values are generally greater than 1.0 for these roads as congestion due primarily to private vehicles set-in during the simualtion. Excess (v/c) implies that these private vehicles that would otherwise be using secondary roads are loaded unto the model's link and node system.

Travel time and delay surveys using GPS along Katipunan and Commonwealth Avenues confirm the claims of the MMDA that traffic speeds increased with the implementation of the U-turn scheme along these corridors. This increase can be clearly seen from the improvements in travel and running speeds at Katipunan (off-peak) and Commonwealth (morning peak) shown in TableVI. There is only a slight improvement in the speeds during the morning peak along Katipunan Avenue.

5. CONCLUSIONS

In the preceding sections, the impacts of various transportation infrastructure and policies were presented. Impact assessment employed tools like simulation (including scenario building and testing), and conventional approaches like before and after studies. These examples convincingly illustrate the capability and utility of impact assessment techniques and tools, thereby proving their value to engineers, planners and, more importantly, to decision-makers, in general.

The current strategy in formulating and implementing policies on traffic involve direct testing of these schemes on the streets. Oftentimes, these experiments have failed, triggering further experimentation where trials are implemented with adjustments made on the previous configuration or set-up. The results have been a burden to motorists and commuters alike, which are supposed to be the beneficiaries of the improvements claimed for the policies implemented.

Impact evaluation of infrastructure has been conducted by government agencies but using conventional methods like before and after studies. The downside of this practice is that it usually entails analysis over a long period of time (between the before and after stages). In the determination of potential impacts of prospective or proposed projects, there is an urgency to produce assessments both technical and economic to justify the endeavor. It is in the technical (i.e., traffic) assessment where advanced tools like simulation and other software have become more useful and practical than conventional methods. Their efficiency and capabilities have led to their being the preference over conventional approaches including direct experimentation.

Already, agencies like the DPWH, the DOTC and the MMDA have come to realize the value of these techniques and tools. However, much is to be desired in terms of the pace and the effort that has gone into adopting these techniques and skills. There is the perception that not enough resources have been committed to proper utilization of available knowledge and software. The opposite situation also exists where the rush in using tools has translated into dubious models and faulty analytical results due to haphazard methodology. Thus, it is important for agencies representing the decision-makers for infrastructure and policies to fully appreciate the value and potential of advanced techniques and tools. This appreciation should lead to the realization of and commitment to investing resources for effective and efficient impact assessment.

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