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CO-BENEFIT ASSESSMENT OF LOGISTICS OPTIMIZATION PROGRAMS: THE CASE OF THE PHILIPPINE GREATER CAPITAL REGION

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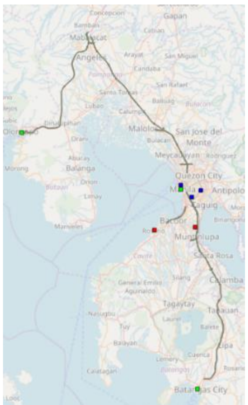
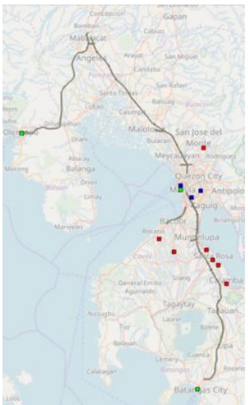
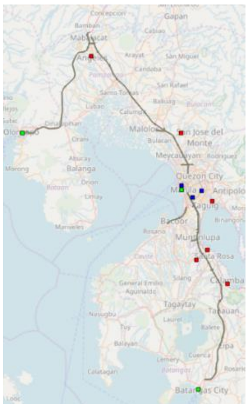
ABSTRACT: In recognition of the impact of logistics sprawl on economic development, there arises a need to find the optimum direction in freight transport development. This paper employs the co-benefit framework to assess three freight development programs: a) Freight consolidation centers; b) Freight volume shift to outer ports and c) Rail freight. Using the benefits of travel time reduction, operating cost reduction and savings in accident losses and CO_2, SOx, NOx, and PM emissions as assessment metrics, the policy assessment procedure undertaken was able to cover the interests of both the stakeholders and the community. It was found that for the Greater Capital Region of the Philippines, shifting freight traffic to the outer ports while consolidating truck trips at designated locations was most effective, resulting to a combined annual benefit of as much as PhP 362.72 billion by the year 2050. Modeling results showed that shifting freight traffic to the outer ports dramatically reduces travel time, while consolidation of truck trips optimizes freight operations, and thus, reduces emissions. It was also found that this combination has a profound relationship, emphasized by the traffic safety benefit.

Keywords: Logistics Sprawl, Urban Freight, Accident, Emission, Policy Evaluation

1. INTRODUCTION

The relocation of logistics and transport companies towards the periphery of the cities, referred to as logistics sprawl [1], is critical to sustaining the growth of developing countries. With the mismatch in truck activity level and local road suitability, an extension of urban area boundaries, increased distance traveled by trucks [2], not only does it damage the economy in the form of reduced operation efficiency, its negative environmental impacts are also detrimental to the well-being of the public. Dablanc and Rakotonarivo [3] discussed its impact on CO_2 emissions while Segalou et al. [4] pointed out how trucks contribute significantly to CO_2, SOx, NOx, and particulate matter (PM) concentrations. Recognizing this substantial association, Sundo et al. [5] used energy demand and CO_2 emissions in the assessment of various low-carbon policy scenarios for inter-regional road transport. With this established relationship, it follows that addressing logistics sprawl would result to the improvement of public health, as well as operational savings for urban freight companies.

Table 1 Spatial Distribution of Manufacturing SEZs, Ports, and CBDs

1975 – 1984		1985 – 1994		1995 – 2004		2005 – 2014	
							
Legend: - Manufacturing SEZs; - Ports; - Central Business Districts; - Highways							
No. of new SEZs:	3	No. of new SEZ:	9	No. of new SEZs:	21	No. of new SEZs:	16
Ave. distance to Metro Manila [km]:	26.05	Ave. distance to Metro Manila [km]:	56.31	Ave. distance to Metro Manila [km]:	50.21	Ave. distance to Metro Manila [km]:	91.66

In a survey conducted on shippers operating in the Philippine metropolitan region, 16 out of 17 are in the manufacturing business [6]. Within the Philippine Greater Capital Region (GCR), over 74% of manufacturing companies operate inside Special Economic Zones (SEZs), where the majority of urban freight traffic comes from and/or goes to. SEZs are locations that attract manufacturing companies through offering fiscal incentives such as a reduction in taxes from 30% [7] to only 5% [8]. Based on the centrifugation of SEZs over the years, shown in Table 1, the logistics sprawl phenomenon was found to be evident in the Philippine GCR.

Considering its potential to hamper economic development, logistics sprawl should be addressed effectively, especially for developing countries like the Philippines. Under the Philippine Institute for Development Studies (PIDS), Patalinghug et al. [6] conducted a system-wide study of the logistics industry in the Philippine GCR. However, assessment of the freight transport modeling scenarios was limited to basic transport metrics (e.g. travel speed, vehicle-kilometers, vehicle-hours). With the strong relationship between transportation and health, a more holistic approach is necessary.

Kwan et al. [9] assessed the carbon savings and health co-benefits of the introduction of the mass rapid transit system in Greater Kuala Lumpur, Malaysia. Shaw et al. [10], on the other hand, examined the impact of fuel price changes in transport-related air pollutants. Alam et al. [11] analyzed the co-benefits of transport fleet and fuel policies in reducing emissions. These papers employed the co-benefit framework to assess transport projects and policies in a way that takes not just the transport industry, but also the environment into consideration. In this paper, several logistics optimization programs were assessed against various co-benefit metrics for the GCR freight transport industry into the future.

By incorporating the benefits of travel time and operating cost reduction with the primary co-benefits of savings in accident losses and CO_2, SOx, NOx, and PM emissions, the policy assessment procedure undertaken was able to cover the interests of both the stakeholders and the community. By capturing more than just the basic traffic characteristics, the method employed made for an all-inclusive long-term assessment to determine the optimum development roadmap that caters to improving freight transport operation efficiency without sacrificing the well-being of the public.

The next section introduces the development programs modeled. Section 3 provides a discussion on the Co-Benefit framework on the estimation of benefits from reductions in travel time, operating cost, accident, and emission cost, while Section 4 contains the modeling methodology and results. Section 5 presents the conclusions and recommendations for future research.

2. LOGISTICS OPTIMIZATION PROGRAM

Numerous studies have proposed various measures to address logistics sprawl. Sakai et al. [12] discussed how an increase in average shipment load and efficient spatial distribution of logistics facilities can offset the negative effects of logistics sprawl. This is in line with the proposition of Olsson and Woxenius [13], where goods can be consolidated at freight consolidation centers (FCCs), combining goods having the same target destinations into one large delivery using high-load vehicles. Possible locations of these facilities could be those proposed by JICA [14] to be developed as regional and sub-regional centers, encouraging a shift to polycentrism.

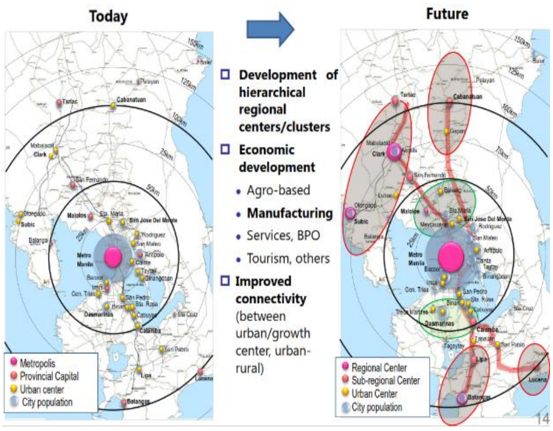


Fig.1 Proposed Spatial Reorganization [14]

In this approach, shippers incur savings from paying only for the space taken up, while everybody else benefits from the reduction in total truck distances traveled and the consequent emissions. However, consolidated shipments can take more time because of the added steps (e.g. consolidation and deconsolidation). With the existing truck ban on Metro Manila roads from 6:00 AM to 10:00 AM and from 5:00 PM to 10:00 PM, time is a critical factor to be considered. In addition, there are also additional costs for infrastructure and the processes involved. Furthermore, there is a risk of increasing truck distances when truck trips are split into three: 1) Origin-to-FCC; 2) FCC-to-FCC, and 3) FCC-to-Destination. It is with these constraints that the authors would like to note that the viability of the use of FCCs depends on a highly substantial volume of freight cargo to be consolidated, to offset the additional costs with the projected savings.

Another option by which travel distances can be reduced is by encouraging the use of the ports outside Metro Manila. Subic and Batangas ports, are gravely underutilized, carrying around 40 thousand and 20 thousand 20-foot equivalent units (TEUs), respectively, corresponding to only 6% and 8% utilization rate of port capacity [15]. Even when approximately 47% of the 45 thousand peak hour truck trips come from and go to areas outside Metro Manila [14], approximately 76% of the shippers still use the Manila ports [6], reportedly having a combined throughput of 3.7 million TEUs and operating at almost 78% utilization rate [15]. Patalinghug et al. [6] enumerate the availability of shipping lines, accessibility with fewer costs and cheaper rates, and location of the port being nearer to the consignee, importers, and warehouses as some of the reasons for shippers' patronage of Manila ports.

Fig. 2 Location of (A) Subic and (B) Batangas Ports

Patalinghug et al. [6] continue that to encourage a shift, a combination of fines and price discounts policy and volume restriction policy must be employed to decongest the Manila ports while also improving the utilization of Subic and Batangas ports. The authors noted that if the pricing incentives do not compensate for the non-price service attributes of the Manila ports, diversion of freight traffic is not likely to materialize. An extensive quantity restriction, on the other hand, may pose congestion problems on the outer ports. It is with these limitations that the authors would like to establish that for the port volume shift (PVS) should come with a systematic incentive framework grounded on projected diverted demand, as well as capacity enhancement policies covering additional customs personnel, cargo handling equipment, and berth and container yard capacities.

Still another possible direction for development is the revival of the existing rail network and using some of its stations as Rail Freight Stations (RFS). Currently, the Philippine National Railway (PNR) is operating as a commuter transit service plying across Metro Manila through to regions to the south [16]. In the past, the PNR also serviced the provinces north of Metro Manila. In consideration of the PNR passenger service, rail freight operations can be limited at night at the onset of railway use for freight transport. However, with the gradual rehabilitation of the PNR lines and much-needed upgrade on the signaling system of the PNR system, a workable arrangement allowing for freight transport by rail to operate hand in hand with passenger transport can be implemented.

Source: Google Images

Fig. 3 PNR Network

Although Patalinghug et al. [6] suggest that rail freight may not provide a significant impact on the improvement of traffic conditions, the utilization of the PNR network for freight operations can certainly alleviate the road congestion attributed to the trucks that would have otherwise plied the city roads. By plying on its own designated space, the impacts of freight vehicles to both private car and public transit users can be kept to a minimum. Furthermore, it can serve as an alternative for shippers to transport their goods while bypassing the brunt of Metro Manila traffic. However, like the FCC scenario, the splitting of truck trips could also pose additional truck distance traveled and risk of accidents. It is within these confines that the authors would like to move forward with the railway freight development option, provided that the development of inland container yards or depots at strategic locations along the PNR line are also on the page.

3. CO-BENEFIT FRAMEWORK

Assessment of transport infrastructure programs has gone beyond traffic system characteristics. As sustainability has been growing in significance, the environmental impacts of various development programs have also been considered in policy evaluation. Ma et al. [17], Xia [18] and Roxas and Fillone [19] employed co-benefits analysis to reconcile environmental and developmental goals. Mayrhofer and Gupta [20] accredits the co-benefits approach as a positive and constructive "win-win" way to operationalize how economic, environmental, and social aspects can be integrated within the concept of sustainable development, instead of framing them in terms of trade-offs.

Endorsed by the Institute for Global Environmental Strategies (IGES), the use of co-benefits analysis maximizes the intended impacts of a policy at reduced overall costs through integration of multiple objectives. For this paper, the benefits of travel time and operating cost reduction are incorporated with the primary co-benefit of savings in accident losses and CO_2, SOx, NOx, and PM emissions. The benefit of travel time saving is the difference between the travel time costs “with” and “without” the transport project, while the benefit of travel operating cost savings is the difference between the vehicle operating costs between the two scenarios, computed as follows:

$$BT_i = \sum_j \sum_l \left(Q_{ijl} * T_l * \alpha_j\right) * 365 \tag{1}$$

$$BR_i = \sum_j \sum_l \left(Q_{ijl} * L_l * \beta_j\right) * 365 \tag{2}$$

where BT_i is the total travel time cost per year, Q_{ijl} is the traffic volume for j vehicle type on link l, T_l is the average travel time on link l, and α_j is the value of time for j vehicle type, BR_i is the total vehicle operating cost per year, L_l is the length of link l, and β_j is the value of operating cost for j vehicle type.

Traffic safety benefits are calculated from the change in occurrence rate of accidents and damages incurred “with” and “without” the transport project. The total traffic accident loss in a road network is the sum of the loss at each link, calculated according to road type, roadside type, and road structure. The total traffic safety benefit is the change in total damage cost, computed as follows:

$$BA = \sum_l (Y + Z)_{l,o} - \sum_l (Y + Z)_{l,w} \tag{3}$$

$$Y = \begin{cases} for\ 2-lane\ road, & 22.52X_1 + 5.55X_2 \\ for\ 4\ lanes\ or\ more, & \begin{matrix} W/o\ median, & 20.95X_1 + 5.55X_2 \\ W/\ median\ strip, & 17.80X_1 + 5.55X_2 \end{matrix} \end{cases} \tag{4}$$

where BA is the total traffic safety benefit, $Y_{l,o}$ is the accident loss at link without project per year, $Y_{l,w}$ is the accident loss at link with project per year, X_1 is the daily vehicle-kilometer on link l with/without project, and X_2 is the daily number of traffic volume multiplied by the number of intersections on link l with/without project.

The cost of a human accident, on the other hand, is calculated using the average damage cost of a human accident, shown in Table 2. The number of accidents is estimated as follows:

$$Z_1 = \begin{cases} for\ 2-lane\ road, & 0.38X_1 \\ for\ 4\ lanes\ or\ more, & \begin{matrix} W/0\ median, & 0.34X_1 \\ W/\ median\ strip, & 0.29X_1 \end{matrix} \end{cases} \tag{5}$$

$$Z_2 = 0.09X_2 \tag{6}$$

where Z_1 is the number of accidents along the road section per year, and Z_2 is the number of traffic accidents at the intersection per year.

Table 2 Average Damage Cost of Human Accident

Type of Road	Average Damage Cost [21] (in thousand USD)		Cost in 2017 (in million PhP)	
	Road Section	Inter-section	Road Section	Inter-section
2-lane	59.16	61.70	4.08	4.25
4 lanes or more	61.50	61.50	4.24	4.24

Environmental cost savings are estimated from the reduction in emissions, monetized using marginal costs per air pollutant shown in Table 3. In this paper, the overall total savings serves as the assessment metric.

Table 3 Marginal Costs of Various Air Emissions

	Marginal Cost (in thousand US/ton)	Cost in 2017 (PhP/kg)
CO_2	0.085 [22]	5.30
SOx	0.46 [21]	39.88
NOx	22.90-28.82 [21]	2241.72
PM	72.04 [21]	6244.90

4. POLICY SCENARIO MODELING

This paper uses the 2012 truck origin-destination (OD) matrix from the Metro Manila Urban Transportation Integration Study Update and Capacity Enhancement Project (MUCEP) of JICA [14]. This matrix was estimated using OD interview surveys of freight vehicle drivers conducted at 20 survey stations along the outer cordon line set-up at the boundaries of the GCR. Standard traffic assignment was performed using the EMME4 transport modeling software to establish base conditions. Peak hour truck trips were assigned on top of off-peak public and private trips as trucks can only ply Metro Manila roads during off-peak periods due to the current truck ban. The OD matrix used in the BASE scenario was calibrated with 2017 truck counts at 7 locations where freight traffic passes through. Table 4 summarizes the combinations of development programs modeled as scenarios.

Table 4 Modeling Scenario Combination

	BASE	A	B	C	D	E	F	G
FCC		■		■		■		■
PVS			■	■			■	■
RFS					■	■	■	■
*Legend:	■	- Included						

In the FCC scenario, a total of 8 consolidation centers were set up at the proposed regional and sub-regional centers specified in the JICA (2014) study while another 7 consolidation centers were set up at the periphery of the metropolitan area. As for the PVS scenario, to limit the Manila ports to only 1 million TEUs, 73% of the trips to and from Manila ports are diverted to Subic or Batangas ports, whichever is nearer. Lastly, a total of 11 stations along the PNR line were set up with freight cargo handling facilities for the RFS scenario. Truck trips with origin and destination zones within 10 km from a designation rail freight station were merged at the nearest RFS.

Table 5 shows a summary of the truck distance traveled (TDT), truck vehicle hours traveled, (THT), average speed, and rail distance traveled (RDT) and rail hours traveled (RHT) for the RFS scenarios, for the base year 2017 and for 2030, 2040, and 2050 projections. Looking the values, the behavior of the results of all scenarios are quite similar. However, when looking at the percentage change of TDT and THT against the BASE scenario, corresponding to Fig. 4 and Fig. 5, respectively, Scenarios E, G, and A can be identified to show a greater reduction in TDT while Scenarios G, C, and F are those for THT. Additionally, applying the FCC and PVS scenarios on top of the RFS scenario correspond to reductions in RDT and RHT. These, however, are insufficient in determining the optimum development scenario. For example, Scenario E resulted in the biggest reduction in TDT but ranks 5th in that of THT. On the other hand, Scenario F was found to provide a notable reduction in THT but results to an increase in TDT.

5. BENEFIT AND PRIMARY CO-BENEFIT ESTIMATION

The unit value of time used in the estimation of the benefit of travel time reduction was taken from JICA [23], while vehicle operating cost factors from Metro Manila Urban Transportation Integration Study (MMUTIS) [24] were used to estimate that of operating cost reduction. Traffic safety benefit was calculated using factors from Table 2. Emission factors were taken from IGES [21] while monetary

Table 5 Traffic Modeling Results

		BASE	A	B	C	D	E	F	G
2017	TDT (thousand km)	829.64	795.04	860.69	805.18	811.45	773.79	847.69	790.39
	THT (thousand hr)	178.18	177.80	170.11	160.57	174.64	173.31	168.24	158.61
	SPEED (km/hr)	34.96	34.85	35.06	35.12	35.05	34.92	35.12	35.13
	RDT (thousand km)	-	-	-	-	3.99	3.83	3.42	3.19
	RHT (thousand hr)	-	-	-	-	0.07	0.06	0.06	0.05
2030	TDT (thousand km)	1,080.61	1,029.10	1,122.30	1,037.77	1,052.61	1,006.04	1,101.78	1,020.69
	THT (thousand hr)	489.12	486.49	467.08	439.29	478.99	476.34	461.19	435.40
	SPEED (km/hr)	30.29	30.19	30.51	30.44	30.44	30.33	30.51	30.47
	RDT (thousand km)	-	-	-	-	4.66	4.45	4.00	3.69
	RHT (thousand hr)	-	-	-	-	0.08	0.07	0.07	0.06
2040	TDT (thousand km)	1,194.33	1,137.17	1,243.94	1,150.75	1,154.59	1,102.51	1,226.50	1,139.85
	THT (thousand hr)	883.15	880.18	844.41	797.22	867.16	862.32	833.36	788.67
	SPEED (km/hr)	27.63	27.52	27.76	27.81	27.74	27.61	27.79	27.83
	RDT (thousand km)	-	-	-	-	5.09	4.85	4.25	3.91
	RHT (thousand hr)	-	-	-	-	0.08	0.08	0.07	0.07
2050	TDT (thousand km)	1,224.34	1,171.87	1,288.61	1,196.72	1,199.58	1,141.92	1,278.22	1,173.32
	THT (thousand hr)	1,249.01	1,244.50	1,192.35	1,131.44	1,229.26	1,224.99	1,183.50	1,117.86
	SPEED (km/hr)	26.10	26.05	26.11	26.33	26.21	26.07	26.27	26.33
	RDT (thousand km)	-	-	-	-	5.23	4.99	4.40	4.05
	RHT (thousand hr)	-	-	-	-	0.09	0.08	0.07	0.07

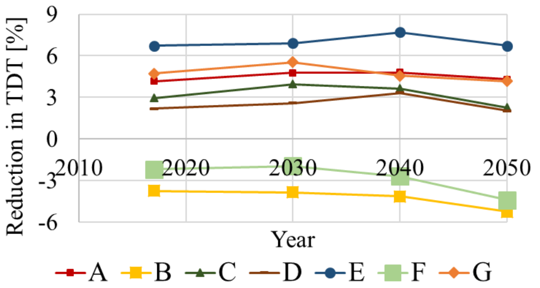


Fig. 4 Reduction in Truck Distance Travelled

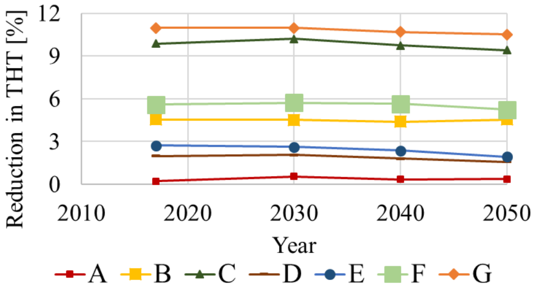


Fig. 5 Reduction in Truck Hours Travelled

value of the reduction in emissions was estimated using factors from Table 3. All factors were projected to modeling years 2017, 2030, 2040, and 2050 using a 5% annual inflation rate. Table 6 shows the estimated benefits of the various modeling scenarios while Table 7 shows its summary.

Looking at the scenarios including only one development program (Scenarios A, B, and D), it was found that scenario A resulted to the biggest emission cost reduction, while scenario B held that for travel time reduction. As for operating cost reduction, the 3 scenarios have similar values, with scenario B having a slight edge. However, scenario B is shown to have resulted in an increase in emission costs. This can be attributed to the negative values for a reduction in TDT shown in Fig. 4. Fortunately, this was compensated for by the benefit of travel time and operating cost reduction, which resulted in a net benefit of PhP 4.65 B in the base year. As for the traffic safety benefit, it shows that all three scenarios resulted in higher accident losses, with scenario D far ahead at over PhP 5.10 B in the base year. This can be attributed to the additional truck volume as truck trips were split in going to and from the RFSs.

Moreover, looking at the various combinations, some of the development programs were found to go well together. For example, despite scenario C simply being a combination of scenarios A and B, the estimated benefits are more than just the individual sums. This effect is even more profoundly emphasized in the estimated traffic safety benefit. This shows that there is an intermediate benefit when the FCC and PVS scenarios are pursued together. This, however, cannot be said for scenario F (i.e. a combination of scenarios B and D). Despite a benefit of PhP 4.65 B and a loss of PhP 1.24 B for scenarios B and D, respectively, scenario F's resulting benefit of PhP 2.34 B it is even lower than the sum of the two. This shows that there is an underlying conflict between the PVS and RFS development programs.

Table 6 Estimated Benefits (Million PhP / Year)

		A	B	C	D	E	F	G
2017	Travel Time Benefit	205.66	4,367.88	9,531.41	1,916.04	2,635.89	5,380.02	10,592.26
	Operating Cost Benefit	1,060.22	1,650.22	6,108.63	1,589.64	3,027.32	2,581.64	7,116.28
	Traffic Safety Benefit	(273.67)	(781.20)	3,425.82	(5,103.85)	(4,944.32)	(5,297.06)	(549.07)
	Traffic Accident Loss	(116.63)	(329.65)	1,448.45	(2,159.31)	(2,092.78)	(2,240.12)	(233.24)
	Human Accident Damage	(157.04)	(451.55)	1,977.37	(2,944.54)	(2,851.54)	(3,056.94)	(315.83)
	Environmental Benefit	650.55	(582.95)	481.16	355.28	1,062.38	(329.34)	764.03
	CO_2	164.74	(147.65)	120.98	89.43	268.53	(83.80)	192.42
	SOx	0.05	(0.05)	0.04	0.03	0.08	(0.03)	0.06
	NOx	371.54	(332.75)	279.39	205.77	609.40	(185.92)	441.98
	PM	114.22	(102.50)	80.75	60.05	184.37	(59.59)	129.57
2030	Travel Time Reduction	2,684.34	22,495.29	50,859.35	10,339.28	13,044.01	28,506.96	54,829.71
	Operating Cost Reduction	2,216.51	5,681.04	16,566.34	3,893.08	5,982.01	8,059.03	18,230.53
	Traffic Safety Benefit	1.09	(1,271.58)	4,227.61	(5,794.80)	(5,447.66)	(6,412.20)	(411.40)
	Traffic Accident Loss	16.08	(536.81)	1,787.13	(2,451.82)	(2,306.16)	(2,711.73)	(175.53)
	Human Accident Damage	25.01	(734.77)	2,440.48	(3,342.98)	(3,141.50)	(3,700.47)	(235.87)
	Environmental Benefit	1,909.38	(1,462.14)	1,710.70	1,146.67	2,860.41	(682.95)	2,375.46
	CO_2	481.37	(369.66)	429.74	287.71	719.92	(173.46)	596.93
	SOx	0.15	(0.12)	0.12	0.08	0.21	(0.06)	0.17
	NOx	1,107.22	(832.85)	1,014.17	684.58	1,676.09	(377.65)	1,405.37
	PM	320.64	(259.51)	266.67	174.30	464.19	(131.78)	372.99
2040	Travel Time Reduction	4,937.78	64,407.35	142,863.27	26,584.25	34,630.99	82,778.56	157,078.09
	Operating Cost Reduction	2,475.58	10,630.27	27,742.22	6,023.63	8,939.94	14,518.27	30,675.06
	Traffic Safety Benefit	108.47	(1,706.51)	4,319.06	(6,042.77)	(5,601.97)	(7,376.87)	(878.04)
	Traffic Accident Loss	44.44	(720.57)	1,825.80	(2,557.00)	(2,371.86)	(3,119.49)	(372.77)
	Human Accident Damage	64.03	(985.94)	2,493.26	(3,485.77)	(3,230.11)	(4,257.38)	(505.27)
	Environmental Benefit	3,568.25	(3,052.92)	2,971.15	2,658.09	5,880.15	(1,903.98)	3,688.62
	CO_2	898.11	(768.94)	744.77	666.87	1,478.20	(480.49)	924.90
	SOx	0.26	(0.23)	0.20	0.18	0.42	(0.15)	0.25
	NOx	2,090.30	(1,780.72)	1,784.29	1,588.09	3,470.51	(1,097.15)	2,211.06
	PM	579.58	(503.03)	441.89	402.95	931.02	(326.19)	552.41
2050	Travel Time Reduction	12,213.66	153,442.77	318,395.12	53,485.63	65,049.34	177,409.76	355,171.56
	Operating Cost Reduction	2,823.88	15,773.20	37,084.71	6,776.88	9,669.52	18,787.35	41,909.93
	Traffic Safety Benefit	(87.91)	(2,257.57)	3,923.73	(6,796.59)	(6,268.50)	(8,429.19)	(1,256.25)
	Traffic Accident Loss	(38.51)	(953.30)	1,658.98	(2,875.48)	(2,653.56)	(3,564.06)	(532.66)
	Human Accident Damage	(49.40)	(1,304.27)	2,264.75	(3,921.11)	(3,614.94)	(4,865.13)	(723.59)
	Environmental Benefit	5,519.66	(6,840.44)	3,318.62	2,820.06	8,748.27	(5,455.93)	5,808.22
	CO_2	1,387.02	(1,717.99)	829.07	706.11	2,197.42	(1,373.50)	1,454.35
	SOx	0.40	(0.48)	0.21	0.19	0.62	(0.41)	0.38
	NOx	3,265.62	(4,060.46)	2,033.16	1,704.81	5,188.94	(3,192.11)	3,510.82
	PM	866.62	(1,061.51)	456.18	408.95	1,361.29	(889.91)	842.67

Finally, looking at the overall estimated benefits, scenario G (i.e. a combination of all 3 development programs) still resulted in the biggest reduction in all metrics except the traffic safety benefit. This shows that despite the RFS scenario having compatibility issues with the PVS scenario, its inclusion still results to an eventual increase in net benefits. Though slightly behind scenario C in the base year, the trend in Table 7 shows that the RFS development program will continue to have a net positive benefit into the future. However, when the constraints on time and resources are considered, the combination of the FCC and PVS programs would be the optimum development roadmap to move forward with.

Table 7 Summary of Benefits (Billion PhP / Year)

Scenario	2017	2030	2040	2050
A	1.64	6.85	11.09	20.47
B	4.65	25.44	70.28	160.12
C	19.55	73.36	177.90	362.72
D	-1.24	9.58	29.22	56.29
E	1.78	16.44	43.85	77.20
F	2.34	29.47	88.02	182.31
G	17.92	75.02	190.56	401.63

6. CONCLUSIONS & RECOMMENDATIONS

In this paper, various freight transport development programs were assessed through the co-benefits approach, using the reduction in travel time, operating cost, accident cost, and emission cost as assessment metrics. With this, a more holistic approach to policy assessment was performed by considering more than the measures directly attributed to the transport sector. By incorporating its impact on the community, the optimum development roadmap that caters to the interests of both the freight transport sector and the society was identified. It was found that when it comes to travel time reduction, shifting of freight volume to the outer ports is most effective. On the other hand, for the emission cost reduction, the use of freight consolidation centers proved to be most efficient. As for the operating cost reduction, the use of railway freight had comparable results with the two previously mentioned programs.

It was also found that as the volume of freight traffic grew into the future, the increase in emission costs under the PVS scenario was eventually compensated for by the benefits in travel time and operating cost reduction. This shows how even when shippers were forced to travel farther distances, the travel time savings incurred from avoiding Metro Manila traffic ultimately outweigh the additional costs of traveling to the outer ports. This tradeoff is one that the port authorities can consider when designing an incentive system for the Batangas and Subic ports.

Lastly, it was found that the use of FCCs on top of the PVS program resulted in even greater benefits. With this, the authors would like to recommend that for the Philippine GCR, the optimum development roadmap should be a combination of the PVS and FCC programs, where the PVS primarily reduces the travel time while the FCC optimizes freight operations and thus, reduces emissions. This combination would effectively address the negative impacts of logistics sprawl on both freight industry and public health.

The authors, however, would like to acknowledge that the assessment procedure conducted for this paper was limited to the co-benefit framework. With sustainability continuing to grow in significance in policy evaluation, resilience metrics can be some of the factors that can be looked into. The authors, thus, recognize this as an avenue for future research. Also, while three development freight development policies and its various combinations were assessed in this paper, the authors would like to acknowledge that some other development options outside of those covered in this paper may be found to be more effective in optimizing logistics operations into the future. It is, therefore, recommended to continue exploring other freight development policies employed elsewhere to see its applicability in the local setting.

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8. REFERENCES

[1] Gupta, S. and Garima, Logistics sprawl in timber markets and its impact on freight distribution patterns in the metropolitan city of Delhi, India. Transportation Research Procedia, Issue 25, 2017, 965-977.

[2] Aljohani, K. and Thompson, R., Impacts of logistics sprawl on the urban environment and logistics: Taxonomy and review of the literature. Journal of Transport Geography, Issue 57, 2016, 255-263.

[3] Dablanc, L. and Rakotonarivo, D., The impacts of logistics sprawl: How does the location of parcel transport terminals affect the energy efficiency of goods' movement in Paris and what can we do about it? Social and Behavioral Sciences Procedia, Vol. 2, Issue 3, 2010, 6087-6096.

[4] Segalou, E., Ambrosini, C., and Routhier, J., The environmental assessment of urban goods movement. In Taniguchi, E., and Thomson, R., Proceedings of the 3rd International Conference on City Logistics, 2003, 215-228.
[5] Sundo, M., Vergel, K., Sigua, R., and Regidor, J., Methods of estimating energy demand and CO2 emissions for inter-regional road transport. International Journal of GEOMATE, Vol. 11, Issue 23, 2016, 2182-2187.
[6] Patalinghug, E., Llanto, G., Fillone, A., Tiglao, N., Salazar, C., Madriaga, C., and Arbo, M., A system-wide study of the logistics industry in the greater capital region, 2015. Retrieved from: https://dirp3.pids.gov.ph/webportal/CDN/PUBLICATIONS/pidsdps1524.pdf.
[7] Bureau of Internal Revenue, National internal revenue code, 1997. Retrieved from: https://www.bir.gov.ph/index.PhP/tax-code.html.
[8] Republic Act No. 7916, The special economic zone act of 1995, 1995. Retrieved from: http://www.peza.gov.ph/index.PhP/about-peza/special-economic-zone-act.
[9] Kwan, S., Tainio, M., Woodcock, J., Sutan, R., and Hashim, J., The carbon savings and health co-benefits from the introduction of the mass rapid transit system in Greater Kuala Lumpur, Malaysia. Journal of Transport & Health, Issue 6, 2017, 187-200.
[10] Shaw, C., Hales, S., Edwards, R., Howden-Chapman, P., and Stanley, J., What can fuel price increases tell us about the air pollution health co-benefits of a carbon price. Journal of Transport & Health, 2017. Advanced online publication. doi: 10.1016/j.jth.2017.11.002
[11] Alam, M., Hyde, B., Duffy, P., and McNabola, A., Analysing the co-benefits of transport fleet and fuel policies in PM2.5 and CO2 emissions. Journal of Cleaner Production, Issue 172, 2018, 623-634.
[12] Sakai, T., Kawamura, K., and Hyodo, T., Spatial reorganization of the urban logistics system and its impacts: Case of Tokyo. Journal of Transport Geography, Issue 60, 2017, 110-118.
[13] Olsson, J. and Woxenius, J., Localisation of freight consolidation centers serving small road hauliers in a wider urban area: barriers for more efficient freight deliveries in Gothenburg. Journal of Transport Geography, Issue 34, 2014, 25-33.
[14] Japan International Cooperation Agency, Roadmap for transport infrastructure development for Metro Manila and its surrounding areas (Region III and Region IV-A), 2014. Retrieved from: http://www.neda.gov.ph/wp-content/uploads/2015/03/FR-SUMMARY.-12149597.pdf
[15] National Economic and Development Authority, Aide Memoir, November 14, 2014.
[16] Philippine National Railways. Corporate Profile, n.d. Retrieved from: http://www.pnr.gov.ph/about-contact-us/who-we-are/corporate-profile.
[17] Ma, Z., Xue, B., Geng, Y., Ren, W., Fujita, T., Zhang, Z., Puppim de Oliveira, J., Jacques, D., and Xi, F., Co-benefits analysis on climate change and environmental effects of wind-power: A case study from Xinjiang, China. Renewable Energy, Issue 57, 2013, 35-42.
[18] Xia, T., A co-benefit analysis of alternative transportation in Adelaide, Australia: Integrating perspectives from communities and stakeholders for sustainable change (PhD thesis). University of Adelaide, Adelaide Australia, 2015.
[19] Roxas, N., Jr., and Fillone, A., Co-benefit analysis of the proposed Panay-Guimaras-Negros bridge project, Westerjn Visayas, Philippines. Transportation Research Procedia, Issue 25, 2017, 3564-3577.
[20] Mayrhofer, J. and Gupta, J., The science and politics of co-benefits in climate policy. Environmental Science and Policy, Issue 57, 2015, 22-30.
[21] Institute for Global Environment Strategies, Mainstreaming transport co-benefits approach: A guide to evaluating transport projects, Kanagawa, Japan: Institute for Global Environment Strategies, 2011.
[22] Clean Air Initiative for Asian Cities Center., Co-benefits calculator for transport projects, 2008. s.l.:s.n.
[23] Japan International Cooperation Agency, Master plan study on high standard highway network development in the Philippines, Metro Manila: CTI Engineering International, 2010.
[24] ALMEC Corporation, Pacific Consultants International, and Yachiyo Engineering Co., Ltd., Metro Manila urban transportation integration study, Metro Manila: Japan International Cooperation Agency, 1999.

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