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ORIGINAL

Social and financial impact of urban mass transportation

Impacto social y financiero del transporte masivo urbano

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ABSTRACT

Introduction: they studied urban mobility as an essential element for the development of contemporary cities. They recognized that efficient, sustainable and cost-effective public transport is key to improving quality of life and economic growth. They considered that economics applied to transportation allowed understanding and optimizing resources, guiding decisions towards collective welfare. Within this framework, they analyzed the BRT (Bus Rapid Transit) system, taking as an example the Macrobús in Guadalajara.
Development: they applied economic principles such as increasing and decreasing returns, common and joint costs, and economies of scale and scope. Through these concepts, they evaluated the economic impacts of the BRT system. They identified that they achieved significant operational savings through substitution of conventional units, automation of fare collection and reduction of pollutant emissions. They estimated more than 8 billion pesos in operational savings over 20 years, 312 million pesos for reduced revenue losses and 96 million pesos for reduction of pollutants. They also evaluated travel time savings as a significant social benefit. They determined that the improvement in travel speed allowed users to use their time for other productive or personal activities. In addition, they noted that the BRT business organization replaced the man-truck model, allowing for a more efficient and safer operation.
Conclusions: they concluded that the BRT system represented an integral solution for urban mobility. Through planning based on sound economic principles, they were able to improve operational efficiency, reduce environmental impacts and promote more equitable and sustainable urban development.

Keywords: Urban Mobility; Public Transportation; Applied Economics; BRT System; Operational Savings.

RESUMEN

Introducción: estudiaron la movilidad urbana como un elemento esencial para el desarrollo de las ciudades contemporáneas. Reconocieron que el transporte público eficiente, sostenible y rentable es clave para mejorar la calidad de vida y el crecimiento económico. Consideraron que la economía aplicada al transporte permitía entender y optimizar los recursos, orientando las decisiones hacia el bienestar colectivo. En ese marco, analizaron el sistema BRT (Bus Rapid Transit), tomando como ejemplo el Macrobús en Guadalajara.
Desarrollo: aplicaron principios económicos como los rendimientos crecientes y decrecientes, los costos comunes y conjuntos, y las economías de escala y de alcance. A través de estos conceptos, evaluaron los impactos económicos del sistema BRT. Identificaron que lograron importantes ahorros operativos por sustitución de unidades convencionales, automatización del cobro y reducción de emisiones contaminantes. Estimaron más de 8 mil millones de pesos en ahorro operativo a lo largo de 20 años, 312 millones por menores mermas en el ingreso y 96 millones por reducción de contaminantes. También evaluaron el ahorro en tiempos de viaje como un beneficio social significativo. Determinaron que la mejora en la velocidad de desplazamiento permitió a los usuarios aprovechar su tiempo en otras actividades productivas o personales. Además, destacaron que la organización empresarial del BRT reemplazó al modelo hombre-camión, permitiendo

una operación más eficiente y segura.
Conclusiones: concluyeron que el sistema BRT representó una solución integral para la movilidad urbana. A través de una planificación basada en principios económicos sólidos, lograron mejorar la eficiencia operativa, reducir impactos ambientales y promover un desarrollo urbano más equitativo y sustentable.

Palabras clave: Movilidad Urbana; Transporte Público; Economía Aplicada; Sistema BRT; Ahorro Operativo.

INTRODUCTION

Urban mobility has become one of the fundamental pillars of modern city development. As urban areas grow and demand for transportation intensifies, the need for efficient, sustainable, and economically viable systems becomes increasingly urgent. In this context, the economics of urban public transportation takes on key relevance, as it allows for an understanding of the economic principles that govern its operation and facilitates decision-making oriented toward social and environmental benefits.[1]

The concept of urban mobility goes beyond the simple movement of people; it encompasses the way these interactions take place within a city, using connection networks that require the intelligent and coordinated use of different modes of public transport, such as buses, subways, taxis, or BRT (Bus Rapid Transit) systems. These systems not only impact transport efficiency, but also the quality of life of citizens, the use of public space, and local economic development.[2]

From an economic perspective, several principles are essential for analyzing the functioning of urban transport: increasing and decreasing returns, joint and common costs, and economies of scale and scope. These concepts provide an understanding of how resources are used and distributed within the system and how strategic decisions can generate significant operational savings.[3]

In particular, BRT systems have proven to be an effective alternative in terms of costs, reduction of pollutant emissions, and time savings for users. Through feasibility studies such as the one carried out for the Macrobús system in the Guadalajara Metropolitan Area, quantifiable benefits have been identified in key areas such as operating costs, fare collection automation, reduction of losses, environmental impact, and reduction in travel times.[4]

Economic analysis of these systems reveals that proper transportation planning and management can translate into substantial improvements in both operational efficiency and social well-being. Thus, an urban mobility approach based on sound economic principles offers a powerful tool for transforming conventional public transportation into a modern, integrated, and future-oriented service.

DEVELOPMENT

Theoretical aspects of economics applied to urban public transport operations

On the concept of urban mobility

Once we have looked at transport in everyday life solely as a key mode of urban mobility, and in accordance with Jans[1], when referring specifically to "urban mobility," this refers to the various journeys made within the city through local transport networks, which requires maximum use of different types of public transport, including not only the public bus and metro systems but also taxis, minibuses, transfers, etc., which are vitally important for quality of life, mobility, and use of public space.

The inclusion of the concept of "urban mobility" and the efficient response to it has led to significant economic growth in various cities that have been able to visualize its advantages.[1]

Some principles in transport economics

Economist Duque[2] assumes that, in addition to government regulation, the transport industry is subject to certain economic laws.

- The law of increasing returns states that expenses do not increase in the same proportion as income when the volume of business does.
- The law of diminishing returns states that after a certain threshold, adding a new factor decreases productivity.
- Once a transportation system is established with fixed capital, an expansion in the volume of shipments causes an increase in operating expenses or variable expenses, but has a limited effect on fixed or constant expenses, and this manifests itself in a decreasing average total cost per unit. However, there will be a limit to expansion.
- Joint costs are those incurred by a company when it obtains more than one product simultaneously or when it purchases raw materials of different qualities in the same purchase transaction.
- The savings obtained by the company in joint production processes are called "economies of scope." It is important to strengthen the coordination between small and medium-sized entrepreneurs

to make their access to input and consumer markets economically viable.

- Common costs occur in production scenarios where individual products use common resources or where certain services are provided to two or more users.[2]

Operating characteristics of a mass transportation system: economy, emissions, and time savings. Feasibility study for BRT systems in the ZMG

Analysis of operating costs and savings benefits "The best structure will not guarantee results or performance. But the wrong structure is a guarantee of failure." Peter Drucker

For De Rus et al.[3], selecting an alternative public transportation system makes no sense if it does not offer a significant improvement in operating costs. However, capital costs are also decisive, and in mass transportation, infrastructure costs are important and categorical in decision-making. According to the Coordinating Agency for Integrated Transport Operations in its feasibility study, the BRT systems implemented have proven to be an alternative in terms of cost-benefit 3 , which is different from operating costs, i.e., evaluated economically according to three elements:

- Savings in vehicle operation due to replacing conventional units with articulated buses.
- Savings from reduced losses through automation of the fare collection system.
- Savings from reduced pollutant emissions.

Savings in vehicle operating costs BRT vs conventional bus

To estimate savings in this area, the operating costs of conventional public transport vehicles currently serving a given corridor are analyzed. The cost analysis must include a series of variables such as average speed, tire consumption, lubricants, maintenance, hours worked per day, the performance of each type of vehicle, depreciation of the cost of units, interest payments, profitability, and operator salaries, among others.[5,6]

To quantify savings in operating costs, the costs of both transport models are compared. For example, for a future line of the Macrobús system, the Coordinating Agency for the Comprehensive Operation of Public Transport Services (OCOIT), now IMTJ, conducted a cost-benefit study in 2009 based on 478 conventional units. To better understand these scenarios, it is necessary to mention that the average operating cost per kilometer for conventional units in that year was 16,27 pesos, while the cost per kilometer for articulated units was 12,91 pesos.[4,7]

Table 1. Savings in vehicle operating costs, BRT line

Period	Year	Annual Operating Cost conventional transportation ($)	Cost Operating Annual with BRT line ($)	Project Benefits ($)
1	2009			
2	2010			
3	2011	425 278 154	96 023 732	329 724 421
4	2012	440 649 339	99 384 563	341 264 776
5	2013	456 072 066	102 863 023	353 209 043
6	2014	472 034 588	106 463 229	365 571 360
7	2015	488 555 799	110 189 442	378 366 357
8	2016	505 655 252	114 046 072	391 609 180
9	2017	523 353 185	118 037 685	405 315 501
10	2018	541 670 547	122 169 004	419 501 543
11	2019	560 629 016	126 444 919	434 184 097
12	20	580 251 032	130 870 491	449 380 541
13	2021	600 559 818	135 450 958	465 108 860
14	2022	621 579 411	140 191 742	481 387 670
15	2023	643 334 691	145 098 452	498 236 238
16	2024	665 851 405	150 176 898	515 674 507
17	2025	689 156 204	155 433 090	533 723 114
18	2026	713 276 671	160 873 248	552 403 423
19	2027	738 241 355	160 503 812	571 737 543
20	20	764 079 802	172 331 445	591 748 357
				8 078 146 531

Source: Coordinating Agency for the Comprehensive Operation of Public Transportation Services[4], now IMTJ.

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Savings from collection losses

To estimate savings from collection losses, in accordance with the Guidelines for the preparation and presentation of cost-benefit analyses of investment programs and projects, a loss value equivalent to 2 % of total revenue is assigned. Although this value is an estimated parameter, it is conservative when compared to possible empirical evidence, which shows that revenue losses in this area can reach up to 5 % of expected savings.

Table 2. Savings from collection losses, BRT line

Period	Year	Annual Revenue BRT line ($)	Losses due to collection ($)	Benefits of Project ($)
1	2009			
2	2010			
3	2011	638 087 625	12 761 753	12 761 753
4	2012	660 420 692	13 208 414	13 208 414
5	2013	683 535 416	13 670 708	13 670 708
6	2014	707 459 156	14 149 183	14 149 183
7	2015	732 220 226	14 664 405	14 644 405
8	2016	757 847 934	15 156 959	15 156 959
9	2017	784 372 612	15 687 452	15 687 452
10	2018	811 825 653	16 236 513	16 236 513
11	2019	840 239 551	16 804 791	16 804 791
12	20	869 647 935	17 392 959	17 392 959
13	2021	900 085 613	18 001 712	18 001 712
14	2022	931 588 609	18 631 772	18 631 772
15	2023	964 194 211	19 283 884	19 283 884
16	2024	997 941 008	19 958 820	19 958 820
17	2025	1 032 868 943	20 657 379	20 657 379
18	2026	1 069 019 356	21 380 387	21 380 387
19	2027	1 106 435 034	22 128 701	22 128 701
20	20	1 145 160 260	22 903 205	22 903 205
				312 658 997

Source: Coordinating Agency for the Comprehensive Operation of Public Transport Services[4], now IMTJ.

As such, the BRT system contributes in the long term with estimated savings of 312,6 million pesos, which in turn translates into benefits such as: increased average speed due to drivers not being distracted by fare collection, increased safety, reduction in free fares (family and friends), elimination of detours for fare collection, and control and recording of demand levels.

Savings from reductions in pollutant emissions

To estimate savings in this area, the Baseline Methodology for Bus Rapid Transit AM-0031 (methodology approved by the United Nations in 2006) is used, which considers four variables for estimating carbon credits:

- Average age of the vehicle fleet resulting in fewer emissions per kilometer traveled.
- Size of the replaced unit so that it produces fewer emissions in proportion to the number of passengers transported.
- Better fleet occupancy rate.
- Modal shift of the fleet.

To quantify this reduction, an economic value per tonne avoided (NOX, CO2, and other suspended particles) of €20 (average value for MGM and Carbon Finance agencies) is assigned. The estimate must be reviewed by an entity certified by the United Nations Development Programme (UNDP).

For example, for the Macrobús system, it was determined that the level of emissions on the trunk line averaged 16,8 tons per day, while the level of emissions under the project scenario (already with BRT) reduced this number to 5,3 tons per day, generating savings of 11,5 tons per day. The exchange rate used for the long-term estimate was 20 pesos per euro. The benefits obtained thanks to the project scenario in this category are presented in table 3.

Table 3. Savings from avoided pollutant emissions, BRT line

Period	Year	Tons Annual	Cost per ton ($)	Benefits of the ($)
1	2009			
2	2			
3	2011	11 279	400	4 511 400
4	2012	11 504	400	4 601 628
5	2013	11 734	400	4 693 661
6	2014	11 969	400	4 787 534
7	2015	12 208	400	4 883 284
8	2016	12 452	400	4 980 950
9	2017	12 701	400	5 080 569
10	2018	12 955	400	5 182 181
11	2019	13 215	400	5 285 824
12	2020	13 479	400	5 391 541
13	2021	13 748	400	5 499 371
14	2022	14 023	400	5 609 359
15	2023	14 304	400	5 721 546
16	2024	14 590	400	5 835 977
17	2025	14 882	400	5 952 696
18	2026	15 179	400	6 071 750
19	2027	15 483	400	6 193 185
20	2028	15 793	400	6 317 049
				96 599 506

Source: Coordinating Agency for the Comprehensive Operation of Public Transport Services[4], now IMTJ.

Thus, the Macrobús system estimated long-term savings of around 96,6 million pesos from avoided pollutant emissions, with significant consequences for the environment.

Considering the methodology used to estimate costs and the particular case of the Macrobús system, the study concludes that the BRT project for the ZMG is an efficient initiative in terms of operating costs according to international standards. This allows, as reviewed throughout this section, for significant savings to be generated in each category, which automatically translate into social benefits quantified in monetary terms.

Opportunity costs (travel time savings)

The opportunity cost of any economic activity is defined as the value of the productive resources used to carry out any activity, for example, travel times. The value of resources must be calculated taking into account other possible alternative uses and selecting the best option for each resource.[3,12]

Thus, not only should traditional productive factors be taken into account in the opportunity cost of transport, but also the time of users making the trips and the negative externalities that this transport may generate for society as a whole.

When we talk about opportunity costs, in this case, we are referring to the value of public transport users' time that could be used for activities other than travel, which is equivalent to saying that this opportunity cost analysis is carried out from the perspective of the consumer/user of public transport. In this sense, it is clear that a transport system that reduces travel times for users will generate significant savings in their time, which translates directly into social benefits.[5,13]

The basis for estimating these savings is to compare the difference in average speed under the scenario with and without the BRT project. In addition to the above, two additional variables are considered for the analysis of time savings. The first is the distance traveled by all users of the corridors. The other aspect to consider is determining the economic value of time, which is equivalent to measuring the monetary cost of time for public transport users.[14] The generally accepted methodology for this type of process considers only the alternative economic use that the user may have as a result of a reduction in travel times on public transport as a benefit for the project.(15,16) Of course, we cannot ignore the importance of leisure time allocated by each individual in a very particular way. However, due to the difficulty of measuring subjectivity, there is a general consensus that the opportunity cost to the consumer/user should be expressed through observable and quantifiable variables.(5)

On the other hand, a BRT system, by contemplating a business model with a corporate perspective and the economic principle of economies of scale, becomes more efficient, which is reflected in a substantial improvement in service quality and considerable savings in resources.(17) Furthermore, the man-truck business model does not allow for any of the economies of scale of a centralized operation, i.e., the reduction of average production costs with the increase in the scale of the service, nor can it offer a sufficient, reliable, coordinated, and acceptable quality service depending on a family and paternalistic structure, which has forced a gradual migration towards a transport company model focused on efficiency and service.(18,19)

Based on studies conducted for the Macrobús line project, it was determined that the average user currently travels approximately 10 km per trip. With regard to the differences in speed between the situation with and without the project, the total travel time for all users in each scenario has been estimated for a 20-year horizon. This is explained graphically in figure 1, which presents the estimates for savings over a 20-year time horizon.(4)

[illegible]	[illegible]	Número de usuarios estimados	Costo/Hora Usuario ($)	Beneficios del Proyecto ($)
1	2009			
2	2010			
3	2011	127,617,525	11.25	724,833,748
4	2012	126,341,350	11.64	742,700,900
5	2013	125,077,936	12.05	761,008,477
6	2014	123,827,157	12.47	779,767,337
7	2015	122,588,895	12.91	798,988,602
8	2016	121,362,996	13.35	818,683,670
9	2017	120,149,367	13.83	838,864,223
10	2018	118,947,873	14.31	859,542,226
11	2019	117,758,394	14.82	880,729,942
12	2020	116,580,810	15.33	902,439,935
13	2021	115,415,002	15.87	924,685,080
14	2022	114,260,852	16.43	947,478,567
15	2023	113,118,244	16.99	970,833,914
16	2024	111,987,061	17.59	994,764,970
17	2025	110,867,190	18.21	1,019,285,926
18	2026	109,758,519	18.85	1,044,411,624
19	2027	108,660,934	19.51	1,070,156,064
20	2028	107,574,324	20.19	1,096,535,410
				16,175,710,615

Source: Coordinating Agency for the Comprehensive Operation of Public Transport Services(4), now IMTJ

Figure 1. Annual benefits from time savings per trip, BRT line

In short, the analysis of the consumer/user opportunity cost is a determining factor in the selection of BRT systems as an alternative to conventional public transport. The perspective of indirect costs estimated using the Social Value of Time methodology provides a measure of well-being through which the benefits in terms of savings for users and society as a whole can be expected once a given mass mobility project is operational.(5)

CONCLUSIONS

The economic analysis of urban public transport, especially as applied to the BRT (Bus Rapid Transit) system, demonstrates the importance of strategic planning geared towards operational efficiency, sustainability, and social well-being. Urban mobility, understood as the ability of people to move efficiently within a city, is a key factor for economic development, social equity, and quality of life. In this context, mass transit systems such as the Macrobús in the Guadalajara Metropolitan Area are a comprehensive solution to the contemporary challenges of public transportation.

The application of economic principles such as increasing and decreasing returns, common and joint costs, and economies of scale and scope allows us to understand and optimize the operation of these systems. From this perspective, the BRT model presents itself as a viable alternative to conventional transportation, offering significant advantages in terms of operating costs, reduction of losses through automated fare collection, reduction of pollutant emissions, and time savings for users.

The data from the Macrobús system feasibility study show cumulative benefits of over 8 billion pesos in operating savings over a 20-year period, along with more than 312 million pesos in savings from reduced fare evasion, and nearly 96 million pesos from avoided pollutant emissions. Added to this are the benefits derived from savings in travel time for users, which translate into a direct improvement in individual and collective well-being, as they allow people to use their time more productively or for personal activities.

In addition, the BRT system allows for the business organization of transportation, abandoning the inefficient man-truck model and facilitating the consolidation of operators under a coordinated and professional structure. This not only raises the quality of service, but also allows for economies of scale, standardizes processes, and ensures a safer, faster, and more reliable service.

In conclusion, sustainable urban mobility based on sound economic principles, as demonstrated by the BRT system, not only improves the operational efficiency of public transport but also promotes the economic, social, and environmental development of cities. Investing in this type of solution represents a firm step towards a more equitable, competitive, and sustainable urban future.

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