

# Impact analysis of urban structure and the economic sustainability of public transport in the city of Murcia (Spain)

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## Abstract

One of the fundamentals of an efficient public transport system is economic sustainability. The poorly structured growth of cities sometimes leads to the difficulty to maintain urban transport systems for public administrations. An interesting example of this territorial problem in urban and intercity transportation is the city of Murcia, the capital of a municipality of nearly 900 km<sup>2</sup> equipped with various multi-modal public transport networks. This city of over 400,000 inhabitants has a historically dispersed urban structure where the population spread has been aggravated in recent years by a strong urban growth. The accelerated development of the city, coupled with the current crisis and budgetary consolidation, has made some public systems of urban and intercity transport economically unsustainable.

This article analyzes the impact that the urban development of the city of Murcia has had on the various systems of urban and intercity transportation: car, bus, tram, suburban, etc. A diagnosis of the current problems and possible solutions for the future will be presented in order to stimulate an economically sustainable public transport strategy.

*Keywords: public transport, urban structure, economic sustainability, Murcia.*

## 1 Introduction

In the current climate of a global economic crisis, the economic sustainability of public services is crucial to the maintenance and proper functioning of the same factor. In the case of urban transport, economic sustainability is closely linked to cost criterion, as long as these tend to be heavily subsidized services by the public administration.



In Spain, in this sense, there have been two complementary phenomena in recent decades whose consequences are surfacing now because of the economic crisis. On one hand, the growth of cities, the result of urban and real estate bubble, which translates into a greater, more dispersed population and requires a number of different public services, of which transportation is a key factor. On the other hand, it can be observed a greater tendency for the public subsidy in the field of urban transport, accompanied by parallel progressive politics commitment to multimodality (metro, tram, bus rapid transit, etc.).

This article will analyze the case of the city of Murcia, a city of 400,000 inhabitants located in the southeast Spanish, where the important population growth has accentuated an already dispersed urban structure. This urban destructure makes it difficult to economically maintain the current public bus transport, whose viability has also entered in recent years to compete with the new tram lines.

## 2 Urban structure of the city of Murcia: sprawl growth as an imbalance factor

One of the main features to assess in a city when one makes its transport strategy is the nature of its urban structure [1]. In this field, there are basically two models linked to parameters of urban infrastructure growth and population dispersion: the “oil slick” model and urban sprawl model (Fig. 1).

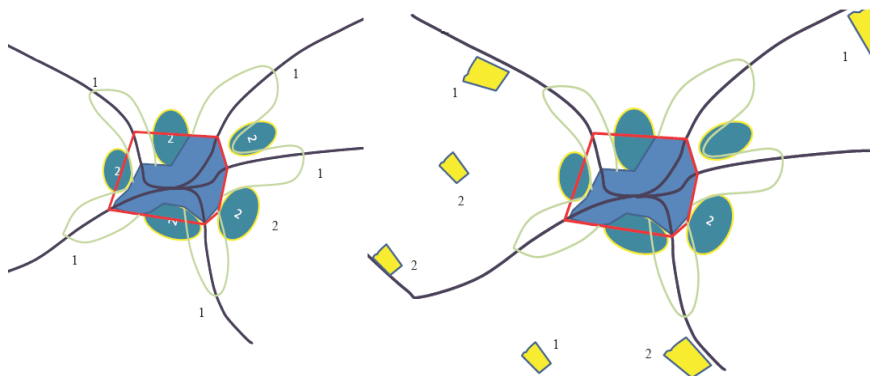


Figure 1: Urban model of “oil slick” (left) and sprawl model (right).  
Source: Miralles, J. L.

In the “oil slick” model, transport infrastructure structures the urban growth resulting from the city centre, with predictable cycles of population growth along land routes. This type of urban planning goes revaluing and silting soil interstitial spaces between nearby infrastructure. In the sprawl model, growth is multipolar, and it is growth who structures the transport infrastructure. Both models pose advantages and disadvantages. In the case of sprawl model, it is definitely a

model that induces an urban structure but with a greater economic cost and energy maintenance, although it avoids better phenomena of real estate speculation with the ground [1].

It must be noted that this is a theoretical approach and in reality no city exemplifies 100% none of these models. In the case of Murcia, we have a strong city sprawl-oriented model, where only 40% of the population resides in the vicinity of the urban plot, the rest being distributed over more than 50 districts of a municipality of about 900 km<sup>2</sup>. This is the result of a poorly planned urban growth in the last 50 years, where for example, the consolidation of the former urban ring A-30 road has strangled the growth of the city to the west (Fig. 2). This phenomenon has generated such a dispersed pattern of small settlements, some of which are located more than 30 km from the city centre.

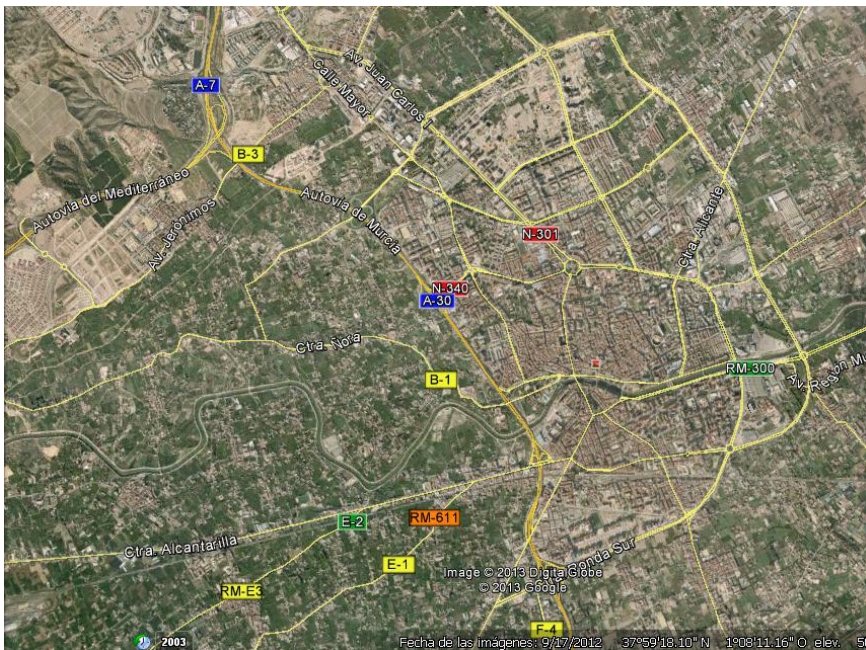


Figure 2: Physical structure of the urban area of the city of Murcia.  
Source: Google maps.

This urban structure becomes increasingly unsustainable with the development of resorts and consolidation of very peripheral settlements that require level of services similar to the city centre. In this way, the urban structure of the municipality is divided into many districts and boroughs with limited transport flows between them. This situation obliges concessionaires of transport services to perform a high number of operations to serve the entire population (Fig. 3).

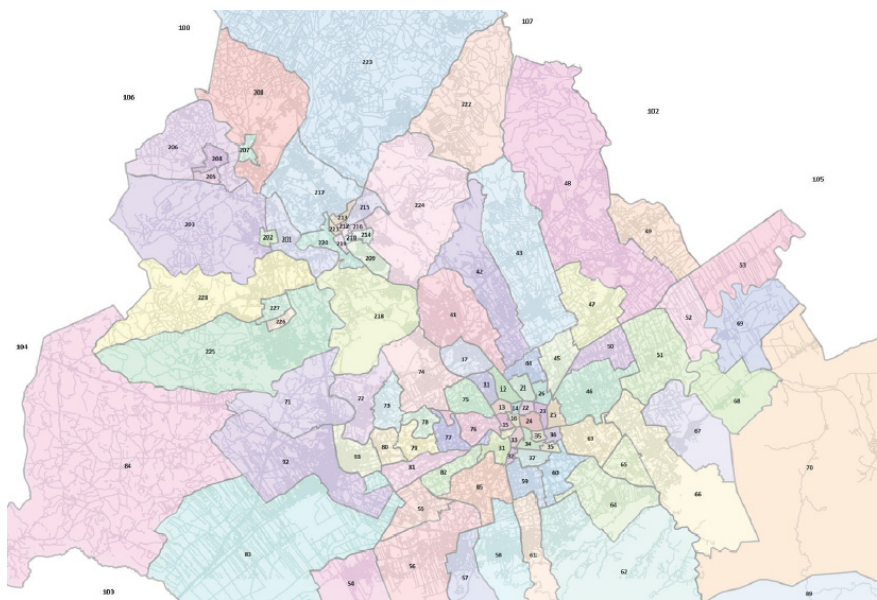


Figure 3: Districts and public transport areas in the municipality of Murcia.  
Source: [2].

These small settlements are linked by a dense and labyrinthine road network, built in many different section typologies. Thus, it coexist high capacity roads or highways bordering to the very centre of the city with characteristic streets of the historical centre with difficult access and pathways of different capacities, including areas of pedestrian use only. All this creates a complex and heterogeneous plot that complicates the treatment of the transport system of the city (Table 1).

Table 1: Summary by type of urban road in the municipality of Murcia.  
Source: [2].

Road type	Total length (km)
Motorways state-owned	150.43
Roads and highways of regional ownership	27.27
High capacity intercity road	224.99
High capacity metropolitan road	613.50
High-capacity urban road	72.25
Secondary urban roads	705.57
Low-capacity urban road and rural road	1,915.32
Pedestrian road use only	31.60
TOTAL	3,740.93

### 3 Sustainability analysis of public urban transport in the city of Murcia

Among the different existing public transport systems in the city of Murcia (tram, bus and commuter rail), it is particularly interesting the case of interurban bus. This service is regulated by three administrative concessions of public-private partnership called MU-092, MU-93-I and MU-93-II, consisting of 35 bus routes covering populations in 900 km<sup>2</sup> (Fig. 4).

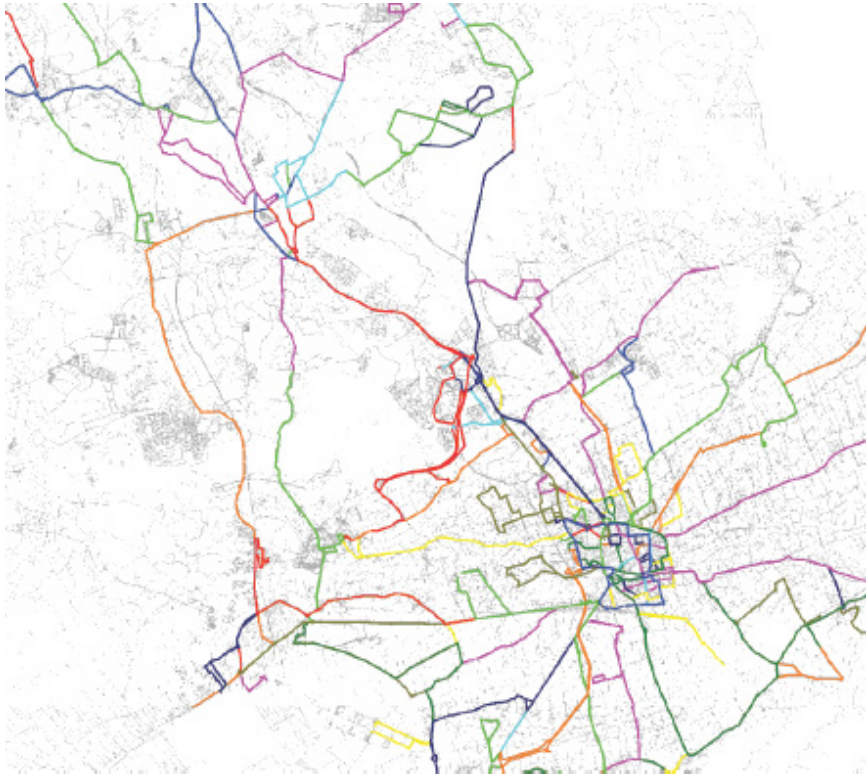


Figure 4: Sharing scheme of intercity bus lines MU-092 and MU-093 in the city of Murcia. Source: LATBUS S.A. [3].

If we analyze the economic and financial viability of these lines it can be seen that most of them (30 of 35) are deficient in the relationship between actual costs and benefits. Some of them are strongly deficient (economic returns less than 20% of cost), implying a possible wastage of under-utilization. If we analyze the total annual cost (26.7 million Euros) versus actual annual income (13 million Euros), it can be observed a strong imbalance as the ratio of cost coverage with real income barely reaches 50%, with important economic losses in several bus lines (Fig. 5).



	Direct Cost	Total Cost	Travellers	real income	Public help	Deficit
Línea 42	733 715 €	1 070 041 €	292 701	289 672 €	-	-780 369 €
Línea 43	150 318 €	214 764 €	65 908	65 226 €	-	-149 538 €
Línea 45	47 942 €	83 550 €	8 095	5 975 €	-	-77 575 €
Línea 70	814 262 €	1 105 033 €	161 601	121 201 €	-	-983 833 €
Línea 72	229 089 €	345 972 €	66 483	50 527 €	-	-295 445 €
Línea 46	40 834 €	133 488 €	12 699	9 524 €	-	-123 964 €
TOTAL MU-092-	2 016 161 €	2 952 849 €	607 487	542 126 €	-	-2 410 723 €
Línea 1	1 055 091 €	1 592 044 €	971 626	854 267 €	513 997 €	-223 780 €
Línea 6	527 879 €	799 396 €	624 269	507 244 €	346 474 €	54 322 €
Línea 7	127 385 €	186 126 €	60 662	37 142 €	54 199 €	-94 785 €
Línea 12	142 051 €	211 826 €	216 440	152 061 €	40 495 €	-19 270 €
Línea 25	117 041 €	173 501 €	86 673	45 937 €	19 239 €	-108 325 €
Línea 26	906 843 €	1 378 357 €	1 503 976	1 202 554 €	254 702 €	78 899 €
Línea 28	482 844 €	698 049 €	483 691	399 171 €	80 931 €	-217 947 €
Línea 29	542 169 €	815 692 €	732 891	565 421 €	351 587 €	101 316 €
Línea 30	632 599 €	923 514 €	773 053	658 631 €	498 191 €	233 308 €
Línea 31	881 356 €	1 285 536 €	1 135 640	955 337 €	468 872 €	138 674 €
Línea 34	129 275 €	186 438 €	49 276	35 228 €	16 019 €	-135 191 €
Línea 37	277 583 €	399 381 €	182 086	136 072 €	50 837 €	-212 472 €
Línea 39	1 104 116 €	1 775 812 €	892 219	562 098 €	405 638 €	-808 076 €
Línea 50	1 396 222 €	2 104 128 €	1 567 084	1 159 642 €	858 772 €	-85 714 €
Línea 61	243 334 €	372 015 €	203 584	157 821 €	78 550 €	-135 644 €
Línea 91	468 147 €	681 633 €	505 581	399 470 €	193 415 €	-88 748 €
Línea 92	268 957 €	402 894 €	207 802	160 468 €	112 903 €	-129 523 €
TOTAL MU-093-I	9 302 895 €	13 986 341 €	10 196 552	7 988 565 €	4 344 821 €	-1 652 956 €
Línea 21	705 749 €	1 000 509 €	617 143	607 355 €	3 215 €	-389 939 €
Línea 22	723 522 €	1 064 178 €	696 598	619 610 €	1 678 €	-442 890 €
Línea 24	266 703 €	399 497 €	156 746	83 076 €	6 021 €	-310 400 €
Línea 27	420 079 €	583 612 €	237 611	211 712 €	6 222 €	-365 678 €
Línea 36	686 590 €	1 000 686 €	525 896	486 514 €	46 948 €	-467 224 €
Línea 38	94 974 €	170 398 €	42 503	23 560 €	951 €	-145 886 €
Línea 41	655 791 €	964 422 €	442 967	438 383 €	1 689 €	-524 350 €
Línea 44	1 999 419 €	3 038 464 €	2 307 017	1 761 326 €	1 034 691 €	-242 447 €
Línea 47	78 418 €	124 141 €	58 637	32 250 €	-	-91 890 €
Línea 49	304 526 €	429 903 €	122 990	109 461 €	-	-320 442 €
Línea 52	363 120 €	624 832 €	351 538	312 869 €	-	-311 963 €
Línea 54	285 991 €	404 213 €	140 193	124 772 €	-	-279 441 €
TOTAL MU-093-II	6 584 883 €	9 804 855 €	5 699 841	4 810 888 €	1 101 415 €	-3 892 552 €
TOTAL MU-093	15 887 778 €	23 791 196 €	15 896 393	12 799 453 €	5 446 236 €	-5 545 507 €
TOTAL	17 903 939 €	26 744 045 €	16 503 880	13 341 579 €	5 446 236 €	-7 956 231 €

Figure 5: Study of current economic ratios of intercity transportation in Murcia MU-092 and MU-093. Source: [4].

This situation occurs in Murcia (but also in many other cities of Spain), and is leading to study for real needs to optimize the costs of urban transport. These studies focus on the reorganization of public transport services, while maintaining service coverage that lowers the current scope in ratios not exceeding 10–20%. These proposals aim to increase the level of economic sustainability of public transport, making funding needs of government grant reduce their ratios from 50% to 30%, a must situation as a result of the current scenario of economic crisis and fiscal consolidation in public finances.

For Murcia, the study has focused on maintaining the highest service coverage ratio and minimum loss of real income by the grantee, in order to give maximum economic and social viability to the proposed reorganization. This work has been done following three criteria:

- a. Hierarchization of lines, following the importance population settlements using arrays of supply and demand,
- b. Adaptation by GIS tools of itineraries to the current urban structure of the city (obsolescence of some itineraries because socioeconomic changes) [4],
- c. Removal of duplication taking advantage of synergies with other public transport systems that have similar performance lines (tram in the town and commuter in intercity routes).

With these criteria a GIS study of possible routes on the urban plot of the municipality was performed, taking a standard buffer covering of 300 meters (Fig. 6). The entire public transport system obtained, has represented spatially, a degree of coverage of the population above 86%, which is a very high value, given the difficulties due to urban settlements distribution described above. So, 86% of the population, has a bus stop within 300 m.

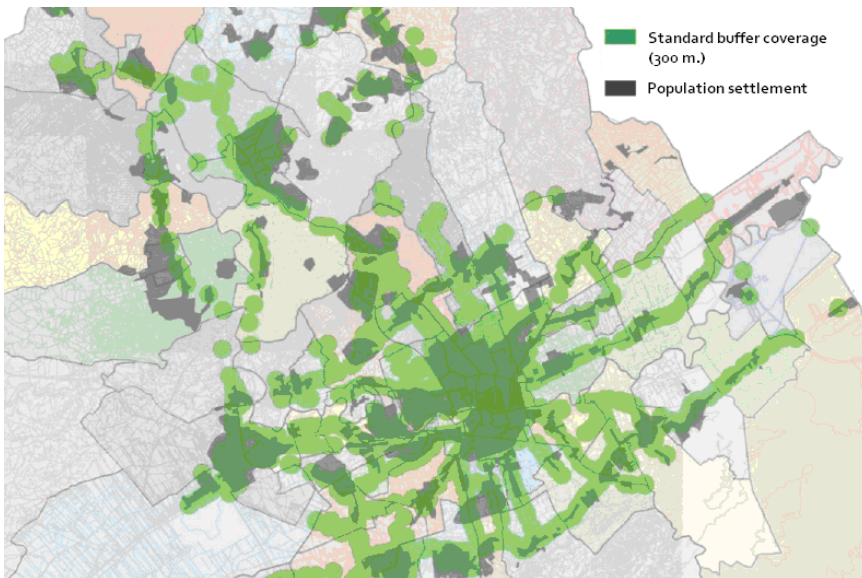


Figure 6: GIS analysis of population centres with coverage buffer of 300 meters in public transportation itineraries of urban and buildable land. Source: [5].

The economic and financial result of this proposal is more than significant. Despite the high rate of coverage, real costs have been reduced from 26.7 to 18.8 million Euros (-30% cost), reducing the required general government grant to just 6.1 million. This is mainly because the new optimized proposal essentially

maintains a level of very similar income of 12.7 million Euros (-4.5%). This way, the city can get a more sustainable urban transport system whose real self-financing rate goes from 50% to 66%, significantly reducing the proportion and especially the amount of public subsidy (Fig. 7).

	Direct Cost	Total Cost	Travellers	real income	Public help	Deficit
Línea 42	280 851 €	422 182 €	120 395	119 149 €	-	-303 033 €
Línea 43	97 289 €	116 988 €	48 900	48 394 €	-	-68 594 €
Línea 45	47 942 €	85 537 €	-	0 €	-	-85 537 €
Línea 70	465 018 €	645 920 €	109 809	82 357 €	-	-563 563 €
Línea 72	180 020 €	296 096 €	68 973	52 419 €	-	-243 676 €
Línea 46	-	-	-	0 €	-	0 €
TOTAL MU-092	1 071 120 €	1 566 722 €	348 077	302 319 €	-	-1 264 403 €
Línea 1	830 381 €	1 291 268 €	974 717	856 985 €	513 997 €	79 714 €
Línea 6	365 133 €	566 437 €	245 618	199 575 €	346 474 €	-20 389 €
Línea 7	-	-	-	-	-	-
Línea 12	-	-	-	-	-	-
Línea 25	-	-	-	-	-	-
Línea 26	742 258 €	1 177 131 €	1 655 834	1 323 977 €	254 702 €	401 548 €
Línea 28	380 740 €	613 600 €	551 989	455 535 €	80 931 €	-77 134 €
Línea 29	461 739 €	723 573 €	1 200 653	926 297 €	351 587 €	554 311 €
Línea 30	607 319 €	952 330 €	775 669	660 860 €	498 191 €	206 721 €
Línea 31	881 954 €	1 337 330 €	1 256 995	1 057 425 €	468 872 €	188 968 €
Línea 34	-	-	-	-	-	-
Línea 37	108 159 €	168 155 €	43 354	32 398 €	50 837 €	-84 919 €
Línea 39	722 787 €	1 202 628 €	675 743	425 718 €	405 638 €	-371 272 €
Línea 50	1 392 331 €	2 187 142 €	1 850 029	1 369 022 €	858 772 €	40 651 €
Línea 61	-	-	-	-	-	-
Línea 91	263 536 €	410 857 €	249 733	197 319 €	193 415 €	-20 124 €
Línea 92	216 516 €	346 787 €	75 564	58 352 €	112 903 €	-175 532 €
TOTAL MU-093	6 972 855 €	10 977 238 €	9 555 897	7 563 462 €	4 344 821 €	722 544 €
Línea 21	514 754 €	764 839 €	401 914	395 540 €	3 215 €	-366 085 €
Línea 22	587 769 €	865 737 €	992 669	882 959 €	1 678 €	18 899 €
Línea 24	140 902 €	216 745 €	148 627	78 772 €	6 021 €	-131 952 €
Línea 27	-	-	-	-	-	-
Línea 36	501 822 €	763 958 €	479 066	443 190 €	46 948 €	-273 820 €
Línea 38	-	-	-	-	-	-
Línea 41	-	-	-	-	-	-
Línea 44	1 710 563 €	2 616 540 €	3 363 863	2 568 190 €	1 034 691 €	986 341 €
Línea 47	78 418 €	129 341 €	43 045	23 674 €	-	-105 666 €
Línea 49	272 443 €	386 300 €	269 472	239 830 €	-	-146 470 €
Línea 52	319 193 €	552 216 €	285 953	254 498 €	-	-297 718 €
Línea 54	-	-	-	-	-	-
TOTAL MU-093	4 125 864 €	6 295 676 €	5 984 608	4 886 653 €	1 101 415 €	-316 470 €
TOTAL MU-093	11 098 719 €	17 272 914 €	15 540 505	12 450 115 €	5 446 236 €	406 074 €
TOTAL	12 169 840 €	18 839 636 €	15 888 582	12 752 435 €	5 446 236 €	-858 330 €

Figure 7: Study of economic ratios with the new reorganization. Source: [6].

If we analyze the technical quality of the proposal disaggregating the analysis of the lines, it can be seen that the ratios of loss-making routes are generally offset by positive ratios in lines that did not have problems of economic viability.



Líne	Current	New	Difference	% Difference
Líne 1	2 835	2 838	- 3	-0.11%
Líne 5	-	-	-	0.00%
Líne 6	2 089	949	1 140	120.13%
Líne 7	286	-	286	100.00%
Líne 10	-	-	-	0.00%
Línea 12	610	-	610	100.00%
Línea 21	1 804	1 225	579	47.27%
Líne 22	2 527	3 730	- 1 203	-32.25%
Líne 24	456	421	35	8.31%
Líne 25	307	-	307	100.00%
Líne 26	5 016	5 646	- 630	-11.16%
Línea 27	1 291	-	1 291	100.00%
Líne 28	1 969	2 166	- 197	-9.10%
Línea 29	2 678	4 121	- 1 443	-35.02%
Líne 30	2 918	2 965	- 47	-1.59%
Líne 31	3 167	4 484	- 1 317	-29.37%
Líne 34	226	-	226	100.00%
Líne 36	1 743	1 514	229	15.13%
Líne 37	778	155	623	401.94%
Líne 38	324	-	324	100.00%
Líne 39	7 222	3 390	3 832	113.04%
Líne 41	1 880	-	1 880	100.00%
Líne 42	978	385	593	154.03%
Líne 43	111	207	- 96	-46.38%
Líne 44	9 450	11 484	- 2 034	-17.71%
Líne 45	45	-	45	100.00%
Líne 46	370	-	370	100.00%
Líne 47	142	196	- 54	-27.55%
Líne 49	422	780	- 358	-45.90%
Líne 50	6 241	6 290	- 49	-0.78%
Líne 52	1 129	981	148	15.09%
Líne 54	517	-	517	100.00%
Líne 61	571	-	571	100.00%
Líne 70	695	441	254	57.60%
Líne 72	266	277	- 11	-3.97%
Líne 91	1 242	878	364	41.46%
Líne 92	794	282	512	181.56%
<b>TOTAL</b>	<b>63 099</b>	<b>55 805</b>	<b>7 294</b>	<b>13.07%</b>

Figure 8: Current and new ratios of passengers by unbundled lines in the study.  
Source: [6].

## 4 Conclusions

The reorganization of existing systems of urban and intercity public transport (according to criteria of urban structure, population ranking service levels and leveraging synergies of multimodality), is a matter required by the economic situation in some cities in Spain. Public transport systems have to achieve higher self-financing ratios to educate the citizens of transport costs and be economically sustainable.

In this field, the correct coordination between land use planning and public transport is very important. In this paper, it can be seen how GIS tools have proven to be a very interesting instrument to adapt the old administrative public transport concessions to the changing reality from the point of view of urban planning and socioeconomic evolution.

The city of Murcia has an urban public transport system that suffers from a structural budget deficit driven by an urban sprawl model developed over the past 50 years. This model in the case of intercity public bus transport is increasingly unsustainable because the development of resorts and consolidation of peripheral settlements that require a similar level of service to the city centre. Implementing a coherent coordination among the urban structure of the city and its transportation systems, it has been achieved a rate of self-financing in the intercity public bus transport, whose ratio went from 50% to 66%.

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