PUBLIC TRANSPORT DEMAND
ELASTICITIES IN SPAIN

By Gines de Rus*

1. INTRODUCTION

Elasticities of fare and service level demand for urban public transport have been estimated for a number of countries, and for different market conditions and econometric specifications (see Bly and Webster, eds., 1980; Goodwin and Williams, 1985; McKenzie and Goodwin, 1986).

This paper provides new evidence on demand response on public transport in Spanish cities. The standard fare structure consists of the combination of the cash fare and a multiple-ride ticket. Short-term elasticities, and elasticities which account for delayed demand response, are estimated.

Elasticity estimates obtained from aggregate data and average revenue as a proxy for the price variable are compared with conditional elasticities (Fairhurst, Lindsay and Singha, 1987) obtained from disaggregate passenger-trips series and actual fares; fare and service level elasticities are examined in terms of their compatibility with maximising patronage, given the present operating (revenue/cost) ratio; and, finally, the implications of own and cross price coefficients with relation to the fare structure are considered.

The second section of this paper describes briefly the set of data. Section 3 discusses the model which has been used in the estimation of fare and service level elasticities. The results of the estimation are discussed in section 4, in which the coefficients from different specifications are presented; disaggregate elasticities are obtained, and there is discussion of the transport policy implications. Finally, the conclusions are presented in section 5. Only the coefficients considered of general interest have been included in this paper.

2. THE DATA

The majority of public transport operators in Spanish cities and towns are small private companies which have a franchise given by the local authority. In the

* University of Las Palmas and University of Leeds. I am indebted to K. M. Gwilliam and P. J. Mackie for valuable comments and helpful suggestions; to J. C. Carbajo for advice and help, especially in the earlier stage of this work; and to the Spanish bus transport operators and the Municipal Transport Association (STEMTUC) for providing the required information. I gratefully acknowledge comments of a referee and an editor.
<table>
<thead>
<tr>
<th>City</th>
<th>Population 1986 (thousands)</th>
<th>Passenger trips (bus-kms)</th>
<th>Revenue costs</th>
<th>Cash fare (pesetas)</th>
<th>OAP (pesetas)</th>
<th>Travelcard (pesetas)</th>
<th>$f_1/f_2$</th>
<th>$q_2 / (q_1 + q_2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordoba</td>
<td>305</td>
<td>4.68</td>
<td>0.61</td>
<td>50</td>
<td>15</td>
<td>2000</td>
<td>1.43</td>
<td>0.60</td>
</tr>
<tr>
<td>Gijon</td>
<td>259</td>
<td>6.61</td>
<td>0.87</td>
<td>40</td>
<td>5</td>
<td>—</td>
<td>1.23</td>
<td>0.35</td>
</tr>
<tr>
<td>Granada</td>
<td>281</td>
<td>6.03</td>
<td>0.92</td>
<td>50</td>
<td>9</td>
<td>—</td>
<td>1.56</td>
<td>0.52</td>
</tr>
<tr>
<td>Huelva</td>
<td>135</td>
<td>5.07</td>
<td>0.61</td>
<td>45</td>
<td>315</td>
<td>OAP</td>
<td>1.32</td>
<td></td>
</tr>
<tr>
<td>Las Palmas</td>
<td>372</td>
<td>4.64</td>
<td>0.82</td>
<td>50</td>
<td>100</td>
<td>OAP</td>
<td>1.43</td>
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<tr>
<td>Lerida</td>
<td>111</td>
<td>6.66</td>
<td>0.83</td>
<td>50</td>
<td>—</td>
<td>1750</td>
<td>1.67</td>
<td>0.58</td>
</tr>
<tr>
<td>Pamplona</td>
<td>184</td>
<td>7.32</td>
<td>0.92</td>
<td>45</td>
<td>16</td>
<td>—</td>
<td>1.64</td>
<td>0.65</td>
</tr>
<tr>
<td>S. Sebastian</td>
<td>180</td>
<td>5.23</td>
<td>0.88</td>
<td>53</td>
<td>free</td>
<td>—</td>
<td>1.56</td>
<td>0.65</td>
</tr>
<tr>
<td>Valencia</td>
<td>739</td>
<td>4.48</td>
<td>0.71</td>
<td>60</td>
<td>1300</td>
<td>3000</td>
<td>1.50</td>
<td>0.61</td>
</tr>
<tr>
<td>Valladolid</td>
<td>341</td>
<td>4.99</td>
<td>0.70</td>
<td>45</td>
<td>free</td>
<td>—</td>
<td>1.43</td>
<td>0.57</td>
</tr>
<tr>
<td>Zaragoza</td>
<td>596</td>
<td>6.09</td>
<td>0.87</td>
<td>40</td>
<td>free</td>
<td>—</td>
<td>1.18</td>
<td>0.46</td>
</tr>
</tbody>
</table>

2. $q_1$: passenger-trips with cash fare ($f_1$).
3. $q_2$: passenger-trips with multi-ride ticket ($f_2$: price of a ride).
5. Weekdays only.
6. Travelcard valid for a month.
8. Student card: academic year only.
10. Extra charge of 5 pesetas on Sundays and bank holidays.
11. Before 9 a.m., a cheaper multi-ride ticket can be used. In this case the ratio is 2.25 and the proportion of total multi-ride tickets is 15%.
largest cities public transport services are normally provided by municipal operators. Table 1 shows the fare structure in Spanish cities: the general pricing system is a combination of cash fares and ten-ride tickets, with important reductions for old age pensioners. In comparison with the rest of Europe, companies cover a high proportion of total cost by operating revenue. With the exception of Valencia (and very recently Córdoba), travelcards are not common in middle-size cities.

Madrid and Barcelona have been excluded for three reasons. Both cities present a highly complex fare system with a wide range of discounts, an integrated network with urban and interurban routes, and interaction with the Underground. In these circumstances, the aggregate approach is inadequate, and a disaggregate analysis would require more information than is available.

The group of eleven urban operators in this study is composed of eight municipalities, a cooperative (Pamplona) and two private companies (Granada and Zaragoza). All the operators have provided monthly information on passenger trips, revenue, bus-kilometres, fares, and major service disruptions within the time period 1980–88; four of them had data available on passenger trips disaggregated by ticket type, as they had used cancelling machines on buses for at least four years.

The number of observations is not the same for all the operators (see Table 2). The longest series is composed of 101 observations (January 1980 to May 1988). The varying lengths of the time series reflect variations in the availability and reliability of data. The last observation dates from May (1988) except that for Lerida the time series extends to September (1988).

A particular problem arising from the use of aggregate data is the impossibility of using actual fare series, as the weights are not available for usage of the different ticket types. The shortcomings of average revenue per trip as a proxy are well known (see Fowkes, Nash and Whiteing, 1985; Owen and Phillips, 1987, for railway passenger demand). Although the fare structure in the Spanish bus transport industry is quite simple, the behaviour of average revenue over time changes both with actual fare changes and with shifts between ticket types caused by seasonal variations or by particular restrictions on some discounts (for example, student cards available only for the academic year). The alternative estimation of disaggregate demand elasticities with actual fare and average revenue per trip shows the sensitivity of demand coefficients to the aggregation of passenger data.

Retail price indices for capitals of provinces have been used to deflate fares series. In the case of Gijón the indices are those corresponding to Oviedo.

3. THE MODEL

The basic model used in this study is double log, and a dynamic specification is introduced to account for possible delayed adjustments of demand to changes in fares and service level. The model is as follows:

\[ q_{it} = \alpha f_{it} f_{zt} p_{it}^{\gamma_t} \exp (\gamma_3 T_t + \sum \lambda_i D_i + \omega_t H_t) e_t \]  

where:
\( q_{jt} \) = passenger-trips per month with cash fare \((j = 1)\) or multiple-ride ticket \((j = 2)\);
\( \alpha \) = constant term;
\( f_{1t} \) = deflated price of an ordinary ticket;
\( f_{2t} \) = deflated price of a trip with multiple ride ticket;
\( B_t \) = vehicle-km per month;
\( T_t \) = time trend;
\( D_i \) = dummy variables \((i = 1 \ldots 11, \text{January to December excluding one month})\);
\( H_t \) = dummy variable to account for major disruptions in services;
\( e_t \) = error term.
Tests of a semilog form did not suggest that it was superior in this case.
Equation (1) assumes that the impact of changes in the explanatory variables is immediate, without any long-term adjustment; this might imply a specification bias if delayed effects are significant. In order to allow for a less restrictive response of demand to changes in fares and service levels, a dynamic specification (McKenzie and Goodwin, 1986; Owen and Phillips, 1987) is required. The basic model is extended with a standard geometric lag structure.
The disaggregate specification gives the estimates of own and cross elasticities which provide a more precise understanding of the response of demand to changes in fare structure and bus-kms run (Fairhurst, Lindsey and Singha, 1987). From equation (1) own and cross-price elasticities are as follows:

\[
\begin{align*}
\frac{\partial \log q_{1t}}{\partial \log f_{1t}} &= \gamma_{11} && \frac{\partial \log q_{1t}}{\partial \log f_{2t}} = \gamma_{12} \\
\frac{\partial \log q_{2t}}{\partial \log f_{1t}} &= \gamma_{21} && \frac{\partial \log q_{2t}}{\partial \log f_{2t}} = \gamma_{22}
\end{align*}
\]

(2)

The response of demand to fare changes is given by:

\[
\begin{align*}
\pi_1 \epsilon_1 &= \gamma_{11} \pi_1 + \gamma_{12} \pi_2 \\
\pi_2 \epsilon_2 &= \gamma_{22} \pi_2 + \gamma_{21} \pi_1
\end{align*}
\]

(3)

where \( \epsilon_1 \) and \( \epsilon_2 \) are conditional elasticities for passengers with ordinary and multiple-ride tickets, and \( \pi_1 \) and \( \pi_2 \) are percentage fare changes for the two types of tickets. When \( \pi_1 \neq \pi_2 \), there is no single value for \( \epsilon_1 \) or \( \epsilon_2 \). The weighted price demand elasticity is:

\[
\epsilon_f = \epsilon_1 s_1 + \epsilon_2 (1 - s_1)
\]

(4)

where \( s_1 \) is the market share of ordinary tickets.
\( \epsilon_f \) changes with market shares and the values of \( \epsilon_1 \) and \( \epsilon_2 \), which depend (given the values of \( \gamma_{11}, \gamma_{12}, \gamma_{22} \) and \( \gamma_{21} \)) on \( \pi_1 \) and \( \pi_2 \).
Special attention must be paid to the interpretation of service level elasticities for users paying cash fares and using multiple-ride tickets, as cross effects are difficult to isolate. A low value of the elasticity of demand from passengers paying cash fares \( (\beta_1) \) does not necessarily mean a weak demand response to service improvements (cuts), as a variation in bus-kms run may produce a shift to
(from) use of multiple-ride tickets because of higher (lower) level of service.

Seasonality is one of the main causes of monthly changes in bus-kms run by
the operators. Other factors affecting service level are an active policy to improve
quality and a passive adjustment to variations in demand. The joint determination
of demand and service level creates difficulties in the estimation of demand
elasticities from single equation models with bus-kms as an exogenous variable
(see Frankena, 1978). Another problem is the impossibility of distinguishing
the effects of route kilometres run, of level of service frequency and of lost
kilometres. In spite of the difficulties bus-kms are generally used as a proxy for
the level of service (Goodwin and Williams, 1985). This has probably no
dramatic impact on the coefficients estimates, as operators in regulated urban
transport do keep their service schedule stable, with marginal adjustments, once
it has been planned and advertised.

4. DEMAND FUNCTIONS ESTIMATION: RESULTS

4.1 Aggregate elasticities

The estimates of demand elasticities for eleven Spanish urban transport operators
are summarised in Tables 2 and 3; time trend and seasonal coefficients are not
discussed in this paper because they are not of general interest. The time trend
variable shows, in a majority of cases, a coefficient which results in an annual
decline or increase of less than 1 per cent, and seasonal behaviour reflects the
change in economic and educational activities during June, July and August.

Both static and dynamic specifications give similar estimates of short-run
demand elasticities. The goodness-of-fit is high in all the equations (adjusted
coefficients of determination and t statistics). Nevertheless, in three cities the
autoregressive model does not lead to statistically significant results, and among
the estimated equations some cases may have first order serial correlation.

The static model has been estimated through first differences, as a problem of
autocorrelation was detected in the estimation with ordinary least squares. In the
case of dynamic specification the Durbin h statistic has been calculated. The null
hypothesis that there is no first order serial correlation may be accepted in five
cases out of eight, at 5 per cent level of significance (the critical value of h is
1.96). Three cities, San Sebastian, Valencia and Valladolid, present a computed h
higher than the critical value at 5 per cent level of confidence, so in them the
hypothesis of absence of first order serial correlation may be rejected.

In the static model fare elasticities range from −0.16 to −0.41, with a mean of
−0.3; service level elasticities present higher variability, with a minimum value of
0.34 and a maximum of 1.26. These values are quite similar to those obtained
with the autoregressive model; in this specification short-term fare and service
level elasticities are slightly lower than those obtained with the static approach
(with the exception of Zaragoza), and the coefficient of the lagged dependent
variable suggests a higher medium-term response of demand to changes in fares
and bus-kms run. The ratio of medium-term to short-term fare and service level
elasticities ranges from 1.2 to 2, with a mean of 1.46.

The aggregate elasticities obtained in this study are in line with the existing
empirical evidence (see Bly and Webster, eds., 1980; Goodwin and Williams, 1985;
TABLE 2

<table>
<thead>
<tr>
<th>City</th>
<th>Number of Observations</th>
<th>$\varepsilon_f$</th>
<th>$\varepsilon_s$</th>
<th>$\bar{R}^2$</th>
<th>$d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Córdoba</td>
<td>45</td>
<td>$-0.16$</td>
<td>0.40</td>
<td>0.94</td>
<td>1.94</td>
</tr>
<tr>
<td>Gijón</td>
<td>101</td>
<td>$-0.23$</td>
<td>0.34</td>
<td>0.99</td>
<td>2.00</td>
</tr>
<tr>
<td>Granada</td>
<td>72</td>
<td>$-0.18$</td>
<td>0.96</td>
<td>0.99</td>
<td>2.01</td>
</tr>
<tr>
<td>Huelva</td>
<td>101</td>
<td>$-0.29$</td>
<td>0.64</td>
<td>0.99</td>
<td>2.12</td>
</tr>
<tr>
<td>Las Palmas</td>
<td>89</td>
<td>$-0.37$</td>
<td>0.72</td>
<td>0.99</td>
<td>2.14</td>
</tr>
<tr>
<td>Lérida</td>
<td>68</td>
<td>$-0.44$</td>
<td>0.68</td>
<td>0.99</td>
<td>2.26</td>
</tr>
<tr>
<td>Pamplona</td>
<td>43</td>
<td>$-0.30$</td>
<td>0.51</td>
<td>0.99</td>
<td>1.90</td>
</tr>
<tr>
<td>S. Sebastian</td>
<td>101</td>
<td>$-0.32$</td>
<td>1.06</td>
<td>0.99</td>
<td>2.44</td>
</tr>
<tr>
<td>Valencia</td>
<td>101</td>
<td>$-0.41$</td>
<td>0.93</td>
<td>0.99</td>
<td>2.34</td>
</tr>
<tr>
<td>Valladolid</td>
<td>77</td>
<td>$-0.31$</td>
<td>0.36</td>
<td>0.99</td>
<td>2.09</td>
</tr>
<tr>
<td>Zaragoza</td>
<td>63</td>
<td>$-0.30$</td>
<td>1.26</td>
<td>0.99</td>
<td>1.90</td>
</tr>
</tbody>
</table>

$\varepsilon_f$: fare elasticity.
$\varepsilon_s$: service level elasticity.
$\bar{R}^2$: coefficient of determination (adjusted).
$d$: Durbin-Watson statistic.

( $t$-statistics in parentheses.)

McKenzie and Goodwin, 1986); but, given the commonly high proportion of cost covered by operating revenue in the Spanish bus industry, the policy implications of these values may be different (see 4.3).
### TABLE 3

*Fare and Service Level Demand Elasticities (dynamic specification)*

<table>
<thead>
<tr>
<th>City</th>
<th>$\varepsilon_f$ (short run coefficients)</th>
<th>$\varepsilon_s$</th>
<th>$\lambda$</th>
<th>$\varepsilon_f^*$</th>
<th>$\varepsilon_s^*$</th>
<th>$R^2$</th>
<th>$h$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granada</td>
<td>-0.06</td>
<td>0.74 (4.16)</td>
<td>0.35</td>
<td>-0.09</td>
<td>1.14</td>
<td>0.90</td>
<td>1.68</td>
</tr>
<tr>
<td>Huelva</td>
<td>-0.20</td>
<td>0.39 (3.66)</td>
<td>0.39</td>
<td>-0.33</td>
<td>0.64</td>
<td>0.85</td>
<td>-0.73</td>
</tr>
<tr>
<td>Las Palmas</td>
<td>-0.35</td>
<td>0.60 (7.33)</td>
<td>0.18</td>
<td>-0.43</td>
<td>0.73</td>
<td>0.82</td>
<td>-0.85</td>
</tr>
<tr>
<td>Lérida</td>
<td>-0.33</td>
<td>0.61 (5.12)</td>
<td>0.50</td>
<td>-0.66</td>
<td>1.22</td>
<td>0.86</td>
<td>-0.01</td>
</tr>
<tr>
<td>S. Sebastian</td>
<td>-0.30</td>
<td>0.87 (8.63)</td>
<td>0.23</td>
<td>-0.39</td>
<td>1.13</td>
<td>0.81</td>
<td>3.93</td>
</tr>
<tr>
<td>Valencia</td>
<td>-0.39</td>
<td>0.66 (7.58)</td>
<td>0.20</td>
<td>-0.49</td>
<td>0.83</td>
<td>0.97</td>
<td>3.69</td>
</tr>
<tr>
<td>Valladolid</td>
<td>-0.28</td>
<td>0.26 (3.70)</td>
<td>0.33</td>
<td>-0.42</td>
<td>0.39</td>
<td>0.93</td>
<td>-2.16</td>
</tr>
<tr>
<td>Zaragoza</td>
<td>-0.32</td>
<td>1.54 (17.49)</td>
<td>0.18</td>
<td>-0.39</td>
<td>1.88</td>
<td>0.98</td>
<td>0.22</td>
</tr>
</tbody>
</table>

$\varepsilon_f$: fare elasticity.

$\varepsilon_s$: service level elasticity.

$\lambda$: coefficient of the lagged dependent variable.

$\varepsilon_f^*$, $\varepsilon_s^*$: medium term elasticities.

$R^2$: coefficient of determination (adjusted).

$h$: Durbin-Watson statistic.

( $t$-statistic in parentheses)

### 4.2 Cash fare and multiple-ride ticket elasticities

The aggregate elasticities reported in this study have been obtained from time series of total passenger trips and average revenue per passenger trip. Average revenue as a proxy for actual fares has important limitations, particularly in urban areas with a tapered fare structure and/or a combination of cash fare, multi-ride tickets, and travelcards. In addition to actual price variations, there are two possible causes of changes in the elasticities.
<table>
<thead>
<tr>
<th></th>
<th>Granada</th>
<th>Las Palmas</th>
<th>Pamplona</th>
<th>Zaragoza</th>
</tr>
</thead>
<tbody>
<tr>
<td>log $q_1$</td>
<td>-0.732</td>
<td>-0.987</td>
<td>-1.156</td>
<td>-1.132</td>
</tr>
<tr>
<td></td>
<td>(−3.414)</td>
<td>(−5.693)</td>
<td>(−3.875)</td>
<td>(−0.929)</td>
</tr>
<tr>
<td>log $q_2$</td>
<td>0.711</td>
<td>0.873</td>
<td>0.869</td>
<td>2.306</td>
</tr>
<tr>
<td></td>
<td>(2.853)</td>
<td>(4.307)</td>
<td>(5.554)</td>
<td>(1.990)</td>
</tr>
<tr>
<td>log $f_1$</td>
<td>0.204</td>
<td>0.565</td>
<td>0.766</td>
<td>0.702</td>
</tr>
<tr>
<td></td>
<td>(0.909)</td>
<td>(2.350)</td>
<td>(2.363)</td>
<td>(0.634)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(−2.992)</td>
<td>(−6.792)</td>
<td>(−2.124)</td>
</tr>
<tr>
<td>$e_j$</td>
<td>−0.528</td>
<td>−0.422</td>
<td>−0.390</td>
<td>−0.430</td>
</tr>
<tr>
<td>log $B$</td>
<td>0.750</td>
<td>0.197</td>
<td>−0.020</td>
<td>1.313</td>
</tr>
<tr>
<td></td>
<td>(2.802)</td>
<td>(4.204)</td>
<td>(3.209)</td>
<td>(17.93)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.010)</td>
<td>(13.49)</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>0.97</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>2.01</td>
<td>2.40</td>
<td>2.00</td>
<td>1.85</td>
</tr>
<tr>
<td></td>
<td>1.99</td>
<td>2.39</td>
<td>1.96</td>
<td>1.97</td>
</tr>
</tbody>
</table>

$f_1$: cash fare deflated.
$f_2$: multi-ride ticket (deflated price of a ride).
$e_j$: fare elasticity ($j = 1, 2$) conditional to equiproportional price changes.
$B$: bus-kms.
$R^2$: coefficient of determination (adjusted for degrees of freedom).
$d$: Durbin-Watson statistic.
($t$-statistics in parentheses).
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(i) changes in the proportions of different lengths of journeys: where there is a tapered fare structure, this will affect average revenue.

(ii) shifts between ticket types, even when actual fares remain constant, will change market shares and average revenue. In Spain the tapered fare structure is common in interurban transport, but in urban areas the general system is a flat fare with the cheaper alternative of a ten-ride ticket sold off the bus.

Table 4 shows the disaggregate demand elasticities which have been obtained for four operators. The own-price and cross elasticities show the expected signs with static and dynamic specification. Inclusion of the lagged dependent variable does not improve results. The interpretation of demand coefficients deserves some attention, as cross effects are crucial to an understanding of demand behaviour.

From equations (2) and (3) and for equiproportional price variations, it is easy to obtain conditional cash fare and multi-ride ticket elasticities, as well as overall service level elasticities. In the case of Pamplona, for example:

\[
\begin{align*}
\varepsilon_1 &= -1.156 + 0.766 = -0.390 \\
\varepsilon_2 &= -1.078 + 0.869 = -0.209 \\
\varepsilon_f &= -0.390 (0.35) - 0.209 (0.65) = -0.272 \\
\varepsilon_3 &= -0.020 (0.35) + 0.880 (0.65) = 0.565
\end{align*}
\]

The overall service level elasticity shows a standard value of 0.6. There is a high and statistically significant elasticity in the multi-ride ticket market segment, and a negative cash fare elasticity. This may be interpreted as indicating important cross effects between the two types of market segments, induced by variations in service quality measured in bus-kms run.

The conditional (for equiproportional fare changes) elasticities for 1988 market shares (see Table 1) are shown in Table 5. In order to compare conditional and aggregate elasticities, Table 6 displays both estimates for ten routes of one of the operators in the study. Conditional short-term elasticities are in general lower than aggregate elasticities. It appears therefore that the aggregate approach overestimates fare elasticities; the relationship does not seem clearly defined for service level elasticities. This bias associated with the aggregate approach (total passenger-trips and average revenue as a proxy for the fare) seems to be caused by the shifts in market shares when price changes occur. These shifts are accounted for in the disaggregate approach through cross-elasticities, and they may well distort the relationship between price and demand in the aggregate approach.

Disaggregate elasticities are crucial for deciding on fare changes. It is worth noticing that for all the operators cross-elasticities of multiple-ride ticket demand with respect to cash fare are higher than cross-elasticities of cash fare demand with respect to multi-ride ticket price. Given the present own fare elasticity values and shares of the two ticket types, it seems possible to obtain lower conditional price elasticities by making a higher proportional increase in cash fares than in multi-ride tickets. This evidence suggests that it is worth exploring alternative pricing policies, taking into account the fact that fare increases (equiproportional or not) produce a readjustment in the composition of demand through shifts between ticketing options as relative prices change.
4.3 Fare and service level demand elasticities

The estimated elasticities of service level demand are higher (in absolute terms) than demand-price elasticities for all the Spanish cities included in the study, with the one exception that Valladolid (see Tables 2 and 3) shows a slightly lower service level elasticity in the equation with dynamic specification.

Estimated fare elasticities are situated in the interval (−0.2, −0.4), and service level elasticities have a mean value of 0.7, but with a high coefficient of variation. An interesting question is how far those values are compatible with the maximisation of patronage, or with other implicit objective functions.

When the operator is breaking even and the elasticity of costs with respect to bus-kms is equal to one, the maximisation of patronage is achieved when both demand elasticities are equal — so that, for example, it is not possible to increase passengers by reallocating resources to sustain lower fares through lower quality. In the case in which there is no restriction on choice of the combination of price and service level, and the operator is not breaking even, the optimal balance has to satisfy the following rule (Webster, 1978):

\[ -\varepsilon_f = \varepsilon_s/xy \]  

where

- \( \varepsilon_f \) = fare elasticity;
- \( \varepsilon_s \) = service level elasticity;
- \( x \) = percentage change in costs when bus-kms increase by 1 per cent;
- \( y \) = cost/revenue ratio at which the company is operating. (This ratio changes with output, as the level of subsidy is fixed in absolute terms.)

If we assume that a company has operating revenue which covers 80 per cent of total costs (\( y = 1.25 \)), the elasticity of costs with respect to bus-kms is one, and fare elasticity is equal to 0.3. With these values, service elasticity must be 0.375 if
TABLE 6

Aggregate and Conditional Demand Elasticities (static specification)

<table>
<thead>
<tr>
<th>Route</th>
<th>$\epsilon_{fa}$</th>
<th>$\epsilon_{fd}$</th>
<th>$\epsilon_{sa}$</th>
<th>$\epsilon_{sd}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>-0.37</td>
<td>-0.18</td>
<td>0.48</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>(-4.67)</td>
<td></td>
<td>(9.06)</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>-0.36</td>
<td>-0.17</td>
<td>0.68</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>(-3.81)</td>
<td></td>
<td>(7.58)</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>-0.39</td>
<td>-0.13</td>
<td>0.60</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>(-3.93)</td>
<td></td>
<td>(7.32)</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>-0.16</td>
<td>-0.04</td>
<td>0.94</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>(-1.26)</td>
<td></td>
<td>(7.61)</td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>-0.21</td>
<td>-0.003</td>
<td>0.46</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>(-2.88)</td>
<td></td>
<td>(4.11)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>-0.18</td>
<td>-0.04</td>
<td>0.88</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>(-1.78)</td>
<td></td>
<td>(7.69)</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>-0.50</td>
<td>-0.27</td>
<td>0.57</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>(-6.22)</td>
<td></td>
<td>(7.21)</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>-0.36</td>
<td>-0.10</td>
<td>1.06</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>(-3.09)</td>
<td></td>
<td>(7.10)</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>-0.35</td>
<td>-0.15</td>
<td>1.26</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>(-4.03)</td>
<td></td>
<td>(9.11)</td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>-0.38</td>
<td>-0.11</td>
<td>0.84</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>(-3.24)</td>
<td></td>
<td>(6.96)</td>
<td></td>
</tr>
</tbody>
</table>

$\epsilon_{fa}, \epsilon_{sa}$: aggregate fare and service level elasticities.
$\epsilon_{fd}, \epsilon_{sd}$: conditional fare and service level elasticities.
$R^2$ is higher than 0.95 for all the equations.
Estimated $d$ values suggest that there is no serial autocorrelation.
($t$-statistics in parentheses).

Passenger trips are to be maximised while the budget constraint is satisfied.
With the estimated elasticities and the actual $y$ ratios (see Table 1), and on the
assumption that $x$ is equal to one, all the Spanish cities in the study, especially
Granada, San Sebastian and Zaragoza, show service level elasticities higher than
they would be if passenger trips were maximised.
Glaister (1987) and Dodgson (1987) have shown that in British and Australian cities, with vehicles of similar capacity to those used in Spain, there exists an imbalance between fares and service levels, which suggests that economic efficiency could be increased by cutting services in order to finance lower fares. The values found in this study suggest a contrary imbalance: patronage could be increased, for a given financial result, by moving to a pattern of higher fares and higher service, though the required readjustment may be marginal in some cases.

The existence of a different imbalance in Spanish cities from that found by Glaister and Dodgson for British and Australian cities is reflected in the average load factors. Table 1 shows the ratio passenger-trips/bus kms for the set of operators in the study; these values are substantially higher than those in Australia and the UK (see Dodgson, 1987, p. 57, and Evans, 1985, p. 111).

A final point arises in relation to the behaviour of the operators and their implicit objective functions. The estimated values are possibly consistent, in the majority of cases, with the maximisation of passenger trips, given the existence of a constraint imposed by the resistance of the Spanish local authorities to higher fares.

5. CONCLUSIONS

In this study aggregate and disaggregate (cash fare and multiple-ride ticket users) elasticities have been estimated for different Spanish cities with monthly time series for the period 1980–88. In the model, changes in passenger trips are explained by variations in real fares and bus-kms run, but also by seasonal factors, and a time trend is used to account for an important set of variables (income, car ownership, etc.), the effects of which cannot be disentangled, mainly because of lack of appropriate data.

Alternative specifications have been used: double log and semilog, static and dynamic. The results produced by the constant elasticity model are robust, and yield broadly the same coefficients as the mean of the elasticities obtained with a semilog specification. Static and dynamic approaches give similar short-term coefficients, with medium-term elasticities which are higher than short-term elasticities by an average proportion of 1.46.

Fare and service level elasticities estimated from data disaggregated by ticket type give us a deeper understanding of demand response when the fare structure combines on-bus cash fares and multiple-ride tickets (the usual system in Spain). Cross effects between ticket types have been estimated, and their role in decisions on pricing policy appears to be crucial to the evaluation of non-equiproportional fare increases.

Conditional elasticities (to equiproportional fare changes) are lower than aggregate elasticities; it seems therefore that the aggregate approach overestimates the fares elasticity by failing to allow explicitly for shifts in demand between ticket types.

The aggregate values of demand elasticities reported in this paper suggest that, at the present level of subsidy, public transport patronage could be increased through higher frequencies (financed from higher fares). The imbalance appears
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G. de Rus

more important when conditional elasticities are considered. This imbalance between fares and service level, and the adjustment that could be introduced within the fare structure in order to increase passenger trips, indicate that it is possible to obtain higher returns from the provision and pricing of urban public transport services in Spain.

Date of receipt of final typescript: August 1989

REFERENCES


