IMPACTS OF THE CAIRO METRO

Authors:

Egyptian National Institute of Transport (ENIT), Cairo:
Prof Dr A-G Bahgat (Executive Director); Dr F. El-Tony, Dr R. El-Mahdi, Dr E. Boshra, Dr K. Abbas, Dr A. Fattah, and Mr O. Al-Keelany.
University of Westminster : Prof P.R.White

Abstract

The Cairo Metro – the first in Africa and the Middle East – is a two-line system, heavily-used. Data from the operator and a direct passenger survey are used to illustrate patterns of use and draw policy implications for other systems. While current revenue exceeds operating costs, cross-subsidies may exist between different passenger groups as a result of highly-discounted student season tickets. A fare increase in 1996 is used to estimate short-run elasticity of demand with respect to price, approximately –0.2, a similar figure to other metro systems. Substantial use is made of motorised feeder modes, notably shared taxis (paratransit minibuses).

The high level of use occurs despite a substantial premium over other public transport fares, and lack of integrated ticketing. A likely explanation is that the fares are 'reasonable' compared with incomes, and that the price differential is offset for many users by the time savings vis a vis congested traffic conditions.

1. The Metro system and the region served

The Metro system in Cairo comprises two lines, as shown on map 1 :

1. Al Marg - Mubarak - Sadat - Helwan (also known as the 'regional line'). A route opened in April 1989, formed by connecting two existing surface suburban lines by a cut-and-cover underground section through the central area. Total route length is 43.5 km, of which about 3 km comprises the central area section, the rest of existing surface suburban lines modernised. About 1.2m passengers per working day are now carried (the annual total in 1997 being 418m). Some 33 stations are served.

2. Shubra El-Kheima - Mubarak - Sadat - University (sometimes referred to as 'urban line 1', being the first purely urban route). The first phase (Shubra - Mubarak, 8.5km) opened in October 1996; the second phase, an extension through the central area to Sadat, in October 1997; and the Sadat – University section under the Nile in April 1999. Current operational length is 14.5 km. The final section, a further 3 km, to Giza Suburban

(interchanging with the ENR services) is under construction. It is mostly in bored tunnel, except for a short section at the northern end approaching Shubra El-Kheima, which is elevated, and a section just south of this by cut-and-cover. In consequence, construction costs per route-km for line 2 were much higher. In the first full year, 1997, an estimated 66 million passengers were carried (about 0.2 million per working day).

Table 1 shows a set of ridership and passenger density figures for a sample of metro systems. It can be seen that Cairo occupies a fairly high level in terms of passenger density, between the relatively low figures in western Europe, and the much higher figures of some NIC cities (notably Hong Kong). Systems in large cities of developing countries are characterised by high population density, low car ownership, and often severe congestion on the road system. In addition, the metro systems are often smaller relative to population than, for example, in London. Hence, the traffic density is much higher. Note that the measure of passenger trips per route-km is a relatively crude one, since it does not take into account average trip length. Ideally, passenger-km per route-km would be a better measure of traffic density, but it is only available for a few systems (such as London and Paris).

However, it does not always follow that better financial performance is always obtained in the large cities of developing countries, despite high ridership density, since fares may be regulated to below-cost levels, and high staffing levels may exist. Furthermore, if capital as well as operating costs are considered, cost over-runs and delays in construction often result in far high costs than initially estimated when systems were proposed, leading to poor (or negative) economic rates of return (1). Where fares are increased from a low initial level to cover a higher proportion of costs, substantial ridership losses may result, as in the Mexico City example quoted in table 1. Detailed financial figures are not available in the Cairo case - it is understood that all operating costs are covered from revenues, but not all depreciation charges (nonetheless, a situation much better than most metro systems).

In the Cairo case, line 1 performed much better than many other systems examined in a comprehensive TRRL/HFA study nine years ago (2), mainly due to the fact that it mostly comprised existing surface suburban lines, with a short new underground section. Hence, total capital costs were low relative to total passenger volume. At 1986 prices, the estimated economic internal rate of return was 15.6%, the fourth highest in the study after Hong Kong, Singapore, and Seoul (but note that these examples, as well as being of high density, also displayed much higher income levels and hence values of time used in estimating benefits).Note that the estimates were based on the likely use of the line, which was only just opening when the study was produced. It was assumed that the metro line 1 would carry 0.39m passengers per day in the

base year (of which 0.16m would be generated), and 2.1m per year in the evaluation year – it is currently about 1.2m per working day after 10 years' operation.

The built-up conurbation (the Greater Cairo Metropolitan area, or GCM) comprises three sectors:

1. The city of Cairo itself, located on the east bank of the Nile, extending south to Helwan, north to Shubra, and North East to Heliopolis and Nasr City.
2. Giza. The district on the west bank of the Nile, effectively part of the city, developed at high density. This includes intensive office and residential development.
3. Shubra Al-Kheima. A district north of the city, located in the adjoining governate (although no further from the centre of Cairo than many districts within the city itself).

The Metro system is largely confined to the city of Cairo itself, apart from the short sections of line 2 extending into Shubra Al-Kheima, and Giza. The total population of GCM rose from 6.70 million in 1976 to 8.63 million in 1986. Within this total, the share represented by Cairo city itself fell - although still growing in absolute terms - as net growth was concentrated in the Giza and Shubra Al-Kheima areas. The gross density over the city as a whole is around 130 per hectare, or around 395 net. This compares with a gross average for London of about 45 per hectare, for example.

The residential zones of Cairo can be grouped by density as follows:
(a) 'Low density' (under 300 per hectare, net). Some of these represent affluent areas with smaller households, others are effectively part of the central area, and hence are used for office and shopping provision rather than being primarily residential.
(b) 'Moderate density' (300 to 500 per hectare) Most of these are around or within the central business district, with the exception of Al Marg (on the north east fringe of the city) and Helwan (the southern extremity), both served by metro line 1.
(c) High density (over 500 persons per hectare).These lie further from the central area in most cases.

Cairo may be seen as similar to many other cities in developing countries, in that high-income groups tend to be located close to the central area, while lower-income, high density areas are located further out. Low-income travellers may be faced with high transport costs (both in absolute terms, and notably as a proportion of disposable income). A similar pattern may be found in India, for example (3).

Map of the Cairo metro system

Line 1 (also known as the 'regional line') runs 43 km from El Marg to Helwan, the central ‘metro’ section (cut and cover tunnel) between Mubarak (Ramses) and Sayeda Zeinab being shown by a heavy line. Line 2 (heavy dotted line) is now open between Shubra El-Kheima and Sadat (Tahrir) and University (‘Uni’), with the section to Giza approaching completion. A third line is proposed (Imbaba - Salah Salem). Also shown is the Heliopolis tramway, serving an area east of central Cairo.

The three stations at which surveys took place are:

A. Azbet Al Nakhl (close to El Marg) on line 1.

B. Shubra El-Kheima (northern end of line 2)

C. Dar Al Salaam (on line 1, south of the city centre)

[Map reproduced from Jane's Urban Transport Systems, with kind permission]

Table 1 : Comparative passenger volumes and densities for selected metro systems.

System	Passenger trips (m)	Route-km	Passengers/route km (m)	Passengers/station (m)
Tokyo (1)	2139	162	13.2	14.4
Hong Kong(2)	779	43	18.1	20.5
Mexico City (3)	1300	178	7.3	n/a
Cairo (4)	483	53	9.1	11.5
Calcutta (5)	80	16	5.0	5.3
Santiago (6)	200	27	7.4	5.5
Rio de Janeiro (7)	92	25	3.7	3.8
London (8)	832	392	2.1	3.4
Paris (9)	1534	302	5.1	3.5

Notes :

(1) 1993 data for TRTA system only. Source : London Transport Market Report, October 1996, page 44.
(2) MRT, data for 1993. Source : as (1)
(3) From Passenger Rail Management June 1998, p 9. NB In 1989 with a network of 141 km, 1,500m passengers were carried, a density of 10.6m/route-km, subsequently falling due to fares being increased from a low level.
(4) Following completion of line 2 to Sadat, 1997 estimates.
Line 1 carried 417.7m, and line 2 65.7m
(5) 1997 data. Line comprises only one route in central area. Source : Piyush Kansal 'Ridership estimate for Metro Railway Extension from Tollygang to Garia in Calcutta - a case study'. Paper in steam D1, World Conference on Transport Research, Antwerp, July 1998.
(6) 1997 passenger estimate
(7) Metro Rio de Janeiro. Anuario Estatistico 1996. Two lines, line 1 being a 'heavy metro' (average pax/route-km 7.0) and line 2 a 'light rail' route (0.9m pax/route-km)
(8) From London Transport Annual Report for 1997/8
(9) RATP plus RER regional metro, for 1994. Source : as 1

Between 1986 and 1996, the city as whole grew by 12.3%, but many zones showed substantial declines, especially in the inner area, while some in the outer area showed growth of over 100%. Growth of commercial and business activity in some inner and central zones may also have displaced residential population. The average household size is about 4 persons, but higher in low-income high-density zones, and lower in zones in or surrounding the central business district.

Data is available from a comprehensive transport survey carried out in 1987 (4), indicating variations in car ownership and income by zone. Average car ownership at that time was about 0.053 per head (about one car per twenty people), or 0.017 per household (about one car per five households). Subsequently, average car ownership levels have increased to about 0.07 per head, but a similar zonal variation is likely to remain. The overall car ownership level could be seen as intermediate between cities such as Mumbai (about 0.04) and London (about 0.30).

Since the main aim of the study was to examine the role of the metro system in serving low-income groups, stations were selected within high-density, low-income zones for user surveys as follows:

1. Shubra Al-Kheima (northern end of line 2). A 1987 car ownership level of 0.018, and household income of 156 LE/month, compared with city-wide averages of 0.053 and 219LE respectively.
2. Dar Al Salaam, on line 1 south of the central area, in the Basatin zone (0.031 cars/person, income 174LE)
3. Azbet Al Nakhl, penultimate station from the northern end of line 1, within the Al Marg zone (0.021 cars/person; 132LE/month).

2. The existing public transport system

The 'formal' public transport system is under public ownership. Two fleets of standard-size urban single-decker buses are operated by the Cairo Transport Authority (CTA) and the Greater Cairo Bus Company (GCBC), together handling about 65% of all passengers. Minibuses run by CTA comprise a further 6%, and street tramways about 2.5%. The metro system, although comprising only two lines, handles about 25% of all trips, and very small shares are handled by the 'Heliopolis metro' and riverbuses. The tram network has been greatly reduced in recent years, partly due to the role of the metro. In 1995/6 a total of 1945 million trips was made on the publicly-owned network, corresponding to about 180 trips per head of population, a similar figure to that in 1985/86. The construction of the metro has thus not necessarily increased the overall public

transport trip rate, but has enabled the public transport system to cope with rapid population increase.

On those corridors which the metro serves it is likely that it represents about 50% of all public transport use. The major role of the metro – a 25% share of the whole public transport market - contrasts with that of the two-line systems in Santiago and Rio which represent about 13% and 4% respectively (5,6) of their cities' public transport markets, albeit in cases where a higher level of bus service is provided.

The quality of the conventional public transport system may be a major factor in the growth of shared taxis. Garib and Abdelmegeed (7) indicate that over 25,000 shared taxis are in operation, carrying about 1.4 million trips per day in 1992, or a similar volume to the metro (on an annual basis, this would raise total public transport use by about 490m, and hence trips per head from about 180 to about 230). Strictly speaking, such services should be operated direct point to point under the laws by which they are authorised, but in practice they stop frequently for passenger boarding and/or alighting, about every 500 metres, i.e. performing a similar function to an urban bus. Few shared taxi vehicular trips exceeded 5 km, suggesting use mostly between the central area and inner zones, or locally within suburban areas.

The average per capita public transport trip rate is somewhat lower than some other large cities (such as London , at around 275-300), despite the low car ownership levels, and may be attributed to constrained public transport supply, limited disposable incomes (affecting off-peak demand) and lower economic activity levels (proportion of the population in paid employment).

Another important characteristic of the travel patterns in Cairo is the distribution of journeys by time of day. The typical working day is somewhat shorter than in Europe, of about 6 - 6.5 hours' duration (from around 0800 to 1430), but applies over a six-day week (Saturday - Thursday). This results in a sharp peak in demand around 0800 (coinciding with education travel, as in Europe), but a better spread and somewhat earlier afternoon-peak. Friday's demand profile is similar to that of Sunday in western Europe.

3. Price structures

Substantial differences are found between the conventional buses, the CTA minibuses, shared taxis and the metro. These apply both to cash single fares and travelcards.

For example, the single trip fares between Shubra El-Kheima and the central business district are as follows :

	Cash single	Travelcards	
		Adult 3-month	Student 3-month
CTA or GCBC conventional bus	25 piastres*	15 LE*#	6 LE#
CTA minibus	30 "	15 LE#	6 LE#
Minibus (shared taxi)	35 "	n/a	n/a
Metro (line 2)	50 or60 "	56 LE	12 LE

The Metro fare varies according to the station used in the central area (50 pt to Ramses or Attaba, 60 pt to Tahrir).

* 100 pt (piastres) = 1 LE (Egyptian pound). Current exchange rate 1 GBP = approx 5.5 LE, i.e. 100 piastres = about 18 pence.

Valid on one route only (metro Travelcard covers whole network).Metro and CTA travelcards are not inter-available.

Hence, the metro single fare or student travelcard is about twice that by bus, the adult travelcard over three times. In addition, passengers using a shared taxi as a feeder to the metro would pay a short-distance fare of about 25 pt. However, it is likely that metro users gain substantial time savings : a journey from Shubra El-Kheima takes only 11 minutes to Ramses or 18 minutes to Tahrir (it is likely that bus and shared taxi journey times are considerably greater, especially at peak times, but data are not available).

As an illustrative example, if the peak journey time savings over bus were 20 minutes, then for a single fare traveller, the implied value of time would be about 75-100 piastres per hour (about 14-18 pence). For travelcard users, the rate would be somewhat lower, due to the lower average price per trip.

In relation to incomes, fares appear relatively modest. For example, at an average income per month of 300 LE, a month's adult travel (on a travelcard) would correspond to 5 LE by bus (1.6% of income) or about 19 LE by metro (6.3% of income). In practice, many metro users would qualify for the much lower-priced travelcard for government or army staff (32LE for there months, or about 11LE per month) or as students (4LE per month).

4. The Metro Users Survey

A survey of metro users was undertaken, at three selected stations, to identify user characteristics, and in particular, the extent to which use from low-income areas could indicate that metro users were representative of such areas. Ideally, a household survey could have been undertaken to identify use of all modes along a corridor, and the share taken by metro, but this was not practicable.

The main survey was survey was completed on Monday 16 March 1998, covering a period between 1200 and about 1600, a total sample of 719 (except where stated, conclusions below are drawn from this sample). In order to make comparisons with travel patterns at a different time period, a further survey was subsequently carried out at Azbet Al Nakl between 2000 and 2300 on Saturday 27 June 1998, giving a further 61 responses to produce a total sample of 780. The full data set is referred to as the 'whole sample'.

By gender, data was obtained for 755 respondents (from the whole sample), of whom 72% were male, and 28% female. From the main survey, the proportion of trips made on single tickets by each gender was very similar (about 35% in each case), but a higher proportion of females were using the student travelcard (32%, compared with 19%), while females were less likely to be using the other travelcard types (34%, compared with 46% of males). This may reflect the degree of female participation in the labour force.

From, the whole sample, data was obtained for 761 respondents, indicating the following split by ticket type:

Singles	37.4%
3-month Travelcards for the general public	6.9%
3-month Travelcards for government and army	34.4%
3-month Travelcards for students	21.1%

The proportion of Travelcards being used by members of the general public is small (7% of all trips), but such cards represent the majority of travel when government & army, and students, are concerned. This is associated with the much lower 'break even ratio' resulting from their low price. For example, if a person makes 12 single trips per week on the metro (i.e. to work or education over six days), and over three months makes such journeys on 12 weeks, they would make 144 journeys, leaving aside any additional travel that

might be encouraged by use of the card (the overall average use is around 228 trips per quarter).

At 144 journeys, the cost of using single tickets would range from LE72 (at 50PT per trip) to LE115 (at 80PT per trip). Hence, one would normally expect all such frequent travellers to switch to travelcards, provided that they could afford the initial purchase price. For students, the ratio is even lower - for example, someone making trips priced at 50PT single, on a 9LE travelcard, would only need to make 18 trips to break even.

The attractiveness of the travelcard to groups such as students is supported by a cross-tabulation of ticket type and employment status from the main survey. Of the 28% of respondents classified as 'students', 76% were travelling with travelcards, the others on singles. Of the respondents classified as ‘government or army’ 75% were also using travelcards. Conversely, only 37% of 'private sector' and 'own business' respondents were using cards. Cross-tabulations by trip frequency likewise confirm this pattern. Of those travelling nine or more times per week, 79% were on travelcards. Note that the form of the survey will tend to exaggerate the proportion of individual metro users who are high-frequency travellers, as such people are, by definition, more likely to be interviewed during a given period at stations.

Of the 700 respondents providing data on car ownership in the main survey, 91% were from non-car-owning households, 9% from one-car households, and under 1% from households with two or more cars. Hence, about 0.1 cars per household is the average, and, assuming an average household size of 4, this would imply a car ownership rate per head of about 0.025 (one in forty). This is very similar to the rates found in the 1987 study for the low-income areas identified in the process of sampling stations (Basatin, Al Marg and Shubra: the unweighted averages for these three areas in 1987 were 0.088 cars per household, and 0.024 cars/head). Hence, it may be assumed that the users interviewed are fairly representative of the zones in which the stations are located (indeed, if car ownership in these zones has risen since 1987, they may represent a lower-than-average income group).

Car ownership and income relationships were also examined. The proportion of respondents in car-owning households rose from 7% where income was less than 200LE per month, to 27% for income levels of over 500LE per month. A chi-squared test indicates a significant relationship at the 0.001 significance level.
Respondents were also asked what modes they had used before the start of metro operation. It should be borne in mind that line 1 has been open for about ten years - hence, many users may have not made the equivalent trip prior to its opening, since experience in other cities indicates that a substantial 'turnover' in the urban

public transport market is observed, i.e. many people will have changed their home and/or work location during this period, possibly in response to transport system changes. In addition, continued population growth in Cairo means that many users would be new to the city itself, quite apart from any particular route or mode. This is confirmed to some extent by a substantial proportion of 'other' modes reported for line 1 stations (23% for Azbet Al Nakhl, and 17% for Dar Al Salaam) compared with the recently opened Shubra El-Kheima (line 2), where this proportion was under 1%. It may be that 'other' modes are, in practice, referring to the trip not being made previously, or on other routes, or use of the previous suburban rail service. The most common previous mode used (excluding 'other' as a category) was the CTA full-size and minibus services (64% overall, rising to 72% in the case of Shubra El-Kheima). Paratransit was generally the next most important mode (25% overall, rising to 41% for Dar Al Salaam). The higher proportion for Dar Al Salaam may be associated with its location closer to the city centre. Car use was negligible, as would be expected from zonal car ownership levels.

As might be expected, the dominant access mode from the station to home (or other destination) for passengers departing from trains was foot, an average of 69%. The next most common mode was paratransit, at 23%, followed by CTA services, at 6%. A much higher proportion of motorised access was found at Shubra El-Kheima, at 41%. This is probably associated with the larger catchment area of the station, being on the northern edge of the built-up area of the city. Given the high population density of the city, one might have expected an even higher walking proportion - the figure is, for example, very similar to that found for London Underground stations (an average of 67%) (8). The main difference is that the motorised element in London is comprised mainly of LT's own bus services (16%) and car (11%), plus 6% other, whereas in these districts of Cairo it is comprised almost entirely of public transport services, mostly paratransit.

Perhaps surprisingly, very little relationship was found between income level and use of paratransit as a feeder mode (not significant at the 95% level). One could have expected the lowest income groups to be more likely to walk. However, it is more likely that distance from the station is the determining factor.

In the case of age distribution of respondents a direct comparison was made with the Rio data (9), showing a very similar pattern, probably typical of such cities and their overall age distribution. In comparison with the city-wide age distribution there is, as would be expected, a smaller share of the youngest age groups (under 15), who are less likely to travel independently on the metro or make journeys requiring its use on a 'working

day'. The comparison with Rio also indicates that travel to/from work comprises 63% of journeys in Cairo, and 75% in Rio : the latter may be affected by higher fares and the lack of equivalent travelcard facilities to those in Cairo, discouraging non-work trips (especially student travel).

A generally very favourable attitude was found toward the metro by users interviewed (by definition, some bias occurs due to non-users being omitted). Ranked by descending percentage of those giving 'excellent', the characteristics are as follows: 1. Trip time and safety, 2.Accessibility to stations, 3. Comfort, 4.Cleanliness and cost. The lower ranking in terms of 'cost' may partly reflect greater sensitivity to cost among low-income groups as a whole, but even if this case, little differerence was found . Within the sample, the proportions of each income group rating each characteristic as 'excellent' ranged from 48% to 56% .

5. Price elasticity

A fares increase averaging about 20% was applied in October 1996. Data has been made available for monthly sales of single tickets and travelcards before and after this date. Whereas single cash ticket sales grew by about 7% in January-October 1996 compared with 1995, this became a reduction of 8% in the equivalent period in 1997. Conversely, travelcard sales continued to grow at a very similar rate (about 7% per annum) throughout this period. It thus appears that single cash tickets display a greater price sensitivity, as might be expected, while that for travelcards is very low. The price increase might also have stimulated some passengers to shift from cash singles to travelcards, as well as shifts to lower-priced bus services, and possibly to walking for short trips in the central area.

A price of elasticity of about -0.4 may thus be derived for cash singles, or one of about -0.2 for the whole market (including travelcards). This is a similar outcome to that found in Santiago (an elasticity of -0.24 for line 2, serving lower-income parts of that city) (5) and in London (an 'own price' elasticity of –0.43, and a 'conditional elasticity' of –0.17) (10), despite the price differential vis a vis bus (which does not apply in the Santiago or London cases).

6. Conclusions

The Cairo Metro plays a major role in that city, comprising about 25% of all public transport trips, or around 50% in those corridors which it serves.

A survey in selected low-income areas confirms that users of the metro appear to be representative of the average income and car ownership levels in such areas, despite the metro fares premium vis a vis bus and shared taxi competitors. Where other metro proposals in low-income cities currently rely on a price differential to justify their construction, notably the proposed privately-funded metro for Mumbai (11) – which assumes a 40% differential vis a vis existing modes - this suggests that, within the range observed, a premium may be acceptable if journey time differentials are sufficiently large.

The survey also indicates that most travel by residents of low-income zones was previously made by other public transport modes. A substantial proportion (about 25%) of access to stations is by motorised modes, primarily bus and shared taxi.

A price elasticity of around –0.2 may be derived from recent fare changes, consistent with evidence from other metro systems. However, the very low fares for students suggest that a cross-subsidy may exist toward this group. While a discount may be found for good marketing reasons (currently 30% in London) the 80% figure is exceptionally high.

Note

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