Pakistan Journal of Applied Economics, (1986), Vol. V No. 2, (143 – 162)

LAND DENSITIES IN KARACHI

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This paper analyses the pattern of gross population densities at the census tract level in Karachi in 1981. The basic negative exponential function of land density with respect to distance from CBD is extended in a number of ways to allow for the peculiar features of urban growth in Karachi. These features include land-use zoning near the CBD, spatial autocorrelation, high density slums in proximity to major employment centers and at the urban periphery, etc. Various econometric refinements are also introduced to remove any bias in estimation.

The basic conclusion is that land density and its gradient is low in Karachi in relation to other major Third World cities. A number of explanations are offered for the extensive pattern of urban development. To the extent that this is sub-optimal, a number of suggestions are made for raising densities over time.

The city of Karachi, which is the largest metropolitan city in Pakistan, currently has one of the lowest city level population densities among the major cities[1] of South and South East Asia [United Nations (1986), and Vining (1986)]. As such, a basic question arises regarding the spatial configuration of land densities in Karachi. Either these are low throughout Karachi, implying a relatively flat density gradient and indicating less conges-

* The authors acknowledge the valuable comments of Salim Chishti and Nuzhat Ahmad and the assistance of Haroon Jamal and Salman Malik. Thanks are also due to the Karachi Development Authority and the Election Commission of Pakistan for making available the required data maps. Any defects which remain are, of course, the sole responsibility of the authors.

[1] These cities are Bombay, Calcutta, Delhi, Madras, Dhaka, Bangkok, Colombo, Kaula Lampur, Jakarta and Manila.

tion and pollution generally or they are high in the central city, but very low at the periphery, suggesting a high density gradient and considerable urban sprawl. It is the objective, therefore, of this paper to determine the magnitude of the population density and its gradient at different locations in Karachi.

A study of land densities in Karachi is also likely to prove useful for urban planning exercises in a number of ways. First, it can provide a basis for projecting the spatial distribution of the city population, as it grows. This will help in the intra-urban organisation and development of municipal services and in the location of commercial and industrial activities. Second, it will identify the presence of pressure points (if any) within the city with relatively high levels of congestion and pollution which may require short-term remedial measures to improve access to and quality of the living environment.

The paper is organised as follows. Section II highlights the principal elements in the long-term process of urbanisation of Karachi and the emerging spatial distribution of economic activity and housing in the city. Section III presents a review of literature on the various techniques that have been used to date to identify the pattern of land densities in a city. Section IV contains the specification of the model and the results of the empirical analysis of land densities in Karachi. Finally, section V develops some of the possible policy implications of the findings.

II. The Process of Urbanisation in Karachi

Karachi's urbanisation process essentially started after 1843 when the British colonial administration extended its territorial control to the Sind and Northern areas following victory in the Afghan War of 1838 [Haider (1974), Raza (1984), Bailler (1975), Feldman (1960)]. Before this, the region was controlled by Kabul and Karachi was primarily a small fishing town of subordinate importance, with a population of about 14,000, and few links inland. Following the British takeover, the location of Karachi was developed due to its commercial and administrative advantages as a port. As a consequence, Karachi's population rose to 90,000 within 50 years of the colonial occupation. In 1947, at the time of creation of Pakistan, it had a population of about 500,000.

During the colonial period, the business center of the city developed in close proximity to the port area. A low income residential area, Lyari, came into being in the western part of the city. It primarily housed the port workers and fishermen. To the east of the center, some four to five kilometers inland, a military cantonment area was established. A wide road

(Bunder Road) was constructed to connect the two centers of activity, viz., the port and the cantonment. Along this road, trading and commercial offices were located. Within the cantonment area, colonial residences were laid out with large plot sizes and high standards of provision of services. From the local population only the elite, consisting primarily of rich traders and property owners, could live in this exclusive part of the city. Thus, the city was divided into a colonial and indigenous part. The structure of the city was essentially characterised by spatial dualism.

After the departure of the British in 1947, Karachi became the capital of the newly created Pakistan.[2] This was accompanied by a massive influx of refugees from India. By 1951, the population of the city had more than doubled to 1.1 million. Given Karachi's role as a port and administrative center, it became the focal point of industrialisation. Due to a series of concessions including cheap credit, low real wages, overvalued foreign exchange, etc., merchant capital was increasingly diverted into investment in large-scale industry. The resulting rapid economic growth attracted a further flow of migrants from up-country. By 1961, the population had grown to 1.9 million.

The rapid growth in housing demand due to the growth in population and income was accommodated by the development of a number of housing schemes essentially at the boundaries of the city at the time of partition. This included areas like the P.E.C.H.S., Clifton, etc. Relatively large plot sizes were provided for, upto 2,000 square yards. A large industrial area, the SITE, was established in the north western part of the city. This led to the emergence of low income settlements and slums in proximity to the centers of employment. An example is Shershah Colony.

During the early 60's, two new townships, Korangi and North Karachi, were planned at the urban periphery (almost twenty miles from the CBD) to relocate the majority of central city slum dwellers by forced eviction. The objective was to clear the central part of the city and provide for urban renewal. This program represents historically one of the biggest failures to relocate the urban poor. The absence of employment opportunities in the vicinity of the townships led to large-scale return migration to areas proximate to the business center of the city. Simultaneously, the process of commercial development by banks, hotels, trading companies to benefit from the agglomeration economies at the center, led to an enormous increase in land prices and brought high-rise construction for the first time to the city.

[2] Karachi ceased to be the capital in 1961 when the new city, Islamabad, in the north of the country was established to play this role.

However, limits were rapidly reached to high-density development at the CBD, primarily due to constraints imposed by the lack of physical infrastructure. As a consequence, secondary centers of trading and business activity have developed, e.g., Tariq Road in P.E.C.H.S., Liaquatabad, etc.

The next major event in the process of urbanisation of Karachi was the separation of the eastern wing of Pakistan in 1971 which again led to a substantial inflow of refugees. By 1972, the population of the city had expanded to 3.5 million. Most of the refugees took residence in the hilly area north of the SITE (Sind industrial trading estate) which had remained largely uninhabited till then because of the difficult terrain and inaccessability of services, although it was proximate to a major employment center. This area is known as Orangi Town and is considered now to be one of the largest slums in the world.

From the mid-70's onwards, the massive inflow of remittances from the Middle East and the shift towards apartment housing have led to substantial investment in the housing sector of the city. This has meant, first, a faster rate of development of existing schemes like North Nazimabad and North Karachi and in the South, Clifton and the Defence Housing Society. Second, a number of new housing schemes have been implemented including Gulshan-e-Iqbal and Gulistan-e-Jauhar in vicinity to the Karachi-Hyderabad Super Highway.

Simultaneously, the planning approach in the city has shifted to one of regularisation and improvement at existing locations rather than one of eviction and relocation at the periphery. Lyari, one of the oldest slums, received a minimum package of municipal services in the 70's for the first time. Also, as per the M.L.O.110, a legal status was awarded to slum dwellers in areas settled prior to 1978. In recent years, a number of slum areas have emerged in low quality locations (beds of rivers, etc.,) in proximity to the new housing schemes. By 1986, it is estimated that almost one-third of the population of Karachi lives in slums.

Altogether, the average land densities in 1981 of census tracts at various distance intervals from the CBD of Karachi are given in Table 1. It reveals that, as expected, there is a decline in densities in Karachi as distance from the CBD increases. However, there appears to be a small hump in the density as the periphery is approached. The highest density tracts consist essentially of central city slums like Lyari and Jacob Lines and of low income settlements near the industrial estates of SITE and Landhi-Korangi. As mentioned above, these include Shershah Colony near SITE. The intermediate density tracts comprise, first, of middle and lower middle income neighbourhoods like Nazimabad, PIB Colony, Malir, Saudabad, Drigh Colony, etc. Second, this category also includes areas proximate to the CBD

TABLE 1

Average land densities[a] of census tracts by distance from CBD in Karachi, 1981

Distance from CBD[b] (in kms)	Number of census tracts	Total population[c] (in 000s)	Total area[d] (in sq. kms.)	Average density (population per sq. km.)
00.0–02.5	22	560	18.5	30,213
02.5–05.0	20	575	19.4	29,613
05.0–10.0	41	1.447	116.9	12,380
10.0–15.0	26	1.032	181.5	5,685
15.0–20.0	22	903	115.0	7,848
20.0 and above	15	575	119.4	4,813

[a] These are gross densities at the census tract level.

[b] This has been derived as the actual transport distance from the mid-point of a census tract to the center of the city with the help of road transport network maps of Karachi Development Authority.

[c] From the District Census Report of 1981 for Karachi published by the Population Census Organisation.

[d] Areas have been estimated from maps provided by the Election Commission of Pakistan.

like New Chali, Ratan Talau and Saddar, where densities have been restricted by the fact that a sizeable portion of the space is devoted to business and commercial activities.

The low density tracts are primarily of three types. First, there are high-income housing schemes like P.E.C.H.S., Clifton, North Nazimabad, Gulshan-e-Iqbal. In addition, the lowest densities are observed in the cantonment areas. Second, low population densities are also prevalent in emerging settlements at the periphery of the city. Third, some industrial areas have low densities because bulk of the land is being used for non-residential purposes.

III. Review of Literature

The first work on the internal structure of cities was by Burgess (1925), a sociologist. He assumed that a metropolitan city area is circular in shape and derived the concentric zone theory, according to which the characteristics (including land density) vary with distance from the CBD or first zone.

Von Thunen (1826) first developed the concept of locational equilibrium. He argued that as a result of competitive forces, households distribute themselves within a city in such a manner that the same utility level is attained irrespective of location. Locational equilibrium implies that housing and land rentals are inversely related to distance from CBD, to compensate for the difference in transport costs. Given higher land prices at the center, densities would, therefore, be higher.

The first major empirical work on urban land densities is by Colin Clark (1951). He analysed the pattern of variation in densities among concentric rings spaced at intervals of one mile for a number of European, United States and Australian cities in the 19th and 20th centuries. He postulated that ring distances were a negative exponential function of distance from the CBD, as follows:

$$D(x) = A \exp(-bx + \epsilon)$$

implying

$$\text{Log } D(x) = \text{Log } A - bx + \epsilon \qquad (1)$$

Where $D(x)$ = average population density of a ring located x miles from the CBD; A = population density at the CBD; ϵ = error term.

Clark was able to demonstrate, first, that the negative exponential function, more or less, accurately depicts the spatial variation in land densities within most cities and, second, that there is a tendency for the density gradient, as measured by b, to decline over time. This flattening of the density curve he attributed primarily to improvements in transport technology over time.

Mills (1972) has given further empirical evidence, by analysis of a number of cities in the U.S.A., in support of Clark's conclusion. In addition, he has computed the integral of the density function over the area of the city to check for consistency of the estimated function with the actual population of a city.

Muth (1969) has tested the negative exponential function for 46 United States cities on 1950 Census data. He has analysed densities at the census tract level rather than concentric rings or annuli used earlier. He has also extended the specification of the density function by including a quadratic term as follows:

$$\text{Log } D(x) = \text{Log } A - b_1 x + b_2 x^2 + \epsilon \qquad (2)$$

with x representing the aerial distance of a census tract from the CBD. He finds that the quadratic term is significant in twelve cities.

Brush (1968) and Asabera and Banahene (1984) represent the first empirical works on urban land densities in developing countries. The latter have used a similar methodology to that developed by Muth. The negative exponential function (with a quadratic term) is fitted to data from five Ghanian cities for 1960 and 1970. The inclusion of the quadratic term is justified on the grounds that in developing countries, the demand far exceeds the supply of low income housing and consequently the excess demand spills over into high density peripheral slums. Asabere and Banahene (1984) conclude that densities in the Ghanian cities studied are generally higher than those found in developed countries.

Kahimbaara (1986) has shown in the context of the city of Nairobi in Kenya that the dualistic pattern of urban development, carried over from the colonial period, has led to a situation where the density gradient for the non-black population can be defined with respect to the conventional CBD while the gravitational point for the black population is actually the industrial area and not the CBD.

Other recent work has extended the analysis of land densities in three directions. First, additional variables have been included in the negative exponential equation to enrich the specification. Second, alternative functional forms have been tried instead of the exponential. Third, various econometric refinements have been suggested to remove any biases in the estimation procedure.

With regard to the first class of extensions, Griffith (1981) has developed a specification which allows for a multi-centered city. In addition, he defines location in terms of (X,Y) co-ordinates in Cartesian space. Further, he allows for externalities in spatial infrastructure, with development in one census unit affecting development in adjoining tracts. This has been incorporated through first order spatial autocorrelation. The resulting specification is as follows:

$$D_i = (1 - \rho)\,\alpha + \sum_j \exp\,(-\sum_k b_{jk}\, x_{ij}^k) + \sum_g \sum_h \alpha_{gh}\, U_i^g V_i^h + \rho \sum_f W_{if}\, D_f + \varepsilon_i \qquad (3)$$

Where D_i = population density of the ith tract; U_i and V_i = orthogonal coordinates of location i; $W_{if} > 0$ if location i and f are juxtaposed; $W_{if} = 0$ otherwise; ρ is the coefficient of autocorrelation. The estimation technique used is non-linear least squares.

Different functional forms, primarily polynomials of different order, have also been tried in the literature. More recently, Anderson (1982) has fitted a cubic spline function on 30 United States cities from 1970 Census data. This approach allows for a multimodal density function arising due to the influence of sub-centers. The spline functions are obtained by making piecewise cubic polynomials continuous at different knots, which are equally spaced from each other.

Attempts to reduce bias in the estimation procedure include the work by McDonald and Bowman (1976). They perform a constrained regression such that the parameters of the density function yield a population estimate consistent with the actual population according to the procedure first suggested by Mills. Frankena (1978) demonstrates that because census tracts are unequal in area, with peripheral tracts being larger than central ones, unweighted OLS estimation of urban population density functions using census tract observations leads to a severe upward bias in the estimated function. He suggests instead a weighted least squares procedure which leads to an unbiased estimate, with weights corresponding to the square root of the land area of a tract. In addition, he points out that if one computes the integral of an unbiased estimate of the density function over the area of a city, that integral is not necessarily an unbiased estimate of total population. This explains the disturbing empirical results concerning density functions reported by McDonald and Bowman.

IV. The Empirical Analysis

The Model

A description of the process of urbanisation in Karachi in terms of emerging spatial distribution of economic activity and housing in section II and a review above of the types of land density functions used elsewhere provide the basis for specification of the particular model to be estimated in the Karachi context.

Two basic functional forms are tried – the negative exponential with and without the quadratic term and the polynomial up to the cubic order. A spatial autocorrelation variable is included, as per Griffith (1981). This variable is measured in the following manner:

$$S_i = \sum_f W_{if} D_f \qquad (4)$$

Where S_i = spatial autocorrelation variable for the ith census tract; $W_{if} > 0$ if the fth census tract adjoins the ith tract, $W_{if} = 0$, otherwise. The magnitude of the weights has been derived as follows:

$$W_{if} = \frac{L_{if}}{\sum_f L_{if}}, \sum_f W_{if} = 1 \qquad (5)$$

Where L_{if} is the land area of the fth tract, D_f is its population density. Therefore, as a simplifying procedure, these weights have been specified *a priori* as corresponding to the share of land in an adjoining tract in all the land in adjoining tracts, and not estimated from the regression. This amounts to taking S_i as being equivalent to the overall land density in all the adjoining tracts combined.

The fact that there has been a spatial clustering of slums and low income settlements (for example, Shershah Colony, Lyari and Orangi Town) in low quality locations proximate to major secondary employment centers, like SITE and other industrial areas, has been allowed for by specifying an interactive dummy variable, as follows:

D_p = 1, when a census tract is located at distance z, with $z < z^*$, from an industrial area;

D_p = 0, otherwise,

z^* is the maximum distance of location of proximate tracts. The interactive dummy variable used is $D_p z$. The value of z^* which yields the best results is used. This again represents a simple, though, as will be shown later, effective way of allowing for a multi-centered city in contrast to the relatively complicated procedure adopted by Griffith. In addition, it permits modelling of the type of dualistic urban development postulated by Kahimbaara, with the gravitational point for lower income groups being industrial areas rather than the conventional CBD of a city.

In addition, a number of extra variables have been included in the specification to capture the peculiar features of urban growth in Karachi. These relate primarily to the impact of zoning on densities. As mentioned earlier, during the colonial period, the pattern of development of the city was characterised by spatial dualism. The neighbourhoods (primarily within cantonment areas) where the colonial population lived had large plot sizes and low-density development. The rest of the city had substantially higher densities. Some of these cantonment areas (especially Karachi, Mauripur and parts of Drigh Road cantonments) now are relatively close to the center of the city as a result of the horizontal expansion of the city following independence. However, densities continue to be low in these areas because, by and large, the colonial housing pattern has been preserved and these areas have not been opened up to more intensive commercial and residential development.

This implies that if the negative exponential function, for example, is estimated without allowing for the fact that some of the tracts closer to the CBD have been demarcated as cantonment areas with associated low densities, then there would be a tendency for the density gradient to be biased downwards.[3] Therefore, an additional dummy variable has been defined which assumes the value of one when a particular census tract is part of a cantonment area, and zero otherwise. Further, population densities are also likely to be low in industrial areas because bulk of the land is devoted to non-residential use. As such, another dummy variable, D_I, has been included. D_I takes a value of one when a tract is part of a designated industrial estate or area, and zero otherwise.

Altogether, the two types of equations estimated are:

$$\text{Log } D_i = (1\text{-}\rho)\,\alpha - b_1 x_i + b_2 x_i^2 + \gamma_1 (D_p z) - \gamma_2 D_c - \gamma_3 D_I + \rho \log S_i + \epsilon_i \qquad (6)$$

and

$$D_i = (1\text{-}\rho')\alpha' - b_1' x_i + b_2' x_i^2 + b_3' x_i^3 + \gamma_1' (D_p z) - \gamma_2' D_c - \gamma_3' D_I + \rho' S_i + u_i \qquad (7)$$

Data

The data on population at the census tract level has been obtained from the District Census Report of 1981 for Karachi, published by the Population Census Organisation. In 1981, there were 151 tracts within the metropolitan limits. These tracts actually correspond to the Karachi Municipal Corporation's (KMC) electoral units (Union Councils). The geographical area of each unit has been measured with a planimeter from maps provided by the Election Commission of Pakistan. Gross population densities have been computed as the population per square kilometer of land area. 146 census tracts have been included in the analysis because adequate data was not available on five tracts due to lack of proper delineation of boundaries or population.

For deriving distances the center of the city has been taken as the head office of the Karachi Metropolitan Corporation (KMC). The choice is justified on the grounds that, first, the KMC office is used as the zero point in the measurement of distances from Karachi to other parts of the country. Second, it is a very central location surrounded by major government offices, railway station, courts, trade and business establishments, wholesale markets, etc. Third, the public transport system in the city converges to this point.

[3] It is perhaps interesting to note that while these low-density zones currently contribute to reducing the density gradient, at an earlier stage of development of the city when such zones were at the periphery they would actually have tended to increase the gradient. Therefore, one factor which could explain the decline in density gradients over time is the presence of tracts where densities have been artificially restricted by zoning which tend to become more central as the city develops over time.

Distances used correspond to actual transport distances from the mid-point of a tract to the center of the city. This is the recommended procedure, as it is shown in Appendix 1 that the use of aerial distance, which is the case with most studies to date, leads to a biased and inconsistent estimate of the density gradient.

The actual road transport distances for different census tracts have been calculated from detailed road network maps of the city provided by the Karachi Development Authority (KDA). Given alternative routes, the shortest distance has been used.

Results

Results of the econometric analysis are presented in Tables 2 and 3. The former presents estimates of the coefficients of equation (6) and the latter of equation (7). A number of conclusions emerge from the empirical analysis. The sign of the quadratic term is positive in both exponential and polynomial regressions, with greater significance in the former. The presence of relatively high density slums and low-income settlements at the urban periphery is confirmed. These densities are apparently higher than what would be indicated given the large distance, over 20 kilometers, from the CBD.

Spatial externalities are also confirmed by the positive sign of the autocorrelation variable in all regressions, and its high level of significance generally in the polynomial regressions. A key result of the study is the high level of significance of the zonal and employment center proximity dummy variables. These, as hypothesized, serve to increase density gradients. For example, the WLS regression with the basic negative exponential form reveals an absolute gradient of 0.05. It rises to 0.16 following the inclusion of the dummies. This underscores the strong impact of land use zoning on the spatial configuration of densities within a city. Other things being equal, it appears that densities in cantonment and industrial areas are lower by 59 and 40 per cent respectively (according to the exponential WLS regression).

V. Policy Implications

A comparison is made of the density gradient in Karachi as estimated from the regressions with those derived for other cities in Table 4. It may be observed that the density gradient, especially as indicated by the basic exponential regression, in Karachi is very low in comparison to other cities. The incorporation of the zonal dummy and proximity variables, as mentioned earlier, increases the density gradient in absolute terms and for most

TABLE 2

Results of regressions (exponential form)

(The dependent variable is log of density)

	OLS[a]			WLS[b]		
Variable[c]	1	2	3	1	2	3
Constant	10.68 (73.0)	8.36 (4.9)	8.71 (5.5)	9.15 (45.4)	7.73 (4.3)	8.26 (4.6)
x	−0.08 (−7.1)	−0.06 (−3.0)	−0.18 (−3.8)	−0.05 (−4.1)	−0.09 (−1.5)	−0.16 (−2.6)
x^2	–	3.01×10^{-3} (1.9)	5.00×10^{-3} (2.8)	–	1.42×10^{-3} (0.7)	3.90×10^{-3} (2.0)
Log S	–	0.25 (1.7)	0.22 (1.6)	–	0.17 (1.1)	0.17 (1.1)
D_c	–	–	−1.71 (−3.2)	–	–	−0.90 (−3.3)
D_I	–	–	−0.86 (−2.4)	–	–	−0.52 (−1.9)
$D_p z$	–	–	0.12 (2.7)	–	–	0.13 (2.1)
R^2	0.26	0.32	0.40	0.94	0.94	0.95
Degrees of Freedom	144	142	139	144	142	139

[a] Ordinary Least Squares.
[b] Weighted Least Squares.

[c] x = distance from CBD,
S = spatial autocorrelation variable,
D_c = dummy variable for cantonment areas,
D_I = dummy variable for industrial areas,
$D_p z$ = dummy variable for proximity to secondary employment centers.

TABLE 3

Results of regressions (Polynomial form)
(The dependent variable is density)

Variable[c]	OLS[a] 1	OLS[a] 2	OLS[a] 3[d]	WLS[b] 1	WLS[b] 2	WLS[b] 3[d]
Constant	50062.00	40203.00	37395.00	17807.00	20858.00	13780.00
	(15.8)	(3.4)	(3.7)	(7.5)	(2.2)	(1.9)
x	−1956.00	−4743.00	−3536.00	−630.00	−4065.00	−1311.00
	(−7.6)	(−2.0)	(−3.0)	(−4.2)	(2.2)	(−1.9)
x^2	–	239.10	103.10	–	273.40	32.00
		(1.2)	(2.5)		(2.1)	(1.3)
x^3	–	−4.03	–	–	−5.90	–
		(−0.8)			(−2.2)	
S	–	0.47	0.50	–	0.39	0.40
		(3.0)	(3.1)		(3.1)	(3.45)
D_c	–	–	−22383.00	–	–	−9349.00
			(−2.0)			(−3.2)
D_I	–	–	−13547.00	–	–	−7689.00
			(−1.8)			(−2.5)
$D_p z$	–	–	2446.00	–	–	1055.00
			(2.2)			(1.7)
R^2	0.29	0.42	0.46	−2.14	−1.57	−1.39
Degrees of Freedom	144	141	139	144	141	139

[a]Ordinary Least Squares.
[b]Weighted Least Squares.
[c] x = distance from CBD;
S = spatial autocorrelation variable;
D_c = dummy variable for cantonment areas;
D_I = dummy variable for industrial areas;
$D_p z$ = dummy variable for proximity to secondary employment centres;
[d]The cubic term has been dropped because of its significance.

TABLE 4

Comparison of average land density gradients
of cities in selected countries with Karachi

U.S.A.[a] (20 cities)	Korea[b] (12 cities)	Latin America[c] (8 cities)	India[d] (12 cities)	Ghana[e] (5 cities)	Karachi[f] 1981
1960 −0.199	1966 −0.701	1950 −0.260	1951 −0.675	1960 −0.590	OLS −0.080 WLS1 −0.193 to 0.042
1970 −0.123	1973 −0.639	1970 −0.230	1961 −0.652	1970 −0.550	WLS2 −0.304 to 0.290

[a] Mills and Ohta (1976).

[b] Mills and Song (1979).

[c] Ingram and Carroll (1981).

[d] Brush (1980).

[e] Asabere and Banahene (1984).

[f] OLS = Basic negative exponential regression with OLS;
WLS1 = Negative exponential regression with quadratic term and dummy variables, etc., with WLS;
WLS2 = Second degree polynomial regression including dummy variables, etc., with WLS.

locations in the city it comes closer to those observed in the United States and Latin American cities. However, it remains much lower than those estimated for India, Korean and Ghanian cities. The latter group of cities are perhaps more relevant for comparison because per capita income levels are likely to be closer to that Karachi than in the former group. Therefore coupled with the initial observation that the overall city level land density is low in comparison to other large cities of South and South East Asia, we have the basic conclusion that densities are generally low at most locations in Karachi. This is not to deny the existence of localized pockets of high density (see Appendix 2) which may need some short-term remedial measures to improve access to and quality of living environment.

Part of the explanation for the generally low land density gradient in Karachi lies in the fact that the analysis has been undertaken for a more recent year, i.e., 1981, in relation to the other cities. There is a secular tendency, as demonstrated by Clark (1951) and Muth (1969), for gradients to decline over time and for larger cities, like Karachi, to have lower gradients [Wheaton (1974)]. Also, since land at the periphery of Karachi consists primarily of culturable waste, the opportunity cost of its conversion to urban use is low. This is likely, as shown by Wheaton (1974), to lead to relatively low land densities throughout the city. Further, as derived earlier, the use of actual as opposed to aerial distance reduces the density gradient.

Perhaps, more importantly, various types of government intervention in the housing and land market of Karachi have also contributed to the extensive form of urban development. These include building height controls, zoning, high planning standards, sub-divisioning of land in housing schemes into relativily big plot sizes, and large subsidies on the sale of land.

It needs to be appreciated that the relatively low density pattern of urban development, as witnessed in Karachi, has both benefits and costs. In terms of the former, the externality costs of congestion and pollution are likely to be lower. However, low densities could have the consequence that costs of provision of municipal services like water, sewerage, electricity, gas, telephone, transport, etc., are higher because the network to serve a given population has to be spread over a larger area.[4] It is possible then that if the higher service costs are traded off against the lower costs of externalities, densities in Karachi are below socially efficient levels. This is likely to be true especially since the present system of development charges underrecovers

[4] According to the National Human Settlements Policy Study (1986), the average capital cost of providing municipal services and housing in Karachi to an additional person is Rs.110,000. This compares with the cost of about Rs.40,000 for an additional person in a small city with a population of about 50,000 to 100,000. The basic reason for the difference is that since Karachi has a substantially larger area there is need to provide for higher trunk infrastructure costs.

the costs of provision of services and as such locational decisions are not based on the actual costs of access to services.[5]

Therefore, if the current level of densities is below socially optimal levels then the case for continued horizontal expansion of the city does not appear to be strong in the medium run. Instead of periodic extension of metropolitan limits a policy of consolidation of existing land may, therefore, be recommended. In the context of the central city, this would imply investment in various forms of urban renewal and development, including improvements in transport (roads and parking) infrastructure and the opening up of parts of cantonment areas nearer the CBD to more intensive commercial and residential development. For the rest of the city, especially in the various housing schemes, building height controls may be at least partially withdrawn and in the future subdivisioning of land, large plot sizes kept to a minimum. In addition, the practice of subsidising land and provision of services will have to be replaced by a policy of pricing land closer to market levels and levying development charges and tariffs which correspond to the true marginal social cost of services.

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[5] Currently development charges for new housing schemes at best recover the retail distribution costs of provision of services. Any additional trunk infrastructure costs are not included in the estimation of these charges. Therefore, there is an implicit subsidy on the latter type of costs.

Appendix 1

Use of Actual Versus Aerial Distances

The standard theoretical models of urban spatial structure define x_i as the actual transport distance. However, x_i will usually be equal to or greater than the aerial distance, z_i. The extent of divergence between x_i and z_i will depend, of course, on how far the ith census tract is from the center of the city and on how developed the transport infrastructure is within a city. It is unlikely that $x_i = z_i$ throughout the city. Therefore, the relationship between x_i and z_i can be expressed as:

$$x_i = z_i f(z_i) + u_i, \; f > 1, \; f' \geqslant 0$$

A particular functional form for f which has the desired properties is:

$$f(z_i) = 1 + \theta_1 + \theta_2 z_i \qquad \text{(A1)}$$

Where $\theta_1 > 0$ and $\theta_2 \geqslant 0$. The higher the magnitudes of θ_1 and θ_2 the less developed is the road network in a city.

Now, the basic negative exponential function for density is

$$\log D_i = \alpha - \beta_1 x_i + \epsilon_1$$

substituting from (A1) we have,

$$\log D_i = \alpha - \beta_1 (1 + \theta_1) z_i - \beta_1 \theta_2 z_i^2 + \epsilon_1' \qquad \text{(A2)}$$

Therefore, if aerial distances are used, and the estimated function is

$$\log D_i = \alpha - \beta_1 z_i + v_i \qquad \text{(A3)}$$

then comparison of (A3) with (A2) reveals clearly the bias in the estimation of β_1, as follows:

Case I: $\theta_1 > 0, \theta_2 = 0$: $E(\hat{\beta}_1) = \beta_1 (1 + \theta_1)$

Case II: $\theta_1 > 0, \theta_2 > 0$: $E(\hat{\beta}_1) = \beta_1 (1 + \theta_1) + \beta_1 \theta_2 E(z_i, z_i^2)$

Therefore, in both cases, the estimated $\hat{\beta}_1$ from (A3) is both a biased and inconsistent estimator of β_1, the density gradient. Since $\theta_1 > 0, \theta_2 \geqslant 0$, and $E(z_i, z_i^2) > 0$ we also have that the nature of bias in the estimation of the absolute value of the density gradient is upwards. The magnitude of this bias is likely to be larger for cities in developing countries, other things being equal, because they will generally have a less elaborate road network than cities in developed countries, implying that θ_1 and θ_2 are higher for the former.

Appendix 2

Census Tracts with High Densities in Karachi, 1981

The census tracts with densities exceeding 60,000 persons per square kilometer are presented below in descending order of magnitude of densities:

KMC Electoral Unit No	Details of Area	Density	Land* Area	Distance from CBD
20	Old Town	123,793	0.17	0.8
30	Dharamsiwara, Ramswami	92,352	0.47	2.4
42	Bhutta Village (part)	88,715	0.52	8.0
29	Ranchore Line III and IV	87,161	0.35	1.6
19	Kharadar	86,329	0.37	0.8
38	Chanesar (part)	82,261	0.40	7.6
8	Shah Beg Lane 1	79,018	0.28	2.2
9	Shah Beg Lane 2	74,963	0.43	2.8
7	Baghdadi	72,962	0.29	1.6
13	Khumbharwara	67,794	0.36	2.2
12	Gul Mohammad Lane	67,702	0.34	2.8
144	Drigh Colony (part), Block 4	65,090	0.69	16.4
108	Jacob Lines	63,977	0.69	3.6
14	Rexer Lane	63,383	0.33	2.6
16	Kalakot	62,782	0.27	3.3
5	Nawaabad	62,238	0.62	1.6
3	Daryabad	61,527	0.64	2.5
29	Ranchore Line I	61,203	0.22	2.0
76	Part IV, F.B. Area, Block 17,18	60,218	0.54	13.6

* Land areas of high-density tracts are relatively small because since they correspond to electoral units an attempt has been made to preserve a degree of constancy in population among the units.

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