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A Study of Population Density Distribution Pattern of Karachi City Using Spatial-Interaction Gravity Models ($Sigm_s$)

[1]Shaheen Abbas, [2]Muhammad Rashid Kamal Ansari

[1] Mathematical Science Research cente, Federal Urdu University of Arts Sciences & Technology, Gulshan-e-Iqbal Campus, Karachi

[2] Department of Mathematics Sir Syed university of Engineering

Abstract: Administratively, before the year 2000 Karachi was distributed in five districts. Afterwards, it was divided into eighteen towns. It gave rise to a great controversy that whether the 5-district system is administratively better or the 18-town system. A study of the population-area distribution of the Karachi city with reference to 5-district system and 18-town system is the basis of this study. Hoover Indices (HI) and Lorenz Curves (LC) are particularly utilized for the purpose. Comparing the outcomes we will be in a position to determine that which system is scientifically better. It is found that the patterns for 18-towns are better than the 5-district patterns. The town wise population density can be determined with the help various models. Spatial-Interaction Gravity Models (SIGM) and FGDM are utilized. These models are based on the selection of a suitable pivot point. Pivots can be selected on the basis of being either most dense or less dense. The system is studied with the help of both the approaches and the results are compared to conclude that selecting the least dense town as the pivot leads to better results. Spatial Interaction Model (SIM) is another model which is developed here to determine the population density distribution. It also utilizes the least pivot. It generates a distance gradient coefficient λ that determines the probability of change of the population density of the towns. SIM results confirm the results obtained by applying FGDM. For this purpose Spatial Interaction Logistic Model (SILM) is utilized.

Keywords: Katchi-Abadies, Spatial Interaction Model (SIM), Flatten Gradient Density Model (FGDM), Hoover Indices (HI) and Lorenz Curves (LC)

1. INTRODUCTION

In this study analyze the pattern of Population-Area (Density) distribution of the past and present patterns of administrative distribution of the city of Karachi into subunits (districts and towns). The population-area data is based on 1998 census and is available district wise (5-district) whereas, 2011 estimates are available town wise(18-Town). The 1998 district wise data corresponds to the five districts of Karachi viz. the Central, South, West, East and Malir districts. Whereas, the 2011 town wise data corresponds to the eighteen towns of Karachi viz. Saddar, Jamshad, Gulshan-Iqbal, Gulberg, Liaquatabad, ShahFaisal, Malir, Landhi, North Naziamabad, North Karachi, New Karachi, Korangi, Orangi, Lyari, Gadap, BinQasim, Baldia and Kemari[1,5 ,7] . It gave rise to a great controversy that whether the 5-district system is administratively better or the 18-town system. Later, it was converted into a hot political debate. Now, the 5-distric system is again adopted. This study is an attempt to explore the truth on scientific basis irrespective of all political biases. we have determined earlier the district wise population area distribution pattern of 100 selected KKA_S utilizing the Hoover index and Lorenz curves [2].We have said

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earlier that in most of the cases the KKAs are embedded in between the settled area and are intermingled on some places so it becomes necessary to study the population-area distribution pattern of the total area as well [5].In this study the total population area distribution pattern of each district as well as each town will be discussed.

In section 2.0 we have determined the best pattern distribution of District and towns by using the Lorenz curves and Hoover index techniques. These analysis are provided the best Population-area Pivotal town on the

basis of DP and LP approaches. In section 2.1, the town wise population density can be determined with the help Spatial-Interaction Gravity Models (SIGMs).we will develop two (Density) Distribution pattern. In section 3 we will selected Densest and least dense such models the Flatten Gradient Density Model (FGDM) and the Spatial Interaction Model (SIM). These models are called modify form of SIGMs. we can forecast the population densities of these towns with the help of their distances from these pivots and the gradient coefficients β ranging over (0.2, 0.5, 1, 1.5, 2). Appropriation of FGDM we will use such models like Linear Regression Model (LRM), Linear Transformation Exponential Model (LTEM) and Log Linear Model (LLM) all indicate a good distance-density correlation. We will construct SIM for the determination of population density distribution using the LP method. This method itself generates a suitable distance gradient coefficient λ.In addition, it determines the probability of change of the population density of the towns. The SIM results are in conformity with FGDM. To confirm the calculations and forecasts so obtained we shall conclude the results and discussion of the all results develop by above techniques and models in section 4.In section 5, include the conclusion in this communication.

2. Hoover Index and Lorenz Curve (HI and LC) Techniques

Hoover index and Lorenz curve (LC) is a practical examination of population deliberation and graphical interpretation [6 and 7] .Hoover index values has in the perspective of Lorenz curve. Hoover index is described as

$$H = 50 \sum_{i=1}^{r} \left| p_i - a_i \right| \qquad (1.1)$$

Lorenz curves are comparing the Spatial patterns of the area as well as the population of Districts and Towns [3,4 and 6]. These cumulative percentage areas against cumulative percentage populations are the required Lorenz curves. It also compares the spatial patterns [3, 4 and 6].

We have selected the cumulative percentage of the population – areas of 18-towns and 5- District ($CP_1, CP_2, \ldots, CP_n$ and $CA_1, CA_2, \ldots, CA_n$) respectively then the Hoover index

$$H = \max \left| CA_i - CP_i \right| \qquad (1.2)$$

In the Tables 1.1- 1.2 depicts the estimate for the

Table 1.1 Districts wise Distribution Pattern of Karachi

Towns	P_n(%)	A_n(%)	CP_n(%)	CA_n(%)	CA_n-CP_n	HI= max|CA_n-CP_n|
Saddar	6.608694	0.971990	6.608694	0.971990	5.636704	5.636704
Jamshed Town	7.870784	0.943158	14.479479	1.915148	12.564330	6.927626
North Nazimabad	5.322064	0.672265	19.801543	2.587413	17.214130	10.286503
Gulberg	4.864023	0.556610	24.665566	3.144023	21.521543	11.235040
SITE	5.014935	1.023954	29.680501	4.167977	25.512524	14.277485
Shah Faisal	3.601961	0.472556	33.282462	4.640533	28.641929	14.364444
Gulshan-e-Iqbal	6.706069	2.159978	39.988531	6.800511	33.188020	18.823575
Landhi	7.151374	1.575188	47.139905	8.375699	38.764206	19.940631
Korangi	5.861671	1.669178	53.001577	10.044877	42.956699	23.016069
New Karachi	7.338382	0.823919	60.339959	10.868797	49.471162	26.455093
North Karachi	3.283855	5.104456	63.623814	15.973253	47.650561	21.195468
Baldia	4.356429	1.175608	67.980243	17.148861	50.831382	29.635915
Malir	4.271953	0.715920	72.252196	17.864781	54.387414	24.751500
Orangi	7.762171	0.945276	80.014366	18.810057	61.204309	36.452810
Bin Qasim	3.396679	22.473061	83.411045	41.283118	42.127927	5.675117
Gadap	3.105789	57.957468	86.516834	99.240587	12.723752	7.048635
Lyari	6.521173	0.322042	93.038008	99.562629	6.524621	0.524014
Liaquatabad	6.961992	0.437371	100.000000	100.000000	0.000000	276.246628
Total	100	100	0	0		

Table1. 2 Town wise Distribution Pattern of Karachi

Districts	P_n(%)	A_n(%)	CP_n(%)	CA_n(%)	CA_n-CP_n	HI= max| CA_n-CP_n|
CD	40.612	40.572	40.612	40.572	0.04	0.04
SD	23.678	16.42	64.29	56.992	7.298	7.258
ED	18.897	10.9549	83.187	67.9469	15.2401	7.9821
WD	10.567	11.0986	93.754	79.0455	14.7085	6.7264
MD	7.1784	21.1363	100.9324	100.1818	0.7506	5.9758
Total	100.9324	100.1818	0	0	0	27.9823

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The fortitude of the HI (=26.9823 and =276.246) of the district and town wide distribution pattern and the respective LC is shown in Figs 1.1-1.2.

Figure 1.1. Lorenz Curve (LC) of Five Districts of Karachi

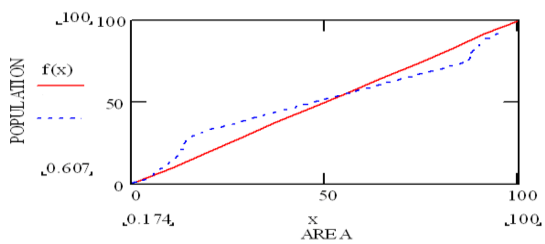
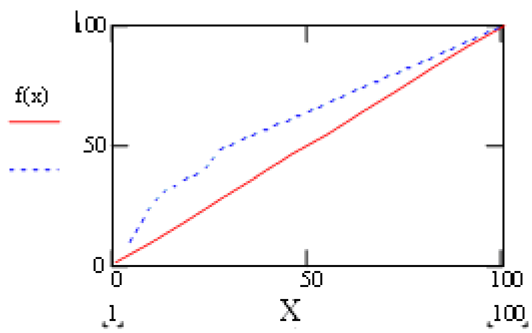


Figure 1.2. Lorenz Curve (LC) of Eighteen Towns of Karachi



In an analysis of the variation of the Lorenz curves from the 45^{o} line (Lorenz line), district, Central appears to be the densest district and the Malir district comes out to be less dense. The patterns do not appear to be uniform. Lorenz curves of the Lorenz line the town wise population distribution pattern appears to be better than district wise population distribution pattern. This perchance can resolve the current debate regarding the resumption of the system comprising of the district wise distribution of Karachi.

2.1 Densest Pivot and Least Pivot (DP and LP) Techniques

DP and LP approaches describe the distribution pattern of eighteen towns of Karachi city with respect to the densest populated town and least populated towns. Let $D_{T_1} \ldots D_{T_{18}}$ be the density of the eighteen towns $T_1 \ldots T_{18}$ respectively arranged in the descending order i.e. $D_{T_1} > D_{T_2} > \ldots > D_{T_{18}}$. The densest town among $D_{T_1} \ldots D_{T_{18}}$ is the densest pivot (DP) represented by D_{DP} (D_{T_1} in our case). The distances di = (D_{DP}, D_{T_i}) and dj = (D_{T_j}, D_{T_k}), i, j, k = 1…18 as depicted in Tabe: 1.3 are then calculated.

Now (D_{DP}, D_{T_i}, di) describe the town wise DP pattern

Table 1.3 Town wise Population Density Distribution by DP Technique

Town ($D_{DP} \ldots D_{T18}$)	Radius $\lvert D_{DP} - D_{T18} \rvert$	$d_i = p_i/a_i$	Distance B/w Two Locations $\lvert D_{TI} - D_{Tj} \ldots - D_{Tk} \rvert$
($D_{DP} = D_{T1}$)	0	467	0
D_{T2}	15	367	15
D_{T3}	16	205	1
D_{T4}	14	202	2
D_{T5}	18	192	4
D_{T6}	17	189.36	1
D_{T7}	10	183	7
D_{T8}	19	176	9
D_{T9}	6	157	13
D_{T10}	20	138	14
D_{T11}	7	113	13
D_{T12}	11	105	4
D_{T13}	8	85	3
D_{T14}	19	81	11
D_{T15}	17	72	2
D_{T16}	22	14.835	5
D_{T17}	27	3.485	5
D_{T18}	7	1.236	20

as depicted in Fig:1.3 Lyari town with density (467) is the densest town and so is considered as DP.

Fig: 1.3 Town wise Population Density Distribution by DP technique

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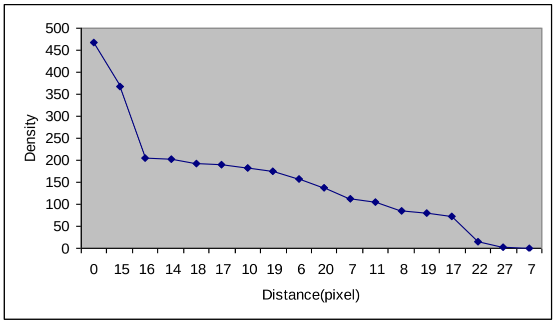


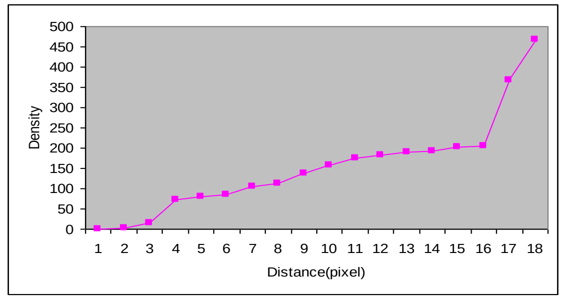
Gadap town has lowest density (1.236) and Liaquat Abad town has density (467) and density wise stands next to the DP. Bin Qasim town is at the largest distance (27 pixel) and density (3.485) from the DP whereas, Saddar town density (157) is closest to DP at a distance (6 pixel). The town with least density is considered as the Least Pivot (LP). So in the above set up $D_{T_{18}}$ is the least pivot LP. LPT is exactly the same as the DPT except that all calculations now will be made with reference to the LP. (D_{LP} , D_{T_i} , di) describe the town wise LP pattern as depicted in Table: 1.4.

Table 1.4 Town wise Population Density distributions by LP Technique

Towns(D_{LP}…D_{T18})	Radius $\lvert D_{Dp}-D_{T18}\rvert$	$d_i = p_i/a_i$	Distance B/w Two Locations $\lvert D_{Ti}-D_{Tj}.....-D_{Tk}\rvert$
$D_{LP}=L_{T1}$	0	1.236	0
L_{T2}	20	3.485	20
L_{T3}	15	14.835	5
L_{T4}	12	72.000	3
L_{T5}	15	81.000	3
L_{T6}	17	85.000	2
L_{T7}	14	105.000	3
L_{T8}	27	113.000	13
L_{T9}	13	138.000	14
L_{T10}	26	157.000	13
L_{T11}	17	176.000	10
L_{T12}	25	183.000	8
L_{T13}	24	189.360	1
L_{T14}	25	192.000	1
L_{T15}	21	202.000	4
L_{T16}	24	205.000	3
LT_{17}	22	367.000	3
LT_{18}	7	467.000	15

The curves in Fig: 1.4 reveal the pivot i.e the gradient varies inversely as the density.

Fig: 1.4 Town wise Population Density Distribution by LP Technique



Tables: 1.5 and 1.6 depict the results. As β varies from 2.0 to 0.2, the population density goes on decreasing and the associated curves finally flatten. In addition, for any value of β the density decreases as we go far from the pivot i.e the gradient varies inversely as the density.

Table 1.5 Population Density Forecasts Based on FGDM by DPT

β=2.0	β=1.5	β=1	β=.5	β=.2
467	467	467	467	467
3.43423E-11	6.20927E-08	0.000112266	0.202982	18.27183
1.91831E-11	3.46839E-08	6.271E-05	0.113382	10.20635
1.89024E-11	3.41763E-08	6.17923E-05	0.111723	10.05699
1.79666E-11	3.24844E-08	5.87332E-05	0.106192	9.559117
1.77196E-11	3.20378E-08	5.79257E-05	0.104732	9.427679
1.71243E-11	3.09617E-08	5.59801E-05	0.101214	9.111034
1.64694E-11	2.97774E-08	5.38388E-05	0.097343	8.762524
1.46913E-11	2.65628E-08	4.80267E-05	0.086834	7.81637
1.29133E-11	2.33482E-08	4.22143E-05	0.076326	6.870613
1.03741E-11	1.91184E-08	3.4567E-05	0.062499	5.625939
9.8255E-12	1.77649E-08	3.21197E-05	0.058074	5.227642
7.95398E-12	1.43811E-08	2.60017E-05	0.047012	4.231901
7.57967E-12	1.37044E-08	2.47781E-05	0.0448	4.032753
6.73749E-12	1.21817E-08	2.2025E-05	0.039822	3.584669
1.3882E-12	2.50993E-09	4.53806E-06	0.008205	0.738591
3.26113E-13	5.89626E-10	1.06607E-06	0.001927	0.173508
1.1566E-13	2.09119E-10	3.78095E-07	0.000684	0.061537

In case of LP for β =2, the densities of Gadap (2.48045E-19), Bin Qasim (6.66992E-16) and Malir (1.55915E-15) towns approach small densities in Table: 1.6

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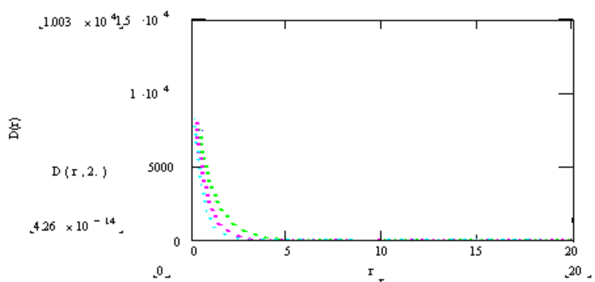
Table1.6 Population Density Forecasts Based on FGDM by LPT

β=2.0	β=1.5	β=1	β=.5	β=.2
2.48045E-19	2.26113E-19	6.18612E-09	0.0000198	0.00738
1.48055E-17	3.26113E-13	7.18312E-09	0.000158	0.06383
6.30243E-17	1.3882E-12	3.05772E-08	0.000674	0.271713
3.05882E-16	6.73749E-12	1.48403E-07	0.003269	1.318726
3.44117E-16	7.57967E-12	1.66953E-07	0.003677	1.483567
3.6111E-16	7.95398E-12	1.75198E-07	0.003859	1.556829
4.46077E-16	9.8255E-12	2.16421E-07	0.004767	1.923142
4.80064E-16	1.05741E-11	2.3291E-07	0.00513	2.069667
5.86273E-16	1.29135E-11	2.84439E-07	0.006265	2.527558
6.66992E-16	1.46915E-11	3.23601E-07	0.007128	2.875555
7.4771E-16	1.64694E-11	3.62763E-07	0.00799	3.223552
7.77449E-16	1.71245E-11	3.77191E-07	0.008308	3.351762
8.04468E-16	1.77196E-11	3.903E-07	0.008597	3.468249
8.15684E-16	1.79666E-11	3.95741E-07	0.008717	3.516603
8.58168E-16	1.89024E-11	4.16353E-07	0.009171	3.699759
8.70913E-16	1.91831E-11	4.22536E-07	0.009307	3.754706
1.55915E-15	3.43425E-11	7.56443E-07	0.016662	6.721839
1.98398E-15	4.37001E-11	9.62559E-07	0.021202	8.553403

and as the gradient goes on declining consistently i.e. the density flattens (Fig: 1.5).

Fig: 1.5 FGDM of Gadap, Bin Qasim and Lyari Town for β= 2



Overall, the LPT seems to be better than the DPT as in case of LP the associated density curves flatten much as compared to the corresponding curves depicts in fig: 1.6-1.7.

Fig: 1.6 FGDM (DP) For Eighteen Towns of Karachi

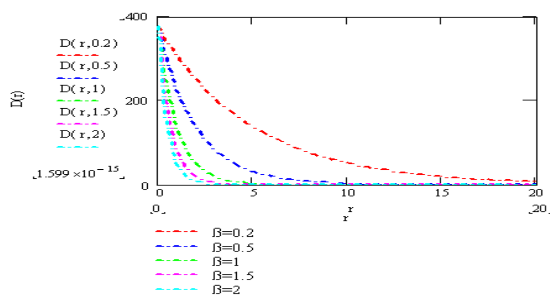
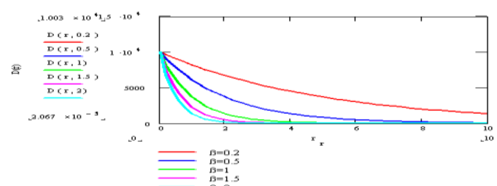


Fig: 1.7 FGDM (LP) for Eighteen Towns of Karachi



The above discussion shows a flattening of distance-density curves. Distance-density correlation is further tested by Linear Regression Model (LRM) , Linear Transformation Exponential Model (LTEM)

$\ln y = \alpha + \beta x$ and Log Linear Model (LLM)

$\ln y = \alpha + \beta \ln x$. All models are indicating a good distance-density correlation. The results are depicted in Table: 1.7.

Table1.7 Linearity of Population Density based on FGDM (LPT) by LRM LTEM and LLM

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Linearity of FGDM based on LPT by LRM			
β	α	β	R²
2	3.5	-1.86	0.948
1.5	3.15	-1.38	0.967
1	27.75	-10.75	0.902
0.5	1.433	-1.14	0.842
0.2	1.34	-0.45	0.852
Linearity of FGDM based on LPT by LTEM			
β	α	β	R²
2	4.32	-2.16	0.993
1.5	2.61	-1.53	0.995
1	1.83	-7.27	0.978
0.5	2.38	-4.13	0.973
0.2	4.15	-2.04	0.965
Linearity of FGDM based on LPT by LLM			
β	α	β	R²
2	5.32	-3.16	0.984
1.5	6.61	-3.53	0.986
1	5.83	-1.26	0.978
0.5	6.38	-2.12	0.953
0.2	7.15	-3.04	0.945

Testing for β ranging over 2.0, 1.5, 1.0, 0.5, 0.2 we see that in case of LTEM the largest R^2 (the coefficient of multiple determination) value exceeds 0.97 for β = 1.0, 0.5, 0.2 and it exceeds 0.99 for β = 0.5 and 2.0 in case of LRM and LLM.

3. Spatial Interaction model (SIM)

We will develop Spatial Interaction Model (SIM) to study the population density of 18 towns of Karachi city.

We will develop another model termed as Spatial Interaction Model (SIM) for the determination of population density distribution using the LP method. This method itself generates a suitable distance gradient coefficient λ. In addition, it determines the probability of change of the population density of the towns. The SIM results are in conformity with FGDM. If *r* is the radial distance of a town from the pivot and λ is the respective density gradient, then the spatial relationship of the towns with respect to the pivot can be explored with the help of Spatial Interaction model (SIM) [12, 13, 19 and 20] described as

$$f(r) = \alpha\, e^{-\lambda r} \qquad (1.3)$$

where ,the function *f* can be referred to the probability *p* (*r*) ,density *d* (*r*) respectively. In fact, we are considering the variation in probability and density to be exponential. The values of *r* used here are obtained with the help of LPT and the densities are determined by putting these *r* in SIM. Fig: 1.8 represent Scatter Plots of *p* (*r*) and *d* (*r*) and Fig:1.9 represent *p* (*r*)- *r* and *d* (*r*)- *r* SIM curves of eighteen towns of Karachi.

Fig: 1.8 Scatter Plots of probability and Density for Eighteen Towns of Karachi

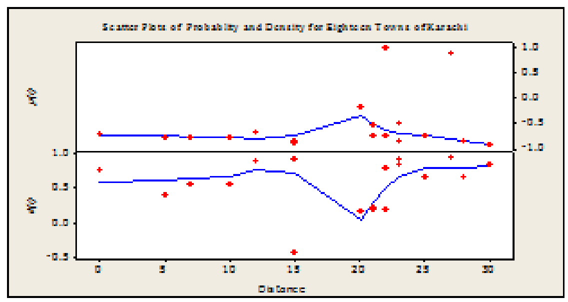
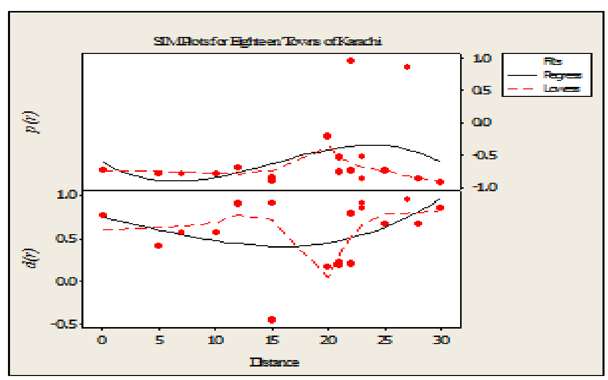


Fig: 1.9 SIM scatter Plots of probability and Density for Eighteen Towns of Karachi



3.1 Spatial Interaction Logistic Model (SILM)

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Spatial Interaction Logistic Model (SILM) which utilizes multiple and logistic regressions [5-15- 16-18]. Combining equations 1.4 and 1.5 for multiple and logistic regressions we can describe SILM by 1.5.

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \dots\dots\dots \dots\dots + \beta_n x_n \quad (1.4)$$

$$y = \log e^{\frac{p}{1-p}} = \log(p) \quad (1.5)$$

$$p = \frac{e^y}{1+e^y} \quad (1.6)$$

Where, $x_1, x_{2,}, x_3 \dots\dots\dots x_n$ are Explanatory variables,y is log(p) logistic regression $\beta_1, \beta_2, \beta_3, \dots\dots\dots \beta_n$ Regression coefficients estimated and p *is* probability of occurrence .To confirm the calculations and forecasts so obtained we develop the Spatial Interaction Logistic Model (SILM).It can be noted that probabilities of change for Gadap, Bin Qasim and Malir towns are showing good correlation coefficients(0.91,0.95 and 0.92).

Table:1.8 SIM and SILM Probabilities and Densities analytical Results

Probability of change				Density of change		
Location (r)	λ	α	Correlation Coefficient	λ	α	Correlation Coefficient
0	-0.0027	1.57	0.91	-0.00046	2.98	0.96
20	-0.00013	1.56	0.95	-0.00016	4.22	0.95
15	-0.00027	0.61	0.87	-0.00027	3.53	0.92
12	-0.00032	0.62	0.85	-0.00026	3.53	0.9
15	-0.0012	0.57	0.89	-0.00009	4.8	0.87
17	-0.0003	0.17	0.84	-0.00086	3.8	0.89
14	-0.0009	0.14	0.92	-0.00175	3.2	0.94
27	-0.0005	1.05	0.86	-0.00018	2.56	0.82
13	-0.00178	2.06	0.85	-0.00008	2.71	0.81
26	-0.00129	2.43	0.83	-0.00011	4.7	0.79
17	-0.00013	1.42	0.84	-0.00003	7.8	0.81
25	1.46	2.14	0.82	-0.00004	4.56	0.87
24	0.465	0.355	0.83	-0.00001	4.34	0.82
25	0.567	0.01	0.84	-4.11	5.7	0.76
21	0.678	0.48	0.84	-0.182	0.87	0.75
24	0.456	2.84	0.78	-10.2	1.73	0.73
22	0.986	1.01	0.74	3	0.37	0.72
7	-1.1	1.51	0.75	2.1	0.6	0.71

Table: 1.8 depicts the results which confirms the significant changing of probability and densities of occurrence into Gadap, Bin Qasim and Malir towns. Results obtained by FGDM and SIM were compared with the help of Spatial Interaction Logistic Model (SILM). In view of the respective correlations and residuals of SIM results appear to be better than the FDGM results.

4. RESULT AND DISCUSSION

Lorenz curves from the 45^o line (Lorenz line), district Central appears to be the densest district and the Malir district comes out to be least dense. The patterns do not appear to be uniform, whereas, Lorenz curves from the Lorenz line the town wise population distribution pattern appears to be better than district wise population distribution pattern. We have considered the densest town and the least dense town among all the eighteen towns of Karachi to be the pivot developing the Densest Pivotal Technique and Least Pivotal Technique. By determination of FGDM β varies from 2.0 to 0.2, the population density goes on decreasing and the associated curves finally flatten. In addition, for any value of β the density decreases as we go far from the pivot i.e the gradient varies inversely as the density. In case of LP for β =2, the densities of Gadap (2.48045E-19), Bin Qasim (6.66992E-16) and Malir (1.55915E-15) towns approach small densities as the gradient goes on declining consistently i.e. the density flattens. Overall, the LPT seems to be better than the DPT as in case of LP the associated density curves flatten much as compared to the corresponding DP curves. The inherent linearity in the FGDM can be gauged from the fact that Linear Regression Model (LRM) ($y = \alpha + \beta x$), Linear Transformation Exponential Model (LTEM)

($\ln y = \alpha + \beta x$) and Log Linear Model (LLM)

($\ln y = \alpha + \beta \ln x$) all indicate a good distance-density correlation. Testing for β ranging over 2.0, 1.5, 1.0, 0.5, 0.2 we see that in case of LTEM the largest R2 (the coefficient of multiple determination) value exceeds 0.97 for β = 1.0, 0.5, 0.2 and it exceeds 0.99 for β = 0.5 and 2.0 in case of LRM and LLM. It can be noted that probabilities of change for Gadap, Bin Qasim and Malir towns are showing good correlation coefficients(0.91,0.95 and 0.92).the results confirm the significant changing of probability and densities of occurrence into Gadap, Bin Qasim and Malir towns. In analysis of the respective correlations and residuals of SIM results appear to be better than the FDGM results.

5. CONCLUSION

We studied the 5-districts and 18-Towns of Karachi population data base 1998 census data(5-districts)and 2011(18-Towns) was used to study the population-area distribution with the help of Lorenz curves and Hoover indices. We considered variation of district and towns future more, suggest town wise pattern is better than the district wise distribution. We have manipulative the distances between various locations with the help of DP and LP techniques. Using FGDM we observed the flattening of the density gradient for all values of β. The density curves were extremely flattened in case of LP with β =2. So we used LP with β =2 to compare the population density distribution of the 18 towns of Karachi. It was found that the population density distributions for Gadap (2.48045E-19), Bin Qasim (6.66992E-16) and Malir (1.55915E-15) towns are better than the other towns. we were tested the appropriateness of the FGDM in LP by using Log-Linear Transformation Model (LLTM) and Log-Exponential Transformation Model (LETM). The former one is linear in nature whereas the later non-linear. these indicate a good distance-density correlation. We have developed another model termed as Spatial Interaction Model (SIM) this method itself generates a suitable distance gradient coefficient λ. we determines the probability of change of the population density of the towns. The SIM results are in conformity with FGDM. Results obtained by FGDM and SIM were compared with the help of Spatial Interaction Logistic Model (SILM). The respective correlations and residuals SIM results appear to be better than the FDGM results[5]. We strongly suggest others to consider such extensions of the work presented here.

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