http://ansinet.com/itj

ITJ

ISSN 1812-5638

# INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (19): 5160-5165, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.5160.5165


# Resources Optimization Model and Application in Port

[1, 2]Zunfeng Liu, [1]Kai Kang and [2]Chunling Zhang
[1]School of Economics and Management, Hebei University of Technology, Tianjin 300401, China
[2]College of management, Hebei United University, Tangshan 063009, China

**Abstract:** In this study, we use the system analysis and optimization of GIS spatial analysis study the allocation of resources of port. First, we use optimize given resource allocation model which of yard space analysis; Second, give the berths dynamic resource allocation optimization function; then GIS spatial analysis is given in the port resource optimization. Port for optimal use of resources space and impact factor model for quantitative analysis and visualization used spatial analysis model which provides effective analytical approach to role and explores the mechanism. Finally, we give application examples. Based on the theoretical analysis and comparative analysis we achieve optimal allocation of resources and development plans in coastal port, which provides a theoretical basis and empirical basis in port resources study.

**Key words:** Optimization analysis method, GIS space analysis method, spatial analysis, spatial analysis model, port resources optimization

## INTRODUCTION

Reform and opening up, especially since entering new century, the coastal areas of economic and social development has made significant achievements. Modern logistics industry, to a port, relying on connected with deep hinterland logistics channel, planning and construction of a batch is given priority to with energy, raw materials and containers of modern logistics Industry Park (Yang and Shao, 2007). Study of port resource optimize configuration of the efforts of many people, such as: Han Xiaolong and Wang Zhengjun for container port shore resources are two of the most important resources in the garage and shore bridge are studied, the effect of the research are validated. Based on berth in Han Xiaolong and d to the resources is related to the operational efficiency of container ports set up at the same time considering the berth and integer programming model of bridge crane resources and through a numerical example proved the effectiveness of the proposed model and algorithm (Han and Ding, 2006); Li Jianzhong using theories and methods of optimization and heuristic method for container port yard resources allocation problem have been studied in detail, for our country's container port resource allocation theory and practical operation provides guidance and decision-making basis; Jin Chun and the others container port operations such as resource allocation optimization problem as the object, put forward a distributed optimization combined with parallel simulation of distributed simulation optimization method (Jin *et al*., 2011); Yang Haijun and the others think that modern geography is dependent on the spatial analysis of the application of the support, analysis and processing of geological data of GIS and spatial characteristics of space-time model, data mining, visualization technology integration and pay attention to the multi-dimensional information space correlation factors of multiple applications; In 1984-2003, Liu Yu used panel data model using pinch and contract relationship between the three industrial added value of industry research (Li *et al*., 2009), proposed our country should take an active use of foreign capital policy, increase the field of foreign investment, to speed up the optimization and upgrading of industrial structure in present country (Han and Wang, 2012); Wu Jian analysis from ESDA technology developed parts of Beijing-Tianjin-Hebei region from 1992 to 2007 mainly in the background, Tianjin and Hebei Langfang, Tangshan area, has obvious diffusion effect; Huang Guoliang modeling methodology, summarizes the existing simulation system modeling method and its application in some existing in terminal system simulation results, points out the main problems (Liu, 2007).

In this study, the author of this study is studied, in this study, the first part of the yard space by using optimization analysis method with optimization model of optimal allocation of resources, the second part presents berth dynamic resource allocation optimization functions, the third part of the GIS space analysis method is given, steps and process modeling, designs the optimal allocation of resources to port, the application example is given.

Corresponding Author: Zunfeng Liu, School of Economics and Management, Hebei University of Technology, Tianjin, 300401, China

## YARD SPACE RESOURCE OPTIMIZING CONFIGURATION

After the ship to port, in order to ensure the vessels can quickly turn over, can maintain a high level of job logistics, logistics cost control, in addition to its configuration corresponding berth, bridge cranes, horizontal transportation equipment resources, it is even more crucial to optimize the yard space resource configuration, the storage space in the container in the field configuration decision making will directly affect the efficiency of gantry crane and collection card within walking distance and indirectly affect the efficiency of bridge cranes, yard space of the reasonable allocation of resources can not only improve the utilization rate of storage area but also can reduce the rate of turn over the box yard machine, reduce the waiting time for bridge crane, improve the efficiency of the port. The container according to the different status of field can be divided into four categories, respectively is imported cases (VSDS), suitcase (CYPI), into the box (CYGD) and outlet box type (VSLD).

To measure the efficiency of container ports and the customer satisfaction index basically has two, respectively is shipping port to minimize time and port equipment efficiency maximization.

In this study, using the method of two phases, the yard space resource allocation problem is divided into two stages, in each phase selection to solve a general goals consistent goal.

The first phase, in order to improve the utilization of yard equipment, to balance the amount each box of times a box will be assigned to each box interval of times, because homework boxes scattered in different times a box area, gantry crane to within the range of each box, box in between times a mobile for container loading and unloading services, operation box in box area times the amount of evenly distributed between can reduce the movement of the gantry crane, gantry crane operation efficiency.

The second phase, in order to reduce the transportation cost of the container in the port area, which reduced set of CARDS from the yard to walking distance of the vessel, minimize shipping port of time, will consider each box area times the amount of each ship work within a box.

First set up the first stage model MYSRD (1), the goal is to balance the stages each box area times the amount of work box, operation box in box area times the amount of evenly distributed between can reduce the movement of the gantry crane, gantry crane operation efficiency. Mathematical model as shown below:

$$\text{o.b.}\min\sum_{t=1}^{T}\sqrt{\sum_{i=1}^{B}\sum_{j=1}^{H_i}\frac{\left(Y_{ijt}-\bar{Y}\right)^2}{\sum_{i=1}^{B}H_i-1}}$$

S.t.

$$\begin{aligned}
&D_{ik}=\sum_{i=1}^{B}\sum_{j=1}^{H_i}D_{ijtk},G_{ik}=\sum_{i=1}^{B}\sum_{j=1}^{H_i}G_{ijtk} && t=1,2,\cdots,T,k=0,1,\cdots,T-t\\
&D_{ijt}=\sum_{k=0}^{T-t}D_{ijtk}+\beta_{ijt},G_{ijt}=\sum_{k=0}^{T-t}G_{ijtk}+\alpha_{ijt} && i=1,\cdots,B,t=1,\cdots,T,j=1,\cdots,H_i\\
&D_i=\sum_{i=1}^{B}\sum_{j=1}^{H_i}\beta_{ijt},G_i=\sum_{i=1}^{B}\sum_{j=1}^{H_i}\alpha_{ijt} && t=1,2,\cdots,T
\end{aligned}\tag{1}$$

$$L_{ijt}=L_{ijt}^{0}+\sum_{k=0}^{t-1}G_{ij(i-k)k}\quad i=1,\cdots,B,t=1,\cdots,T,j=1,\cdots,H_i$$

$$P_{ijt}=P_{ijt}^{0}+\sum_{k=0}^{t-1}D_{ij(i-k)k}\quad i=1,\cdots,B,t=1,\cdots,T,j=1,\cdots,H_i$$

$$V_{ij(t+1)}=V_{ijt}+\left[\left(G_{ijt}+D_{ijt}\right)-\left(P_{ijt}+L_{ijt}\right)\right]\quad i=1,\cdots,B,t=1,\cdots,T,j=1,\cdots,H_i$$

$$V_{ijt}\le C_{ij}\quad i=1,\cdots,B,t=1,\cdots,T,j=1,\cdots,H_i$$

$$\left\{\alpha_{ijt},\beta_{ijt},G_{ijtk},G_{ijt},D_{ijtk},D_{ijt},L_{ijt},P_{ijt},V_{ijt}\right\}\subseteq N^{+}$$

Type (1) B express pile of places have box area number; T express a plan during the period of planning stage; $E_i$ express a collection of box I area times the digits; $C_{ij}$ express box area I times a storage capacity of j; $V_{ijt}$ express in the planning stage has been in the initial stage of box i section times a storage box j; $P^0_{ijt}$ express in the first stage of initial pile t exist in the times j of box area i, in phase t will be withdraw the amount of import box; $L^0_{ijt}$ express in the first stage of initial pile t exist in the times j of box area i, in phase t will be withdraw the amount of outpost box; $G_{tk}$ express in phase t from the customer to the port of destination, in phase t+k the amount of import box be withdraw by customers; $G_t$ express in phase t from the customer to the port of destination, Outside the plan period shipped into the amount of the box; $D_t$ express in phase t discharged from the ship, Outside the plan period by the customer the amount of import box of the box.

The second stage mathematical model MYSRD (2) as shown in Eq. 2:

$$\text{o.b.}\min\sum_{i=1}^{B}\sum_{j=1}^{H_i}\sum_{l=1}^{M}d_{ijt}X_{ijlt}$$

S.t.

$$\begin{aligned}
&\sum_{l=1}^{M}X_{ijlt}=U_{ijt}\quad i=1,2,\cdots,B,j=1,2,\cdots,H_i,\\
&\sum_{i=1}^{B}\sum_{j=1}^{H_i}X_{ijlt}=N_{lt}\quad l=1,2,\cdots,M\,X_{ijlt}\in N
\end{aligned}\tag{2}$$

## BERTH DYNAMIC RESOURCE ALLOCATION OPTIMIZATION

The optimal berths of container terminal size should be on the premise of meet the throughput requirements, shipping, loading and unloading the goods in Hong Kong and port berths cost of most hours on the number of berths. This section to consider the cost of project is a combination of the ship, port, the cost of goods three aspects, mainly including ship the fees incurred in Hong Kong, the berth of the cost of operating costs and the backlog of goods, in the port of the total cost is a function of the number of berths, expressed as shown in Eq. 3:

$$C_p(B) = C_b B + \left(C_v + \frac{i}{365}V\right)L(B) \tag{3}$$

When The type 3 meet type4 you get the number of berths b* is the best berth number, at this time the type 3 into type 4 can be type 5:

$$C_{B^*} < C_{B^*+1} \,\&\, C_{B^*} < C_{B^*-1} \tag{4}$$

$$L(B^*) - L(B^*+1) \le \left(\frac{C_b}{C_v + \frac{i}{365}V}\right) \le L(B^*-1) - L(B^*) \tag{5}$$

In the type 5 the function L(B*) by the container terminal berth queuing system M/M/C model is obtained, according to the M/M/C model satisfy the condition available type 6 with type 7:

$$P_0 = \left[\sum_{k=0}^{B-1}\frac{1}{k!}\left(\frac{\lambda}{\mu}\right) + \frac{1}{B!}\frac{1}{\beta-1}\left(\frac{\lambda}{\mu}\right)^B\right]^{-1} \tag{6}$$

$$P_n = \begin{cases} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n P_0 & (n \le B) \\ \frac{1}{B!}\frac{1}{\beta-1}\left(\frac{\lambda}{\mu}\right)^n P_0 & (n > B) \end{cases} \tag{7}$$

On this basis, can export container berths queuing system at captain the average residence time and average waiting time and as shown in type 8:

$$\begin{cases} L_s = L_q + \frac{\lambda}{\mu} \\ L_q = \frac{(B\beta)^B \beta}{B!(1-\beta)^2} P \\ W_q = L_q/\lambda \\ W_s = L_s/\lambda \end{cases} \tag{8}$$

In the type $8_s$ express the mean number of ship berthing queuing system, $L_q$ express the berthing ships waiting in the queue system number average, $W_s$ express the ship the mean residence time in queuing system, $W_q$ express the ship waiting for berthing time average, λ express the ship arrival rate, μ express the berth handling operation ability, β express the mean number of ports of loading and unloading ships every day, $P_0$ express the probability of no-ship in port, $P_n$ express the probability of there are n ships in port.

Three, the GIS spatial analysis method, the application of optimal utilization of resources in the harbor.

**Basic spatial analysis method:** The GIS spatial analysis connotationis extremely rich, in this study, the spatial query, spatial measurement, superimposed analysis, buffer analysis and network analysis is presented in several aspects.

Spatial query is peer review is the most commonly used graphics and attribute query, there are mainly two kinds, one is to query the location according to the requirement of the attribute information space, referred to as the "attribute check graphics", the other is based on object's spatial location query information on properties, called "graphic attributes", in most GIS provides spatial query method based on spatial relationship with the query, based on the characteristics of spatial relationship and attribute query and address matching the query.

Spatial measurement are divided into geometric measurement, shape measurement, the center of mass measurement and distance measurement, including geometrical quantity is on four types of feature point, line, face, body, the general GIS software has to, line, face shape features of geometric measurement function, or is in view of the data structure, or for raster data structure of spatial data.

Shape measurement is the target object shape measurement, generally there is two aspects, on the one hand is a consistent problem space, namely the processing of perforated polygon and broken polygons, on the other hand is a polygon boundary feature description of the problem. Metric space consistency is the most commonly used indicator of ruler function, used to calculate polygon broken degree and number of holes, the polygon boundary description problem of the most commonly used indicators including the ratio of the polygon axle, perimeter area ratio and the area such as the ratio of the length, the vast majority of the index is based on the area and perimeter of the target object type belongs to the compact or expansion extremely fuzzy judgment, for a standard circular feature is not compact or inflating, then can define coefficient expression of the shape factor r as shown below:

$$r = \frac{P}{2\sqrt{\pi}\sqrt{A}} \tag{9}$$

In the Eq. 9 P express the perimeter of the target object, A express the target feature area, If r<1, the target object is compact, If r = 1, the target object as the standard circle, If r>1, the target object type for expansion. Center of mass quantity is described an important indicator of spatial distribution of geographical object, the center of mass is usually a polygon or the geometric center, in some cases, the center of mass is the distribution center, the center of mass is aim to keep balance of uniform distribution, it can be given weight coefficient and its calculation formula as shown in Eq. 10:

$$\left( X_G = \frac{\sum_i W_i X_i}{\sum_i W_i}, Y_G = \frac{\sum_i W_i Y_i}{\sum_i W_i} \right) \tag{10}$$

In the Eq. 10 i p express the discrete target, $W_i$ express the target weight of discrete target, ($X_i$, $Y_i$) express the coordinates of discrete objects, ($X_G$, $Y_G$) express the centric coordinates of target object.

In GIS, the calculation of distance is usually between two locations, the most commonly used distance concept is the Euclidean distance, both in structure of vector and grid structure is easy to implement, to describe vector structure of dot, line and plane coordinates, a different concept of distance, Euclidean distance, such as Eq. 11:

$$d = \sqrt{(X_i - X_j)^2 + (Y_i - Y_j)^2} \tag{11}$$

When there are obstacles or resistance, the distance between two points, it is not linear distance, calculation of standard Euclidean distance formula as shown in Eq. 12:

$$d = \left[ (X_i - X_j)^2 + (Y_i - Y_j)^2 \right]^{\frac{1}{k}} \tag{12}$$

In the Eq. 12when k = 2, put Eq. 12 into 11 as shown in the formula of Euclidean distance, when k = 1 the gotten distance is called the Manhattan distance.

Superimposed analysis is double layer or multilayer map elements to overlay to create a new layer of operation, the result will be the original elements by splitting or generate new elements such as merger and new elements integrated the original two layer or multilayer elements has the properties of the superimposed analysis not only contains spatial relations, also contains the comparison of properties concerned.

Buffer analysis is in view of point, line, surface entity, automatically set up the surrounding a certain width within the buffer polygons, buffer to produce has three, one is based on some elements of the buffer, usually based on point circle radius is a certain distance of the circle, the second is based on linear elements of the buffer, usually in line as the center axis, the distance from the center axis parallel stripe polygon, the third is based on area feature polygon boundary buffer, inward or outward extension distance to generate new polygons.

Geographical analysis of geographical network, infrastructure network and modeling, is the main purpose of the network analysis functions of GIS, the basic purpose of network analysis is the study of planning a project how to arrange and make it running effect is best, such as certain resource optimal allocation, from one place to another low transportation costs, etc., the basic idea is that human activities are always tend to be in a certain spatial location of target selection best results. Network analysis mainly includes the path analysis, address matching three methods of analysis and resources allocation.

**Spatial analysis process:** Spatial analysis is based on the geographic location and shape of the object characteristics of spatial data analysis technology, its purpose is to extract and transport spatial information, GIS provides a series of spatial analysis tool, the user through the existing data model, after a series of operation sequence, finding a new model, the new model can show the internal data sets or heart or not clear relationship between data sets, to answer user questions, good spatial analysis process design will be very beneficial to the solution of the problem, its basic steps as shown below:

- Focus on the purpose of the analysis and evaluation standards
- Prepare space data of the operation
- Spatial analysis model is set up and perform spatial analysis operation
- Interpretation and evaluation result (if it is necessary to return to step 1)
- To improve the results of the analysis, the result output (forms, documents and map)

Spatial analysis process is actually a geographic modeling process, dependent on the spatial analysis and spatial analysis model, so the research on spatial analysis and how to implement in the GIS environment modeling is very important.

**Exploratory spatial analysis:** There are a lot of statistical index can be used as a measure of port resources difference or imbalance, coefficient of variation is one of the most widely used in it, coefficient of variation CV is:

$$CV = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(Y_i - \bar{Y}\right)^2}}{\bar{Y}} \tag{13}$$

In the Eq. 13 CV express the coeficient of variation, $\bar{Y}$ express the average utilization of resources value, n express the types of resources, $Y_i$ express the use value of the resources in the i. The greater the coefficient of variation, the greater the difference of the value of the resource utilization but due to the difference coefficient of variation can only explain the general development rule, while ignoring the spatial relationships between the various resources, so this article USES the coefficient of variation of mainly adopted exploratory spatial data analysis methods at the same time, it is using both local and global spatial autocorrelation spatial autocorrelation method to analyze the difference of the value of the use of various resources in the change of space.

ESDA is a collection of a series of spatial data analysis methods and techniques, spatial correlation measure as the core, through the description of the spatial distribution pattern of things or phenomena and visualization, found that the spatial agglomeration and spatial anomaly reveal the spatial interaction mechanism between the object of study. GIS with the ESDA to strengthen its spatial analysis function, ESDA on GIS platform, can the space to visualize the results of correlation analysis table, better space law, analysis of space structure.

Global spatial autocorrelation is a global index for measuring spatial autocorrelation, said the global spatial autocorrelation of index and method mainly includes the Moran's I, Geary's C and G Gets', which is commonly used Moran's I. Moran index is to analyze the overall degree of spatial correlation and space difference, its computation formula:

$$I_t = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} = \frac{\sum_{i=1}^{n}\sum_{j\neq i}^{n} w_{ij}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{S^2\sum_{i=1}^{n}\sum_{j\neq i}^{n} w_{ij}} \tag{14}$$

In the Eq. 14, $I_t$ express the Moran index of period t; $x_i$, $x_j$ express the observed value of area i, j:

$$S^2 = \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2$$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

where, $w_{ij}$ express the weighted space adjacent matrix, if area i and j belong to the adjacency relation, then $w_{ij} = 1$, otherwise $w_{ij} = 0$ and regulations area i does not belong to the adjacency relation with itself, then there is $w_{ij} = 0$.

Moran's I values between plus or minus 1, generally greater than 0 that is not related, if at a given level Moran's I tend to be 1 indicates the level of regional significantly on the space agglomeration, narrow the gap, to agglomeration area and Moran's I is significantly negative indicates the level of area and its surrounding areas has significant spatial difference, concentration of fade away, When the expectations of Moran's i close observations:

$$-\frac{1}{n-1}$$

that are independent of each other, between random distribution in space.

Local spatial autocorrelation Moran's I is the overall space statistical indicators, only shows that the overall process of space growth cannot provide local spatial heterogeneity, it is very difficult and the index of visualization in GIS. Local Moran's I is Moran's I decomposition form, can be further measure of the space difference degree between area and its surrounding areas and its significance and its calculation formula as shown in Eq. 15:

$$I_i = \frac{x_i - \bar{x}}{S^2}\sum_{j} w_{ij}\left(x_i - \bar{x}\right) \tag{15}$$

In the Eq. 15 $I_i$ express the Local Moran's I of area i, the meaning and type of other variables (14) in the same meaning. It comes as said the area around the unit a similar value of spatial agglomeration, that show regional spatial differences between i and the surrounding area is small, the negative value $I_i$ express the spatial agglomeration of similar value, show regional spatial differences between i and the surrounding area is big.

## EMPIRICAL ANALYSIS BERTH RESOURCES OPTIMIZATION

Assumptions have four container berths, container terminal berth coastline of total degree of 1140 m, including 1 berth length of 200 m, depth of 11 m; 2 berth

Table 1: Container terminal, the optimal No. of berths calculation table

| No. of berths β | 4 | 5 | 6 | 7 |
|---|---|---|---|---|
| β | 0.7286 | 0.6343 | 0.5286 | 0.4531 |
| $P_0$ | 0.0287 | 0.0384 | 0.0410 | 0.0417 |
| $L_q$ | 2.2340 | 0.4869 | 0.1377 | 0.0404 |
| $L_s$ | 5.4053 | 3.6583 | 3.3092 | 3.2119 |
| $W_q$ | 0.2516 | 0.0548 | 0.0155 | 0.0045 |
| $W_s$ | 0.6087 | 0.4120 | 0.3727 | 0.3617 |
| Total | 328.8166 | 243.4799 | 233.7330 | 237.6040 |

length of 240 m, depth of 12 m; 3 berth length of 350 m, depth of 14 m; 4 berth length of 350 m, depth of 14 m. Analysis during march to may, with the ship to port 444, to the port of time interval in line with the poison distribution, density of ship to port $\lambda$ = 8.88, daily operation of ship is 2.8, namely $\mu$ = 2.8. The ship to the port in the majority with medium 3000 TEU ship type, container ship day waiting costs including the rent ($28000), the crew salary ($01500), the ship's fuel consumption (16000 Yuan), port handling (190000 Yuan) to the exchange rate of 6.8 will be converted into RMB 406600 Yuan above, notice o handling work an average of 600 TEU, worth $80000 on average, single cases goods cash at an annual rate of 15%, single berth investment cost is about 670 million Yuan, recovery period of 20a, single berth allocation cost is about 91300 Yuan every day. Optimal container terminal berth size calculation as shown in Table 1.

Based on actual data, through the calculation, according to the wharf now ship, cargo value, port operating capital flow density, etc., the optimal number of berth should be 6, can achieve the lowest total cost, container terminal and the terminal of the four operating berth situation, such as can increase two berths, the cost can reduce 950000 Yuan, the ship's average residence time can be reduced to 8.9 from 14.6 h, so it is to optimize the configuration of the port service level, efficiency and social efficiency can be significantly improved.

## CONCLUSIONS

Based on actual data and through the above results show optimized configuration of the port service level, efficiency and social efficiency can be significantly improved. Two-phase model solve the problem of yard space allocation of resources effective and feasible. Due to space limitations, this article only gives empirical analysis berth resources optimization and for yard space resources optimization allocation model and the GIS space analysis model, according to the steps of the model to the data. In this study, we give the mathematical method as to optimize the configuration of the port of new research methods, has a broad application prospect.

## ACKNOWLEDGMENT

This study was supported by the National Natural Science Foundation of China (No. 11126213 and No.61170317) and the National Natural Science Foundation of Hebei Province (No. E2013209123).

## REFERENCES

Han, X.L. and Y.Z. Ding, 2006. Optimization of berth allocation problem in container terminals. Syst. Eng. Theory Methodol. Appl., 15: 275-280.

Han, X.L. and Z.J. Wang, 2012. Container port shore optimal allocation of resources research. Mod. Bus. Trade Indu., 36: 57-59.

Jin, C., L.L. Deng and P. Gao, 2011. Optimization of operating resource allocation in container terminals based on distributed simulation. J. Syst. Manage., 20: 364-371.

Li, H.Y. and D.W. Wang, 2009. Parallel simulation-based optimization on dynamic truck configuration of container terminals. J. Syst. Simulation, 4: 4243-4247.

Liu, Y., 2007. The effect of foreign direct investm enton the industrial structure in China: An empirical research with panel data. Nankai Econ. Stud., 1: 124-134.

Yang, H.J. and Q.Q. Shao, 2007. Consideration on GIS spatial analysis in geospatial data processing. Geo-Inform. Sci., 9: 70-75.