DESCRIPTIVE ANALYSIS OF TRIP MAKING CHARACTERISTICS IN ADO-EKITI, EKITI STATE, NIGERIA

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Abstract — In this study, the trip making characteristics in Ado-Ekiti, Ekiti State, Nigeria are descriptively analysed. The city was divided into nine zones out of which 1,597 households were interviewed out of a total population of 15,945 households Trips generated and attracted to each zone of the city of Ado-Ekiti for business and non-business purposes were determined. The relationship between the number of trips generated and land use factors were also determined. The effects of income on car ownership and the effects of both on trip making pattern were established while trips were accrued to various modes of transport in the city. The study showed that land-use is the main factor responsible for trips production and attraction. It was established that commercial zones attracted the highest number of trips generated per week for both business and non-business trips while high and medium residential zones produced the highest number of business and non-business trips. In contrast, public zone produced the lowest number of business and non-business trips. Finally, the study shows that income is directly proportional to car ownership and that both income and car ownership have considerable effects on trip generation.

1.0 INTRODUCTION

An analysis of trip making characteristics in Ado-Ekiti is the study of movement of people within the city. It encompasses determining the purpose of trips either for business or non-business purposes, origin and destination of trips, frequency with which trips are made, the economy of making the trips and the available transport modes for making trips in the city.

Ado-Ekiti had relatively small population and low availability of vehicles before the creation of Ekiti state in October 1996. As a result of being made the capital of the state, people from different parts of the state and country (Nigeria) gradually migrated into the city to seek government work. Also, aspiring politicians and business tycoons moved to the city with the hope of finding a steady source of income and a decent standard of living. As a result of considerable growth in population, land use increased for ministry offices, industries, schools, business centers, police and military barracks, recreational centers and residential quarters.

The transportation system in Ado-Ekiti was developed to serve people so as to undertake their economical, social and cultural activities [1]. Hence, it has to be efficient by being able to balance a variety of usually conflicting requirements that the society in general considers to be important to it. These requirements include cost consideration, convenience and protection related to making a trip. Consequently, the road transportation system would include not only the roads but also vehicles, passengers and cargo which are all interdependent [2].

Hence, transportation depends greatly on land use which include residential, commercial, industrial, recreational, institutional and any other diverse ways in which land is being put to use. Land use and transportation planning are therefore closely related because the demand for travel facilities is a function of human land activity and in contrast the provision of transport facilities has often promoted land use activity [3].

Trip studies in this case include the study of the purpose for making trips, origin and destination of the trips within the city, frequency of making trips, the economy of making trips and finally the available transport modes in the city [4]. The study area, Ado-Ekiti, is divided into traffic zones for which trip attractions and productions are estimated. In addition, the relationship between travel patterns and land use, the relationship between travel and socio-economic factors and the relationship between travel patterns and modes of transport in Ado-Ekiti are determined.

2.0 BACKGROUND LITERATURE

The process of analyzing trips requires travel forecasting which takes place through a model comprising of four stages namely trip generation, trip distribution, modal split and traffic assignment. Trip generation attempts to determine the connection between trip making and land use and predicts the number of trips per time period made to and from a given zone. Trip distribution is concerned with finding the zones to or from which the generated trips are directed. Modal split is concerned with determination of the particular mode of transportation used by trip makers while traffic assignment involves assigning the distributed volumes of trips to individual network links [5].

In trip generation analysis, three approaches are commonly used for developing models namely regression analysis, trip rate analysis and cross-classification analysis [6]. Trip generation models are a set of mathematical equations that collectively relate travel patterns to land use, residential density, socio-economic characteristics, demographic characteristics and other parameters of the transport system.

In case of distribution, many mathematical models have been tried such as linear programming formulations, regression models, growth factor models, opportunity models and gravity type models (which is the most popular). In the case of modal split, three types of models are also used namely trip-end models, trip interchange models and individual mode choice models [7]. Lastly, trip assignment techniques used include all-or-nothing, iterative, incremental, user-equilibrium and system optimal traffic assignments [8]. The major movement within urban areas, related to the travel available for urban passenger transportation, are mainly land-based and include private transportation (walking and private vehicles) and various public transportation services of which some are highway-based (such as regular city buses, taxi or cabs.

Initially, modern-era cities were pedestrian oriented. Even after the development of mechanized long distance transportation system such as rail roads, the size of most cities was sufficiently small for people to traverse by walking. Private transportation in the form of horseback was sufficient for longer distances. In addition, significant differences in the pattern of urban travel, however necessitated the development of more refined techniques. An important difference was the fact that in urban areas, street capacities between various parts of the city involve multiple rather than single routes [9].

At present, large urban areas in Nigeria are suffering from transportation congestion. Changes in transport mode frequently produce changes in land-use pattern. Recently, the availability of private transport has led to the growth of housing development which cannot be economically served by public transport. Hence there is a need to carry out a transportation survey to be able to meet demand with supply of transportation services [10].

The transportation survey is an attempt to take an inventory of trip making pattern as it exists at the present time together with details of travel facilities available, land-use activities and socio-economic factors that can be considered to influence travel [11]. This is followed by the production of a mathematical model

which can be used to explain the relationship between the observed travel pattern and socio-economic factors obtained by the transportation survey, predict transportation needs and evaluate alternative transportation plans. Next, the existing land-use characteristics are inserted into the trip generation procedure in which the trips are distributed, assigned and a modal split decision is carried out. It is then possible to forecast the travel needs of future land-use and transport plans once confidence in the ability of the developed models is established.

At this stage, it is important to make some basic definitions. A trip is a one-way person movement by one or more modes of travel and each trip has an origin and a destination. Most surveys divide trips into home-based and non-home based trips. All trips which have one end at the home are said to be generated by the home and other ends of trip is said to be attracted to the zone in which it terminates. In this study, trips are divided into business and non-business trips where business trips are work related and the converse applies to non-business trips.

The form of the relationship connecting trip generation, land use and socio-economic factors depends upon the basic framework of the transportation process [12]. If the study is designed to use trip end modal split models which allocates trips to differing modes of transport before the distribution of trips between the traffic zones, then the trip generation models are designed to predict movement by differing modes of transport or travel. Conversely, a trip interchange model (which predicts person movement in terms of total person movement by all modes of travel) is required when trips are distributed between zones before decision is made regarding the modes of travel.

Trip generation equations have as their dependent variable the number of trips generated per person or per household for different trip purposes while independent variables are the land use and socio-economic factors that are considered to affect trip making. Land use is of course a major consideration in the generation of trips. Similarly, the type of activity and the number of workers employed per unit area will influence trip generation in areas where commercial or industrial land use is of importance. Other factors connected with home that are considered to influence trip generation rates are the family size, income, motor vehicle ownership and socio-economic status of the head of the family being considered.

3.0 METHODOLOGY

The complete area of investigation, Ado-Ekiti, was divided into nine zones. These zones are as follows: high residential, medium residential, low residential, commercial, educational, industrial, military, public and recreational zones. The methods used in collecting data ranged from simple observation to extensive home interviews by administering questionnaires to selected households in each zone. The households interviewed were selected using random number generation sampling method which amounted to ten percent of households in the study area out of a total of fifteen thousand nine hundred and forty-five households.

The following information was extracted from the questionnaires administered:
A. Origins and destinations of both the business and non-business trips of the respondents and members of their family
B. Car ownership
C. Modes of transport of respondents to places of work and from their places of work to their various homes.
D. Number of persons per household
E. Household income

3.1 DESCRIPTION OF THE STUDY AREA

Ado-Ekiti is the capital of Ekiti state, located south-west of Nigeria. Ekiti was declared a state on October 1, 1996 alongside five others by the then military government. Ado-Ekiti is situated about one hundred and six kilometers east of Ibadan City and about four hundred and seven kilometers north-east of Lagos.

Ado-Ekiti lies on latitude 7º 38´ 0´´ North of the equator and longitude 5º 13´ 0´´ East of the Greenwich Meridian. It is about two hundred and fifty meters above sea level. The city enjoys good accessibility from other surrounding cities especially Akure (the capital of Ondo state) and Osogbo (the capital of Osun state) as a result of its good regional positioning and geographical location.

4.0 RESULTS AND DISCUSSION

The number of households to interview in each zone was obtained by multiplying the number of households in each zone by 10 percent as shown in Table 1. Table 1 shows that 1,597 households were interviewed out of a total population of 15,945 households.

Table 1. Distribution of Households in zones

Zones	Number of Households	Number of Households Interviewed
Low Residential	1200	120
Medium Residential	4975	498
High Residential	4196	420
Commercial	2478	248
Recreational	697	70
Educational	985	99
Industrial	738	74
Military	228	23
Public	448	45
Total	15945	1597

Thereafter, the four stage process of the transport model was implemented. The total number of trips generated and attracted to the zones are as shown in Table 2. Table 2 presents the total number of business and non-business trips per week generated from each zone and attracted from other zones and it shows that high residential zones generated the highest number of business trips per week followed by medium residential and commercial zones while public and recreational zones generated the least business trips respectively.

Table 2 also shows that commercial zones attracted the highest number of business trips per week followed respectively by recreational zones, medium residential zones and high residential zones while industrial zones attracted the least business trips. Medium residential zones generated the highest number of non-business trips per week followed respectively by high residential zones and commercial zones while military and recreational zones generated the least non-business trips. It is also apparent that commercial zones attracted the highest number of non-business trips followed by high residential zones while public, industrial and educational zones attracted the least non-business trips.

Table 2. Total Trips generated and attracted

Zones	Business Trips per week		Non-Business Trips per week	
	Total trips generated	Total trips attracted	Total trips generated	Total trips attracted
Low Residential	12,720	26,921	5,520	14,856
Medium Residential	90,454	42,540	64,095	12,442
High Residential	126,000	41,518	45,360	26,448
Commercial	74,648	68,732	20,178	64,799
Recreational	3,960	46,904	4,217	12,229
Educational	7,975	41,213	5,934	3,872
Industrial	9,102	12,526	6,364	4,747
Military	12,573	21,749	4,356	14,810
Public	2,208	14,135	1,344	5,848

The relationship between the level of income of the households in each zone and car ownership was also examined as shown in Table 3. Table 3 shows how household income affects car ownership in each zone and it indicates that as income increases more households are able to own or afford a car with car ownership reaching a maximum of 40 for a corresponding number of households of 44 and income level exceeding ₦100,000 in medium residential zones. However, in terms of average number of cars per household, public and residential zones have the highest average number of vehicles per household of 1 for income level exceeding ₦100,000.

Table 3. Income distribution and car ownership in the zones

Income Classes (₦)/Month	Low Residential Zone		Medium Residential Zone		High Residential Zone		Commercial Zone		Educational Zone		Industrial Zone		Public Zone		Military Zone		Recreational Zone	
	No. of Households	Car Ownership	No. of Households	Car Ownership	No. of Households	Car Ownership	No. of Households	Car Ownership	No. of Households	Car Ownership	No. of Households	Car Ownership	No. of Households	Car Ownership	No. of Households	Car Ownership	No. of Households	Car Ownership
< 10,000	1	0	21	0	18	0	10	0	0	0	2	0	0	0	0	0	2	0
10,000-25,000	4	0	38	0	32	0	23	0	3	0	4	0	0	0	3	0	5	0
25,001-40,000	9	0	62	2	62	0	59	0	5	0	8	0	0	0	5	0	9	0
40,001-55,000	13	2	101	7	91	2	54	0	10	0	16	0	3	0	10	0	12	2
55,001-70,000	20	8	94	9	80	6	38	3	13	1	14	2	6	2	13	1	17	9
70,001-85,000	28	18	78	16	65	13	31	10	15	2	12	4	11	7	15	2	19	11
85,001-100,000	23	22	60	25	41	24	19	13	12	6	11	8	12	10	12	6	18	15
>100,000	22	21	44	40	31	28	15	14	11	9	7	6	13	13	11	9	17	17

The modal split for the different zones for business and non-business trips were determined as shown in Tables 4 to 21. Table 4 shows that the highest number of business trips per week generated from low residential zones is attracted to public zones while military zones attracted the least number.

Table 4. Modal split for business trips with low residential zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Medium Residential	1200	360	0	480	0	360
High Residential	840	240	0	360	120	120
Commercial	2400	720	0	1440	0	240
Recreational	600	120	0	480	0	0
Educational	1940	740	0	720	480	0
Industrial	360	120	0	120	120	0
Military	480	120	0	360	0	0
Public	5400	840	960	2160	0	1440

With regards to non-business trips, Table 5 shows that the highest number generated per week from low residential zones is attracted to public zone and the least to educational zones. This is due to the fact that civil servants mainly reside in low residential zones and they work in public zones. The closeness of public zones to low residential zones acts as a "magnet" that draws trips from low residential zones to public zones.

Table 5. Modal split for non-business trips with low residential zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Medium Residential	360	120	0	120	0	120
High Residential	1320	240	120	840	120	0
Commercial	1320	360	0	720	0	240
Recreational	360	120	0	240	0	0
Educational	120	120	0	0	0	0
Industrial	240	120	0	120	0	0
Military	360	120	0	240	0	0
Public	1440	360	480	0	0	600

Table 6 shows that the highest business trips per week generated from medium residential zones is attracted to commercial zones while the least number is attracted to industrial zones.

Table 6. Modal split for business trips with medium residential zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	2485	497	0	1491	0	497
High Residential	20377	2982	1491	9940	4473	994
Commercial	29323	3976	994	16401	5467	2485
Recreational	1988	994	0	497	497	0
Educational	1491	497	0	497	497	0
Industrial	994	497	0	0	0	0
Military	2485	994	0	0	0	497
Public	8449	2982	497	884	884	994

It is evident from Table 7 that the highest number of non-business trips per week generated from medium residential zones is attracted to commercial zones and the least to educational zones. This can be adduced to the fact that trading activities in medium residential zones attract trips to commercial zones.

Table 7. Modal split for non-business trips with medium residential zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	4620	1680	0	7140	0	0
High Residential	5880	1620	840	2940	0	420
Commercial	18900	5880	1680	6720	2100	2520
Recreational	5460	1680	420	2100	1260	0
Educational	1680	420	0	840	420	0
Industrial	2100	420	0	1260	420	0
Military	2520	420	0	2100	0	0
Public	4200	1680	0	1680	0	840

Table 8 shows that the highest number of business trips per week originating from high residential zones is attracted to commercial zones while the least is attracted to educational zones.

Table 8. Modal split for business trips with high residential zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	5467	1491	497	2982	0	497
Medium Residential	15407	3479	1491	6958	1491	1988
Commercial	35287	6958	2982	11928	4970	7455
Recreational	3976	994	0	2485	497	0
Educational	497	497	0	0	0	0
Industrial	1988	497	0	994	497	0
Military	1491	497	0	994	0	0
Public	2982	994	0	1491	0	497

Table 9 shows that he highest non-business trips per week from high residential zones is attracted to commercial zones while the least is attracted to industrial zones. This is because business activities in commercial zones always pull both business and non-business trips to it. The presence of hotels and other relaxation centers serve as "magnet" to trips particularly non-business trips.

Table 9. Modal split for non-business trips with high residential zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	15120	3360	840	9240	0	1680
Medium Residential	25200	4200	1260	15540	3360	840
Commercial	27720	5040	4200	13020	0	5460
Recreational	11340	2100	1680	5460	2100	0
Educational	10080	2100	0	5460	2520	0
Industrial	7140	1680	420	2940	1680	420
Military	8400	1680	840	5040	0	2520
Public	21000	6300	840	11340	0	840

Table 10 shows that the highest number of business trips per week originating from commercial zones is attracted to industrial zones while the least is attracted to both low residential and military zones.

Table 10. Modal split for business trips with commercial zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	148	74	0	74	0	0
Medium Residential	592	148	0	370	74	0
High Residential	1480	444	74	370	592	0
Recreational	1850	370	296	740	296	0
Educational	1628	370	222	444	592	0
Industrial	2146	296	0	1110	740	0
Military	148	74	0	74	0	0
Public	1110	444	0	518	0	148

Table 11 shows that he highest non-business trips per week from commercial zones is attracted to high residential zones while the least is attracted to industrial zones.

Table 11. Modal split for non-business trips with commercial zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	2840	496	0	1736	608	0
Medium Residential	4464	744	248	2232	1240	0
High Residential	5456	1240	496	1736	1984	0
Recreational	2480	744	0	1488	248	0
Educational	992	248	0	496	248	0
Industrial	476	248	0	0	228	0
Military	992	248	0	744	0	0
Public	2728	744	0	1488	0	496

Table 12 shows that the highest number of business trips per week generated from recreational zones is attracted to commercial zones while the least is attracted to both educational and industrial zones.

Table 12. Modal split for business trips with recreational zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	115	46	0	69	0	0
Medium Residential	184	46	0	115	23	0
High Residential	230	69	0	138	0	23
Commercial	368	115	46	207	0	0
Educational	23	23	0	0	0	0
Industrial	23	23	0	0	0	0
Military	276	92	0	138	46	0
Public	138	46	0	69	0	23

Table 13 shows that he highest non-business trips per week from recreational zones is attracted to both commercial and educational zones while the least is attracted to low residential, medium residential and military zones.

Table 13. Modal split for non-business trips with recreational zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	99	0	0	99	0	0
Medium Residential	99	0	0	60	39	0
High Residential	1485	198	0	990	297	0
Commercial	3960	693	198	2079	990	0
Educational	3960	792	279	1782	108	0
Industrial	297	99	0	198	9	0
Military	99	0	0	99	396	0
Public	2475	1089	0	990	0	0

Table 14 shows that the highest number of business trips per week generated from educational zones is attracted to commercial zones while the least is attracted to military zones.

Table 14. Modal split for business trips with educational zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	90	45	0	45	0	0
Medium Residential	675	180	0	360	90	0
High Residential	315	90	40	180	5	0
Commercial	1864	316	0	803	745	0
Recreational	965	194	70	532	169	0
Industrial	185	56	55	56	18	0
Military	81	81	0	0	0	0
Public	350	116	0	234	0	0

Table 15 shows that the highest number of non-business trips per week from educational zones is attracted to commercial zones while the least is attracted to military zones.

Table 15. Modal split for non-business trips with educational zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	138	69	0	69	0	0
Medium Residential	276	69	0	138	69	0
High Residential	1380	345	138	897	0	0
Commercial	2070	483	0	1035	552	0
Recreational	1380	207	69	621	483	0
Industrial	207	69	69	69	0	0
Military	69	69	0	0	0	0
Public	414	138	0	276	0	0

Table 16 shows that the highest number of business trips per week generated from industrial zones is attracted to high residential zones while the least is attracted to commercial zones.

Table 16. Modal split for business trips with industrial zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	1818	365	0	1232	0	221
Medium Residential	3673	643	257	1646	730	397
High Residential	3903	1010	395	1281	802	415
Commercial	447	156	54	0	237	0
Recreational	917	244	0	673	0	0
Educational	516	258	0	0	258	0
Military	809	136	0	673	0	0
Public	2565	455	0	1724	0	386

Table 17 shows that the highest number of non-business trips per week generated from industrial zones is attracted to military zones while the least is attracted to low residential zones.

Table 17. Modal split for non-business trips with industrial zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	276	138	0	138	0	0
Medium Residential	690	138	0	414	138	0
High Residential	759	207	69	345	138	0
Commercial	828	138	0	414	276	0
Recreational	552	138	0	414	0	0
Educational	690	138	138	414	0	0
Military	1035	150	0	775	110	0
Public	552	138	0	414	0	0

Table 18 shows that the highest number of business trips per week generated from military zones is attracted to commercial zones while the least is attracted to industrial zones.

Table 18. Modal split for business trips with military zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	73	0	0	73	0	0
Medium Residential	345	59	46	161	0	69
High Residential	598	115	0	483	0	0
Commercial	690	92	46	506	46	0
Industrial	69	46	0	23	0	0
Recreational	138	46	0	92	0	0
Educational	115	23	0	92	0	0
Public	230	69	0	138	0	23

Table 19 shows that the highest number of non-business trips per week generated from industrial zones is attracted to commercial zones while the least is attracted to both industrial and educational zones.

Table 19. Modal split for non-business trips with military zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	148	74	0	74	0	0
Medium Residential	296	74	0	148	74	0
High Residential	1110	296	0	518	296	0
Commercial	3700	740	74	666	2220	0
Industrial	74	74	0	0	0	0
Recreational	518	148	0	296	74	0
Educational	74	74	0	0	0	0
Public	444	148	0	222	0	74

Table 20 shows that the highest number of business trips per week generated from public zones is attracted to industrial zones while the least is attracted to military zones.

Table 20. Modal split for business trips with public zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	8678	1984	494	5456	0	744
Medium Residential	10895	1967	1240	6944	0	744
High Residential	7688	1984	496	4464	0	744
Commercial	15624	2480	2232	7936	2480	496
Industrial	21824	3224	0	11160	7440	0
Recreational	2722	248	0	1730	744	0
Educational	3276	796	248	992	1240	0
Military	1488	248	248	992	0	0

Table 21 shows that the highest number of non-business trips per week generated from industrial zones is attracted to commercial zones while the least is attracted to military zones.

Table 21. Modal split for non-business trips with public zone as origin

Destination	Trips per week	Private vehicle	Trek	Public transport		
				Cab	Bus	Motor cycle
Low Residential	1395	315	180	720	0	450
Medium Residential	180	45	0	45	0	90
High Residential	540	180	0	315	0	45
Commercial	1620	450	45	720	0	405
Industrial	135	90	0	45	0	0
Recreational	360	135	0	180	0	45
Educational	90	45	0	45	0	0
Military	45	45	0	0	0	0

An appraisal of Tables 4 to 21 shows that the zone with the highest total number of business and non-business trips terminating therein is the commercial zone with 90,215 trips. This result is anticipated as commercial zones are the 'hub' or 'central zones' of cities which attract a lot of activities. Hence, such zones need to be provided with well laid out network of roads for easy access by other zones.

5.0 CONCLUSION

Based on the results of analysis carried out in this study, it is reasonable to conclude that the number of persons per household and the number of households in various zones have direct proportionality to the number of business and non-business trips generated per week in Ado-Ekiti. Similarly, land-use activities have considerable effect on both business and non-business trips attracted per week. The closeness in distance between one zone and the other has a direct proportionality to the number of trips attracted per week. The study also shows that there is a direct proportionality between the level of income of households and the ownership of cars.

The outcomes of this study showed that land-use and socio-economic factors have considerable effect on trip making behavior of commuters within Ado-Ekiti. It is therefore recommended that the outcomes of this study be used for future planning of Ado-Ekiti's transportation system.

6.0 ACKNOWLEDGEMENT

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