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ELASTICITY OF INTERNET TRAFFIC DISTRIBUTION IN COMPUTER NETWORK IN TWO MARKET ENVIRONMENT

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Abstract: The Internet service is managed by operators and each one tries to capture larger proportion of Internet traffic. This tendency causes inherent competition in the market. The location of the market in also an important factor. This paper assumes two different markets and two operators are in competition. It is found that elasticities value depend on market position. The priority position market has higher level. This paper present Elasticities analysis of traffic sharing pattern among operators. Simulation study is performing to analyze the Elasticities impact on traffic sharing.

Keywords: Markov chain model, Transition probability, Initial preference, Blocking probability, Call-by-call basis, Internet service providers [operators or ISP], Quality of service (QOS), Transition probability matrix.

INTRODUCTION

We assume a situation that there are two markets situated at distant apart in a city. Both the markets have Internet café with connection of two operators, O_u *(u=1,3)* and O_v *(v=2,4)*. A user has a choice to pickup one market based on his liking and then selected the favourate operators in the Internet café. Both operators are in competitions to occupy more and more proportion of internet users. The network of both operators is suffering from blocking. The matter of interest is to know how blocking probability affects the customer proportion in the setup of two markets. Elasticities means rate of change of one variable with respect to other when many other parameters are kept constant. The traffic sharing by two operators is a variable and needs to examine in the light of Elasticities. This paper presents Elasticities based analysis of internet traffic sharing in multi operator and multi markets environment.

A REVIEW

Shukla *et al*. (2007) discussed analysis of internet traffic distribution between two markets using Markov chain model in computer networks. This contribution has initiated the problem of traffic sharing in two-market environment. Shukla *et al*. (2009) has extended the above approach by incorporating the share loss analysis of internet traffic distribution. Medhi (1991) discussed the basic fundamentals of Markov chain model. Shukla et al. (2009 b) presented all comparison analysis of internet traffic sharing using Markov chain model which is an extension of Naldi (2002). Catledge and Pitkow (1995) discussed a contribution on characterization of browsing strategies. Pirolli and pitkow (1996) suggested usable structure for web in light of many users. A similar study performed by pitkow (1997) regarding search of reliable usage data on www. Naldi (2001) presented Markov chain model based study in a multioperator environment. The detail distribution of Markov chain model is in Medhi (1991) and web browsing details are in Han and Kamber (2001). Shukla *et al*. (2007) discussed stochastic model for space decision switches for computer network. Shukla *et al*. (2007 a, b, c) suggested the use of Markov chain model in networking and operating system analysis. Shukla and Jain (2007) used Markov chain model for the analysis of multilevel Queue Scheduler in the operating system. Shukla and Singhai (2010 a) discussed traffic share analysis of massage flow in three crossbar architecture space division switches. Deshpande & Karypis (2004) discussed selective Markov chain model for predicting webpage access. Shukla *et al*. (2010 a, b, c, d, e, f, g, h) discussed different aspects on Markov chain model in determining the system behavior. Shrivastava et al. (2000) presented a thought oriented contribution on web page mining discovery and application of usage patterns from web data.

MARKOV CHAIN MODEL

Let $\{X_n, n \geq 0\}$ be a Markov chain model. As per Fig 3.1, let O_1, O_2, O_3 and O_4 be operators (ISP) in the two competitive Market-I (M_1) and Market-II (M_2). User chooses a market first, and then enters into a cyber-café situated inside. Where computer terminals of different operators are available to access the Internet. Operators are grouped as O_u *(u=1,3)* and O_v *(v=2,4)* for market-I and market-II Let$\{X^{(n)}, n \geq 0\}$ be a Markov chain having transitions over the state space M_1, M_2 and $\{O_1, O_2, O_3, O_4, Z_1, Z_2, A\}$

State O1: First operator in market-I,

State O_2: Second operator in market-I,

State O_3: Third operator in market-II,

State O_4: Fourth operator in market-II,

State Z_1: Success (link) in market-I (M_1)

State Z_2: Success (link) in market- II (M_2)

State A: Abandon the attempt process.

The $X^{(n)}$ stands for the state of random variable X at n^{th} attempt of connectivity $(n \geq 0)$ made by the user. Some underlying assumptions of the Markov chain model are:

(a) A User (or Customer or CU) first select the Market-I with probability q and Market-II with probability $(1-q)$, (see Fig 3.1)

(b) After choosing a market, User enters in the cyber-café (shop), chooses the first operator O_u with probability p or to O_v with $(1-p)$.

(c) Blocking probability experienced by the operator O_u are L_1 & L_3 and by O_v are L_2 & L_4

(d) The connectivity attempts by user between operators are on call-by-call basis, if the call for O_u is blocked in k^{th} attempt $(k > O)$ then in $(k+1)^{th}$ attempt user shifts to O_v. If this also fails, user switches to O_u in $(k+2)^{th}$.

(e) Whenever call connects through either of operators O_u or O_v, we say system reaches to the state of success in n attempts.

(f) User can terminate the attempt process which is marked as system to the abandon state Z at n^{th} attempts with probability p_A (either O_u or from O_v).

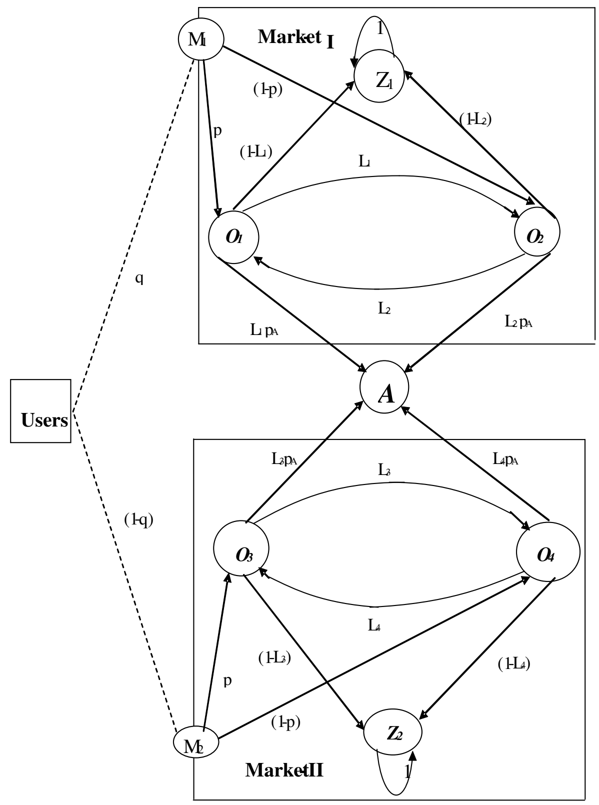

Figure.1 Transition Diagram of model.

Fig.3.1 Explains the transition mechanism with transition probability matrix in (3.1)

States $X^{(n)}$

$X^{(n-1)}$	O_1	O_2	O_3	O_4	Z_1	Z_2	A	M_1	M_2
O_1	0	$L_1(1-p_A)$	0	0	$1-L_1$	0	$L_1 P_A$	0	0
O_2	$L_2(1-p_A)$	0	0	0	$1-L_2$	0	$L_2 p_A$	0	0
O_3	0	0	0	$L_3(1-p_A)$	0	$1-L_3$	$L_3 p_A$	0	0
O_4	0	0	$L_4(1-P_A)$	0	0	$1-L_4$	$L_4 P_A$	0	0
Z_1	0	0	0	0	1	0	0	0	0
Z_2	0	0	0	0	0	1	0	0	0
A	0	0	0	0	0	0	1	0	0
M_1	p	1-p	0	0	0	0	0	0	0
M_2	0	0	p	1-p	0	0	0	0	0

SOME USEFUL RESULTS FOR n^{th} CONNECTIVITY ATTEMPTS

Theorem 1.0 : The odd and even n^{th} step probability for O_1 in Market –I is:

$$P[x^{(n)} = O_1]_{M_1} = q\,(1-p)\,(1-p_A)[\,[(1-p_A)^{n-2}]\,]$$

(Even)

$$P[x^{n} = O_1]_{M_1} = q\,p\,[\,[(1-p_A)^{n-1}]\,]$$

(Odd)

Proof: For n=0 at M_1, we have $P[X^{(0)}=M_1]=q$

The start is either from O_1 or from O_2 after choosing M_1, therefore,

$$P[X^{(1)} = O_1] = p[X^{(0)} = M_1]P[X^{(1)} = O_1/X^{(0)} = M_1]$$
$$= q\,p$$
$$P[X^{(1)} = O_2] = P[X^{(0)} = M_1]P[X^{(1)} = O_2/X^{(0)} = M_1]$$
$$= q(1-p)$$
$$P[X^{(2)} = O_1] = P[X^{(0)} = O_2]\,P[X^{(2)} = O_1/X^{(1)} = O_2]$$
$$= q(1-p)\,(L_2)\,(1-p_A)$$
$$P[X^{(2)} = O_2] = P[X^{(1)} = O_1]\,P[X^{(2)} = O_2/X^{(1)} = O_1]$$
$$= qpL_1(1-p_A)$$
$$P[X^{(3)} = O_1] = P[X^{(2)} = O_2]\,P[X^{(3)} = O_1/X^{(2)} = O_2]$$
$$= q\,p\,L_2(1-p_A)$$
$$P[X^{(3)} = O_2] = P[X^{(2)} = O_1]\,P[X^{(3)} = O_2/X^{(2} = O_1]$$
$$= q(1-p)\,L_1\,L_2(1-p_A)$$
$$P[X^{(4)} = O_1] = P[X^{(3)} = O_2]\,P[X^{(4)} = O_1/X^{(3)} = O_2]$$
$$= q(1-p)\,L_1\,L_{2^2}\,(1-p_A)^3$$
$$P[X^{(4)} = O_1] = P[X^{(3)} = O_2]\,P[X^{(4)} = O_1/X^{(3)} = O_2]$$
$$= q(1-p)\,L_1\,L_{2^2}\,(1-p_A)^3$$
$$P[X^{(4)} = O_2] = P[X^{(3)} = O_1]\,P[X^{(4)} = O_2/X^{(3)} = O_1]$$
$$= q\,p\,L_{1^2}\,L_2(1-p_A)$$

The continuation provides proof of theorem for n^{th} odd and even attempts.

Theorem 1.1: The n^{th} step transitions probability for O_2 in Market -1 is:

$$P[x^{(n)} = O_2]_{M_1} = q\,p\,(1-p_A)[\,[(1-p_A)^{n-2}]]$$
(Even)

$$p[x\,(n) = O_2]_{M_1} = q\,(1-p)[\,[(1-p_A)^{n-1}]]$$
(Odd)

Theorem 1.2: The n^{th} step transitions probability for O_3 in Market-II is:

$$P[x^{n} = O_3]_{M_2} = (1-q)\,(1-p)\,L_4\,(1-p_A)\,[(1-p_A)^{n-2}]$$

$$p[X^{n} = O_3]_{M_2} = (1-q)\,p\,[\,[(1-p_A)^{n-1}]]$$
(Odd)

Theorem 1.3: The n^{th} step transitions probability for O_4 in Market-II is:

$$P[x^{n} = O_4]_{M_2} = (1-q)\,p\,L_3\,(1-p_A)\,[\,[(1-p_A)^{n-2}]]$$

$$P[x^{(n} = O_4]_{M2} = (1-q)\,(1-p)[\,[(1-p_A)^{n-1}]]$$
(Odd)

QUALITY OF SERVICE [QOS]

There are two types of users as:

Faithful User [FU]

A user who is faithful to an operator O_u only otherwise he goes to abandon state but does not attempt for O_V. The converse of it may as he attempts for O_V only and goes to state A otherwise.

Impatient User [IU]

A user who attempts between the two Operators O_u and O_v only all the time until call complete or otherwise abandons the process.

$$B_f = q\,[p\,L_1 + (1-p)L_2] + (1-q)\,[p\,L_3 + (1-p)\,L_4]$$

ELASTICITY STUDIES OVER LARGE ATTEMPT

Let p_1 be the traffic sharing by the first operator, p_2 be the traffic sharing by the second operator using Markov chain model using Naldi (2002), Shukla et al. (2007) we can obtain the expressions of traffic sharing as:

$$\overline{p_{1\,M1}} = \frac{(1-L_1)q}{1-L_1L_2(1-p_A)^2}[\,p + (1-p)L_2(1-p_A)]$$

$$\overline{p_{2\,M1}} = \frac{(1-L_2)q}{1-L_1L_2(1-p_A)^2}[(1-p) + pL_1(1-p_A)]$$

$$\overline{p_{3\,M2}} = \frac{(1-L_1)(1-q)}{1-L_1L_2(1-p_A)^2}[\,p + (1-p)L_2(1-p_A)]$$

$$\overline{p_{4\,M_2}} = \frac{(1-L_2)(1-q)}{1-L_1L_2(1-p_A)^2}[(1-p) + pL_1(1-p_A)]$$

If y=f (x, z) is function then elasticity of y with respect to z is

$\left(\dfrac{\partial y}{\partial z}\right)$ Where x is a constant.

Similarly with respect to x is

$\left(\dfrac{\partial y}{\partial x}\right)$ Where z is a constant.

Differentiate with respect to L_1 we get

$$e_1(.) = \left(\frac{\partial \overline{p_{1\,M_1}}}{\partial L_1}\right)_{L_2,p,q,p_A} = \frac{[q\{p + (1-p)L_2(1-p_A)\}]\,\{L_1L_2(1-p_A)^2 - 1\} + \{(1-L_1).L_2(1-p_A)^2\}}{\{1-L_1L_2(1-p_A)^2\}^2}$$

Differentiate with respect to L_2 we get

$$e_2(.) = \left(\frac{\partial \overline{p_{1M_1}}}{\partial L_2}\right)_{L_1,p,q,p_A} = \{(1-L_1)q \frac{\{1-L_1L_2(1-p_A)^2\}.\{(1-p)(1-p_A)\} + \{p+(1-p)L_2(1-p_A)\}.\{L_1(1-p_A)^2\}}{\left[1-L_1L_2(1-p_A)^2\right]^2}$$

Differentiate with respect to L_1 we get

$$f_1(.) = \left(\frac{\partial \overline{p_{2M_1}}}{\partial L_1}\right)_{L_2,p,q,p_A} = \frac{(1-L_2)q[\{1-L_1L_2(1-p_A)^2\}\{(p(1-p_A))\} + \{(1-p)+pL_1(1-p_A)\}\{L_2(1-p_A)^2\}]}{[1-L_1L_2(1-p_A)^2]^2}$$

Differentiate with respect to L_2 we get

$$f_2(.) = \left(\frac{\partial \overline{p_{2M1}}}{\partial L_2}\right)_{L_1,p,q,p_A} = \frac{q\{(1-p)+pL_1(1-p_A)\}[\{L_1L_2(1-p_A)^2-1\} + (1-L_2)L_1(1-p_A)^2\}]}{[1-L_1L_2(1-p_A)^2]^2}$$

Differentiate with respect to L_1 we get

$$g_1(.) = \left(\frac{\partial \overline{p_{3M2}}}{\partial L_1}\right)_{L_2,p,q,p_A} = \frac{(1-q)\{p+(1-p)L_2(1-p_A)\}[\{L_1L_2(1-p_A)^2-1\}+\{(1-L_1)L_2(1-p_A)^2\}]}{\{1-L_1L_2(1-p_A)^2\}^2}$$

Differentiate with respect to L_2 we get

$$g_2(.) = \left(\frac{\partial \overline{p_{3M2}}}{\partial L_2}\right)_{L_1,p,q,p_A} = \frac{\{(1-L_1)(1-q)[\{1-L_1L_2(1-p_A)^2\}\{(1-p)(1-p_A)\}+\{p+(1-p)L_2(1-p_A)\}L_1(1-p_A)^2]}{[1-L_1L_2(1-p_A)^2]^2}$$

Differentiate with respect to L_1 we get

$$h_1(.) = \left(\frac{\partial \overline{p_{4m2}}}{\partial L_1}\right)_{L_2,p,q,p_A} = \frac{\{(1-q)(1-L_2)\}[\{1-L_1L_2(1-p_A)2\}\ p(1-p_A)+\{(1-p)+pL_1(1-p_A)\}L_2(1-p_A)^2)]}{[1-L_1L_2(1-p_A)^2]^2}$$

Differentiate with respect to L_2 we get

$$h_2(.) = \left(\frac{\partial \overline{p_{4M2}}}{\partial L_2}\right)_{L_1,p,q,p_A} = \frac{(1-q)\{(1-p)+pL_1(1-p_A)\}[\{L_1L_2(1-p_A)^2-1\}+\{(1-L_2).L_1(1-p_A)^2\}]}{[1-L_1L_2(1-p_A)^2]^2}$$

SIMULATION STUDY

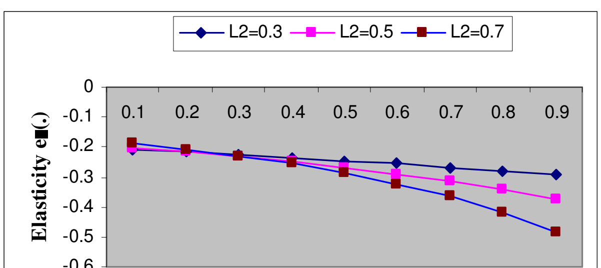

Fig (1.0) Blocking probability L_1 (p=0.5, q=0.4, p_A=0.2)

In view to fig. 1.0 the elasticities of the traffic share of the first operator in the first market is going down with the increasing level blocking probability. However if opponent operator also bears the same in increasing patterns, then the elasticity curve is further lower down.

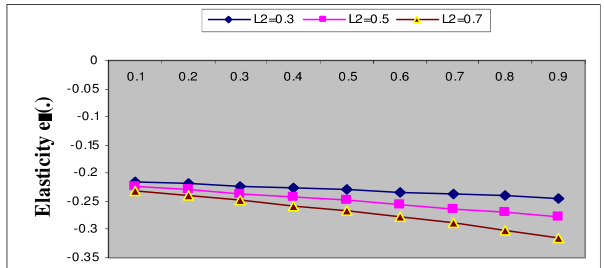

Fig. (2.0) Blocking probability L_1 (p=0.5, q=0.4, p_A=0.5)

According to fig. 2.0, when p_A probability is little high the similar pattern exists at the higher down fall level. If opponent bears higher level of blocking then the elasticity has negative trend.

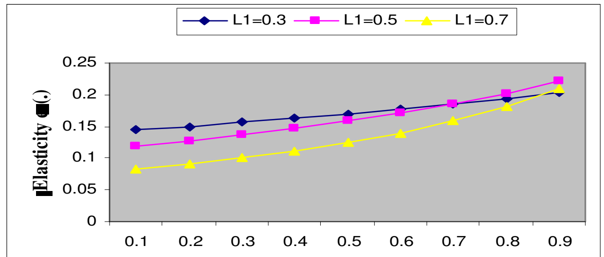

Fig (3.0) Blocking probability L_2 (p=0.5, q=0.4, p_A=0.2)

When to consider the opponent blocking probability as a base (fig 3.0) the trend is linear and by increasing L_2 the elasticity bears positive sign. If L_1 is also high with L_2, the rate of linear increment becomes small.

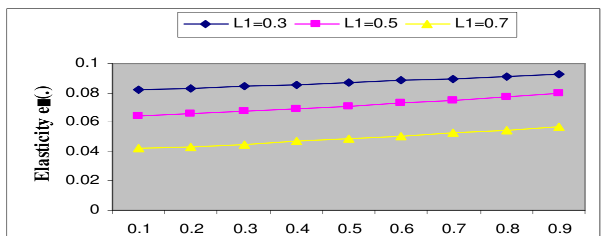

Fig (4.0) Blocking probability L_2 (p=0.5, q=0.4, p_A=0.5)

But when p_A is little high (fig. 4.0) the curves are sifted toward higher values with similar trend. This is observed in the first market.

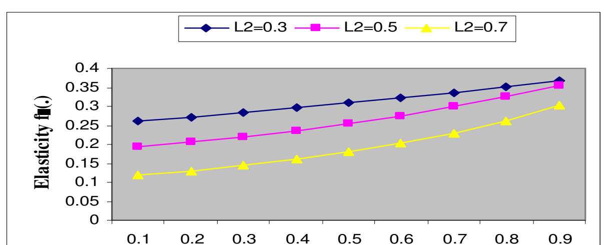

Fig (5.0) Blocking probability L_1 (p=0.5, q=0.4, p_A=0.2)

While to consider traffic sharing of second operator, the elasticities pattern is in upward trend as in case of first market. With the increase of opponent L_2 this pattern remains the same but elasticity value is lower.

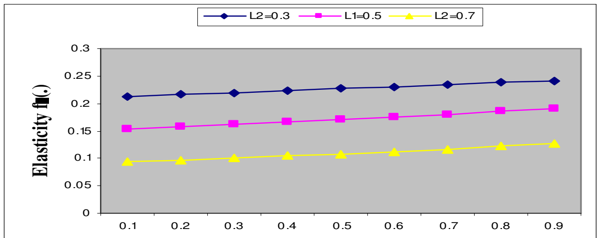

Fig. (6.0) Blocking probability L_1
(p=0.5, q=0.4, p_A=0.5)

When p_A probability is high (fig. 6.0) the more stable pattern is found. In this case elasticities are looking like independent to L_1 variation.

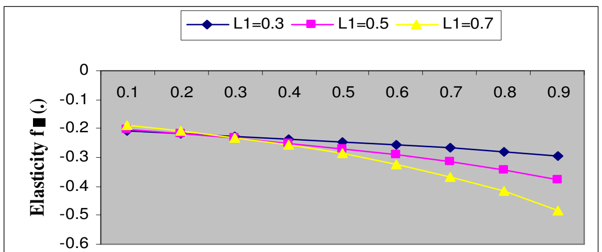

Fig (7.0) Blocking probability L_2
(p=0.5, q=0.4, p_A=0.2)

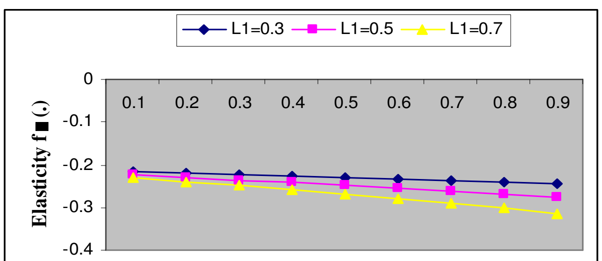

Fig. (8.0) Blocking probability L_1
(p=0.5, q=0.4, p_A=0.5)

Fig. (7.0, 8.0) are similar type but having L_2 probability as variant. These graphs are similar to figure (5.0, 6.0) but differ for traffic share p_2 of O_2.

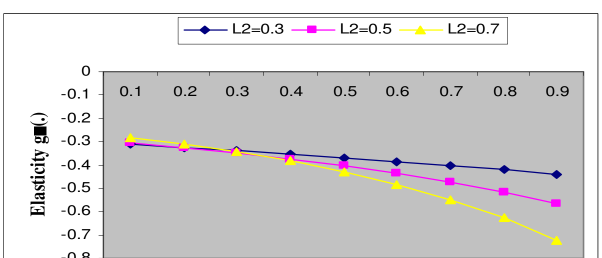

Fig. (9.0) Blocking probability L_1
(p=0.5, q=0.4, p_A=0.2)

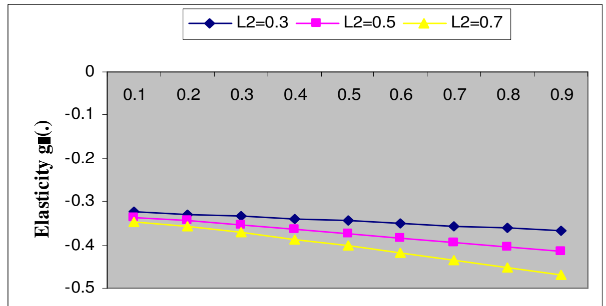

Fig. (10.0) Blocking probability L_1
(p=0.5, q=0.4, p_A=0.5)

Fig. (9.0, 10.0) are showing elasticities pattern for third operator bearing the blocking probability L_1. The trend is downward and sharper than earlier cases. For little high L_2 level this goes further down.

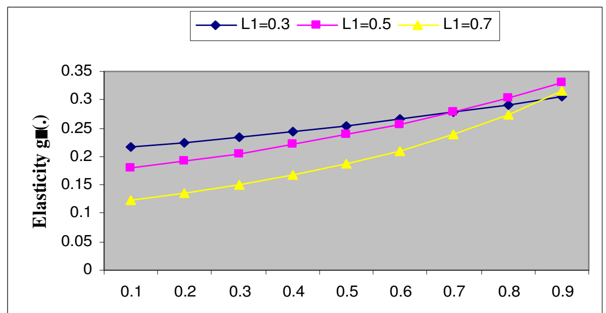

Fig. (11.0) Blocking probability L_2
(p=0.5,q=0.4,p_A=0.2)

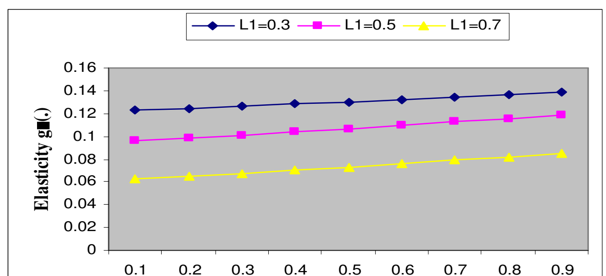

Fig. (12.0) Blocking Probability of L_2
(p=0.5,q=0.4, p_A=0.5)

Fig. (11.0-12.0) are similar but with respect to L_2 probability for P_3 of operator O_3 is high in the second market. Both the curves are having increasing Elasticities over L_2 and decreasing probability level over L_1.

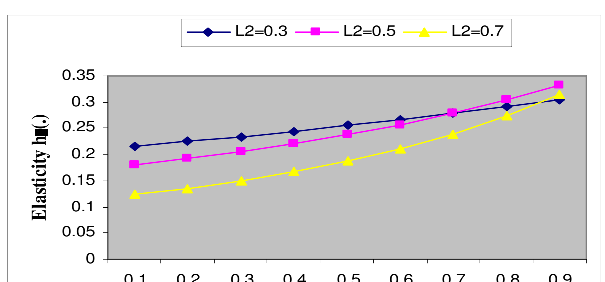

Fig. (13.0) Blocking probability L_1
(p=0.5, q=0.4, p=0.2)

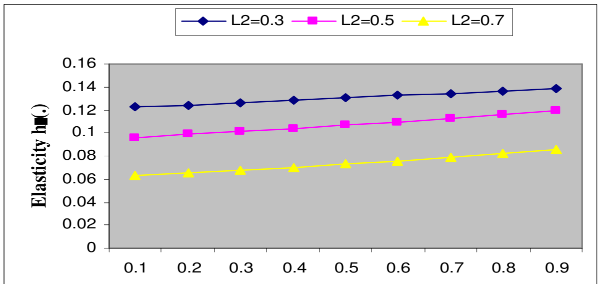

Fig. (14.0) Blocking probability L_1
($p=0.5$, $q=0.4$, $p_A=0.5$)

Fig. (13.0-14.0) are similar to fig. (11.0, 12.0) and showing the positive value of elasticity. When p_A is high then value of positive elasticity is also high.

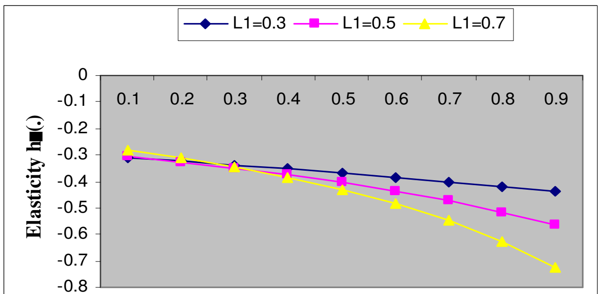

Fig. (15.0) Blocking probability L_2
($p=0.5$, $q=0.4$, $p_A=0.2$)

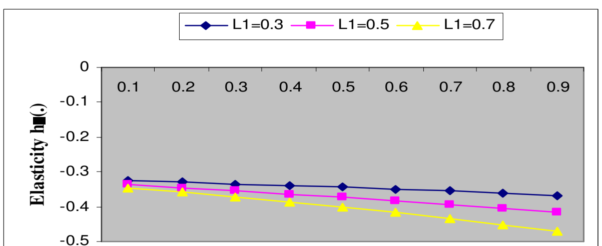

Fig. (16.0) Blocking probability L_2
($p=0.5$, $q=0.4$, $p_A=0.5$)

Fig. (15.0, 16.0) are matching to fig. (9.0, 10.0) and the pattern of elasticity is downward showing a sharp decrement in the tendency.

CONCLUDING REMARKS

The Elasticities of traffic share of operator depends on blocking probability. These are negative in trend but when opponent blocking is high the negativity becomes high. Elasticities value depends on market position. If a market is of high priority, it has higher elasticities level. The abandon probability affects the elasticity level. High abandon chance produces stable pattern of traffic share independent to the blocking probability.

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