TOLL PRICING AND ITS RELATIONSHIP TO TRAVEL DEMAND, ELASTICITY, AND DISTRIBUTION OF ECONOMIC ACTIVITIES FOR HAMPTON ROADS, VIRGINIA

Salvatore J. Bellomo, Alan M. Voorhees and Associates, Inc.

This paper presents the effect of toll pricing on travel demand and distribution of economic activities in the Hampton Roads area of southeastern Virginia. A methodology is described that projects simultaneously travel demand and distribution of population and employment. The results of testing future alternative conditions for crossing Hampton Roads are used to illustrate the impact of changes in new facilities and toll pricing on travel demand, average vehicular trip length, trip purpose, and distribution of future population and employment. The findings in this paper offer an alternative method to the projection of a single-demand estimate used in most urban area transportation studies. The consideration for the elasticity of demand with respect to price described in this paper could be applied to the analysis of major facilities within urbanized areas or between major regions that are considering toll-pricing policies or broader transport-pricing policies.

•PRICING POLICIES can be used by the transportation and urban planner to control travel demand and the distribution of economic activities. Roth (1) pointed out qualitatively how the road pricing of congestion could be used to reduce vehicular travel demand. Golenburg and Keith (2) illustrated quantitatively through a simulation technique how the price on parking could be used to reduce automobile travel demand in Canberra, Australia. The purpose of this paper is to present quantitatively the effect of future toll-pricing schemes on the demand for highway travel and the distribution of economic activities in the Hampton Roads area of southeastern Virginia shown in Figure 1. In order to achieve this objective, it was necessary to develop and apply simultaneously a land use and traffic model that was sensitive to changes in toll pricing, changes in facility operation, new facilities, changes in transport accessibility, and changes in land use for fixed policies related to land-holding capacity and the availability of sewer and water services.

To convey the effects of toll-pricing policy, this paper is organized to discuss existing conditions in the study area, analysis framework used to project travel and land use, evaluation of the traffic and economic impacts of alternatives concerned with new facilities and variations in toll-pricing policy, and conclusions and implications. Through a discussion of existing conditions, the background related to the study area is presented. The analysis framework section discusses the general approach, the testing process, the land use model, and the traffic model. In the evaluation section, the alternatives examined are described. In addition, the evaluation section contains the economic and traffic impacts and financing implications of the alternatives. These impacts indicate the quantitative effects of toll pricing on total economic growth, distribution of economic activities, and travel demand. The last section presents the conclusions and implications.

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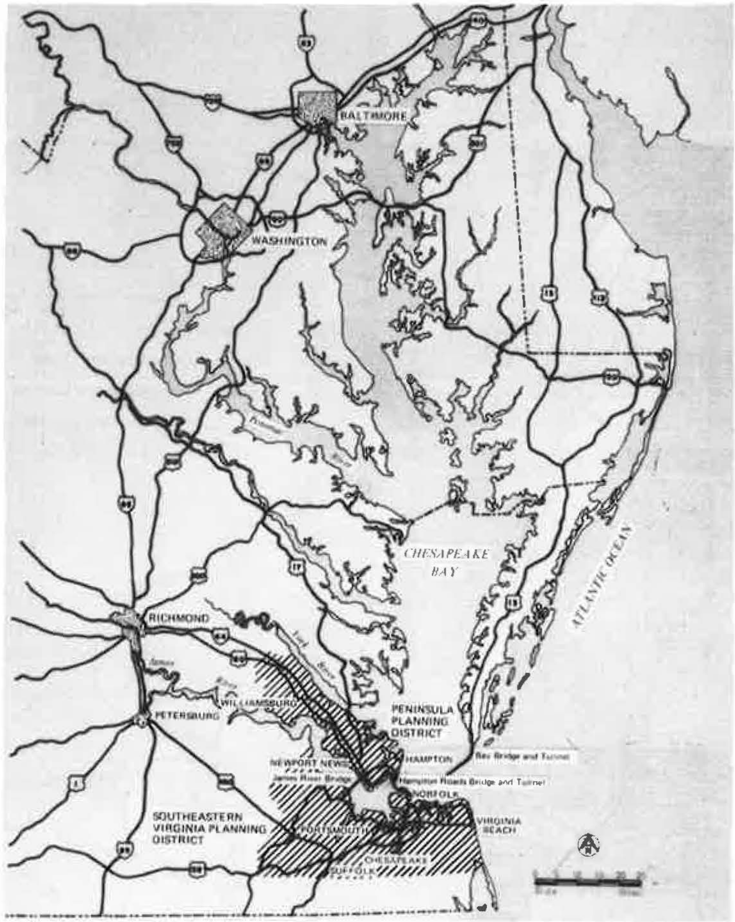

Figure 1. Study area.

EXISTING CONDITIONS

The Hampton Roads region contains many facilities that currently charge tolls. Figure 2 shows the existing highway network and the location of these toll facilities. Table 1 gives the toll rates charged at the various facilities. These tolls were in effect during the conduct of the 1962 Southeastern Transportation Studies with the following exceptions: (a) the new Elizabeth River Tunnel was opened after the data were collected for the Southeastern Study but before the beginning of the Peninsula Study, and (b) the Nansemond Bridge was made free after the data-collection phase of the Southeastern Study and before the beginning of the Peninsula Study. In addition, the toll rates shown are those in use during the 1964 Peninsula Study except for the charge per passenger for the Hampton Roads Bridge-Tunnel and the change in cost of commuter tickets for the Coleman Bridge. This toll summary indicates that the most expensive crossing is the Hampton Roads Bridge-Tunnel ($1.25 for automobiles), while the least expensive crossing is the Jordan Bridge ($0.25 for automobiles).

The traffic within the study area as measured in these origin-destination surveys was approximately 1,300,000 vehicle trips on an average day. These trips were made for a variety of purposes and were generated by the residents and businesses of the jurisdictions within the study area. Of the total vehicular trips made in the study area in 1962-64, only 18,474 trips were crossings of the Hampton Roads channel. Of the 18,474 vehicles that crossed Hampton Roads, 77 percent were automobiles and 23 percent

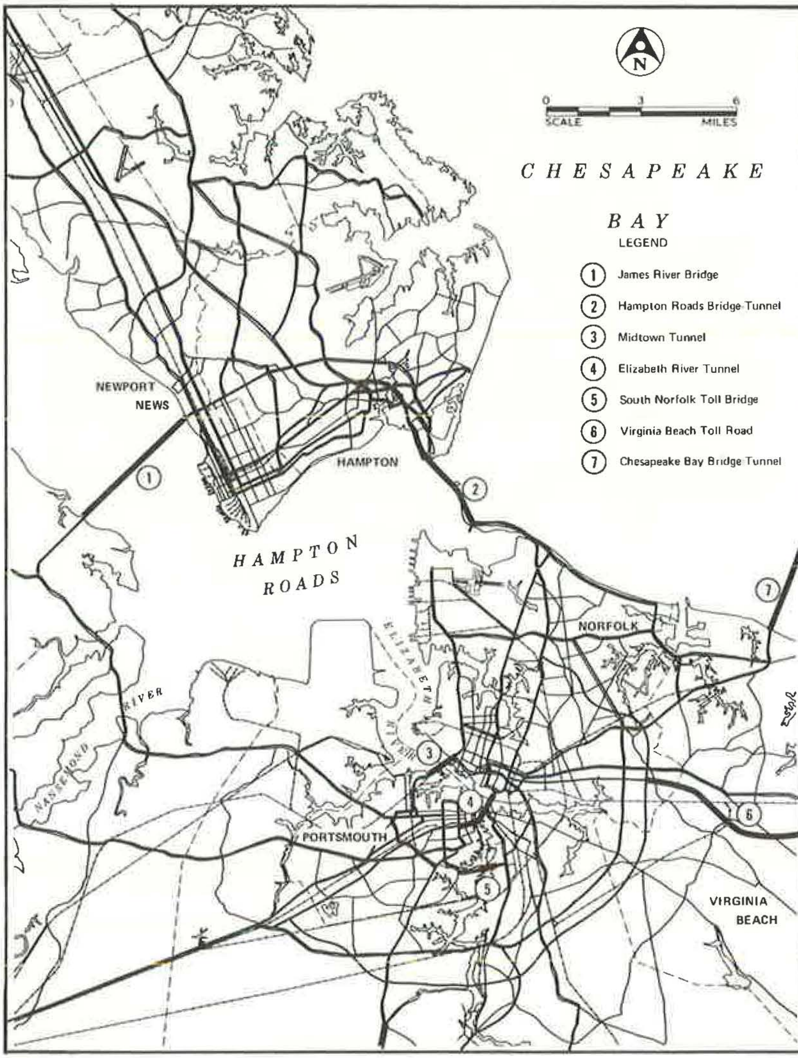

Figure 2. Existing highways and toll facilities.

were trucks. In addition, it was found that, on the average, there were 2.40 persons for each of the Hampton Roads automobile crossings. This is much higher than the region-wide average and is an indication of the barrier to free traffic flow imposed by the Hampton Roads automobile crossings and the existing toll rates. Of the approximately 8,000 nonlocal trips crossing the Hampton Roads channel, 3,700 had trip ends on the peninsula, 3,700 had trip ends in the southeastern region, and 600 were through trips.

The basic cause for the amount and location of trip generation within the Hampton Roads region is the spatial distribution of economic activities that take place on the land. There are approximately 876,000 people in the study area with the majority (599,000) being in the southeastern region. In addition, there are approximately 305,000 jobs with over two-thirds located in the southeastern subregion.

ANALYSIS FRAMEWORK

This section decribes the general approach, the testing process, the land use model, and the traffic model used in the evaluation of alternative methods of crossing the Hampton Roads channel that considered variations in toll pricing in addition to a third crossing.

TABLE 1

1962 TOLLS IN HAMPTON ROADS REGION

Vehicles	Hampton Roads Bridge-Tunnel[a]	James River Bridge[b]	Coleman Bridge[a]	Jordan Bridge	Elizabeth River Tunnel[c]
Automobile					
Cash	$1.25	$0.90	$0.75	$0.25[d]	$0.20[e]
Commuter ticket	0.75[f]	0.55[d]	0.50[g]	—[h]	—
Extra passenger	0.20[i]	—	—	0.05	—
Commercial vehicle					
2 tons or less					
2 axles	1.50	1.20	1.00	0.40	0.40
3 axles	1.75	1.40	1.25	0.60	0.60
2 tons or more					
2 axles	1.75	1.50	1.50	0.40	0.40
3 axles	2.25	1.75	1.75	0.60	0.60
Tractor-trailer					
3 axles	2.50	2.00	2.00	0.60	0.60
4 axles	3.00	2.25	2.50	0.80	0.80
5 axles	3.50	2.50	3.00	1.00	1.00

[a] All bonds to be retired November 1, 1974.
[b] No change since 1956-57.
[c] Opened September 6, 1962; bond to be retired during 2000.
[d] Pickup trucks permitted to use commuter tickets.
[e] Per axle.
[f] Book of commuter tickets costs $9; pickup trucks not permitted to use commuter tickets.
[g] Commuter tickets reduced to 30 cents September 1, 1967; pickup trucks permitted to use commuter tickets.
[h] Twenty-five cents one way, 35 cents round trip; book of 11 round-trip tickets costs $3.50.
[i] Charges for 1 or more passengers changed to 20 cents in 1969.

General Approach

Figure 3 shows the general approach used to measure both the economic and the traffic impacts of alternatives for Hampton Roads. As shown in this figure, the socio-economic impacts of an alternative are measured in terms of the estimated differences between the 1995 population and employment at a jurisdiction level, assuming that the alternative Hampton Roads improvements were made and then comparing these to a base-line economic condition. Transportation impacts are measured in terms of the

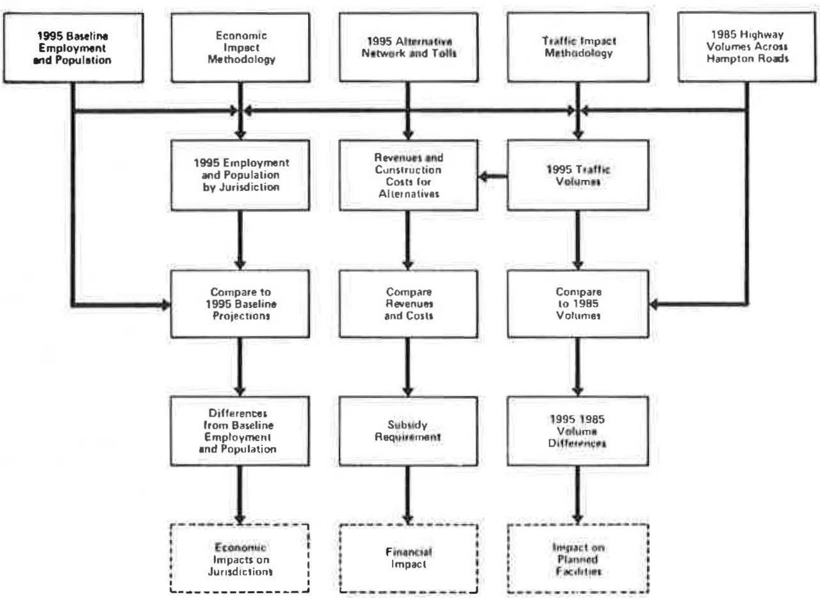

Figure 3. General approach for impact measurement.

magnitude of 1995 vehicular traffic crossing the Hampton Roads channel and the distribution of this traffic on the regional highway network. Transit was assumed to be buses on the highway network. As shown in Figure 3, these 1995 traffic estimates for each alternative are based on the specific population and employment projections for that alternative. The resulting traffic estimates, in addition to estimated construction costs and assumed toll levels, are then utilized to describe the financial implications of each alternative.

The trip categories used in the analysis were as follows:

1. Home-based work trips by civilians in automobiles from home to work and work to home where the home zone is considered as the point of production.
2. Home-based work trips by military personnel in automobiles from home to work and work to home where the home zone is considered as the point of production.
3. Home-based shopping trips by residents of each region in automobiles from home to shop and shop to home where the home zone is considered the point of production.
4. Home-based other trips by the study-area residents in automobiles from home to other activities and from other activities to home where the home zone is considered the point of production.
5. Non-home-based trips in automobiles from one point to another that have neither end at home. Pickup trucks are also included in this category.
6. Heavy truck trips from one point to another that have neither end at home.

Testing Process

The testing process, shown in Figure 4, has several basic components such as (a) the time value of toll costs, (b) the 1975 and 1990 population and employment estimates, (c) the procedure for the distribution of economic activities to small areas, (d) the trip-generation equations, and (e) the trip-distribution procedures. These components are inputs for each alternative to permit the determination of various economic (population and employment projections) and traffic impacts (traffic volumes across Hampton Roads). These major impacts are the basic input for a decision on future transportation needs across the Hampton Roads channel. The testing process, however, requires that certain intermediate steps be undertaken as shown in Figure 3. Travel time between geographic areas is determined by utilizing an alternative network with specified toll rates and the time value of tolls given in Table 2. These values to convert tolls into travel time were calibrated by mode and purpose until the travel patterns from the 1962-64 survey and gravity model were matched. The estimates of travel time across Hampton Roads include a 5-min time period to reflect the psychological effect of this physical barrier. The existence of this time barrier has been demonstrated in many metropolitan areas where parts of the area are physically separated.

After estimates are made of travel times between geographic areas and of basic and nonbasic jobs, a calculation is then made that reflects the accessibility of all jobs to a particular geographic area. This measure of accessibility and the 1975-95 population and employment growth projections make it possible to allocate this growth to small areas. This allocation of economic impacts to small areas permitted the determination of payroll and the assessed valuation increases for each of the alternatives.

TABLE 2

VALUE OF TIME BY TRIP PURPOSE AND MODE

Purpose	Mode	Value of Time per Hour[a]
Home-based work, civilian	Automobile	$ 2.50
Home-based work, military	Automobile	0.60
Home-based shop	Automobile	0.60
Home-based other	Automobile	1.50
Non-home-based	Automobile and pickup truck	1.50
Non-home-based	Heavy truck	14.55

[a]Further information related to the calibration of these values for travel time for the Hampton Roads area is given in another report (5).

For each of the alternatives, future travel was determined from estimates of economic activity, a network, and the procedures for trip generation and distribution. The application of these procedures resulted in an estimate of travel among geographic areas internal to the Hampton Roads region. The internal traffic was then combined with an estimate of nonlocal

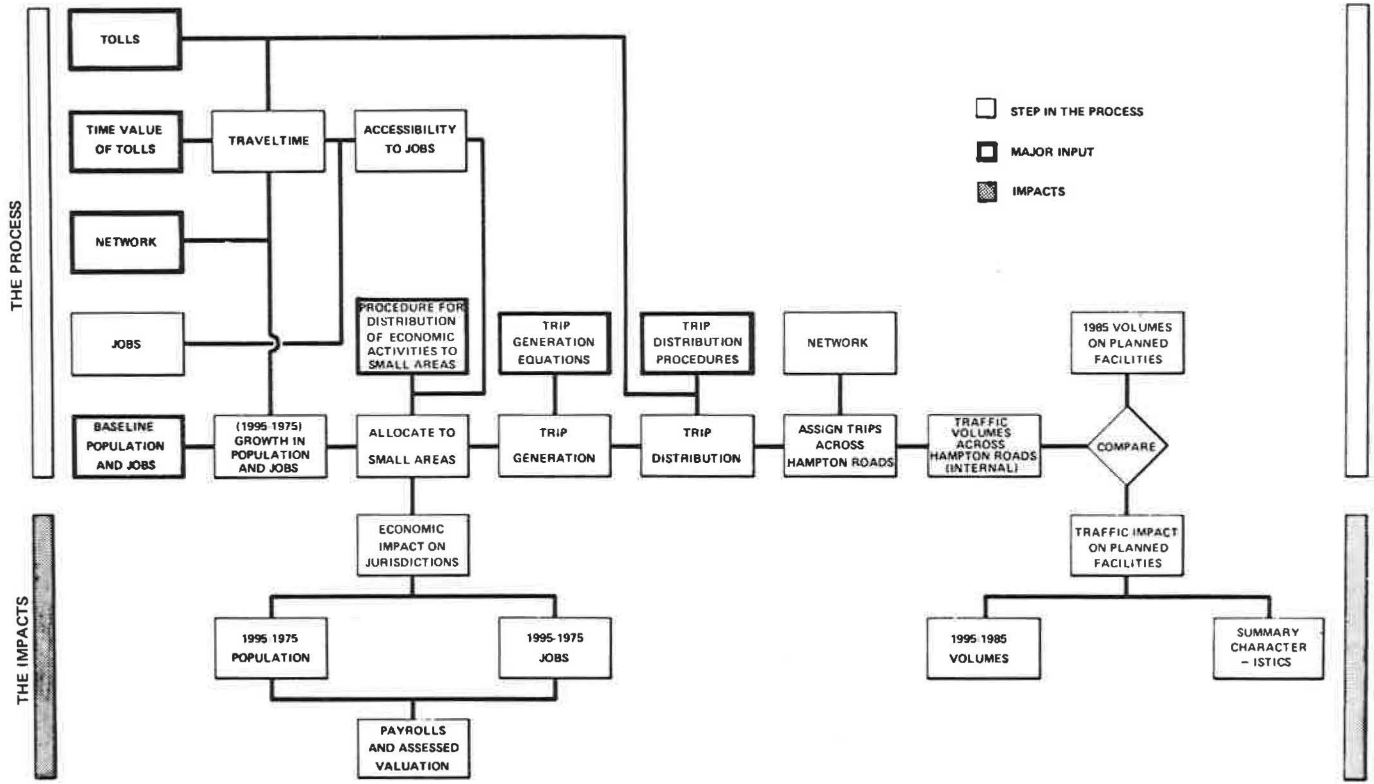

Figure 4. Testing process.

trips and was assigned to the alternative highway network. Examination of these 1995 traffic volumes illustrated the impact of local and nonlocal traffic on the alternative network tested. The 1995 traffic volumes were then compared to 1985 traffic volumes estimated previously by the Peninsula and Southeastern Transportation Studies. This comparison resulted in a measure of impact on facilities planned for the Hampton Roads regions.

Land Use Model

The land use model consists of two basic components: macroallocations and microallocations of economic activities within the Hampton Roads region under basic alternative transportation strategies and assumed conditions related to holding capacity, sewer service, and ocean proximity. The macroallocation of economic activities, particularly employment projections, was based on an economic base study and regional analysis conducted for the Tidewater area. This study was concerned with the changes in the basic industrial sector brought about by changes in the competitiveness of the Hampton Roads region with other regions on the Eastern Seaboard. The background and methodology for the macroanalysis are not presented in this paper.

The distribution of basic employment at a microlevel was estimated by using available information on the present employment characteristics of small areas as well as previous small-area projections developed by the planning agencies. Of particular concern were the areas that would be opened to development because of one of the five alternatives that were investigated as part of the analysis. The distribution of future population growth was accomplished, however, through the use of a mathematical population distribution model, given in the following equation, that was developed and calibrated for the Southeastern Virginia Planning District.

$$G_i = G_T \frac{A_i^c \times H_i \times S_i \times O_i}{\sum_{i=1}^{n} A_i^c \times H_i \times S_i \times O_i}$$

where

- G_i = population growth in zone i;
- G_T = population growth in subregion;
- A_i = accessibility of zone i;
- H_i = holding capacity of zone i;
- S_i = special factors relating to sewer service—sewer, 4.67, septic tank, 2.67, and nonseptic tank, 1.00;
- O_i = special factors related to ocean proximity—adjacent to ocean, 3.0 and not adjacent, 1.0; and
- c = empirical exponent = 0.78.

The model distributed the aggregate population growth projected to analysis zones based on the population holding capacity, accessibility, ocean access, and the availability of sewers for each traffic zone in the study area.

Traffic Model

Trip-generation, trip-distribution, and trip-assignment procedures were the basic techniques used in the traffic model developed to synthesize travel within and between the two regions.

In order to determine future trip generation from forecasts of land activity, we established a set of relationships or equations between trip generation and these land-activity measures.

The following trip-production equations were developed:

Home-based work, civilian = 0.45 (civilian labor force, CBD) + 35 + 0.95 (civilian labor force, remainder)

Home-based work, military = 0.93 (military labor force) + 9

Home-based shop = 0.09 (population, CBD) + 0.23 (population, urban)
+ 0.22 (population, rural) - 10

Home-based other = 0.23 (population, CBD) + 0.44 (population, urban)
+ 0.33 (population, rural) + 99

Non-home-based = 0.19 (population)
+ 2.15 (retail employment, Peninsula shopping center)
+ 1.58 (retail employment, Peninsula other)
+ 0.29 (retail sales, Southeastern shopping center)
+ 0.18 (retail sales, Southeastern other)
+ 1.09 (white-collar employment, CBD)
+ 0.89 (white-collar employment, military areas)
+ 2.62 (white-collar employment, other)

Truck = 0.04 (population) + 0.34 (retail employment, Peninsula)
+ 0.02 (retail sales, Southeastern)
+ 0.15 (white-collar employment) + 33

The following trip-attraction equations were developed:

Home-based work, civilian = 0.83 (civilian employment)

Home-based work, military = 0.63 (military employment) + 102

Home-based shop = 1.61 (retail employment, Peninsula CBD)
+ 8.15 (retail employment, Peninsula shopping center)
+ 3.09 (retail employment, Peninsula other)
+ 0.08 (retail sales, Southeastern CBD)
+ 0.38 (retail sales, Southeastern shopping center)
+ 0.27 (retail sales, Southeastern other)
+ 125

Home-based other = 0.22 (population)
+ 1.42 (retail employment, Peninsula)
+ 0.09 (retail sales, Southeastern)
+ 0.51 (white-collar employment, CBD)
+ 1.73 (white-collar employment, other)
+ 0.68 (white-collar employment, military base) - 35

Non-home-based = Non-home-based production

Truck = Truck productions

In the development of these final trip-production and trip-attraction equations by trip purposes, it was necessary to stratify certain of the land-activity variables into areas such as the central business district (CBD), urban area, rural area, shopping center, or military base. It was also necessary to analyze special generators in the Hampton Roads region such as the downtown Norfolk Redevelopment Area, the Naval Base and Naval Air Station, the Norfolk Naval Shipyard, Fort Eustis, and the Virginia Beach ocean front.

The trip-distribution theory used to simulate the travel within and between the two regions was the gravity model. The equations are as follows:

$$T_{ij} = P_i \left[(A_j K_{ij})/(d_{ij})^b\right] \Big/ \sum_{j=1}^{n} \left[(A_j K_{ij})/(d_{ij})^b\right]$$

where

T_{ij} = trips produced at zone i that are attracted by zone j,
P_i = total trips produced at zone i,
A_j = total trips attracted to zone j,
d_{ij} = driving time from zone i to zone j,
b = empirically determined exponent to account for effect that zonal separation has on zone-to-zone movement, and
K_{ij} = socioeconomic factor between zone i and zone j.

For computational purposes the preceding equation has been converted to the following form in actual application:

$$T_{ij} = P_i(A_j F_{ij} K_{ij} / \sum_{j=1}^{n} A_j F_{ij} K_{ij})$$

where F_{ij} = empirically determined "friction factor" equal to $1/(d_{ij})^b$.

The model required the calibration of travel-time factors, socioeconomic factors and the value of time given in Table 2. The traffic-assignment technique used was the minimum-path, all-or-nothing algorithm developed by the Federal Highway Administration. Because one of the basic purposes of the study was to investigate the demand associated with alternative strategies, it was felt that constrained traffic flows would "muddy" the analysis. Capacity restraint, however, was not precluded as an operational device to implement the strategy desired by the decision-makers.

EVALUATION

The fundamental purpose of this paper is to describe the effects of pricing policy on travel demand and the distribution of economic activities. In this section, the five alternative concepts tested are briefly described. The economic and traffic impacts of these alternatives as well as the financial implications of toll pricing are also discussed.

Alternatives

Based on new facilities and the variations in tolls possible, there are over 200 ways of providing transportation service across the Hampton Roads channel. Of these possibilities, five alternatives were selected for thorough analysis. Table 3 gives the toll assumption for each crossing for each of the alternatives. For alternatives 3 and 4, the tolls on the third crossing are comparable with those currently applied to commuter tickets on the Hampton Roads Bridge-Tunnel. These alternatives are briefly described in the following and arc shown in Figure 5.

Alternative 1 consists of the combined 1985 recommended plans from the regional transportation studies in the Southeastern and Peninsula planning areas, a third crossing between Newport News and the southeastern subregion in the vicinity of Craney Island, and connections from the third crossing to the downtown areas of Norfolk and Portsmouth. In this alternative, the James River Bridge, the Hampton Roads Bridge-

TABLE 3
SUMMARY OF ALTERNATIVES TESTED

Crossing	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Hampton Roads Channel					
Hampton Roads Bridge-Tunnel	Free	Free	Free	Free	Free
James River Bridge	Free	Free	Free	Free	Free
Third Crossing	Free	None	$0.97	$0.79	Free
Elizabeth River					
Midtown Tunnel	$0.40	$0.40	$0.40	Free	$0.40
Elizabeth River Tunnel	Free	None	None	None	None

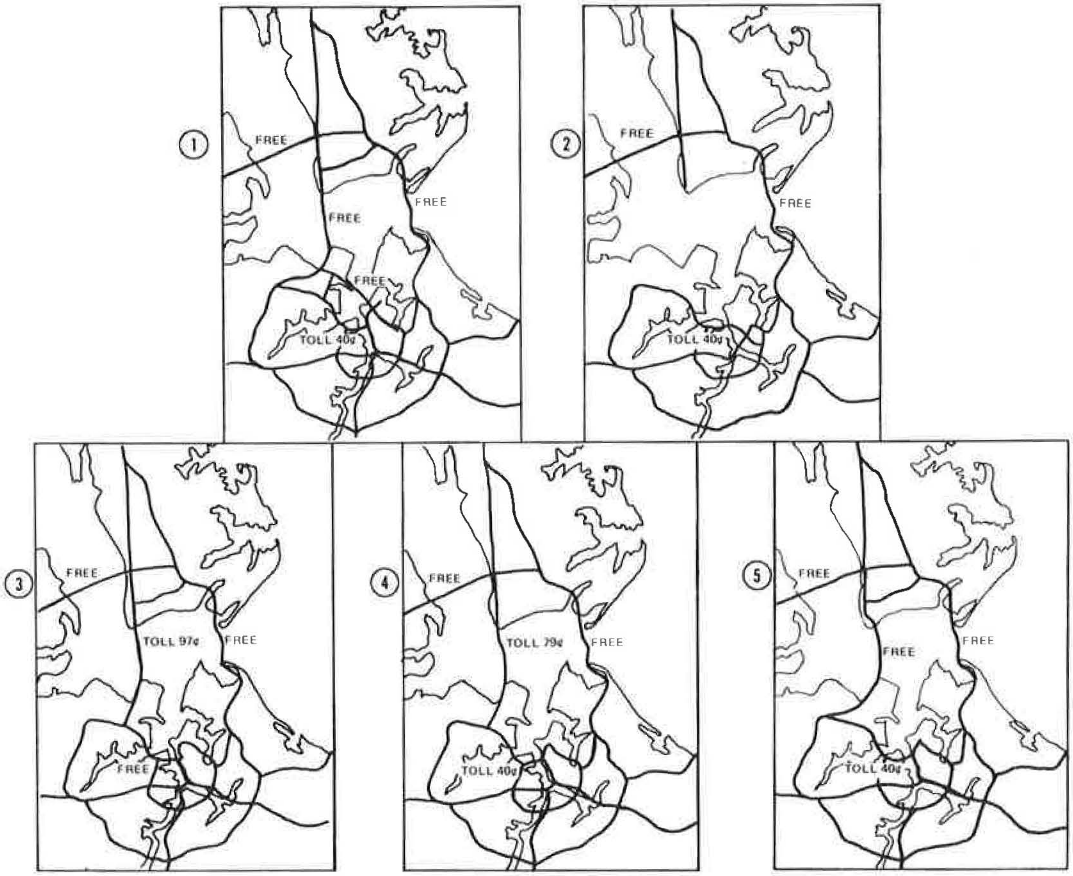

Figure 5. Alternative crossings tested.

Tunnel, and the third crossing were assumed to be free and capable of handling traffic demands.

Alternative 2 assumes that the Hampton Roads Bridge-Tunnel and the James River Bridge are toll free. This alternative was designed to determine the traffic demands on the Hampton Roads Bridge-Tunnel without a third crossing under toll-free conditions. This is the minimum alternative because it assumed no additional facilities over and above those already planned.

Alternative 3 provides for a third crossing between Newport News and the proposed Western Freeway in Portsmouth. It assumes that the tolls on the Elizabeth River Midtown Tunnel are removed. In addition, it was assumed that the third crossing would have tolls sufficient to amortize the cost of a third crossing and the debt remaining on the Elizabeth River Midtown Tunnel. This alternative was designed to determine if a third crossing could be self-supporting as a toll facility.

Alternative 4 is the same configuration as alternative 3 with the exception that the Midtown Tunnel would retain its present tolls. In this alternative, the impact of Elizabeth River tolls on 1995 estimated traffic crossing Hampton Roads was examined.

Alternative 5 consists of an all-free third crossing with a direction connection from the northern tip of Craney Island to the Belleville-Bowers Hill connector. This test was designed to measure the impact of providing direct service to the outer metropolitan loop serving the Portsmouth fringe, Nansemond County, and the city of Chesapeake while tying into the Western Freeway that provides access to the core areas of Norfolk and Portsmouth.

TABLE 4

SUMMARY OF REGIONAL ECONOMIC IMPACTS

Area	Base-Line Projection	Increase Over Base-Line Projection									
		Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Southeastern subregion											
Employment	464,200	16,600	3.6	2,100	0.5	11,900	2.6	12,900	2.8	14,500	3.1
Population	1,178,200	42,100	3.6	6,100	0.5	30,400	2.6	32,700	2.8	36,800	3.1
Peninsula subregion											
Employment	243,000	7,100	2.9	1,150	0.5	4,600	1.0	4,900	2.0	6,000	2.5
Population	582,900	17,000	2.0	2,700	0.5	11,000	1.9	11,700	2.0	14,400	2.5
Hampton Roads region											
Employment	707,200	23,700	3.4	3,250	0.5	16,500	2.3	17,800	2.5	20,500	2.9
Population	1,761,100	59,100	3.4	8,800	0.5	41,400	2.3	44,400	2.5	51,200	2.9

Economic Impacts

The land use model described in the previous section was used to prepare an estimate of increases in population and employment for each of the alternatives examined. Table 4 gives the economic impacts for the Southeastern and Peninsula regions and Table 5 gives the impacts by jurisdiction.

TABLE 5

ECONOMIC IMPACTS BY JURISDICTION

Jurisdiction	Base-Line Projection	Increase Over Base-Line Projection				
		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Employment						
Peninsula region	243,000	7,100	1,150	4,600	4,900	6,000
Hampton	76,200	1,670	335	1,110	1,175	1,430
Newport News	120,600	3,870	590	2,485	2,660	3,265
Williamsburg	11,300	65	25	50	50	55
York County and Poquoson	24,450	450	150	325	340	390
James City and County	10,450	1,045	50	630	675	860
Southeastern region	464,200	16,600	2,100	11,900	12,900	14,500
Norfolk	226,500	7,170	1,050	5,180	5,600	265
Portsmouth	67,800	4,320	280	3,025	3,290	3,740
Virginia Beach	97,950	1,100	440	885	940	1,005
Chesapeake	45,500	2,100	200	1,480	1,610	1,830
Nansemond County and Suffolk	26,450	1,910	130	1,330	1,460	1,660
Hampton Roads region	707,200	23,700	3,250	16,500	17,800	20,500
Population						
Peninsula region	582,900	17,000	2,700	11,000	11,700	14,400
Hampton	217,000	5,100	1,100	3,360	3,560	4,280
Newport News	190,300	4,400	900	2,930	3,100	3,800
Williamsburg	13,100	400	200	320	320	360
York County and Poquoson	123,100	5,700	300	3,430	3,700	4,690
James City and County	39,400	1,500	200	960	1,020	1,270
Southeastern region	1,178,200	42,100	6,100	30,400	32,700	36,800
Norfolk	344,000	5,000	1,800	4,120	4,220	4,630
Portsmouth	127,250	4,550	650	3,360	3,610	4,090
Virginia Beach	404,100	15,700	2,100	11,500	12,450	13,940
Chesapeake	206,250	10,950	1,050	7,100	7,810	8,860
Nansemond County and Suffolk	96,600	5,900	500	4,320	4,610	5,280
Hampton Roads region	1,761,100	59,100	8,800	41,400	44,400	51,200

Table 4 shows that different toll-pricing policies for alternatives 1, 3, 4, and 5 do account for differences in economic growth. Generally higher toll rates resulted in lower population and economic growth. The lowest toll rate (alternatives 1 and 5) accounted for a population-employment increase of 3.4 to 2.9 percent over base-line conditions, while the highest toll rate (alternative 3) resulted in the lowest growth rate (-2.3 percent) over base-line conditions. In terms of annual payroll, the increase of 23,700 jobs in alternative 1 represents approximately $150 million. In terms of assessed valuation, the increase in population and employment in alternative 1 would add $340 million to the books usually in an annual increase in revenues of approximately $14 million.

Table 5 gives by jurisdiction the distribution of economic impacts within each of the regions. In general, the effect of tolls impacts the jurisdictions according to the patterns noted previously. Jurisdictions receiving the major economic growth are in close proximity to the third crossing. Differences between alternatives 1 and alternatives 3, 4, and 5 indicate the amount of population or employment that would be subtracted or added under different toll conditions. Greater tolls had the impact of decreasing population and employment growth.

Traffic Impacts

Changes in the toll-pricing policy had an impact on trip length, traffic volumes crossing Hampton Roads, planned facilities in each of the regions, and distribution of trips by purpose.

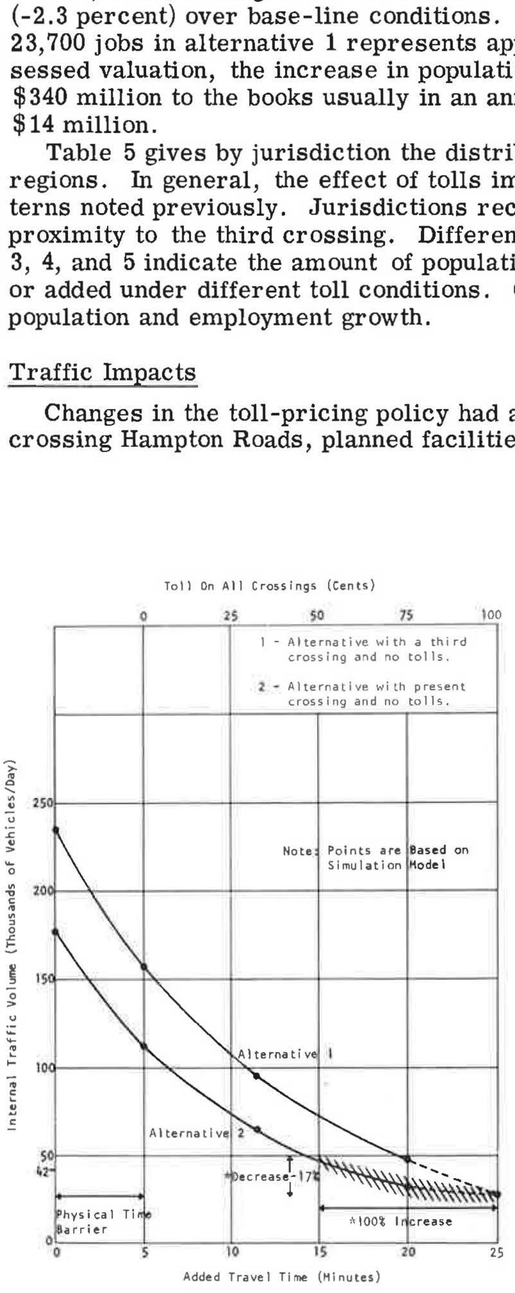

Figure 6. 1995 traffic volume across Hampton Roads versus travel times and tolls [* indicates part of the curve that closely follows the findings of Dash and Vey (12) whereby a 0.17 percent loss in traffic resulted for each 1.00 percent increase in tolls].

Table 6 gives the trip length and traffic volumes crossing Hampton Roads for each of the five alternatives examined. The trip length in miles decreased from 21.6 to 21.0 miles with the removal of tolls on the Elizabeth River Midtown Tunnel. Otherwise, new facilites for a constant price had no appreciable change on the trip length of crossing traffic.

Traffic volumes across Hampton Roads channel decreased with increases in toll rates. Figure 6 shows future traffic volumes across Hampton Roads versus travel times added and versus equivalent toll prices for alternatives 1 and 2. These relationships show a dramatic decrease in traffic with an increase in travel times added that are equivalent to uniform increases in toll rates. This reduction is due to decreases in urban development, trip generation, and trip length. The drop in volume with increases in price in the latter part of the curve tie in with previous toll studies by Dash and Vey (12). As an example parallel to the effect of increases in tolls, Figure 7 shows the effect of parking costs on the amount of automobile traffic measured in Canberra, Australia (2). As indicated, the parking and toll-pricing policies work toward reducing the demand for vehicular travel.

The toll-pricing policy also has an effect on the distribution of traffic demands on facilities adjacent to or in close proximity to the facilities where tolls were charged. Table 7 gives the impact (expressed as additional lanes required) on planned facilities in the region. The greatest number of additional lanes required was two for certain major highway sections for the alternatives examined.

TABLE 6
IMPACTS ON TRAFFIC CROSSING HAMPTON ROADS

Alternatives	Average Trip Length		
	Miles	Minutes	Crossing Volumes
1	21.5	34.0	157,500
2	23.5	36.2	114,700
3	21.6	34.2	126,000
4	21.0	33.8	115,000
5	21.6	35.0	125,700

Note: Only trips made within the Hampton Roads region are shown.

Toll pricing coupled with new facilities can also affect the purpose of travel. Table 8 gives the trip-purpose split for existing and future conditions under alternative 4 for traffic crossing Hampton Roads and within the Tidewater region. In general, crossing traffic under toll conditions (existing and future) has a greater percentage of work travel than the Tidewater region as a whole—35 percent versus 20 percent. Higher toll charges have the effect of decreasing nonwork travel. As noted, 1995 estimated crossing traffic had 53 percent nonwork automobile volumes, whereas the average for the region was 62 percent. In addition, a trip purpose change split from existing crossing

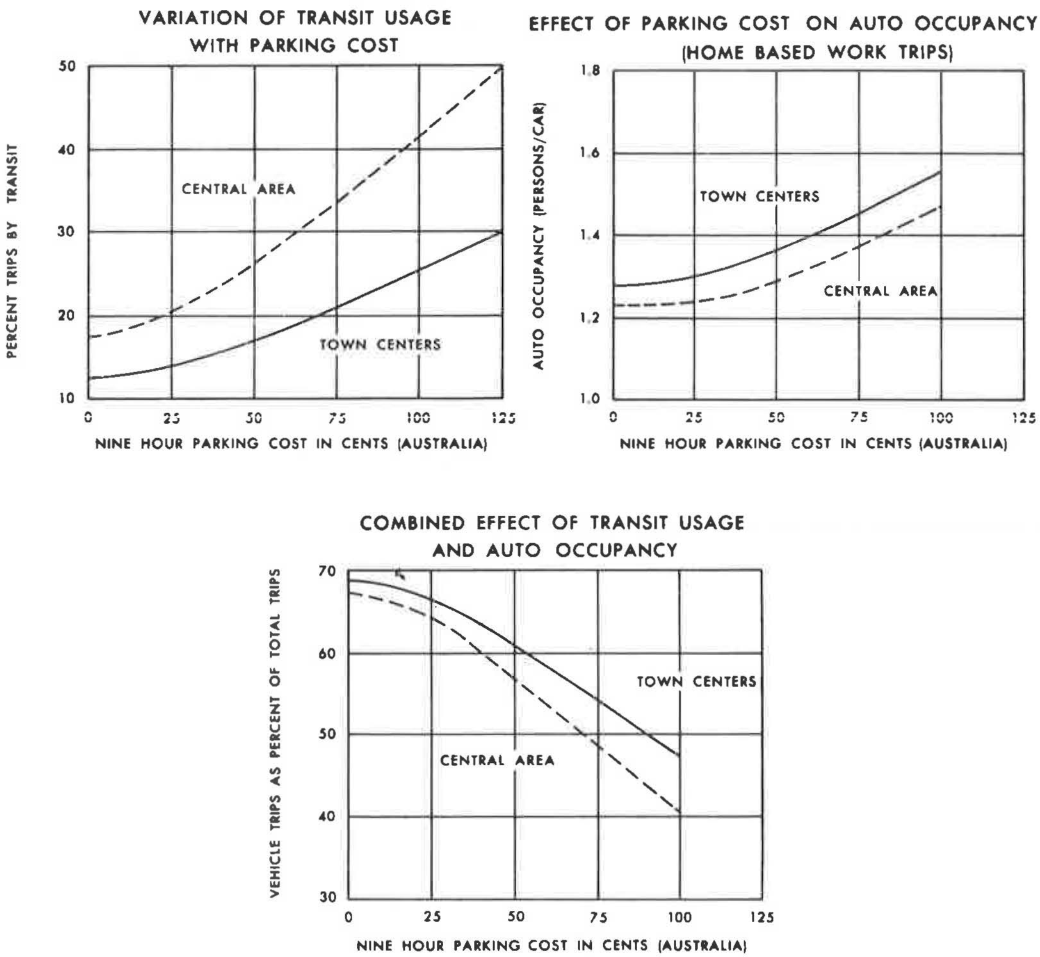

Figure 7. Effects of parking costs in Canberra, Australia.

TABLE 7

TRAFFIC IMPACTS ON PLANNED FACILITIES

Facility[a]	Number of Additional Lanes Required Over 1985 Plan[b]				
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Peninsula region					
North-South Freeway					
I-64 to Mercury Boulevard	4	0	2	2	2
Mercury Boulevard to East-West Expressway	4	0	2	2	2
East-West Expressway to Chesapeake Avenue	2	0	0	0	0
I-64					
North-South Freeway to Mercury Boulevard	2	2	2	2	2
Mercury Boulevard to the Newport News Tunnel Connector	2	4	4	2	2
Newport News Tunnel Connector to Mallory Street	2	4	4	4	4
Mallory Street to the Hampton Roads Bridge-Tunnel	4	6	6	6	4
Warwick Boulevard	2	0	0	0	–
Jefferson Avenue	2	0	0	2	–
Southeastern region					
Western Freeway					
Bowers Hill Belleville Connector to extension of third crossing	–	–	0	0	–
Third crossing extension to River Shore Road	0	–	0	2	2
River Shore Road to Midtown Tunnel	2	0	0	0	2
I-64					
Hampton Roads Bridge-Tunnel to I-564	4	6	6	6	4
I-564 to Northern Connector Freeway	4	4	6	4	4
Northern Connector Freeway to I-264 (east)	2	2	2	2	2
Bowers Hill Belleville Connector	0	0	0	0	0
Elizabeth River Tunnel	4	–	–	–	–
Metropolitan Loop					
Western Freeway to Glasgow Street	2	0	0	2	0
Glasgow Street to I-264	0	0	0	0	0
I-264 to Northern Connector Freeway	0	2	2	2	0
Northern Connector Freeway to Waterfront Drive Freeway	2	0	2	0	0
Northern Connector Freeway	0	2	2	2	2

[a]All freeway facilities are assumed to be planned for a minimum of four lanes.

[b]These are total lane requirements (both directions) to satisfy traffic demands under a reasonable level of service based on the difference between assigned 1985 crossing volumes and 1995 crossing volumes.

travel with the future toll changes. Work travel as a percentage of the total increased from 30 to 35 percent and nonwork automobile travel decreased from 61 to 53 percent.

Financing

Figures 8 and 9 show the financial implications of the variations in traffic volumes with changes in toll conditions. Figure 8 shows the effect of revenue collected on the third crossing versus toll charges for alternative 4. As indicated, the maximum revenue occurs when the toll on the third crossing reaches $0.80. The shape of the curve follows a classic economic revenue curve and indicates that the revenue generated by a $1.30 would essentially eliminate the revenue and, hence, the need for the facility.

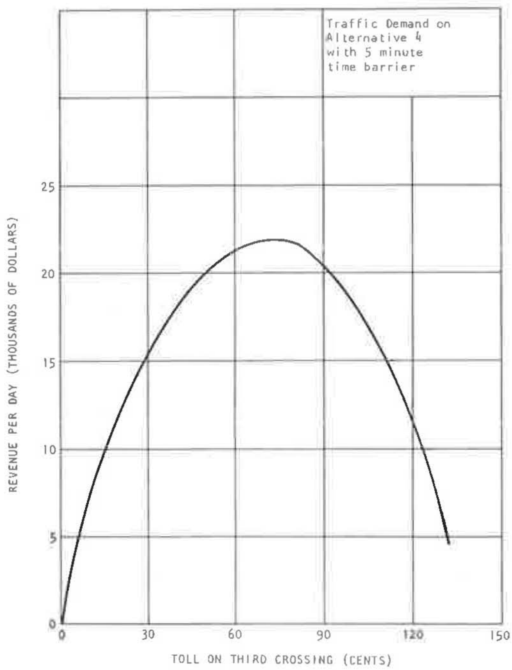

Figure 8. 1995 revenue versus tolls.

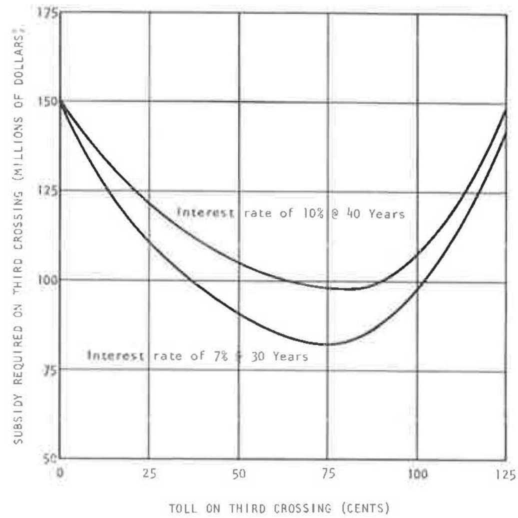

Figure 9. Subsidy versus tolls.

Figure 9 shows the subsidy required on the third crossing versus various toll rates. As indicated, some form of subsidy would be required under all conditions, including the optimum condition of $0.80, an interest rate of 7 percent, and an analysis period of 30 years. The results of this analysis indicate that a new crossing could not be self-supporting under any toll-rate structure and would as a minimum require a grant capital subsidy of $80 million.

TABLE 8

EXISTING AND FUTURE TRIPS BY PURPOSE

Trip Purpose	1962-64 Trips (percent)	1995 Trips (percent)	
		Crossings[a]	Tidewater Region[b]
Home-based work	30	35	20
Home-based shop	1	5	12
Home-based other and non-home-based	61	53	62
Truck	8	7	6

[a]Based on alternative 4.
[b]Consists of both Southeastern and Peninsula Planning Districts.

CONCLUSIONS AND IMPLICATIONS

The analysis of 1995 alternatives for Hampton Roads indicates certain conclusions about the effect of tolls and transportation price on the spatial arrangement of economic activities of the demand for travel and its elasticity.

1. Increasing the price of transportation across Hampton Roads has the effect of decreasing economic growth as expressed in population employment. The toll-pricing policy becomes a tool, therefore, for controlling or influencing the potentials associated with land development.
2. Increasing the price of transportation across Hampton Roads has the effect of decreasing traffic crossing Hampton Roads. Small changes in tolls (equivalent to addition of travel times) can have dramatic impacts on travel demand, particularly if these toll facilities are placed in areas with potentially developable land.
3. There is an optimum charge for transportation across Hampton Roads that generates the maximum revenue. However, a subsidy is still required under the alternatives investigated.

4. Travel demand is quite elastic with respect to transportation pricing for a large part of the demand-price curve. Under free conditions, a third crossing across Hampton Roads generates an ADT volume (local trips only) of 157, 500. However, even under an optimum toll charge of $0.80, a new facility would require a capital grant subsidy of $80 million.
5. Optimum toll rates can be determined as part of the transportation planning process through the simultaneous application of transport and land use models.

These effects between transportation pricing and transportation demand and land use arrangements indicate that the transportation price can be used as a tremendous tool by the urban and transportation planner with the proper governmental and institutional support. This kind of tool can be used to shape economic growth and control traffic in parts of an urbanized area where this may be required.

In addition to tolls, pricing as a control on vehicular traffic could also involve a special tax on vehicles using congested streets at certain hours. The theoretically perfect tax would equal the congestion tax imposed by other vehicles. This could be approached most closely by modern metering equipment or daily licenses. This type of planning action might be required as we are challenged by the travel demands of the 1970's.

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