more users than in the no-information situation because a reduction in the search time would generate an increase in customer volume and longer queues.

Once calibrated, the model presented in this paper may be used to obtain first-cut estimates of the effects of relief policies. One such policy directed at reducing the search time is the above-mentioned information dissemination. Another policy, directed at reducing the queuing time, can be a variance-reduction policy, used in the summer of 1979 by many station attendants (i.e., $7 worth of gasoline to every car, or variants of this policy). Such a policy would decrease the queuing time; however, as with all other variables, this reduction is absorbed to some extent by the equilibrium effect (the reduced queuing time encourages more customers to look for gasoline, which causes an increased queuing time). A minimum purchase policy can be modeled by decreasing N_0, which should be interpreted as the number of gasoline trips rather than the number of customers. A maximum purchase policy can be modeled by increasing N_0, which of course would cause increased queues. In appplying our model to the evaluation of an odd-even plan, one might naively assume that N_0, the number of potential gasoline trips per hour, should be halved and therefore (after allowing for the equilibrium effect) queuing time should decrease somewhat. However, under an odd-even plan, individuals' determination to obtain gasoline is drastically increased; or, in terms of our model, α decreases substantially. In other words, under an odd-even plan (which is usually coupled with weekend closing as well), customers are relatively inelastic with respect to queuing delays, and stay in the system, which causes even larger delays.

The model presented in this paper should not, of course, be used for detailed analysis and policy assessment. It is intended more as a framework for thought about the problem and general assessment of the search and queuing delays involved in obtaining gasoline in a situation similar to that of the summer of 1979.

REFERENCES

1. D. Kendal and P. Moran. Geometrical Probability. Griffin and Company, London, 1963.
2. D. Fairborne. The Distances Between Pairs of Points in Towns of Simple Geometrical Shapes. Proc., 2nd International Symposium on the Theory of Traffic Flow, London, 1963, pp. 391-406.
3. C. Daganzo, C. Hendrickson, and N. Wilson. An Approximate Analytical Model of Many-to-One Demand-Responsive Transportation Systems. Proc., 7th International Symposium on Transportation and Traffic Theory, Kyoto, Japan, 1977, pp. 743-772.
4. L. Kleinrock. Queueing Systems, Volume 1: Theory. Wiley, New York, 1975.6

Publication of this paper sponsored by Committee on Energy Conservation and Transportation Demand.

Demand for Travel and the Gasoline Crisis

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This paper uses traffic count data to estimate and analyze the demand for gasoline and different kinds of work and leisure travel in California from 1970 to 1975. Empirical results of the ordinary least-squares regressions show the price elasticity of gasoline and travel to be quite inelastic—between -0.05 and -0.50. The income elasticities range between 0.5 and 1.5. Furthermore, the results suggest that leisure-oriented travel is less price- and income-sensitive than work-oriented travel. Results also indicate that travel and gasoline are affected by seasonal variations. In addition to the conventional demand analysis, the study investigates the gasoline crisis in California in 1974. During the gasoline crisis, the existence of queuing at service stations suggested that disequilibrium existed in the gasoline market. Due to the difficulty in purchasing gasoline, the true price of gasoline exceeded the actual price paid at the pump. Results show that the true price of gasoline rose from a precrisis price of $0.31/gal to more than $1.00/gal in some instances during the height of the crisis in March 1974. Furthermore, the value that would have been transferred from consumers of gasoline to suppliers was approximately $355 million. This amount, which averages about $27/licensed California driver, could be thought of as a measure of the gross welfare loss of gasoline rationing.

Recent developments in the worldwide energy situation have caused economists to become interested in the demand for both gasoline and automobile travel. In general, studies in this area have estimated the price and income elasticities of demand for gasoline and have come to reasonably consistent conclusions. However, these studies generally are subject to two main shortcomings:

1. By focusing on gasoline demand they are unable to distinguish between different types of automobile travel and

2. They have failed to analyze the period from December 1973 to April 1974 (henceforth referred to as the gasoline crisis), a period when the gasoline market was in disequilibrium.

This paper presents an analysis that overcomes these shortcomings by direct assessment of the demand for automobile travel by the use of monthly traffic counts on the California state highway system. These traffic counts have been disaggregated into urban, rural, weekday, and weekend trips. Furthermore, by employing traffic count locations of different characters near the San Francisco area, the study investigates the demand for recreation (I-80) and commercial and commuter travel (I-580). By using ordinary least-squares regression techniques on the monthly time series data from January 1970 to December 1975, along with seasonal monthly dummy variables, the price and income elasticities of each category of travel with respect to the price of gasoline are determined. In addition, monthly gasoline-crisis dummy variables are used to calculate what shall be called the waiting price for gasoline (due to nonprice rationing) for each month of the gasoline crisis. Once the waiting price of gasoline is calculated, the effects of the disequilibrium situation are investigated empirically by calculating the welfare loss caused by the gasoline crisis. Finally, as a

Table 1. List of variables.

Variable Name	Notation for Econometric Specification	Variable Name	Notation for Econometric Specification
Monthly average daily traffic[a]	TT	California real personal income[d]	RINC
Total monthly weekend traffic[a]	TWE	California population	POP
Monthly average weekday traffic[a]	TWD	December 1973 gasoline crisis dummy	DEC73
Urban monthly average daily traffic[a]	URT	January 1974 gasoline crisis dummy	JAN74
Urban total monthly weekend traffic[a]	URWE	February 1974 gasoline crisis dummy	FEB74
Urban monthly average weekday traffic[a]	URWD	March 1974 gasoline crisis dummy	MAR74
Rural monthly average daily traffic[a]	RUT	April 1974 gasoline crisis dummy	APR74
Rural total monthly weekend traffic[a]	RUWE	February seasonal dummy	DFEB
Rural monthly average weekday traffic[a]	RUWD	March seasonal dummy	DMAR
I-80 monthly average daily traffic[a]	SFT	April seasonal dummy	DAPR
I-80 total monthly weekend traffic[a]	SFWE	May seasonal dummy	DMAY
I-80 monthly average weekday traffic[a]	SFWD	June seasonal dummy	DJUN
I-580 monthly average daily traffic[a]	DUBT	July seasonal dummy	DJUL
I-580 total monthly weekend traffic[a]	DUBWE	August seasonal dummy	DAUG
I-580 monthly average weekday traffic[a]	DUBWD	September seasonal dummy	DSEP
Adjusted average daily gallons of gasoline[b]	GAL	October seasonal dummy	DOCT
California retail price for regular gasoline, real terms[c]	RPG	November seasonal dummy	DNOV
		December seasonal dummy	DDEC

[a]Data taken from the California Department of Transportation.
[b]Data taken from the California State Board of Equalization.
[c]Data taken from the Oil and Gas Journal.
[d]Data taken from the California Department of Finance.

byproduct of this research, the price and income elasticities of the demand for gasoline are determined.

SPECIFICATION OF THE AGGREGATE DEMAND FOR TRAVEL

The aggregate demand for gasoline and for each kind of travel is a function of the real price of gasoline, total real personal income, population, and seasonal variables:

$$Q = g(\mathrm{RPG, RINC, POP, S}) \tag{1}$$

Table 1 identifies the variables. The expected a priori partial derivatives are as follows:

$$\partial Q/\partial \mathrm{RPG} < 0,\ \partial Q/\partial \mathrm{RINC},\ \partial Q/\partial \mathrm{POP} > 0 \tag{1a}$$

For empirical testing, Equation 1 must be specified explicitly. To achieve this, both the linear and logarithmic forms for the demand function were chosen. The linear explicit form of the equation becomes

$$A = A + \beta_1 \mathrm{RPG} + \beta_2 \mathrm{RINC} + \beta_3 \mathrm{POP} + \beta_4 S \tag{2}$$

and the logarithmic form becomes

$$Q = A\mathrm{RPG}^{\beta_1}\, \mathrm{RINC}^{\beta_2}\, \mathrm{POP}^{\beta_3}\, S^{\beta_4} \tag{3}$$

Once the demand equation is specified, the gasoline crisis can be integrated into the analysis.

Gasoline Crisis

During the gasoline crisis of late 1973 and early 1974, automobile travel and gasoline consumption were both reduced substantially. Furthermore, the gasoline market was in a state of disequilibrium. As a result of this disequilibrium, queuing occurred in service stations. Queuing causes the true price of gasoline (P_T) to exceed the pump price (RPG) by a waiting premium (P_W) when the model is specified in the linear form (i.e., P_T = RPG + P_W). When specified logarithmically, P_T = RPG x P_ω where P_ω is a unitless rationing parameter. If P_T is decomposed and substituted in Equations 2 and 3,

$$Q = A + \beta_1(\mathrm{RPG} + P_W) + \beta_2 \mathrm{RINC} + \beta_3 \mathrm{POP} + \beta_4 S \tag{4}$$

$$Q = A(\mathrm{RPG} \times P_\omega)^{\beta_1}\, \mathrm{RINC}^{\beta_2}\, \mathrm{POP}^{\beta_3}\, S^{\beta_4} \tag{5}$$

Estimation Procedure

A single-equation ordinary least-squares (OLS) estimation procedure was applied to Equations 4 and 5:

$$Q = \beta_0 + \beta_1\left(\mathrm{RPG} + \sum_{i=1}^{5} D_i P_{Wi}\right) + \beta_2 \mathrm{RINC} + \beta_3 \mathrm{POP} + \sum_{i=1}^{11} \beta_{3+i} D_{mi} + \mu \tag{6}$$

$$Q = \beta_0\left(\mathrm{RPG} \prod_{i=1}^{11} P_{\omega i}^{D_i}\right)^{\beta_1} \mathrm{RINC}^{\beta_2}\, \mathrm{POP}^{\beta_3}\, e^{\prod_{i=1}^{11} \beta_{3+i} D_{mi}}\ \mu \tag{7}$$

for each dependent variable.

In both specifications, the error term (μ) is assumed to be normally distributed with zero mean and constant variance. In accordance with the theoretical structure presented by Equation 5, it is expected that

$\beta_1 < 0$ and β_2, $\beta_3 > 0$

for each dependent variable.

The estimate of the time and true prices of gasoline (P_W and P_T) during the months when nonprice rationing was effective comes directly from the estimate of Equations 6 and 7. When Equation 6 is multiplied by β_1 the equation becomes

$$Q = \beta_0 + \beta_1 \mathrm{RPG} + \beta_1 \sum_{i=1}^{5} D_i P_{Wi} + \beta_2 \mathrm{RINC} + \ldots + \mu \tag{8a}$$

$$Q = \beta_0 + \beta_1 \mathrm{RPG} + \sum_{i=1}^{5} \gamma_i D_i + \beta_2 \mathrm{RINC} + \ldots + \mu \tag{8b}$$

The coefficient on each gasoline crisis month (D_i) is $\beta_1 P_{Wi}$ or γ_i. To solve for the time price in each month (P_{Wi}) the estimated value of γ_i is divided by the estimate of the coefficient of the price of gasoline (β_1). The resulting value is an estimate of P_{Wi} because γ_i/β_1 equals P_{Wi}. The sum of P_{Wi} and the actual pump price of gasoline (RPG) equals the true price of gasoline (P_{Ti}) during each month of the gasoline crisis. The solution for $P_{\omega i}$ in the logarithmic specification is similar, except that $P_{\omega i}$ is a multiplicative constant.

It would also be expected that the calculated

Table 2. Linear estimation results excluding seasonal effects.

Independent Variables	Dependent Variables Constant	RPG	RINC	POP	DEC73	JAN74	FEB74	MAR74	APR74	R^2	F	Durbin-Watson Statistic (d)
GAL	-25 193.1	-18 552.8	277.283	1 567.94	-1 801.5	-1 629.67	-2 313.14	-2 524.14	162.7	0.9188	30.96	1.97
t-value	3.378	5.342	6.293	2.923	-2.836	-2.573	-3.604	3.879	0.248			
TT	-1 211 080	-370 235	4578.84	65 660.1	-20 744.1	-20 841.2	-51 063.3	-87 070.6	-6 221.33	0.9693	86.46	1.37
t-value	-7.51	-4.93	4.80	5.66	-1.51	-1.52	-3.68	-6.19	-0.44			
TWE	-2 064 710	-588 820	6527.38	125 584	-75 404	-146 590	-230 998	-282 479	-16 269.3	0.9394	42.393	1.53
t-value	-4.11	-2.51	2.19	3.47	1.76	-3.43	-5.34	-6.43	-0.369			
TWD	-1 282 570	-400 565	5104.91	66 807.4	-13 961	140.31	-25 289	-65 403	-5 455.98	0.9655	76.61	1.599
t-value	-7.61	-5.10	5.12	5.51	0.972	0.0098	-1.74	-4.44	-0.369			
URT	-847 807	-193 364	2749.13	41 229.3	-7 474.25	-8 124.20	-26 664.9	-34 185.8	-8 451.3	0.9807	138.909	1.73
t-value	-14.64	-7.17	8.03	9.90	-1.51	-1.65	-5.35	-6.76	-1.66			
URWE	-1 591 920	-288 960	2348.8	88 966.1	-21 990.3	-32 869.3	-81 322.2	-101 796	-9 807.49	0.9389	42.0751	1.50
t-value	-7.28	-2.84	1.82	5.66	-1.18	-1.77	-4.32	-5.34	-0.51			
URWD	-808 547	-212 917	3379.02	39 927.8	-6 065.91	-4 800.04	-21 066.5	-27 501.0	-9 870.30	0.9722	95.81	1.6547
t-value	-12.382	-6.519	8.15	7.91	-1.01	-0.806	-3.48	-4.49	-1.60			
RUT	-363 300	-176 900	1830	24 430	-13 270	-12 720	-24 400	-52 880	2 230	0.9438	45.93	1.52
t-value	-2.84	-2.96	2.42	2.65	-1.22	-1.17	-2.21	-4.73	0.20			
RUWE	-472.800	-299 900	4179	36 620	-53 410	-113 700	-149 700	-180 700	-6 462	0.8822	20.50	1.5
t-value	-1.10	-1.50	1.65	1.19	-1.46	-3.12	-4.05	-4.83	-0.17			
RUWD	-414 000	-187 600	1726	26 880	-7 895	4 940	-4 223	-37 900	4 414	0.9393	42.32	1.91
t-value	-3.16	-3.08	2.23	2.85	0.71	0.44	-0.37	-0.332	0.38			
SFT	-108 786	-11 165.9	570.303	5 755.32	-1 281.55	1 023.62	-4 072.55	-13 143	-3 662.13	0.9222	32.4265	1.398
t-value	-3.44	-0.787	2.79	2.44	-0.443	0.354	-1.39	-4.46	-1.23			
SFWE	-10 339.3	-31 858.9	1344.57	1 552.00	-11 828.8	-18 888.2	-41 696.3	-43 068.7	-13 621.0	0.8099	18.31	1.61
t-value	-0.109	-0.746	2.197	3.73	-1.359	-2.178	-4.75	-4.87	-1.52			
SFWD	-150 232	-9 260.44	529.51	7 747.05	571.6	5 210.71	2 637.68	-9 786.98	-2 402.79	0.9055	26.22	1.81
t-value	-4.22	-0.579	2.30	2.93	0.17	1.60	0.802	-2.95	-0.719			
DUBT	-200 811	-66 921.5	849.858	9 672.98	-2 220.57	-2 660.9	-5 104.78	-8 102.91	-952.087	0.9564	60.0958	1.6578
t-value	-9.17	-6.81	6.01	5.94	-1.10	-1.33	-2.52	-3.97	-0.464			
DUBWE	-323 520	-150 704	1446.74	16 755.8	-9 391.86	-3 374.79	-18 470.0	-21 611.6	-3 758.40	0.8974	23.9731	1.7933
t-value	-4.70	-4.89	3.26	3.28	-1.49	-0.538	-2.91	-3.38	-0.584			
DUBWD	-216 432	-63 549.3	900.453	10 191.0	-1 230.43	-3 050.40	-3 452.70	-7 021.77	-581.241	0.9445	46.56	1.728
t-value	-8.47	-5.53	5.46	5.36	-0.525	-1.31	-1.46	-2.95	-0.242			

Table 3. Price and income elasticities of demand for gallons and trips.

Dependent Variable	Price Linear	Price Logarithmic	Income Linear	Income Logarithmic
Gallons	-0.216	-0.211	0.876	0.890
Total trips	-0.236	-0.264	0.792	0.820
Weekend trips	-0.174	-0.203	0.525	0.540
Weekday trips	-0.263	-0.292	0.910	0.960
Urban trips	-0.305	-0.361	1.179	1.271
Urban weekend trips	-0.221	-0.268	0.489	0.568
Urban weekday trips	-0.340	-0.399	1.460	1.560
Rural trips	-0.189	-0.205	0.531	0.552
Rural weekend trips	-0.145	-0.164	0.546	0.546
Rural weekday trips	-0.209	-0.220	0.523	0.556
I-80 trips	-0.056	-0.092	0.760	0.750
I-80 weekend trips	-0.069	-0.098	0.773	0.712
I-80 weekday trips	-0.050	-0.090	0.753	0.773
I-580 trips	-0.381	-0.438	1.288	1.330
I-580 weekend trips	-0.428	-0.462	1.092	1.140
I-580 weekday trips	-0.363	-0.432	1.367	1.420

waiting prices of gasoline would correspond to the severity of the nonprice rationing. In other words, when rationing was most prevalent, the greatest amount of excess demand existed and, therefore, the waiting price was highest. When rationing was insignificant, excess demand was minimal and P_{Ti} would approach RPG. Given these a priori notions, it is expected that $P_W(P_\omega)$ for March 1974 weeks would be the highest, whereas $P_W(P_\omega)$ for April 1974 weekends would be lowest, and $P_W(P_\omega)$ for December, January, and February would fall between the two.

In addition to the hypothesis that the purchase of gasoline was more difficult on weekends than on weekdays, other hypotheses can be tested. Because the general uncertainty of purchasing gasoline increases the farther drivers are from familiar surroundings, they would be expected to remain close to home during the crisis. If this is indeed the case, other things being equal, the waiting price of gasoline in rural areas would be higher than the waiting price in urban areas. Vacation (or recreation) travel would also be expected to be affected more adversely by the gasoline crisis than would commercial and commuter traffic. For this reason, the waiting price of gasoline along I-80 should exceed the waiting price along I-580.

ANALYSIS OF RESULTS

Table 2 presents the results of the linear estimating equations for the demand for gasoline and the different classifications of trips for 1970-1975. All of the signs on the regressors are consistent with the theoretical implications discussed earlier. Besides having the expected signs, nearly all the parameters are significant at the 5 percent level. The coefficients of determination (R^2) are all significant and explain at least 80 percent of the variation of each of the dependent variables. The linear specification of the models is discussed first.

Table 2 shows that the change in the dependent variable with respect to a change in the real price of gasoline was negative in all cases. These coefficients are converted into price elasticities calculated at the means and are reported along with the income elasticities in Table 3. Also reported here are the logarithmic elasticities. These results imply that both gasoline and all kinds of travel are price inelastic with respect to the price of gasoline in the short run.

Considerable information is contained in the pattern of the price and income elasticity coefficients of the different classes of travel (Table 3). First of all, the price elasticity of weekend travel (TWE) is less (in absolute value) than that of weekday travel (TWD) for all aggregate categories. For example, the elasticity (linear) of weekend trips with respect to the price of gasoline is -0.174, whereas the elasticity of weekday trips is -0.263. Furthermore, results show that, for both weekdays and weekends, rural travel is less responsive to changes in gasoline prices than is urban travel. The elasticity of urban total trips (URT) with respect to the price of gasoline is -0.305, whereas that of rural total trips (RUT) is only -0.209. Finally, the isolated points as measured by I-80 and I-580, respectively, show that travel on the vacation-oriented route is much less responsive to price (SFT = -0.056) than is travel on the commercial and commuter route (DUBT = -0.381).

Taken together, these results show that leisure-oriented trips (weekend, rural, and I-80) are less responsive to price than are their work-oriented counterparts (weekday, urban, and I-580). This can be explained because of the lack of substitute modes for driving when taking a leisure-oriented trip. Once the decision is made to take a leisure trip in California, few good substitutes exist for driving. However, in the case of work trips, substitutes such as alternative modes (rapid transit) or carpooling can be found. Furthermore, because leisure trips are probably more time-intensive than work trips, it would be expected that they exhibit a small money price-responsiveness.

As to the income effects, it can be seen from Table 3 that the income effects are positive in all cases, which is also consistent with theoretical expectations. The income effects are similarly converted into elasticities and are also shown in Table 3. In most classes of travel, the weekend income elasticity is less than the weekday income elasticity. For example, the income elasticity of total weekend trips (TWE) is 0.525, whereas the income elasticity of weekday trips is 0.910. Furthermore, rural travel tends to be less sensitive to income than urban travel (e.g., the income elasticity of RUT equals 0.531, whereas the income elasticity of URT equals 1.179). Finally, vacation travel (SF) is less sensitive to income than is commercial and commuter travel (e.g., the income elasticity of SFT equals 0.760; for DUBT it is 1.788). This implies that leisure trips are less sensitive to income than are work trips. One explanation for this is the inverse relationship between income and income elasticity. In other words, as income increases, luxury goods exhibit more of the properties of necessities; hence, as income increases, the income elasticity associated with leisure (luxury) travel would decrease. Assume that high-income groups take a higher percentage of leisure-oriented trips than do lower-income groups. That is, higher-income groups are more likely to travel through rural vacation areas on weekends than are lower-income groups. Under these assumptions, these types of travel would be expected to exhibit smaller income elasticities than the work-oriented counterparts. These findings are summarized below:

1. Leisure trips (rural, weekend, or vacation): Price elasticities are lower (more inelastic) since there are few good substitutes; income elasticities are lower because of a larger percentage of high-income groups.
2. Work trips (urban, weekday, and commercial or commuter): Price elasticities are higher (less inelastic) as a result of model substitution and carpools; income elasticities are higher because of the proportion of lower-income groups.

The logarithmic results conform favorably to the linear specification of the models. The significance of the monthly dummies also conforms well with those in the linear specification, as do the R^2 and F statistics.

Because the Durbin-Watson statistics gave some evidence of autocorrelation in both linear and logarithmic specifications, the Cochrane-Orcutt iterative technique was used to correct for this on all of the equations. Because the effect of running this technique on the signs, magnitudes, and t-values of all the coefficients was negligible, it appears that autocorrelation had little effect on the results. Furthermore, the correlation between the residuals of the dependent variables did not warrant any sort of seemingly unrelated regression procedure.

The remaining variables in the models are gasoline crisis parameters. By using the coefficients on the gasoline crisis months, the waiting price of gasoline is determined for each dependent variable. Next, the true price of gasoline is calculated. Finally, some measurement of the total value lost due to nonprice rationing is determined.

The coefficient for each gasoline crisis month (γ_i) represents the change in the dependent variable due to nonprice rationing being in effect. For example, Table 2 shows that there were 282 479 fewer weekend trips (TWE) made in March 1974 than would have been made had gasoline been available with a zero waiting cost.

Next, the actual time price of gasoline is calculated for each month by

$$P_{Wi} = \gamma_i/\beta_1$$

because $P_{Wi}\beta_1 = \gamma_i$, where γ_i is the coefficient on each gasoline-crisis dummy variable and β_1 is the coefficient of RPG. Thus, on the average, on the basis of their actual behavior, individuals would have been explicitly willing to pay $\$P_{Wi}$ more per gallon of gasoline at the pump rather than implicitly pay by waiting. Table 4 shows the calculated waiting prices for each month of the gasoline crisis for each classification of travel. This waiting price was highest during the height of the gasoline crisis--February-March 1974.

The true price of gasoline was calculated by summing the pump price and the waiting price each month for the different models and is presented in Table 5. This table reports the actual price, including waiting, that was, on the average, being paid for a gallon of gasoline. For example, during the acute period of the crisis (March 1974), if the reduction in total trips is considered, consumers of

Table 4. Time prices of gasoline.

	Linear Specification ($/gal)				
Dependent Variable	DEC73	JAN74	FEB74	MAR74	APR74
Gallons	0.097	0.088	0.125	0.134	
Total trips	0.056	0.056	0.138	0.235	0.168
Weekend trips	0.128	0.249	0.392	0.478	0.028
Weekday trips	0.035		0.063	0.163	0.014
Urban trips	0.039	0.042	0.138	0.177	0.044
Urban weekend trips	0.076	0.114	0.281	0.352	0.034
Urban weekday trips	0.029	0.023	0.099	0.129	0.046
Rural trips	0.075	0.071	0.138	0.299	
Rural weekend trips	0.178	0.379	0.499	0.603	0.022
Rural weekday trips	0.042		0.023	0.202	
I-80 trips	0.115		0.365	1.180	0.328
I-80 weekend trips	0.371	0.593	1.310	1.352	0.428
I-80 weekday trips	0.062			1.060	0.259
I-580 trips	0.033	0.040	0.076	0.121	0.014
I-580 weekend trips	0.062	0.022	0.123	0.143	0.025
I-580 weekday trips	0.019	0.048	0.054	0.111	0.010

Table 5. True prices of gasoline.

Dependent Variable	Linear Specification ($/gal)				
	DEC73	JAN74	FEB74	MAR74	APR74
California pump price, real	0.313	0.324	0.326	0.357	0.367
Gallons	0.410	0.412	0.415	0.491	
Total trips	0.369	0.380	0.464	0.592	0.535
Weekend trips	0.441	0.523	0.718	0.835	0.395
Weekday trips	0.348		0.389	0.520	0.381
Urban trips	0.352	0.366	0.464	0.534	0.411
Urban weekend trips	0.389	0.438	0.607	0.709	0.401
Urban weekday trips	0.342	0.347	0.425	0.486	0.413
Rural trips	0.388	0.395	0.464	0.656	
Rural weekend trips	0.491	0.703	0.825	0.960	0.389
Rural weekday trips	0.355		0.349	0.559	
San Francisco area pump price, real	0.315	0.329	0.331	0.358	0.368
I-80 trips	0.430		0.696	1.538	0.696
I-80 weekend trips	0.686	0.922	1.641	1.710	0.786
I-80 weekday trips	0.377			1.418	0.627
I-580 trips	0.348	0.369	0.407	0.479	0.372
I-580 weekend trips	0.377	0.351	0.454	0.501	0.393
I-580 weekday trips	0.334	0.377	0.385	0.469	0.378

gasoline were, on the average, paying $0.84/gal on the weekends and $0.52/gal on the weekdays. However, the true price of gasoline converged to the pump price the following month (April 1974) as nonprice rationing subsided.

So far, all indications point to the conclusion that driving was drastically reduced during the gasoline crisis for all categories of travel. However, the reduction was by no means uniform. Certain kinds of travel were more adversely affected than others, as can be seen when the waiting and true prices of gasoline are examined. First of all, Table 5 shows that the waiting price of gasoline on the weekends exceeded that on the weekdays for all categories of travel in nearly every month of the gasoline crisis. Furthermore, during the rationing period those routes classified by the California Department of Transportation as urban were much less adversely affected than were those classified as rural. Although the waiting price of gasoline was nearly $0.18/gal for URT, it rose to nearly $0.30/gal for RUT in March 1974. This difference was accentuated on the weekends. In other words, these results imply that travel was much more costly in rural areas than in urban areas during the gasoline crisis. The waiting price of gasoline in the rural areas was practically twice the price that it was in urban areas during this period.

It appears that the bulk of driving during the gasoline crisis shifted toward urban areas. As long as the population distribution between urban and rural remained constant during this period, individuals were driving closer to home. It is concluded that, during the gasoline crisis, drivers traveled, on the average, shorter distances. Additional credence for this conclusion can be found in the results for the two locations. Along the recreational rural route, the waiting price of gasoline exceeded $1.00/gal during March 1974. This is in marked contrast to the commercial and commuter location where the waiting price of gasoline rose only about $0.14/gal at best. This result conforms to the earlier reasoning that leisure travel is more time-intensive and is undertaken by people from high-income groups (with high opportunity costs). Therefore, as the waiting price of travel increased during the gasoline crisis, it would be expected that leisure travel would be more adversely affected than work travel.

The measurement of the welfare loss due to nonprice rationing can be decomposed into two parts. One part represents the amount consumers of gasoline would have been willing to transfer to suppliers of gasoline rather than implicitly forgo gasoline to avoid queuing and inconvenience. This would be represented by the rectangle P_W times GAL. The other component of the loss is the loss in consumers' surplus from having to pay a higher price for less gasoline. This is represented by $(P_W/2)$ (ΔGAL). The total value thus lost due to rationing during the gasoline crisis in California from December 1973 through April 1974 was $355 million. At the 1974 figure of approximately 13 million licensed California drivers, this averages about $27/driver. Assuming that California represents approximately one-tenth of the licensed drivers in the nation and that the nonprice rationing affected drivers across the nation in a similar way, the value lost because of nonprice rationing could be placed in the order of magnitude of $3 billion nationally.

CONCLUSIONS

Statistical analyses of the empirical assessment are highly encouraging and conform well to theoretical expectations. The coefficients for price, real income, population, seasonal variation, and the gasoline crisis take on the hypothesized sign and are generally statistically significant at conventional levels.

In addition to the conventional demand analysis, this study investigated the gasoline crisis directly. Results of the analysis indicate that, on the basis of the waiting price paid for gasoline, leisure travel was much dearer than commercial travel during the gasoline crisis. Furthermore, driving during the crisis was confined to shorter distances. Finally, by using the results of the waiting-price calculations, measurements of the cost of the nonprice rationing of gasoline determined that it averaged about $27/driver.

Publication of this paper sponsored by Committee on Energy Conservation and Transportation Demand.