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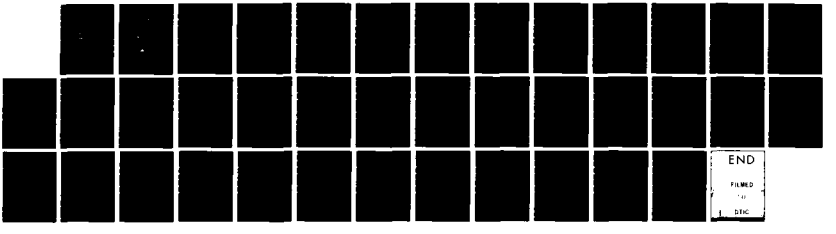

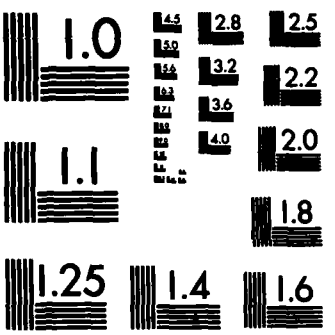

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MILITARY FAMILY HOUSING COMPARED TO PRIVATE HOUSING: A BENEFIT COST MODEL

MAJOR FRANKLIN L. GERTCHER

DEPT OF ECONOMICS

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This paper provides a method for determining whether the current Department of Defense (DOD) military family housing program is economic according to the criterion that social benefits exceed social costs. A benefit-cost model is presented which extends the models developed by previous researchers in the field of public housing. This model tests the hypothesis that indeed the DOD does have an economic justification for providing military rental housing according to the criterion stated above. The test was based on data obtained for Travis, Ellsworth, MacDill, and Tinker Air Force bases. The paper (contd)

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MILITARY FAMILY HOUSING COMPARED TO PRIVATE HOUSING: A BENEFIT-COST MODEL

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ABSTRACT

This paper provides a method for determining whether the current Department of Defense (DOD) military family housing program is economic according to the criterion that social benefits exceed social costs. A benefit-cost model is presented which extends the models developed by previous researchers in the field of public housing. This model tests the hypothesis that indeed the DOD does have an economic justification for providing military rental housing according to the criterion stated above. The test was based on data obtained for Travis, Ellsworth, MacDill, and Tinker Air Force bases. The paper concludes with a presentation of empirical results and a brief discussion of the possibilities for further research.

I. INTRODUCTION

Since World War II, Congress has authorized and the Department of Defense (DOD) has provided government-owned rental housing exclusively for military families at virtually every major military installation in the United States.[1] In fiscal year 1978 alone, the DOD family housing and assistance program involved a total obligation authority of over 1.5 billion dollars. In light

[1]Public Law 345, August 11, 1955, which amends sections 401 through 409, Title VIII of the National Housing Act, June 27, 1934.

of this relatively large expenditure of resources, it is striking how little is known about the social benefits and costs of military rental housing compared to private market alternatives.[2]

This paper addresses the issue of the social benefits and costs of military rental housing. Its primary purpose is to provide a general method for determining whether the current DOD housing program is economic according to the criterion that social benefits exceed social costs at given military installations.

Consistent with this purpose, a model is presented which estimates both net social and net family benefits for military families grouped according to field grade, company grade, senior enlisted, and junior enlisted categories. The model is used to test the hypothesis that the DOD has an economic justification for providing military rental housing service according to the criterion that social benefits exceed social costs. It is shown that if a mean net social benefit per family in a given category is obtained, then the DOD has an economic justification for pro-

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[2]This paper is the first in a series of three papers which address certain economic issues associated with the DOD military family housing program. The second paper is entitled: "Military Rental Housing Compared to Private Housing: Alternative Amounts of Housing Service Consumption." The third and final paper is entitled: "A Model of Housing Choice Behavior." Each paper includes a model and the results obtained from an empirical application.

viding housing service to each family in that category. On the other hand, if a mean net social cost per family is obtained, then society would be better off and each family no worse off, on the average, if the DOD gave each family a cash grant equal to the mean net family benefit for its respective category.

The analysis is limited to two DOD policy options. The first option is the current DOD program of providing military rental housing to families in a given category at rents equal to each family's Basic Allowance for Quarters (BAQ). The second option is a program which provides no military rental housing to families in a given category, but as an alternative, provides a cash increase in BAQ for each family equal to the average (mean) net family benefit for its respective category.[3]

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[3] A possible third policy option is for the DOD to provide cash grants restricted to the purchase of housing service. It is possible that such a cash grant would be smaller than the unrestricted cash grant necessary to induce a family to voluntarily choose at least the equivalent amount of private housing service. This alternative was discussed with responsible officials at Headquarters U.S. Air Force, Directorate of Engineering and Services, Housing and Services Division. The DOD has not used restricted cash grants for housing in the past because of the administrative cost and the possible adverse reaction of military members to perceived restrictions on their consumer sovereignty. For these reasons, a program of restricted cash grants in addition to current BAQ or a program of totally restricted BAQ are not likely alternatives for the future. Restricted cash grant programs were therefore not included in the analysis. Other alternative programs were not considered.

II. THEORY

Net social benefit is defined as the social benefit minus social cost associated with the fact that a given family exclusively consumes a given amount of military rental housing service. Net family benefit is defined as the difference between the benefit and cost which accrues directly to a given family that exclusively consumes a given amount of military rental housing service. Net family benefit is therefore a subset of net social benefit; however, as explained in detail later, it was assumed that all relevant benefits and costs accrue either to families that consume military rental housing service or to the DOD.[4]

Consider the term "housing service." Following Muth, Olsen, et al., housing service is an unobservable good emitted in some quantity by each dwelling unit during each period of time.[5] It is the one and only thing in a dwelling unit to which consumers attach value. Intuitively, the quantity of housing service

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[4]Given freedom of choice between military rental and private housing alternatives, a family that voluntarily chooses military rental will not experience a net cost compared to the private market. However, society may experience a net cost even though the family experiences a net benefit.

[5]Muth, Richard F., "The Demand for Non-Farm Housing," (1960), M. Edel and J. Rotherberg, ed. Readings in Urban Economics. New York: MacMillan Publishing Company, Inc., 1972. Also see Olsen, Edgar O., "An Econometric Analysis of Rent Control," Journal of Political Economy (November-December 1972).

emitted by a dwelling unit can be thought of as an index of both quantitative and qualitative attributes.

For the purpose of this paper, all dwelling units were measured in terms of homogeneous housing service units. Apparent differences between housing service units in owner-occupied, private rental, and military rental sectors were resolved by using imputed rents.[6] Thus, in equilibrium on a monthly basis, an owner-occupied unit with an imputed rent of $400 yields twice the housing service compared to an owner-occupied unit with an imputed rent of $200 or a private rental unit with a rent of $200 or finally, a military rental unit with an imputed rent of $200.

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[6] An apparent difference between owner-occupied and private rental housing service exists because owner-occupied dwelling units are joint investment-consumption alternatives, whereas private rental units are strictly consumption alternatives. This apparent difference was resolved by imputing a monthly rent for each owner-occupied dwelling unit. To obtain an imputed rent from the cash flow experienced by a family that occupies an owned dwelling unit, discounted amounts were subtracted for both the expected net capital appreciation over the period of occupancy, and the annual income tax benefit; the foregone interest to the actual down payment was added.

Likewise, an apparent difference between military rental and private rental housing service exists because the rent for a military rental dwelling unit is arbitrarily determined by the DOD, not by a perfectly competitive market. To obtain an imputed rent, it was assumed that the monthly expenditure for a military dwelling unit on the private market would be the same as the average monthly rent for private rental units or the average monthly imputed rent for owner-occupied units with the same physical attributes. Using cost proxies for physical attributes, regression techniques were used to obtain an equation which permitted a prediction of the imputed rent for each military dwelling unit.

Now consider the following assumptions which concern military rental housing. First, it was assumed that dwelling units are standardized for families within each of the four categories. Second, it was assumed that the standard dwelling unit in each category represents the DOD standard amount of housing service for each family within that category.

These assumptions were made in light of the following empirical evidence. First, at each installation included in this study, the total floor space per dwelling unit was essentially constant for all dwelling units in each category. Second, the major appliances were almost invariably the same type, brand, and model for all dwelling units within each category. Third, all dwelling units within each category had access to approximately the same yard space, and finally, all dwelling units, regardless of category, had a uniform off-white paint on interior walls.

However, minor differences between dwelling units existed in some categories at each installation. Specifically, there were minor differences in floor plans to accommodate different size families. There were also minor differences in the colors of exterior paint. Of course, minor differences due to dwelling unit location within housing tracts were noted. However, for the purpose of this paper, these minor differences were considered to be negligible within categories, and the dwelling units within each category at each installation were sufficiently alike to be

considered standardized.

The following assumptions concern private housing markets in communities adjacent to military installations. First, it was assumed that perfectly competitive conditions prevail in these markets. In addition, it was assumed that military families are free to move from military rental to private housing in response to market conditions. The assumption of perfect competition is consistent with previous studies by Muth (1960), deLeeuw (197 , et al.[7] The freedom of movement assumption was consistent w empirical conditions at all military installations examined du- ing this study. Further, information concerning prices and corresponding amounts of housing service were readily available to military families through housing referral offices located on each military installation.

Now consider the following assumptions concerning benefits and costs. Even at the individual family level, a comprehensive benefit-cost analysis of military rental housing service would include all benefits and costs which accrue to all economic entities in society that are affected by the fact that a given family consumes a certain amount of military rental housing service. A list of those affected would include: the family itself, the DOD,

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[7]Muth, op. cit., also see deLeeuw, Frank, "The Demand for Housing, a Review of the Cross-Sectional Evidence," Review of Economics and Statistics, (February 1971).

local governments, landlords, real estate firms, home builders and sellers, consumers of private housing service, businesses which provide non-housing goods and services, public utilities, and local and federal taxpayers. However, the measurement problem was simplified by assuming that except for the benefits and costs which accrue to the family and the costs which accrue to the DOD, all other benefits and costs were either negligible in themselves or would tend to balance out to negligible net amount.[8]

Consider the following framework based upon the above assumptions. Suppose a family chooses military rental as opposed to private housing. Since this family had the option of living in private housing, military rental must make it better off. There is some amount of money X that would have made the family indifferent to the following two alternatives: (1) living in military rental housing during some time period (say an entire tour of duty at given military installation), or (2) accepting an unrestricted cash grant of X dollars on the stipulation that the family live in private housing during the same time period. If a

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[8]Note the assumption that the DOD experiences no benefits, only costs, for providing military rental housing. This is not precisely true, since the DOD may experience some benefits due to the externalities which may be associated with having an exclusively military community on the installation itself. This study is therefore limited because these possible benefits were not considered.

family were offered a cash grant of more than X for the given period it would accept; if it were offered an amount less than X, it would reject the offer. Following Bish and Olsen, X dollars is defined as the net benefit of military rental housing service to this hypothetical family.

There are only three alternative housing consumption patterns associated with military families that choose to exclusively consume military rental housing service.[9] A family may choose to consume more housing service compared to private market alternatives. It may consume at a point on or below its housing service demand curve, or it may consume at a point above its demand curve but at a price below the price of the same amount of housing service in the private market. As a third alternative, a family may choose to consume less housing service compared to private market alternatives, in which case it will consume at a point below its demand curve.[10]

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[9]The estimating procedure outlined in this section extends the theory set forth by Robert L. Bish (1969) which concerned public housing within civilian communities. See Bish, R.L., Public Housing "The Magnitude and Distribution of Direct Benefits and Effects on Housing Consumption," Journal of Regional Science, Vol 9, No. 3, 1969. Also see: Edgar O. Olsen, "An Econometric Analysis of Rent Control," Journal of Political Economy, November/December 1972.

[10]These three alternative housing consumption patterns can easily be demonstrated by using standard indifference curve and budget line analysis.

Figure 1 illustrates military housing consumption at point F. A hypothetical family has chosen to consume more military housing service compared to its next best private market alternative, which is illustrated by point A. In Figure 1 and the subsequent discussion,

Q_J = The amount of military rental housing service to which a given family is nominally entitled.

P_J = Price per unit of Q_J.

Q_H = Amount of private housing service (either rental or owned) which corresponds to a point on an individual family's demand curve and which represents the family's next best alternative in the private market.[11]

P_H = Price per unit of Q_H, and finally,

D_i = Individual family demand curve for housing service.[12]

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[11]The amount of $P_H Q_H$ corresponds to the uniform monthly imputed rent for a private dwelling unit.

[12]In this model, the demand curve is drawn as if money income was held constant when the price of housing was changed. To be completely correct, a decrease in the price of housing with money income unchanged could also lead to an increase in the purchase of housing service as the result of the increase in real income. Thus, a demand curve with the increase in real income

Private housing service consumption as a second choice would have occurred at Q_H, for which the outlay would have been $P_H Q_H$. However, this hypothetical family has actually chosen military housing at Q_J for an outlay of $P_J Q_J$, where Q_J is greater, in this illustration, than the private alternative by the amount $Q_J - Q_H$.

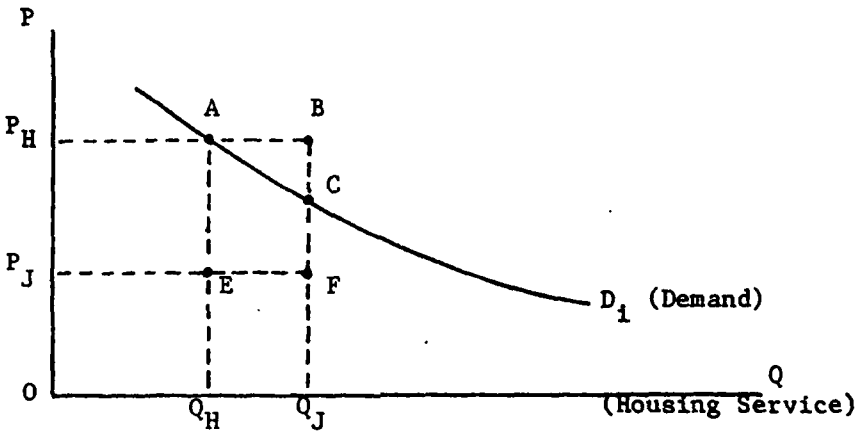

Figure 1: Housing consumption pattern where the selected amount of military rental housing service is greater than the private housing alternative, and point F is below the demand curve.

The market value of this increase in housing consumption is $Q_H ABQ_J$.[13] However, as perceived by the family, $Q_H ABQ_J$ is an over-estimate of net benefit due to an increase in housing ser-

taken into account would be more elastic than a demand curve with real income held constant. See Friedman, Price Theory, Chicago, Aldine Publishing Company, 1962.

[13]Note that in a perfectly competitive market, the supply curve faced by each family is perfectly elastic at price P_H. On the other hand, military housing supply is a point at F which is consistent with the fact that the amount of military housing service and the price are determined by rank, not by market conditions.

vice by the amount of the triangle ABC and the cost to the family of the additional housing service.[14] The net benefit to the family due to an increase in housing service is therefore $Q_H ACQ_J - Q_H EFQ_J$.

Now consider the fact that this hypothetical family also has more income available to spend on non-housing goods.[15] To be precise, a family with total income I that occupies a military rental unit consumes $P_H Q_H - P_J Q_J$ more non-housing goods than they would have on the private rental market.

Net family benefit X is equal to the excess in consumer surplus at point F compared to the consumer surplus at point A. Mathematically,

$$X = P_H Q_H + \int_{Q_H}^{Q_J} DdQ - P_J Q_J \qquad (1)$$

Finally, note that the net benefit of the military rental

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[14] In his study of public housing, Bish (1969) includes area ABC as part of the value of the benefit which accrues directly to the tenant of a public housing unit. However, in this paper, ABC represents a dead weight loss which is consistent with traditional consumer surplus theory.

[15] A comparatively lower price for military rental housing service may induce a family to buy (1) more military rental housing service, (2) more non-housing goods, or (3) more of both, depending on the income elasticities, etc. This paper adapts the general case which permits the increase in purchase of both to be positive or zero.

option to the family whose housing situation is depicted in Figure 1 can be thought of as the sum of (1) the net benefit derived from spending more money on non-housing service and (2) the net benefit due to the increase in housing service consumed.

Now consider a housing consumption pattern where $Q_J > Q_H$, but consumption occurs at point G. Using the same notation as in Figure 1, Figure 2 illustrates military housing consumption at point G, which is compared to the family's next best private housing alternative at point A. As in Figure 1, private housing consumption as a second choice would have occurred at Q_H, for which the outlay would have been $P_H Q_H$.

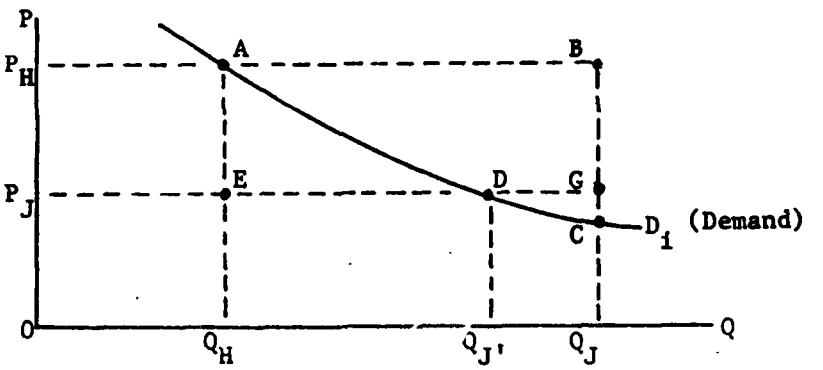

Figure 2: Housing Service consumption pattern with the selected amount of military rental housing service greater than the private market alternative, and point G is above the demand curve.

Again, the family has actually chosen military housing at Q_J for an outlay of $P_J Q_J$, where Q_J is greater than the private alternative by $Q_J - Q_H$. However, there is now a difference

compared to Figure 1 because point G is above the demand curve.

Consider the implications of this difference. The amounts of housing service ($Q_H - Q_J'$) and ($Q_J' - Q_J$) can be analyzed separately. For the amount of housing service between Q_H and Q_J' the net benefit to the family equals (Q_HADQ_J' minus Q_HEDQ_J'), which is consistent with Figure 1. Added to this increase in benefit due to an increase in consumption of non-housing goods, there exists a net benefit equal to (OP_HADQ_J' minus OP_JEDQ_J'), which is the excess in consumer surplus at point D compared to point A. For the amount between Q_J' and Q_J, the additional outlay is $Q_J'DGCQ_J$. However, the perceived benefit is only $Q_J'DCQ$. The additional outlay exceeds the perceived benefit by an amount equal to area DGC. Thus, area DGC must be subtracted from (OP_HADQ_J' minus OP_JEDQ_J') to obtain a correct measure of net family benefit for consumption at point G compared to consumption at point A. At this point, it can easily be shown that (OP_HADQ_J' minus OP_JEDQ_J' minus DGC) is measured precisely be equation (1). The model expressed in equation (1) therefore accommodates the housing consumption pattern illustrated in Figure 2.

Now consider a housing consumption pattern where $Q_J < Q_H$, and consumption occurs at point K. In Figure 3, private housing consumption as a second choice would have occurred at Q_H, for which the outlay would have been P_HQ_H. Again, the family has actually chosen military housing at Q_J for an outlay of P_JQ_J. However, in

this case $Q_J < Q_H$. Given the assumption that the family could have moved to private housing if it had chosen to do so, the only incentive it had for choosing military rental is that P_JQ_J permits them to consume a sufficiently greater amount of non-housing goods to offset the smaller consumption of housing service.

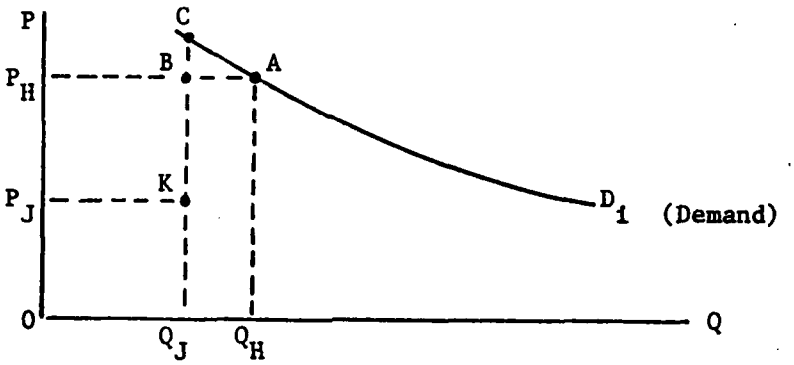

Figure 3: Housing service consumption pattern with the selected amount of military rental housing service less than the private housing alternative.

In the case depicted in Figure 3, the family consumer $P_HQ_H - P_HQ_J$ less housing service than they would have in the private housing market. The market value of this decrease in housing consumption is Q_JBAQ_H. However, as perceived by the family, Q_JBAQ_H is an under-estimate of the value of the decrease in housing service by the amount of the triangle ABC. The net loss to the family due to a decrease in housing service is therefore Q_JCAQ_H. On the other hand, if the family chooses military housing at P_JQ_J, it consumes $P_HQ_H - P_JQ_J$ more non-housing goods. As depicted in Figure 3, the net family benefit X is equal to the

excess in consumer surplus at point K compared to the consumer surplus at A, or

$$X = P_H Q_H - \int_{Q_J}^{Q_H} D dQ - P_J Q_J \qquad (2)$$

By reversing the limits and changing the sign on the integral, one could show that equation (2) is precisely equal to equation (1). Intuitively, the net benefit of the military rental option to the family whose housing situation is depicted in Figure 3 can be thought of as the algebraic sum of the net benefit derived from spending more money on non-housing goods and the net loss from consuming less housing service.

Net family benefit estimates can now be aggregated according to field grade, company grade, senior enlisted, and junior enlisted categories. From these aggregate amounts, the net benefit can be determined for the average family in each category. First, consider equation (3) where $\bar{X}_h$ is the average net family benefit per family for category h, h = 1, 2, 3, and 4. Also, X_i, which corresponds to X in equations (1) and (2), is the net benefit for family i in category h, i = 1, 2, 3, ...n. Thus, equation (3) provides a method for determining the average net family benefit.

$$\bar{X}_h = \frac{1}{n} \sum_{i=1}^{n} X_i \qquad (3)$$

Now consider the additional cost to the DOD of providing a given amount of housing service to a military family. For a family in a given category, the net cost to the DOD of amount Q_J is simply $(AC_M - P_J)Q_J$, where AC_M is the average cost per unit of housing service to the DOD. Also note that AC_M is determined exogenously from the model presented above.[16] Thus, given the assumptions concerning all other costs and benefits associated with military rental housing, the net social benefit of Q_J for family i in category h is $X - (AC_M - P_J)Q_J$.[17]

The framework is now set for a test of the hypothesis that the DOD has an economic justification for providing military rental housing to families in each of the four categories. Essentially, if an average (mean) net social benefit per family for a given category is obtained, then the hypothesis is true and the

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[16]Values of AC_M for each category and installation in this study were obtained from Headquarters U.S. Air Force, Directorate of Engineering and Services, Housing and Services Division. These data include the interest on the construction cost debt and all operating and maintenance costs per dwelling unit for 1978.

[17]Based on a review of the data from the installations included in this study, the DOD may actually experience a tangible net benefit by providing housing service to military families by taking in more in terms of forfeited BAQ than they spend for maintenance, utilities, etc. Date were obtained on the average cost per dwelling unit data for field grade, company grade, senior enlisted, and junior enlisted units at Travis, Ellsworth, MacDill, and Tinker Air Force bases. There were no positive cash flows except for each family's forfeited BAQ, which we include in our analysis. Although there may be certain intangible benefits to the DOD, they were assumed to be negligible.

DOD has an economic justification for providing housing service on a voluntary basis to families in that category is obtained, the hypothesis is false and society would be better off and each family no worse off, on the average, if the DOD gave each family an unrestricted cash increase in BAQ equal to the average net family benefit for that category. According to the terms defined in the previous discussion, if

$$\frac{1}{n} \sum_{i=1}^{n} [X_i - (AC_M - P_J)Q_J]i > 0, \tag{4}$$

then the hypothesis is true. If inequality (4) is not true, then the hypothesis is false.

III. EMPIRICAL MODEL

The theoretical model can now be converted into practical equations for the manipulation of available empirical data. First, a simple demand equation of the form

$$P = a - bQ, \tag{5}$$

was assumed, where a and b are constants. Since D was assumed to be linear, it can be shown that

$$a = (P_H + bQ_H) \text{ and} \tag{6}$$

$$b = \frac{1}{\varepsilon} \frac{P_H}{Q_H}, \tag{7}$$

where ε is the absolute value of the price elasticity of demand.

$$\int_{Q_H}^{Q_J} DdQ = \int_{Q_H}^{Q_J} (a - bQ)dQ, \tag{8}$$

therefore

$$\int_{Q_H}^{Q_J} DdQ = a\,(Q_J - Q_H) - \frac{b}{2}\,(Q_J - Q_H)\,(Q_J + Q_H) \qquad (9)$$

Substituting equations (6) and (7) into (9),

$$\int_{Q_H}^{Q_J} DdQ = (P_H Q_J - P_H Q_H)\left[(1 + 1/\varepsilon) - \frac{P_H Q_J + P_H Q_H}{2\varepsilon P_H Q_H}\right] \qquad (10)$$

and finally:[18]

$$X_i = P_H Q_H + (P_H Q_J - P_H Q_H)\left[(1 + 1/\varepsilon) - \frac{P_H Q_J + P_H Q_H}{2\varepsilon P_H Q_H}\right] - P_J Q_J \qquad (11)$$

Thus, the empirical X_i is a function of $P_J Q_J$, ε, $P_H Q_H$, and $P_H Q_J$. The amount of $P_J Q_J$ is simply a given family's expenditure per time period on military rental housing, which is precisely equal to the family's BAQ. Again, ε is the price elasticity of demand for housing service. The amount $P_H Q_H$ is the cost per time period of a given family's best alternative in the private market, and finally, $P_H Q_J$ is the cost per time period in the private market, of Q_J housing service. The amount of $P_J Q_J$ is available directly from the data. However, ε, $P_H Q_H$ and $P_H Q_J$ were estimated.

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[18]Recall that in equation (5), a linear segment to a demand curve was assumed. This assumption, which simplifies the mathematics considerably, results in a positive bias to the estimate of net family benefit. However, over the price range involved, this bias is negligible.

Previous studies (deLeeuw, 1971, et al) found price elasticities ranging from -0.7 to -1.7 for rental housing and price elasticities ranging from -0.7 to -1.5 for owner-occupied housing. Since data were available, observations of military families were used to estimate price elasticities. Consider the following equations which express the quantity of housing service units demanded by a family as a function of the relative price of housing service units and real income.

$$\text{Ln}\left(\frac{P_H Q_H}{P}\right) = \alpha + \beta \text{Ln}\left(\frac{P}{Q}\right) + \beta_2 \text{Ln}\left(\frac{I}{Q}\right), \text{ (lower bound)} \qquad (12)$$

and

$$\text{Ln}\left(\frac{P}{Q}\right) = \alpha + \beta_3 \text{Ln}\left(\frac{P_H Q_H}{P}\right) + \beta_4 \text{Ln}\left(\frac{I}{Q}\right), \text{ (upper bound)}$$

where

$P_H Q_H$ = Uniform monthly cost of a private sector dwelling unit, pooled home owner and private renter observations.

P = Regional Median monthly rental cost

Q = Regional average cost of living (housing plus all other goods).

I = Monthly military income.

Thus, the estimator of price elasticity has a lower bound of

$\hat{\beta}_1$ and an upper bound of $1/\beta_3$.[19] Of course, the sensitivities of the subsequent estimates of price elasticities indicated by equation (12) were computed.

Now consider a method of estimating $P_H Q_H$, the imputed rent of a given family's best alternative in the private market. For $P_H Q_H$, Olsen's method was used.[20] It was assumed that a family in military rental housing would have spent the same amount on housing in the private market as the average expenditure on housing of military families with the same military rank who actually live in private housing. To estimate $P_H Q_H$, refer to the observations on military families in private housing.

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[19]See deLeeuw, Frank. "The Demand for Housing, A Review of the Cross-Sectional Evidence," Review of Economics and Statistics (February 1971). deLeeuw developed a similar equation which also held the price of non-housing goods and money income constant and permitted the price to vary. The use of $(\frac{P_H Q_H}{P})$ as the dependent variable and P/Q as an independent variable is also consistent with deLeeuw's approach. Also, see deLeeuw for a detailed explanation of the terms "upper and lower bound" with reference to the upper and lower limits for price elasticity. Note, however, that the data for this study included individual observations of pooled monthly housing (imputed) rents and incomes for private renters and owner-occupants whereas deLeeuw used median values and estimated separate renter and home owner elasticities. Also note that the monthly imputed rents for home ownership were adjusted for the income tax benefit, the expected capital gain when the dwelling unit is sold at the end of the expected period of occupancy, and the foregone interest on the actual down payment. Finally, the private renter observations of monthly cost were taken directly from survey data; each observation included all expenses associated with private rental.

[20]Olsen, op. cit.

Again, a family in military rental housing could have chosen either private rental or home ownership. Private rental and home ownership observations were therefore pooled. Also, it was assumed that the average (mean) $P_H Q_H$ for each category and installation calculated from private market observations is a suitable approximation to the foregone $P_H Q_H$ for military renters. Thus, values of $P_H Q_H$ for field grade, company grade, senior enlisted, and junior enlisted families at each installation included in this study were obtained.

Now consider the following method for estimating $P_H Q_J$. In his study of rent control in New York City in 1968, Olsen assumed that a controlled dwelling unit would rent on the uncontrolled market for the average rent of uncontrolled units with the same physical attributes. He went on to assume that the stochastic model that explained the differences in rents of different uncontrolled dwelling units in New York City in 1968 was:

$$P_H Q_H = b_o + \sum_{i=1}^{31} b_i X_i + \mu \qquad (13)$$

where the X_i represent certain physical attributes of dwelling units. Thus, his predictor of the uncontrolled market rent of a controlled dwelling unit was:

$$P_H Q_J = \hat{b}_0 + \sum_{i=1}^{31} \hat{b}_i X_i, \qquad (14)$$

where the $\hat{b}$'s were least squares estimates of the b's in equation (13).

If Olsen were followed, it would be assumed that the monthly expenditure for a military dwelling unit on the private market would be the same as the average monthly expenditure for private rental or owner-occupied dwelling units with the same physical attributes. However, sufficient data were not available on the physical attributes of either private rental or owner-occupied units to justify using equations similar to (13) and (14) above. The following alternative method was therefore used.

Instead of observations which include values for physical attributes, observations on owner-occupied dwelling units which include the 1978 purchase price and the 1978 average monthly operating and maintenance cost were available. By using these cost attributes as proxies, physical attributes which influence the monthly cost of the dwelling unit in the private market were accounted for.

It was therefore assumed that the model which explains the differences in average monthly expenditures among military families that actually purchased homes during 1978 was:

$$P_H Q_H = \sigma_0 + \sum_{i=1}^{2} \sigma_i Z_i + \mu, \mu \ N(0,\sigma^2) \qquad (15)$$

where the Z_i are defined as follows:

Z_1 = The 1978 selling (purchase) price of the housing unit,

Z_2 = Average monthly operating and maintenance cost, including utilities, maintenance, and property tax during 1978.

It was also assumed that given a sample of T joint observations of the dependent variable and the regressors produced by the model (15), the successive disturbances μ_t (t = 1, 2, 2, . . . T) are mutually independent and the regressors are non-stoachistic. Thus, the predictor of the average monthly cost ($P_H Q_H$) for a military rental unit during 1978 is:

$$P_H Q_J = \hat{\sigma}_0 + \sum_{i=1}^{3} \hat{\sigma}_i Z_i \qquad (16)$$

where the $\hat{\sigma}_i$'s are the least squares estimators of the σ_i's in equation (15).

Since equation (16) was used to predict $P_H Q_J$ for the military rental-home ownership comparison, values for the Z_i associated with military rental housing units were needed. Consider the fact that military installations have traditionally built distinct housing units for four categories of military families: field grade officers, company grade officers, senior enlisted, and junior enlisted. As stated earlier, the associated housing units within each category were physically alike, with minor

variations due to location and in some cases, minor variations in floor plans and exterior paint. Thus, it was reasonable to use average values of Z_i for each category at each installation.

To obtain Z_i, the 1978 equivalent selling (purchase) price for each category of housing unit at each installation, actual values for construction cost, including improved land, housing appreciation rates, and the year that units in each category were built for each installation covered by this study were used. From these data, values were constructed for Z_1.

If a perfectly competitive home owner housing market prevails, then the cost of construction, including improved land and a normal profit, equals the approximate selling price during the year of construction.[21] Also, since military housing units ar normally maintained in good repair, it is reasonable to apply the housing unit appreciation rate associated with existing housing units in the adjacent civilian community to military housing units. Thus, the 1978 equivalent private market selling prices for field grade, company grade, senior enlisted, and junior enlisted housing units were approximated at each installation.

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[21]Military housing construction projects, by law and military regulation, are assigned to private contractors on a competitive bid basis. Thus, given the assumption of perfect competition, the average construction cost per military housing unit within each category approximates the construction cost per unit in similar tract housing developments in the adjacent civilian community.

Now consider Z_2, the monthly operating and maintenance cost. For Z_2, average values per housing unit at each installation included in the study were available. These operating and maintenance costs include utilities and repairs, which implicitly includes the cost of self-insurance. However, property tax as a component of operating costs was not included since by law, federal government property cannot be taxed by local governments. Thus, operating and maintenance cost data for military housing units were lower than the private market equivalent by the amount of the equivalent property tax. However, the equivalent property tax associated with each military housing unit was accounted for by using local single family home effective tax rates multiplied by estimated 1978 selling prices. The estimated monthly tax for each type of unit was then added, as appropriate, to make Z_2 for military rental dwelling units comparable to the Z_2 for owner-occupied units in the private market. The discussion of the model for evaluating the current DOD housing program in terms of net social and net family benefits is now complete.

IV. THE DATA

The data for this study included 1,822 individual family observations of values for the variables described in our model. These observations represent statistically representative samples of military families assigned to Travis, Ellsworth, MacDill and Tinker Air Force bases. All observations were for calendar year

1978.

The data were obtained from two sources. First, data were obtained from the 1978 Department of Defense Family Housing Survey. These data included all completed survey forms (DD Forms 1376, Family Housing Questionnaires) returned to all U.S. military installations that participated in the survey during calendar year 1978. Questionnaires were completed and returned by over 95 percent of all military families at each installation. Each observation was identified by the social security number of the military member of each family. Additional data were obtained from a Family Housing Preference Survey. The data from this survey, provided as a set of returned questionnaires, included 812 observations of individual military family home owners at four Air Force installations: Travis, Ellsworth, MacDill, and Tinker. Observations from this survey were correlated with the corresponding observations from the 1978 DOD Family Housing Survey by the social security number of the military member.

Thus, by combining the data from the two surveys, a statistical sample of individual family observations of the variables described in our model were obtained from Travis Air Force Base in California, Ellsworth in South Dakota, MacDill in Florida, and Tinker in Oklahoma. Further, by selecting four installations near urban areas in widely separated geographical regions within the continental U.S., the sample was representative of all such

installations.

V. EMPIRICAL RESULTS

This section presents and interprets the results obtained from the model as applied to the data described above. The following table presents the mean monthly net social and net family benefits obtained for each military family category for each of our four installations. The table also shows results from the pooled observations from all four installations. A negative sign represents a net cost.

TABLE 1

MEAN MONTHLY NET BENEFIT OF
MILITARY RENTAL HOUSING

NET BENEFIT TO	INSTALLATION	JUNIOR ENLISTED	SENIOR ENLISTED	COMPANY GRADE	FIELD GRADE
Society	Travis	$141 (8.20)	$123 (18.1)	$120 (25.1)	$139 (47.2)
Family	Travis	155 (16.2)	116 (39.2)	84 (45.1)	64 (73.1)
Society	Ellsworth	130 (25.0)	132 (27.2)	192 (30.1)	207 (28.2)
Family	Ellsworth	145 (36.5)	152 (37.2)	176 (40.9)	135 (34.8)
Society	MacDill	79 (32.2)	-60 (32.3)	38 (29.0)	91 (21.0)
Family	MacDill	83 (62.1)	-13 (42.1)	26 (25.3)	3 (28.1)
Society	Tinker	2 (2.10)	-6 (6.10)	47 (35.0)	40 (40.0)
Family	Tinker	26 (12.2)	38 (13.8)	23 (27.8)	28 (38.5)
Society	*Four Base Average	71 (16.2)	100 (22.0)	49 (27.8)	119 (36.5)
Family	*Four Base Average	99 (26.3)	79 (34.5)	75 (40.5)	57 (46.6)

*Weighted average with respect to proportion of population in each category at each installation. Values in parenthesis are standard deviations.

For some categories and installations, the net social benefit exceeded the net family benefit. After examining the data in light of equation (4) presented earlier, it was found that for

some categories and installations, the DOD was simply taking in more money per family in terms of forfeited monthly BAQ ($P_J Q_J$ in equation 4) than it paid out in terms of average monthly costs (AC_M in equation 4).

Now consider the sensitivity of our net social and net family benefits to variations in the estimates for the elasticity of demand for housing service, $P_H Q_H$, and $P_H Q_J$. First, the sensitivities of net social and net family benefits to variations in elasticity (ε) were tested over the range $-0.7 \leq \varepsilon \leq -1.7$. On the average, the estimates of net benefits varied only a few dollars over this range (plus or minus eight-tenths of one percent). The sensitivity of the results to variations over a broad range of owner-occupied imputed rents was also tested.[22] It was found that on the average, a plus or minus variation of 10 percent in imputed rent resulted in less than four percent variation in net benefits. Finally, the sensitivity of the results to variations in our estimate of $P_H Q_J$ was tested. It was found that on the average, a plus or minus variation of ten percent in $P_H Q_J$ resulted in a plus or minus variation of less than three percent in the estimates of net benefits.

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[22]The estimate of $P_H Q_H$ included pooled home owner and private renter imputed rents. Since the imputed rents for private renters were directly observable from the data, variations in these values were not included in the sensitivity analysis.

VI. SUMMARY AND CONCLUSIONS

As originally stated, this paper provides a model which permits an evaluation of the current DOD housing program in terms of social benefits and costs. The empirical application of the model resulted in reasonably accurate estimates of mean net social and net family benefits for each of the four categories and installations included in this study, given the assumptions of the model. However, future research might include testing or relaxing the assumptions and refining the estimates of social costs which were used as a basis for our estimate of net social benefit. Also, the estimate of the private market equivalent rent for a military rental dwelling unit ($P_H Q_J$) should be refined. Specifically, $P_H Q_J$ should be estimated using Olsen's method as outlined earlier. Estimates of AC_M, the average cost per unit of housing service to the DOD, were obtained from Headquarters, U.S. Air Force and represent the best data available at the time of this study. The possibility exists that more precise data can be obtained; however such extensive research is beyond the scope of this study. Until the refinements identified above are made, other researchers are cautioned against using the mean estimates presented in this paper for policy decisions which require precise dollar amounts.

A more extensive statistical analysis of the refined estimates of net social and net family benefits should also be

performed. In particular, variances from the mean for each estimate should be calculated and certain statistical tests should be applied to determine if the estimates are statistically different across categories.

Finally, the value of this benefit cost model lies primarily in the methodology and theory, not in the particular estimates which admittedly need refinement and further statistical tests. Specifically, the theoretical model extends the work of Olsen and Bish to the area of military family housing. Further, the estimates of net social benefits, though in need of refinement, clearly indicate that overall, the current DOD housing program results in a net social benefit rather than a net social cost compared to private market alternatives at the installations included in this study.

As is apparent from the statements throughout this section, this study represents only the beginning of a much-needed comprehensive analysis of the current DOD housing program. Aside from the issues of quantity and quality of housing service available to military families, note that in fiscal year 1978, DOD family housing and assistance programs involved a total obligation authority of over 1.5 billion dollars. The current DOD housing program is obviously big business; the taxpayers deserve

an efficient and effective program consistent with the intent of Congress.[23]

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[23]Public Law 345, op. cit.

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