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The Demand for Service Contracts*

A model of the interrelated demands for appliance service contracts and for appliance repairs is developed and estimated with data from a 1975 national sample of households. The demand for service contracts is found to be income and price inelastic and about unitary elastic with respect to the number of appliances owned. Appliance service contracts introduce moral hazard into the appliance repair market, the elasticity of the demand for repairs with respect to service contract ownership being in the neighborhood of .55.

The Magnuson-Moss Warranty–Federal Trade Commission Improvement Act of 1975 for the first time explicitly provided the federal government with the legislative authority to regulate warranties on goods and services. The Act provided for the regulation of the form and some of the terms and language used in warranties (Gerner and Bryant 1976; Heaton and Katz 1978; Heaton, Katz, and Adam 1978). The attention paid to warranties, however, has also created interest in substitutes for written warranties, among which is the service contract. While the service contract has been used not as a substitute for a written warranty but rather as an option available on the expiration of the warranty, there is little question that under appropriate conditions manufacturers would offer service contracts in place of warranties.

An appliance service contract typically provides repair service, specified maintenance service, preventive checkups, and may provide specified consequential damages. Service contracts have been available for many years on some products. However, their widespread

* W. Keith Bryant is the senior author. Research support was provided by a subcontract to the authors from the Center for Policy Alternatives, Massachusetts Institute of Technology, under NSF grant APR-7501261, and from the Agricultural Experiment Station, Cornell University. M. Bredahl, R. Ehrenberg, M. Johnson, S. Lane, and R. Lund all made valuable comments on earlier drafts. Econometric advice was given by W. Greene. Computer work was done by J. Greene. Errors of fact and judgment made despite their good advice are solely our responsibility.

(*Journal of Business,* 1982, vol. 55, no. 3)

0021-9398/82/5503-0004$01.50

availability and use appears to be a phenomenon of the late 1960s and 1970s.[1] In 1975 about 28% of all owners of appliances purchased new (as opposed to used) had at some time owned at least one service contract (Prohaska et al. 1978). Service contracts appear to have been offered first by manufacturers and were available only in urban areas. More recently, more manufacturers have entered the market, and local appliance dealers and repair firms have entered also.

Financially, a service contract can be viewed as failure insurance or prepaid maintenance and repair service over a specified length of time called the term of the contract. Or, it can be viewed as an extension of the new product warranty for which a price separate from the price of the appliance is paid. Both views exist in the appliance industry, the view varying roughly in accordance with whether the features of the service contract exactly duplicate those of the warranty or differ from them.

In addition to the features listed above, service contracts may have other attributes of interest to the purchaser. Because of their prepaid nature, purchasers spread their risks, sharing them with other contract purchasers. In effect, the purchase of a service contract exchanges the uncertainty of sustaining large appliance repair bills for the certain, but presumably smaller, charges for the service contract.[2] The promotional literature of service contract sellers also points out that the prepaid nature of the contract protects the purchaser against rising repair service costs in a period of inflation. Further, the contract assures the purchaser of service authorized by the manufacturer (if sold by the manufacturer), which puts the reputation of the manufacturers behind not only the appliance but also appliance maintenance and repair. Finally, most service contract literature promises prompt and efficient service.

In spite of the public attention to and the analysis of warranties (Spence 1973; Brown 1974; Courville and Hausman 1978), little economic analysis of service contracts of either a theoretical or an empirical nature has appeared. This paper begins to fill the gap by examining the microeconomics of the demand for service contracts. A simple model of consumer choice is presented in which the consumer owning an appliance has the option of paying cash for repairs as breakdowns occur or of buying a service contract. The demand for repairs and the

1. In 1974–75 prices for the first-year service contract varied widely among and within appliance types. They averaged $21 for contracts on air conditioners, ranges, and refrigerators; $26 on washing machines; and $80–$100 on color televisions. A few had deductible clauses or coinsurance features (Bryant and Gerner 1976).

2. Service contracts go under several names. Others are maintenance agreement and extended warranty. This paper will use the term "service contract" throughout. See Heaton and Katz (1978) for a legal analysis of service contracts.

demand for service contracts are derived and then estimated with data from a national sample of households taken in 1975.

The paper is organized as follows: The next section develops a household model from which the demand relations for repairs and service contracts are derived. The section following modifies the model in the light of data inadequacies and discusses the estimation techniques. Two final sections report the results of the emprical analysis and interpret them.

The Model

The theoretical consideration of the consumer begins after the purchase of an appliance at the point at which a service contract is offered. This is either after the purchase of the appliance or before expiration of the warranty. Consumers face uncertainty about appliance reliability and about repair service cost and quality. Service contracts may be purchased as a form of insurance against any of these types of uncertainties. In any case, the service contract alters the price of using the appliance. Thus, the decisions about optimum use and whether to purchase a service contract are interdependent.[3]

Consider, then, a consumer who has an appliance and who must decide its optimum use and whether to purchase a service contract. The appliance may fail to work on any particular trial attempted by the consumer. Since the consumer derives satisfaction only from trials in which the appliance works, we define a use as a successful trial. The consumer chooses the optimum number of uses per year and makes trials until the optimum number occurs.

A technical feature of the type of appliance is its reliability measured as the probability, β, that it will not break down on any trial. In this model we assume that the probability of successful use on any given try is independent of previous successes or failures. A relation exists, then, between total trials per year, V, and the expected number of successful trials or uses, N, as follows:

$$E(N) = \beta V. \tag{1}$$

The consumer chooses the level of successful use, N, to maximize his utility over use (Gerner and Bryant 1980). The total use, V, varies randomly as the number of unsuccessful uses, or breakdowns, varies.

3. A case might be made for the interdependence of three decisions: appliance purchase, appliance use, and whether to purchase a service contract. But the fact that the service contract is typically not offered until after the consummation of the warranty seriously weakens such a case. For a discussion of this approach, see Gerner and Bryant (1980).

Over many periods $V = (1/\beta)N$, but any given period total use is

$$V = \frac{1}{\beta}N + e, \tag{2}$$

where e is the random variation in total uses caused by breakdown.

Suppose, now, that the consumer knows the probability of successful use for this type of appliance and views the problem of determining optimum use as an insurance problem.[4] The consumer can engage in self-insurance by setting up a fund into which he pays each year and out of which he draws cash to pay for any repairs incurred as a result of breakdowns.[5] Alternatively, the consumer may purchase a service contract from a dealer for a flat fee of $\$F$ per year under which the dealer repairs the appliance on demand at zero marginal cost per repair to the consumer.

Consider the implications of self-insurance. The total cost per year for the consumer's N uses is the sum of the operating cost on successful trials (CoN), the operating cost on unsuccessful trials (CoR), and the total repair cost involved in repairing each breakdown (CrR), where Co = operating cost per trial, Cr = repair cost per breakdown, and R = number of repairs which are presumed to equal the number of unsuccessful trials. Thus,

$$TC^c = (Cr + Co)R + CoN.$$

Defining P_n^c as the expected cost per successful trial or the price of use under a self-insurance scheme, then,

$$P_n^c = \alpha(Cr + Co) + Co = \alpha Cr + (1 + \alpha)Co.\text{[6]} \tag{3}$$

The interpretation of P_n^c is as follows: $\alpha\,\$1.00$ is the annual premium per use on an actuarially fair \$1.00 insurance policy against appliance failure; $(Cr + Co)$ is the total cost of a failure. Thus, $\alpha(CR + Co)$ is the

4. The consumer does not, of course, know the probability of successful use on his specific example of the appliance. One reason he might be interested in the service contract is to insure himself against the possibility that he has purchased a "lemon," i.e., an item with a lower than average probability of successful use. Although our model does not specifically deal with this case, it can easily be modified to do so.

5. See Oi (1978) and Gerner and Bryant (1978) for similar approaches.

6. If P_n^c is the expected price of use and R is the number of repairs which are presumed to equal the number of unsuccessful trials, then

$$P_n^c = E\{[(Cr + Co)R + CoN]/N\}. \tag{4}$$

Since by definition

$$V = N + R, \tag{5}$$

then from (2) and (5),

$$R = \alpha N + e, \tag{6}$$

where $\alpha = (1 - \beta)/\beta$. Equation (3) is found by substituting (6) into (4) and carrying out the expectation operation.

annual premium per use on a policy which pays $(Cr + Co)$ per breakdown. Co, of course, is the per use operating cost.

Presuming that all other goods are collapsed into a collective good, X, with a price Px, then the consumer who chooses the self-insurance option faces a budget constraint of

$$I = PxX + P_n^c N, \tag{7}$$

where I = annual income of the consumer.

Next, consider the price of use under a service contract regime. Since all repair costs are paid by the appliance dealer selling the service contract, annual costs are

$$TC^s = CoR + CoN.$$

Denoting the price of use under a service contract as P_n^s, then

$$P_n^s = (1 + \alpha)Co. \tag{8}$$

Here, the consumer need only insure himself against the lost operating cost incident upon breakdown.[7] If the consumer opts for a service contract and pays a flat annual fee of $\$F$ in exchange for zero repair costs, the budget line he faces is:

$$I = PxX + P_n^s N + F. \tag{9}$$

Given that the consumer's utility function is

$$U = u(X, N; H, A), \tag{10}$$

where H is a vector of the consumer's household characteristics and A is the purchased appliance, then the consumer can be conceived as inquiring which regime (self-insurance or a service contract) yields more satisfaction. This choice is illustrated in figures 1 and 2. In both figures, X goods are measured along the vertical axis and N uses are measured along the horizontal axis. Line *ab* in each figure represents the budget line under the self-insurance option. Line *ab* has a slope of $-[\alpha Cr + (1 + \alpha)Co]/Px$. *Line cd* represents the budget line under a service contract scheme. The slope of line *cd* is $-[(1 + \alpha)Co]/Px$. In both figures distance *ac* measures $\$F/Px$, the real value of the annual fee for the service contract. Figure 1 shows the case in which the consumer maximizes satisfaction ($U^s > U^c$) by choosing to buy a service contract. Note that, given the lower price of use, the demand for use is expanded over that had the service contract not been pur-

7. If the service contract pays incidental damages and if lost operating cost is considered a part of incidental damages, then the price of use becomes

$$P_n^s = Co. \tag{8a}$$

Since no service contract known to us does consider lost operating cost as incidental damages, eq. (8) will be used.

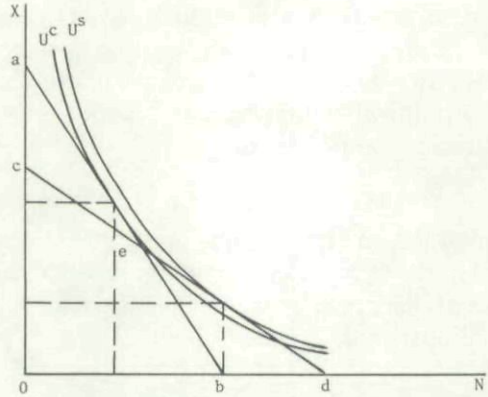

FIG. 1.—The case in which the consumer buys a service contract

chased. This phenomenon is termed ''moral hazard'' in the insurance literature. Figure 2 shows the case in which the consumer maximizes satisfaction ($U^s < U^c$) by choosing not to buy a service contract. Since the marginal price of use under this regime is higher, the demand for use is lower than would have been the case had the service contract been purchased.

The Demands for Use, Repairs, and Service Contracts

The individual's demand for appliance use flows directly out of the first-order conditions for maximum utility under the two alternative

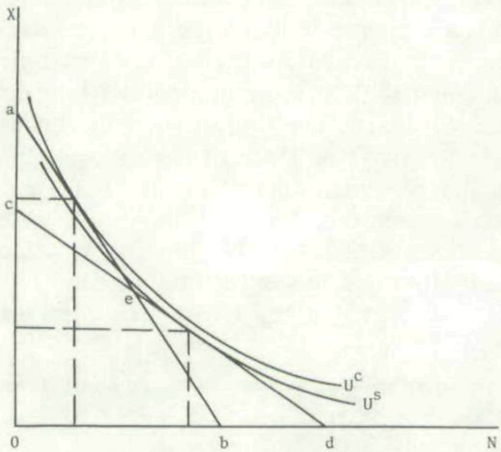

FIG. 2.—The case in which the consumer pays cash for repairs

regimes. In particular,

$$N = \begin{cases} n^c(Px, P_n^c, I; A, H), \text{ if } U^s - U^c < 0 \\ N^s(Px, P_n^s, F, I; A, H), \text{ if } U^s - U^c \geqslant 0 \end{cases} \tag{11}$$

where $n^c(\cdot)$ and $n^s(\cdot)$ represent the demand functions under self-insurance and under service contract regimes, respectively. Equation (11) can be written more compactly if it is recognized, first, that P_n^c and P_n^s are not different variables but rather different values of the same variable, the price of use; second, that F is the expenditure on a service contract if one is purchased and the expenditure is zero if it is not; and, third, that $n^c(\cdot)$ and $n^s(\cdot)$ are identical functions differing only in the values of their arguments. Therefore, we can define

$$Pn = \begin{cases} P_n^c, \text{ if } U^s - U^c < 0 \\ P_n^s, \text{ if } U^s - U^c \geqslant 0 \end{cases} \tag{12}$$

and

$$Es = \begin{cases} 0, \text{ if } U^s - U^c < 0 \\ F, \text{ if } U^s - U^c \geqslant 0 \end{cases} \tag{13}$$

where Pn is the price of use and Es is the expenditure on a service contract. Equation (11), then, becomes:

$$N = n(Px, Pn, Es, I; A, H). \tag{14}$$

The individual's demand for repairs is obtained by substituting (14) into (7):

$$R = r(Px, Pn, Es, I; A, H) + e, \tag{15}$$

where $r(\cdot) = \alpha n(\cdot)$.

The individual's demand for an appliance service contract is derived from the alternative maximum utility conditions under the two regimes. Define a variable, $S^* = U^s - U^c$, as the difference in utilities derived from the two regimes. Then,

$$S^* = s^*(Px, Pn, Es, I; A, H), \tag{16}$$

since both U^s and U^c are functions of the demands for X and N, which, in turn, are functions of Px, Pn, Es, I, A, and H. S^* is, of course, unobservable. However, if we define an index, S, such that

$$S = \begin{cases} 1, \text{ if } S^* \geqslant 0 \\ 0, \text{ if } S^* < 0, \end{cases} \tag{17}$$

then

$$S = s(Px, Pn, Es, I; A, H) \tag{18}$$

can be taken as the individual's demand for a service contract.

Equations (1) through (18) are specified in terms of only two goods: use of the appliance in question, and good, X. Using subscript i to denote appliance i and recognizing that the prices of use (Pn_i) and expenditures on service contracts (Es_i) probably have cross effects as well as own effects requires the expansion of (15) and (18) to:

$$R_i = r_i(Px, Pn_1, \ldots, Pn_M, Es_1, \ldots, Es_M, I; A_i, H) \tag{15a}$$

$$S_i = s_i(Px, Pn_1, \ldots, Pn_M, Es_1, \ldots, Es_M, I; A_i, H) \tag{18a}$$

where $i = 1, \ldots, M$ appliances.

Finally, the aggregate (over appliances) demands for service contracts and for appliance repairs can be written as:

$$\begin{aligned} TR = \sum_i^M R_i = \sum_i^M r_i(\cdot) = tr(Px, Pn_1, \ldots, Pn_M, \\ Es_1, \ldots, Es_M, I; A_1, \ldots, A_M, H) \end{aligned} \tag{19}$$

$$\begin{aligned} TS = \sum_i^M S_i = \sum_i^M s_i(\cdot) = ts(Px, Pn_1, \ldots, Pn_M, \\ Es_1, \ldots, Es_M, I; A_1, \ldots, A_M, H). \end{aligned} \tag{20}$$

In (19) the effect of Pn_i on the total demand for repairs on appliances is the sum of the own-price effect of Pn_i on R_i and the cross-price effects of Pn_i on each of the R_j's ($j \neq i$). Similar points may be made with respect to each of the variables in the two equations.

The supply of service contracts can be envisioned to be perfectly elastic, given appliance age. But for older appliances manufacturers are only willing to supply service contracts at higher prices to cover the increased costs of repair. Thus, for the purposes of this paper, the supply price of a service contract on appliance i, $E^s_{s_i}$, can be expressed solely as a function of age:

$$E^s_{s_i} = e^s_i\,(AA_i). \tag{21}$$

This relationship can now be substituted into (18a). Aggregating (18a) over appliances yields:

$$\begin{aligned} TS = \sum_i^M S_i = \sum_i^M s_i(\cdot) = ts(Px, Pn_1, \ldots, Pn_M, \\ AA_1, \ldots, AA_M, I, A_1, \ldots, A_M; H). \end{aligned} \tag{20a}$$

The effect of age, then, includes the effect that appliance age has on the supply price structure as well as its independent effect on demand.

We now turn to the estimation of (19) and (20a) in the section to follow.

The Econometric Model and the Data

A national telephone survey of consumers was taken in 1975 which included questions about service contract ownership on five major appliances: color television sets, room air conditioners, refrigerators, ranges, and clothes washing machines (Prohaska et al. 1978). The data were used to estimate a version of the aggregate model discussed above.

The analysis was restricted to analyzing the behavior of those respondents who at the time of the survey owned at least one appliance of the five studied which they had purchased "new" rather than "used." This was done to exclude respondents dealing in the used appliance market where service contracts typically are not available.

TR_j is defined as the total number of repairs to the five appliances experienced by respondent j over the lives of the appliances up to the survey date. TS_j is specified either as the total number of service contracts ever owned by respondent j on the appliances to date, ETS_j, or the total number of service contracts still owned on the appliances at the survey date, STS_j. Both specifications of TS_j were tried in separate analyses.

The ages of appliances purchased new, AA_{ij}, are proxies for the stocks of the appliances. The demand for repairs can be expected to increase or to remain constant as appliance ages increase because the frequency of repair increases or remains constant with age. The demand for survice contracts is expected to remain constant or to decline with the age of each appliance because the stock declines and because manufacturers increase service contract prices with age or cease to sell them on older appliances (Gerner and Bryant 1976).

The number of new appliances purchased can be expected to increase the demands for both service contracts and repairs and is intertwined with the specification of appliance age. Since the issue is primarily empirical we will not discuss it until the next section.

The absence of general price level information, Px_j, was rectified by using variables on region, Re_j, and city size, CS_j, of the respondent's place of residence. These will capture general differences in prices across regions and by city size and not relative price differences between other prices and appliances. Since there were no questions asked in the survey about Pn_{ij}, use was made of data on respondents' expected costs of repair of each of the five appliances as proxies for Pn_{ij}. These data came from the question, "What would you expect to pay on a hypothetical new appliance of type i if it needed repair?" The response to this question is analogous to Cr_i, which plays a large part of $P^c_{n_i}$. Since the expected cost of repair is to a hypothetical new appliance rather than to the appliance owned by the respondent at the time when its use was determined, it is denoted as C^e_{rij}. It is expected to differ from Cr_{ij} principally because of inflation in repair costs and any change in repair productivity which occurred in the intervening period. Since these forces will have affected all respondents equally (holding appliance age constant), measurement error bias introduced by the use of C^e_{rij} can be expected to affect primarily the constant term and have little impact on slope coefficients.

The survey also included no questions on the prices paid for service contracts. Since F is simply a deduction from total income and consequently its effects on repair and service contract demand contain no substitution effects, the effect of annual family income, I_j, can be adjusted to estimate the effects of Es on repairs and service contract ownership.

Of the information available on the respondent's family characteristics, family size (FS_j), respondent's age in years (RA_j), and whether the respondent was white (WH_j) were considered to be important enough to warrant inclusion. Family size and respondent's age capture important elements of the family's size and life-cycle stage. WH_j captures any taste-related differences between whites and nonwhites in appliance use and thence in repairs and service contract ownership and, perhaps more important, any differential market responses to the two types of people.

Theoretically, the demand for repairs, the demand for service contracts, the price of use, and the prices of service contracts form a system of simultaneous equations (eqq. [12], [13], [19], and [20a]). This is so because (19) and (20a) clearly are simultaneous, and since (12) and (13) can be written as

$$Pn = pn\ (S^*) \tag{12a}$$

$$Es = es\ (S^*), \tag{13a}$$

Pn and Es are simultaneously determined with (19) and (20a). Econometrically we substituted (12a) and (13a) into (19) and used C^e_{rij} in (20a) as proxies for Pn_{ij}. With the other variables included, the econometric specification of (19) and (20a) is:

$$TR_j = r(Re_j, CS_j, TS_j, I_j, FS_j, RA_j, WH_j, AA_{ij}) + u_j \tag{19a}$$

$$TS_j = s(Re_j, CS_j, C^e_{rij}, AA_{ij}, I_j, FS_j, RA_j, WH_j) + v_j, \tag{20b}$$

where u_j and v_j are random disturbance terms (u_j includes the e_{ij}'s implicit in the probabilistic nature of repairs). This specification makes (19a) and (20b) a recursive system in which (20b) can be estimated first after which predicted values of TS_j may be used in (19a). Specified in this fashion, the system allows empirical estimation of the extent of moral hazard.[8]

Since TR_j can take on any positive or zero value, the appropriate estimating technique appears to be ordinary least squares. Not so for equation (20b). TS_j is a variable with a range from zero to 5. Furthermore, TS_j is regarded as an index of the difference in the latent satisfaction gained by the consumer under service contract versus cash regimes for each combination of the five appliances. The difference in the latent utilities under the two regimes is a continuous variable with a very wide range of negative and positive values. Denoting the difference as U^*, then equation (20b) can be regarded as:

$$TS_j = \begin{cases} 5, \text{ if } U^* \geq U_b^* \\ s(\cdot), \text{ if } 0 < U^* < U_b^*, \\ 0, \text{ if } 0 \geq U^* \end{cases} \tag{20c}$$

where 5 is the maximum and zero is the minimum value of TS_j; U_b^* is the minimum level of U^* necessary for five service contracts to be owned; and $s(\cdot)$ is the right-hand side of equation (20b).

Given such an interpretation of TS_j, the appropriate estimating technique is ordered probit (McKelvey and Zovoina 1975) in which the dependent variable takes on integer values from zero through 5 and the probabilities of owning one through five service contracts are computed. Unfortunately, the data set on neither ever nor still owning contracts has sufficient cases of ownership of more than one contract to estimate the full range.[9]

In the face of these difficulties two courses of action were taken. First, probit estimates of (20b) were made utilizing two alternative dichotomous dependent variables, ES_j and SS_j, which took on values of one and zero as families owned (ever or still, respectively) or did not own at least one service contract. Second, ordered probit estimates were made utilizing two alternative trichotomous dependent variables, OES_j and OSS_j, which took on values of two, one, and zero as families

8. The recursive empirical system is only a response to data deficiencies. Other responses are possible, each using less information than the alternative chosen and each yielding less information as a result. For instance, the Pn_i could have been replaced by $C_{r_j}^e$ in both (19a) and (20a) and equations (12a) and (13a) not used. This would have made it impossible to examine empirically the link between service contract demand and the demand for repairs. Or, equations (12a) and (13a) could have been substituted in both (19a) and (20a), making it impossible to examine empirically the link between service contract demand and expected repair costs. By utilizing both the information about expected repair costs and eqq. (12a) and (13a), the alternative chosen allows some empirical light to be shed on both questions.

9. Only 12% of the sample ever owned more than one service contract, and 4% still owned more than one at the time of the survey. Twenty-nine percent ever owned at least one and 16% still owned at least one.

owned (ever or still, respectively) more than one, one, or no service contracts.

It is also possible independently to estimate (21), the supply price structure of service contracts. This can be done using the published age-specific supply price schedules for the population of service contract vendors for each of the five appliances.

The Empirical Analysis

The results of the analyses and certain calculations based on them are contained in tables 1 through 3.[10] The probit and ordered probit equations of ever owning and still owning service contracts are presented and discussed first with the discussion of the OLS estimates of the demand for repairs equation following.

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Columns 1 and 3 of tables 1 and 2 contain the probit and ordered probit estimates of the probability of ever owning, ES_j, and still owning, SS_j, at least one or more than one service contract on the five appliances, respectively. The pseudo R^2's range from .09 to .13 and the χ^2 tests that the variables account for none of the variance in the dependent variables must be rejected. Both the probit and ordered probit estimates can be regarded as estimates of the consumer demand for service contracts.

While individually none of the coefficients on the expected cost of repair variables is significantly different from zero, as a group these variables do contribute significantly. A priori, the coefficients on these variables could be positive or negative since they are the sums of own- and cross-price effects, and were expected to be quite small and probably not different from zero. These expectations were confirmed.[11]

10. The supply price schedules, $E^s_{s_i} = m_0 + m_1 AA_i$, i.e., eq. (21), are:

$E^w_s = 30.28 + 4.42AA$	clothes washing machines
$E^{ac}_s = 28.70 + 2.43AA$	room air conditioners
$E^r_s = 26.51 + 2.60AA$	refrigerators
$E^{st}_s = 21.81 + 2.02AA$	stoves
$E^{tv}_s = 64.84 + 47.35AA$	television sets.

Since these are computed on the population of service contract supply price schedules, no statistics are computed.

11. Theoretically, the effect of an increment in Cr_i on S_i *is*, from (17):

$$\partial S_i/\partial Cr_i = (\partial S_i/\partial Pn_i)(\partial Pn_i/\partial Cr_i) \quad (22)$$

$$\partial S_i/\partial Cr_i = \begin{cases} 0, \text{ if } S_i^* > 0 \\ (\partial S_i/\partial Pn_i)\alpha_i, \text{ if } S_i^* \leq 0. \end{cases} \quad (23)$$

The effect of Cr_i on TS_i is, from (20):

$$\partial TS_j/\partial Cr_i = (\Sigma_k \partial S_k/\partial Pn_i)(\partial Pn_i/\partial Cr_i) \quad (i, k = 1, \ldots, 5). \quad (24)$$

Family income has a small positive effect on the probabilities of ever and of still owning service contracts: the higher the family income, the greater the demand for appliance service contracts.[12] In part, the income effect may be a reflection of a positive cross-price effect with respect to the price of time: the higher the price of time, the more onerous the job of finding service or performing the job oneself and the greater the demand for service contracts.

Since the effect of the price of any service contract is simply the negative of the income effect, the higher the price of any service contract, the lower the demand for service contracts. These effects are as expected: appliance service contracts must be judged as normal goods and as gross complements of each other.

The ages of appliances and the number of appliances are interrelated. The AA_{ij} take on values of zero if respondent j does not possess appliance i purchased new. Otherwise they take on values equal to the ages in years of the appliances. The variable N_j has a range of 1–5 and indexes the number of appliances possessed by household j. Furthermore, the effect of the age variables is confounded with the effect of the supply price of service contracts. Of the coefficients on the appliance age variables, all but those on television age in the ever owned equations are negative, with those on ranges and air conditioners appearing to be most significant. If the effect of price of the service contract is the negative of the income effect, as asserted above, and since the supply price effect is positive in all cases, then the pure age effect is positive for television sets and negative or small for the remaining appliances.

As expected, the greater the number of new appliances purchased, the greater the demand for service contracts. This is one of the two most powerful shifters of the demand for service contracts. The number of appliances appears to affect the probability of still owning more than the probability of ever owning service contracts. This suggests that the number of new appliances purchased affects the length of service contract ownership.

Of the three family characteristics included in the demand equation, whether the family is white affects the demand most, with nonwhites having a much greater demand for service contracts than whites.

Thus, the effect of CR_i on TS_j is the sum of the own-price and cross-price effects on S_k, each multiplied by α_i or zero depending on whether a service contract is owned. Since there is no reason to suppose the cross-price elasticities of demand for use are any greater than the own-price elasticity, it is clear that the coefficients on the Cr_i's in (20) can be expected to be positive and very close to zero. Given the measurement errors introduced by using $C^e_{r_i}$'s as proxies for Cr_i's in (20b), it may be unrealistic to expect the estimated coefficients on the $C^e_{r_i}$'s to be statistically different from zero.

12. The positive income effect could also be a reflection of a positive income elasticity of demand for major appliances. It is more likely that the inclusion of number of appliances removes any such influence.

TABLE 1 Results of Analyses of Probability of Ever Owning at Least One Service Contract; Probability of Ever Owning 0, 1, or More than One Service Contract; and Regression Analysis of Numbers of Repairs on Appliances Purchased "New"

Variables	Ever Owned Service Contract (Probit)	Number of Repairs (OLS)	Number of Service Contracts Ever Owned (Ordered Probit)	Number of Repairs (OLS)
Expected cost of repairs on:				
Televisions	.00073	. . .	.00261	. . .
	(.00337)		(.00323)	
Air conditioners	−.00433	. . .	−.00430	. . .
	(.00520)		(.00542)	
Ranges	.00113	. . .	−.00104	. . .
	(.00548)		(.00533)	
Refrigerators	.00108	. . .	.00133	. . .
	(.00420)		(.00402)	
Washing machines	.00010	. . .	−.00087	. . .
	(.00533)		(.00520)	
Number of appliances:	.19590***	. . .	.22074***	. . .
	(.06924)		(.06637)	
Age of appliances				
Televisions	.02732*	.43490***	.01933	.46700***
	(.01853)	(.09202)	(.01779)	(.08621)
Air conditioners	−.02982*	−.03183	−.02453	−.05271
	(.02217)	(.08647)	(.02108)	(.08623)
Ranges	−.02016**	.07606*	−.02464**	.07783*
	(.01239)	(.05214)	(.01193)	(.05284)
Refrigerators	−.00570	.02946	−.00311	.02319
	(.01286)	(.05253)	(.01241)	(.05292)
Washing machines	−.00407	.06290	.00028	.07480
	(.01631)	(.07248)	(.01563)	(.07122)
Respondent's age[a]	−.00634*	2.09226**	−.00551	1.92561**
	(.00494)	(.92936)	(.00473)	(.91421)
If white	−.59490***	2.06360*	−.56066***	1.69411*
	(.20966)	(1.31286)	(.19679)	(1.24317)

Family size[a]	.05735	1.34623**	.06526*	1.39687*
	(.04478)	(.72032)	(.04282)	(.72056)
Family income[a]	.01321*	−.69494	.00951	−.51881
	(.00814)	(.55727)	(.00763)	(.52495)
Estimated probit or ordered probit index	. . .	2.57822**	. . .	2.09137**
		(1.25269)		(1.10171)
Place size:				
Rural area	. . .	−.75361	. . .	−.72974
		(.90269)		(.90336)
Small town	. . .	−1.17302	. . .	−1.12101
		(.95459)		(.95426)
Town	. . .	−.80292	. . .	−.76727
		(.86871)		(.86870)
Small city	. . .	.33742	. . .	.37278
		(.79353)		(.79408)
Constant	−.68185	−6.33671	−.74293	−6.31140
Threshold for one	. . .	. . .	.0	. . .
Threshold for more than one	. . .	. . .	.65977**	. . .
West	. . .	. . .	(.06502)	. . .
χ^2 or F	35.5127***	6.34139***	38.4370***	6.28495***
$\bar{R}^2$ or pseudo R^2	.0965	.17646	.13468	.17492
Number of observations	508	350	508	350

[a]Natural logarithm of variable used in repairs equation.
*Significant at .10.
** Significant at .05.
*** Significant at .01.

TABLE 2 Results of Analyses of Probability of Still Owning at Least One Service Contract; Probability of Still Owning 0, 1, or More Service Contracts; and Regression Analysis of Number of Repairs on Appliances Purchased "New"

Variables	Still Own Service Contract (Probit)	Number of Repairs (OLS)	Number of Service Contracts Still Owned (Ordered Probit)	Number of Repairs (OLS)
Expected cost of repair on:				
Television	.00324	. . .	.00353	. . .
	(.00369)		(.00360)	
Air Conditioner	−.00609	. . .	−.00459	. . .
	(.00591)		(.00604)	
Range	.00336	. . .	−.00246	. . .
	(.00624)		(.00612)	
Refrigerator	−.00476	. . .	−.00360	. . .
	(.00540)		(.00519)	
Washing machine	.00492	. . .	.00258	. . .
	(.00551)		(.00548)	
Number of appliances	.25145***	. . .	.26665***	. . .
	(.07962)		(.07765)	
Age of appliances:				
Television	−.00774	.51263***	−.00948	.51592***
	(.02182)	(.08011)	(.02144)	(.07975)
Air conditioner	−.02453	−.05784	−.01824	−.07405
	(.02518)	(.08647)	(.02422)	(.08738)
Range	−.01692	.05675	−.02320**	.06755*
	(.01405)	(.05053)	(.01406)	(.05148)
Refrigerator	−.01323	.04257	−.01497	.04552
	(.01532)	(.05269)	(.01520)	(.05277)
Washing machine	−.00285	.08378	−.00361	.08162
	(.01921)	(.07048)	(.01884)	(.07044)
Respondent's age[a]	−.00822*	1.99826**	−.00674	1.91752**
	(.00573)	(.93009)	(.00558)	(.91497)
If white	−58933***	1.59280*	−.53298**	1.54696
	(.22669)	(1.24823)	(.21942)	(1.21539)

Family size[a]	.01078	1.76988**	.02734	1.65696***
	(.05157)	(.66386)	(.05006)	(.67539)
Family income[a]	.01382*	−.56067	.01451**	−.01845
	(.00911)	(.54826)	(.00810)	(.55479)
Estimated probit or ordered probit index	. . .	1.82141**	. . .	1.92212**
		(1.06368)		(1.04815)
Place size:				
Rural area	. . .	−.74746	. . .	−.74941
		(.90444)		(.90386)
Small town	. . .	−1.16085	. . .	−1.15962
		(.95682)		(.95584)
Town	. . .	−.85079	. . .	−.85329
		(.87391)		(.87280)
Small city	. . .	.33684	. . .	.34917
		(.79515)		(.79447)
Constant	−.80982	−6.28676	−1.03521	−5.61997
Threshold for one	. . .	. . .	.0	. . .
Threshold for more than one	. . .	. . .	.81083***	. . .
West	. . .	. . .	(.09684)	. . .
χ^2 or F	27.6159***	6.22506***	30.8007***	5.25349***
R^2 or pseudo R^2	.08975	.17328	.13412	.17433
Number of observations	508	350	508	350

[a] Natural logarithm of variable used in repairs equation.
*Significant at .10.
**Significant at .05.
***Significant at .01.

Whether this large difference emanates from the demand or the supply side of the market is unknown. It appears that the demand for service contracts is more a characteristic of the young than of the old, although the effect is weak. Since each of the appliance age variables is positively correlated with respondent's age, however, such an effect is not surprising. Independent of this link with appliance age, older respondents would be likely on average to have more liquid assets than young people and thus would be in a better position to engage in self-insurance. Older people may also be more willing or able to perform the repairs themselves and thus demand fewer service contracts than the young.

Family size seems to have more of an effect on the demand for ever than still owning appliance service contracts. The effect of size is weak, however, and contrary to expectations. Since the demand for appliance use—at least for televisions (Gerner and Bryant 1980)—is strongly affected by family size, it was expected that family size would also be an important shifter of the demand for service contracts. But intercorrelation between number of new appliances purchased and family size may be obscuring this effect.

The Demand for Repairs

Columns 2 and 4 of tables 1 and 2 show the OLS estimates of the demand for repairs on the five appliances studied. The two versions of the estimates in each table differ only in that probit estimates of TS_j were used in column 2 and ordered probit estimates of TS_j were used in column 4.

The theory underlying this paper requires a positive coefficient of the index of the demand for service contracts in the repairs equation. In all equations the coefficient of the probit index of service contract ownership is positive and significant at the .05 level. At the point of means, the elasticities of demand for repairs with respect to the indices of service contract demand are .52 based on the ever-owned-at-least-one-contract index and .50 based on the still-owned index.[13]

The effect of the demand for service contracts on the demand for repairs is the "moral hazard" effect that is caused by the zero marginal out-of-pocket costs of repair as a result of owning a service contract. Our estimates of the moral hazard effect are biased because, while the empirical estimates are based on a recursive system, the theoretical system is simultaneous.

Family income appears to have a negative, though insignificant, effect on the incidence of appliance repairs. This could arise for a

13. The analogous elasticities of demand for repairs with respect to the ordered probit indices are .40 and .62 based on the ever owned and still owned ordered probit equations in tables 1 and 2, respectively.

number of reasons, among them that high-income families may buy higher-quality appliances and, because of higher time costs, use them less frequently than low-income families. Because city size and region were used to proxy price, income measures effects of both real and nominal income changed.

We used the same alternative ways of specifying the presence and ages of appliances purchased new that we tried in the service contract demand equation. N_j was positively correlated with the probit indices of service contract demand, as could be expected given the important role N_j plays in the determination of service contract demand. Since the AA_{ij} variables do index the presence of appliances purchased new as well as their ages, N_j was deleted from the repairs equation. Televisions and ranges contribute significantly to total appliance repairs as they age: televisions by a large amount—between .44 and .50 repairs per year of age—and ranges by a small amount. It was expected that washing machine age would contribute importantly to total repair demand since they appear to be second to televisions in frequency of repairs.[14]

All three of the family characteristics variables have statistically significant effects on total repair demand. The demand for appliance repairs increases with both respondent's age and family size and is higher for white than for nonwhite families.

In contrast to the demand for service contracts, the demand for repairs on the five appliances differs somewhat by the size of the respondent's place of residence. Relative to respondents in cities, residents of towns and rural areas appear to have slightly lower demands. This could be because residents of rural areas and small towns are more likely to do their own repairs. While none of the coefficients of this set of variables individually was significantly different from zero, as a group they augmented R^2 sufficiently to justify their inclusion in the final equation. Both region and city size variables were eliminated from the service contract equations because their contributions were slight and their theoretical justification weak.

Interpretation and Concluding Remarks

Two interpretations of the service contract results are possible. One is to interpret the probit and ordered probit equations in the probability sense—as equations for the probabilities of ever/still owning service contracts on the five appliances studied. Under this interpretation, elasticities of demand for service contracts may be computed from the

14. Average frequencies of repair on ever owned appliances as estimated from the national survey are: televisions, .63; washing machines, .48; refrigerators, .27; and air conditioners, .17 (Prohaska et al. 1978).

effects of the exogenous variables on the probability of ever/still owning service contracts. The elasticities from the probit equations must refer to the probabilities of ever and still owning at least one service contract. Since the modal family owns (ever or still) no service contract, the elasticities from the ordered probit equations refer to probabilities of ever and still owning exactly one service contract.

Another interpretation springs from equation (20c). Here the probit indices predicted by the probit and ordered probit equations are taken as measures of the difference in the latent satisfaction gained by the consumer under service contract versus cash regimes for the various combinations of the five appliances (i.e., as U^* in eq. [20c]). Under the interpretation, the probit and ordered probit equations themselves are estimates of the demand function for service contracts. Thus, elasticities of demand for service contracts (as distinct from at least one service contract) may be computed from the probit coefficients on the exogenous variables.

Both interpretations are taken for purposes of comparison. Of the possible elasticities, three are computed: the income elasticity, the own-price elasticity, and the elasticity with respect to the number of appliances owned which were purchased new. The own-price elasticities are derived from the income coefficients (recall that their effects are the negative of the income effects) evaluated at an annual service contract price of $30 (Gerner and Bryant 1976).

The estimates of the elasticities are shown in table 3. Since the

TABLE 3 **Elasticities of Demand for Service Contracts, at Least One Service Contract, and Exactly One Service Contract**

Elasticity	Demand for at Least One Service Contract (1)	Demand for Exactly One Service Contract (2)	Demand for Service Contracts: Probit (3)	Demand for Service Contracts: Ordered Probit (4)
Income:				
η^e	.39	.41	.28	.21
η^s	.69	1.39	.21	.19
Own price:				
ϵ_p^e	−.0008	−.0009	−.0006	−.0004
ϵ_p^s	−.0013	−.0029	−.0004	−.0004
Number of appliances:				
$\epsilon_{no.}^e$	1.24	2.05	.88	1.05
$\epsilon_{no.}^s$	2.68	5.48	.83	.75

SOURCES.—Estimates in cols. (1) and (3) are derived from probit equations in tables 1 and 2. Estimates in cols. (2) and (4) are derived from ordered probit equations in tables 1 and 2.

NOTE.—Superscripts *e* and *s* refer to ever owned and still owned equations, respectively.

predicted probability of ever owning contracts is much larger than for still owning them, the elasticities based on ever owning are smaller. Similarly, since the probability of owning exactly one contract is lower than the probability of owning at least one contract, the elasticities, based on the latter, are smaller.

Regardless of the method of computation or the interpretation taken, the demand for service contracts is income inelastic and extremely own-price inelastic. The demand for service contracts is elastic with respect to the number of appliances owned if the equations are interpreted in a probabilistic sense and about unitary elastic if the equations are interpreted as demand functions. In either case, the elasticity with respect to number of appliances is much higher than the analogous price and income elasticities. This finding seems reasonable, given that the probability of repairs can be expected to increase more with an increase in the number of appliances owned than with an increase in income.

Perhaps the most interesting finding is the presence of moral hazard in the appliance repairs market due to service contracts. The ownership of appliance service contracts increases the demand for appliance repairs, the elasticity of the demand for repairs with respect to service contract ownership being in the neighborhood of .55.

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