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**The Impact of Credit Constraints on Housing Demand: Assessed with  
Endogenous Price and Expenditure**

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# **The Impact of Credit Constraints on Housing Demand: Assessed with Endogenous Price and Expenditure**

## **1. Introduction**

During 2002 to early 2007, the low federal interest rate and increasing popularity of securities backed by subprime mortgage convinced lenders to lower their credit standards and extend loans to many borrowers with low down-payments and poor credit histories. As a result, housing demand got larger, so did the housing bubble. However, those subprime borrowers started to have difficulties paying off their mortgage when the rates for their ARMs rose with the increasing treasury interest rates. The home loan default rates went up and housing bubble burst.

After the credit boom and housing bubble, house price collapsed in 2007, and millions of American households are underwater on their mortgage. Because house is the largest single asset for most people, the contraction in housing wealth inevitably has a significant impact on consumer demand and on the aggregate economy. The recovery of the whole housing market seems to be tied to the recovery of the general economy, so enormous government stimulation, low interest rate, tax credit and other forms of modification of loans are put into practice to get housing market back on track.

The housing market may be on its way to recovery, but lenders learned their lessons in the subprime mortgage crisis and no longer make home mortgage loan easy to borrowers. According to the Federal Reserve's April survey of senior officers, those officers are not loosening up their tight credit requirements while their banks are seeing stronger demand for home loans. The question we want to answer in this paper is how credit constraints affect housing demand.

With the aim of assessing the impact of credit constraints on housing demand with price and expenditure treated as endogenous variables. This essay distinguishes itself from previous papers in two aspects. First, it uses almost ideal demand system (AIDS) to estimate housing demand with loan-to-value (LTV) on the right hand side as an exogenous variable. By doing this, we not only estimate income, own-price and cross price elasticities, we also estimate the sensitivity of housing demand to the changes in the tightness of credit constraints. Second, with the concern about price and expenditure endogeneities, this essay explicitly specifies price and expenditure equations and jointly estimates both the AIDS model.

The remainder of this paper is organized as follows. Section 2 provides a literature review. Section 3 introduces and illustrates the AIDS model and endogenous test for prices and expenditures. Section 4 discusses the data. Section 5 present and discuss the empirical results. Section 6 concludes the paper and discusses the limitations of the employed models.

## **2. Literature review**

Mayo (1980) summarizes papers published before 1980 and reviews the theoretical and empirical developments in the economics of housing demand. Double log model is found to be employed most, with the hypothesis that a single elasticity of demand suffices for everyone. However, this model conceals variation in responses to price and income which is not uniform across prices, income, or demographic groups, so alternative functional forms should be considered. Deaton and Muellbauer (1980) propose AIDS model, which gives an arbitrary first-order approximation to any demand system. AIDS

model has many desirable properties, such as satisfying the axiom of choice exactly, aggregating perfectly over consumers, being easy simple to estimate, and can be used to test the restrictions of homogeneity and symmetry. No other demand systems possess all of these properties simultaneously.

There are many literatures study housing demand over the last two decades, but not many papers examine the interaction between housing demand and credit constraints until recent years. Here, we only review the papers which aim to sort out such interaction. Ortalo-Magne and Rady (2005) propose a life-cycle model to replicate the facts that credit constraints delay some households' first home purchase and force other households to buy a home smaller than they would like. Landvoigt (2010) discusses the role that expectations and credit constraint played in shaping household behavior during the boom by inferring short-run expectations of future house price growth and minimum down payment requirements from observed household choice. These two papers use simulation technique to replicate households' behaviors and to derive the model-implied values of the variables of interest. In their models, no default or delinquency risk is considered, thus the implied effect of credit constraints is biased.

Instead of examining the behavior of individual household, this essay discusses the effect of credit constraints from an aggregate perspective using AIDS model which has not been used before in housing market analysis. Moreover, econometric method is employed with the demand theory to overcome endogeneity problem and derive unbiased estimates. The model specification is discussed next.

### **3. Model**

A price endogeneity problem can arise in the estimation of aggregate demand functions when the price determination process involves significant interplay of supply and demand, and expenditure endogeneity issues may arise whenever the household expenditure allocation process across products or product groups is correlated with the demand behavior of the products being analyzed (Dhar, Chavas and Gould, 2003). For housing market, we question the validity of price and expenditure exogeneity assumptions and concern about the biasedness of estimates under such assumptions. Thus, at the same time we estimate housing demand based on demand theory, we estimate the reduced form equations for prices and expenditure to account for the potential endogeneity.

### 3.1 AIDS Demand Specification

The specification of AIDS model follows the work of Deaton and Muelbauer (1980), which can be written as:

$$w_i = \alpha_i + \sum_{j=1}^n \gamma_{ij} \log p_j + \beta_i \log(x / P) \quad (1)$$

where  $p = (p_1, \dots, p_n)$  is a  $(n \times 1)$  vector of CPIs for industries examines here,  $x$  denotes expenditure on the  $n$  goods,  $w_i = p_i q_i / x$  is the budget share for the  $i^{\text{th}}$  good, and  $P$  is a price index defined by:

$$\log P = \delta + \sum_{k=1}^n \alpha_k \log p_k + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \gamma_{kj} \log p_k \log p_j \quad (2)$$

The above AIDS specification can be extended to incorporate the effects of demographic characteristics and credit constraint. Let LTV be a proxy for credit constraint. Then, the AIDS specification (1) becomes

$$w_i = \alpha_{0i} + \mu_i LTV + \sum_{j=1}^n \gamma_{ij} \log p_j + \beta_i \log(x / P) \quad (3)$$

where  $\mu_i$  captures the effect of credit constraint on the budget share of the  $i^{\text{th}}$  good for the group.

The theoretical restrictions are composed of symmetry restrictions:

$$\gamma_{ij} = \gamma_{ji} \quad \text{for all } i \neq j \quad (4a)$$

and homogeneity restrictions:

$$\sum_{i=1}^n \alpha_{0i} = 1, \quad \sum_{i=1}^n \lambda_{ik} = 0 \quad \forall k, \quad \sum_{i=1}^n \gamma_{ij} = 0 \quad \forall j, \quad \sum_{j=1}^n \gamma_{ij} = 0 \quad \forall i, \quad \sum_{i=1}^n \beta_i = 0 \quad (4b)$$

The parameter  $\delta$  can be difficult to estimate and is often set to some predetermined value (Deaton and Muellbauer, 1980), so we set  $\delta = 0$  in this essay. Also, in the analysis, we use Stone's price index to approximate  $\log P$ , i.e.,

$$\log P \propto \sum_{i=1}^n w_i \log P_i \quad (5)$$

### 3.2 Test for Price and Expenditure Endogeneity

Follow Dhar, Chavas and Gould (2003), the approach we used to control for price and /or expenditure endogeneity involves the specification of reduced form expenditure equation and price equations to capture the supply side of the price information mechanism. The price equation for the  $i^{\text{th}}$  industry is

$$p_i = f(\text{supply/ demand shifters}) \quad (6)$$

where supply and demand shifter should be exogenous to the price formation mechanism. We specify the price function in (6) with market characteristics as explanatory variables as:

$$p_i = \theta_{i0} + \theta_{i1}MS_i + \theta_{i2}CR_i + \theta_{i3}pop \quad (7)$$

where  $MS_i$  is the market size of the  $i^{th}$  industry,  $CR_i$  measures the market concentration ratio of the  $i^{th}$  industry and  $pop$  represents population.

The expenditure equation is a function of median household income and a time trend:

$$x = f(time\ trend, income) = \eta_0 t + \eta_1 Inc + \eta_2 Inc^2 \quad (8)$$

where the exponential term of income captures the assumed nonlinear impact of income on expenditure. Given these reduced form specifications for price and expenditure, equation (3), (7) and (8) are estimated simultaneously using a nonlinear full information maximum likelihood (FIML) procedure. FIML is recommended by Dhar, Chavas and Gould (2003). They state the major advantage of using FIML is that the asymptotic efficiency does not depend on the choice of instruments. Also, simultaneous equation bias issue occurs when there is covariance in the error terms, but FIML gives consistent parameter estimates by taking into account the effects of these covariances.

Price and expenditure endogeneities are tested using a test developed by Durbin, Wu and Hausman (DWH test). The test is based on the difference between parameter estimates with and without controlling for potential endogeneity. The null hypothesis is that parameters estimated without controlling for endogeneity are consistent. The DWH test statistic is specified as

$$H = (\Phi_{NC} - \Phi_{FIML})(\text{var}(\Phi_{NC}) - \text{var}(\Phi_{FIML}))^{-1}(\Phi_{NC} - \Phi_{FIML}) \quad (9)$$

where  $\Phi_{NC}$  is the vector of estimated parameters without controlling for endogeneity and  $\Phi_{FIML}$  is the vector of consistent parameter estimates from FIML model. Under the null hypothesis,  $H$  is asymptotically distributed as  $\chi^2(r)$ , where  $r$  is the number of potentially endogenous variables.

#### **4. Data**

The national housing demand of U.S. from 1973-2009 are examined. The consumption of housing good and housing price data are obtained from the American Housing Survey (AHS) report. AHS is conducted annually from 1973 to 1983 and every two years after 1983, which gives 24 pairs of observations in total. Six industries other than housing market are included in the analysis, which are food, clothing, gasoline, health, transportation and recreation. The price index and expenditure data for the six groups of goods are obtained from the Panel Survey on Income Dynamics. Following Huang and Haidacher (1983), the quantity index for each industry is calculated from expenditure for the industry dividing by the price index of the industry. Data for household median income, market size and market concentration ratio are obtained from U.S. Census Bureau website.

#### **5. Results**

Our base nonlinear AIDS model without controlling for endogeneity consists of six budget share equations (3) for the seven industries. One equation is dropped due to the adding up constraints of the AIDS specification. The model specification that controls for

only price endogeneity is based on the same six budget share equations and seven price equations (7). Similarly the model that only controls for expenditure endogeneity has six budget share equation and one expenditure equation (8). Finally, the model specification controlling for both price and expenditure endogeneities has 14 equations: six budget share equations, seven price equations and one expenditure equation. The parameters estimated with and without controlling for endogeneity are reported in table 1 and 2 respectively. The main results are discussed next.

From table 1, we can find that loan-to-value has negative impacts on the budget shares of health, housing and recreation, and has positive impacts on those of clothing, food, gasoline and transportation. This suggests that, when households face a tightened up loan policy, they will lower their relative spending on housing and other seemingly luxury activities or products and increase their relative spending on necessary activities and products, such as food, clothing and transportation. Moreover, the impacts of loan-to-value on the budget share of clothing, food and health are significant at 5% significance level, while its impacts on the budget share of gasoline, housing, recreation and transportation are not significant. Compared to the numbers in table 1, the estimated parameters of LTV in table 2 are much smaller and only less significant. Thus, the model without controlling for price and expenditure endogeneities tends to underestimate the impact of credit constraint on the budget shares of all the products.

Table 3 and 4 present the income, own and cross price elasticities before and after controlling for price and expenditure endogeneities, and several interesting findings can be obtained. First, the own-price elasticities for all the products except for health and recreation have negative signs, which suggests that they are normal goods and

households have less consumption of them when their prices increase. Second, based on the signs of cross-price elasticities, some products are substitutes for each other and some are complements. Third, with an increase of one percent point in loan-to-value ratio, the consumption on clothing, food, gasoline and transportation increases by around 1.5, 0.45, 0.61 and 3.58 units respectively. At the same time, the consumption in health housing and recreation products declines by around 1.5, 0.33 and 1.5 units respectively. This is consistent with the findings in table 1 that households will lower their spending on housing and other seemingly luxury activities or products when facing a tightened credit standard, and increase their relative spending on necessary activities and products, such as food, clothing and transportation. Fourth, the elasticities calculated from model without controlling for endogeneity are much less than those from model with such control. In addition, the elasticities are less significant as well from a model with no endogeneity control.

## **6. Conclusion**

This paper investigates the impact of credit constraints on U.S. housing demand with price and expenditure treated as endogenous variables. It has two contributions. First, it uses AIDS model to estimate housing demand with LTV as an exogenous variable. By doing this, the sensitivity of housing demand to the changes in the tightness of credit constraints is estimated. Second, it treats price and expenditure as endogenous variables and estimates them jointly with the AIDS model. With the data from 1973 to 2009, we estimate AIDS model with and without controlling for price and expenditure endogeneity.

Both estimated parameters and calculated elasticities are reported. Among the findings from our estimation, two of them are very interesting.

First, with a tighter the credit constraint, households spend less on housing, recreation and other seemingly luxury activities and products. At same time, they increase their consumptions on necessary activities and products, such as food, clothing and transportation. Second, the model without controlling for price and expenditure endogeneities tends to underestimate the impact of credit constraint on the budget shares of all the products, and the estimates are less significant.

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Table 1. Parameters estimated with controlling for price and expenditure endogeneities.

Industry	$a_i$	$b_i$ (LTV)	$b_i$ (Expd)	$c_{i1}$	$c_{i2}$	$c_{i3}$	$c_{i4}$	$c_{i5}$	$c_{i6}$	$c_{i7}$
Clothing	-0.1836 (0.4330)	0.1488 (0.0060)*	-0.0787 (0.0000)*	0.0003 (0.9750)	-0.0146 (0.0330)*	-0.0239 (0.0000)*	-0.0551 (0.0000)*	0.0326 (0.0000)*	-0.0199 (0.0120)*	0.0806 (0.0000)*
Food	0.9003 (0.0000)*	0.0983 (0.0460)*	-0.2365 (0.0000)*	-0.0146 (0.0330)*	0.0643 (0.0020)*	-0.0148 (0.0070)*	-0.0551 (0.0000)*	0.0326 (0.0000)*	-0.0199 (0.0120)*	0.0076 (0.7680)
Gasoline	0.5351 (0.0900)	0.0455 (0.5410)	-0.1324 (0.0000)*	-0.0239 (0.0000)*	-0.0148 (0.0070)*	0.0469 (0.0000)*	-0.0107 (0.2210)	0.0326 (0.0000)*	-0.0199 (0.0120)*	-0.0101 (0.4650)
Health	2.0363 (0.0000)*	-0.3565 (0.0010)*	-0.0392 (0.1930)	-0.0551 (0.0000)*	-0.0571 (0.2290)	-0.0107 (0.2210)	0.2383 (0.0000)*	-0.1075 (0.0000)*	0.0454 (0.0010)*	-0.0534 (0.2340)
Housing	-1.1126 (0.0330)*	-0.0796 (0.5020)	0.3483 (0.0000)*	0.0326 (0.0000)*	0.0940 (0.1980)	0.0134 (0.3890)	-0.1075 (0.0000)*	0.0193 (0.4020)	-0.0917 (0.0000)*	0.0398 (0.5360)
Recreation	0.2314 (0.4070)	-0.0899 (0.1510)	0.0468 (0.0150)*	-0.0199 (0.0120)*	0.0033 (0.9410)	0.0043 (0.5670)	0.0454 (0.0010)*	-0.0917 (0.0000)*	0.1147 (0.0000)*	-0.0561 (0.0760)
Transportation		0.2335 (0.1350)	0.0917 (0.0820)	0.0806 (0.0000)*	0.0076 (0.7680)	-0.0101 (0.4650)	-0.0534 (0.2340)	0.0398 (0.5360)	-0.0561 (0.0760)	-0.0085 (0.9220)

Note: ‘\*’ indicates the number is statistically significant at 5% significance level.

Table 2. Parameters estimated without controlling for price and expenditure endogeneities.

Industry	$a_i$	$b_i$ (LTV)	$b_i$ (Expd)	$c_{i1}$	$c_{i2}$	$c_{i3}$	$c_{i4}$	$c_{i5}$	$c_{i6}$	$c_{i7}$
Clothing	0.4567 (0.1560)	0.0055 (0.8810)	-0.0536 (0.0030)*	0.0114 (0.7650)	-0.0576 (0.2140)	-0.0119 (0.1230)	0.0154 (0.7510)	-0.0021 (0.8310)	-0.0069 (0.9320)	0.0205 (0.5400)
Food	1.0676 (0.0010)*	0.0001 (0.9970)	-0.1760 (0.0000)*	-0.0071 (0.8230)	-0.0338 (0.3680)	-0.0083 (0.1860)	-0.0765 (0.0740)	-0.0191 (0.0300)*	0.1062 (0.1270)	0.0292 (0.2970)
Gasoline	0.0578 (0.7320)	-0.0022 (0.9150)	-0.0155 (0.0740)	0.0264 (0.2220)	-0.0102 (0.6790)	0.0592 (0.0000)*	-0.0415 (0.1360)	-0.0247 (0.0000)*	0.0650 (0.1580)	-0.0529 (0.0120)*
Health	0.9069 (0.1880)	-0.0725 (0.3700)	-0.1964 (0.0000)*	-0.0312 (0.7060)	0.0023 (0.9810)	-0.0338 (0.0490)*	0.0786 (0.4570)	-0.0084 (0.6850)	0.0882 (0.6130)	0.0524 (0.4700)
Housing	-0.8296 (0.1440)	-0.0077 (0.9050)	0.4312 (0.0000)*	-0.0297 (0.6600)	0.1310 (0.1160)	0.0129 (0.3260)	0.0765 (0.3770)	0.1117 (0.0000)*	-0.5000 (0.0040)*	-0.0217 (0.7120)
Recreation	-0.1213 (0.2160)	0.0311 (0.0160)*	-0.0187 (0.0010)*	-0.0056 (0.6340)	-0.0046 (0.7410)	-0.0075 (0.0050)*	0.0055 (0.7140)	-0.0196 (0.0000)*	0.0828 (0.0050)*	-0.0174 (0.1090)
Transportation	-0.5381 (0.0500)*	0.0457 (0.1490)	0.0290 (0.0310)*	0.0357 (0.2670)	-0.0271 (0.4670)	-0.0107 (0.0930)	-0.0580 (0.1610)	-0.0378 (0.0000)*	0.1647 (0.0250)*	-0.0101 (0.7110)

Note: ‘\*’ indicates the number is statistically significant at 5% significance level.

Table 3. Elasticity matrix after controlling for price and expenditure endogeneities.

Industry	LTV elas.	Income elas.( $\varepsilon_i$ )	Own and Cross price elasticities ( $\varepsilon_{ij}$ )						
Clothing	1.4690 (0.0060)*	-0.7772 (0.0000)*	-0.9187 (0.0000)*	0.0236 (0.7300)	-0.1780 (0.0000)*	-0.3569 (0.0000)*	0.5101 (0.0000)*	-0.1497 (0.0470)*	0.8467 (0.0000)*
Food	0.4548 (0.0460)*	-1.0943 (0.0000)*	0.0432 (0.1160)	-0.4661 (0.0000)*	0.0132 (0.6050)	0.0079 (0.8560)	0.4162 (0.0000)*	-0.0264 (0.4670)	0.1063 (0.3800)
Gasoline	0.6077 (0.5410)	-1.7690 (0.0000)*	-0.1404 (0.0110)*	0.1839 (0.0050)*	-0.2415 (0.0160)*	0.2817 (0.0620)	0.8645 (0.0000)*	-0.1596 (0.1330)	-0.0195 (0.9160)
Health	-1.4853 (0.0010)*	-0.1634 (0.1930)	-0.2128 (0.0000)*	-0.2026 (0.2730)	-0.0323 (0.3730)	0.0320 (0.7130)	-0.4080 (0.0000)*	0.1989 (0.0010)*	-0.2118 (0.2640)
Housing	-0.3285 (0.5020)	1.4364 (0.0000)*	-0.0111 (0.6380)	0.0773 (0.7780)	-0.0521 (0.4380)	-0.7879 (0.0000)*	-1.2686 (0.0000)*	-0.4645 (0.0000)*	0.0705 (0.7950)
Recreation	-1.4986 (0.1510)	0.7805 (0.0150)*	-0.4105 (0.0020)*	-0.1135 (0.8760)	0.0125 (0.9210)	0.5694 (0.0270)*	-1.7182 (0.0000)*	0.8650 (0.0190)*	-0.9852 (0.0650)
Transportation	3.5807 (0.1350)	1.4053 (0.0820)	1.0940 (0.0000)*	-0.1879 (0.6770)	-0.2600 (0.2140)	-1.1560 (0.1040)	0.2698 (0.7670)	-0.9438 (0.0440)*	-1.2215 (0.3650)

Note: ‘\*’ indicates the number is statistically significant at 5% significance level.

Table 4. Elasticity matrix before controlling for price and expenditure endogeneities.

Industry	LTV elas.	Income elas.( $\varepsilon_i$ )	Own and Cross price elasticities ( $\varepsilon_{ij}$ )						
Clothing	0.0546 (0.8810)	-0.5292 (0.0030)*	-0.8336 (0.0440) *	-0.4546 (0.3190)	-0.0776 (0.2820)	0.2791 (0.5560)	0.1081 (0.3410)	-0.0360 (0.9640)	0.2373 (0.4790)
Food	0.0005 (0.9970)	-0.8146 (0.0000) *	0.0499 (0.7330)	-0.9804 (0.0000) *	0.0227 (0.4100)	-0.1583 (0.3900)	0.1093 (0.0230) *	0.5403 (0.0970)	0.1883 (0.1580)
Gasoline	-0.0289 (0.9150)	-0.2067 (0.0740)	0.3733 (0.2000)	-0.0915 (0.7820)	-0.1930 (0.0030) *	-0.5049 (0.1650)	-0.2802 (0.0050) *	0.8804 (0.1530)	-0.6940 (0.0140) *
Health	-0.3021 (0.3700)	-0.8183 (0.0000) *	-0.0470 (0.8920)	0.1864 (0.6470)	-0.0795 (0.2290)	-0.4761 (0.2780)	0.1633 (0.1260)	0.4165 (0.5670)	0.2716 (0.3760)
Housing	-0.0319 (0.9050)	1.7783 (0.0000) *	-0.3025 (0.2890)	0.1559 (0.6360)	-0.0799 (0.1410)	-0.1115 (0.7480)	-0.9707 (0.0000) *	-2.1687 (0.0030) *	-0.2054 (0.4060)
Recreation	0.5185 (0.0160)*	-0.3113 (0.0010) *	-0.0623 (0.7530)	-0.0092 (0.9690)	-0.1015 (0.0150) *	0.1662 (0.5010)	-0.2513 (0.0010) *	0.3992 (0.3440)	-0.2692 (0.1370)
Transportation	0.7001 (0.1490)	0.4444 (0.0310) *	0.5028 (0.3090)	-0.5111 (0.3770)	-0.1976 (0.0440) *	-0.9965 (0.1150)	-0.6874 (0.0000) *	2.4988 (0.0270) *	-1.1844 (0.0140) *

Note: ‘\*’ indicates the number is statistically significant at 5% significance level.