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Allocation Inflexibilities, Female Labor Supply, and Housing Assets Accumulation: Are Women Working to Pay the Mortgage?

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This article uses data from the 1986 Canadian Family Expenditures Survey to estimate a life-cycle-consistent model of household labor supply and commodity demand that incorporates a mortgage qualification constraint based on earnings. Both the parametric and nonparametric implications of the model suggest that the labor supply of a nontrivial percentage of married women is constrained by mortgage commitments. The results of generalized selectivity models of female labor force participation and labor supply show that the positive effect of a high debt service ratio exceeds the negative effect of young children.

I. Introduction

This article studies the impact of liquidity constraints in the accumulation of housing assets on female labor supply. It presents a life-cycle-consistent model of household labor supply and commodity demand that incorporates a mortgage qualification constraint based on earnings. Both the parametric and nonparametric implications of the model are considered. The article

The analysis is based on Statistics Canada 1986 Survey of Family Expenditures Public Use micro data files. All computations in this article from these micro data were prepared by the author. Analysis and interpretation of these data are the sole responsibility of the author. The author wishes to thank Orley Ashenfelter, David Card, and Thomas Lemieux for valuable comments. The author gratefully acknowledges funding from the Social Sciences and Humanities Research Council, Canada and from the Fonds pour la Formation de Chercheurs et l'Aide à la Recherche, Québec.

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also presents reduced-form estimations of the impact of households' mortgage commitments on the labor market participation and labor supply of married women.

Recent studies (Hall and Mishkin 1982; Hayashi 1985; Mariger 1987; Zeldes 1989; Deaton 1991, among others) have focused on the presence of liquidity constraints to explain the inability of the traditional life-cycle model to track patterns of consumer choice. Yet few studies (Artle and Variaya 1978) have paid attention to the role of housing assets in life-cycle behavior. This role has many facets of varying importance. First, in the earlier part of the life cycle, down-payment requirements combined with high house prices may induce prospective owners to save a greater share of their income, as argued by Yoshikawa and Ohtake (1989) and others to explain the high Japanese savings rate. Later, housing equity could be used, notwithstanding the high transaction costs, to smooth transitory drops in income.[1] Among the elderly, substantial home equity extraction in transactions has been noted after age 75 (Ai, Feinstein, McFadden, and Pollakowski 1990), especially among surviving spouses. However, evidence of such behavior before age 70 is weak (Feinstein and McFadden 1988; Venti and Wise 1988).[2] More important, after the mortgage is paid, measured consumption may fall. Lower measures of housing expenditures of home owners without mortgages may appear to falsify the implications of the permanent income model.[3] Clarifying the importance of these effects may provide further evidence on the validity of the life-cycle/permanent income hypothesis and of its refinements.

This article concentrates on another implication of borrowing constraints on life-cycle behavior: the effect of mortgage qualification constraints on patterns of female labor supply. The empirical success of life-cycle models in explaining patterns of labor supply has been analyzed for male labor supply (Browning, Deaton, and Irish 1985; Card 1991). Yet, many studies of male labor supply have claimed to find evidence of labor market constraints (Blundell and Walker 1982; Ham 1986). Primary male workers

[1] In the 1986 FAMEX, only 0.5% of nonretired families, who did not move, borrowed against their home equity. There was no downsizing among movers.

[2] Elderly home owners may demonstrate a considerable attachment to their habitual housing. Other considerations, such as bequest motives, transaction costs, tax burden on sizeable capital gains, and in the United States, some provisions of the welfare and medical assistance programs, also may encourage elderly households to hold on to their wealth in the form of housing.

[3] In the 1986 Canadian FAMEX, while the median after-taxes income of retired couples was $19,500, the median housing outlays were $3,700 for home-owning retired couples against $5,200 for retired couples who were tenants. Feinstein and McFadden (1988) do not find such significant differences in the average share, which approaches 20%, of out-of-pocket costs of housing in after-tax income between home owners and renters in the PSID. However, they report that home owners consume larger amounts of housing as they live in dwellings of excess size.

may not be free to choose their hours of work; in fact, most already work full-time. Under these circumstances, the relationship between asset accumulation, consumption, and labor supply might be better assessed in terms of female labor supply. This is the line of investigation pursued in this study.

The empirical analysis utilizes the 1986 Canadian Family Expenditures Survey (FAMEX). The Canadian institutional framework provides an ideal environment to study the impact of mortgage qualification constraints. Contrary to fiscal practices prevalent in many countries, mortgage interests are not tax deductible in Canada.[4] Also, the mortgage lending rules are more uniform across the country, because these are set largely by the Canada Mortgage and Housing Corporation (CMHC). In addition, the length of mortgage contracts is typically very short (around 5 years), so the effect of mortgage lending rules may be more pervasive. However, an analysis from a cross section of cohorts will tend to understate the effects of mortgage lending rules on the households that are directly affected by the borrowing constraints.[5] The mortgage qualification constraint is directly affected by changes in interest rates and by fiscal rules facilitating the provision of a down payment.

The article is organized as follows. Section II presents simple evidence on the relationship between mortgage commitments and the labor force participation and labor supply of married women by means of cross tabulations and generalized selectivity models. Section III incorporates a housing assets accumulation constraint into the traditional life-cycle model. Functional form implications are derived, in terms of a simple linear expenditure system, for models that allow the wife's earnings to be included or excluded from the household's mortgage qualification constraint. Section IV gives the details of the empirical specification, which includes random preferences and optimization errors. The estimation relies on a multiregime maximum-likelihood technique. The results are discussed in Section V. The comparison of the models features an application of Vuong's (1989) likelihood ratio test for nonnested hypotheses. Nonparametric evidence also is used to compare the models. Finally, the implications of the results are qualified in Section VI.

II. Labor Market Decisions of Married Women and Mortgage Commitments

Before proceeding further into the discussion of female labor supply and housing assets accumulation, it is appropriate to motivate the issue by presenting some stylized facts drawn from the 1986 Canadian Family Expenditure Survey public use micro data files. This study is concerned with

[4] Australia is another exception.

[5] Panel data are unfortunately not available for Canada.

the contribution of women's labor market activities to the housing assets accumulation process in the context of a family setting. Cases where the woman is the sole potential earner and mortgage underwriter are not the focus of attention.[6]

A. Data

The original FAMEX sample contained observations on 10,356 households. Because they lived in agglomerations of fewer than 100,000 inhabitants, for which price data are not available, 3,706 households were removed. Because the focus of the study is on married women, 2,542 households were excluded as they were made up of unattached individuals, single-parent families, or other nonfamily units. Another 556 households were deleted because the husband was retired. Various other exclusions are described in detail the appendix. Tenants or other types of households were excluded as required by the analysis.

The FAMEX survey contains data describing the family unit, its housing arrangements, various financial variables, and a somewhat detailed account of expenditures per commodity categories. In particular, data on the value of the house owned, outstanding mortgage amount, mortgage payments, employment status, number of weeks worked full-time, number of weeks worked part-time, and labor earnings are available. Data from the 1986 Canadian Labor Market Activity Survey (LMAS) were used to derive a measure of hours worked per week. Regional prices were constructed from prices available from the Canadian Socio-economic Information Management System (CANSIM) main database for selected metropolitan cities, with weights based on population. Further details on variable descriptions, selection, and construction are given in the appendix.

B. Descriptive Statistics

Table 1 shows the percentage of married women who participated in the labor market in 1986 by tenure choice and age.[7] The higher labor force participation rate of younger women is a striking feature. This is usually thought to be a "cohort" effect attributed to changes in tastes and lifestyle. Yet, another important and lesser known fact is that, between the ages of 35 and 65, the participation rate of married women in home-owning families with mortgages is approximately 10 percentage points higher than among women from families that either rent or own a home with no mortgage. It

[6] The issue of the women's contribution in the context of split families is interesting. However, it was not possible to take on this issue, because no data were available on contributions from family members living outside the family unit.

[7] A woman is a labor market participant if the number of weeks she worked full-time or part-time is greater than zero and if her labor income is greater than zero.

Table 1
Labor Force Participation Rates of Married Women, by Age and Family Tenure, in 1986

	Owners without a Mortgage		Owners with a Mortgage		Tenants		Changed from Tenant to Owner*	
Age	No. of Observations†	%	No. of Observations†	%	No. of Observations†	%	No. of Observations†	%
≤24	3/3	100.0	37/45	82.2	172/217	79.3	31/34	91.1
25–34	83/115	72.1	446/579	77.0	318/414	76.8	61/75	81.3
35–44	159/241	66.0	453/582	77.8	106/155	68.4	19/25	76.0
45–64	246/467	52.6	245/379	64.6	77/138	55.8	11/15	73.3
≥65	2/11	18.2	1/5	20.0	3/5	60.0	0	.0
All	493/837	58.9	1,182/1,590	74.3	676/929	72.8	122/149	81.9

* Includes families who changed tenure, from tenant to home owner, in 1986.
† These numbers represent the ratio of the number of participating women (the numerator) to the total number of women (the denominator) in any given category.

also might be argued that before age 35, the participation rate of tenants is closer to that of owners with a mortgage than it is after age 35, because some of the tenants are working to accumulate a down payment.[8]

In most countries, mortgage lending institutions impose limits on the minimum acceptable down payment as a percentage of the property value.[9] Home buyers also typically face an earnings test to qualify for a mortgage.[10] In Canada, the mortgage lending rules are set largely by the CMHC. The corporation encourages lenders to ensure that the gross debt service ratio (the ratio [$k1$] of annual housing charges to the estimated gross annual income of the home owner) does not exceed 30%.[11]

Table 2 shows that, among home owners with a mortgage, the labor market participation rates and levels of married women increase nonlinearly as the ratio ($k2$) of housing charges to the gross family income, exclusive of the wife's labor income, approaches the allowable limit.[12] The change of regime at the ($k2 \geq .25$) mark is slightly more striking among home owners whose home equity is below 25%. These are likely to be more recent buyers.[13] However, the earnings test may apply at all stages of ownership. In Canada, virtually all single-family mortgages are of the adjustable rate variety (Lessard 1976), with interest rates fixed only for a fraction (from 6 months to 5 years) of the total amortization period (20–30 years).

[8] The FAMEX survey does not contain information on the future plans of renters, which could actually allow this hypothesis to be tested. By contrast, the Japanese National Survey of Family Income and Expenditure contains such information. Yoshikawa and Ohtake (1989) report that, in 1984, 18% of renters had plans to purchase a house. This figure is probably very low by Canadian standards, as only 27% (956/3,552) of families are renters.

[9] The down-payment constraint could be seen as a means to decrease the probability of default, as shown in Zorn and Lea (1989). In Canada, when the ratio of home equity to the value of the property falls below 25%, the borrower is required to buy costly mortgage loan insurance (at a 2.5% premium), available from the CMHC.

[10] In most countries, mortgage payments cannot exceed a proportion, usually around one-third, of the home buyer's income. An exception is Japan, where home buyers can borrow up to six times their salary, but they can extend the loan over two generations. This constraint serves as an affordability test.

[11] The housing charges include mortgage charges for principal and interest plus taxes, as well secondary financing and condominium charges (Canada Mortgage and Housing Corporation 1992*a*, 1992*b*). If the borrower has incurred additional debts, such as personal loans, car loans, etc., then the gross debt service ratio includes these loans and can reach a maximum of 40%. Exceptions are admissible under special circumstances. Data on personal debts in the FAMEX include only interest on those debts, thus that information cannot be used.

[12] The number of weeks worked by participating women was computed as the sum of the number of weeks worked full-time plus half the number of weeks worked part-time.

[13] Data on the year the home was bought or the mortgage refinanced were not available.

Table 2
Labor Market Participation among Married Women Home Owners with a Mortgage: Rates and Levels by Percentage of Ownership and Gross Debt Service Ratio ($k2$)

A. Labor Market Participation Rates

Home Equity as a % of Value of Home	$k2 < .10$		$.10 \le k2 < .175$		$.175 \le k2 < .25$		$k2 \ge .25$	
	No. of Observations*	%	No. of Observations*	%	No. of Observations*	%	No. of Observations*	%
% < .25	23/33	69.7	29/36	80.6	45/59	76.3	46/48	95.8
.25 ≤ % < .50	41/59	69.5	123/173	71.1	98/124	79.0	100/109	91.7
.50 ≤ % < .75	78/118	66.1	187/264	70.8	95/116	81.9	57/62	91.9
.75 ≤ % < 1	227/361	62.9	100/115	86.9	29/36	80.6	18/19	94.7
All	369/571	64.6	439/588	74.7	267/335	79.7	221/238	92.9

B. Number of Weeks Worked by Participating Women†

Home Equity as a % of Value of Home	$k2 < .10$		$.10 \le k2 < .175$		$.175 \le k2 < .25$		$k2 \ge .25$	
	No. of Observations	Mean	No. of Observations	Mean	No. of Observations	Mean	No. of Observations	Mean
% < .25	23	30.2	29	39.3	45	34.1	46	42.1
.25 ≤ % < .50	41	32.5	123	33.7	98	34.5	100	42.0
.50 ≤ % < .75	78	31.4	187	35.6	95	39.0	57	44.9
.75 ≤ % < 1	227	33.5	100	39.3	29	38.6	18	39.5
All	369	32.7	439	36.2	267	36.5	221	42.6‡

NOTE.—$k2$ is the ratio of the sum of mortgage charges, property taxes, and home-owner's insurance to gross family income, exclusive of the wife's labor income.
* In panel A, these numbers represent the ratio of the number of participating women (the numerator) to the total number of women (the denominator) in any given category.
† Number of weeks is computed as the number of weeks worked full-time plus half the number of weeks worked part-time.
‡ Going from 36.5 to 42.6 represents a 15% increase.

Borrowers are thus faced with the periodic refinancing of their mortgages.[14] Indeed, the pattern of increasing rates and levels of labor market participation for women in families with ($k2 \geq .25$) is also observed among home owners with higher home equity ratios. While the number of observations is not large, this nonlinear pattern seems to fade away among home owners with home equity ratios of 0.75 plus. Even though housing choices for the principal residence have been shown to be determined primarily by consumption demand for housing for a larger segment of the population (Ioannides and Rosenthal 1994), there may be a segment of the population for which housing demand is driven by investment demand. Very high levels of home equity ratios (of housing assets investment) could signal the continued attachment of these wives to the labor market. Conversely, lower levels of home equity ratios could signal that housing choices are determined by consumption demand. In these cases, the lumpiness of housing assets together with borrowing constraints would force the wives' labor market choices over 40 working weeks.

In the United States, the Federal Home Loan Bank Board approved adjustable rate mortgages in 1981, following a period of excessively high levels of interest rate risk for lenders in the late 1970s. However, the share of adjustable mortgages among all mortgages varied considerably during the 1980s, from a high of 60% in 1986 to a low of 20% in 1987. Thus, the overall effect of the earnings test may be more transitory in the United States.

The effect of the earnings test on labor market decisions of married women is likely to be truly constraining if their husbands' labor supply is somehow rationed.[15] Unfortunately, data on the number of weeks the husband was involuntary unemployed are not available. A partial rationing effect may exist when the husband works full-time or more 52 weeks a year, that is, when his leisure is rationed. As shown in table 3, higher gross debt service ratios ($k1$) are associated with a lower percentage of husbands working full-time all year. When the household's gross debt service ratio ($k1$) approaches the allowable limit and the wife works, it is two times more likely that the husband is rationed than when the wife does not work.[16]

It is difficult to distinguish households in which the wife chooses a high level of labor supply, because the household is burdened by a high gross debt service ratio, from households who choose high levels of gross debt service ratio, because the wife enjoys a high level of labor supply. The

[14] This was especially true in the late 1980s. The higher interest rates of the early 1980s led many home owners to take on mortgage contracts of very short terms (2–3 years).

[15] A wife's labor supply could be viewed as constrained if curtailing her labor supply would imply defaulting on mortgage payments.

[16] The number of observations in the high gross debt service ratio ($k1$) categories were insufficient to allow disaggregation by levels of participation.

Table 3
Percentage of Husbands Working Full-Time or More 52 Weeks a Year, by Wives' Labor Force Status and Gross Debt Service Ratio ($k1$)

	$k1 \geq .15$		$k1 \geq .175$		$k1 \geq .20$		$k1 \geq .225$		$k1 \geq .25$	
Wives Labor Force Status	No. of Observations*	%	No. of Observations*	%	No. of Observations*	%	No. of Observations*	%	No. of Observations*	%
Participating	213/311	68.5	121/189	64.0	65/105	61.9	32/55	58.2	16/30	53.3
Nonparticipating	101/149	67.8	55/91	60.4	30/54	55.6	13/24	38.2	5/22	22.7

NOTE.—$k1$ is the ratio of the sum of mortgage charges, property taxes, and home-owner's insurance to gross family income.
* Denotes the ratio of the number of households in which the husband work full-time full-year to the total number of households in any given category.

direction of the causality cannot be assessed without panel data. Yet table 4 presents some evidence that households where the wife's attachment to the labor market is presumably stronger (the full-year workers) do not take on mortgage debt in higher proportions, in relation to family income, than other households. Given the relatively high cross-sectional variability in home values, the differences in the value of homes owned among households where the wives are participating at different levels in the labor market are not statistically significant at the 5% level.[17]

C. Reduced-Form Models of Female Labor Supply

The link between mortgage commitments and the labor market activities of married women is explored further using reduced-form models of participation and weeks-of-work decisions. First, a standard probit model of labor market participation is estimated separately among all home owners and among home owners with a mortgage. The estimates of the model, where the explanatory variables are a set of financial and sociodemographic characteristics, are presented in the first two columns of table 5.[18]

It is interesting to note that the coefficients of both the value of the home owned and the balance of mortgage are positive, with the latter being larger. Housing assets are largely illiquid. Thus, the positive coefficient of the variable "value of home owned" signals that this variable acts as an indicator of wealth. The larger positive coefficient of the "balance of mortgage" signals that this variable may have enticing effects beyond those of a wealth indicator. Home equity, the difference between the value of the property and the mortgage outstanding, is the largest single asset in most households' portfolio. The results of table 5 explain why the coefficient of "assets," when these include home equity, is typically of the "wrong" sign in a female labor force participation equation.

In terms of probabilities, these results indicate that, given that the family has mortgage commitments, the probability of the average woman working increases by 0.5% for each additional $10,000 in the value of the house owned and by 1.25% for each additional $10,000 of mortgage outstanding.[19] The impact of the mortgage amount is clearly enough to induce a nontrivial percentage of women to work. The estimates of the probit model that includes dummies for different classes of $k2$ (cols. 3 and 4 of table 5) confirm that the effect of the threshold for the gross debt service ratio is very

[17] Even the difference in the value of the home owned between households with a nonparticipating female and households where the wife work 48 weeks or more per year is not significant (P-value = 0.2050).

[18] The means of the variables used in the probit model are presented in the appendix.

[19] Similar results are obtained when the balance of mortgage is replaced by the actual mortgage payments.

Table 4
Means of Housing and Financial Variables by Levels of Female Labor Market Participation

Levels of Labor Market Participation	Owners without a Mortgage			Owners with a Mortgage		
	No. of Observations	Mean	SD	No. of Observations	Mean	SD
Value of home owned:						
Nonparticipant	346	110,552	89,739	438	97,520	55,632
0 < no. of weeks < 20	109	115,522	67,446	249	100,251	53,982
20 ≤ no. of weeks < 28	95	120,112	66,557	265	97,701	48,629
28 ≤ no. of weeks < 48	47	92,657	49,725	167	94,662	57,445
No. of weeks ≥ 48	240	118,047	78,690	620	105,506	55,723
Balance of mortgage:						
Nonparticipant				438	31,987	24,110
0 < no. of weeks < 20				249	35,529	22,495
20 ≤ no. of weeks < 28				265	36,361	24,134
28 ≤ no. of weeks < 48				167	41,582	27,910
No. of weeks ≥ 48				620	40,215	25,975
Family after-taxes income:						
Nonparticipant	346	39,022	35,004	438	34,757	15,528
0 < no. of weeks < 20	106	39,472	18,342	249	37,570	14,764
20 ≤ no. of weeks < 28	95	44,842	21,780	265	40,545	14,917
28 ≤ no. of weeks < 48	47	44,864	21,781	167	42,311	14,653
No. of weeks ≥ 48	240	55,493	51,708	620	45,745	14,890

NOTE.—Analysis of variance indicates that the differences in the value of home owned between households where the wife participates in the labor market at different levels are not statistically significant at the 5% level. Differences in the balance of mortgage and family after-taxes income are highly significant. However, the ratio of the balance of mortgage to family after-taxes income, which is one to one, is not found to be statistically significant across the different levels of female labor market participation. Number of weeks is computed as the number of weeks worked full-time plus half the number of weeks worked part-time.

Table 5
Probit Estimates of the Wife's Probability of Participating in the Labor Market

	All Home Owners (1)	Home Owners with a Mortgage (2)	All Home Owners (3)	Home Owners with a Mortgage (4)	All Home Owners (5)	Home Owners with a Mortgage (6)
Value of house owned (10,000 $)	.0062 (1.30)	.0168 (2.21)	.0055 (1.17)	.0126 (1.70)	.0051 (1.08)	.0122 (1.64)
Balance of mortgage (10,000 $)	.0447 (3.78)	.0415 (2.58)				
Husband's income (1,000 $)	−.0030 (−4.14)	−.0123 (−6.39)	−.0020 (−2.73)	−.0068 (−3.16)	−.0021 (−2.79)	−.0072 (−3.33)
Wife's other income (1,000 $)	−.0133 (−1.80)	−.0205 (−1.80)	−.0105 (−1.43)	−.0128 (−1.12)	−.0104 (−1.43)	−.0130 (−1.13)
Wife's age	−.0402 (−11.27)	−.0354 (−7.69)	−.0400 (−11.32)	−.0355 (−7.79)	−.0394 (−11.15)	−.0348 (−7.66)
Wife's education	.0742 (7.37)	.0755 (5.90)	.0761 (7.49)	.0746 (5.77)	.0768 (7.54)	.0760 (5.86)
Number of young children (0–6)	−.4181 (−9.05)	−.4058 (−7.74)	−.4288 (−9.13)	−.4160 (−7.81)	−.4282 (−9.10)	−.4146 (−7.78)
Number of older children (7–15)	−.1196 (−3.57)	−.0982 (−2.46)	−.1192 (−3.51)	−.1036 (−2.57)	−.1212 (−3.56)	−.1063 (−2.62)
Dummy ($.10 \le k2 < .175$)*			.1767 (2.54)	.1683 (2.00)	.1799 (2.59)	.1679 (1.99)
Dummy ($.175 \le k2 < .25$)*			.3394 (3.67)	.2877 (2.71)	.3436 (3.72)	.2866 (2.70)
Dummy ($k2 \ge .25$)*			.9070 (7.09)	.8714 (5.74)	.6386 (4.01)	.5786 (3.05)
Dummy ($k2 \ge .25$ and husband works full-time full-year)*					.6632 (2.51)	.6299 (2.29)
Constant	1.5585 (7.47)	1.6234 (6.24)	1.4578 (6.95)	1.4223 (5.34)	1.4320 (6.81)	1.4036 (5.26)
Log likelihood	−1,423.9	−886.96	−1,399.0	−871.57	−1,395.6	−868.80
No. of working women/sample size	1,792/2,576	1,301/1,739				

NOTE.—*t*-Ratios are in parentheses.
* $k2$ is the ratio of the sum of mortgage charges, property taxes, and home-owner's insurance to gross family income, exclusive of the wife's labor income.

important, irrespective of the effect of income variables. It takes 2.2 additional preschool children to offset the increase in the probability of the average woman working brought about by a gross debt service ratio approaching the allowable limit.

The association of high gross debt service ratio, male leisure rationing, and female labor participation is further established by incorporating the corresponding dummy in the probit model. The estimates of columns 5 and 6 of table 5 indicate that the probability of the average woman working, given that the family's gross debt service ratio exclusive of her labor income approaches the allowable limit ($k2 \geq .25$), is 9.1% higher if her husband is working full-time and full-year than when he is not.

The impact of the mortgage qualification constraint on female labor supply per se is investigated using a selection bias–corrected regression procedure (Heckman 1976). The estimates of this model, where the dependent variable is the number of weeks worked by participating women, are reported in table 6. The parameter estimates of λ, the inverse of Mill's ratio, indicate less than marginal evidence of censoring-induced bias (P value = 0.196) only for model 1. For this model, there is no evidence that the parameters that determine participation (the probit estimates) are different from the parameters that determine the weeks of work for participating females (the selection bias–corrected regression estimates divided by the parameter estimates of λ). This suggests that the fixed cost of labor market participation may not be important.[20]

The parameter estimates from the selection bias–corrected regressions that include dummies for the different classes of gross debt service ratios (cols. 3–6 of table 6) indicate that the positive effect of the threshold ($k2 \geq .25$) on female labor supply exceeds the negative effect of young children. The effect of the threshold on labor supply is less important than it is on labor market participation. This is due partially to the differential effect of male leisure rationing on female labor market participation and female labor supply. Given that the family is burdened by a high gross debt service ratio, the labor supply of the average participating woman is not significantly affected by the fact that her husband works full-time full-year. Whereas in this situation, there is an increased probability that the nonparticipating wife will enter the labor market. The jointness of male and female labor supply decisions, in the presence of the mortgage commitments, is studied next using a life-cycle-consistent model.

[20] In fact, from the distribution of weeks worked shown in table 4 there appears to be a greater discontinuity in labor supply going from part-time status (26 full weeks) to full-time status (52 full weeks) than from nonparticipation to a small number of weeks worked. Five percent of participating women work 5 full weeks or less, and more than 10% work exactly 26 full weeks. Previous studies (Heckman 1980; Cogan 1981) that found substantial discontinuities in the labor supply schedule used data from the 1960s when part-time work was not widespread.

Table 6
Parameter Estimates of the Wife's Number of Weeks Worked Using a Selection Bias–Corrected Regression Procedure

	All Home Owners (1)	Home Owners with a Mortgage (2)	All Home Owners (3)	Home Owners with a Mortgage (4)	All Home Owners (5)	Home Owners with a Mortgage (6)
Value of house owned (10,000 $)	.2144 (2.42)	.3262 (2.13)	.1702 (2.01)	.2831 (2.13)	.1676 (1.99)	.2752 (2.07)
Balance of mortgage (10,000 $)	.6399 (2.92)	.6799 (2.75)				
Husband's income (1,000 $)	−.0580 (−2.05)	−.2009 (−3.08)	−.0161 (−.68)	−.1043 (−2.19)	−.0152 (−.64)	−.0999 (−2.05)
Wife's other income (1,000 $)	−1.0491 (−5.21)	−1.3220 (−5.32)	−.8937 (−4.63)	−1.1878 (−5.11)	−.8892 (−4.62)	−1.1787 (−5.07)
Wife's age	−.3397 (−1.99)	−.0955 (−.63)	−.0650 (−.54)	−.0135 (−.11)	−.0529 (−.48)	.0064 (.06)
Wife's education	.5152 (1.53)	.2863 (.83)	.0263 (.10)	.0711 (.25)	.0033 (.01)	.0285 (.10)
Number of young children (0–6)	−7.8269 (−4.64)	−5.9950 (−3.46)	−5.4666 (−4.37)	−5.0745 (−3.59)	−5.3481 (−4.53)	−4.8450 (−3.60)
Number of older children (7–15)	−2.1225 (−3.58)	−1.7675 (−2.85)	−1.6935 (−3.20)	−1.7609 (−2.95)	−1.6683 (−3.17)	−1.7168 (−2.88)
Dummy ($.10 \le k2 < .175$)*			2.9805 (2.52)	3.2691 (2.37)	2.9184 (2.49)	3.1437 (2.30)
Dummy ($.175 \le k2 < .25$)*			2.7485 (1.75)	2.8445 (1.64)	2.6419 (1.71)	2.6503 (1.56)
Dummy ($k2 \ge .25$)*			7.3342 (3.02)	6.5331 (2.36)	7.0449 (3.01)	5.9787 (2.32)
Dummy ($k2 \ge .25$ and husband works full-time full-year)*					.0821 (.04)	.1803 (.08)
Constant	41.7329 (14.32)	41.6095 (12.47)	40.4873 (13.34)	40.0638 (10.86)	40.5896 (13.32)	40.3270 (10.90)
λ-inverse of Mill's ratio	12.4543 (1.29)	4.2514 (.40)	−2.0014 (−.29)	−2.5790 (−.30)	−2.7129 (−.42)	−4.0497 (−.50)
Adjusted R^2	.082	.129	.096	.137	.096	.136
No. of working women	1,792	1,301				

NOTE.—Number of weeks is computed as the number of weeks worked full-time plus half the number of weeks worked part-time. *t*-Values in parentheses are the ratio of the estimated parameters to the robust (Huber 1967; White 1980) standard errors.

* $k2$ is the ratio of the sum of mortgage charges, property taxes, and home-owner's insurance to gross family income, exclusive of the wife's labor income.

III. Housing Assets Accumulation in a Simple Life-Cycle Model

The model applies to married couples with or without children who purchased a home of value V_0 at time $t = 0$ and plan to occupy this home for L periods.[21] Each household borrowed an amount $(1 - d_0)V_0$ toward this purchase, where d_0V_0 represents the principal paid at time $t = 0$. The amount borrowed must be repaid with interest $i_t > 0$ in the form of an annuity, $M_t = i_t(1 - d_{0t})V_0$, where d_{0t} denotes the fraction of principal paid off in period t.[22] The mortgage payments actually made by the household are observable, although the terms of the mortgage contract are not. For expositional simplicity, I assume that the mortgage payments in each period take the form of a constant annuity, M_0.

The household's assets are made up of the home equity $(d_{0t} + \eta_t)V_0$, where η_t represents the cumulative net appreciation of the house, and of other liquid assets, A_t. To preserve intertemporal separability, further borrowing against housing assets is disallowed.[23] The home is considered as an illiquid component of wealth. Thus, the following constraint on asset accumulation holds

$$S_t = \Delta A_t - (r_t A_{t-1} - M_0), \tag{1}$$

where S_t is a measure of net saving, ΔA_t is the additional asset allocation, and r_t is the rate of return in period t, which, under the assumption of perfect capital markets, is fixed and independent of A_t. Following Killingsworth (1983) and Blundell and Walker (1986), I define y_t as the net current period allocation of lifetime wealth, $y_t = w_{mt}T_m + w_{ft}T_f - S_t$, where $w_{mt} = (1 - \tau_m)\tilde{w}_{mt}$ is the male's after-tax wage rate, and $w_{ft} = (1 - \tau_f)\tilde{w}_{ft}$ is the female's after-tax wage rate, and where a constant time endowment is assumed for all periods.[24] The wages rates, as well

[21] This restriction eliminates 249 families who sold or purchased a home in 1986. When the three-stage decision process—to buy, occupy, and sell—is considered (Artle and Variaya 1978), the optimal assets and consumption paths exhibit discrete jumps.

[22] In Canada, mortgage interests are not tax deductible. There is no need to distinguish between i_t and an after-tax interest rate, as in Anas and Arnott (1991). Renegotiation is ruled out by assumption.

[23] This restriction eliminates 96 families who borrowed against their houses. It is consistent with other empirical evidence showing that very little home equity extraction occurs before retirement (Feinstein and McFadden 1988; Venti and Wise 1988).

[24] In Canada, working husbands and wives must file separate income tax returns. The use of an after-tax wage rate assumes an implicit linearization of the budget set. A piecewise treatment of the budget set is beyond the scope of this article.

as the initial assets A_0, are assumed to be known with certainty.[25] Since S_t summarizes all changes in liquid assets, the current life-cycle wealth is given by

$$W_t = \sum_{s=t}^{L} \rho_s(w_{ms}T_m + w_{fs}T_f - M_0) - \rho_L A_L + \rho_t A_t = \sum_{s=t}^{L} \rho_s(y_s), \qquad (2)$$

where ρ_t is the market discount rate.

Additionally, there is a borrowing constraint imposed by lending institutions in the form of a maximum gross debt service ratio,

$$k[w_{mt}(T_m - l_{mt}) + w_{ft}(T_f - l_{ft})] - M_0 \geq 0, \qquad (3)$$

where k represents the maximum proportion of eligible income to be allocated to mortgage payments, and l_{mt} and l_{ft} represent levels of male and female leisure.[26] This maximum ratio of mortgage payments to annual income will be assumed to hold over the horizon considered. This corresponds with the Canadian institutional setting, where families reapply for new mortgages every 2–5 years. Constraint (3) could correspond to allocational inflexibilities where such institutional constraints do not exist.[27]

The household chooses levels of male and female leisure, l_{mt} and l_{ft}, and of consumption q_t at price p_t to maximize a stream of utilities discounted at the rate δ, subject to the current period allocation of lifetime wealth constraint and to a borrowing constraint

[25] It is well known (Zeldes 1989; Card 1991) that analytic solutions to intertemporal labor supply and consumption demand models cannot generally be derived in an uncertain environment.

[26] The eligible income may include self-employment income, commission income, bonuses, rental income, investment income, alimony or child support income, etc., only if it can be clearly demonstrated that such incomes are typical and supportable in the future (Canada Mortgage and Housing Corporation 1992*b*). In the empirical analysis, incomes other than labor incomes will be accounted for as explained in the appendix. For expositional simplicity, these are not included in eq. (3). Also, it is first assumed that equal weight is given to the income share of each spouse. Many lenders in the United Kingdom (Smith 1991) give the income of the bigger earner greater weight (sometimes three times the weight) in this calculation. This practice is not applied in Canada.

[27] In the sample, a 35% ratio of total housing expenditures to gross annual income holds for 95% of the families among both tenants and home owners. The U.S. government considers housing affordable if it consumes no more than 30% of family income. When families apply for food stamps, they can deduct shelter costs in excess of 30% of household income.

$$\left.\begin{aligned} &\max_{\{l_{mt},\, l_{ft},\, q_t\}} \sum_{t=1}^{L} \delta^{(t-1)} U_t(l_{mt}, l_{ft}, q_t) \\ &\text{subject to} \\ &W_{t+1} - W_t = -\rho_t y_t = -\rho_t(w_{mt} l_{mt} + w_{ft} l_{ft} + p_t q_t) \\ &k[w_{mt}(T_m - l_{mt}) + w_{ft}(T_f - l_{ft})] - M_0 \geq 0 \\ &l_{mt} \geq 0, \qquad T_f - l_{ft} \geq 0, \qquad l_{ft} \geq 0, \qquad W_1 \text{ fixed.} \end{aligned}\right\} \tag{4}$$

The inequality constraints on levels of male and female leisure imply that reaching a lower zero bound for male leisure, or for female leisure, or an upper bound for female leisure separately or in combination represents different corner solutions to the optimization problem.[28]

Solutions to problem (4) can be derived for a few specific utility functions. Here, I choose a simple augmented Stone-Geary utility function, as used by Abbott and Ashenfelter (1976), Ashenfelter and Ham (1979), and Johnson and Pencavel (1984), among others:

$$U_t(l_{mt}, l_{ft}, q_t) = \beta_m \ln(l_{mt} - \gamma_m) + \beta_f \ln(l_{ft} - \gamma_f) + \beta_q \ln(q_t - \gamma_q), \tag{5}$$

where $\sum_{s=m,f,q} \beta_s = 1$, and where the γ_s, $s = m, f$, will be parameterized to capture individual differences, following the demographic translating approach defined by Pollak and Wales (1981).

The expression for the marginal utility of income will change with each corner solution, as will the precise form of y_t. However, in the absence of panel data, y_t will be recovered from the intraperiod budget constraint. The demands for leisure and commodities also will vary across the 12 relevant regimes. With no constraints binding, aside from the intraperiod budget constraint, they are the traditional linear expenditure system functions. When the mortgage qualification constraint is binding, the commodity expenditures will be determined by the intraperiod budget constraint and by the borrowing constraint

$$p_t q_t = y_t - \sum_{s=m,f} w_{st} T_s + \frac{M_0}{k}. \tag{6}$$

[28] In the empirical analysis, the upper bound on the number of hours worked (or equivalently, the lower bound on leisure) arguably will be set at the maximum of the number of hours resulting from working full-time full-year and of the number of hours actually worked. This implicitly assumes that housing decisions are made in accordance with normal hours of work; that is, housing decisions do not presume moonlighting. The CMHC guidelines on borrower eligibility allow overtime/secondary employment income to be considered only if it is reasonable and expected to continue in the future. In this sample, only 1% of males and 0.3% of working females worked more than full-time full-year. Only for these workers does the upper bound on hours exceed the equivalent of working full-time full-year.

If the husband has not reached full market participation and if the wife does not work ($l_{ft} = T_f$), the demands for male leisure will be determined by the mortgage payments:

$$w_{mt} l_{mt} = w_{mt} T_m - \frac{M_0}{k}. \tag{7}$$

If the wife works less than full-time full-year, the demands for leisure of both husband and wife will depend on the mortgage payments:

$$w_{rt} l_{rt} = w_{rt} \gamma_r + \frac{\beta_r}{\beta_m + \beta_f} \left[\sum_{s=m,f} w_{st} (T_s - \gamma_s) - \frac{M_0}{k} \right], \quad r = m, f. \tag{8}$$

If the wife has reached full market participation ($l_{ft} = 0$), the husband's demand for leisure will be given by

$$w_{mt} l_{mt} = \sum_{s=m,f} w_{st} T_s - \frac{M_0}{k}. \tag{9}$$

If the husband has reached full market participation ($l_{mt} = 0$) and if the wife has not, her demand for leisure will be the counterpart to (9). Cases where the husband has reached full market participation ($l_{mt} = 0$) and the wife is either a nonparticipant ($l_{ft} = T_f$) or a full-time participant ($l_{ft} = 0$) are trivial. Cases where the housing constraint is not binding are derived similarly and imply demands for leisure and goods that are not affected by the mortgage payments.

If it were true that binding constraints on housing allocations did not induce women to participate in the labor market, one would expect to find a similar fraction of households for which the constraint on housing binds whether it is computed with or without female labor income.[29] More formally, the hypothesis that female labor supply is constrained by the household's housing decisions will be tested by comparing a model where it is thus constrained with one where it is not. This latter situation represents a polar case where the wife's labor supply decisions would not factor into the household's housing decisions.

Let us now suppose that the housing constraint applies only to male labor supply and that it is binding, $kw_{mt}(T_m - l_{mt}) - M_0 = 0$. Then if the wife is a labor market participant and the husband has not reached full

[29] This is unless household tastes for mortgage payments are positively correlated with the wife's tastes for work.

market participation, his demand for leisure will be identical to (7). If the wife works less than full-time full-year, her demand for leisure will be

$$w_{ft}l_{ft} = w_{ft}\gamma_f + \frac{\beta_f}{\beta_f + \beta_q}\left[y_t - w_{ft}\gamma_f - w_{mt}T_m + \frac{M_0}{k} - p_t\gamma_q\right]. \quad (10)$$

When male labor supply is rationed but female labor supply is not, the rationing constraint supersedes the housing constraint and leads to

$$w_{ft}l_{ft} = w_{ft}\gamma_f + \frac{\beta_f}{\beta_f + \beta_q}[y_t - w_{ft}\gamma_f - p_t\gamma_q]. \quad (11)$$

In these cases, as well as all others, commodity expenditures are obtained as the difference between y_t and the values of male and female leisure demands.

The two extreme cases, one where the labor income of both spouses is given equal weight in the mortgage qualification constraint and the other where the wife's labor income is given zero weight, are being compared by fitting the resulting models to data.

IV. Econometric Specification

The specification of errors leading to the econometric implementation of the models presented above is discussed next. In considering a single cross section, time indices are now dropped, and the variables $h_s = T_s - l_s$, $s = m, f$, are introduced to denote hours of work for males and females. A first source of stochastic variation arises in the value of minimum required leisure. I assume that $w_s\gamma_s = w_s\tilde{\gamma}_s + \varepsilon_s$, $s = m, f$, where ε is distributed as a bivariate normal with zero mean and variance-covariance matrix Ω_ε, and the $\tilde{\gamma}_s$ are allowed to depend on observable characteristics.[30] A second source of errors arises from optimization (or measurement) errors: they are the υ_m and υ_f below. The υ's are assumed to be similarly distributed as a bivariate normal with zero mean and corresponding variance-covariance matrix Ω_υ. In the regimes where labor earnings are determined solely by the mortgage constraint, they are the only source of stochastic variation. It is assumed, following Hausman (1981) and Arrufat and Zabalza (1986), that these two types of errors are independent.

In model I, the female labor supply decision is subject to the housing constraint; in model II, it is not. The corresponding male and female labor income equations are obtained by adding the appropriate error terms to

[30] $\Omega_\varepsilon = \begin{pmatrix} \sigma_{\varepsilon_m}^2 & \rho_\varepsilon\sigma_{\varepsilon_m}\sigma_{\varepsilon_f} \\ \rho_\varepsilon\sigma_{\varepsilon_m}\sigma_{\varepsilon_f} & \sigma_{\varepsilon_f}^2 \end{pmatrix}$.

the equations of the previous section; they provide the latent variables of interest. The equations for commodity expenditures may be derived from the adding-up and are omitted in the estimation. The expressions for labor earnings are given in terms of wages, current allocation of life-cycle wealth, mortgage burden, and various parameters. Labor earnings, current allocation of life-cycle wealth, and mortgage burden are observed directly in the FAMEX. As is the case for most retrospective surveys, hourly wages must be constructed from total earnings and hours. Unfortunately, the FAMEX survey reports only the numbers of weeks worked part-time and full-time.

To construct an hourly wage measure, I used information on average weekly hours and other characteristics from the 1986 LMAS to impute hours per week by occupation and full-time/part-time status, as explained in detail in the appendix. Labor income equations then are preferred to hours of work equations, because the measurement error pertaining to annual earnings is expected to be smaller than the one pertaining to the annual hours. The measurement error in weekly hours is thought to be smaller than the one that would be associated with wages, because there is seemingly less flexibility in hours.[31] The hours of work specification would compound the attenuation and division biases on hours of work, whereas the labor income specification compounds such errors on earnings. As with other nonlinear wage models (Hausman 1981; Arrufat and Zabalza 1986), there is no simple cure for the measurement error problem. The hourly earnings of nonparticipating females are imputed from a selection bias–corrected regression of the hourly earnings of participating females on a number of socioeconomic characteristics.[32]

The life-cycle-consistent utility maximization of the previous section implies 12 possible regimes: (1) no binding constraints, (2) housing constraint on both spouses' earnings binding, (3) rationed female labor supply, (4) housing constraint on both spouses' earnings binding and rationed female labor supply, (5) nonparticipating female, (6) nonparticipating female and housing constraint on both spouses' earnings binding, (7) rationed male labor supply, (8) housing constraint on both spouses' earnings binding and rationed male labor supply, (9) both spouses' labor supply rationed, (10) housing constraint on both spouses' earnings binding and both spouses' labor supply rationed, (11) rationed male labor supply and nonparticipating

[31] For example, in the LMAS, 62% (78%) of female (male) full-time clerical employees and 72% (81%) of female (male) full-time manufacturing employees work exactly 40 hours per week. As a result, the distribution of imputed wages for full-time workers from the FAMEX reproduces very well the distribution of wages observed in the LMAS. Given that there is more flexibility in hours of work for part-time workers, the same is not true for these workers.

[32] See the appendix.

female, (12) housing constraint on both spouses' earnings binding, rationed male labor supply, and nonparticipating female.

To specify the models, observed variables corresponding to each of the regimes are defined in terms of the latent variables obtained from the labor income equations. The stochastic implications of each regime lead to different likelihood components that are combined according to the following formula, which gives the likelihood of one observation:

$$L_i^I(\varepsilon_m, \upsilon_m, \varepsilon_f, \upsilon_f) = \prod_{r=1}^{12} (L_r^I)^{d_{ir}}, \tag{12}$$

where L_r^I is the likelihood of regime r, and d_{ir} is an indicator variable that takes the value one if the observation is in regime r and is zero otherwise.[33] One could compare this likelihood function with a bivariate Tobit with one limit for male earnings and two limits for female earnings, which also incorporates a constraint on minimum joint earnings.[34]

The second model ignores the effect of the housing constraint on female labor supply. In model II, the female labor earnings equations will thus never depend on the mortgage constraint. They will take on functional forms in the regimes where the housing constraint is binding (the even regimes), which are different from those of model I, in terms of the variables, parameters, and functional relations used. Also, when male labor supply is rationed, the housing constraint does not have any stochastic implications. The probabilities associated with regimes 8, 10, and 12 in model II will then be different from those of model I. The two models are thus strictly nonnested.

To further account for individual differences, demographic characteristics are used to parameterize the male and female minimum amounts of required leisure:

$$\left.\begin{aligned} \tilde{\gamma}_m &= \alpha_{m0} + \alpha_{m1}\mathrm{AGE}_m + \alpha_{m2}\mathrm{EDU}_m, \\ \text{and} \\ \tilde{\gamma}_f &= \alpha_{f0} + \alpha_{f1}\mathrm{AGE}_f + \alpha_{f2}\mathrm{EDU}_f + \alpha_{f3}\mathrm{YKIDS} + \alpha_{f4}\mathrm{OKIDS}, \end{aligned}\right\} \tag{13}$$

[33] The formulas for the latent and observed variables, as well as the likelihood formula, are extremely cumbersome. They are available from the author on request.

[34] Because wages are fixed, the use of the "upper-limit Tobit" form for males is empirically justified by the fact that 78% of working men work full-time full-year. The use of the "two-limit Tobit" form for females is empirically justified by the fact that approximately 30% of females are nonparticipants and another 30% of females work full-time full-year.

where AGE_s is the age of the husband or wife, EDU_s is the number of years of schooling of the husband or wife, $s = m, f$, YKIDS is the number of children aged 6 years and younger, and OKIDS is the number of children aged 7–15.[35]

V. Empirical Results

The present specification aims at improving the traditional modeling of life-cycle labor supply by incorporating an institutional constraint thought to have important effects. Yet, because it estimates both male and female labor supply, it is still plagued with many of the usual problems encountered in such estimations (Card 1991). As in most of the literature, the absence of good predictors for part-year male labor supply implies that the estimates from the male labor earnings equations are not particularly successful.[36] Furthermore, given the high variability in weekly hours of work among part-time workers, the imputed wage is a less reliable variable for part-time workers than for full-time workers.

The parameter estimates together with their standard errors and corresponding log-likelihood values for models I and II are reported in table 7. The likelihood functions are the same for households for which the housing constraint is not binding (78.2% of the observations). It is thus not surprising to find many parameter estimates that are similar between the two models. For model I, the estimates of the marginal propensity to consume leisure out of current allocation of life-cycle wealth is approximately .17 for husbands and .39 for wives, while the corresponding estimates for model II are .16 and .43, respectively. These estimates of the marginal propensity to consume leisure for husbands are close to the estimate (.19) of Johnson and Pencavel (1984), obtained from a Stone-Geary specification in an intertemporal setting. The estimates for wives seem rather high; they rest predominantly on part-time workers.

The estimates of the demographic effects are generally statistically significant and in line with empirically accepted notions. They indicate that the amount of required leisure decreases with education for both sexes. Age increases leisure for women, whereas for men it has a nonsignificant (model I) or mild (model II) effect. The numbers of younger and older children increase the amount of required leisure for females, with younger children having a greater effect. One also should note that the potential problem of

[35] The number of children was not included in the male labor earnings equation because it was not found to be statistically significant. The husband's earnings will be indirectly affected by the family composition through the wife's earnings.

[36] Such problems would have been decreased if male labor rationing could have been more precisely defined from the maximum number of weeks of possible employment rather than from 52 weeks. However, data on the numbers of weeks the male was involuntary employed were not available.

Table 7
Parameter Estimates of the Labor Earnings Equations

	Model I Housing Constraint on Both Spouses' Earnings		Model II Housing Constraint on Husband's Earnings	
	Female	Male	Female	Male
β	.38669	.16662	.43049	.15651
	(.02192)	(.01004)	(.02630)	(.01534)
α_0	5,325.5	2,587.3	2,913.7	1,533.3
	(666.6)	(195.6)	(704.6)	(267.2)
α_1 (AGE)	125.43	3.0893	175.43	10.299
	(13.31)	(3.2299)	(16.89)	(4.442)
α_2 (EDU)	−545.68	−159.93	−479.56	−107.24
	(36.69)	(13.08)	(41.97)	(15.42)
α_3 (YKIDS)	1,510.9		1,751.7	
	(25.8)		(166.8)	
α_4 (OKIDS)	108.54		135.19	
	(82.72)		(80.57)	
γ_q	6,370.6		5,538.8	
	(382.6)		(243.1)	
σ_ε	39,817	17,846	34,198	23,678
	(14,542)	(6,342)	(24,281)	(7,998)
ρ_ε	−.00031		−.00289	
	(.07639)		(.06835)	
σ_v	10,474	10,128	11,270	9,257.4
	(3,880)	(3,748)	(11,741)	(2,418.2)
ρ_v	.04830		.65292	
	(.16623)		(.38255)	
Log likelihood	−15,450.16		−15,548.15	
Vuong's likelihood ratio (LR) statistic:*				
$n^{-1/2}\mathrm{LR}_n(\hat{\theta}_n^{\mathrm{I}}, \hat{\theta}_n^{\mathrm{II}})/\hat{\omega}_n \xrightarrow{D} N(0,1)$	2.6405			
Mean square error ($\times 10^7$)	13.65	8.372	15.62	6.574
Correlation between prediction errors and M_0/k	−.0098	.0116	.0029	.1468

NOTE.—Figures in parentheses are asymptotic standard errors.
* $\mathrm{LR}_n(\hat{\theta}_n^{\mathrm{I}}, \hat{\theta}_n^{\mathrm{II}}) = L_n^{\mathrm{I}}(\hat{\theta}_n^{\mathrm{I}}) - L_n^{\mathrm{II}}(\hat{\theta}_n^{\mathrm{II}})$ and $\hat{\omega}_n = 1/n \sum_{i=1}^n [L_i^{\mathrm{I}}(\hat{\theta}_n^{\mathrm{I}}) - L_i^{\mathrm{II}}(\hat{\theta}_n^{\mathrm{II}})]^2 - [1/n\mathrm{LR}_n]^2$, where L_i^{I} is the log likelihood of one observation, and L_i^{I} is the sum over n observations. See Vuong (1989) for a complete description of the LR test for nonnested hypotheses.

endogeneity of mortgage payments does not appear to be important, as indicated by the correlations between the prediction errors and the mortgage burden (M_0/k), with the exception of male earnings in model II.

The two models can be compared in various ways. A formal test for nontested models is Vuong's (1989) likelihood ratio statistic. It indicates that, overall, model I fits the data better than model II. As explained in Vuong and Zabel (1990), such a test may be preferred to a Cox-type test, because it compares the alternative models by measuring the closeness of the competing models to the true data-generating process, rather than by assuming that one model is the true model. The mean square error statistic indicates that model I predicts female labor earnings more accurately than model II, but that model I does worse at predicting male labor earnings

Table 8
Actual and Predicted Distributions for Annual Hours of Work

Annual Hours of Work	Actual		Model I		Model II	
	No. of Observations	%	No. of Observations	%	No. of Observations	%
Wives (N = 2,049):						
$h \leq 0$	615	30.0	786	38.4	1,332	65.0
$0 < h \leq 600$	332	16.2	103	5.0	11	0.5
$600 < h \leq 1{,}600$	350	17.1	173	8.4	14	0.7
$1{,}600 < h \leq 2{,}000$	413	20.2	381	18.6	321	15.7
$2{,}000 < h$	339	16.5	606	29.6	371	18.1
Husbands (N = 2,049):						
$h \leq 900$	105	5.1	81	4.0	154	7.5
$900 < h \leq 1{,}500$	98	4.8	28	1.4	76	3.7
$1{,}500 < h \leq 2{,}000$	162	7.9	87	4.3	91	4.4
$2{,}000 < h \leq 2{,}300$	1,022	49.9	990	48.3	971	47.4
$2{,}300 < h$	662	32.3	863	42.1	757	36.9

than model II. A more refined picture of the predictive accuracy of the models is given in table 8, which reports the actual and predicted annual hours of work. The reported distributions show that the models would not pass a formal chi-square test, mainly because they fail to predict accurately the hours of work of part-time workers.[37] Given the imprecision of the part-time data available, this result is not surprising. These distributions, however, are useful to compare the two models. They indicate that model I somewhat overpredicts the hours of work of wives and model II vastly underpredicts their hours of work. Conversely, model II gives a more accurate picture of the hours of work of husbands. These results signal that a less polar case than that implied by models I and II would fit the data better. The housing constraint should apply to both spouses, but the husband's earning should be given a somewhat greater weight than the wife's.

Another common way of evaluating the point estimates of structural models is to derive the implied effect on hours of work of marginal changes in the wages rates. The hours functions are not defined at the censoring positions. They cannot be used to derive elasticities at the corner positions.[38] It is possible however to derive elasticities for the regimes where the earnings are not fixed. Following Blundell and Walker (1986), the own-wage

[37] This is not unusual in labor supply models. See, e.g., Nakamura and Nakamura (1983), table 4.

[38] An alternative is to derive the unconditional elasticities as in Arrufat and Zabalza (1986). However, in a multiregimes model like the present, it is not clear what interpretation could be given to such elasticities.

Table 9
Conditional Labor Supply Elasticities for Unrationed Wives among Selected Household Types

	Model I			Model II			
	Regime 1	Regime 2	Regime 7	Regime 1	Regime 2	Regime 7	Regime 8
A. Range:							
Husband's age	35–50	30–45	35–45	35–50	35–50	35–45	35–50
Husband's education	10–17	10–17	10–17	10–17	10–17	10–17	10–17
Wife's age	30–45	25–40	30–40	30–45	30–45	30–40	30–40
Wife's education	10–17	10–17	10–17	10–17	10–17	10–17	10–17
Number of young children (0–6)	0–1	0–1	0–1	0–1	0–1	0–1	0–1
Number of older children (7–15)	0–1	0–1	0–1	0–1	0–1	0–1	0–1
Sample size	30	5	69	17	15	98	26
B. Mean:							
Husband's number of hours worked	1,745	1,232	2,296	1,859	1,638	2,284	2,301
Husband's wage	15.1	9.6	13.1	15.4	11.5	13.5	10.7
Wife's number of hours worked	1,160	733	725	1,139	1,083	665	891
Wife's wage	13.6	11.8	13.7	11.1	15.2	13.0	11.8
Mortgage burden M_0/k	16,518	23,851	16,733	9,197	27,194	13,645	32,285
Current allocation of lifetime wealth	59,050	50,922	57,564	56,146	56,958	56,163	49,050
Uncompensated own-wage elasticity	−.279	−.845	−.887	.354	.542	.052	.011
Compensated own-wage elasticity	.108	−.854	−.422	.783	1.053	.562	.522

NOTE.—These elasticities are computed using the parameter estimates of table 7 for the corresponding model and the hours of work predicted by the models. The reported elasticities are the mean of the elasticities computed for the selected households. Regime 1 is with no binding constraints, regime 2 with the housing constraint binding, regime 7 with male labor supply rationed, and regime 8 with male labor supply rationed and with the housing constraint binding.

elasticities for wives in selected household types are reported in table 9.[39] They are more instructive than the usual elasticities at the mean, because they are representative of actual elasticities.[40]

Finally, it is useful to appraise the importance of wives' earnings contribution to the mortgage qualification process independently of the functional form estimations. Table 10 reports the distribution of households across regimes as implied by the structure of the two models. As explained earlier, the two models have different nonparametric implications for the distribution of households across regimes. If the mortgage qualification constraint were an effective constraint, one would expect to find a very low number of households for which this constraint is binding, when it is properly applied. In effect, a low percentage of households (7.1%) violate the constraint when it applies to the earnings of all market participants.[41] However, when the mortgage constraint applies only to the husband's earnings in double-income households, the percentage of violators exceeds 20%. Without the labor market participation of wives, an additional 13.7% of households would not qualify for the mortgage arrangement they now have, at their actual levels of male and female earnings. A more conservative appraisal would focus on unrationed wives whose labor supply decisions are less likely to be endogenous to the household's housing decisions. Focusing on that group, one finds that 5% of households would not qualify for their current mortgage arrangement if the female labor earnings were not included.

VI. Concluding Remarks

The empirical evidence presented above clearly shows that mortgage commitments influence the labor market decisions of married women. If the outstanding mortgage amount of the average household (among owners with a mortgage) were to vanish suddenly, the labor market participation rate of the wife in this household, which is 77%, would be reduced by 5%. The maximum gross debt service ratio allowed by lending institutions has

[39] The households are selected over a wide range of demographic characteristics. They exclude outliers for which the computed elasticities are unreasonable. The reported elasticities are still unusually high, reflecting the deficiencies of the imputed wage data. The imputed wage rates for females at lower levels of annual hours are unreasonably high.

[40] In a multiregimes model, because the mean of each group does not coincide with the overall mean, the sign of the predicted earnings at the mean of each group adversely affects the elasticities.

[41] Here, the earnings exclude government transfers. The CMHC's Borrower Eligibility guide allows the inclusion of such transfers when they represent typical cyclical patterns. Because it was not possible to determine whether the transfers were likely to continue in the future, they were not deducted from the mortgage charges as were the investment incomes, as explained in the appendix. If they had been deducted, the percentage of violators would have been smaller.

Table 10
Distribution of Households across Regimes

	Model I Housing Constraint on Both Spouses' Earnings				Model II Housing Constraint on Husband's Earnings			
	Not Binding		Binding		Not Binding		Binding	
	No. of Observations	%	No. of Observations	%	No. of Observations	%	No. of Observations	%
Husband unrationed:								
Wife unrationed	157	7.6	23	1.1	129	6.3	51	2.5
Wife rationed	108	5.3	9	.4	58	2.8	59	2.9
Wife nonparticipating	100	4.9	30	1.5	100	4.9	30	1.5
Husband rationed:								
Wife unrationed	556	27.1	50	2.4	485	23.7	121	5.9
Wife rationed	513	25.0	13	.6	381	18.6	145	7.1
Wife nonparticipating	449	21.9	21	2.0	449	21.9	21	2.0
Total	1,883	91.9	146	7.1	1,602	78.2	427	20.8

a significant impact on the labor force participation rate and labor supply of married women. Among recent home buyers whose debt service ratio would approach the allowable limit without the labor participation of the wives, the female labor force participation rate exceeds 95%. As the ratio of mortgage charges to the family income, exclusive of the wife's labor income, approaches the allowable limit, the labor supply of participating wives increases by 15% on average. The reduced-form estimations indicate that the positive effect of a high debt service ratio on the wives' labor supply exceeds the negative effect of young children. The nonparametric evidence, derived from the structures of the life-cycle-consistent models independently of the functional form estimations, shows that the mortgage borrowing requirements affect the labor supply of 13.7% of married women.

These results may paint a conservative view of the impact of borrowing constraints on female labor supply. They rely on a cross section of households who bought their home at unknown points in the past. Many more households may have been constrained in the years preceding the decision to buy a home, by the down-payment requirement, and in the years following that decision, by the need to maintain family income at a level high enough to requalify for a mortgage. A better test of the impact of mortgage qualification constraints would focus on those years. A natural extension of this study will be to apply the analysis to panel data. Issues of women's entry and exit from the labor market could then be studied in relation to changes in housing variables, such as mortgage interest rates. If borrowing constraints actually prevent a number of wives from exiting the labor market at will, mortgage rates and housing policies could have a significant effect on family life and child rearing.

Conversely, an interesting view that would downplay the constraining effect of mortgage payments would argue that the wife's labor supply decisions and the household's housing decisions are joint. Here, I have studied the household's labor supply decisions taking the value of the home owned and the mortgage debt assumed by the households as given. In another study (Fortin 1993), I performed specific tests of the endogeneity, in a reduced-form female labor supply equation, of a debt service ratio variable and of a variable capturing the borrowing constraint imposed by the earnings test. The results of these tests support the weak exogeneity of both variables, especially that of the borrowing constraint. Nonetheless, in view of the soaring housing prices and high interest rates of the late 1970s and early 1980s and the changes in the occupational choices of women, it would be interesting to study the interaction between housing decisions and female labor supply decisions in a dynamic context.[42]

[42] Using the PSID, Phillips and Vanderhoff (1991) found that households in which the wife is employed full-time in a professional or managerial occupation spend more on housing for given levels of current income than other two-earner

Appendix

Data Construction

Sample Selection Criteria

The Canadian Family Expenditures Survey of 1986 comprises a total of 10,356 observations. The following rejection criteria were used to obtain the appropriate samples in table A1.

Variable Selection and Construction for Life-Cycle Model

As far as labor supply is concerned, the FAMEX survey contains information only on the number of weeks worked full-time and the number of weeks worked part-time. To obtain data on annual hours of work, additional information from the 1986 LMAS was used to estimate average numbers of hours worked per week. The LMAS contains information on average hours worked per day and average numbers of days worked per week. These data were multiplied to obtain the average numbers of hours worked per week. Regressions on hours worked per week, based on approximately 12,000 observations from the LMAS survey, were run using a number of sociodemographic variables, such as geographic location, age, number of children, and education, for each of 11 types of occupation defined in the FAMEX survey for full-time male and female workers, separately. In the regressions for part-time male and female workers, which made up 2.6% and 28.4% of the samples respectively, workers were regrouped and dummy variables for occupation were introduced. The regressions results were used to make predictions on weekly hours of work using the same sociodemographic variables from the FAMEX. Maximum available hours (T_m, T_f) were estimated as the maximum of the estimated annual hours and of the number of hours that would result from 52 weeks of full-time employment. An alternative specification for the maximum available annual hours of work would subtract the number of hours of involuntary employment. However, such data were not available. The hourly wages were computed as the ratio of after-taxes salaries and self-employment incomes to estimated annual hours of worked. This implied a constant tax rate. The after-tax hourly earnings of nonparticipating females were imputed from the selection bias–corrected regression presented in table A2.

Total household expenditures were defined as the sum of expenditures on food, alcohol and tobacco, shelter (excluding mortgage charges), household operations, clothing, transportation, health, education, reading materials, recreation, and miscellaneous, excluding motor vehicle purchases. The price indexes used were constructed from regional price

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households. However, the effect of these occupational choices was no longer significant when age and education variables were included in the housing demand equation.

Table A1
Sample Selection

Selection Criteria	Number of Observations Deleted	Number of Observations Remaining
1. Living in agglomerations of fewer than 100,000 inhabitants	3,706	6,650
2. Singles, single-parent families, and other nonfamily units	2,542	4,108
3. Husband retired	556	3,552
4. Tenants and free renters	976	2,576
5. Husband not working in 1986	143	2,433
6. Home sold or bought in 1986	249	2,184
7. Reduced value of principal paid	96	2,088
8. Negative after taxes or negative self-employment income and other peculiar income	20	2,068
9. Current period allocation of lifetime wealth greater than $150,000 or less than $1,000	19	2,049

indexes for each of the preceding categories. Using these categorical price indexes, household-specific price indexes were constructed. It was not appropriate to use the intercity indexes of retail price differentials (Statistics Canada, Catalogue 62-010, table 24), because these are given only for six broad categories of goods. Notably, they do not include a price index for all goods and for housing in particular. Net liquid savings were computed as after-taxes family income minus total household expenditures minus illiquid savings, which included mortgage payments,

Table A2
Means of Variables Used in Reduced-Form Models of Female Labor Market Participation and Labor Supply

	All Home Owners		Home Owners with Mortgage	
Variable	All Women	Working Women	All Women	Working Women
Husband's income (1,000 $)	37.07	35.71	35.75	34.49
Value of house owned (10,000 $)	10.48	10.53	10.05	10.15
Balance of mortgage (10,000 $)	2.50	2.81	3.70	3.87
Wife's number of weeks worked	25.13	36.12	27.18	36.32
Wife's other income (1,000 $)	1.67	1.54	1.46	1.40
Wife's age	40.59	38.93	37.70	36.78
Wife's education	11.43	11.77	11.64	11.89
Number of young children (0–6)	.41	.40	.51	.48
Number of older children (7–15)	.58	.59	.63	.62
Dummy ($.10 \leq k2 < .175$)	.24	.26	.34	.34
Dummy ($.175 \leq k2 < .25$)	.13	.15	.19	.21
Dummy ($k2 \geq .25$)	.10	.13	.14	.17
No. of observations	2,576	1,792	1,739	1,301

Table A3
Regression to Predict the After-Tax Hourly Earnings of Nonparticipating Females

Variables	Parameter	*t*-Ratio
Wife's age	.123	1.82
Wife's education	.812	6.10
Number of young children (0–6)	1.173	1.61
Number of older children (7–15)	.768	2.38
Born in the United States or Western Europe	1.664	1.80
Immigrated to Canada less than 5 years ago	−8.910	−2.22
Immigrated to Canada between 5 years and 10 years ago	−2.791	−1.62
Region of residence:		
Quebec	.987	1.15
Ontario	2.668	3.02
Prairies	.169	.17
Alberta	.487	.43
British Colulmbia	.708	.66
Constant	−4.773	−2.57
λ	−.813	−.27
$\bar{R}^2$	0.089	
No. of observations	1,444	

home improvements net of transitory income, expenditures on durables, life insurance premiums, and other security expenditures. Current period allocation of lifetime wealth was computed as the sum of male and female full labor income minus net liquid savings. The net mortgage burden was measured as the excess of the mortgage payments divided

Table A4
Means and Standard Deviation of Variables Used in the Estimation of the Structural Models

Variables	Mean	SD
Male annual hours of work (h_m)	2,086.28	468.93
Male maximum hours of work (T_m)	2,263.09	172.66
Female annual hours of work (h_f)	939.41	874.21
Female maximum hours of work (T_f)	2,045.85	1,114.47
Male net wage ($/hour) ($w_m$)	13.02	6.28
Female net wage ($/hour) ($w_f$)	10.87	6.11
Price index (1981 = 10) (p)	13.16	.37
Total real household expenditures (q)	2,104.51	868.20
Total household expenditures (pq)	27,685.23	11,331.87
Net liquid savings (S)	2,744.61	11,178.01
Current period allocation of lifetime wealth (y)	49,475.46	20,338.06
Net mortgage burden (M_0/k)	14,753.03	11,807.20
Male's age (AGE_m)	43.19	9.96
Male's education (EDU_m)	11.90	3.19
Female's age (AGE_f)	40.72	9.97
Female's education (EDU_f)	11.42	2.90
Number of children ages 0–6 (YKIDS)	.40	.71
Number of children ages 7–15 (OKIDS)	.61	.87

by $k = 0.25$ over the household investment and miscellaneous incomes. Investment and miscellaneous incomes were assumed to be sufficiently stable to be part of the eligible income according to the guidelines of the CMHC, whereas transfer payments were not. The threshold of $k = 0.25$ corresponds to the CMHC threshold that accounts for the other home owners' charges and applies to after-tax income.

References

Abbott, Michael, and Ashenfelter, Orley. "Labour Supply, Commodity Demand and the Allocation of Time." *Review of Economic Studies* 43 (October 1976): 389–411.

Ai, Chunrong; Feinstein, Jonathan; McFadden, Daniel; and Pollakowski, Henry. "The Dynamics of Housing Demand by the Elderly: User Cost Effects." In *Issues in the Economics of Aging,* edited by David A. Wise, pp. 33–87. Chicago: University of Chicago Press, 1990.

Anas, Alex, and Arnott, Richard J. "Dynamic Housing Market Equilibrium with Taste Heterogeneity, Idiosyncratic Perfect Foresight, and Stock Conversions." *Journal of Housing Economics* 1 (March 1991): 2–32.

Arrufat, Jose Luis, and Zabalza, Antonio. "Female Labor Supply with Taxation, Random Preferences, and Optimization Errors." *Econometrica* 54 (January 1986): 47–63.

Artle, Roland, and Variaya, Pravin. "Life-Cycle Consumption and Homeownership." *Journal of Economic Theory* 18 (June 1978): 38–58.

Ashenfelter, Orley, and Ham, John. "Education, Unemployment, and Earnings." *Journal of Political Economy* 87 (October 1979): S99–S116.

Blundell, Richard, and Walker, Ian. "Modelling the Joint Determination of Household Labour Supplies and Commodity Demands." *Economic Journal* 92 (June 1982): 351–64.

———. "A Life-Cycle Consistent Empirical Model of Family Labour Supply Using Cross-Section Data." *Review of Economic Studies* 53 (August 1986): 539–58.

Browning, Martin; Deaton, Angus; and Irish, Margaret. "A Profitable Approach to Labor Supply and Commodity Demands over the Life-Cycle." *Econometrica* 53 (May 1985): 503–43.

Canada Mortgage and Housing Corporation (CMHC). *Insurance Initiation Manual—CMHC Mortgage Insurance Loan Handbook.* Ottawa: CMHC, November 1992. (*a*)

———. *Borrower Eligibility—Practical Advice for Homeownership Loan.* Ottawa: CMHC, October 1992. (*b*)

Card, David. "Intertemporal Labor Supply: An Assessment." In *Advances in Econometrics, Sixth World Congress,* vol. 2, edited by Christopher A. Sims. pp. 49–80. Cambridge: Cambridge University Press. 1994.

Cogan, John F. "Fixed Costs and Labor Supply." *Econometrica* 49 (July 1981): 945–63.

Deaton, Angus. "Saving and Liquidity Constraints." *Econometrica* 59 (September 1991): 1221–48.

Feinstein, Jonathan, and McFadden, Daniel. "The Dynamics of Housing Demand by the Elderly: Wealth, Cash-Flow, and Demographic Effects."

In *The Economics of Aging,* edited by David A. Wise, pp. 55–92. Chicago: University of Chicago Press, 1988.

Fortin, Nicole M. "Borrowing Constraints and Female Labor Supply: Nonparametric and Parametric Evidence of the Impact of Mortgage Lending Rules." Working Paper no. 9308. Montréal: Université de Montréal, March 1993.

Hall, Robert E., and Mishkin, Frederic S. "The Sensitivity of Consumption to Transitory Income: Estimates from Panel Data on Households." *Econometrica* 50 (March 1982): 461–81.

Ham, John. "Testing Whether Unemployment Represents Intertemporal Labor Supply Behavior." *Review of Economic Studies* 53 (August 1986): 559–78.

Hausman, Jerry A. "Labour Supply." In *How Taxes Affect Economic Behavior,* edited by Henry J. Aaron and Joseph A. Peachman, pp. 27–83. Washington, D.C.: Brookings Institution, 1981.

Hayashi, Fumio. "The Effect of Liquidity Constraints on Consumption: A Cross-Sectional Analysis." *Quarterly Journal of Economics* 100 (February 1985): 183–206.

Heckman, James. "The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models." *Annals of Economic and Social Measurement* 5 (Fall 1976): 475–92.

———. "Sample Selection Bias as a Specification Error with an Application to the Estimation of Labor Supply Functions." In *Female Labor Supply: Theory and Estimation,* edited by James P. Smith, pp. 206–48. Princeton, NJ: Princeton University Press, 1980.

Huber, Peter J. "The Behavior of Maximum Likelihood Estimates under Non-standard Conditions." *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability* 1 (1967): 221–33.

Ioannides, Yannis M., and Rosenthal, Stuart S. "Estimating the Consumption and Investment Demands for Housing and Their Effect on Housing Tenure Status." *Review of Economics and Statistics* 76 (February 1994): 127–41.

Johnson, Terry R., and Pencavel, John H. "Dynamic Hours of Work Functions for Husbands, Wives, and Single Females." *Econometrica* 52 (March 1984): 363–89.

Killingsworth, Mark R. *Labor Supply.* Cambridge: Cambridge University Press, 1983.

Lessard, Donald R. "Roll-Over Mortgages in Canada." In *New Mortgage Designs for an Inflationary Environment,* edited by Franco Modigliani and Donald R. Lessard, pp. 131–99. Boston: Federal Reserve Bank of Boston, 1976.

Mariger, Randall P. "A Life-Cycle Consumption Model with Liquidity Constraints: Theory and Empirical Results." *Econometrica* 55 (May 1987): 533–57.

Nakamura, Alice, and Nakamura, Masao. "Part-Time and Full-Time Work Behaviour of Married Women: A Model with a Doubly Truncated Dependent Variable." *Canadian Journal of Economics* 26 (May 1983): 229–57.

Phillips, Richard A., and Vanderhoff, James H. "Two-Earner Households and Housing Demand: The Effect of the Wife's Occupational Choice." *Journal of Real Estate Finance and Economics* 4 (December 1991): 83–91.

Pollak, Robert A., and Wales, Terence J. "Demographic Variables in Demand Analysis." *Econometrica* 49 (November 1981): 1533–51.

Smith, Stephen. "Economic Analysis and the Division of Income within the Family." In *Economic Policy and the Division of Income within the Family,* edited by Stephen Smith, pp. 10–31. London: Institute for Fiscal Studies, 1991.

Venti, Steven F., and Wise, David A. "Aging, Moving, and Housing Wealth." In *The Economics of Aging,* edited by David A. Wise, pp. 9–54. Chicago: University of Chicago Press, 1988.

Vuong, Quang. "Likelihood Ratio Tests for Model Selection and Nonnested Hypotheses." *Econometrica* 57 (March 1989): 307–33.

Vuong, Quang, and Zabel, Jeffrey E. "Likelihood Ratio and Cox Tests: A Comparison." Paper presented at the World Congress of the Econometric Society, Barcelona, August 1990.

White, Halbert. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica* 48 (May 1980): 817–30.

Yoshikawa, Hiroshi, and Ohtake, Fumio. "An Analysis of Female Labor Supply, Housing Demand and the Saving Rate in Japan." *European Economic Review* 33 (May 1989): 997–1030.

Zeldes, Stephen P. "Consumption and Liquidity Constraints: An Empirical Investigation." *Journal of Political Economy* 97 (April 1989): 305–46.

Zorn, Peter M., and Lea, Michael J. "Mortgage Borrower Repayment Behavior: A Microeconomic Analysis with Canadian Adjustable Rate Mortgage Data." *Journal of the American Real Estate and Urban Economics Association* 17 (Spring 1989): 118–35.