Provincial Variations in the Determinants of Retrofitting Behaviour in the Context of the CHIP and COSP Programmes: I. Dwelling Characteristics

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This is the first of two papers that assess the determinants of retrofitting behaviour in the context of the Canadian Home Insulation Programme (CHIP) and Canadian Oil Substitution Programme (COSP) and explain provincial variations in this behaviour. This paper concentrates on dwelling characteristics as determinants of retrofitting; the second paper examines household characteristics by themselves and in comparison with dwelling characteristics.

The binary logit model is used to analyze the 1982 HIFE (Household, Income, Facilities, and Equipment) data set, which contains detailed information on a large sample of Canadian households. This is the first study to utilize the HIFE data and logit analysis in assessing CHIP and COSP. A previous assessment of CHIP by the U.S. House of Representatives (1979) preceded the peak period of retrofitting activity in Canada. The most comprehensive examination of CHIP was undertaken by Energy, Mines and Resources (1983) and incorporated the results of consulting firms and government research. That study, however, was not conducted within a rigorous

© Canadian Journal of Regional Science/Revue canadienne des sciences régionales, XIV:1 (Spring/printemps 1991), 113-128.
ISSN: 0705-4580 Printed in Canada/Imprimé au Canada

analytical framework. Little analysis of COSP has taken place with the exception of a study by Anderson et al. (1983). It is important to emphasize that none of these studies are retrospective since they were conducted while the programmes were still in effect.

The first section of this paper describes the CHIP and COSP programmes, and the second section examines the background literature. The sections that follow detail the HIFE data and the variables relevant to this study. An outline of the model used for this analysis and its specification is next, followed by a discussion of the major results. In the concluding section, the contribution of this paper is summarized, and some pointers to the analysis in the follow-up paper are given.

A Description of CHIP and COSP

The CHIP and COSP programmes represented the core of the federal government's attempt in the 1970s and 1980s to improve the thermal efficiency of the Canadian housing stock with a view toward reducing dependency on foreign oil. The forerunner of CHIP was the Home Insulation Programme (HIP) of Nova Scotia and Prince Edward Island. When the federal government was sufficiently encouraged by the public response to HIP, the other provinces were included in CHIP, which was initiated in 1977. While HIP offered non-taxable grants to assist in improving thermal efficiency, CHIP grants were taxable as income to the prospective households.

It was not until 1979 that CHIP became popular. Initially, the programme provided taxable grants covering two-thirds of the cost of insulation and draft-exclusion materials up to a maximum of $350 for all houses constructed before 1946. By 1982, the grants covered the full cost of the materials up to $350 and one-third of labour costs up to $150 on all houses built before 1971. Later, the programme was expanded to include as eligible all dwellings built up until 1977. This shift in the eligibility of households reflected the government's effort to maintain demand for insulation materials at a level with which the industry could cope (Energy, Mines and Resources 1983). Considering the slow response of Canadians to CHIP from 1977 to 1979, this measure was initially unjustified. In 1984, the new Conservative government began to reduce the grants, and CHIP was terminated on March 31, 1986, having provided 2.4 million grants at a cost of approximately $900 million (Energy, Mines and Resources 1986). Almost one-third of the eligible housing stock had been retrofitted under this program.

The Canadian Oil Substitution Programme was introduced in 1980 as part of the federal government's major energy policy initiative, the National Energy Programme (NEP). One of the main objectives of NEP was to reduce the need for foreign oil. To reduce oil consumption in the residential sector, the government offered $800 grants to homeowners wishing to convert from oil to such fuels as natural gas, electricity, propane, and, in rural areas, wood and solar energy. Grants of up to $5,500 were available for centrally heated, multiunit dwellings (*Globe and Mail* 1981). In effect from October 28, 1980, to March 31, 1985, COSP assisted in the conversion of heating systems in 1.1 million dwelling units. In Ontario, for example, only 20 percent of households were heated with oil by 1985, compared with 54 percent in 1970 (Ontario Ministry of Energy 1986).

Background Literature

A substantial empirical research base exists on the determinants of retrofitting behaviour—but largely in the American context. The categorical dependent variable associated with retrofitting necessitated the use of logit models in many of these studies. Although analytical papers relating to CHIP and COSP are conspicuous by their absence, the American studies are helpful in understanding the behaviour of Canadians. The major findings of this body of research are presented in this review.

Variables reflecting dwelling characteristics are in general better predictors of retrofitting behaviour than those related to the social and economic characteristics of households. For example, the age of a dwelling is an excellent variable (Smiley 1979; Walsh 1989; Hirst et al. 1981, 1983; Hirst and Goeltz 1982), with the older dwellings being the more likely candidates for improvements. Tonn and Berry (1986) point out, however, that this variable cannot be used to predict participation in home audit programmes where owners of newer houses are equally interested in having their homes appraised, even if only to confirm that their homes are indeed thermally efficient. Larger dwellings are also more likely to retrofit (Laquatra and Chi 1989; Curtin 1976), but people who live in multifamily dwellings are less likely to make an energy improvement (Walsh 1989).

There is evidence that the fuel used to heat a dwelling can play a role in predicting insulation levels. Smiley (1979) found that electrically heated homes are better insulated because they represent a newer housing stock and because electricity is expensive. Walsh (1989) provided evidence that the future price of a homeowner's fuel is a reasonably good predictor of conservation action. Laquatra and Chi (1989) observed that families heating with oil were the most likely to invest in improvements, while the opposite was true for those in electrically heated homes. They reason that the decentralized nature of electric heating allows room-to-room control of the temperature and more prudent use of energy. In addition, the higher thermal efficiency of electrically heated homes minimizes the need to retrofit.

The Data

The Household, Income, Facilities, and Equipment (HIFE) data set is a 1982 sample of 35,595 Canadian households, which at the time represented approximately 0.42 percent of all Canadian households. This data set consolidates information from four surveys administered by Statistics Canada: the Household Facilities and Equipment Survey (May 1982), Labour Force Survey (April 1982), Survey of Consumer Finances (April 1982), and Rent Survey (April 1982). The sampling methodology used for the overall HIFE set is patterned after the methodology of the Labour Force Survey, which is described as a "multistage stratified clustered probability sample". To ensure that estimates made from analysis of the data are representative of the actual national values, a weighting scheme is used to eliminate bias introduced by the sampling methodology. Each case is weighted according to the number of households that it represents nationally. Thus, the 35,595 households have a total weighted count of 8,429,220.

Retrofitting Behaviour and Dwelling Characteristics

Retrofitting behaviour is expressed in the data set as a variable defined as "energy improvements made in the past three years (i.e. 1979-82) to owner-occupied dwellings". The variable is composed of 10 categories: seven that involve combinations of insulation improvements, heating equipment improvements, and draft exclusion; one that accounts for those households that make no energy improvements; and two that represent rented dwellings and dwellings in which recent energy improvements are not known. Households in the latter two categories are excluded from the analysis.

It is uncertain whether households were aware that draft exclusion was covered under a CHIP grant, especially in light of the fact that CHIP became marketed by contractors as an attic insulation program (Energy, Mines and Resources 1983). As a result, households that draft excluded *only* were removed from the analysis, and households that draft excluded in conjunction with some other measure were retained.

Insulation improvements can involve materials added to the attic, roof, walls, or basement. A heating equipment improvement refers to both space and water heating and includes the installation of a wood stove, new furnace, or heat pump. Draft exclusion includes such measures as weatherstripping, caulking, new storm doors and windows, or the replacement of poorly fitting doors and windows. A homeowner who has made no energy improvements may have undertaken such regular maintenance as cleaning the furnace filter or repairing existing caulking and weatherstripping.

Six variables related to dwelling characteristics are taken from the data, most of which have emerged as important determinants of retrofitting behaviour in past literature: period of dwelling construction, primary heating fuel, size of dwelling, dwelling repairs needed, age of heating equipment, and type of dwelling. The categorical variable for period of dwelling construction, depicted in Table 1, reveals that the tendency to retrofit increases roughly with the age of the dwelling.

The fuel variable refers to the primary heating fuel being used in May 1982, at the end of the three-year period under consideration. The four categories used in the analysis are oil, gas, electricity, and wood. Two other categories—coal or coke and other (such as solar)—were omitted because the numbers are negligible in many provinces. From Table 1, dwellings heated with oil and wood appear the most likely to have undergone energy improvements, while those heated with gas and electricity are less likely to have been improved. Among dwellings heated with oil or gas, there is little difference between retrofitters and non-retrofitters.

The number-of-rooms-in-dwelling variable is a surrogate for the size of a dwelling. Past studies have indicated a positive relationship between dwelling size and conservation action. This particular surrogate may have limitations in the sense that two dwellings of quite different size can have the same number of rooms. In the data, this variable ranges in value from one to nine, with the last category representing all households with nine or more rooms. Table 1 indicates that dwellings with six or more rooms are more likely to retrofit than not, while the opposite is true of smaller dwellings.

The "dwelling repairs needed" variable has not been studied in the past. It might be expected that homeowners who perceive a need for substantial repairs in their dwellings are more likely to have undertaken renovations, such as energy improvements, in the recent past. Current perceptions may reflect past retrofitting behaviour. Indeed, this variable is composed of three categories: major repairs needed, minor repairs needed, and regular maintenance only required. Major repairs needed are serious structural deficiencies in the

TABLE 1 Retrofitters versus Non-retrofitters by Dwelling Characteristics (millions of households)

	Non-retrofit		Retrofit		Total	
	No.	%	No.	%	No.	%
A. Period of dwelling construction						
Pre-1940	0.422	17.7	0.624	27.2	1.046	22.4
1940-1949	0.163	6.8	0.256	11.2	0.419	9.0
1950-1959	0.275	11.5	0.504	22.0	0.779	16.7
1960-1969	0.510	21.5	0.445	19.4	0.955	20.4
1970-1980	1.009	42.4	0.464	20.2	1.473	31.5
B. Primary heating fuel						
Oil	0.786	33.1	0.811	35.3	1.597	34.2
Gas	1.010	42.4	0.922	40.2	1.932	41.4
Electricity	0.486	20.4	0.353	15.4	0.839	17.9
Wood	0.097	4.1	0.208	9.0	0.305	6.5
C. Size of dwelling (Number of rooms)						
Four or less	0.240	10.1	0.192	8.4	0.432	9.2
Five	0.574	24.1	0.476	20.7	1.050	22.5
Six	0.590	24.8	0.597	26.0	1.187	25.4
Seven	0.436	18.3	0.454	19.8	0.890	19.0
Eight	0.285	12.0	0.310	13.5	0.595	12.7
Nine	0.255	10.7	0.264	11.5	0.519	11.1
D. Dwelling repairs needed						
Major	0.255	10.7	0.429	18.7	0.684	14.6
Minor	0.292	12.3	0.372	16.2	0.664	14.2
Maintenance	1.832	77.0	1.492	65.1	3.324	71.1
E. Age of heating equipment						
< 5 years	0.467	19.6	0.729	31.8	1.196	25.6
5-10 years	0.661	27.8	0.439	19.1	1.100	23.5
> 10 years	1.251	52.6	1.125	49.0	2.376	50.8
F. Type of dwelling						
Single-family detached	1.868	78.5	1.977	86.2	3.845	82.3
Other types	0.511	21.5	0.317	13.8	0.828	17.7
Total	2.379	100.0	2.294	100.0	4.672	100.0

Note: Chi-square: A: 33,275; B: 6,299; C: 1,964; D: 8,606; E: 10,775; F: 4,681. Significance: 0.0000 in all cases.

dwelling, as well as problems with the plumbing, electrical, and heating systems. Minor repairs include deficiencies in the dwelling surface and covering material and less serious problems with plumbing, electrical, and heating systems. Regular maintenance refers to such upkeep as painting and unclogging gutters or eaves. According to Table 1, households that perceive a need for minor or major repairs have an increased tendency to retrofit.

The age of the principal heating equipment is a useful variable. Although this variable cannot be used to predict heating equipment improvements in the previous three years, it is relevant as a predictor of other types of retrofitting behaviour. In the latter two categories (that is, equipment more than five years old), retrofitting increases with older heating equipment (Table 1). When the heating equipment is less than five years old, it is probable that it was installed in the previous three years, the time span defined by the dependent variable. Thus, there is a high proportion of retrofitters in the category with the newest heating equipment.

Finally, since renters have been omitted from this analysis of owner-occupied housing, it makes little sense to concentrate on the different types of dwellings in any detail. Apartment dwellers and people living in row housing, for example, would be underrepresented, and their predicted behaviour patterns would be biased. As a result, dwelling type is presented as a binary variable to test the hypotheses that CHIP and COSP had a more substantial impact on single-family detached dwellings. Clearly, as Table 1 indicates, people who live in single-family detached dwellings are more likely to retrofit.

The Model and Model Specification

In the past, discrete choice models have been used in the multivariate analysis of retrofitting determinants (Tonn and Berry 1986; Walsh 1989). Following in this tradition, we utilize a binary logit model

$$\ln (P_1/P_0) = ß_0 + ß_1X_1 + \ldots + ß_nX_n$$

where P_0 and P_1 are the probabilities of not retrofitting and retrofitting, respectively, $X_1 \ldots X_n$ are independent variables, and $ß_0 \ldots ß_n$ are parameters to be estimated—see Wrigley (1985) and Ben-Akiva and Lerman (1985) for a thorough introduction to logit modelling.

Because this paper assesses the impacts of CHIP and COSP separately, two distinct types of models are useful: one that contrasts those who undertake at least some insulation improvement (CHIP) with those who perform no energy improvement, and one that compares those who improve their heating equipment (COSP) with those who make no improvement. Four categories in the 10-category variable imply an insulation improvement and, likewise, four categories are indicative of an equipment improvement. In each case, the four categories of households associated with energy improvements are grouped into one category which is contrasted with the non-retrofitters to form a binary dependent variable. Households that insulated *and* improved their heating equipment participate in both models.

A household considered in this analysis as a non-retrofitter may in fact be one that took advantage of the incentive programmes before 1979 or after mid-1982—the latter, of course, being far more likely since COSP commenced in 1980 and the initial response to CHIP was poor. As a result, the distinction in the models between a retrofitter and a non-retrofitter is not as clear as it might be. Certainly, we are able to contrast those households that respond *quickly* to government incentive programmes with others that respond slowly or not at all.

One possible alternative model is the multinomial logit in which the four alternatives would be defined as (1) make no energy improvement, (2) insulate only, (3) improve equipment only, or (4) insulate *and* improve equipment. Although such a model would be more complete, it does not allow independent evaluation of CHIP and COSP, and it would be more difficult to disentangle the results obtained. Thus, the binary model discussed previously is used in the analysis with the following specification and usage of independent variables.

With the exception of dwelling size (number of rooms), all the other variables are categorical, each with multiple categories. The number of dummy variables representing each categorical variable equals the number of categories minus one. The category left out is viewed as the base category. Thus, in the case of the first characteristic (period of dwelling construction) for which the 1970-1980 category is viewed as the base category, there are four dummy variables: $x_1 = 1$ if the dwelling was built in pre-1940 and 0 otherwise; $x_2 = 1$ if it was built in 1940-1949 and 0 otherwise; etc.

The logistic regression program SPSS-PC was used to estimate the parameters of the models. The statistic rho-squared, used to assess the overall goodness-of-fit of the model—that is, $\rho^2 = 1 - L(ß)/L(c)$— is not provided by the program. Nevertheless, sufficient information is provided to calculate rho-squared manually. In the rho-squared formula, L(ß) refers to the value of the log-likelihood function with the final parameter estimates, and L(c) is the value of the log-likelihood function when a model including only the constant term is calibrated. This formula permits equitable comparisons of model fit, which allow for differing proportions of retrofitters and non-retrofitters in the provinces.

Results

The constant terms shown in the models of Tables 2 and 3 are generally negative and strongly significant. Thus, the households in the anchor group—that is, the households defined by dummy variables all equal to zero—are less likely to make energy improvements. Those are households in non-single-family detached houses built in the 1970s with no need for repairs and with new (less than five years old) wood-burning heating equipment. Positive parameter estimates will increase the value of the constant and the odds of retrofitting as opposed to non-retrofitting. The opposite is true for negative parameter estimates.

Period of Dwelling Construction

The variable "period of dwelling construction" best predicts insulation improvements. To a lesser extent, this variable also excells at predicting the improvement of heating equipment. According to Tables 2 and 3, the period-built parameter estimates for insulation improvements are, in most provinces, more significant than those for heating equipment improvements.

In analyzing the differential provincial impact of this variable, note that the Maritime provinces had by far the highest dependence on oil (for example, a 75 percent reliance in Prince Edward Island), while no non-Maritime province had a dependence in excess of 50 percent. Since Maritime oil originated from potentially unstable foreign sources, energy conservation was a political issue in the Maritimes, and HIP received strong support from every level of government (U.S. House of Representatives 1979: 14), not to mention the general public. Thus, this data set examining the period from mid-1979 to mid-1982 reflects a considerably more developed conservation awareness in the Maritimes than in the other provinces, where in 1979 CHIP had hardly been utilized (*Globe and Mail* 1979).

What accounts for the comparative lack of significance of the period-built variable in the Maritimes? In households with a low level of retrofitting awareness, it is suggested that the age of the dwelling is the most important determinant of that household's tendency to act. These homeowners may be poorly informed, and they may incorrectly assume that energy improvements are for older housing. As awareness increases, however, homeowners realize that retrofitting can save money regardless of the dwelling age and that, generally, something can always be done to improve thermal efficiency.

TABLE 2 Results of Binary Logit Model of Insulation Improvements versus No Energy Improvements

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC
Period of dwelling construction										
Pre-1940	0.33*	0.43*	0.73***	1.66***	1.65***	1.38***	1.22***	1.22***	1.55***	1.71***
1940-1949	0.43*	1.11***	0.86***	1.56***	1.77***	1.72***	1.22***	1.09***	1.72***	1.48***
1950-1959	0.94***	0.68	1.18***	1.48***	1.84***	1.78***	1.51***	1.41***	1.95***	1.72***
1960-1969	0.69***	0.86***	0.92***	1.29***	1.29***	0.99***	0.66***	0.78***	0.76***	0.79***
Primary heating fuel										
Oil	-0.41**	-0.80***	-0.27*	0.18	-0.04	-0.30	-0.06	-0.02	0.08	-0.19
Gas	—	—	-0.32	0.17	-1.03***	-0.22	0.17	0.24	0.22	-0.35
Electricity	-0.59***	—	-0.33	0.07	-0.26	-0.74***	-0.02	-0.12	-0.29	-0.58**
Size of dwelling (No. of rooms)	0.09**	0.24***	0.13***	0.15***	0.08***	0.15***	0.06*	0.04	0.04	0.11***
Dwelling repairs needed										
Major	0.39**	0.42*	0.48***	0.11	0.69***	0.43***	0.33**	0.08	0.28*	0.36**
Minor	0.42**	0.57**	0.38***	0.34**	0.23*	0.16	0.12	-0.15	0.36***	0.17
Age of heating equipment										
>10 years	-0.69***	-0.37	-0.69***	-0.90***	-0.98***	-0.74***	-1.05***	-0.23	-0.29**	-1.21***
5-10 years	-0.20	-0.14	-0.22**	-0.40***	-0.49***	-0.38***	-0.35***	0.42***	-0.07	-1.01***
Type of dwelling										
Single-family detached	0.79***	0.47	0.22	0.11	0.61***	0.21**	-0.05	0.56***	0.38**	0.48***
Constant	-0.81***	-1.86***	-1.36***	-2.09***	-1.90***	-1.39***	-0.53	-1.66***	-2.26***	-1.69***
Sample size	1,406	1,543	1,470	1,548	2,605	3,869	1,838	2,375	2,462	2,044
Rho-squared	0.07	0.09	0.05	0.09	0.12	0.09	0.06	0.04	0.10	0.11

* Significant at 0.1. ** Significant at 0.05. *** Significant at 0.01.

Note: Dashes indicate insufficient or no observations falling into that category for the given province.

TABLE 3 Results of Binary Logit Model of Equipment Improvements versus No Energy Improvements

	Nfld	PEI	NS	NB	Que	Ont	Man	Sask	Alta	BC
Period of dwelling construction										
Pre-1940	-0.55**	-0.26	-0.34*	0.03	1.07***	1.25***	1.25***	1.75***	1.46***	1.45***
1940-1949	-0.32	-0.28	0.28	-0.08***	1.49***	1.46***	1.3***	1.42	1.36***	1.01***
1950-1959	0.39	-0.18	0.22	-0.04	1.6***	1.76***	1.96***	1.99***	1.69***	1.1***
1960-1969	0.2	-0.15	0.42*	0.11	1.12***	0.29*	0.5**	1.17***	0.79***	0.67***
Primary heating fuel										
Oil	-1.8***	-1.54***	-1.48***	-1.52***	-1.13***	-1.98***	-2.33***	-1.47***	-0.74	-2.49***
Gas	—	—	-0.27	0.09	-0.95***	-1.39***	-2.14***	-1.58***	-1.31**	-2.44***
Electricity	-1.15***	—	-1.13***	-0.96***	0.19	-1.06***	-0.93***	-0.19	-5.48***	-1.99***
Size of dwelling (No. of rooms)	0.05	0.38***	0.18***	0.14***	0.09**	0.2***	0.1**	0.14***	0.04	0.17***
Dwelling repairs needed										
Major	0.07	0.41	0.85***	-0.01	0.58***	0.68***	0.2	0.47**	0.44	-0.07*
Minor	0.04	0.62**	0.77***	0.3*	0.43***	0.08	0.18	0.16	0.54**	0.37**
Type of dwelling										
Single-family detached	0.58**	0.26	0.5**	-0.05	-0.01	0.38***	-0.24	-0.95***	-0.68***	0.1
Constant	-0.35	-2.13***	-1.74***	-0.7**	-2.15***	-2.0***	-0.79**	-1.44***	-1.49**	-0.93***
Sample size	921	474	1,174	1,340	2,157	2,666	1,223	1,438	1,807	1,888
Rho-squared	0.10	0.14	0.11	0.08	0.10	0.12	0.12	0.09	0.08	0.13

* Significant at 0.1.
** Significant at 0.05.
*** Significant at 0.01.

Note: Dashes indicate insufficient or no observations falling into that category for the given province.

Interestingly, the impact of the period-built variable does not appear to increase linearly with older dwellings. Those constructed between 1950 and 1960 are more likely to retrofit than would be expected. Possibly, this post-war period of perceived infinite energy supply led to relaxed building standards and thus a thermally less efficient housing stock in comparison with older and newer dwellings. Also, dwellings built in the fifties were newly eligible for CHIP (pre-1961 dwellings were eligible in the time period studied) and thus may have been retrofitted at an increased rate for this reason.

Primary Heating Fuel

The fuel variable refers to the principal heating fuel used in May 1982 at the *end* of the three-year period under examination. The type of fuel does not seem to be a good predictor of an insulation improvement (Table 2). It might be expected that houses heated with expensive fuels, or fuels thought to be expensive in the future, would be more likely to insulate, but this hypothesis is generally not supported. In fact, the opposite is true in British Columbia, Ontario, and Newfoundland, where households heating with electricity, a more expensive fuel, are the least likely to insulate. This finding likely reflects the well-insulated nature of the newer electrically heated homes. Interestingly, households that heat with wood tend to be the most likely to insulate. A possible explanation is that a homeowner willing to accept the relative inconvenience of heating with wood is more likely to possess the necessary initiative to insulate.

It is noteworthy that in three of the four Maritime provinces, oil is unlikely to encourage an insulation improvement in comparison with other fuels. Of course, the fact that these households were still using oil in 1982 indicates that they disregarded COSP and may have viewed CHIP similarly. Moreover, homeowners heating with other fuels felt that they too could benefit from insulating and that it was not a measure uniquely for oil-heated homes.

The primary heating fuel is a better discriminator when applied to a heating equipment improvement model (Table 3). Houses that were heated with wood and electricity in mid-1982 were more likely to have upgraded their heating equipment in the previous three years. Electrical systems are often decentralized in nature, meaning that the simple addition of a baseboard heater in one room constitutes an improvement in equipment. Certainly, households heating with an older wood stove would have viewed an improvement favourably since there has been considerable recent progress in more efficient wood space heaters and furnaces that are inexpensive when compared with equipment that uses other fuels (Energy, Mines and Resources 1985).

It must be remembered that the time period of the data set (1979-1982) does not coincide entirely with the COSP programme, which extended from late 1980 to early in 1985. As a result, the expected trend that people heating with gas would be more likely to have made an equipment improvement than those heating with oil does not strongly materialize. The expected relationship between oil and gas does exist in all provinces except Alberta and Saskatchewan, but it is not generally significant. Since western households heated with domestic oil, they would not have felt the same urgency to change fuels as Maritime households.

The lack of strong differentiation in the equipment models between oil, gas, and electricity reflects the fact that even with an $800 grant a heating conversion away from oil was viewed as a formidable expense. Many homeowners who heated with oil compensated for the uncertainty of oil prices by pursuing other measures such as insulation. There is evidence that many people were simply not informed about their numerous equipment options under COSP (Anderson et al. 1983). For example, partial conversions were available, allowing homeowners to improve their heating systems without radically altering them. Also, complementary measures such as heat pumps were eligible improvements (Energy, Mines and Resources 1985). Overall, people were not as well informed about COSP, a programme with many potential measures, as they were about CHIP, a programme that was more readily understood.

Size of Dwelling

One might expect that as the size of a dwelling increases, the additional heating cost would provide a greater incentive to retrofit. Using the number of rooms in a dwelling as a surrogate for size of dwelling, this hypothesis was tested and proved true, but the relationship was not significant in each province. "Number of rooms" does not predict significantly better an equipment improvement as opposed to an insulation improvement, but the parameter estimates are consistently larger. There is the possibility that in larger dwellings homeowners perceive the conversion of inadequate heating equipment to be relatively less costly than installing insulation, while the opposite is true in smaller dwellings. There are no interpretable provincial variations in the behaviour of this variable.

Dwelling Repairs Needed

The "repairs needed" variable is behaviourial in nature in that it assesses how a homeowner's current perception of the dwelling affects the likelihood that retrofitting activity has taken place in the previous three years. There is generally no significant difference in the effects of a perceived need for major versus minor repairs, implying that the important aspect is whether the homeowner thinks regular maintenance alone is sufficient. According to the models, homeowners who feel that their dwellings require something more than regular maintenance are more likely to retrofit. There are no major differences in the behaviour of this variable among the provinces, although it is not significant in every province and there are no grounds for saying that the perceived need for repair better predicts a past insulation improvement (Table 2) as opposed to a past heating equipment improvement (Table 3).

Age of Heating Equipment

This variable was applied to the insulation model to determine whether equipment improvements are indicative of simultaneous insulation improvements. The consistent significance of this variable across the provinces would seem to suggest that they are. If the principal heating equipment was installed in the previous five years, it is considerably more likely that an insulation improvement was undertaken in the preceding three years. Apparently, homeowners are likely to undertake more than one type of retrofitting improvement once they have made the initial decision to retrofit. Even if the equipment was installed five to ten years previously, there is an increased likelihood of a recent insulation improvement in comparison to households having older heating equipment. It might be argued that households improving heating equipment between 1972 and 1977 were "energy aware" in the sense that their actions preceded government initiatives. Homeowners of this type should be more likely to insulate at some point, as the models show. Finally, there are no noticeable provincial trends related to this variable, a fact that is not surprising.

Type of Dwelling

A trend apparent from the insulation models is that single-family detached dwellings are more likely to have been insulated than other types of dwellings. From the point of view that these kinds of dwellings are larger and have more exposed walls, this finding is to be expected. In contrast, single-family detached dwellings are not necessarily more likely to have upgraded their heating equipment. But the provinces in which the parameter estimate is significantly negative—Alberta and Saskatchewan—are also the provinces that

have extremely high concentrations of natural gas systems in such dwellings. Thus, little incentive would have existed to upgrade heating equipment. Undoubtedly, dwelling type is a better predictor of an insulation improvement than an equipment improvement.

Conclusions

The models described here are characterized by relatively poor fits; nevertheless, many variables are significant. To some extent, the large provincial samples make the models more sensitive while not guaranteeing good fits. Almost without exception, the equipment models are better fits than the insulation models, implying that insulation improvements are more difficult to predict. Acceptance of CHIP was so widespread that many variables that otherwise differentiate between retrofitters and non-retrofitters do not do so as successfully. Use of the HIFE weighting scheme improved the models' explanatory powers and served to create unbiased provincial and national representations in the models and the national cross-tabulations.

The use of a logit model for each province yielded interesting results. Some of the variables had a generic impact in the sense that their effects were similar in each model. Such variables are number of rooms, dwelling repairs needed, and the age of the principal heating equipment. Other variables, such as the period of dwelling construction and the primary heating fuel, had a differential impact, depending on the province's energy situation.

There are distinct differences between the Maritime models and all the other models. The age of the dwelling is a dominant variable in all non-Maritime provinces but in many cases is not significant in the Maritime models. The foreign oil dependence of eastern Canada provided Maritimers with an incentive to recognize that newer dwellings also can benefit from energy improvements. Other variables discussed in the second paper may describe Maritime retrofitting behaviour better.

In the follow-up paper, these initial findings will be examined in the context of such household characteristics as income and level of education. The ability of socio-economic variables to predict retrofitting behaviour in comparison with dwelling characteristic variables will be assessed and the implications for future research discussed, especially if it is decided that neither group of variables satisfactorily accounts for retrofitting variance. The follow-up study will assimilate the results of the two papers and consider the policy implications of the findings.

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