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Explaining Consumption: A Simple Test of Alternative Hypotheses[1]

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Abstract

A method of testing the relative importance for consumption of risk sharing behavior and changes in current income is proposed and estimated using data across Canadian provinces. The focus of the estimation is less on whether or not the risk sharing model can be rejected than on how much each of these hypotheses can contribute to explaining overall variation in consumption. Both types of behavior are found to be statistically significant, but the risk sharing model is found to explain considerably more of the growth in consumption than does changes in income.

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SUMMARY

As might be expected from an activity that comprises well over half of aggregate economic spending, the behavior of private consumption remains one of the most important areas of economic research. As yet, however, there is little consensus on how to characterize the behavior of consumption empirically, with some investigators focusing on the importance of optimizing behavior in a world with complete markets and infinitely lived consumers and others on the impact of market imperfections, rules of thumb, and life-cycle effects.

This paper combines elements of both literatures. Methodologically, a new specification for testing the *relative* importance of the path implied by risk sharing and by sensitivity to current income is derived. The specification is tested using data on consumption across Canadian provinces. The results indicate that both types of behavior are statistically significant. However, most of the marginal explanatory power comes from risk-sharing behavior rather than from changes in income, and the inclusion of terms that capture the behavior of fully insured consumers reduces the estimated proportion of consumption associated with changes in income.

These results may help explain why the empirical characterization of consumption has been difficult to resolve. They imply that, while changes to income are a significant factor in explaining consumption, its importance may have been overstated in models that take no account of risk-sharing behavior. At the same time, the sensitivity to income is small enough to be difficult to identify in microeconomic data sets, where the data suffer from large amounts of noise. In summary, changes in income appear to be a significant, but relatively subsidiary, part of the explanation of variations in consumption, at least across Canadian provinces.

I. INTRODUCTION

As might be expected from an activity which comprises well over half of aggregate economic spending, the behavior of private consumption remains one of the most important areas of economic research. As yet, however, there is little consensus on how to characterize this behavior empirically, with some investigators focusing on the importance of optimizing behavior in a world with complete markets and infinitely lived consumers, and others on the impact of market imperfections, rules of thumb, and life-cycle effects. This paper provides a way of assessing the *relative* contribution of these different types of behavior to aggregate consumption.

Much of the recent empirical work on consumption has focused on the adequacy of the permanent income hypothesis, as characterized by the "random walk" model proposed by Hall (1978). Two strands of research can be identified in this literature. The first has focused on further describing, extending, and testing the degree to which consumption corresponds to this optimizing model.[2] Most recently, such work has focused on the implications of full contingent markets for the path of consumption across individuals.[3] The central insight is that if people use such markets to insure themselves against idiosyncratic risks then consumption movements across individuals should be the same and, in particular, that they should be unaffected by personal circumstances.

By contrast, the other strand of the literature has focused attention on assessing the degree to which consumption deviates from the predictions of the permanent income hypothesis. In particular, there is now a large empirical literature looking at the sensitivity of consumption to (predictable) changes in income.[4] Various explanations of this behavior have been suggested, including liquidity constraints and the use of simple rules of thumb. Most

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[2]For example, Campbell (1987).

[3]For example Mace (1991), Cochrane (1991), and Townsend (1994). Townsend also provides a survey of evidence from other work. Obstfeld (1994) uses a similar approach to look at consumption across countries.

[4]The "excess" sensitivity of consumption to income was originally highlighted by Flavin (1981). Subsequent work estimating the size and importance of such "liquidity constraints" includes Campbell and Mankiw (1989 and 1990) and Japelli and Pagano (1991) on the macroeconomic side, and Hall and Mishkin (1982), Hayashi (1985), Zeldes (1989), and Hubbard, Skinner and Zeldes (1994) on the microeconomic side. Other authors using microeconomic data, however, have failed to find evidence of liquidity constraints, including Altonji and Siow (1987), Runkle (1991), and Maringer and Shaw (1993). This microeconomic evidence is surveyed in Browning and Lusardi (1995). One reason for this variety in results from microeconomic studies may be different approaches to the problems of the underlying microeconomic data, as discussed in Lusardi (1995).

recently, theoretical work using precautionary saving and liquidity constraints in life cycle models has tried to rationalize the behavior of consumers, including the sensitivity of consumption to income, with observed microeconomic and macroeconomic data.[5]

This paper combines elements of both literatures. Methodologically, a new specification for testing the *relative* importance of the path implied by risk sharing and by sensitivity to current income is derived. The specification is tested using data on consumption across Canadian provinces. Canadian provinces are subject to relatively large and persistent idiosyncratic income disturbances, making them a particularly good test of the difference between changes in income and risk sharing behavior. They also provide a useful benchmark against which to compare results for consumption across countries, and to look at the macroeconomic significance of these alternative theories. Empirically, the focus is less on whether or not the models can be rejected based on parameter constraints than on how much each of the main hypotheses—risk sharing and sensitivity to current income—can contribute to explaining overall variation in regional consumption.

To anticipate the conclusions in advance, while both hypotheses are found to be statistically significant, the risk sharing model explains considerably more of the variation in consumption than does changes in current income. It is also found that the estimated proportion of consumption associated with changes in income is significantly smaller once allowance is made for risk sharing behavior.

II. THEORY

Much of the recent empirical work on consumption has focused on the Euler equation defining optimal behavior. As formulated by Hall, this assumes that rational, infinitely lived consumers maximize the expected value of their utility, subject to an intertemporal budget constraint. Given free access to capital markets and assuming that the utility for nondurable consumption is separable,[6] the solution to the optimization problem yields the equation:

$$E_{t-1}\{(U'(C_t)/U'(C_{t-1}))(\beta/(1+R_{t-1}))\} = 1 \qquad (1)$$

where C_t is nondurable consumption, E_{t-1} is the mathematical expectation conditional on the information available at t-1, β is a subjective discount factor, R_{t-1} is the real interest rate between t-1 and t.

If the utility function U(.) is assumed to have a constant elasticity of intertemporal substitution ($U=C_t^{1-\Psi}$) and the errors are log-normal, then the solution to the model is:

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[5]Hubbard, Skinner, and Zeldes (1994, 1995), Deaton (1992), and Carroll (1992).

[6]This assumption is relaxed later.

$$\Delta c_t = \Psi(\sigma^2_t/2) + \Psi^{-1}\ln(\beta(1+R_{t-1})) + \epsilon_t, \tag{1'}$$

where c_t is $\log(C_t)$, σ^2_t is the variance of future shocks to the change in the logarithm of consumption, R_{t-1} is the real interest rate between t-1 and t, and the error ϵ_t represents unexpected revisions to permanent income, which should be orthogonal to all information known at t-1 or earlier.

This implies the following path for consumption across provinces a, b, to r:

$$\begin{aligned} \Delta c_{at} &= \Psi(\sigma^2_{at}/2) + \Psi^{-1}\ln(\beta(1+R_{t-1})) + \epsilon_{at} \\ \Delta c_{bt} &= \Psi(\sigma^2_{bt}/2) + \Psi^{-1}\ln(\beta(1+R_{t-1})) + \epsilon_{bt} \\ \Delta c_{rt} &= \Psi(\sigma^2_{rt}/2) + \Psi^{-1}\ln(\beta(1+R_{t-1})) + \epsilon_{rt} \end{aligned} \tag{2}$$

where equations (2) assume the provinces face the same ex ante real interest rate and have the same utility function—in particular, they have the same intertemporal elasticity of substitution and discount rate. (The implications of relaxing these constraints will be discussed further below.)

The central insight of the risk sharing literature is that unexpected changes to permanent income, and hence the errors in these equations, should be highly correlated across provinces. This is because individuals have an incentive to insure against idiosyncratic risk. In the limiting case of full and costless contingent markets, all such idiosyncratic risk will be avoided and unexpected revisions to permanent income (and hence changes in consumption) will be identical across all provinces.[7] This implies the following path for consumption:

$$\Delta c_{at} = \Psi(\sigma^2_t/2) + \Psi^{-1}\ln(\beta(1+R_{t-})) + \epsilon_t \tag{2'}$$

The crucial difference from equation (2) is that the variance and error terms have no province-specific subscripts, implying identical behavior across provinces.

The possibility that consumption is dependent upon current income can be added to this specification by dividing consumers into two types, along the lines proposed by Campbell and Mankiw (1989).[8] A proportion $(1-\lambda_r)$ of consumption in province r is assumed to be

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[7]An alternative derivation of this result considers the path for consumption which would be chosen by a benign social planner. For any given trajectory for total consumption, the Pareto optimal solution for each individual or province involves identical comovements in consumption. This reflects the more general proposition that the solution with full contingent markets should correspond to one chosen by a social planner.

[8]This model has been used extensively in empirical applications. See, for example, Jappelli and Pagano (1989) and Blundell-Wignal, Brown, and Cavaglia (1991).

associated with individuals who behave according to the risk sharing model given in equations (2) above. The remaining proportion λ_r is assumed to be associated with "rule of thumb" consumers who vary the growth in their consumption in line with the growth in their disposable income. For these consumers:

$$\Delta c_{rt} = \Delta y_{rt}, \tag{3}$$

where y_{rt} is the logarithm of disposable income in province r.

Aggregating over these two types of consumers, consumption in provinces a, b, ..., r is equal to:

$$\begin{aligned} \Delta c_{at} &= \lambda_a \Delta y_{at} + (1-\lambda_a)(\Psi(\sigma^2_t/2) + \Psi^{-1}\ln(\beta(1+R_{t-1})) + \epsilon) + \epsilon'_{at}, \\ \Delta c_{bt} &= \lambda_b \Delta y_{bt} + (1-\lambda_b)(\Psi(\sigma^2_t/2) + \Psi^{-1}\ln(\beta(1+R_{t-1})) + \epsilon) + \epsilon'_{bt}, \\ \Delta c_{rt} &= \lambda_r \Delta y_{rt} + (1-\lambda_r)(\Psi(\sigma^2_t/2) + \Psi^{-1}\ln(\beta(1+R_{t-1})) + \epsilon) + \epsilon'_{rt}. \end{aligned} \tag{4}$$

The province-specific errors, ϵ'_{rt}, reflect errors in measurement and deviations from the behavior predicted by the two simplified models.

Equations (4) identify two factors which should be important for the rate of growth of consumption across provinces. The first is the common movement in consumption across all provinces, which reflects the risk sharing allocation of consumption. The second is the change in local disposable income. Although the model is formally set up with two very different types of consumers, the equation is consistent with a much broader range of consumption processes, including those in which risk sharing behavior is not complete due to limited access to financial markets or precautionary saving motives. In particular, Hubbard, Skinner, and Zeldes (1994) find that the correlations between consumption and income reported by Campbell and Mankiw (1989) are consistent with models which include an important element of precautionary saving.

The expression for risk sharing behavior can be replaced by a constant term and dummy variables for each time period.[9] The empirical counterpart to equations (4) for any province r then becomes:

$$\Delta c_{rt} = \lambda_r \Delta y_{rt} + (1-\lambda_r)(\alpha + \sum_{J=2}^{T} \delta_j d_j) + \epsilon_{rt} \tag{5}$$

where the d_js are dummy variables equal to 1 when j=t and zero otherwise.

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[9]To ensure the model is identified, the dummy variable for the first time period is excluded in the estimation.

Equation (5) can be used to test the significance of sensitivity to income and of risk sharing behavior on consumption. The coefficients λ_r indicate the degree to which (predictable) changes in income affect consumption and hence behavior departs from the permanent income hypothesis. The importance of the time dummies, the d_js, measures the degree to which consumption follows the risk sharing path. Such a decomposition is only possible because the data vary by both province and time period, i.e., they are a panel. Without variation across both dimensions, it would not be possible to estimate the coefficients on the time dummies d_j, and hence the contribution of risk sharing behavior to consumption in this manner.[10]

More importantly, equation (5) allows one to test the *relative* importance of these two extensions of the basic permanent income hypothesis, namely the impact of predictable changes in income and the comovement of consumption across all provinces predicted by the risk sharing model. This can be done by running the equation excluding changes in disposable income and then, after adding these income variables back, rerunning the equation excluding the time dummies. The deterioration in the performance of the partial equations compared with the performance of the general equation can be used to estimate the marginal contribution of income (in the case when the change in disposable income is excluded from the model) and risk sharing behavior (in the case of the time dummies) on aggregate consumption, while the proportion of the overall variance to consumption not explained at the margin by either hypothesis provides a measure of the degree to which the two explanations cannot be differentiated. Hence, the approach allows the relative contributions of these two explanations to be evaluated.

The restrictions imposed on the utility function can also be tested. If subjective discount rates differ across provinces then so will the constant terms (α). Similarly, if intertemporal elasticities of substitution vary then, in addition to the constant terms, the coefficients on the time dummies (δ_js) should be multiplied by province-specific constant terms. Both restrictions involve simple parameter tests on the estimating equation.

The use of time dummies to reflect the path of risk sharing consumption may appear at first to be something of a catchall. On reflection, however, little more can be said about the path of risk sharing consumption. There should be a relationship between *ex ante* real interest rates and the predictable part of risk sharing consumption, but the correlation between observed real interest rates and risk sharing consumption is unclear, as unexpected changes in

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[10]Dummy variables for each period have been included in most empirical microeconomic studies of consumption in order to eliminate the impact of aggregate changes in activity. However, the focus of this work has remained on the size of the coefficient on income or other personal characteristics, not on the relative contribution of alternative hypotheses. In principle, however, the same methodology could be applied. Indeed, by measuring the information content of the risk sharing model, the approach adopted here might help to determine the importance of noise in the data.

permanent income will be associated with unanticipated changes to inflation and hence in observed real interest rates. An alternative approach of measuring the risk sharing path for consumption is to include the growth in aggregate consumption in the regression instead of the time dummies, as suggested by Mace (1991). If aggregate consumption is defined as a simple average of changes in consumption across provinces (or individuals) then including aggregate consumption is exactly equivalent to using time dummies in the pure risk sharing model. In the case where individual consumption depends upon individual income, the empirical results from the two approaches will differ. But in this case aggregate consumption will also depend upon aggregate income, and so will not be an accurate measure of the underlying risk sharing consumption path. For this reason, the specification using time dummies is to be preferred. As a check on the specification, results using the Mace approach are also reported. They are similar to those using time dummies, indicating that the main case results are not being driven by the use of the dummy variables. Another potential concern with the specification is that the utility function may not be separable. To test for this, the empirical section includes estimates from an extended model in which some of the more restrictive assumptions used to derive equation (5), such as the assumption that durable and nondurable goods consumption are nonseparable, are relaxed.

The approach suggested here can be compared with earlier approaches such as those used by Cochrane (1991) on the microeconomic side and Campbell and Mankiw (1989) on the macroeconomic side. The difference between equation (5) and the work of Cochrane is that he used cross-sectional data.[11] As a result, he was not able to estimate the contribution of risk sharing behavior in consumption, as such behavior is subsumed in the constant term. Rather, he focused on testing whether the risk sharing model can be rejected by seeing if individual-specific factors such as income or unemployment are significant in the equation. The main difference between equation (5) and the work of Campbell and Mankiw is that, because they use time series rather than panel data, they too cannot use time dummies in their model. Rather, they generally make the assumption that the *ex ante* real interest rate is constant.[12] Again, this means the contribution of fully optimizing behavior to consumption is not estimated directly, but only the deviation from optimizing behavior. In many respects, equation (5) can be seen as an extension of both the Cochrane and Campbell and Mankiw models to a panel data set.

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[11]Other workers with microeconomic data have used data over several years. Cochrane's paper is used to illustrate a potential derivation of the estimating equation.

[12]They also include direct estimates of the *ex ante* real interest rate in some regressions.

III. Estimation

A. Data

Annual data on real consumption of nondurable goods and services (hereafter simply nondurable consumption),[13] nominal household disposable income, the deflator for total consumption, and population by province were collected from the Canadian *Provincial Economic Accounts* for the period 1971–90. They were used to calculate per capita values of real nondurable consumption and real household disposable income (deflated using province-specific consumption deflators) for each of the 10 Canadian provinces.[14] Nondurable consumption was used because the theory is concerned with the marginal utility derived from consumption. Durable goods provide utility over several years, making measured consumption a bad proxy for the marginal utility derived from their ownership. Possible nonseparabilities between consumption of durable and nondurable goods are discussed below. Data transformations and lags meant that the estimation period was 1974–90.

Using data across Canadian provinces has a number of attractive features. It is a relatively unstudied data source which contains detailed panel data on both consumption and disposable income without many of the inaccuracies generated by individual questionnaires.[15] At the same time, Canada has a unified national banking system and highly integrated financial markets. Canadian provinces are also subject to large idiosyncratic income disturbances, particularly in the western half of the country and Atlantic regions where the local economies are dominated by raw material production. Chart 1 shows the percentage changes in disposable income and nondurable consumption for two halves of Canada, the western provinces (British Columbia, Alberta, Saskatchewan, and Manitoba) and the remaining eastern provinces. The two series generally move in tandem, although there are exceptions. In 1976 and 1987, income decelerated in the west but not in the east, while in 1985 the opposite occurred. Income is also considerably more variable in the western half of the country, particularly over the recession of 1982–83. Consumption patterns are more coherent than income patterns. The rate of growth of consumption is much less variable, and behavior in the two halves of the country is often very similar—for example, the growth in consumption accelerates in both east and west in 1976, despite a deceleration in western income.

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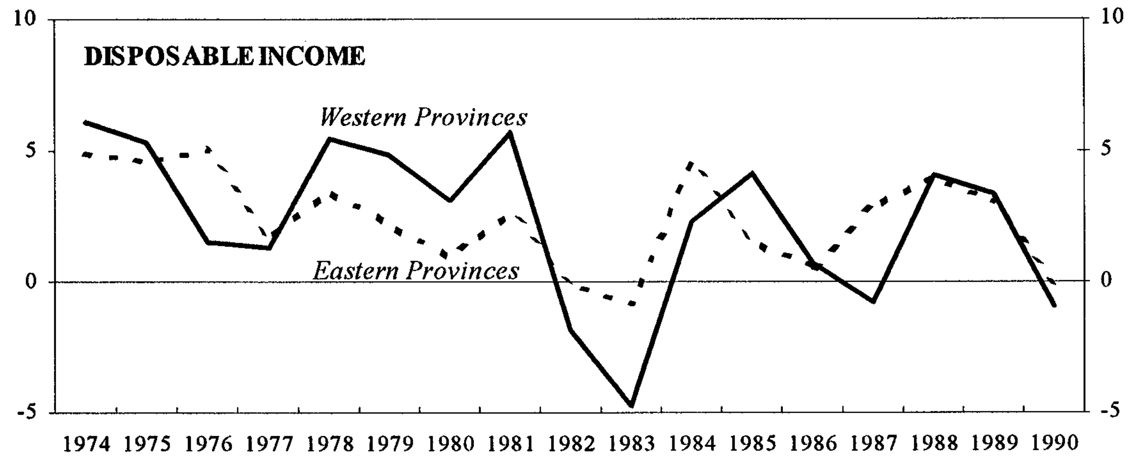
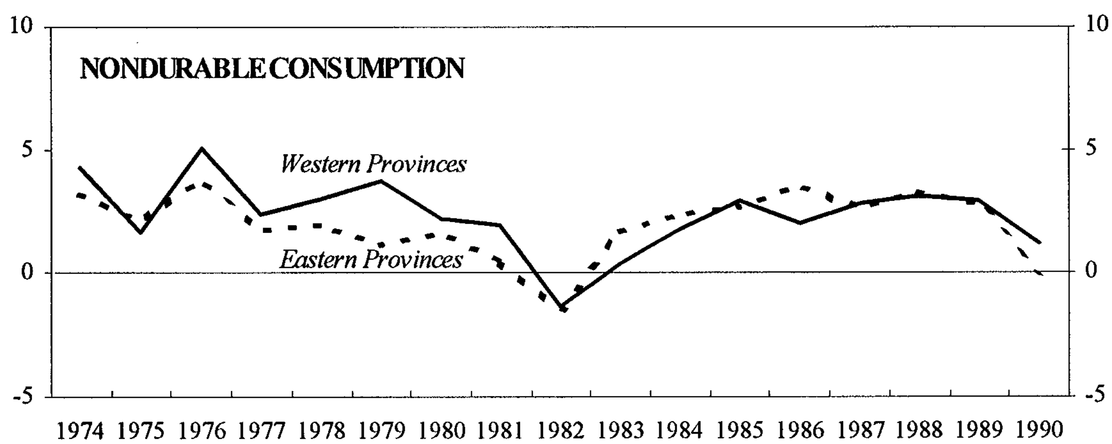
[13]Results using nondurable consumption without including services are very similar.

[14]Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Price Edward Island, Quebec, and Saskatchewan. Full data were not available for the Yukon or Northwest Territories.

[15]On the other hand, the data may suffer from aggregation bias. As discussed earlier, it would certainly be interesting to also run this specification on data for individual consumers.

Chart 1. Percentage Change in Income and Consumption Across Canadian Regions





This diversity in provincial income streams provides considerable scope for consumption smoothing, making it easier to distinguish between sensitivity to income and risk sharing behavior. By way of comparison, Table 1 reports the standard deviation of the percent growth of disposable income per capita relative to the Canadian aggregate for each Canadian province and the equivalent values for the nine standard U.S. census regions.[16] Six Canadian provinces have standard deviations which are larger than that of any of the U.S. regions. More generally, the average standard deviation across all Canadian provinces (2.5 percent per annum) is over double that across U.S. regions. Innovations to relative income are also quite persistent. This was tested by estimating a first order autoregressive process for the detrended growth in provincial personal disposable income relative to that in Canada as a whole (each series was detrended by regressing it on a constant term and a time trend). For 8 of the 10 provinces, the estimated AR1 coefficient was between 0.58 and 0.77 and highly significant, indicating that movements in the growth of provincial income relative to national income can be expected to persist for some time. In the absence of risk sharing behavior, such persistent deviations in provincial income would expect to find a counterpart in movements in consumption. The coefficient for Saskatchewan, however, was smaller (0.31) and insignificant, while that for Prince Edward Island was negative.

The Canadian provincial data also provide a benchmark against which to compare results for consumption across countries. There has been considerable recent interest in looking at such behavior across countries, with deviations from risk sharing behavior being used as a way of measuring the level of integration of international financial markets.[17] For such an exercise to be fully convincing, however, it is useful to have a measure of behavior within a region with high capital mobility against which to compare these results. With its national banking system, unified financial laws across provinces, and a common currency, Canada provides just such a benchmark.

The data were converted into a panel data set, and equation (5) was estimated using two stage least squares. Unexpected changes in real disposable income can contain information about idiosyncratic changes in permanent income. To identify only those changes in consumption associated with predictable change in income, it is therefore necessary to use instrumental variables.[18] The choice of instruments can be important for this type of model

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[16]The U.S. data come from the state-by-state personal income accounts. U.S. data on consumption by state do not exist, except for retail sales every several years. The U.S. data cover the period 1974–87.

[17]Obstfeld (1994), Lewis (1994), and Bayoumi and MacDonald (1995).

[18]If the objective was simply to test the risk sharing model then there is no need to instrument the change in income, as all movements in permanent income are represented by the time dummies. However, the risk sharing model is a refinement of the more general permanent income model, which makes no assumptions about the correlation of movements in permanent income across

Table 1. Standard Deviation of the Growth In Personal Disposal Income per Capita Relative to the National Value

Canadian Provinces		U.S. Regions	
British Colombia	1.6	New England	1.2
Alberta	3.1	Mid-Atlantic	0.9
Saskatchewan	5.5	East North Central	0.9
Manitoba	2.5	West North Central	2.0
Ontario	1.1	South Atlantic	0.6
Quebec	1.1	East South Central	0.9
New Brunswick	1.5	West South Central	2.1
Prince Edward Island	4.1	Mountain	1.0
Nova Scotia	2.2	Pacific	0.7
Newfoundland	2.5		
Average	2.5		1.2

Sources: Statistics Canada *Regional Economic Accounts* and Bureau of Economic Analysis *Regional Economic Summary Tables*.

Notes: The Canadian data covers the period 1974–90, the U.S. data 1974–87.

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provinces. Results without instrumental variables are also reported below.

(Campbell and Mankiw, 1989). Past changes in income should be useful in helping to predict future changes in consumption and income. In addition, since the consumption model underlying our approach is the permanent income model, it follows that current consumption will summarize agents' information about the future path of income (Campbell, 1987), thus lagged values of the change in consumption should also be a useful predictor of changes in income. Finally, the permanent income model also implies that the ratio of consumption to income should also be useful in predicting future income (Campbell, 1987).

An important limitation on the instrument set is that first lags are inadmissable as instruments because the time averaging of the consumption data induces a correlation between the change in consumption and its first lag (Working, 1960). To preserve degrees of freedom in the estimation, only second lags of the instruments were used. Accordingly, the instruments were a constant term and the second lag of the growth in real consumption, real disposable income, and ratio of nondurable consumption to disposable income.[19] The instruments were made specific to each province, so as to ensure that their full potential explanatory power was used. Finally, the time dummies were included in the instrument set, as there is no need to instrument these variables in the equation. The R^2 for the instrumental variables equation was 0.56, indicating that the instruments have a significant degree of explanatory power.[20]

B. Main Regression Results

Table 2 reports the results from estimating the basic model. The first column reports the R-squared and adjusted R-squared from equation (5) using the instruments discussed earlier (the coefficients themselves are not reported as they are so numerous). The model explains just under 60 percent of the variance of consumption (due to the large number of estimated coefficients, when the fit is adjusted for the number of degrees of freedom the explanatory power falls to just under 50 percent of the initial variance). The time dummies and predictable elements of disposable income collectively explain somewhat more than half of the total variance in consumption across Canadian provinces.

Three Wald tests of coefficient restrictions are also reported. The first tests the joint significance of the coefficients on the change in disposable income. The hypothesis that these are jointly zero, and hence that the income terms are statistically insignificant, is overwhelmingly rejected. The subsidiary hypothesis that these coefficients are equal across provinces is also marginally rejected, implying that the importance of such rule of thumb

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[19]Maringer and Shaw (1993) criticize earlier (microeconomic) studies of consumption by noting that, although expectational errors should be uncorrelated over time, they need not be uncorrelated across individuals or provinces within a single time period. As different instruments are being used across provinces, this issue does not arise in the current analysis.

[20]Poor instruments can cause misspecification (Nelson and Startz, 1990).

Table 2. Decomposition of Consumption: Basic Results

$$\textit{Estimating Equation: } \Delta c_{it} = \lambda_i \Delta y_{it} + (1-\lambda_i)(\alpha + \sum_{j=2}^{T} \delta_j d_j)$$

	Complete Model	Risk Sharing Model	Income Model
R^2	0.57	0.47	0.21
Adjusted R^2	0.49	0.42	0.16
Wald tests for:			
Joint significance of income terms (λ_i=0) $\chi^2(10)$	42.9**	--	87.6**
Equality of income terms (λ_i=λ) $\chi^2(9)$	18.6*	--	21.2*
Joint significance of time dummies (δ_t=0) $\chi^2(16)$	117.8**	151.6**	--
Durbin-Watson statistics	0.50-2.52	0.83-2.46	1.41-2.69

Notes: All tests are calculated using heteroscedastic adjusted standard errors. The instruments in the estimation for each province were a constant term, the second lags of the growth in consumption, growth in disposable income, and ratio of consumption to disposable income, and time dummies. One asterisk indicates the test is significant at the 5 percent level; two asterisks indicates the test is significant at the 1 percent level.

behavior differs across provinces.[21] The third test measures the joint significance of the coefficients on the time dummies. The hypothesis that the coefficients on the time dummies are jointly equal to zero, and hence that risk sharing behavior is not important for consumption, is also emphatically rejected.[22]

The second and third columns in Table 2 give some idea of the relative importance of these two types of behavior for the overall fit of the model. The second column reports the results when the terms in the growth in disposable income, and hence the impact of changes in income, were excluded from the model. The third column reports the impact of restoring the terms in the growth in disposable income but excluding the time dummies from the estimation. Hence, in this case it is the behavior of the fully insured consumers which is eliminated from the estimation.

Excluding changes in disposable income from the model results in a modest lowering of the explanatory power of the model, with the R-squared falling by 10 percentage points, from 0.57 to 0.47. At the margin, therefore, predictable changes in disposable income explain 10 percent of the variance of consumption in this model.[23] The third column indicates that the elimination of the time dummies from the estimation produces a significantly larger reduction in the R-squared, from 0.57 to 0.21. At the margin, risk sharing behavior explains around 35 percent of the variance of consumption in this specification.[24] An alternative way of looking at these results is to compare the explanatory power of the two underlying models of behavior. The risk sharing model, in the form of separate time dummies, explains almost half of total variance in consumption, predictable change in consumption only one fifth.

In round figures, the results indicate that 60 percent of the explained variance of consumption is attributable to the time dummies, 20 percent to changes in income, while the

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[21]Coefficients on individual provinces show little obvious relationship between the estimated values and per capita income, raw material production, or economic size. Ontario, the largest and one of the richest provinces per capita has a middling coefficient on income. Quebec, the second largest province, and tiny Prince Edward Island have small values. Alberta, a major oil-producing and relative prosperous province, has a large coefficient, while Saskatchewan, another western province, does not.

[22]The model was also run using changes in the levels of real nondurable consumption per capita and real disposable income per capita instead of the logarithms of these variables. The results from these regressions were very similar to those using change in logarithms, and are not reported.

[23]As might be expected, the significance of the time dummies increases.

[24]The coefficient restrictions implied by the assumptions of equal discount rates and equal rates of intertemporal substitution across provinces were accepted in all three regressions.

remaining 20 percent can be explained by either set of variables. All three figures are of interest. The large contribution from the time dummies indicates that risk sharing behavior is the dominant factor in explaining movements in consumption across Canadian provinces. However, the results also indicate that changes in income remain an important, if subsidiary, part of the overall explanation. Finally, the fact that only 20 percent of the overall explained variance could be explained by either variable indicates that colinearity between the income terms and time dummies is not a significant problem. Despite the existence of a national business cycle, the variation in the behavior of income across Canadian provinces is apparently large enough that the two types of consumption behavior are relatively easy to distinguish from each other, presumably reflecting, at least in part, the relatively idiosyncratic nature of the underlying disturbances to disposable income discussed earlier.

Durbin-Watson statistics were calculated for each province for the different models. For the complete model (the one including both the income terms and time dummies), there is a very low value for Saskatchewan (0.50), indicating a significant degree of autocorrelation in this case. However, as none of the other models showed any evidence of significant autocorrelation (the Durbin Watson statistics for the other provinces vary between 1.73 and 2.52), this does not appear to indicate general misspecification. The same pattern, a very low DW statistic for Saskatchewan but not for other provinces, also occurs in the risk sharing model (which includes only time dummies), while all of the DW statistics appear satisfactory in the model with only income terms (they vary between 1.41 and 2.69). I also calculated correlations of the residuals for each province. A high correlation between residuals could indicate that the equation was missing an significant explanatory variable—for example, changes in the price of oil could potentially have a positive impact on consumption in Alberta and Saskatchewan but a negative impact in the more industrial east coast, over and above its direct impact on personal disposable income. For the complete model, the residual correlations showed no evidence of misspecification. Only three of the 45 correlations were significant at the 5 percent level, almost exactly what would be predicted from chance, and none of these correlations involved provinces with particularly close economic connections.[25] The risk sharing model also showed relatively little sign of mispecification. It had only 4 significant residual correlations; however, one of these was between Prince Edward Island and New Brunswick, indicating that consumption across these provinces may be more closely tied than would be indicated by the model. The income model showed the most evidence of misspecification. Eleven of the 45 correlations were significant at conventional levels including significant positive correlations between Alberta and Saskatchewan, New Brunswick and Prince Edward Island, and Ontario and Quebec, all of which have close economic connections. In short, the income model appears to be missing an important element in explaining provincial consumption. These basic patterns for the Durbin Watson statistics and residual correlations—satisfactory DW values except for Saskatchewan, and high numbers of

[25]The statistic $1/2 \ln[(1+r)/(1-r)]$, where r is the correlation coefficient, is distributed approximately normally, with mean $1/2 \ln[(1+\varrho)/(1-\varrho)]$ and variance (T-3) (Kendall and Stuart, 1967, pp. 262-263). For $\varrho=0$, this implies a 5 percent confidence interval of + or -0.48.

significant residual correlations for the income model—persist in the alternative versions of the model reported below.

C. Additional Results

Table 3 shows the results from the regression when the coefficients on the change in disposable income, λ_i, are made equal across provinces.[26] Results are only reported for the two specifications in which the change in disposable income is included in the specification as the results for the regression including only time dummies remains unchanged from those reported earlier.

In terms of overall fit and specification tests, these regressions show a very similar pattern to those in Table 2. The estimated coefficients on the change in disposable income, however, illustrate an interesting feature of the results. When the time dummies are included in the model, the estimated coefficient on the change in disposable income is 0.15, implying that around 15 percent of consumption is associated with predictable income changes. When the time dummies are excluded, however, this coefficient rises to 0.25, indicating a somewhat larger percentage of consumption to be associated with changes in income. These results indicate that, even using instrumental variables, the type of model proposed by Campbell and Mankiw (1989) in which the behavior of optimizing consumers is approximated by a constant term may tend to overestimate the importance of changes in income, as some of the covariation between income and consumption may still reflect changes in the optimum consumption path.

A second experiment involved using aggregate consumption instead of time dummies as the measure of the risk sharing path of consumption, as discussed earlier. Two measures of aggregate consumption were used in the estimation; a simple average of per capita consumption growth in all provinces and per capita consumption growth in Canada as a whole. Table 4 shows the results from this estimation. In the case of the simple average, results are only reported for the complete model, as those for the risk sharing and income models are identical to the main case reported in Table 2. The fit of the complete model is very similar to that reported earlier (0.56 as opposed to 0.57), indicating that this change makes almost no difference to the analysis. When average consumption growth in Canada is used there is a signification deterioration in the fit of the complete model, with the R^2 falling from 0.57 to 0.50. There is also a similar deterioration in the fit of the risk sharing model (the risk sharing result are different from those using time dummies because the growth in consumption is implicitly weighted by population). The risk sharing model still fits significantly better than the income model, however, paralleling the results from the preferred specification.

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[26]As discussed earlier, this restriction is narrowly rejected by formal tests.

Table 3. Results When the Income Coefficients are Constrained to be Equal

$$\textit{Estimating Equation: } \Delta c_{it} = \lambda \Delta y_{it} + (1-\lambda)(\alpha + \sum_{j=2}^{T} \delta_j d_j)$$

	Complete Model	Income Model
R^2	0.57	0.22
Adjusted R^2	0.52	0.22
Change in disposable income (λ)	0.15 (0.06)*	0.25 (0.04)**
Joint significance of time dummies (δ_t=0) $\chi^2(16)$	115.9**	--
Durbin-Watson statistics	0.95-2.77	1.23-2.51

Notes: All tests are calculated using heteroscedastic adjusted standard errors. The instruments in the estimation for each province were a constant term, the second lags of the growth in consumption, growth in disposable income, and ratio of consumption to disposable income, and time dummies. One asterisk indicates the test is significant at the 5 percent level; two asterisks indicates the test is significant at the 1 percent level.

Table 4. Decomposition of Consumption: Mace Specification

Estimating Equation: $\Delta c_{it} = \lambda_i \Delta y_{it} + (1-\lambda_i)(\alpha + \beta\ \Delta c_{AGG,t})$

	Simple Average Complete Model	Canadian Average Complete Model	Canadian Average Risk Sharing Model
R^2	0.56	0.50	0.37
Adjusted R^2	0.52	0.47	0.37
Aggregate consumption (β)	1.03 (.09)**	0.80 (.08)**	0.76 (.08)**
Wald tests for:			
Joint significance of income terms (λ_i=0) $\chi^2(10)$	31.5**	36.1**	--
Equality of income terms (λ_i=λ) $\chi^2(9)$	17.4*	18.5*	--
Durbin-Watson statistics	0.77-2.21	1.18-2.40	1.22-2.49

Notes: Simple average is the average of per capita consumption growth across all provinces, whereas Canadian average indicates the average per capita value in Canada as a whole. All tests are calculated using heteroscedastic adjusted standard errors. The instruments in the estimation for each province were a constant term, the second lags of the growth in consumption, growth in disposable income, and ratio of consumption to disposable income, and time dummies. One asterisk indicates the test is significant at the 5 percent level; two asterisks indicates the test is significant at the 1 percent level.

To this point all of the reported regression results have used instrumental variables, as changes in provincial income may be correlated with changes in permanent income. One concern with using instrumental variables, however, is that the estimation technique may underestimate the explanatory power of the change in disposable income in the regression. One way of assessing the potential size of this problem is to estimate the model by least squares. This regression, which ignores the potential problem of the correlation of changes in permanent income with current income, indicates the *maximum* explanatory power of income in the regression.[27] If there were to be a large increase in the explanatory power when least squares was used, this would imply considerable uncertainty as to the role of income in the behavior of consumption. If the rise is relatively modest, on the other hand, the potential level of uncertainty would likewise be modest.

Table 5 shows the results from estimating the complete model and the regression using only the income terms using least squares (again, the results from the equation including only the time dummies is unchanged). In both equations, the estimated significance of the income coefficients rises considerably, as might be expected. However, the increase in explanatory power in the equations is relatively small. The R-squared rises from 0.57 to 0.63 in the main regression, and 0.24 to 0.30 in the equation excluding time dummies. This increase is not large enough to make a material impact on the decomposition of explanatory power discussed above, implying that the potential biases from the use of instrumental variables is relatively unimportant for the results.[28]

IV. Additional Variables

The results to this point are based on a utility function which is separable with respect to durable consumption, government consumption, and leisure, and the assumption that the impact of deviations from the risk sharing model can be captured using changes in aggregate provincial income. This section explores the impact of using a more general model of consumption on the results.

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[27]A further argument for using least squares is that income should not be instrumented in the pure risk sharing model, as the change in permanent income should be fully accounted for by the time dummies, and hence there will be no simultaneity bias.

[28]When the instrumented values for the income terms were substituted for the actual income terms in the least squares regression, the fit of the equation fell, suggesting that the lack of explanatory power of the actual income terms does not reflect errors in measurement.

Table 5. Results Using Least Squares

$$\textit{Estimating Equation}: \Delta c_{it} = \lambda_i \Delta y_{it} + (1-\lambda_i)(\alpha + \sum_{j=2}^{T} \delta_j d_j)$$

	Complete Model	Income Model
R^2	0.63	0.30
Adjusted R^2	0.57	0.25
Wald Tests for:		
Joint significance of income terms (λ_i=0) $\chi^2(10)$	103.1**	115.3**
Equality of income terms (λ_i=λ) $\chi^2(9)$	28.0**	19.4*
Joint significance of time dummies (δ_t=0) $\chi^2(16)$	111.4**	--

Notes: All tests are calculated using heteroscedastic adjusted standard errors. One asterisk indicates the test is significant at the 5 percent level; two asterisks indicates the test is significant at the 1 percent level.

Lack of separability between nondurable consumption, other types of consumption, and leisure, will effect the behavior of optimizing consumers.[29] If durable goods are partial substitutes for nondurable goods, this implies that their relative price should be included in the part of the regression explaining the behavior of optimizing consumers, with a rise in the relative price of nondurable goods being associated with lower nondurable consumption.[30] Similarly, if government consumption is a partial substitute for private nondurable consumption, the change in government consumption should be included in the regression, with a rise in government expenditures being associated with a fall in nondurable consumption.

Finally, if there is a trade-off between consumption and leisure then real wages or hours worked should also be included in the equilibrium part of the regression, with increases in wages or hours being associated with higher consumption. The unemployment rate was used as a proxy for changes in hours worked.[31] A potential problem with this is that changes in unemployment are also often considered to be a useful additional variable to explain the behavior of liquidity constrained consumers. To the extent that such consumers differ from the population as a whole, for example, by being poorer or located in specific industries, changes in the disposable income of constrained consumers may not equal changes in income for the province as a whole, and unemployment may therefore be a useful additional proxy for such effects.

As these two effects operate in the same direction, it is very difficult to disentangle their relative influence. In what follows, the impact of the unemployment rate on the results is reported in such a manner that either hypothesis, that it reflects optimizing behavior or the impact of constrained consumers, can be ascertained.

Taking all of these considerations into account, and retaining the assumption that utility functions are identical across regions, the estimating equation becomes:

$$\Delta c_{rt} = \lambda_r \Delta y_{rt} + \phi_r U_{rt} + (1-\lambda_r)(\alpha + \omega \Delta p_{rt} + \nu \Delta g_{rt} + \sum_{j=2}^{T} \delta_j) \qquad (5')$$

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[29]Earlier work on these issues includes Mankiw, Rottenberg, and Summers (1985) and Eichenbaum, Hansen, and Singleton (1988) on labor supply, Bernanke (1985) on durable goods, and Aschauer (1985) on government purchases. Empirical microeconomic work has generally ignored these nonseparabilities (Browning and Lusardi, 1995).

[30]Lewis (1994) argues that nonseparabilities between traded and nontraded goods can explain most of the correlation between consumption and income across countries. Our data do not distinguish between traded and nontraded goods, hence we are only able to consider nonseparabilities between durable and nondurable goods.

[31]Comprehensive data on hours worked are not available for all provinces. Hourly wages are only available from 1983, which would have severely restricted the sample.

where UN_{rt} is the unemployment rate in province r, p_{rt} is the logarithm of the relative price of nondurable goods to durable goods (measured using implicit price deflators), g_{rt} is the logarithm of real government consumption per capita, and Greek letters represent estimated coefficients.[32] The coefficients on relative prices and government consumption are constrained to be equal across provinces since the underlying utility functions are assumed to be the same, while the coefficients on unemployment, whose effect is more ambiguous, are allowed to vary.[33] The instrument set was augmented by the new variables, i.e., the change in the relative price of nondurables for all provinces, the change in real government consumption for all provinces, and the change in the unemployment rate for each province separately.

The results from this exercise are shown in Table 6. The full model now explains 70 percent of the variation in consumption over time, somewhat higher than the equivalent model reported in Table 2. The coefficients on income and on the time dummies continue to be highly significant, as is the coefficient on the rate of change in government consumption. However, the coefficient on the relative price of nondurable goods and on unemployment are not significant at conventional levels.[34] Hence, the improvement in the equation appears to largely reflect the inclusion of government consumption, whose coefficient of -0.14 implies that each 1 percent rise in government consumption lowers private consumption of non-durable goods by 0.14 percent. As government consumption represents around 45 percent of private nondurable good consumption over the estimation period, this implies that each dollar increase in government consumption lowers nondurable private consumption by about 30 cents.

The results for the risk sharing model are reported both excluding and including changes in the unemployment rate. All of the variables in these regressions, including the change in the relative price of nondurable goods and (when included) the unemployment rate, are highly significant. The results indicate that the loss in explanatory power from excluding changes in disposable income and changes in the unemployment rate are quite limited, lowering the R-squared by .07 and .02, respectively. Even when the unemployment rate is regarded as measuring the behavior of liquidity constrained consumers, therefore, the extended version of the risk sharing model explains over 60 percent of the variance of consumption. By contrast, the model which ignores risk sharing behavior continues to

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[32]Strictly speaking, this specification will only occur if the underlying utility function has a Cobb-Douglas form. For other utility functions there should also be interaction terms between the various types of consumption and leisure. The chosen specification, however, is the one usually used in the literature.

[33]The unemployment coefficients are constrained to be the same in the risk sharing specification, as the utility functions are assumed to be the same across provinces.

[34]When the coefficients on income are constrained to be equal across provinces the coefficient is 0.16, very similar to that found in the simpler model discussed earlier.

Table 6. Decomposition of Consumption: Extended Model

Estimating Equation: $\Delta c_{it} = \lambda_i \Delta y_{it} + \phi_i \Delta UN_i + (1-\lambda_i)(\alpha + \theta_i \Delta p_{it} + \gamma \Delta g_{it} + \sum_{j=2}^{T} \delta_j d_j$

	Complete Model	Full Insurance Model: Unemployment Excl.	Full Insurance Model: Unemployment Incl.	Income Model: Unemployment Excl.	Income Model: Unemployment Incl.
R^2	0.70	0.61	0.65	0.24	0.38
Adjusted R^2	0.61	0.57	0.58	0.19	0.30
Coefficient on relative prices	-0.19 (.13)	-0.26 (.07)**	-0.20 (.07)**	--	--
Coefficient on government consumption	-0.14 (0.03)**	-0.14 (.02)**	-0.14 (.02)**	--	--
Wald tests for:					
Joint significance of income terms (λ_i=0) $\chi^2(10)$	49.8**	--	--	122.8**	72.8**
Joint significant of unemployment terms (ϕ_i=λ) $\chi^2(10)$	15.1	--	30.6**	--	72.1**
Joint significance of time dummies (δ_t=0) $\chi^2(16)$	85.9**	173.1**	135.8**	--	--

Notes: All tests are calculated using heteroscedastic adjusted standard errors. The instruments in the estimation for each province were a constant term, the change in relative prices, the change in government consumption, the change in the unemployment ratio, the second lags of the growth in consumption, growth in disposable income, and ratio of consumption to disposable income, and time dummies. One asterisk indicates the test is significant at the 5 percent level; two asterisks indicates the test is significant at the 1 percent level.

produce a large deterioration in the explanatory power of the model, particularly when the unemployment terms are excluded. Adding the variables which represent risk sharing behavior either doubles or triples the explanatory power of the equation, depending on the assumption made about unemployment. In short, extending the model does not effect the basic results.

V. Conclusions

This paper has proposed a specification for testing the relative importance on consumption of risk sharing behavior and changes in income, and tested it using data on nondurable consumption across Canadian provinces. Empirically, the focus has been less on whether or not either model can be rejected based on parameter constraints, than on how much each of the main hypotheses can contribute to explaining overall variation in consumption.

Formal statistical tests consistently indicate that both types of behavior are statistically significant. However, most of the marginal explanatory power comes from risk sharing behavior rather than changes in income. This is true of both the basic model and an extension which takes account of nonseparabilities in the utility function and the impact of changes in unemployment. The results also indicate that the inclusion of terms that capture the behavior of full insured consumers reduces the estimated proportion of consumption associated with changes in income.

These results may help explain why the empirical characterization of consumption has been difficult to resolve. They imply that, while changes to income are a significant factor in explaining consumption, its importance may have been overstated in models which take no account of risk sharing behavior. At the same time, the sensitivity to income is small enough to be difficult to identify in microeconomic data sets, where the data suffer from large amounts of noise. In summary, changes in income appear to be an significant but relatively subsidiary part of the explanation of variations in consumption, at least across Canadian provinces.

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