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SEDAP Research Paper No. 27

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How Do Contribution Limits Affect Contributions to Tax-Preferred Savings Accounts? *

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Abstract

Contributions to tax-preferred savings accounts are typically constrained by a contribution limit. These limits influence contributions not just in periods in which they bind, but in other periods as well. I develop a simple life-cycle model in which consumers exhibit "use-it-or-lose-it" contribution behaviour. This connects current contributions to future contribution limits, which leads to the result that an increase in contribution limits can decrease contributions. Empirical evidence provides support for the model - larger future contribution room is associated with smaller contributions.

JEL Classification: H24 Keywords: Income tax; Saving

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1 Introduction

Several countries allow preferential tax treatment for contributions made to special savings accounts, such as 401(k) plans in the United States or Registered Retirement Savings Plans in Canada. A literature has developed examining the effects of this type of tax preference on consumers' savings and consumption choices.¹ Gravelle (1991) notes that interpretation of this evidence has been hampered by shortcomings in the understanding of how consumers plan contributions through time. Auerbach and Slemrod (1997) conclude that the empirical evidence suggests tax policy has its strongest effect upon the timing of economic transactions. Thus, timing considerations are not well understood, but are potentially very important. In this paper, I address one aspect of the decision to contribute to tax-preferred savings accounts. Specifically, I consider the influence of contribution limits on the decision to contribute, and show how changes in the structure of contribution limits affect contributions.

Tax-preferred savings accounts generally take the following form. Contributions are deductible for income tax purposes, up to some limit set by the tax authority. Interest on the accumulating stock of contributions accrues tax-free. Finally, withdrawn funds are added to taxable income in the year of withdrawal. In the United States, Individual Retirement Accounts and 401(k) plans conform to this structure, as do Registered Retirement Savings Plans in Canada, and Personal Pensions in the United Kingdom. Many important details of tax treatment vary across countries, however. For example, withdrawals from Individual Retirement Accounts in the United States before age 59.5 attract a ten percent penalty, while withdrawals from Registered Retirement Savings Plans in Canada do not. These differing institutional details may influence contributions, but are not central to the focus of this paper.

Previous work has explored the intertemporal nature of the contribution decision. Daly (1981), and Androkovich, Daly, and Naqib (1992) develop a dynamic model to explain the optimal path of contributions to tax-preferred savings accounts. In the model, they find that an optimal path for contributions performs a tax base smoothing role, allowing a consumer to minimize his lifetime tax bill. Ragan (1994) constructs a two-period model to look at the effect of progressive income taxes on savings when tax-preferred savings accounts are available, then uses the model to explore differences between this system and a conventional consumption tax. Shoven and Sialm (1999) present a model

¹Bernheim (1999) reviews the empirical literature examining the degree to which contributions to tax-preferred savings accounts represent new savings rather than mere portfolio reallocations.

of asset allocation when choosing between tax-preferred and taxable savings accounts. Their model calculates optimal allocations based on the differences between the two types of accounts in risk and tax treatment of different forms of income.

Absent from these models is adequate consideration of the influence of contribution limits on the contribution decision. In this paper, I build a simple three period model in which a consumer saves for retirement through two assets, each receiving different tax treatment. When future contributions to the tax-preferred asset are constrained by a contribution limit, current contributions increase in order to make use of the contribution room while it is available. This is the "use-it-or-lose-it" motivation to contribute. In an extension, I allow unused contribution room to be carried forward for use in future periods. With this structure, the use-it-or-lose-it effect on contributions diminishes, and in some cases can disappear.

Following the development of the model, I examine empirically the relationship between current contributions and future limits. Using administrative data collected from tax returns, I follow a panel of Canadian tax filers through a period in which Registered Retirement Savings Plan contribution limits underwent a reform. This makes possible an empirical comparison among those who received different treatment under the reform. I find evidence in support of an inverse relationship between future contribution limits and current contributions.

The paper proceeds as follows. I first discuss the basic model and the carry-forward extension in Section 2. This is followed in Section 3 by a description of Registered Retirement Savings Plans and presentation of empirical evidence relating changes in contributions to changes in contribution limits. The paper then concludes with a brief discussion.

2 The Model

2.1 No limits

A simple partial equilibrium three period life-cycle framework provides sufficient structure to explore several aspects of the influence of contribution limits on contributions. To begin the analysis I set up a benchmark model without contribution limits.² In periods 1 and 2, the consumer is endowed with exogenous income y_1 and y_2 . In period 3, the consumer retires, earns no income, and consumes all savings. In the first two periods, unconsumed income may be saved in one of two forms,

²This model borrows from Androkovich, Daly, and Naqib (1992).

differing only in their tax treatment. Contributions to the *registered* asset R_t are deductible from income for tax purposes, while savings allocated to the *non-registered* asset N_t are not. Amounts withdrawn from the registered asset at retirement in period 3 are added to taxable income in that period. Both asset types earn the safe interest rate r in each period.³ Interest earned on R_t is not taxed as it accrues, but interest on N_t is taxed in each period. Thus, the tax base z_t in each period comprises the exogenous income for the period plus interest on the stock of non-registered savings, less net new contributions to the registered asset.⁴ This base is taxed according to a fixed, smooth and progressive tax function τ satisfying $0 \le \tau'(z_t) \le 1$ and $\tau''(z_t) > 0.5$ Utility is derived from consumption c_t in each period according to a standard time separable concave utility function. Finally, future utility is discounted at the rate β , with $0 < \beta < 1$.

This setup differs from the tax structure of most countries in at least three noteworthy ways. First, I do not explicitly rule out short positions in R. Because there is no income in period 3, tax base smoothing alone would make consumers want to make positive contributions in periods 1 and 2. So, if income in the first two periods were large enough, short positions would not be optimal. Second, I assume that interest on short positions of N is tax deductible. Tax-deductible interest on borrowing makes consumers more willing to borrow in order to finance contributions to tax-preferred savings accounts than if no deduction for interest were allowed. However, it will be shown that the key result does not depend on this assumption. Finally, the restriction on the tax function to be strictly convex is at odds with observed income tax schedules, which tend to follow step functions through tax brackets. Furthermore, income-tested tax credits and transfers add 'bubbles' to the marginal tax rate schedule, which can lead to the violation of the assumption that the marginal tax rate is strictly increasing.⁶ The assumptions on the tax function ensure that contributions are an increasing function of income, which greatly simplifies the analysis.

This can be summarized in the following problem. The consumer maximizes utility by allocating

³The average return of assets in tax preferred accounts may earn a different rate of return than assets held in taxable forms. For example, the assets may have different risk characteristics (Shoven and Sialm 1999) or be subject to investment restrictions (Milligan and Smart 2000). A generalization to allow different rates of returns would complicate the analysis, but not change the nature of the results.

⁴An algebraic description of the tax-base for periods 1 to 3 appears in equations (5) to (7). In this setup, the investor pays tax on interest out of ordinary income, rather than out of the proceeds of the interest itself. This corresponds with a tax system in which tax on capital income is not withheld at source.

⁵From here forward, $\tau(z_t)$ will be written as τ_t in order to simplify notation.

⁶Income-testing for pension and other benefits can lead to retirees facing higher marginal tax rates when withdrawing funds from a tax preferred savings account than when working. Shillington (1999) and Poschman and Richards (2000) document this for Canada.

savings to the registered and the non-registered assets in periods 1 and 2, subject to the constraints defined by (2) to (7). Consumption and taxable income are determined endogenously through the values taken by the choice variables.

$$\max_{\langle R_1, R_2, N_1, N_2 \rangle} U = \sum_{t=1}^3 u(c_t) \beta^{t-1}$$
(1)

s.t.

$$c_1 = y_1 - \tau (z_1) - R_1 - N_1 \tag{2}$$

$$c_2 = y_2 - \tau \left(z_2 \right) - R_2 - N_2 \tag{3}$$

$$c_3 = (1+r)^2 \left(R_1 + N_1\right) + (1+r) \left(R_2 + N_2\right) - \tau \left(z_3\right)$$
(4)

$$z_1 = y_1 - R_1 (5)$$

$$z_2 = y_2 - R_2 + rN_1 \tag{6}$$

$$z_3 = (1+r)\left[(1+r)R_1 + R_2\right] + r\left[(1+r)N_1 + N_2\right]$$
(7)

Consumption in the first two periods is the residual from income after paying taxes and making savings choices for assets R and N. In the third period, the terminal value of all assets, less the tax payment, is consumed. Taxable income in each period is the endowment income y less the contribution to R plus the interest that has accrued on N.

Substitution of (2) to (7) directly into the objective function (1) transforms this into an unconstrained optimization problem. The derivatives of U with respect to the four choice variables (R_1, R_2, N_1, N_2) imply the following first order necessary conditions:

$$R_1: \qquad u'(c_1)\left(1-\tau_1'\right) = u'(c_3)\left(1-\tau_3'\right)\left(1+r\right)^2\beta^2 \tag{8}$$

$$R_2: \qquad u'(c_2)\left(1-\tau'_2\right) = u'(c_3)\left(1-\tau'_3\right)(1+r)\beta \qquad (9)$$

$$N_1: \qquad u'(c_1) + u'(c_2) \tau'_2 r\beta = u'(c_3) \rho_3 (1+r) \beta^2$$
(10)

$$N_2: u'(c_2) = u'(c_3) \rho_3 \beta, (11)$$

where ρ_t is defined as the after-tax return to saving for period t:

$$\rho_t \equiv \left[1 + r\left(1 - \tau_t'\right)\right].$$

The second order conditions for a maximum will be satisfied because of the assumption of a strictly concave utility function.

These four equations can be combined and rearranged to produce a solution affording easier interpretation:

$$\rho_2 \rho_3 = \frac{(1 - \tau_3')}{(1 - \tau_1')} \left(1 + r\right)^2 \tag{12}$$

$$\rho_3 = \frac{(1 - \tau_3')}{(1 - \tau_2')} (1 + r) \tag{13}$$

$$u'(c_1) = u'(c_2) \rho_2 \beta$$
(14)

$$u'(c_2) = u'(c_3) \rho_3 \beta.$$
(15)

Equations (12) and (13) are no-arbitrage conditions for the allocation of saving between periods 1 and 3, and periods 2 and 3 respectively.⁷ In each case, the return to taxable saving is on the left-hand side, and the return to saving through the registered asset is on the right-hand side. Contributions to the tax-preferred asset will be made up to the point at which the return to a marginal investment in either asset is identical. Equations (14) and (15) are Euler equations describing the path of consumption between periods 1 and 2, and periods 2 and 3. In these equations, the growth of consumption is governed by the after-tax rate of return ρ , even though a tax-preferred asset offering the before-tax rate of return is available. This occurs because the consumer optimally contributes to the tax-preferred account, then borrows at ρ to reach the desired level of consumption. Thus, this feature of the solution is an artifact of the assumption that borrowing may be made at the after-tax rate of interest. Together, these four equations implicitly define the solution for the choice of (R_1, R_2, N_1, N_2) that provides the utility maximizing amounts of consumption.

Further manipulation provides a solution analogous to Androkovich, Daly, and Naqib (1992). Both sides of (13) are multiplied by $(1 - \tau'_1)$ and substituted into (12), so that the optimal rate of growth for the marginal tax rate can be written as:

$$\frac{\tau_2'}{\tau_1'} = \rho_2.$$
(16)

⁷These equations can also be manipulated to provide an analogous no-arbitrage condition for saving between periods 1 and 2: $\rho_2 = (1+r) \frac{(1-\tau'_2)}{(1-\tau'_1)}$. This does not appear as part of the solution, as it is redundant.

Because $\rho_2 > 1$, (16) means that the marginal tax rate will follow an increasing path through time. This has an intuitive interpretation. Standard tax base smoothing equates marginal tax rates through time, so that an increment of income received in any period will face the same marginal rate, which allows the consumer to minimize his lifetime tax bill. In (16), however, the desire to smooth the tax base (the left-hand side), is traded off against the taxation of interest income on the taxable asset (the right-hand side).

2.2 With Limits

The model presented above ignores a key institutional fact: contributions to tax-preferred savings accounts are constrained by contribution limits. In the United States, for example, Individual Retirement Account contributions are limited to \$2000 for eligible taxpayers.⁸ In Canada, Registered Retirement Savings Plan annual contribution limits increase with earned income, but are capped at C\$13,500. Similar regulations exist in other countries, as well. When contribution limits are incorporated into the model, several interesting results emerge. Current contributions must now reflect the constraints on contributions in future periods. This makes the consumer want to make use of contribution room while it is available. This use-it-or-lose-it motivation to contribute contrasts with the tax base smoothing motivation described above for the no-limit case.

In this section, the model changes through the introduction of a contribution limit L_t for each period. This adds an extra constraint to the problem:

$$R_t \leq L_t.$$

To analyze the effect of the limit on contributions, four cases must be considered. First, the limit could be binding in both periods 1 and 2. In this case, the consumer is no longer able to choose R_1 and R_2 . Increases in the limit in one period may increase contributions in that period, but will not be able to affect contributions in the other period. Second, if the limit is not binding in either period, then the consumer's behaviour when confronted with limit changes is no different than in the no-limit model. The more interesting cases arise when the limit is binding in one period but not the other. When this holds, changes to the limit in the constrained period affect contributions in the unconstrained period.

⁸See Burman, Cordes, and Ozanne (1990) for a more complete description of the eligibility rules for IRAs.

I focus on the case with contributions constrained in period 2 but unconstrained in period $1.^9$ The model changes by replacing R_2 with L_2 in (3), (4), (6), and (7). The first order condition (9) changes as R_2 is constrained by the limit. For the solution, this means that the no-arbitrage condition for saving between periods 2 and 3 no longer holds with equality:

$$R_2: \qquad \rho_3 \le \frac{(1-\tau_3')}{(1-\tau_2')} (1+r) \,. \tag{17}$$

The remaining equations (12), (14), and (15) implicitly define the solution for (R_1, N_1, N_2) when R_2 is constrained by L_2 .

The influence of the limit on contributions can be seen more clearly by rearranging the first order conditions. First, define γ_0 as the Lagrangian multiplier on the constraint $L_2 - R_2 \ge 0$. This can be written as the difference between the left-hand side and the right-hand side of (9):

$$\gamma_0 \equiv u'(c_3) \left(1 - \tau'_3 \right) (1+r) \beta - u'(c_2) \left(1 - \tau'_2 \right).$$
(18)

This expression is combined with (8) through substitution for $u'(c_3)$. After dividing each side by $u'(c_2)(1-\tau'_1)\beta$, the following expression results:

$$\frac{u'(c_1)}{u'(c_2)\beta} = \frac{(1-\tau_2')}{(1-\tau_1')}(1+r) + \frac{\gamma_0(1+r)}{u'(c_2)(1-\tau_1')}.$$
(19)

Using (11) to cancel $u'(c_3)$ in (10) leads to

$$\frac{u'(c_1)}{u'(c_2)\beta} = \rho_2.$$
(20)

For simplicity, define

$$\gamma \equiv \frac{\gamma_0}{u'\left(c_2\right)\rho_2}.$$

Equating (19) and (20), and rearranging produces

$$\tau_1' = \frac{\tau_2'}{\rho_2} - (1+r)\,\gamma. \tag{21}$$

The solution for the case without limits in equation (16) can be rewritten to provide an intuitive comparison of the solutions.

⁹All results hold symmetrically for the case with contributions in period 1 constrained and period 2 unconstrained.

$$\tau_1' = \frac{\tau_2'}{\rho_2} \tag{16'}$$

The solution without limits in (16') sets the marginal tax rate in period 1 equal to the tax rate in period 2, discounted by the after-tax rate of return. With limits in place, the solution represented in (21) appears similar to the no-limit case, but with the right-hand side now reduced by a term reflecting the cost of being constrained by the limit.

The solution facilitates the analysis of an interesting question: what happens to contributions when limits change? Before approaching this question formally, an informal examination of (21) hints at the answer. Holding everything else constant, increasing the limit in period 2 shrinks the cost of being constrained by the limit, γ_0 . This increases the right-hand side of (21), which necessitates a decrease in R_1 to bring about an increase in τ'_1 on the left-hand side of (21) in order to maintain the equality. Thus, an increase in the limit decreases the cost of being constrained, which leads to a decrease in R_1 .

To confirm this result formally, the three equations comprising the solution ((12), (14), and (15)) are used to form three implicit functions of the endogenous choice variables $x = (R_1, N_1, N_2)$, the limit L_2 , and the other exogenous parameters.

$$F_1(x, L_2, \bullet) \equiv \frac{(1 - \tau_3')(1 + r)^2}{\rho_2 \rho_3} - (1 - \tau_1') = 0$$
(22)

$$F_2(x, L_2, \bullet) \equiv u'(c_1) - u'(c_2) \rho_2 \beta = 0$$
(23)

$$F_3(x, L, \bullet) \equiv u'(c_2) - u'(c_3) \rho_3 \beta = 0$$
(24)

Proposition 1 If $R_2 = L_2$, then contributions in period 1 move inversely with the limit in period 2: $\frac{dR_1}{dL_2} < 0.$

Proof. By Cramer's rule. See Appendix A. ■

When the limit increases, a larger contribution may be made in period 2. This diminishes the need of the consumer to "use it or lose it," which decreases R_1 . Because this result does not require restrictions on r, it also holds when r = 0. This is noteworthy because there is no advantage to interest deductibility when r = 0. This indicates that the result does not depend on the interest deductibility assumption.

In standard life-cycle models of consumption, an increase in income leads to an increase in consumption in all periods, so long as marginal utility is decreasing. This implies that an increase in income early in life will increase savings in order to provide for more future consumption. Similarly, an increase in income later in life will lead to a decrease in savings in order to allow for more early consumption. Within the present model, the response of the allocation of savings between the registered and the non-registered asset to changes in income can be addressed. Using the solution described in the equations above, I find the comparative statics derivatives of saving with respect to changes in income.

Proposition 2 If
$$\tau_2'' r \rho_3 (1 - \tau_3') > \tau_3'' \rho_2^2$$
 then $\frac{dR_1}{dy_1} > 0$.
Proposition 3 If $\tau_2'' \rho_3 (1 - \tau_3') > \tau_3'' \rho_2 (1 - \tau_2')$ then $\frac{dR_1}{dy_2} > 0$; $\frac{dN_1}{dy_2} < 0$

Proof. By Cramer's rule. See appendix A.

The sign of the derivative in Proposition 2 is intuitive. Greater income leads to a desire to consume more in the future through an income effect, leading to greater savings. The restrictions are necessary to ensure that the tax benefit of contributing more does not outweigh the cost. An increased contribution lowers taxable income in periods 1 and 2 by lowering the amount of interest that is included in the taxable income in those periods. However, it increases the taxable income in period 3 when the withdrawal from the registered asset is added to taxable income. If the tax rate in period 3 increases "too" quickly (meaning that τ_3'' is large), then a larger contribution would not lower lifetime taxes. The derivative $\frac{dN_1}{dy_1}$ cannot be signed unambiguously without strong restrictions. This means that the change in overall savings in period 1 from an increase in y_1 cannot be signed.

When y_2 increases, Proposition (3) shows that R_1 will increase and N_1 will decrease, if the sufficient condition holds. For the same reasons as above, the consumer wishes to contribute to R_1 so long as the decrease in taxes in period 2 is greater than the increase in taxes in period 3. If R were the only asset, an increase in future income would lead to a decrease in current saving in order to facilitate more current consumption. However, in this model with two assets, the amount contributed to R increases as y_2 increases, when the necessary conditions are satisfied. Any decrease in period 1 savings must take place through the non-registered asset N.

This model provides a setting in which the use-it-or-lose-it motivation plays a pivotal role in the contribution decision. This gives rise to several implications. First, when the future contribution

limit is binding, an increase in that limit will cause current contributions to fall. Second, changes in income may have counterintuitive effects on contributions to the registered asset. This model proves useful for the analysis of certain types of policy changes. As an example, I use the model to analyse the effects of a carry-forward provision on contributions.

2.3 Carry-forward Limits

In both Canada and the United Kingdom, any difference between a consumer's contribution and the contribution limit may be carried forward for use in future years.¹⁰ By 1996, Canadian taxpayers had accumulated over C\$179 billion in contribution room, or \$10,740 per tax filer. This was equal to 37 percent of taxable income in that year (Revenue Canada 1998). The implications of this limit structure for contributions have not been well explored.¹¹

In this section, I extend the model to consider a provision allowing for the carry-forward of unused contribution room. The carry-forward is integrated with the model in the following way. Unused contribution room from period 1, calculated as the allowed limit L_1 less the chosen contribution R_1 , can be carried forward. In period 2, the consumer may contribute the allowed limit for that period plus the unused room from period $1.^{12}$ To make the problem more general, assume that the stock of unused room grows at the gross rate θ , so that one dollar of contribution room carried forward from the period 1 provides θ dollars of extra contribution room in period 2. The constraint on second period contributions becomes

$$R_2 \leq L_2 + \theta (L_1 - R_1).$$

The consumer now must contemplate how a contribution in period 1 will change the constraint to be faced in period 2. The new first order condition from the derivative with respect to R_1 is

$$u'(c_1)(1-\tau_1') = u'(c_2)\theta(1-\tau_2')\beta + u'(c_3)(1-\tau_3')(1+r)(1+r-\theta)\beta.$$
(25)

This, combined with (10) and (11), provides the first order conditions for the problem.

¹⁰In Canada the carry-forward was initially limited to seven years when introduced in 1991, but was expanded to an indefinite carry-forward in 1996. In the United Kingdom, unused contribution room for Personal Pensions may be carried forward for six years, and carried back for one year.

¹¹Gupta, Venti, and Wise (1994) present predictions of the future path of aggregate RRSP contributions with a carry-forward provision. However, their simulations are based on the assumption that the introduction of the carry-forward does not change contribution behaviour.

¹²In Canada, the deduction need not be taken in the same year as the contribution is made, but instead may be carried forward. This feature is not captured within the present model.

Table 1: Comparison of solutions for different values of θ

	θ	$ au_1' =$
no limit	n.a.	$\frac{\tau_2'}{\rho_2}$
with annual limit	0	$\frac{\tau_2'}{\rho_2} - (1+r)\gamma$
carry-forward	1	$\frac{\tau_2^7}{\rho_2} - r\gamma$
carry-forward	1+r	$\frac{\tau_2}{\rho_2}$

Again, I analyze the solution through solving for τ'_1 . Equation (18) is used to substitute for $u'(c_3)$, then both sides are divided by $\beta u'(c_2)$ in (25) leaving

$$\frac{u'(c_1)}{\beta u'(c_2)} \left(1 - \tau_1'\right) = (1+r) \left(1 - \tau_2'\right) + (1+r-\theta) \frac{\gamma_0}{u'(c_2)}.$$
(26)

After substituting (20) into the left-hand side, the resulting expression can be rearranged to give

$$\tau_1' = \frac{\tau_2'}{\rho_2} - (1 + r - \theta) \gamma.$$
(27)

Three interesting cases can be generated from (27) by choosing different values for θ . If $\theta = 0$, there is no carry-forward. In this case, (27) reproduces the result from (21) without the carry-forward. The case for which $\theta = 1$ corresponds to the standard concept of a carry-forward provision - room is carried forward dollar for nominal dollar. Compared to the case without the carry-forward, the influence of the γ term diminishes sharply, as it is now premultiplied only by r. Finally, if $\theta = 1 + r$, the γ term vanishes. Here, the result appears identical to the no-limit case in equation (22). These are summarized in Table 1.

The third case $(\theta = 1 + r)$ occurs if interest were paid on the accumulating stock of contribution room at the same rate earned by savings. Here, a dollar of contribution not made in this period can always be made next period without hitting the limit. This frees the consumer from the need to make a higher contribution in the current period to account for being constrained in the future. However, this does not mean that the consumer becomes indifferent between contributing in period 1 versus period 2, since the interest on non-registered savings will be taxable. Rather, the consumer is returned from being concerned with adjusting contributions to reflect being constrained in the future to being concerned solely with the trade-off described in equation (16) between tax base smoothing and tax-exempt accrual.

3 Evidence

To explore the implications of Proposition 1, I analyze contributions to Registered Retirement Savings Plans (RRSPs) in Canada. Contribution limits for RRSPs underwent a reform in 1990 and in 1991, and these reforms had different effects on different groups of taxpayers. I identify four such "treatment" groups, and compare their contribution behaviour to other contributors who act as "control" groups. In this section, I first provide some background on RRSP contributions, contribution limits, and the reforms to the contribution limits. Next, I describe in more detail the empirical strategy. This leads to a description of the data set used for the estimation, followed by the presentation of the results.

Contributions to RRSPs receive the following tax treatment. Contributions are deductible from income for tax purposes, and income within an RRSP accrues tax-free. When funds are withdrawn, the full amount is added to taxable income for that year. Until 1996, contributions could be made until age 71, when a planned series of withdrawals must begin.¹³ In contrast with IRAs, early withdrawals from RRSPs attract no penalty.¹⁴ RRSP contributions are subject to a contribution limit. Through the 1980s, the RRSP contribution limit was calculated as 20 percent of earned income, up to a prescribed maximum (\$7,500 from 1986 to 1990). This maximum limit differed for members of employment based pension plans - called Registered Pension Plans (RPPs). The contributions of RPP members were capped at \$3,500, less any employee contribution to the RPP. Special provisions also existed for those receiving pension income. Each dollar of pension income could be "rolled over" into an RRSP, which effectively increased the contribution limit of pensioners by the annual amount of their pensions. Finally, eligible lump sum retirement allowances and transfers can be deducted in some circumstances.¹⁵

From 1982 to 1990, aggregate annual contributions to RRSPs grew from \$2.1 billion to \$4.1

¹³This age was changed to 69 in 1996.

¹⁴Even though there is no penalty for early withdrawal, there remains asymmetry between contributions and withdrawals - a withdrawal does not replenish contribution limits. This may still make consumers reluctant to withdraw.

¹⁵Two types of transfers into RRSPs are possible. In some cases, the transfer does not have to appear as income, and so is not eligible for a deduction. In other cases, the transfer receives 'in and out' treatment, meaning that it appears as income, but then is deducted.

billion. The stock of RRSP savings jumped from \$32.6 billion in 1983 to \$129.3 billion in 1991 (Statistics Canada 1999). This growth in RRSP saving was a result of an increase in the number of taxpayers making a contribution, rather than an increase in the average size of contributions. This is illustrated in Figure 1, which displays some aggregate RRSP statistics from Revenue Canada (1984-1992). The line graphs the percentage of those with earned income making a positive contribution.¹⁶ From 23.3 per cent in 1982, this RRSP participation rate grew to 31.7 per cent in 1990. The bars show the size of the average contribution of those making a positive contribution, in constant 1990 dollars. The average contribution remained fairly steady throughout this period, reaching a peak of \$3,068 in 1988. The sharp drop in the average contribution in 1990 to \$2,567 may have been related to two reforms of RRSP contribution limits, each of which is described in detail below.

In 1990 and 1991, two reforms changed contribution limits. Starting in 1990, the roll-over provisions for pension income were removed. This had a large effect on the contribution room available to pensioners, who represented 12.6 percent of tax filers in 1990.¹⁷ In 1991, a major reform further changed the structure of contribution limits in three ways. First, the calculation of the limit changed. The percentage of earned income used to calculate the limit decreased from 20 per cent to 18 per cent, and the maximum limit for those without an RPP increased from \$7,500 to \$11,500. This is illustrated in Figure 2. Before 1990, the maximum limit was reached at \$37,500. With the new percentage and higher maximum limit, the threshold is not reached until \$63,889. The cross-over point for the two contribution limit calculations is \$41,667. So, among those without an RPP, those with earned income over \$41,667 experienced an increase in their limits, while those earning under that threshold had a decrease. The second part of the reform changed the way the limits of RPP members were calculated. Starting in 1991, RPP members calculated their limit as 18 per cent of earned income up to \$11,500, less a Pension Adjustment.¹⁸ The introduction of the Pension Adjustment affected RPP members, but not non-members.¹⁹ The final feature of the

¹⁶Some taxfilers without earned income could still make contributions. See footnote 21 for more details on eligible earned income for RRSP purposes. Defining participation using the percentage of all taxfilers shows a similar trend.

¹⁷From 1989 to 1994, a special transitional provision allowed roll-overs of amounts up to \$4000 into an RRSP in the spouse's name.

¹⁸The Pension Adjustment aimed to adjust the contribution limit to account for the tax preference given to the accruing pension rights in the RPP (Horner and Poddar 1992). Because a uniform actuarial calculation is applied to all RPPs, those with less generous plans receive an unduly large Pension Adjustment, while those with very generous plans are assigned a Pension Adjustment that is less than the actuarial value of their accruing benefits. The average Pension Adjustment in 1993 (the first year aggregate Pension Adjustments are reported), among those with a positive Pension Adjustment, was \$3,499 (Revenue Canada 1995).

¹⁹In 1991, 45.5 per cent of paid workers were members of an RPP (Statistics Canada 1999).

reform was the introduction of a carry-forward provision. From 1991, unused contribution room could be carried forward for use in future years.

3.1 Empirical Strategy

The model predicts that current RRSP contributions move inversely with future contribution limits. This will be tested using the following reduced form equation:

$$RRSP_{i,t} = \gamma LIMIT_{i,t+1} + \beta' X_{i,t} + \alpha_i + u_{i,t}$$
(28)

The contribution of individual *i* at time *t*, $RRSP_{i,t}$, is expressed as a linear function of the contribution limit in the next period, $LIMIT_{i,t+1}$, other relevant covariates, $X_{i,t}$, an individual fixed effect, α_i , and a disturbance term, $u_{i,t}$. Through subtraction of equation (28) written for period t-1 from the same equation in period *t*, a first-differenced equation results:

$$\Delta RRSP_{i,t} = \gamma \Delta LIMIT_{i,t+1} + \beta' \Delta X_{i,t} + \varepsilon_{i,t}.$$
(29)

For each variable, the first difference operator Δ represents the difference between the realization in one period and the realization in the preceding period. This facilitates the estimation of the parameters γ and β by removing the influence of the individual fixed effect α_i . The new disturbance term $\varepsilon_{i,t}$ replaces $\Delta u_{i,t}$, and is assumed to be normally distributed with mean zero.

Some taxpayers will have their RRSP contribution censored. For some, the censoring occurs because they are contributing at their contribution limit. To deal with this censoring, I assume contributions are censored at the full value of the contribution limit. Gupta, Venti, and Wise (1994) examine the possibility that, owing to rounding or integer considerations, individuals may be constrained by a "pseudo-limit" rather than the calculated statutory limit. For example, someone with a calculated limit of \$3,078 may decide to contribute only \$3,000, in order to keep the contribution at a round number. I check the sensitivity of the results to using a pseudo-limit as the censoring point by reporting the results of a regression with contributions censored at a 90 per cent of the actual limit.

The RRSP contributions of other taxpayers will be censored on the other side. The maximum withdrawal that could be made from an RRSP would be to liquidate the account. This means that the maximum withdrawal ranges from zero (if the taxpayer did not have an RRSP) to the total accumulated stock of RRSP assets. Unfortunately, the data set does not report the accumulated stock of RRSP assets, so the true censoring point is unobservable. For the main regressions, I therefore assume that there is no accumulated stock of RRSP assets from which a withdrawal could be made, which means that the RRSP contribution is censored at zero. I check the sensitivity of the results by taking the opposite assumption that any size withdrawal could be made, so RRSP contributions are not censored on the left.

To account for the censoring of the dependent variable, I follow Wise (1984) and estimate (29) as a Tobit. I assume that the level of RRSP contributions are censored on the left at zero, and on the right at the contemporaneous contribution limit:

$$0 \le RRSP_{i,t} \le LIMIT_{i,t} \tag{30}$$

The censoring points for the change in RRSP contributions at time t can be found by subtracting the contribution made in period t - 1:

$$-RRSP_{i,t-1} \le \Delta RRSP_{i,t} \le LIMIT_{i,t} - RRSP_{i,t-1} \tag{31}$$

Because contribution limits are a function of income, the 1990 and 1991 reforms to contribution limits are crucial for identifying the effect of future contribution limits. I define four groups of taxpayers who receive different treatment under the reform, and compare their contributions with the contributions of taxpayers outside the four groups. If the contributions of members of the groups react differently to the changes in contribution limits brought about by the reforms than do the contribution of taxpayers outside the groups, then a more credible inference can be made about the causal link between future contribution limits and current contributions. The definition of the treatment groups is discussed in the next section.

This empirical strategy raises some ground for caution. Observed responses to the reform more likely reflect the reaction to the change in the lifetime total future contribution room, rather than the one-year change in contribution room as I assume here. To calculate the change in lifetime contribution room would require strong assumptions about the future paths of income and policy.²⁰

²⁰The same criticism could be levied against the assumption that consumers know their one-year forward contribution limit. However, RRSP contributions can be made up to 60 days into the next tax year. So, consumers will already be in the "future" year when making the contribution decision for the "present" year. Furthermore, in the case of each reform, the new limit structure for the coming year was known well before the deadline for contributions for the current tax year. (Bill C-52, which contained amendments to the RRSP sections of the Income Tax Act

So, the one-year change in future contribution limits serves here as a proxy for the total change in expected future contribution limits, to which contributions in fact may be responding. For this reason, interpretation of the magnitude of the estimated response is difficult.

3.2 Data

I examine contribution behaviour using administrative data on a random sample of Canadian tax filers. This panel follows the same set of tax filers through the years 1987 to 1991. Only those who file a tax return in a given year appear in the data set. From this data set, I exclude those ineligible to contribute to an RRSP in a given year. Ineligibility occurs when age exceeds 71, or when the year's RRSP contribution limit is zero. Finally, I removed any tax filer making a transfer of a retirement allowance or lump sum into an RRSP because of difficulty in distinguishing the type of transfer.²¹ The construction of the desired variables requires information from one year forward and one year back. Accordingly, observations for 1987 and 1991 could not be used because of the inability to create these variables. The data set used for estimation takes the form of an unbalanced panel with 41,764 observations for 1988, 41,801 for 1989, and 39,556 for 1990.²²

The primary advantage of administrative data is the ability to calculate the desired variables with greater accuracy than is possible using survey data. The actual RRSP contribution made by the taxpayer, $RRSP_{i,t}$, is reported in the data set. The dependent variable for the regressions, $\Delta RRSP_{i,t}$, is then constructed using the difference of $RRSP_{i,t}$ and $RRSP_{i,t-1}$ for each individual. The calculation of the RRSP contribution limit $LIMIT_{i,t}$ requires several pieces of information. First, I must distinguish between members and non-members of RPPs. For 1990 and 1991, RPP members are distinguished by having a non-zero Pension Adjustment. Unfortunately, RPP status before 1990 is unobservable.²³ To assign RPP status for prior years, I assume that those who are members of RPPs in 1990 were also members from 1987 to 1989. Once RPP status is determined, the next step is to combine this with a measure of earned income in order to arrive at the RRSP reflecting the reforms implemented for 1991, received Royal Assent on June 27, 1990.) This renders plausible the assumption that a contributor has enough information about both earnings and tax regulations to predict his limit

for the coming year when current contributions are made.

²¹Some transfers appear as income and then later are deducted. Other transfers appear neither as income nor as a deduction. This ambiguity made the measurement of the year's contribution imprecise. Results from regressions on a data set including these observations produced comparable results.

²²Regressions on a balanced panel including only those tax filers eligible to contribute in all five years showed similar results.

²³Only employee contributions to an RPP are observed before 1990. Those in non-contributory pension plans are indistinguishable from those with no RPP.

contribution limit. From 1987 to 1989 earned income is constructed from the reported components of income.²⁴ In 1990 and 1991, the exact earned income for RRSP purposes is provided in the data set. This calculated value of earned income is then used to derive the RRSP contribution limit. Finally, for years prior to 1990, pension income could be rolled into an RRSP, which effectively increased the contribution limit by the amount of pension income received. Thus, the calculated value of $LIMIT_{i,t}$ used in the estimation comprises the sum of the contribution limit derived from earned income and eligible pension income. To calculate $\Delta LIMIT_{i,t+1}$, I subtract next year's limit $LIMIT_{i,t+1}$ from this year's limit $LIMIT_{i,t}$.

There are four groups of taxpayers who receive different treatment under the reforms. First, RPP members had their RRSP contribution limit change with the introduction of the Pension Adjustment for the 1991 tax year. Those who were not members of RPPs did not experience this change in their limit calculation. Second, pension income recipients saw their ability to roll over income into an RRSP curtailed in 1990. This reform did not affect those without pension income. Third, the increase in the maximum limit from \$7500 to \$11500 in 1991 affected only those with high contribution limits. Those with lower levels of earned income actually saw a small decrease in their contribution limit as the percentage of earned income used in the limit calculation decreased from 20 to 18 per cent. Finally, the model predicts that those who are constrained in period t + 1 will change their contribution in period t in response to a change in the contribution limit in period t + 1. Those who are not constrained in the future period, however, are not predicted to show any response. For this reason, I identify the group of taxpayers whose future RRSP contribution was constrained by the contribution limit. These four groups of taxpayers have the value 1 assigned to the variables RPPMEM, PENSIONER, HIGHLIMIT, and FUTCONSTRD. More detail about the construction of these variables, as well as the other control variables used in the regressions, is provided in Appendix B.

Table 2 reports descriptive statistics for the key variables in the data set. The first three columns calculate the statistics over all the observations for each year. The rest of the columns report the same statistics for members of each of the treatment groups. The average RRSP contribution falls slightly from 1988 to 1989 to \$997, then drops sharply in 1990 to \$702. There is also a decrease

²⁴Before 1990, earned income for RRSP purposes comprised the sum of T4 income, other employment income, Old Age Security pension income, Canada/Quebec Pension Plan income, other pension income, net rental income, net business income, net professional income, net farming income, and net fishing income. From 1990, the definition excluded Old Age Security pension income, Canada/Quebec Pension Plan income, and other pension income.

in contribution room available in that year, so the response seen in the mean RRSP contribution may be related. Much of this drop is attributable to the cessation of pension income roll-overs by pension recipients. This is confirmed by looking at the third panel which reports the statistics for the subsample of pension income recipients. Both the average RRSP contribution and average contribution limit fall greatly in 1990 for members of this group. The number of pensioners in the data set also drops in 1990 to 3608. This occurs because the RRSP contribution limit of many pension income recipients became zero once pension income roll-overs were disallowed.

The next two rows compare the mean of $\Delta RRSP_{i,t}$ to the mean of $\Delta LIMIT_{i,t+1}$. On average over all observations, RRSP contributions grew in 1989 by \$28. The average change in the RRSP contribution limit in the coming year for these taxpayers was -\$1473. This large drop in the contribution limit is driven mostly by the group of pension income recipients, whose limits fell greatly. The subsample of taxpayers whose future RRSP contribution was constrained show a clear pattern in the means for these two variables. In 1988 and 1989 when future limits are becoming smaller, RRSP contributions are growing. In 1990 however, their future contribution limits increased by \$884 due to the 1991 reforms. In that year, the average contribution by these taxpayers dropped by \$447. These means reveal some preliminary evidence of a negative relationship between current RRSP contributions and future RRSP contribution limits. The regressions in the next section expand on this analysis by controlling for other individual characteristics that may influence RRSP contributions, as well as taking into account the censoring of the dependent variable.

3.3 Results

I report regression results for a series of specifications. After confirming the existence of a simple relationship between current contributions and future limits, I progressively add more control variables for income and demographic characteristics. Next, I add the dummy variables for the four treatment groups as well as interactions of these variables with the policy variable, $\Delta LIMIT_{i,t+1}$. Finally, I check the result for robustness using different subsamples and varying the definition of the key RRSP variables. A consistent picture emerges from the analysis. The results show a strong, negative relationship between future limits and current contributions, which is consistent with the prediction of Proposition 1.

Table 3 reports the base regression results. Beneath each coefficient appears the corresponding standard error. The standard errors are derived from the Huber-White robust variance-covariance matrix, which adjusts for arbitrary forms of heteroskedasticity. Wald tests for significance of the estimated coefficients are chi-squared distributed with one degree of freedom. Those variables significant at the five percent level are indicated with an asterisk. To begin, specification (a) shows the results of an ordinary least squares (OLS) regression of $\Delta RRSP_{i,t}$ on $\Delta LIMIT_{i,t+1}$. The estimated coefficient is a significant -0.119. This provides some initial evidence of a negative relationship between the two variables provides. However, this OLS estimate does not account for the censoring of the dependent variable. The Tobit estimate in specification (b) improves on the OLS specification by taking the censoring of contributions into account. In the data, 25,929 observations are uncensored, 89,972 observations are censored on the left, and 7,220 are censored on the right. The estimated coefficient for the Tobit specification is -0.190. This estimate implies that a \$1,000 increase in the future limit leads to a decrease in current contributions of \$190 for an unconstrained contributor. However, as noted earlier, a taxpayer's current contributions may be reacting not only to the change in the limit in the coming period, but also to the total change in contribution room over all future periods. For this reason, interpretation of the magnitude of the response should be made with caution.

Contribution limits are a function of income. To ensure that the observed negative relationship between future limits and current contributions is not simply reflecting changes in income, I explore a specification including measures of income. The best measure of the resources available to an individual would be his or her after-tax income. However, RRSP contributions change the tax liability of the individual, so after-tax income is endogenous. Instead, I recalculate the individual's tax liability as if there were no RRSP contribution to derive an after-tax, but before RRSP, income. This calculation also provides the marginal tax rate facing the individual before RRSP contributions are made.²⁵

Specification (c) includes both current and future income, as well as marginal tax rates. The square of current and future income is also included. These variables all appear in first-differenced form. The coefficient on $\Delta LIMIT_{t+1}$ is now -0.232, which is larger than in specification (b). Income is measured in units of one thousand dollars, meaning that the coefficient of 12.15 implies that a thousand dollar increase in income leads to a \$12.15 increase in the RRSP contribution. So, those with higher incomes save more through RRSPs than those with lower incomes, which is

²⁵Triest (1998) argues that this first-dollar marginal tax rate may still be endogenous if RRSP contributions change reported income or the use of other tax deductions. This endogeneity will bias the estimated coefficient on the marginal tax rate toward zero.

consistent with Proposition 2. However, the estimated coefficient on future income is -14.39, which conflicts with the prediction of Proposition 3. The marginal tax rate is measured as a percentage between zero and one hundred. So, the estimated coefficient of 16.88 means that a ten percentage point increase in the marginal tax rate faced by the consumer increases the contribution by \$168.80. This is consistent with the positive relationship between marginal tax rates and Individual Retirement Account contributions reported by Long (1990), but differs from Veall (1999), who finds no evidence that higher marginal tax rates increase RRSP contributions. The coefficient on the future marginal tax rate is also positive. All else equal, a higher future marginal tax rate increases the benefit to the taxpayer of tax-exempt accrual on current contributions, but should also increase the desire of the taxpayer to abstain from current contributions in order to smooth marginal tax rates between the two years. Overall, this specification confirms that the observed negative coefficient on $\Delta LIMIT_{t+1}$ is not caused by correlations of limits with tax rates and income.

Specification (d) augments the regression by adding trends for several demographic characteristics reported in the data set. The positive estimated coefficients on MALE and MARD suggest that males and married individuals increased their RRSP contributions on average over the sample period. The variables AGE and AGESQ taken together form a quadratic in the individual's age. The estimated coefficients of 593.98 and -6.46 imply that the time trend in RRSP contributions is decreasing with age, and that this trend is positive and increasing for individuals under 46 years of age, and decreasing thereafter. The administrative data also provides some information on the individual's type of employment. Three of these four income source dummies are insignificant, however. The regression also includes provincial trend variables, to pick up changes in contribution patterns specific to residents of a province. Finally, the variables Y1989 and Y1990 are indicators to pick up the overall trend from 1988 to 1989, and 1989 to 1990. With these trend variables included, the coefficient on the future limit is larger, at a statistically significant -0.320. This suggests that the result is robust to the inclusion of controls for this set of observable trends.

In order to exploit the existence of the four groups receiving different treatment under the reform, I create dummy variables for membership in each of the groups along with interactions of this set of dummies with $\Delta LIMIT_{t+1}$. The results of regressions including these variables are reported in Table 4. Specification (e) includes the regressors used in specification (d), with the addition of the set of treatment group dummies as controls. Because pensioners, for example, received different treatment through the reform period, the estimated coefficient on $\Delta LIMIT_{t+1}$

may pick up other trends affecting the RRSP contributions of pensioners differently than those of non-pensioners. With these variables included, I can control for the effect of any linear trends for the treatment groups. The estimated coefficient in specification (e) is -0.308, which is slightly smaller in absolute value than the coefficient reported for specification (d). This suggests that the identification of the effect of future limits on RRSP contributions in these regressions does not rely on differences across groups.

Specification (f) extends the regression in specification (e) by including the interaction terms described above. This specification permits heterogeneity across the treatment groups in the response of contributions to limits. The estimated effect of future limits on taxpayers in none of the treatment groups is now an insignificant 0.053. Because these taxpayers in the control group received little change to their contribution limits, this is expected. In contrast, the coefficients on three of the four interaction terms are negative and significant. RPP members show a stronger reaction to the reform than non-members, with an estimated coefficient for this group of -0.161. Pensioners show the strongest reaction to a change in their limits, with an estimated coefficient of -0.287. Those with high contribution limits have an estimated coefficient of -0.103, although it is insignificant at the five percent level. Finally, the theory predicted a reaction only for those who are constrained in the future. In the data, these individuals do show a significant negative response with an estimated coefficient of -0.093. Thus, members of three of the four treatment groups show a statistically significant stronger response to changes in their future contribution limits than do those outside the treatment group.

Finally, Table 5 presents estimates from four regressions using different sample and variable definitions. In the first two columns, I report results from regressions identical to specification (e) on observations from 1989 only and 1990 only. The 1989-only sample isolates the effect of the 1990 contribution limit reform on 1989 RRSP contributions, while the 1990-only sample looks at the effect of the 1991 reform on 1990 RRSP contributions. In both cases, the coefficient on the future limit is statistically significant and negative. The estimated magnitude of the effect in 1990, is much smaller than in 1989: -0.089 compared to -0.243. However, the negative relationship between current contributions and future limits holds in each of these subsamples. To check the assumptions made about the censoring points, I explore a different definition of contributions and limits. The regression reported in column (i) uses a taxpayer's *net* contribution to RRSPs. Rather than assuming that no withdrawals are possible, here I assume that a taxpayer can withdraw

as much as he would like from the RRSP account. If zero contributions are observed, then the taxpayer is assumed to prefer making this level of contribution over making a withdrawal. With this extreme assumption, the estimated coefficient on $\Delta LIMIT_{i,t+1}$ is closer to zero at -0.160, but is still significantly different from zero. Finally, I apply the pseudo-limit concept of Gupta, Venti, and Wise (1994) by censoring contributions at 90 per cent of the year's limit.²⁶ The results are reported in column (i). The estimated coefficient here is almost unchanged from specification (e), at a significant -0.301. Comparing the results from changing assumptions about the left-hand and the right-hand limits, it appears that the assumption about those contributing zero to RRSPs is much more important to the Tobit estimation than is the assumption about the right censoring point at the contribution limit. These regressions show that the negative relationship between RRSP contributions and future contribution limits is remarkably robust across variations in samples and variable definitions.

4 Conclusion

This paper developed a simple life-cycle model to describe the path of contributions to tax-preferred savings accounts when contributions are subject to contribution limits. The solution to this model differs from existing models by featuring a use-it-or-lose-it effect on contributions. This leads to a new result - as limits increase current contributions will decrease. The model also provides insight into contribution behaviour in the presence of a carry-forward provision. Under this institution, the use-it-or-lose-it motivation is diminished, and under certain parameter values could disappear. The empirical evidence draws from reforms to RRSP limits in Canada, and supports the primary proposition of the model. Increased contribution limits are associated with a decrease in contributions.

This model improves on existing models of contribution behaviour, but remains incomplete. A model incorporating uncertainty about incomes and future tax rates, precautionary savings, or liquidity constraints might provide richer conclusions about allocations of saving across assets receiving different tax treatment. Instead, this model emphasizes the importance of thinking about limit changes in a life-cycle context. By providing an improved framework in which to interpret results, this model should aid empirical researchers interested in understanding the real effects

 $^{^{26}\}mathrm{A}$ 95 percent pseudo-limit was also tried, and similar results were obtained.

of tax-preferred savings accounts on saving, as well as policy makers interested in predicting the response to a change in contribution limits.

A Proofs

In order to sign the required derivatives, the Jacobian of F with respect to x must be evaluated. Define $\nabla_x F$ as the matrix composed of the derivatives of identities F_1 , F_2 and F_3 with respect to the set of choice variables $x = \{R_1, N_1, N_2\}$.

Lemma 4 $|\nabla_x F| < 0.$

Proof.

$$|\nabla_{x}F| = (\rho_{2}\rho_{3})^{-2} \begin{vmatrix} -\tau_{3}''(\rho_{2}\rho_{3})^{2} - \tau_{3}''\rho_{2}(1+r)^{4} & \tau_{2}''(1-\tau_{3}')\rho_{3}(1+r)^{2}r^{2} \\ -\tau_{3}''\rho_{2}(1+r)^{3}r & -\tau_{3}''\rho_{2}(1+r)^{2}r \\ -u''(c_{1})(1-\tau_{1}') & u'(c_{2})\tau_{2}'r^{2}\beta - u''(c_{1}) \\ +u''(c_{2})\tau_{2}'\rho_{2}r\beta & u''(c_{2})\rho_{2}\beta \\ u'(c_{3})\tau_{3}''(1+r)^{2}r\beta & u'(c_{3})\tau_{3}''r^{2}(1+r)\beta & u'(c_{3})\tau_{3}''r^{2}\beta \\ -u''(c_{3})(1-\tau_{3}')\rho_{3}(1+r)^{2}\beta & -u''(c_{2})\tau_{2}'r & -u''(c_{2}) \\ -u''(c_{3})\rho_{3}^{2}(1+r)\beta & -u''(c_{3})\rho_{3}^{2}(1+r)\beta & -u''(c_{3})\rho_{3}^{2}\beta \end{vmatrix}$$

This Jacobian is expanded, then terms are collected and arranged in the following form:

$$|\nabla_x F| = (\rho_2 \rho_3)^{-2} \begin{bmatrix} \pi_1 u''(c_1) u''(c_2) + \pi_2 u''(c_1) u'(c_3) + \pi_3 u''(c_1) u''(c_3) + \pi_4 u'(c_2) u''(c_2) \\ + \pi_5 u'(c_2) u'(c_3) + \pi_6 u'(c_2) u''(c_3) + \pi_7 u''(c_2) u'(c_3) + \pi_8 u''(c_2) u''(c_3) \end{bmatrix}.$$

The coefficient on each term can be signed as follows:

$$\begin{aligned} \pi_{1} &= - \left\{ \begin{array}{c} \tau_{3}'' \rho_{2} \left(1+r\right)^{2} \left[\left(1+r\right) \left(1+\tau_{1}'r\right)+\tau_{2}'r^{2} \left(1-\tau_{1}'\right) \right] \\ &+ \tau_{2}'' \left(1-\tau_{1}'\right) \left(1-\tau_{3}'\right) \rho_{3} \left(1+r\right)^{2} r^{2} \right) \right\} - \tau_{1}'' < 0 \\ \pi_{2} &= \left[\tau_{2}'' \tau_{3}'' \rho_{3} \left(1-\tau_{1}'\right) \left(1-\tau_{3}'\right) \left(1+r\right)^{2} r^{4} \beta \right] + \tau_{1}'' \tau_{3}'' r^{2} \beta > 0 \\ \pi_{3} &= - \left[\begin{array}{c} \tau_{3}'' \rho_{2} \rho_{3} \left(1+r\right)^{4} \beta \\ &+ \tau_{2}'' \rho_{3}^{3} \left(1-\tau_{1}'\right) \left(1-\tau_{3}'\right) \left(1+r\right)^{2} r^{2} \beta \end{array} \right] - \tau_{1}'' \rho_{3}^{2} \beta < 0 \\ \pi_{4} &= \left[\tau_{2}'' \tau_{3}'' \rho_{2} \left(1+r\right)^{4} r^{2} \beta \right] + \tau_{1}'' \tau_{2}'' r^{2} \beta > 0 \\ \pi_{5} &= -\tau_{1}'' \tau_{2}'' \tau_{3}'' r^{4} \beta^{2} < 0 \\ \pi_{6} &= \tau_{2}'' \tau_{3}'' \rho_{2} \rho_{3} \left(1+r\right)^{4} \beta^{2} r^{2} + \tau_{1}'' \tau_{2}'' \rho_{3}^{2} \beta^{2} r^{2} > 0 \\ \pi_{7} &= \tau_{2}'' \tau_{3}'' \rho_{2} \rho_{3} \left(1-\tau_{3}'\right) \left(1+r\right)^{4} r^{3} \beta^{2} + \tau_{1}'' \tau_{3}'' \rho_{2}^{2} r^{2} \beta^{2} > 0 \end{aligned}$$

$$\pi_8 = -\left[\tau_3'' \rho_2^3 \rho_3 \left(1+r\right)^4 \beta^2 + \tau_2'' \rho_2 \rho_3^2 \left(1+r\right)^4 r^2 \beta^2\right] - \tau_1'' \rho_2^2 \rho_3^2 \beta^2 < 0.$$

Given the assumption of strictly concave utility, each term in the expansion of the determinant is negative. Since each individual term is negative, the sum of all the terms must be negative: $|\nabla_x F| < 0.$

A.1 Proof of Proposition 1

Define $\nabla_{L_2} F$ as the matrix of first derivatives of identities F_1 , F_2 and F_3 with respect to L_2 . The total derivative of the system is placed in matrix form:

$$\left[\nabla_x F\right] \left[\begin{array}{c} dR_1 \\ dN_1 \\ dN_2 \end{array} \right] = \left[-\nabla_{L_2} F \right] \left[dL_2 \right].$$

To solve this for $\frac{dR_1}{dL_2}$, I first replace the first column of $[\nabla_x F]$ with $[-\nabla_{L_2} F]$ to form the matrix $\nabla_x F_{R_1}^{L_2}$. The determinant of this matrix is then evaluated.

$$\left| \nabla_{x} F_{R_{1}}^{L_{2}} \right| = (\rho_{2} \rho_{3})^{-2} \begin{vmatrix} \tau_{2}'' (1 - \tau_{3}') \rho_{3} (1 + r)^{2} r \\ + \tau_{3}'' \rho_{2} (1 + r)^{3} \end{matrix} & \tau_{2}'' (1 - \tau_{3}') \rho_{3} (1 + r)^{2} r^{2} \\ - \tau_{3}'' \rho_{2} (1 + r)^{3} r \end{matrix} & -\tau_{3}'' \rho_{2} (1 + r)^{2} r \end{vmatrix}$$
$$\begin{vmatrix} u'(c_{2}) \tau_{2}'' r^{\beta} \\ - u''(c_{2}) (1 - \tau_{2}') \rho_{2} \beta \end{matrix} & u'(c_{2}) \tau_{2}'' r^{2} \beta - u''(c_{1}) \\ + u''(c_{2}) \tau_{2}' \rho_{2} r \beta \end{matrix} & u''(c_{2}) \rho_{2} \beta \end{vmatrix}$$
$$\begin{vmatrix} u''(c_{2}) (1 - \tau_{2}') \rho_{2} \beta \\ + u''(c_{3}) (1 - \tau_{3}') \rho_{3} (1 + r) \beta \\ - u''(c_{3}) \tau_{3}'' r^{2} (1 + r) \beta \end{vmatrix} & u'(c_{3}) \tau_{3}'' r^{2} \beta \\ - u''(c_{3}) \tau_{3}'' (1 + r) r \beta \\ - u''(c_{3}) \rho_{3}^{2} (1 + r) \beta \\ - u''(c_{3}) \rho_{3}^{2} (1 + r) \beta \end{vmatrix}$$

Terms are collected and rearranged as follows:

$$\left|\nabla_{x}F_{R_{1}}^{L_{2}}\right| = \left(\rho_{2}\rho_{3}\right)^{-2} \left[\begin{array}{c}\eta_{1}u''\left(c_{1}\right)u''\left(c_{2}\right) + \eta_{2}u''\left(c_{1}\right)u'\left(c_{3}\right) + \eta_{3}u''\left(c_{1}\right)u''\left(c_{3}\right) + \eta_{4}u'\left(c_{2}\right)u''\left(c_{2}\right) \\ + \eta_{5}u'\left(c_{2}\right)u'\left(c_{3}\right) + \eta_{6}u'\left(c_{2}\right)u''\left(c_{3}\right) + \eta_{7}u''\left(c_{2}\right)u'\left(c_{3}\right) + \eta_{8}u''\left(c_{2}\right)u''\left(c_{3}\right) \\ \end{array}\right],$$

where

$$\begin{split} \eta_{1} &= \tau_{3}'' \rho_{2} \left(1+r\right)^{2} \left(1+\tau_{2}'r\right)+\tau_{2}'' \left(1-\tau_{3}'\right) \rho_{3} \left(1+r\right)^{2} r > 0 \\ \eta_{2} &= -\tau_{2}'' \tau_{3}'' \left(1-\tau_{3}'\right) \rho_{3} \left(1+r\right)^{2} r^{3} \beta < 0 \\ \eta_{3} &= \tau_{3}'' \rho_{2} \rho_{3} \left(1+r\right)^{3} \beta + \tau_{2}'' \left(1-\tau_{3}'\right) \rho_{3}^{3} \left(1+r\right)^{2} r \beta > 0 \\ \eta_{4} &= -\left[\tau_{2}'' \tau_{3}'' \rho_{2} \left(1+r\right)^{2} r^{2} \beta\right] \left(2+r\right) < 0 \\ \eta_{5} &= 0 \\ \eta_{6} &= -\tau_{2}'' \tau_{3}'' \rho_{2} \rho_{3} \left(1+r\right)^{3} r^{2} \beta^{2} < 0 \\ \eta_{7} &= -\left[\tau_{2}'' \tau_{3}'' \left(1-\tau_{3}'\right) \rho_{2} \rho_{3} \left(1+r\right)^{2} r^{3} \beta^{2}\right] \left(2+r\right) < 0 \\ \eta_{8} &= \left[\tau_{2}'' \left(1-\tau_{3}'\right) \rho_{2} \rho_{3}^{2} \left(1+r\right)^{2} r \beta^{2}\right] \left[\rho_{3}+r \left(1-\tau_{3}'\right)\right] + \tau_{3}'' \rho_{3}^{2} \rho_{3}^{2} \left(1+r\right)^{3} \beta^{2} > 0 \end{split}$$

Given the assumptions about the utility function and the signs of η_1 through η_8 , $\left|\nabla_x F_{R_1}^{L_2}\right| > 0$. By Cramer's rule, the sign of the derivative $\frac{dR_1}{dL_2}$ can be found through dividing $\left|\nabla_x F_{R_1}^{L_2}\right|$ by $\left|\nabla_x F\right|$:

$$\frac{dR_1}{dL} = \frac{\left|\nabla_x F_{R_1}^{L_2}\right|}{\left|\nabla_x F\right|} = \frac{[+]}{[-]} < 0$$

A.2 Proof of Proposition 2

The proof follows as above. The total derivative of the system is placed in matrix form:

$$\left[\nabla_x F\right] \left[\begin{array}{c} dR_1 \\ dN_1 \\ dN_2 \end{array} \right] = \left[-\nabla y_1 F \right] \left[dy_1 \right].$$

The determinant $\left| \nabla_x F_{R_1}^{y_1} \right|$ can be written as:

$$\nabla_{x}F_{R_{1}}^{y_{1}}\Big| = (\rho_{2}\rho_{3})^{-2} \begin{vmatrix} -\tau_{1}''(\rho_{2}\rho_{3})^{2} & \tau_{2}''(1-\tau_{3}')\rho_{3}(1+r)^{2}r^{2} \\ -\tau_{3}''\rho_{2}(1+r)^{3}r & -\tau_{3}''\rho_{2}(1+r)^{2}r \end{vmatrix}$$

$$= (\rho_{2}\rho_{3})^{-2} \begin{vmatrix} -u''(c_{1})(1-\tau_{1}') & u'(c_{2})\tau_{2}'r^{2}\beta - u''(c_{1}) \\ +u''(c_{2})\tau_{2}'\rho_{2}r\beta & u''(c_{2})\rho_{2}\beta \end{vmatrix}$$

$$= \begin{pmatrix} u'(c_{3})\tau_{3}''r^{2}(1+r)\beta & u'(c_{3})\tau_{3}''r^{2}\beta \\ -u''(c_{3})\rho_{3}^{2}(1+r)\beta & -u''(c_{2}) \\ -u''(c_{3})\rho_{3}^{2}(1+r)\beta & -u''(c_{3})\rho_{3}^{2}\beta \end{vmatrix}$$

•

When expanded, terms can be collected by utility:

$$\left| \nabla_x F_{R_1}^{L_2} \right| = (\rho_2 \rho_3)^{-2} \left[\begin{array}{c} \varphi_1 u''(c_1) \, u''(c_2) + \varphi_2 u''(c_1) \, u'(c_3) + \varphi_3 u''(c_1) \, u''(c_3) + \varphi_4 u'(c_2) \, u''(c_2) \\ + \varphi_5 u'(c_2) \, u'(c_3) + \varphi_6 u'(c_2) \, u''(c_3) + \varphi_7 u''(c_2) \, u'(c_3) + \varphi_8 u''(c_2) \, u''(c_3) \end{array} \right],$$
where

$$\begin{split} \varphi_{1} &= -\tau_{1}'' \left(\rho_{2}\rho_{3}\right)^{2} - \left(1 - \tau_{1}'\right)r\left(1 + r\right)^{2} \left[\tau_{2}''r\rho_{3}\left(1 - \tau_{3}'\right) - \rho_{2}^{2}\tau_{3}''\right] < 0 \; if \; \tau_{2}''r\rho_{3}\left(1 - \tau_{3}'\right) > \rho_{2}^{2}\tau_{3}'' \\ \varphi_{2} &= \tau_{1}''\tau_{3}''r^{2}\beta\left(\rho_{2}\rho_{3}\right)^{2} + \tau_{3}''\left(1 - \tau_{1}'\right)\left(1 - \tau_{3}'\right)r^{4}\beta\rho_{3}\left(1 + r\right) > 0 \\ \varphi_{3} &= -\tau_{1}''\rho_{3}^{2}\beta\left(\rho_{2}\rho_{3}\right)^{2} - \tau_{2}''\left(1 - \tau_{1}'\right)\left(1 - \tau_{3}'\right)r^{2}\beta\rho_{3}^{3}\left(1 + r\right)^{2} < 0 \\ \varphi_{4} &= \tau_{1}''\tau_{2}''r^{2}\beta\left(\rho_{2}\rho_{3}\right)^{2} > 0 \\ \varphi_{5} &= -\tau_{1}''\tau_{2}''r^{2}\beta^{2}\rho_{3}^{2}\left(\rho_{2}\rho_{3}\right)^{2} > 0 \\ \varphi_{6} &= \tau_{1}''\tau_{2}''r^{2}\beta^{2}\rho_{3}^{2}\left(\rho_{2}\rho_{3}\right)^{2} > 0 \\ \varphi_{7} &= \tau_{1}''\tau_{3}''r^{2}\beta^{2}\rho_{2}^{2}\left(\rho_{2}\rho_{3}\right)^{2} > 0 \\ \varphi_{8} &= -\tau_{1}''\beta^{2}\left(\rho_{2}\rho_{3}\right)^{4} < 0. \end{split}$$

Given the assumptions about the utility function and the signs of φ_1 through φ_8 , $\left|\nabla_x F_{R_1}^{y_1}\right| < 0$ if $\tau_2'' r \rho_3 \left(1 - \tau_3'\right) > \rho_2^2 \tau_3''$.

By Cramer's rule, the sign of the derivative $\frac{dR_1}{dy_1}$ can be found through dividing $\left|\nabla_x F_{R_1}^{y_1}\right|$ by $\left|\nabla_x F\right|$:

$$\frac{dR_1}{dy_1} = \frac{\left|\nabla_x F_{R_1}^{y_1}\right|}{\left|\nabla_x F\right|} = \frac{[-]}{[-]} > 0 \text{ if } \tau_2'' r \rho_3 \left(1 - \tau_3'\right) > \rho_2^2 \tau_3''.$$

A.3 Proof of Proposition 3

The proof follows as above. The total derivative of the system is placed in matrix form:

$$\left[\nabla_x F\right] \left[\begin{array}{c} dR_1\\ dN_1\\ dN_2 \end{array}\right] = \left[-\nabla y_2 F\right] \left[dy_2\right].$$

To sign the desired derivatives requires the evaluation of the determinants $\left|\nabla_x F_{R_1}^{y_2}\right|$ and $\left|\nabla_x F_{N_1}^{y_2}\right|$. First, I expand $\left|\nabla_x F_{R_1}^{y_2}\right|$:

$$\begin{vmatrix} -\tau_{2}^{\prime\prime} \left(1 - \tau_{3}^{\prime}\right) \left(1 + r\right)^{2} r \rho_{3} & \tau_{2}^{\prime\prime} \left(1 - \tau_{3}^{\prime}\right) \rho_{3} \left(1 + r\right)^{2} r^{2} \\ -\tau_{3}^{\prime\prime} \rho_{2} \left(1 + r\right)^{3} r & -\tau_{3}^{\prime\prime} \rho_{2} \left(1 + r\right)^{2} r \end{vmatrix} \\ \begin{vmatrix} u^{\prime\prime} \left(c_{2}\right) \left(1 - \tau_{2}^{\prime}\right) \rho_{2}\beta & u^{\prime} \left(c_{2}\right) \tau_{2}^{\prime\prime} r^{2}\beta - u^{\prime\prime} \left(c_{1}\right) \\ -u^{\prime\prime} \left(c_{2}\right) r \tau_{2}^{\prime\prime} \beta & +u^{\prime\prime} \left(c_{2}\right) \tau_{2}^{\prime\prime} \rho_{2} r \beta & u^{\prime\prime} \left(c_{2}\right) \rho_{2}\beta \end{vmatrix} \\ \begin{vmatrix} u^{\prime\prime} \left(c_{2}\right) \left(1 - \tau_{2}^{\prime}\right) & u^{\prime\prime} \left(c_{3}\right) \tau_{3}^{\prime\prime} r^{2} \left(1 + r\right) \beta & u^{\prime\prime} \left(c_{3}\right) \tau_{3}^{\prime\prime} r^{2} \beta \\ -u^{\prime\prime} \left(c_{2}\right) \left(1 - \tau_{2}^{\prime}\right) & -u^{\prime\prime} \left(c_{2}\right) \tau_{2}^{\prime} r & -u^{\prime\prime} \left(c_{2}\right) \\ -u^{\prime\prime} \left(c_{3}\right) \rho_{3}^{2} \left(1 + r\right) \beta & -u^{\prime\prime} \left(c_{3}\right) \rho_{3}^{2} \beta \end{vmatrix}$$

This can be expanded, and terms collected by utility:

$$\left| \nabla_x F_{R_1}^{y_2} \right| = (\rho_2 \rho_3)^{-2} \left[\begin{array}{c} \omega_1 u''(c_1) u''(c_2) + \omega_2 u''(c_1) u'(c_3) + \omega_3 u''(c_1) u''(c_3) + \omega_4 u'(c_2) u''(c_2) \\ + \omega_5 u'(c_2) u'(c_3) + \omega_6 u'(c_2) u''(c_3) + \omega_7 u''(c_2) u'(c_3) + \omega_8 u''(c_2) u''(c_2) \\ + \omega_9 u''(c_2) u''(c_3) \end{array} \right],$$

where

$$\begin{split} \omega_{1} &= (1+r)^{2} r \left[\tau_{3}'' \left(1 - \tau_{2}' \right) \rho_{2} - \tau_{2}'' \left(1 - \tau_{3}' \right) \rho_{3} \right] < 0 \text{ if } \tau_{2}'' \left(1 - \tau_{3}' \right) \rho_{3} > \tau_{3}'' \left(1 - \tau_{2}' \right) \rho_{2} \\ \omega_{2} &= \tau_{2}'' \tau_{3}'' \left(1 - \tau_{3}' \right) \rho_{3} r^{3} \beta \left(1 + r \right)^{2} > 0 \\ \omega_{3} &= -\tau_{2}'' \left(1 - \tau_{3}' \right) r \beta \rho_{3}^{3} \left(1 + r \right)^{2} < 0 \\ \omega_{4} &= \tau_{2}'' \tau_{3}'' r^{2} \beta \left(1 + r \right)^{2} \rho_{2} > 0 \\ \omega_{5} &= 0 \\ \omega_{5} &= 0 \\ \omega_{7} &= \tau_{3}'' r^{3} \beta^{2} \rho_{2} \rho_{3} \left(1 + r \right) \left(1 - \tau_{3}' \right) \left(1 + \rho_{2} r \right) > 0 \\ \omega_{8} &= 0 \\ \omega_{9} &= -\tau_{2}'' \left(1 - \tau_{3}' \right) \left(1 + r \right)^{2} \rho_{3}^{3} r \beta^{2} < 0. \end{split}$$

Given the assumptions about the utility function and the signs of ω_1 through ω_9 , $\left|\nabla_x F_{R_1}^{y_2}\right| < 0$ if $\tau_2'' (1 - \tau_3') \rho_3 > \tau_3'' (1 - \tau_2') \rho_2$.

if $\tau_2''(1-\tau_3')\rho_3 > \tau_3''(1-\tau_2')\rho_2$. By Cramer's rule, the sign on the derivative $\frac{dR_1}{dy_2}$ can be found through dividing $\left|\nabla_x F_{R_1}^{y_2}\right|$ by $\left|\nabla_x F\right|$:

$$\frac{dR_1}{dy_2} = \frac{\left|\nabla_x F_{R_1}^{y_2}\right|}{\left|\nabla_x F\right|} = \frac{[-]}{[-]} > 0 \text{ if } \tau_2'' \left(1 - \tau_3'\right) \rho_3 > \tau_3'' \left(1 - \tau_2'\right) \rho_2.$$

Next, I expand $\left| \nabla_x F_{N_1}^{y_2} \right|$:

$$-\tau_{1}''(\rho_{2}\rho_{3})^{2} - \tau_{3}''\rho_{2}(1+r)^{4} - \tau_{2}''(1-\tau_{3}')(1+r)^{2}r\rho_{3} - \tau_{3}''\rho_{2}(1+r)^{2}r$$

$$\left|\nabla_{x}F_{N_{1}}^{y_{2}}\right| = (\rho_{2}\rho_{3})^{-2} \left| \begin{array}{c} -u''(c_{1})(1-\tau_{1}') & u''(c_{2})(1-\tau_{2}')\rho_{2}\beta \\ -u'(c_{2})r\tau_{2}''\beta & u''(c_{2})\rho_{2}\beta \end{array} \right|$$

$$\begin{array}{l} u'(c_3) \,\tau_3''(1+r)^2 \,r\beta \\ -u''(c_3) \,(1-\tau_3') \,\rho_3 \,(1+r)^2 \,\beta \end{array} - u''(c_2) \,(1-\tau_2') \qquad \begin{array}{l} u'(c_3) \,\tau_3''r^2\beta \\ -u''(c_2) \\ -u''(c_3) \,\rho_3^2\beta \end{array}$$

•

Terms are collected according to utility:

$$\left|\nabla_{x}F_{N_{1}}^{y_{2}}\right| = (\rho_{2}\rho_{3})^{-2} \left[\begin{array}{c} \xi_{1}u''(c_{1}) u''(c_{2}) + \xi_{2}u''(c_{1}) u'(c_{3}) + \xi_{3}u''(c_{1}) u''(c_{3}) + \xi_{4}u'(c_{2}) u''(c_{2}) \\ + \xi_{5}u'(c_{2}) u'(c_{3}) + \xi_{6}u'(c_{2}) u''(c_{3}) + \xi_{7}u''(c_{2}) u'(c_{3}) + \xi_{8}u''(c_{2}) u''(c_{3}) \end{array}\right],$$

where

$$\begin{aligned} \xi_{1} &= \left(1 - \tau_{1}^{\prime}\right)\left(1 + r\right)^{2}r\left[\tau_{3}^{\prime\prime}\left(1 - \tau_{2}^{\prime}\right)\rho_{2} - \tau_{2}^{\prime\prime}\left(1 - \tau_{3}^{\prime}\right)\rho_{3}\right] > 0 \ if \ \tau_{2}^{\prime\prime}\left(1 - \tau_{3}^{\prime}\right)\rho_{3} > \tau_{3}^{\prime\prime}\left(1 - \tau_{2}^{\prime}\right)\rho_{2} \\ \xi_{2} &= -\tau_{2}^{\prime\prime}\tau_{3}^{\prime\prime}r^{3}\beta\rho_{3}\left(1 - \tau_{1}^{\prime}\right)\left(1 - \tau_{3}^{\prime}\right)\rho_{3}^{3}\beta\left(1 + r\right)^{2}r > 0 \\ \xi_{3} &= \tau_{2}^{\prime\prime}\left(1 - \tau_{1}^{\prime}\right)\left(1 - \tau_{3}^{\prime}\right)\rho_{3}^{3}\beta\left(1 + r\right)^{2}r > 0 \\ \xi_{4} &= -\tau_{1}^{\prime\prime}\tau_{2}^{\prime\prime}r\beta\left(\rho_{2}\rho_{3}\right)^{2} - \tau_{2}^{\prime\prime}\tau_{3}^{\prime\prime\prime}\left(1 + r\right)^{4}\rho_{2}r\beta < 0 \\ \xi_{5} &= \tau_{1}^{\prime\prime}\tau_{2}^{\prime\prime}r\beta^{2}\rho_{3}^{2}\left(\rho_{2}\rho_{3}\right)^{2} < 0 \\ \xi_{6} &= \tau_{1}^{\prime\prime}\tau_{2}^{\prime\prime}r\beta^{2}\rho_{3}^{2}\left(\rho_{2}\rho_{3}\right)^{2} - \tau_{2}^{\prime\prime}\tau_{3}^{\prime\prime}r\beta^{2}\left(1 + r\right)^{4}\rho_{2}\rho_{3} < 0 \\ \xi_{7} &= -\tau_{1}^{\prime\prime}\tau_{3}^{\prime\prime}r^{2}\beta^{2}\rho_{2}\left(1 - \tau_{2}^{\prime}\right)\left(\rho_{2}\rho_{3}\right)^{2} + \tau_{2}^{\prime\prime}\left(1 - \tau_{3}^{\prime}\right)^{2}\left(1 + r\right)^{4}\beta^{2}\rho_{2}\rho_{3}^{2}r + \tau_{3}^{\prime\prime}\rho_{2}^{2}\rho_{3}\beta^{2}\left(1 + r\right)^{4}\left(1 - \tau_{2}^{\prime}\right) > 0. \end{aligned}$$

Given the assumptions about the utility function and the signs of ξ_1 through ξ_8 , $\left|\nabla_x F_{N_1}^{y_2}\right| > 0$ if $\tau_2'' (1 - \tau_3') \rho_3 > \tau_3'' (1 - \tau_2') \rho_2$.

By Cramer's rule, the sign on the derivative $\frac{dN_1}{dy_2}$ can be found through dividing $\left|\nabla_x F_{N_1}^{y_2}\right|$ by $\left|\nabla_x F\right|$:

$$\frac{dN_1}{dy_2} = \frac{\left|\nabla_x F_{N_1}^{y_2}\right|}{\left|\nabla_x F\right|} = \frac{[+]}{[-]} < 0 \text{ if } \tau_2'' \left(1 - \tau_3'\right) \rho_3 > \tau_3'' \left(1 - \tau_2'\right) \rho_2.$$

B Variable Definitions

RRSP - The amount contributed to an RRSP, comprising regular contributions and roll-overs of pension income into own or spousal RRSP. Inflated to 1990 dollars.

LIMIT - Sum of earned income derived limit and income eligible for pension roll-over. Earned income part of limit for RPP members, 1988 to 1990: the minimum of 20% of earned income and \$3500, less employee contribution to RPP. Earned income part of limit for those without RPPs, 1988 to 1990: the minimum of 20% of earned income and \$7500. Earned income part of limit for both RPP members and non-members, 1991: minimum of 18% of earned income and \$11,500, less any Pension Adjustment for RPP members. Inflated to 1990 dollars.

INCOME - Reported taxable income, less taxes owing on income without any RRSP contribution.

MTR - Marginal income tax rate on next dollar of income, calculated without any RRSP contribution.

MALE - Takes the value 1 for males; 0 for females.

MARD - Takes the value 1 for those who report a legal spouse; 0 otherwise.

CHLDRN - Number of children reported for child tax benefit calculations.

AGE - Calculated as current year less year of birth.

Y1989 - Year dummy for 1989.

Y1990 - Year dummy for 1990.

BUSDUM - Takes the value 1 for those reporting nonzero business income; 0 otherwise.

COMMDUM - Takes the value 1 for those reporting nonzero commission income; 0 otherwise.

FARMDUM - Takes the value 1 for those reporting nonzero farming income; 0 otherwise.

FISHDUM - Takes the value 1 for those reporting nonzero fishing income; 0 otherwise.

NF, PEI, NS, NB, QUE, MAN, SAS, ALB, BC, TERR - Takes the value 1 for residents of

Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Manitoba, Saskatchewan,

Alberta, British Columbia, and the Northwest or Yukon Territories, respectively; 0 otherwise.

RPPMEM - For 1990 and 1991, takes the value 1 for those reporting a positive Pension Adjustment. For 1988 and 1989, each taxpayer's RPP status from 1990 is assigned.

PENSIONER - Takes the value 1 if reported pension income is positive; 0 otherwise.

HIGHLIMIT - Takes the value 1 if calculated RRSP contribution limit exceeds \$7500 in

years 1988 to 1990, and \$11500 in 1991; 0 otherwise.

FUTCONSTRD - Takes the value 1 for year t if taxpayer is deemed to be constrained in year t + 1; 0 otherwise. Taxpayer is deemed to be constrained in the future year if the observed RRSP contribution in year t + 1 meets or exceeds the contribution limit for year t + 1 calculated using the limit calculation rules for year t. This captures the desired set of taxpayers - those who would have been constrained had the limit calculation rules not changed.

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Figure 1: RRSP Average Contribution and Participation 1982-1990.



Figure 2: Contribution Room and Earned Income

	All	observati	ons	RF	PMEM=	L;	PEN	VIONER	<u>[]]</u>	JIH	3HLIMIT ¹		FUTQ	CONSTRI	D=1
	1988	1989	1990	1988	1989	1990	1988	1989	1990	1988	1989	1990	1988	1989	1990
u	41764	41801	39556	13254	13158	13269	5504	5713	3608	5043	5400	2313	5133	5380	5875
$RRSP_{i,t}$ standard deviation	1026 (4490)	997 (3836)	702 (1633)	759 (2101)	758 (1692)	698 (1256)	3543 (11383)	2964 (9363)	960 (2518)	4952 (11787)	4288 (9595)	3810 (3696)	3469 (7933)	2329 (2659)	1992 (2658)
LIMIT _{i,t} standard deviation	4385 (5846)	4298 (5688)	2913 (2055)	2843 (2112)	2702 (1822)	2429 (1147)	13091 (11957)	12758 (11309)	3917 (2749)	15127 (11264)	14420 (10563)	8017 (5149)	4448 (7228)	3143 (2591)	2858 (2424)
${\it \Delta} {\it RRSP}_{i,t}$ standard deviation	84 (4910)	28 (3489)	-223 (3244)	52 (2100)	12 (1702)	-44 (1505)	567 (12769)	109 (8286)	-2741 (9879)	710 (13267)	220 (8623)	-93 (4380)	267 (8293)	120 (3016)	-447 (4454)
Δ <i>LIMIT</i> $_{i,t+I}$ standard deviation	18 (2723)	-1473 (5267)	53 (1200)	-69 (2282)	-326 (1567)	661 (1544)	-250 (6044)	-10158 (10314)	-254 (1426)	-641 (6512)	-9560 (8623)	911 (1989)	-514 (3980)	-594 (1723)	884 (1611)
RPPMEM	0.317	0.315	0.335	1.000	1.000	1.000	0.088	0.083	0.191	0.037	0.035	0.036	0.455	0.475	0.501
PENSIONER	0.132	0.137	0.091	0.037	0.036	0.052	1.000	1.000	1.000	0.625	0.628	0.135	0.079	0.018	0.097
HIGHLIMIT	0.121	0.129	0.058	0.014	0.014	0.006	0.573	0.594	0.087	1.000	1.000	1.000	0.175	0.132	0.141
FUTCONSTRD	0.123	0.129	0.149	0.176	0.194	0.222	0.073	0.017	0.159	0.178	0.131	0.359	1.000	1.000	1.000
Note: All dollar	values reț	oorted in	1990 Canadi	an dollars.	Definitio	ns for RPPI	MEM, PEN	ISIONER	, HIGHLIN	IIT, AND I	FUTCON	STRD Appe	ar in Appe	endix B.	

	(a)	(b)	(c)	(d)
	OLS	TOBIT	TOBIT	TOBIT
CONSTANT	-90.55 *	-3128.63 *	-3201.81	-15890.46
	(15.63)	(19.56)	(20.21)	(418.38)
$\Delta LIMIT_{i,t+1}$	-0.119 *	-0.190 *	-0.232 *	-0.320 *
	(0.033)	(0.190)	(0.002)	(0.003)
$\Delta INCOME_{i,t}$			12.15 *	14.70 *
			(1.06)	(1.29)
Δ INCOMESQ _{i,t}			0.015 *	-0.001
			(0.003)	(0.004)
$\Delta INCOME_{i,t+1}$			-14.39 *	-7.193 *
			(1.89)	(2.137)
Δ INCOMESQ _{i,t+1}			0.036 *	0.017 *
			(0.007)	(0.008)
$\Delta MTR_{i,t}$			16.88 *	19.12 *
			(1.68)	(2.32)
$\Delta MTR_{i,t+1}$			20.58 *	21.15 *
			(1.68)	(2.13)
MALE				445.29 *
				(51.10)
MARD				587.44 *
				(58.98)
CHLDRN				-547.33 *
				(53.53)
AGE				593.98 *
ACESO				(1/.1/)
AGESQ				-0.47
<i>V1080</i>				-357.15 *
11)0)				(69.97)
Y1990				-38.34
				(62.84)
BUSDUM				54.46
				(80.48)
COMMDUM				746.89 *
				(221.16)
FARMDUM				77.87
				(98.01)
FISHDUM				-271.42
				(687.15)

Table 3 Regression Results

Continued on Next Page

Table 3 (con	ntinued)
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	(a) OLS	(b) TOBIT	(c) TOBIT	(d) TOBIT
PEI				-1150.98 *
				(455.65)
NS				-891.31 *
				(209.71)
NB				-1022.47 *
				(181.43)
QUE				-357.15 *
				(55.17)
MAN				76.96
				(109.10)
SAS				46.48
				(171.55)
ALB				281.81 *
				(79.20)
BC				202.36 *
				(64.87)
TERR				-1390.14
				(775.15)

Notes: Robust standard errors in parentheses. Estimates significant at the five per cent level are indicated with an asterisk.

	(e) TOBIT	(f) TOBIT
	-0.308 *	0.053
	(0.003)	(0.032)
$\Delta LIMIT_{i+1} * RPPMEM$		-0.161 *
1,1+1		(0.071)
$\Delta LIMIT_{i,t+1}$ *PENSIONER		-0.287 *
		(0.051)
$\Delta LIMIT_{i,t+1}$ *HIGHLIMIT		-0.103
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		(0.054)
$\Delta LIMIT_{i,t+1} * FUTCONSTRD$		-0.093 *
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		(0.022)
RPPMEM	926.59 *	804.05 *
	(60.99)	(61.03)
PENSIONER	-1188.72 *	-1298.67 *
	(115.37)	(118.58)
HIGHLIMIT	2939.30 *	2736.78 *
	(80.86)	(80.94)
FUTCONSTRD	2979.70 *	2950.37 *
	(48.42)	(51.20)

Table 4Regression Results - with Interactions

Notes: Robust standard errors in parentheses. Estimates significant at the five per cent level are indicated with an asterisk. Also included in these regressions but not reported is the set of control variables used in specification (d).

	(g)	(h)	(i)	(j)
	TOBIT	TOBIT	TOBIT	TOBIT
	1989	1990	Net RRSP	90%
$\Delta LIMIT_{i,t+1}$	-0.243 *	-0.089 *	-0.160 *	-0.301 *
	(0.014)	(0.030)	(0.016)	(0.002)

Table 5
Sensitivity Analysis

Notes: Robust standard errors in parentheses. Estimates significant at the five per cent level are indicated with an asterisk. Also included in these regressions but not reported is the set of control variables used in specification (e) in Table 4.

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