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Should the Average Tax Rate Be Marginalized?*

Naomi E. Feldman†and Peter Katuščák‡

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Abstract

Economic theory assumes that taxpayers use their true marginal tax rate (MTR) to guide their economic decisions. However, complexity of the personal income tax system implies that taxpayers may incorrectly perceive true marginal prices and incentives. We first develop an updating model that formalizes this proposition. A prediction of this model is that an unexpected innovation in the previous year's average tax rate (ATR) influences the perception of the MTR in the current year, even though the MTR is not in fact changing between the two years. This model generalizes the "schmeduling" hypothesis of Liebman and Zeckhauser (2004), who suggest that taxpayers use the ATR in place of the MTR in making their decisions. Then, assuming that taxpayers react to their *perceived* after-tax price as economic theory would suggest, we test this prediction empirically by examining whether household labor income responds to *predictable* (but not necessarily predicted) variation in the previous year's ATR due to eligibility for the Child Tax Credit, which depends on the exact timing of a child's 17th birthday. We find that household labor income *decreases* in response to losing eligibility for the Child Tax Credit. This finding is inconsistent with the rational taxpayer hypothesis, but consistent with the schmeduling hypothesis. Our robustness tests do not provide any consistent evidence that this result is entirely driven by an omitted variable bias due to a direct timing of birth effect. We also discuss the welfare consequences of schmeduling.

Keywords: tax, labor supply, average tax.

JEL Classification: H21, H24, H31

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Abstrakt

Ekonomická teória predpokladá, že daňoví poplatníci pri rozhodovaní používajú skutočnú marginálnu daňovú sadzbu (MTR). Avšak pre komplexnosť daňového systému je možné, že daňoví poplatníci nesprávne vnímajú skutočné marginálne ceny. V tejto štúdii najskôr prezentujeme aktualizačný model, ktorý formalizuje túto myšlienku. Tento model predpovedá, že neočakávaná zmena v priemernej daňovej sadzbe (ATR) za predchádzajúci rok ovplyvňuje vnímanie MTR v súčasnom roku, a to aj v prípade, že k žiadne zmene v MTR v skutočnosti nedošlo. Tento model zovšeobecňuje hypotézu schmeduling podľa Liebmana a Zeckhausera (2004), ktorí argumentujú, že daňoví poplatníci pri rozhodovaní používajú ATR namiesto MTR. Za predpokladu, že daňoví poplatníci reagujú na ich vnímanú čistú cenu po dani podľa ekonomickej teórie, testujeme túto predpoveď na základe toho, či pracovné príjmy domácností reagujú na predpovedateľné (ale nie nutne predpovedané) zmeny v ATR za predchádzajúci rok sôsobené nárokom na daňový bonus na dieťa, ktorý závisí na presnom termíne 17-tych narodenín tohto dieťaťa. Naše výsledky ukazujú, že pracovné príjmy domácností *klesajú* v reakcii na stratu nároku na tento daňový bonus. Teno záver nie je konzistentný s hypotézou racionálnych daňových poplatníkov, ale je konzistentný s hypotézou schmeduling. Testy robustnosti nepotvrdzujú, že tento výsledok je spôsobený iba vychýlením odhadu kvôli nezohľadneniu priameho vplyvu dátumu narodenia dieťaťa. V článku sa tiež zaoberáme dopadmi schmeduling na blahobyt.

1 Introduction

Economic theory presumes that individuals respond to marginal prices when deciding on their labor supply, portfolio allocation, saving decisions, and many other behavioral margins. Because marginal prices are affected by marginal tax rates (MTRs), the latter have been recognized as important for behavioral responses. Indeed, there is now a voluminous empirical literature identifying significant behavioral responses to tax changes.[1] Under the usual interpretation, these responses are attributed to changes in MTRs. This interpretation assumes, however, that taxpayers correctly perceive their MTRs and, hence, marginal net-of-tax prices. Nonetheless, a literature survey in Section 2 documents that the existing empirical evidence on such an assumption is mixed.

A major source of confusion over the correct MTR stems from the complexity of the tax code due to the great number of tax deductions, credits, and exemptions, together with their diverse and often arbitrary eligibility rules, phase-in and phase-out ranges, and the great number of tax law changes (on average about two a day since 1986). This is documented in a quote from a recent report by the President's Advisory Panel on Federal Tax Reform:

> "For millions of Americans, the annual rite of filing taxes has become a headache of burdensome record-keeping, lengthy instructions, and complicated schedules, worksheets, and forms - often requiring multiple computations that are neither logical nor intuitive. ...
>
> Since the last major reform effort in 1986, there have been more than 14,000 changes to the tax code, many adding special provisions and targeted tax benefits, some of which expire after only a few years. These

[1] See, for example, Eissa (1995) or Eissa and Liebman (1996) for labor force participation of women, Looney and Singhal (2004) for the intertemporal elasticity of labor earnings, Bernheim (2002) for saving, Poterba (2002) for risk-taking and portfolio behavior, and Gruber and Saez (2002) for taxable income.

> myriad changes decrease the stability, consistency, and transparency of our current tax system while making it drastically more complicated, unfair, and economically wasteful." [2]

This complexity makes it costly for taxpayers in terms of cognitive abilities, time, or money to learn about the details. It is therefore plausible that many taxpayers are not aware of most tax law provisions that currently affect them, or that will affect them in the future. In response, taxpayers are increasingly looking to experts or computer software for help in navigating this complexity.[3] To the extent that a preparer or software is used only as a tax compliance tool or an ex-post minimizer of tax liability, it is not clear that the use of these tools leads to better informed taxpayers. On the contrary, tax preparers and software allow taxpayers to escape the complexity of the tax code to a large degree, which is likely to further reduce taxpayer knowledge of the tax system. Put differently, by going through their tax forms and instructions the old-fashioned way, line by line, taxpayers who use the traditional method of tax filing may actually be better informed about details of the tax system.

If taxpayers have only a basic knowledge of the tax system, predictable changes (such as losing eligibility for the dependent exemption once the child ages) and unpredictable changes (such as sudden tax reforms) in the tax schedule may have unexpected effects on taxpayer perceptions of marginal incentives, behavior, and welfare. We believe that it is important to understand how and to what extent

[2]Excerpted from "America Needs a Better Tax System", a memorandum by the President's Advisory Panel on Federal Tax Reform, April 2005. Source: www.taxreformpanel.gov.

[3]For example, of about 130 million individual tax returns filed for the tax year 2001, 72.5 million, or 56 percent, were prepared by a professional preparer. By 2003, this number jumped to about 79 million, or 61 percent. Many taxpayers are also turning to tax preparation software, which, beyond simplification, also brings about the benefits of electronic filing (if chosen) and a faster refund. For example, about 47 million (36 percent) of returns were e-filed in 2001. By 2003, this number jumped to 61 million, or 47 percent. This amount is split roughly equally between e-filing by individual taxpayers and tax preparers. As a result, about 84 percent of taxpayers relied either on a preparer or software in 2003. Source: Statistics of Income Division of the Internal Revenue Service.

taxpayers misperceive their true tax schedule and whether this misperception has any impact on behavior.

The first contribution of this paper is in developing a formal model that captures the rudimentary understanding of the tax schedule that a taxpayer might have. It generalizes the standard rational taxpayer model by allowing for misperception of the income tax code. In the model, a taxpayer is subject to a linear income tax schedule that changes from year to year due to innovations that are predictable well in advance, as well as innovations that are predictable only a short time in advance. A taxpayer perceives these innovations with noise because it may be costly in terms of cognitive abilities, time, or money to follow them exactly. As a result, the taxpayer is uncertain about the exact tax schedule he faces. In this environment, the taxpayer will use any signal generated by interaction with the tax system to update his beliefs. In particular, the model predicts that the beliefs about future MTRs are affected by a surprise in the realization of the average tax rate (ATR) in the preceding period.

This model formalizes and generalizes the "schmeduling" hypothesis of Liebman and Zeckhauser (2004), who suggest that when individuals have a limited understanding of the actual price schedules they face, they default to a rule of thumb which approximates the unknown true marginal price by the average price realized in the previous period – a form of schmeduling they coin as "ironing." Within the context of the personal income tax system, ironing corresponds to basing one's decisions on a historical measure of the ATR instead of the actual MTR in the current year.[4] This hypothesis may be somewhat extreme because it ignores any possibility that a taxpayer may also rely on other contemporaneous or historical signals about his tax schedule. Indeed, although our model allows for such an extreme form of

[4]For example, based on tax law effective in 2002, a married household with two children under the age of 17 earning $60,000 a year is in the 15 percent MTR bracket. However, the household observes that it paid $4,223 in personal income taxes for the previous year, and concludes that it faces a flat tax rate of 7 percent. Consequently, the household makes decisions as if it were to keep 93 percent of every dollar it earns.

schmeduling, it does so only under very special circumstances. In general, realization of the previous year's ATR only partially shifts the pre-existing beliefs about the tax schedule.

To illuminate the potential welfare effects of schmeduling, consider the household labor supply decision under the special case of schmeduling proposed by Liebman and Zeckhauser. Because the personal income tax system is progressive, the MTR often exceeds the ATR. As a result, if households use the ATR instead of the MTR in their decisions, the undesired substitution effect and, hence, the excess burden of the income tax are both diminished.[5] Generalizing from this special case, as long as schmeduling leads taxpayers to underestimate their true MTR, it may reduce the excess burden of taxation and lead to an improvement in overall welfare.[6]

When we consider how to empirically identify schmeduling, most variation in the income tax schedule utilized by existing empirical studies on the effect of taxation on behavior is unsuitable for the purpose. This is because changes in the MTR utilize variation in the tax schedule that simultaneously affects both the MTR and the ATR and may, in addition, be unexpected, as would likely be the case if variation in the tax schedule were driven by a tax reform. As a result, due to the progressivity of the income tax system or the manner by which reforms affect the tax schedule, changes in the ATR are often positively correlated with changes in the MTR and, through the surprise effect, negatively correlated with revisions in lifetime income in a cross-section of households. This implies that such tax schedule variation generally cannot be used to distinguish between behavioral responses to changes in the MTR versus changes in the ATR, because any behavioral response is consistent with both types of responses.

[5]Excess burden is defined as the additional amount of tax revenue that could be collected from a household without making it worse off. We show this formally in Section 3.

[6]On the other hand, though, once the tax code is sufficiently cluttered, it may be difficult for taxpayers to correctly perceive new additions to the tax code that are intended to provide incentives for specific behavior. To the extent that such behavior is socially beneficial, pre-existing clutter may be welfare reducing.

The second contribution of this paper is therefore in finding an *exogenous* and *predictable* cross-sectional variation in the ATR that is *independent of variation in the MTR* and using it to identify the effect of potentially unexpected innovations in the realized ATR on taxpayer labor supply measured by labor income. This variation is derived from child age-eligibility requirements for the Child Tax Credit (CTC). The CTC, first introduced in 1998, allowed households to reduce their tax liability by $400 per eligible child, with the amount of the credit gradually increasing to $1,000 per eligible child by 2003. In order for a child to be eligible, he or she must not have reached 17 years of age by December 31 of the tax year in question. This identification strategy offers three advantages. First, because aging is a perfectly predictable process, the variation in the tax schedule is predictable well in advance. As a result, if a household is fully rational, this variation should have no lifetime income effect on labor supply at the time when it affects the tax schedule. Second, in an intermediate income range, this variation in the ATR has no impact on household MTR. This is because the CTC is subtracted from the regular tax liability without having any effect on taxable income; therefore, an additional dollar of income is subject to the same MTR regardless of whether the household is or is not eligible for the credit. As a result, if a household is fully rational, this variation in the tax schedule has no substitution effect on labor supply either.[7] Third, while it may be possible to plan the timing of a child's birth for a particular year, it is much harder to do so for a particular month or week. Therefore if the sample is constrained only to households whose child turns 17 in a sufficiently narrow time band around the turn of a year, the induced variation in the tax schedule is virtually exogenous.[8] This minimizes the potential for our results to be driven by an endogeneity bias. In

[7]One exception to this conclusion would be if losing the CTC subjects a household to a binding liquidity constraint. We discuss implications of this possibility for our empirical conclusions in Subsection 6.2.

[8]Subsection 6.2 discusses evidence suggesting that this may not be the case and evaluates its impact on our conclusions.

addition, because the variation in the tax schedule is discontinuous in the timing of the child's 17th birthday, such a design also minimizes the potential for our results to be driven by an omitted variable bias due to a direct effect of the child's date of birth on parents' labor income.[9] Putting all three points together, under the null hypothesis of rationality, we should not be able to identify any statistically significant effect of the CTC-induced variation in ATR on household labor supply; finding an effect would be supportive of the schmeduling hypothesis.

We implement our identification strategy using panel data from the 2001-2003 wave of the U.S. Census Bureau's Survey of Income and Program Participation (SIPP). We focus on households that randomly become ineligible for the CTC between 2001 and 2003, depending on the exact timing of their child's birth, thus facing an increase in ATR. We measure labor supply by household, or, more precisely, by parents' labor income and use a first-difference specification in order to control for time-invariant household characteristics. We find that household labor income *decreases* in response to losing eligibility for the CTC. This finding cannot be reconciled with rationality even if one allows for the possibility of a binding liquidity constraint. In addition, it cannot be explained by a surprise lifetime income effect either. While the finding is inconsistent with the rational taxpayer hypothesis, it is consistent with the schmeduling hypothesis where the perceived substitution effect outweighs any perceived lifetime income effect and, potentially, a liquidity constraint effect. We therefore interpret our evidence as being supportive of the schmeduling hypothesis. Finally, we conduct several robustness tests in order to evaluate the sensitivity of this finding to the timing of the child's birthday having a direct effect on parents' labor income. These robustness tests provide no consistent evidence to suggest that a major part of our estimated effect is driven by such a direct effect.

[9] An exception to this is any omitted variable effect that is *discontinuous* in the timing of the child's 17th birthday at (approximately) the *same time threshold*. We examine such a possibility in Subsection 6.2.

The rest of the paper is organized as follows. Section 2 expands upon our motivating evidence for why individuals may respond to average tax rates alongside with, or instead of, marginal tax rates. Section 3 uses a simple static model of labor supply to highlight theoretical implications for behavior and for excess burden of taxpayers basing their decisions entirely on the ATR rather than the MTR. Section 4 presents a model of updating based on unexpected innovations in the ATR when taxpayers perceive the tax system in a rudimentary way followed by a life cycle model of labor supply based on the resulting sequence of beliefs, and highlights different implications of rationality and schmeduling for intertemporal variation in labor supply. Section 5 gives details of the identification strategy based on the Child Tax Credit, the data, and our estimating equation. Section 6 discusses our results as well as the robustness checks. Section 7 concludes.

2 Existing Evidence of MTR Misperceptions and Complexity

There have been numerous survey-based studies that have shed doubt on individuals' ability to estimate their effective MTR. For example, Brown (1968) compares self-reported MTRs of a group of UK taxpayers to their actual MTRs computed out of employer pay records and concludes that taxpayers "think they pay higher rates of tax than is in fact the case." Fujii and Hawley (1988), using Survey of Consumer Finances data, compare respondent self-reported MTRs to estimates of these MTRs based on the available survey demographic and income data. They find that individuals systematically underestimate their computed MTRs, although the significance of the finding is sensitive to the assumption made on the use of itemized deductions. Romich and Weisner (2000) find that a high fraction of low-income households do not correctly perceive MTRs implied by the Earned Income

Tax Credit for hypothetical levels of income. In particular, their knowledge is based on their own experience, which they incorrectly extrapolate to other income ranges. For example, households which are in the phase-in portion of the credit often assume that the amount of the credit increases linearly with the amount of labor income even in the plateau range of the credit.

As discussed in Section 1, a likely reason for such confusion is the inherent complexity of the US personal income tax system. Implications of this complexity are illustrated in Figure 1, which plots the effective federal MTR excluding payroll taxes for married couples filing jointly and for heads of household in 2002 as a function of household labor income, assuming no other income. In contrast to the statutory tax schedule, under which MTR is an increasing step function of income with just a few brackets, the actual effective MTR is non-monotone and quite variable, especially below the income level of $30,000. The complexity hypothesis is also supported by recent survey evidence from the 2003 NPR/Kaiser Family Foundation/Kennedy School of Government Taxes Study. In this survey, 36 percent of respondents reported to be more bothered by the complexity of the federal income tax system than by the amount they pay in taxes or by the feeling that rich people do not pay their "fair" share of taxes.[10] In addition, 90 percent of the respondents find the tax system very or at least somewhat complicated.[11] When asked what factors contribute to this complexity, the respondents named factors such as "too much record-keeping" (62 percent), "too many different tax rates" (59 percent), or "forms being too hard to fill" (56 percent). However, all of these percentages are eclipsed by the 96 percent of respondents who declared that complexity is partially due to "so many different kinds of deductions and tax credits, and so many rules about how

[10]This finding is based on the following question: "Which of the following bothers you most about taxes: the large amount you pay in taxes, the complexity of the tax system, or the feeling that some wealthy people get away with not paying their fair share?"

[11]This finding is based on the following question: "How complex do you think the current federal income tax system is? Do you think it is very complex, somewhat complex, not too complex or not complex at all?"

to take them." Moreover, 64 percent consider the latter to be the most important source of complexity.

Complexity of the tax code is not the only potential source of taxpayers' confusing the ATR for the MTR. For example, de Bartolome (1995) provides experimental evidence based on revealed choices that when the tax schedule is presented as a table mapping taxable income to the amount of tax entry by entry (as in the table accompanying the personal income tax form 1040), "there are at least as many individuals who use the average tax rate 'as if' it were the marginal tax rate, as individuals who use the true marginal tax rate." However, given that as many as 85 percent of taxpayers nowadays rely on a tax preparer or tax preparation software, with the fraction growing over time, the significance of tax schedule framing for taxpayer decisions potentially affects only a relatively small and declining portion of taxpayers.

Liebman and Zeckhauser (2004) try to identify the extent of schmeduling by comparing household taxable income in 1997 and 1999 based on data from the IRS Statistics of Income using the introduction of the Child Tax Credit in 1998 as a policy experiment that changed the ATR of many taxpayers without affecting their MTR. In particular, for taxpayers who were not constrained by the non-refundability of the credit and could claim a full $500 credit per child in 1999, this credit reduced their ATR without affecting their MTR. Focusing on this group of taxpayers, Liebman and Zeckhauser estimate the share of schmedulers to be 0.54. However, their identification strategy relies on ad hoc functional form assumptions and on the distribution of wage rates remaining invariant up to a scalar multiple between 1997 and 1999.

In this paper, we set out to improve upon this existing evidence by using survey-based reported behavior data and relying on an exogenous *cross-sectional* variation in the ATR that is not confounded by secular time trends in wage distribution and whose utilization does not require assuming specific functional forms for preferences. Before we describe our identification strategy in Section 5, the following two sections discuss why schmeduling may have important welfare consequences, and outline a formal model of schmeduling and its behavioral implications in a life-cycle model of labor supply.

3 Welfare Implications of Schmeduling: A Static Example

We know from economic theory that income-dependent taxation has two effects on behavior: the income effect, by which taxpayers change their behavior because the value of their endowment is diminished by tax payments, and the substitution effect, by which taxpayers change their behavior in response to changes in relative prices caused by the presence of the tax system. While the income effect is an unavoidable and intended consequence of taxation, the substitution effect is not. The latter generates "excess burden," defined as the additional tax revenue that could be extracted from a household while maintaining its level of well-being, or equivalent variation. For a rational taxpayer, the substitution effect could in theory be avoided by lump-sum taxation. However, to the extent that such taxation is deemed politically infeasible, the theory of optimal income taxation analyzes how the excess burden can be minimized given that income-dependent taxes need to be levied instead (Mirrlees, 1971).

The theory of optimal income taxation shows that the excess burden increases with the MTR. However, if schmeduling results in taxpayers' underestimating their true MTR, it may reduce the excess burden of taxation and can therefore be socially beneficial. As a motivating example, consider the extreme form of schmeduling proposed by Liebman and Zeckhauser (2004) when taxpayers approximate their

MTR by their ATR. Because the ATR is usually below the MTR (see Figure 1), schmeduling results in a social gain, as illustrated in Figure 2.[12] The horizontal axis measures labor time, while the vertical axis measures consumption. The wage rate is w and the price of consumption is normalized to unity. The boldface curve is the after-tax income available for consumption for any given labor input. It is assumed that the tax schedule has a demogrant built into it, and that a taxpayer receives a transfer $-T(0)$ when not working at all. Because the tax schedule is assumed to be convex (i.e., with increasing MTR), the after-tax income schedule is concave. A fully rational taxpayer (denoted by subscript R) maximizes her utility at point $E_R \equiv (L_R, wL_R - T(wL_R))$ on the indifference curve U_R. She pays $T(wL_R)$ in taxes, and her taxation generates an excess burden of EB_R. A schmeduler, by contrast, (denoted by subscript S) maximizes her utility at point $E_S \equiv (L_S, wL_S - T(wL_S))$ on the indifference curve U_S. She pays $T(wL_S)$ in taxes, and her taxation generates an excess burden of EB_S.[13]

Because the loss in welfare relative to lump-sum taxation is measured by the excess burden, welfare is higher if the taxpayer schmedules because $EB_S < EB_R$. Note, though, that while S is strictly worse off than R, the loss in her welfare is more than compensated for by the gain in tax revenue. That is, the gain in social welfare comes from the reduction in the excess burden. If the economy starts with a high fraction of identical schmedulers, each would gain if she *individually* switched to being rational. However, if all schmedulers switched, all would be worse off.

Even though the theory does predict a welfare gain from confusing ATR for MTR,

[12]This figure is similar to Figure 2 in de Bartolome (1995).

[13]It is important to mention that whereas for a rational taxpayer the excess burden can be understood as a difference between a utility-equivalent lump-sum tax revenue and the actual tax revenue, this is not the case for a schmeduler. The reason is that due to the perception bias, even a lump-sum tax is distorting for a schmeduler. In particular, only the ATR realized at E_S is consistent with the level of utility at E_S. In other words, the work-consumption point where the indifference curve U_S is tangent to the budget line with the slope of w is not incentive compatible for a schmeduler. Therefore in the case of a schmeduler, we define the excess burden as the additional tax revenue that could be collected by a social planner with dictatorial powers while keeping the taxpayer's utility fixed.

it is not clear what the size of such a gain is. To shed light on this question, suppose that a household's preferences over consumption and leisure are characterized by the constant elasticity of substitution utility function

$$U(c,l) = [\alpha c^{\rho} + (1-\alpha)(1-l)^{\rho}]^{\frac{1}{\rho}}, \tag{1}$$

where c is consumption, l is labor supply, and $\alpha \in (0,1)$ and $\rho < 1$ are parameters. The constant elasticity of substitution between consumption and leisure is given by $1/(1-\rho)$. In addition, suppose that the tax schedule is linear of the form $T(y) = ty - D$, where t is the marginal tax rate and D the demogrant. Assuming that the wage rate w is equal to unity and $\alpha = 0.5$, Figure 3 plots the excess burden for a rational taxpayer and for a schmeduler, still assuming the most extreme form of schmeduling by relying exclusively on the ATR.[14] Because the value of the endowment is given by the wage rate, which is equal to unity, this reduction in the excess burden can be understood as a proportional increase in the value of the endowment, or the wage rate. In the left column, the MTR is equal to 0.25, while in the right column, it is equal to 0.5. In the top row, the demogrant is equal to 0, while it is equal to 0.1 and 0.2 in the middle and the bottom row, respectively. The two graphs in the first row show that there is no difference in excess burden between the two types of taxpayers if there is no demogrant. This is because without any demogrant, the ATR coincides with the MTR. When the demogrant is increased above 0, the ATR drops below the MTR, resulting in the excess burden being larger for a rational taxpayer. For example, for Cobb-Douglas preferences ($\rho = 0$), the reduction in excess burden due to schmeduling is about 0.01 when $t = 0.25$ and $D = 0.1$, 0.038 when $t = 0.5$ and $D = 0.1$, 0.009 when $t = 0.25$ and $D = 0.2$, and 0.059 when $t = 0.5$ and $D = 0.2$. This example shows that, for reasonable

[14] Details of the calculation are provided in Appendix A.

preference specifications, the welfare gain from schmeduling may be large, on the order of several percentage points of the wage rate.[15]

4 A Dynamic Model of Taxation and Labor Supply

The previous section illustrated potential welfare effects of the most extreme form of schmeduling in a stylized static model of labor supply. However, a major premise of the schmeduling hypothesis is that taxpayers approximate their MTR by their ATR realized in the *previous year*. In light of this assumption, the static model of the previous section can be understood as a model of a steady state in a dynamic environment under the most extreme form of schmeduling. But given that the real-world decision-making environment is nonstationary and the most extreme form of schmeduling may not be realistic, this model is not fully satisfactory as background for an empirical evaluation of the schmeduling hypothesis. In this section, we formulate a more general model of life-cycle belief formation and labor supply and consider the difference in the behavioral predictions for rational taxpayers and schmedulers. In Subsection 4.1, we outline how beliefs about the tax system are formed over time depending on available signals. Then, given this belief process, we formulate a life-cycle model of labor supply in Subsection 4.2.

[15] In all cases except when $t = 0.25$ and $D = 0$, the excess burden for both a rational taxpayer and a schmeduler falls as consumption and leisure become more substitutable (i.e., as ρ approaches 1). There are two reasons for this. First, given the parametrization of the example, the optimal choice of labor supply is a corner solution at zero, which limits the extent of the tax distortion. Second, the shape of the indifference curve approaches a line with the slope of unity, which coincides with the pre-tax wage rate, hence reducing the welfare cost of any existing tax distortion.

4.1 Belief Process

Suppose that household i faces a linear tax schedule in every period $t \in \{0, ..., T\}$ of its lifetime with the MTR given by τ_{it} and the demogrant (a negative of the intercept) given by D_{it}. That is, the tax liability $T_{it}(y)$ of this household in period t based on the taxable income of y is determined by $T_{it}(y) = \tau_{it} y - D_{it}$ for all $y \geq 0$. This schedule varies from household to household because of different demographic characteristics such as the number of children and their age, taxpayers' age, disability status, type of income, etc. It also varies from year to year because of predictable and unpredictable changes in the tax schedule. The predictable changes are due to a variety of provisions related to the age of the taxpayers or their children, or due to tax consequences of planned actions such as mortgage interest payments. These changes are predictable many years in advance. In our model we assume, for simplicity, that these changes are predictable for the entire remaining lifetime of a household. Unpredictable changes, on the other hand, are due to tax reforms as well as realization of states of the world that have tax consequences, such as medical expenditures, disability status, number and timing of children, etc. We assume that these unpredictable changes can be, barring retroactive tax reforms, predicted only one period in advance.[16] Formally, the parameters of the tax schedule affecting household i follow a stationary AR(1) process

$$\begin{pmatrix} \tau_{it+1} \\ D_{it+1} \end{pmatrix} = (1-\rho_i) \begin{pmatrix} \overline{\tau}_i \\ \overline{D}_i \end{pmatrix} + \rho_i \begin{pmatrix} \tau_{it} \\ D_{it} \end{pmatrix} + \begin{pmatrix} \phi_{\tau it+1} \\ \phi_{Dit+1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{\tau it+1} \\ \varepsilon_{Dit+1} \end{pmatrix}, \quad (2)$$

where $\rho_i \in (0, 1)$, and ϕ_{it+1} and ε_{it+1} are period-by-period independent draws from $N(\overline{\phi}_{it+1}, F_i)$ and $N(0, G_i)$, respectively. The vector ϕ_{it+1} captures the predictable changes. However, the taxpayer may predict these changes with error, resulting in

[16] For example, the introduction of a new credit for 2006 and beyond can happen anytime during 2005, and hence the tax schedule for 2006 may not be perfectly predictable until late 2005.

his expectation of the change $\overline{\phi}_{it+1}$ diverging from the actual change ϕ_{it+1}. The matrix F_i measures the household's ability to predict the predictable changes. For a rational household, $F_i = 0_{2\times 2}$, and hence the predictable changes are in fact predicted without error. For a schmeduler, F_i is a positive definite matrix, meaning that $\overline{\phi}_{is}$ is only a crude measure of the predictable change in the parameters of the tax schedule in period $s \in t+1, ..., T$. The vector ε_{it+1} captures the unpredictable changes in the tax schedule and the matrix G_i captures the variation in these unpredictable changes. We assume mean reversion captured by ρ_i in order to limit the variance in the actual MTR and the demogrant as well as the household's beliefs about them for distant future time periods. With this assumption, the unconditional long-run distribution of $(\tau_{it}, D_{it})^T$ is normal with a finite variance $(G_i + F_i)/(1-\rho_i^2)$. Although the normal distribution places a positive measure on the MTR exceeding unity or falling below any arbitrary negative threshold, such probability will be negligible for a properly chosen set of parameters, and we therefore ignore it. In other words, the stochastic specification in (2) may be thought of as a tractable approximation of beliefs over a bounded interval.[17]

At the end of period t, the household observes a signal s_{it} about unpredictable changes in its tax schedule in the following period given by ε_{it+1} . In particular, this signal is generated by

$$\begin{pmatrix} s_{\tau it} \\ s_{Dit} \end{pmatrix} = \begin{pmatrix} \varepsilon_{\tau it+1} \\ \varepsilon_{Dit+1} \end{pmatrix} + \begin{pmatrix} u_{\tau it} \\ u_{Dit} \end{pmatrix}, \tag{3}$$

where u_{it} are period-by-period independent draws from $N(0, S_i)$. The matrix S_i captures the precision with which the household observes or comprehends realizations in

[17]An alternative modeling solution would be to define the stochastic process for the parameters of the tax schedule in terms of unbounded monotone transformations of τ_{it} and D_{it} such as $\ln[\tau_{it}/(1-\tau_{it})]$ or $\ln D_{it}$. This would, however, complicate the analytical exposition of updating based on realized ATR discussed later. For tractability reasons, we therefore define the process in terms of the levels of the two parameters.

unpredictable changes in the tax schedule that become known just one period ahead of becoming effective. For a rational household, $S_i = 0_{2\times 2}$, while for a schmeduler, S_i is a positive definite matrix.

Finally, we assume that the household does not necessarily have exact knowledge of the tax schedule when it first enters the labor force. In particular, its prior beliefs about the MTR and the demogrant of the tax schedule at the beginning of period 0 are given by

$$\begin{pmatrix} \tau_{i0} \\ D_{i0} \end{pmatrix} \sim N\left[\mu_{i0}, \Sigma_{i0}\right]. \tag{4}$$

Again, the matrix Σ_{i0} indexes the extent to which the household is aware of details of the tax schedule when it first enters the labor force. For a rational household, $\Sigma_{i0} = 0_{2\times 2}$, while for a schmeduler, Σ_{i0} is a positive definite matrix.

The assumption that households may not be fully aware of the tax schedule or its innovations is a major departure from the existing models of behavioral responses to taxation. These models assume that taxpayers are fully aware of the current tax schedule as well as of all of its future predictable changes. Our model allows for such a possibility as a special case when $F_i = S_i = \Sigma_{i0} = 0_{2\times 2}$. However, if at least one of the matrices F_i, S_i, or Σ_{i0} is non-zero, this will not be the case. Such a household can be understood as having cognitive or information search costs when trying to understand the tax schedule or its innovations. One would expect such costs to be especially salient when the tax system is very complex. It is likely that the degree of signal precision is determined endogenously by conscious information-gathering actions of the household such as investing time to learn about the tax code or hiring a tax advisor. Although explicitly modeling such information acquisition decisions is beyond the scope of the current paper, our approach can be understood as a reduced form specification that already incorporates such household choices. Note that even if a household is fully rational but faces a non-negligible cost of acquiring information, it may decide not to obtain perfect information about the tax schedule or its innovations, and hence face a positive definite F_i, S_i, or Σ_{i0}. Having noted that, however, we will refer to any household with $F_i = S_i = \Sigma_{i0} = 0_{2\times 2}$ as rational, and any other household as a schmeduler.

Apart from the noisy signals of unpredictable tax innovations, at the end of period t the household also files its tax return for that period.[18] Conditional on pre-tax income y_{it} in period t, the household observes its tax liability given by

$$T_{it} = \tau_{it} y_{it} - D_{it}. \tag{5}$$

This tax liability serves as an additional signal about (τ_{it}, D_{it}). The following proposition characterizes the evolution of beliefs about the parameters of future tax schedules bases on past and current realizations of T_{it} and s_{it}.

Proposition 1 *Given the initial beliefs in (4), the stochastic process for the parameters of the tax schedule in (2), signals about unpredictable tax schedule innovations in (3), and observation of tax liabilities in (5), the beliefs about the parameters of the tax schedule in period $s \in \{t+1, .., T\}$ at the end of period t are given by a normal distribution with mean*

$$E_{it}\left[(\tau_{is}, D_{is})^T\right] = \rho_i^{s-t-1}\mu_{it+1} + (1-\rho_i^{s-t-1})(\overline{\tau}_i, \overline{D}_i)^T + \sum_{v=t+2}^{s} \rho_i^{s-v}\overline{\phi}_{iv}, \tag{6}$$

and variance

$$Var_{it}\left[(\tau_{is}, D_{is})^T\right] = \rho_i^{2(s-t-1)}\Sigma_{it+1} + \frac{1-\rho_i^{2(s-t-1)}}{1-\rho_i^2}\left(G_i + F_i\right), \tag{7}$$

[18] In reality, households file their tax returns in the early part of the subsequent year. However, as long as such filing has the potential to affect the behavior in that year, the exact timing of the filing is less important and we assume it happens at the end of period t for simplicity of notation.

where μ_{it+1} *is defined recursively by*

$$\mu_{iu+1} = (1-\rho_i)(\overline{\tau}_i, \overline{D}_i)^T + \rho_i m_{iu} + \overline{\phi}_{iu+1} + A_i s_{iu},\ u = 0, ..., t \tag{8}$$

and

$$m_{iu} \equiv \mu_{iu} + \Gamma_{it}\left[ATR_{iu} - E_{iu-1}\left(ATR_{iu}\right)\right],\ u = 0, ..., t, \tag{9}$$

and Σ_{it+1} *is defined recursively by*

$$\Sigma_{iu+1} = \rho_i^2 V_{iu} + F_i + B_i,\ u = 0, ..., t \tag{10}$$

and

$$V_{iu} = \Sigma_{iu} - \frac{\Sigma_{iu}(y_{iu}, -1)^T (y_{iu}, -1)\Sigma_{iu}}{(y_{iu}, -1)\Sigma_{iu}(y_{iu}, -1)^T},\ u = 0, ..., t. \tag{11}$$

In these formulas, y_{iu} *is the taxable income in period* u*,* $A_i \equiv G_i(G_i + S_i)^{-1}$*,* $B_i \equiv G_i - G_i(G_i + S_i)^{-1}G_i$*,* $ATR_{iu} \equiv T_{iu}/y_{iu}$*, and*

$$\Gamma_{it} \equiv \frac{\Sigma_{it}(y_{it}, -1)^T}{(y_{it}, -1)\Sigma_{it}(y_{it}, -1)^T} y_{it} \tag{12}$$

as long as $(y_{it}, -1)\Sigma_{it}(y_{it}, -1)^T$ *is positive, and* $\Gamma_{it} \equiv 0_{2\times 1}$ *otherwise.*[19]

Proof. See Appendix B. ■

Intuitively, looking backward, μ_{iu} is the mean and Σ_{iu} is the variance of the belief about $(\tau_{iu}, D_{iu})^T$ that the household enters the period u with, which already incorporates updating on all previously available signals. Upon observing its tax liability, or, equivalently, the average tax rate at the end of period u, the household updates this belief such that the mean changes to m_{iu} and the variance changes to V_{iu}. Beliefs about the parameters of the tax schedule for the next period are

[19]Note that since $(y_{it}, -1)\Sigma_{it}(y_{it}, -1)^T$ is a quadratic form of a positive semi-definite matrix, it is non-negative.

then further modified based on the stochastic process given in (2), the distribution of ϕ_{iu+1}, and the distribution of ε_{iu+1} conditional on s_{iu}. At the end of period t, the belief about the parameters of the tax schedule in period $t+1$ is given by $N(\mu_{it+1}, \Sigma_{it+1})$. Then, looking forward, because no future signals are available yet, the conditional mean and variance of the tax schedule parameters for periods $t+2, ..., T$ are derived from the stochastic process in (2) as given by (6) and (7).

The signs of the effects of unpredicted ATR realizations in period t on the expected value of the beliefs about the parameters of future tax schedules are given by the signs of the elements of Γ_{it}. Assuming that $y_{it} > 0$, as long as $(y_{it}, -1)\Sigma_{it}(y_{it}, -1)^T$ is positive, the signs of the elements of Γ_{it} depend on the signs of the elements of $\Sigma_{it}(y_{it}, -1)^T = (\sigma_{it}^{11} y_{it} - \sigma_{it}^{12}, \sigma_{it}^{12} y_{it} - \sigma_{it}^{22})^T$. Without imposing further assumptions on the parameters of the model, it is not possible to sign these two terms unambiguously. Instead of forcing a particular sign pattern on the result by making such assumptions, let us consider several special cases. First, if the household is rational, then $F_i = S_i = \Sigma_{i0} = 0_{2\times 2}$, implying that $B_i = 0$, and hence, by Proposition 1, that $\Sigma_{it} = 0$. As a result, the tax schedule is known with certainty one period ahead and $ATR_{it} = E_{it-1}(ATR_{it})$, implying that there is nothing to learn from ATR realizations. Second, suppose that the household is only confused about the demogrant, but not about the MTR. That is, all of the elements of F_i, S_i, and Σ_{i0} except for the element $(2, 2)$ are equal to zero. Then, by Proposition 1, the same is also true of Σ_{it} (in fact, $\Sigma_{it} = B_i$), and $\Gamma_{it} = (0, -y_{it})^T$. As a result, any unexpected hike in the ATR is reflected in a reduction in expectation of future demogrants equal to the amount of the surprise in the tax liability, without any impact on the beliefs about future MTRs. Third, suppose that the household is only confused about the MTR, but not about the demogrant. That is, all of the elements of F_i, S_i, and Σ_{i0} except for the element $(1, 1)$ are equal to zero. Then, by Proposition 1, the same is also true of Σ_{it} (in fact, $\Sigma_{it} = B_i$), and hence $\Gamma_{it} = (1, 0)^T$.

As a result, any unexpected hike in the ATR is reflected in an increase in the expectation of future MTRs by the magnitude of the surprise, without any impact on the beliefs about future demogrants. In addition, if there are no predictable changes in the parameters of the tax schedule, i.e., $\overline{\phi}_{is} = 0$ for $s \in \{1, ..., T\}$, the unpredictable changes are observed with an infinite variance noise, i.e., the element $(1, 1)$ of S_i is equal to infinity, there is no mean reversion, i.e. $\rho_i = 1$, and the household initially believes that the demogrant is equal to zero, i.e., the second element of μ_{i0} is zero, then $E_{it}(\tau_{is}) = ATR_{it}$ for $s \in \{t + 1, ..., T\}$, which corresponds to the extreme form of schmeduling considered by Liebman and Zeckhauser (2004).

Having outlined how a surprise in the realization of the ATR in period t affects perceptions of the MTR and the demogrant in periods beyond t, the next subsection analyzes a life-cycle model of labor supply that takes these beliefs as given. Before going to the next subsection, though, it is important to mention that there may also be a feedback effect from the choice of labor supply to the process of belief evolution over time. In particular, as shown by (11), choosing a different level of y_{it} leads to a different posterior variance matrix, and hence a different precision of the signal based on the realized ATR for the MTR and the demogrant. In light of this, a household may want to manipulate its choice of labor supply if the cost of doing so falls short of the resulting value of information. Although the model presented in this section illustrates how realizations of the ATR may affect formation of beliefs about future tax schedules in the world of linear tax schedules, real world tax schedules are more complicated, and we do not believe that such channel of information seeking is empirically important. We therefore leave exploration along this line of thought to future research and assume that, when deciding on the labor supply, the household perceives the beliefs process as exogenous.[20]

[20]That is, the beliefs are given by a fixed point based on mapping of beliefs to the choice of labor supply, treating beliefs as exogenous, and mapping of the latter back to the beliefs process.

4.2 Labor Supply Over the Lifecycle

Suppose that at the beginning of period t, household i maximizes its remaining lifetime expected utility

$$E_{it-1} \sum_{s=t}^{T} \delta_i^{s-t} U(c_{is}, h_{is}, a_{is}), \tag{13}$$

where c_{is} is the consumption in period s, $h_{is} \in [0,1]$ is the labor supply in period s, and a_{is} captures life-cycle heterogeneity in preferences. The expectation is taken with respect to the beliefs of this household at the end of period $t-1$ because the parameters of the tax schedule in period t are not necessarily known with certainty. Under the linear tax schedules analyzed in the previous subsection, the intertemporal budget constraint is given by

$$\begin{aligned} &A_{is+1} = (1 + r_{is+1}) \left[A_{is} + (1 - \tau_{is}) w_{is} h_{is} + D_{is} - c_{is} \right], \quad s = t, .., T, \\ &A_{it} \text{ given, } A_{iT} \geq 0, \end{aligned} \tag{14}$$

where A_{is} is the household's stock of assets at the beginning of period s, w_{is} is the wage rate in period s, and r_{is+1} is the interest rate between periods s and $s+1$. In this setting, current and future wages, interest rates, and parameters of the current and future tax schedules are all potentially stochastic. Indeed, the model of the previous subsection explicitly assumes this for the case of the tax schedules parameter. However, to simplify the exposition, we assume that w_{is} and r_{is} are both known at the beginning of period s, or, without loss of generality, at the end of period $s-1$, after all the economic decisions in that period have already been made. In addition we assume, for tractability, that the parameters of current or future tax schedules are statistically independent of current and future wage and interest rates,[21] and that capital income is not taxed.

Let $V_{it}(A_{it})$ be the maximized value of (13) conditional on the asset stock at the beginning of period t and all the information available at the end of period $t-1$. These value functions are recursively defined by the last period value function

$$V_{iT}(A_{iT}) \equiv \max_{h_{iT}} E_{iT-1} U\left[A_{iT} + (1-\tau_{iT}) w_{iT} h_{iT} + D_{iT}, h_{iT}, a_{iT}\right] \tag{15}$$

and the Bellman equation

$$\begin{aligned} V_{is}(A_{is}) \equiv & \max_{c_{is}, h_{is}} U(c_{is}, h_{is}, a_{is}) \\ & + \delta_i E_{is-1} V_{is+1}\left\{(1+r_{is+1})\left[A_{is} + (1-\tau_{is}) w_{is} h_{is} + D_{is} - c_{is}\right]\right\} \end{aligned} \tag{16}$$

for $s = t, ..., T-1$. Denoting by $\lambda_{is+1} \equiv \delta_i (1 + r_{is+1}) V'_{is+1}(A_{is+1})$ the future *realized* discounted marginal utility of a unit of savings at time s, the optimal intratemporal choice of c_{it} and h_{it} at time t is characterized by the first-order conditions

$$U_c(c_{it}, h_{it}, a_{it}) = E_{it-1}(\lambda_{it+1}), \tag{17}$$

and

$$\begin{aligned} U_h(c_{it}, h_{it}, a_{it}) &= -w_{it} E_{it-1}\left[\lambda_{it+1}(1-\tau_{it})\right] \\ &= -w_{it}\left[1 - E_{it-1}(\tau_{it})\right] E_{it-1}(\lambda_{it+1}) + w_{it} Cov_{it-1}(\lambda_{it+1}, \tau_{it}). \end{aligned} \tag{18}$$

In addition, the optimal intertemporal allocation of consumption and labor is characterized by the Euler (envelope) equation

$$\lambda_{it} = \delta_i (1 + r_{it}) E_{it-1}(\lambda_{it+1}). \tag{19}$$

[21] In the opposite case, current wage and interest rate realizations would also serve as potential informative signals about current and future tax schedule parameters.

Intuitively, $E_{it-1}(\lambda_{it+1})$ is a summary statistic that incorporates beliefs about tax schedules and wage and interest rates in periods $t, ..., T$ based on information available at the end of period $t-1$, or, equivalently, at the beginning of period t before consumption and labor supply decisions are made. Equation (17) is the standard condition that says that the household will consume in period t until the current marginal utility of consuming a unit of assets is equal to the expected discounted marginal utility of having an extra unit of assets put aside for the future. Likewise, (19) is the usual Euler equation that links the marginal utility value of a unit of assets over time. Equation (18) states that the household will supply labor until the disutility of doing so is equal to the expected after-tax discounted utility gain in terms of asset accumulation. However, as shown on the second line of this equation, the latter is equal to the expected discounted utility of an additional unit of asset accumulation evaluated at the expected after-tax share if and only if $Cov_{it-1}(\lambda_{it+1}, \tau_{it}) = 0$. If $Cov_{it-1}(\lambda_{it+1}, \tau_{it}) > 0$, then the household is left with a higher after-tax share of its wage in those states when it is otherwise better off, and vice versa. As a result, controlling for $E_{it-1}(\tau_{it})$ and $E_{it-1}(\lambda_{it+1})$, the expected marginal utility payoff to supplying an extra unit of labor is lower relative to the zero covariance baseline, which leads the household to supply less labor. On the other hand, just the opposite is true if $Cov_{it-1}(\lambda_{it+1}, \tau_{it}) < 0$.

The first-order conditions (17) and (18) can be solved simultaneously to implicitly give the household's labor supply

$$h_{it} = h^* \left[w_{it}, E_{it-1} \left(1 - \tau_{it} \right), E_{it-1}(\lambda_{it+1}), Cov_{it-1}(\lambda_{it+1}, \tau_{it}), a_{it} \right], \tag{20}$$

or, in a semi-log-linearized form,

$$\ln h_{it} = \alpha_0 + \alpha_1 \ln w_{it} + \alpha_2 E_{it-1}(\tau_{it}) + \alpha_3 E_{it-1}(\lambda_{it+1}) + \alpha_4 Cov_{it-1}(\lambda_{it+1}, \tau_{it}) + \alpha_5 a_{it} + \nu_{it}. \tag{21}$$

This equation captures key determinants of labor supply over time. First , *ceteris paribus*, a higher current wage rate w_{it} increases labor supply by the substitution effect, implying that $\alpha_1 > 0$. Second, just the opposite is true of the current expected MTR $E_{it-1}(\tau_{it})$ since the lifetime income effect of all the implied changes in future tax schedules on household well-being are controlled for by $E_{it-1}(\lambda_{it+1})$, implying that $\alpha_2 < 0$. Third, being richer, i.e., having a lower $E_{it-1}(\lambda_{it+1})$, decreases labor supply, assuming that leisure is a normal good, which implies that $\alpha_3 > 0$. Fourth, a higher value of $Cov_{it-1}(\lambda_{it+1}, \tau_{it})$ decreases the expected utility gain from supplying more labor, implying that $\alpha_4 < 0$. Finally, labor supply is also affected by current tastes a_{it}. The term ν_{it} captures the approximation error.

Differencing (21) between periods t and $t+1$, proxying for a_{it} by a vector of household demographic characteristics X_{it}, gives

$$\begin{aligned}\Delta \ln h_{it+1} = {} & \alpha_1 \Delta \ln w_{it+1} + \alpha_2 \left[E_{it}(\tau_{it+1}) - E_{it-1}(\tau_{it})\right] + \alpha_3 \left[E_{it}(\lambda_{it+2}) - E_{it-1}(\lambda_{it+1})\right] \\ & + \alpha_4 \left[Cov_{it}(\lambda_{it+2}, \tau_{it+1}) - Cov_{it-1}(\lambda_{it+1}, \tau_{it})\right] + \delta' \Delta X_{it+1} + \Delta \nu_{it+1}. \end{aligned} \tag{22}$$

Note that, using Proposition 1, it follows that

$$\begin{aligned}E_{it}(\tau_{it+1}) - E_{it-1}(\tau_{it}) = {} & \gamma_{it} \left[ATR_{it} - E_{it-1}(ATR_{it})\right] \\ & + a_i s_{it} - (1 - \rho_i)\left[E_{it-1}(\tau_{it}) - \overline{\tau}_i\right] + \overline{\phi}_{\tau it+1}, \end{aligned} \tag{23}$$

where $\gamma_{it} \equiv \rho_i (1,0) \Gamma_{it}$ and $a_i \equiv (1,0) A_i$.

After substituting this result back into (22), we obtain

$$\Delta \ln h_{it+1} = \alpha_2 \gamma_{it} \left[ATR_{it} - E_{it-1}\left(ATR_{it}\right)\right]$$
$$+ \alpha_2 \left\{a_i s_{it} - (1-\rho_i)\left[E_{it-1}\left(\tau_{it}\right) - \overline{\tau}_i\right] + \overline{\phi}_{\tau it+1}\right\}$$
$$+ \alpha_3 \left[E_{it}(\lambda_{it+2}) - E_{it-1}(\lambda_{it+1})\right] + \alpha_4 \left[Cov_{it}(\lambda_{it+2}, \tau_{it+1}) - Cov_{it-1}(\lambda_{it+1}, \tau_{it})\right]$$
$$+ \alpha_1 \Delta \ln w_{it+1} + \delta' \Delta X_{it+1} + \Delta \nu_{it+1}. \tag{24}$$

If the household is completely rational, τ_{it} and D_{it} are known with certainty at the end of period $t-1$, implying that $ATR_{it} = E_{it-1}\left(ATR_{it}\right)$ and $Cov_{it-1}(\lambda_{it+1}, \tau_{it}) = 0$. Analogously, $Cov_{it}(\lambda_{it+2}, \tau_{it+1}) = 0$. As a result, the household changes its labor supply between periods t and $t+1$ only due to an objective change in the MTR captured by $a_i \varepsilon_{it+1} - (1-\rho_i)\left[E_{it-1}\left(\tau_{it}\right) - \overline{\tau}_i\right] + \phi_{\tau it+1}$, a change in the wage rate $\Delta \ln w_{it+1}$, a change in lifetime wealth captured by $E_{it}(\lambda_{it+2}) - E_{it-1}(\lambda_{it+1})$, a change in tastes between periods t and $t+1$ captured by ΔX_{it+1}, or a change in omitted factors $\Delta \nu_{it+1}$. In particular, realization of the ATR has no effect on the intertemporal change in labor supply. On the other hand, if the household schmedules, τ_{it} and D_{it} are *not* known with certainty at the end of period $t-1$, implying that $\gamma_{it} \neq 0$, $Cov_{it-1}(\lambda_{it+1}, \tau_{it}) \neq 0$, and, analogously, $Cov_{it}(\lambda_{it+2}, \tau_{it+1}) \neq 0$. As a result, the household changes its labor supply between periods t and $t+1$ also due to an unexpected innovation in the realization of the ATR in period t and a change in the covariance between the MTR and the marginal utility of wealth between periods t and $t+1$.

Having derived an intertemporal theory of labor supply based on a potentially imperfect knowledge of the tax schedule that nests both the rational taxpayer and the schmeduling hypotheses, the remainder of the paper attempts to empirically distinguish between these two competing hypotheses.

5 Identification Strategy and Data

In this section, we first outline the rationale behind our identification strategy. We then describe the dataset used in our analysis and the implementation of our identification strategy.

5.1 Identification Strategy

In order to test the prediction of the rational taxpayer hypothesis that taxpayers do *not* react to predictable innovations in their ATR in their subsequent labor supply decisions against the prediction of the schmeduling hypothesis which claims that taxpayers *do* react, there are three requirements for any identification strategy. First, the variation in the ATR should be *predictable* but *not necessarily predicted* in advance. Second, this variation should not be correlated with variation in the MTR. This is because such correlation, especially if positive, poses an identification problem for distinguishing between the two hypotheses. The problem arises because the substitution effect due to a *perceived* MTR change for a schmeduler affects his labor supply in the same direction as the substitution effect due to the *actual* MTR change for a rational taxpayer. Third, to avoid omitted variable and endogeneity biases, this variation in the ATR should be exogenous and uncorrelated with any unobserved variables that may also be affecting the labor supply.

In order to satisfy the first requirement, we adopt a strategy of relying on the variation in the tax schedule due to the aging of household members, which is perfectly predictable.[22] There are several provisions in the tax code that make the tax schedule a function of whether a dependent child did or did not reach a certain age in a given tax year. One such provision that has been exploited by researchers

[22]We could alternatively rely on variation generated by tax reforms, but since the latter are often not predictable far enough in advance, they may affect the behavior of rational taxpayers too through a lifetime income effect, making it hard to draw conclusions for the validity of the two hypotheses.

(Looney and Singhal, 2004; Dokko, 2005) in order to estimate the effect of marginal tax rates on labor supply is the loss of eligibility for a personal exemption and the Earned Income Tax Credit for a dependent child who turns 19 (or 24, if a full-time student) during the tax year.[23] This provision does not satisfy our second requirement, however, because the resulting increase in taxable income increases not only the ATR, but also the MTR if the taxpayer is pushed into a higher tax bracket.[24]

Our identification strategy is based on variation in eligibility for the Child Tax Credit (CTC) generated by the timing of a dependent child's 17th birthday. Beginning in 1998, U.S. households with a dependent child under 17 years of age on December 31 of the tax year were eligible to claim a $400 Child Tax Credit (CTC). This credit was generally nonrefundable and only households with sufficiently high tax liability could take full advantage of the credit. At the same time, though, the Additional Child Tax Credit (ACTC) was introduced. This credit provided for a limited refundability of the nonrefundable part of the CTC for families with three or more qualifying children.[25] The CTC was increased to $500 for the 1999 and 2000 tax years, $600 for the 2001 and 2002 tax years, and $1,000 for the 2003 tax year, where it currently stands. At the same time, beginning in 2001, the ACTC was expanded to allow *any* family to claim the nonrefundable part of the CTC up

[23]For households whose child is turning 19 and whose taxable income is just below a kinkpoint of the tax schedule, this provision creates a predictable variation in the MTR as well as the ATR, while for households whose child is turning 19 but whose taxable income is further below such a kinkpoint, it affects only the ATR. Under the rationality assumption, this change in the tax schedule should be anticipated and its realization should have no lifetime income effect. As a result, for households in the former group, any systematic change in labor supply between the year when their child turns 18 and the year when their child turns 19 should reflect only a substitution effect due to swinging to a higher MTR bracket, while households in the latter group should not exhibit any systematic change in labor supply at all. This provision can therefore be, under the assumption of rationality, used to identify the compensated intertemporal elasticity of labor supply.

[24]To avoid this problem, one could possibly envision using only the households for whom the MTR would not change under the assumption that that income stays fixed or grows in a predictable way from year to year. We instead utilize a different strategy described in the next paragraph.

[25]These families could claim the nonrefundable part of the CTC up to the amount of employee contributed social security and medicare taxes less any earned income tax credit they received.

to one tenth of the excess of their earned income over $10,000.[26] The CTC has historically been phased out with adjusted gross income above $110,000 for married couples filing a joint tax return at the rate of 5 percent.[27] None of these thresholds are indexed for inflation.

Our identification strategy offers an important advantage in satisfying the second requirement that variation in the ATR be uncorrelated with variation in the MTR. This is the case because the CTC is subtracted from regular tax liability after the latter has been computed from taxable income. As a result, the MTR that applies to an additional dollar of taxable income is unaffected by this credit except for households in the phase-in and phase-out range of the credit. In 2001, these are households with adjusted gross income below approximately $20,000 and above $110,000 if married and $75,000 if single, as shown in Figure 1. The MTR of the phase-in households is affected when these households hit the nonrefundability constraint of the CTC. When eligible for the credit, phase-in households may be able to offset any marginal tax liability before the Earned Income Tax Credit against the unused portion of their CTC, hence facing an effective pre-EITC MTR of zero. As a result, losing eligibility for the CTC increases their effective MTR. In contrast, the phase-out households face a reduction of $0.05 in the credit for every extra dollar of income, until the credit is exhausted. Therefore, losing a child eligible for the CTC implies a five percentage point reduction in effective MTR. To minimize the resulting correlation between variation in the ATR and variation in the MTR, we restrict our sample to households with adjusted gross income in 2001 between $30,000 and $90,000.

[26]The $10,000 threshold was later indexed to $10,350 in 2002, $10,500 in 2003, and $10,750 in 2004. In addition, starting in 2004, the ACTC limit was increased to 15 percent of earned income in excess of the threshold. Families with three or more eligible children could still claim the nonrefundable part of the CTC up to the amount of employee-contributed social security and medicare taxes less any earned income tax credit they received if this limit turned out to be higher.

[27]That is, a household loses $0.05 of the credit for every extra dollar of adjusted gross income above the threshold.

In order to satisfy the third requirement that the variation in the ATR be exogenous and uncorrelated with any unobserved variables that may also be affecting the labor supply, we compare the labor supply of households who are barely ineligible for the credit due to their child turning 17 shortly before the turn of a year to households who are barely eligible due to their child turning 17 shortly after the turn of the year. Because it is possible to plan the timing of a child's birth for a particular year but much harder to do so for a particular quarter or month, by restricting our sample to households whose children turn 17 in a relatively narrow time band around the turn of the year, the CTC-induced variation in the ATR is seemingly exogenous. Dickert-Conlin and Chandra (1999) show, however, that the timing of birth around the turn of the year is not necessarily exogenous, as households try to speed up the birth of their children in order to receive child-related tax benefits for the ending tax year, and that the responsiveness to such tax benefits increases with income. In order to deal with this potential endogeneity problem, instead of examining the impact of the variation in the ATR on the *level* of labor supply, we examine its impact on the *growth rate* of labor supply as suggested by equation (24). In this way our identification strategy implicitly differences out any time-invariant household characteristics such as lifetime income.

First-differencing is likely to solve some but not all of the potential omitted variable problems. In particular, Bound et al. (1995) cite a number of references documenting that the season of birth may influence the incidence of mental disorders, IQ, capacity to learn, or that it may be directly correlated with income since children from high income families are less likely to be born in the winter months. This would suggest a correlation of the timing of birth with a lifetime capacity to supply labor and generate income. First-differencing, by controlling for any time-invariant unobserved effects on the level of labor supply, solves this potential omitted variable problem. However, there may be other omitted variables correlated with eligibility for the CTC or the timing of birth that directly affect the growth rate of labor supply. We discuss these potential omitted variable biases and their effect on our estimates and their interpretations in Subsection 6.2.

5.2 Data and Estimating Equation

Our identification strategy requires a dataset that contains information on household labor and non-labor income, labor supply, number of children and their dates of birth, as well as basic household demographic characteristics. Data used in this study come from the 2001-2003 wave of the U.S. Census Bureau Survey of Income and Program Participation (SIPP). The SIPP is a nationally representative longitudinal survey of households that collects information on income, employment, and detailed demographic information on all family members. The SIPP data also contain very specific information on the year and month of birth of each child in the household, which allows us to divide households into treatment (child turning 17 near the end of a tax year) and control (child turning 17 early in the subsequent tax year) groups. Using this information, we compute tax liabilities and tax rates using the NBER's TAXSIM (see Feenberg and Coutts, 1993) calculator.[28]

The 2001-2003 panel contains information on 36,700 households. Each household is interviewed every four months over the three years for a total of nine waves. We measure household labor supply by parents' labor income. This measure offers a methodological advantage in that it incorporates various other aspects of labor market activity apart from hours worked, such as finding a better paying job or reoptimizing the distribution of hours worked across different household members.

[28]An alternative dataset with more precise information on income and tax variables and a larger sample size would be the IRS Statistics of Income (SOI) Tax Return Microfiles. However, this dataset is unsuitable for our analysis for two reasons. First, it does not provide information on the timing of birth of a child, and only very coarse information on household demographics. Second, for the time period after the CTC was introduced in 1998, only annual cross-sectional datasets, but not a panel dataset, are publicly available.

We restrict our attention to single and married households with complete data on yearly income, at least one child who turns 17 between 2000 and 2004 (some of the households are used only in our robustness tests), and who have adjusted gross income, as computed by TAXSIM, in the range between $30,000 and $90,000 in 2001. These stringent data requirements significantly reduce the available sample size to 1,607 households with 5,476 household-year observations. The number of household-years available by year of survey and six-month period when the child turns 17 along with the means and standard deviations of household labor income are presented in Table 1.

We use eight demographic variables in our analysis. These are whether the household is a married couple or a single mother,[29] wife's and husband's age (set to zero for the husband in case of a single-parent household), indicator variables for whether they graduated from high school, indicator variables for whether they graduated from college, and the number of dependents in the household, where a dependent is defined as a child under the age of 24 living at home with parents. Table 2 tabulates summary statistics for these variables. Of the 1,607 households in the data, 370 belong to two, 42 to three, and two to four different cohorts as a result of having more than one child turn 17 between 2000 and 2004. Also, 45 households have more than one dependent in the same cohort (as would be the case for twins, for example).

Tables 3 and 4 illustrate the impact of a child turning 17 on the marginal and average tax rates. Table 3 compares the growth rates between 2001 and 2002 of mean MTR and ATR for households whose child turns 17 in 2002 to those households whose child turns 17 in 2003. Table 4 compares the growth rates between 2002 and 2003 of mean MTR and ATR for households whose child turns 17 in 2003 to those households whose child turns 17 in 2004. The tables display the overall comparison

[29]There are no single fathers in our dataset.

as well as comparison by the household income level in 2001. Table 3 shows that, for 2001 income in the range of $30,000 to $50,000, the ATR of households that do not lose an eligible dependent in 2002 decreases, on average, by 0.18 percentage points (6.9 percent), whereas the ATR of the households that do lose an eligible dependent in 2002 increases, on average, by 1.45 percentage points (48.0 percent). In the next income class of $50,000 to $70,000, the ATR of households that do not lose a dependent in 2002 decreases by 0.12 percentage points (1.7 percent), and increases by 1.12 percentage points (15.9 percent) for households that do. In the income class of $70,000 to $90,000, the ATR increases by 1.03 percentage points (10.1 percent) in the former group, while it decreases by 0.05 percentage points (0.5 percent) in the latter group. As expected, the difference between the average growth rates of the two groups decreases with income since a given amount of the CTC constitutes a progressively smaller change in the ATR. Over all three income classes, the ATR increases, on average, by only 0.08 percentage points (1.32 percent) for households that do not lose a dependent, whereas it increases, on average, by 0.95 percentage points (14.99 percent) for those that do. Table 4 shows a similar pattern between 2002 and 2003, with two notable differences. First, the ATR increases more for households that lose an eligible dependent in 2003 relative to the households that do not even in the $70,000 to $90,000 income group. Second, the ATR is, except for the treatment group in the income range of $30,000 to $50,000, falling across the board between 2002 and 2003. This is due to an expansion of the CTC in 2003 from $600 to $1,000 per eligible child and a cut in all of the MTRs above the 15 percent MTR bracket that took effect in 2003.[30]

Other than for the highest income group between 2001 and 2002, and assuming that all other factors which affect the ATR affect both groups equally, this table

[30] One could argue that the 2003 increase in the amount of the CTC is an unexpected tax schedule innovation that may pose a challenge for our identification strategy. However, the latter will only utilize CTC variation in 2001 and 2002, hence avoiding this potential problem.

supports the hypothesis that those households that lost an eligible dependent in 2002 (2003) should have seen larger increases in their ATR than those households that lost an eligible dependent in 2003 (2004). The high-income group, however, shows the exact opposite of what we would expect between 2001 and 2002. The sample size for this income class is rather small, however, and the equality of the difference in average ATR between 2001 and 2002 across the treatment and control groups cannot be rejected in a two-tailed t-test at 5% level of significance, whereas we can reject in a two-tailed t-test at 5% level of significance the equality of the difference in average MTR between the same two years. Higher-income households tend to have much more variable income and given the small sample size, it is quite possible that we are capturing a significant amount of noise in taxable income. As such, our identification strategy appears to be somewhat weaker for this high-income group. The results reported below confirm this suspicion but, reassuringly, also show that we do not rely on this high-income group to drive our main findings.

Overall, between 2001 and 2002, we cannot reject the equality of the average growth in MTR between those households that lose an eligible dependent and those that do not in a two-tailed t-test at 5% level of significance. In contrast, we *can* reject the equality of the average growth rate in ATR between those households that lose an eligible dependent and those that do not in a two-tailed t-test at 5% level of significance.

Our estimating equation is based on (24) with $t \in 2001, 2002$ and labor supply h_{it} measured by parents' labor income Y_{it}. That is, it is based on the equation

$$\Delta \ln Y_{it+1} = \alpha_2 \gamma_{it} \left[ATR_{it} - E_{it-1} \left(ATR_{it} \right) \right] + \delta' \Delta X_{it+1} + v_{it+1}, \qquad (25)$$

where

$$v_{it+1} \equiv \alpha_2 \left\{ a_i s_{it} - (1-\rho_i) \left[E_{it-1} \left(\tau_{it} \right) - \overline{\tau}_i \right] + \overline{\phi}_{\tau it+1} \right\} + \alpha_3 \left[E_{it}(\lambda_{it+2}) - E_{it-1}(\lambda_{it+1}) \right]$$
$$+ \alpha_4 \left[Cov_{it}(\lambda_{it+2}, \tau_{it+1}) - Cov_{it-1}(\lambda_{it+1}, \tau_{it}) \right] + \alpha_1 \Delta \ln w_{it+1} + \Delta \nu_{it+1}. \qquad (26)$$

We approximate $ATR_{it} - E_{it-1} (ATR_{it})$ by indicator variable T_{it} for a loss of a dependent eligible for the CTC in year t. In addition, because the demographic characteristics that we have in our data are either time invariant or increase linearly in time, we replace ΔX_{it+1} by X_{it+1}, which generalizes the model by allowing the demographic characteristics to affect not only the level, but also the slope of the labor supply profile over time. We also allow for an intercept and an indicator variable for $t = 2002$ to control for a secular non-linear time trend in labor supply. That is, we estimate

$$\Delta \ln Y_{it+1} = \beta_0 + \beta_1 T_{it} + \beta_2 I_{2002} + \pi' X_{it+1} + z_{it}, \qquad (27)$$

where I_{2002} is the indicator for the year 2002. We estimate this equation by OLS and adjust the standard errors for clustering at household level. Note that this first-difference specification already implicitly controls for the effect of *any* time-invariant unobserved household characteristics on the *level* of household labor income.

Based on our discussion at the end of Section 4, the null hypothesis of rationality predicts that $\beta_1 = 0$. On the other hand, under the schmeduling hypothesis, $\gamma_{it} \neq 0$ and hence $\beta_1 \neq 0$. This suggests a straightforward test of the null hypothesis of rationality against the alternative hypothesis of schmeduling. Although we expect $\beta_1 \neq 0$ under the schmeduling hypothesis, it is difficult to predict what this hypothesis implies for the sign of β_1. As discussed in Section 4, the signs of the elements of Γ_{it} are ambiguous in general, resulting in ambiguity in the signs of γ_{it} and β_1. In our opinion, it is more plausible that an unexpectedly high realization of the ATR would lead a household to conclude that "taxes have gone up" and reflect such an increase partly in an upward revision of its expected MTR and partly in a downward revision of its expected demogrant. This would suggest that γ_{it} is positive, and therefore $\beta_1 \simeq \alpha_2\gamma_{it}$ is negative (because $\alpha_2 < 0$).

Obtaining a consistent estimate of β_1 requires that the treatment variable is uncorrelated with the error term in (26). Under the null hypothesis of rationality, losing the CTC is predicted well in advance, and therefore, T_{it} does not affect realizations of λ_{it+1} or λ_{it+2}, implying that it is uncorrelated with revisions in lifetime income captured by $E_{it}(\lambda_{it+2}) - E_{it-1}(\lambda_{it+1})$ or by $Cov_{it}(\lambda_{it+2}, \tau_{it+1}) - Cov_{it-1}(\lambda_{it+1}, \tau_{it})$. Also, because the loss of the CTC in our sample should have no impact on the MTR, T_{it} is uncorrelated with any predicted changes in the MTR captured by $a_i s_{it} - (1 - \rho_i)\left[E_{it-1}(\tau_{it}) - \overline{\tau}_i\right] + \overline{\phi}_{\tau it+1}$. As a result, if T_{it} is uncorrelated with $\Delta \ln w_{it+1}$ and $\Delta\nu_{it+1}$, our procedure consistently estimates β_1 under the null hypothesis of rationality. Because rationality predicts that $\beta_1 = 0$, the test for the null hypothesis of rationality against the alternative hypothesis of schmeduling corresponds to testing $\widehat{\beta}_1 = 0$. Not rejecting this null hypothesis would provide support for the rationality hypothesis, while rejecting it would provide support for the schmeduling hypothesis.

The next section presents results of this estimation procedure and their interpretation for the validity of the null hypothesis of rationality versus the alternative hypothesis of schmeduling. In addition, the section discusses how these conclusions are affected by an omitted variable bias due to the potential correlation of T_{it} with $\Delta \ln w_{it+1}$ or $\Delta\nu_{it+1}$, and we present a number of robustness tests to examine the magnitude of such a bias and eliminate the suspicion that our results simply reflect a spurious correlation between loss of the CTC and labor income.

6 Results

6.1 Main Result

To implement our estimation procedure, we require at least two complete consecutive years of data for each household in the sample. The treated group consists of households that have at least one child who turns 17 in year t and the control group consists of households that have at least one child who turns 17 in year $t+1$. For both groups, we use data for years t and $t+1$. Because we only observe labor income in years 2001, 2002, and 2003, we use $t = 2001$ and $t = 2002$ for both groups. We select our sample based on the timing of the 17th birthday in three different time windows around the turn of the year $t+1$: plus or minus six months (baseline specification), plus or minus 12 months, and plus or minus three months.[31]

Table 5 reports our baseline results for the time window of plus or minus six months. Specification (1) presents the estimate based on the entire sample. The estimate of β_1 shows that households whose child turns 17 in the last six months of tax year t (treatment group) have a 5.7 percent *lower* growth rate of labor income between years t and $t+1$ than do households whose child turns 17 in the first 6 months of the tax year $t+1$ (control group).[32] This coefficient estimate is significantly different from zero at the one percent significance level. Specifications (2) through (4) repeat this analysis by income class. As intuition would suggest, and as confirmed by Tables 3 and 4, the CTC matters most for the ATR in the income class of \$30,000 to \$50,000. The estimate in Specification (2) shows that, within this

[31] In order to minimize any omitted variable bias, it is desirable to define this time window as narrowly as possible. One could speculate that an ideal experiment would compare children who turn 17 on December 31 of year t to children who turn 17 on January 1 of year $t+1$. However, in light of the findings by Dickert-Conlin and Chandra (1999), such a narrow time window may suffer from an endogeneity problem. For this reason, but mainly because of data availability constraints, we use larger time windows.

[32] Recall that the exact change is calculated by the following formula: $100 \times (exp(-0.059) - 1) = -5.73\%$

income class, households in the treatment group have a 14.2 percent lower growth rate of labor income than do households in the control group and this coefficient is significant at the one percent level. The analogous estimate for the income group of \$50,000 to \$70,000 in Specification (3) is negative too, but is not statistically significant at conventional levels. Finally, the estimate for the income group of \$70,000 to \$90,000 in Specification (4) is positive and statistically insignificant. These results support the intuition that the loss of eligibility for the CTC and the resulting increase in the ATR have the highest behavioral impact among households where the relative change in the ATR is largest.

Tables 6 and 7 report the results of the analysis employing the time window of plus or minus 12 months and plus or minus 3 months, respectively. The results in both tables are qualitatively similar to the estimates reported in Table 5, except that they are smaller in absolute value and the coefficient in Specification (4) has a negative sign. These two tables therefore show that our principal findings are not qualitatively affected by the choice of time window around the turn of the year.

For each of the specifications listed above, we verified our identification assumption that the loss of the CTC had no impact on the MTR. This was implemented by reestimating Equation (27), though replacing $\Delta \ln Y_{it+1}$ with $\Delta \ln(1 - MTR)_t$. In each of these regressions, for other than the highest income category of \$70,000 to \$90,000, the loss of the CTC was not found to have any statistically significant effect on the MTR by any conventional level of significance. In contrast, for this high-income group, the loss of the credit was found to have a significant negative effect on the MTR (positive effect on $(1 - MTR)$) as predicted by our previous discussion on being in the phase-out range.[33] These regressions verify the more casual observation from Tables 3 and 4 that our identification strategy is weaker for this high-income group because, despite restricting adjusted gross income at \$90,000,

[33] Results of these regressions are available from the authors upon request.

there are still a number of households that are affected by the phase-out range. It is reassuring, however, that our baseline specification and 12- and 3-month window specifications are not dependent on this group to drive our results.

Because losing the CTC does not constitute the same absolute or proportional change in the ATR even within any one income class, we repeat the baseline estimation from Table 5 with the treatment indicator variable replaced by the predicted implied increase in the ATR based on the number of dependents who become ineligible for the CTC, the credit of \$600 per eligible child, and adjusted gross income in 2001. We multiply the resulting measure by 100 to express it in percentage terms. For example, for a household with 2001 adjusted gross income of \$40,000 who loses one eligible dependent in 2002, the implied magnitude of the treatment is $100 \times 1 \times \$600/\$40,000 = 1.5$.[34] Results of this estimation are presented in Table 8. Again, the results show that the loss of the credit is associated with a lower growth rate of labor income and are qualitatively similar to the previous three tables.

Even though some of the estimates may seem large, once normalized by the percentage increases in the ATR presented in Tables 3 and 4, the implied elasticities with respect to the ATR are moderate, on the order of one third. However, what is more interesting for our purpose is the sign and statistical significance of the estimates. Based on our discussion in the previous section, the finding that the estimates of β_1 are negative and statistically significant, especially for the lower income class, is inconsistent with the rational taxpayer hypothesis, but consistent with the schmeduling hypothesis. The latter hypothesis would suggest that at least some households find the high realization of their ATR in year t unexpected and at least partly perceive it as an increase in the MTR. They in turn react to this perception in their labor supply decision in year $t+1$, with the substitution effect dominating

[34]This approach is, in spirit, a reduced form of the strategy of instrumenting for the actual ATR by the predicted ATR based on the eligibility for the dependent child exemption utilized by Looney and Singhal (2004) and Dokko (2005).

any lifetime income effect inferred from the high realization of the ATR.[35]

6.2 Discussion and Robustness Tests

The interpretation of our results rests on the assumption that the treatment variable is uncorrelated with $\Delta \ln w_{it+1}$ and $\Delta\nu_{it+1}$. The purpose of this subsection is to examine potential violations of this assumption and their impact on our interpretation of the results.

Reasons for a correlation between T_{it} and $\Delta \ln w_{it+1}$ or $\Delta\nu_{it+1}$ could come from two sources. First, they could be due to the economic consequences of ATR variation not captured by the life-cycle model in Section 4. One particular aspect of intertemporal allocation of consumption and labor not captured by this model and likely to be relevant for at least some households is the presence of a binding liquidity constraint. Under such a constraint, a household's current consumption possibilities are limited by its current cash-flow, which is reduced by losing eligibility for the CTC. This should, then, increase the marginal utility of consumption in the current period and the desirability to supply more labor. However, because taxes for year t are filed and paid only in year $t+1$, even if the credit is formally lost in year t, one would expect the effect of such a liquidity constraint to manifest itself in year $t+1$. This effect would suggest a positive correlation between T_{it} and $\Delta\nu_{it+1}$, and consequently z_{it+1}, and would lead to an upward bias in our estimate of β_1. This potential bias only strengthens our interpretation of the results in favor of the schmeduling hypothesis because it implies that a rational household would, if anything, increase its labor income in year $t+1$ in response to losing the CTC in year t.

Second, the correlation between the treatment variable and $\Delta \ln w_{it+1}$ or $\Delta\nu_{it+1}$ could be driven by non-tax factors such as a direct effect of the child's date of

[35]Some of this effect may reflect a shift of labor supply to an untaxed informal sector rather than to leisure or household production. However, since our dataset does not contain information on informal labor market earnings, we are not able to address this hypothesis formally.

birth on parents' labor income. As we have already discussed in Subsection 5.1, our identification strategy implicitly controls for the correlation between any time-invariant household characteristics such as its lifetime income-generating capacity and the timing of the child's birth. One may speculate that, due to increasing income inequality, higher-income households experience a predictably higher wage growth rate than lower income households. Since $\alpha_1 > 0$, this scenario would, together with the positive correlation between being born in December rather than January and lifetime income suggested by Dickert-Conlin and Chandra (1999), lead to a positive correlation between the treatment variable and the error term in (27), and result in a positive bias in the estimate of β_1. However, again, such a bias would only strengthen our interpretation of the results.

Finally, one can also argue that the treatment variable may be correlated with unobserved changes in the tastes for supplying labor captured by $\Delta\nu_{it+1}$. In our baseline specification, children in the treatment group are on average about 6 months older than children in the control group. As a result, in year $t+1$, children from the treatment group are turning 18 and hence are more likely to leave home, whether going to college or not, than children from the control group, who only turn 17 in that year. Depending on the school attendance laws that were in effect when the eligible dependents began schooling, children born in year $t-17$ (treatment group) were more likely to have started schooling a year earlier than children born in year $t-16$ (control group).[36] In turn, the former ones are then more likely to go to college in year $t+1$, whereas the latter ones are then still one year away from college. It is not clear, however, what the impact of a child leaving home or going to college on the labor supply of parents is. It is possible that it induces parents to increase their labor supply because of having more available time or because of a need to meet child educational expenditures. For example, Christian (2004) documents that col-

[36] The cutoff date differs from state to state, and sometimes even by a school district within a state.

lege educational expenditures tend to increase mothers' labor supply. Alternatively, parents could also feel that their child has reached adulthood and that they are no longer responsible for providing him or her with full financial support, and, as a result, they may decide to work less. We are not aware of any evidence in support of this hypothesis, though. The former possibility would introduce a positive bias into our estimate of β_1, which would only strengthen our interpretation of the results. The latter possibility would, however, introduce a negative bias into our estimate of β_1, which could potentially invalidate our interpretation of the results.

Table 9 displays three placebo tests for a negative direct effect of an earlier timing of the child's birth on parent labor income with an artificial division into treatment and control groups based on child age in adjacent time windows. In these robustness checks, we focus on sources of potential correlation between the date of the child's birth and transitory variation in the household's wage rate or other factors affecting labor supply. That is, we examine the impact of timing of the child's birth on parents' labor income at times when our "treatment" has no tax consequences. If the direct effect is an important determinant of parents' labor income, we should find a statistically significant effect of the "treatment" despite the lack of any underlying innovation in the tax schedule. Specification (1) investigates the effect of the "treatment" of turning 17 in January through June of year t as opposed to the control of turning 17 in July through December of the *same* year on the growth of household labor income between years t and $t + 1$. The estimate of β_1 is statistically insignificant at conventional levels. Furthermore, even if taken at face value, the size of the estimate suggests that at most one third of the effect estimated in Specification (1) of Table 5 can be attributed to the direct effect of the birth timing.

Specification (2) of Table 9 is analogous to our baseline Specification (1) of Table 5 except that it defines the treatment and the control group by when the child turns

18. Again, if a negative direct effect of an earlier timing of birth on parents' labor income is a significant feature of behavior, it should be picked up by this estimate. The coefficient estimate is not statistically significant, though. In addition, it is positive rather than negative. That is, if anything, the direct effect seems to go in the opposite direction. Specification (3) conducts an analogous test of turning 16. The coefficient estimate is qualitatively similar to the estimate from Specification (1), but smaller in absolute value.[37]

Put together, these robustness checks do not provide any consistent evidence to suggest that our baseline estimate of β_1 is for the most part driven by a direct negative effect of an earlier date of the child's birth on parents' labor income. In addition, they provide evidence that we are not simply capturing spurious correlation between our treatment variable and the growth of labor income in our baseline specification. We therefore conclude that our estimates from Tables 5, 6, and 7 provide evidence in contrast to the rational taxpayer hypothesis and in support of the schmeduling hypothesis.

7 Conclusion

Due to the complexity of the income tax system, taxpayers may have difficulties recognizing their true marginal tax rate. As a result, they may turn to rules of thumb in approximating how much of an additional dollar of income is taken away in taxes. We present a formal model in which households have only a limited understanding of the tax schedule they face and update their estimate of the current year's marginal tax rate based on an unexpected innovation in the average tax rate realized in the previous year, a hypothesis dubbed as "schmeduling." Under the assumption that

[37]We also estimated the analogues of Table 9 with time windows of plus or minus 12 months and plus or minus 3 months. The resulting conclusions are qualitatively similar to the ones we discuss here.

taxpayers react to perceived after-tax incentives as predicted by economic theory, we examine the validity of the schmeduling hypothesis by measuring taxpayer labor income responses to an exogenous and predictable variation in the average tax rate due to losing eligibility for the Child Tax Credit when the child turns 17. The main advantage of this identification strategy is that variation in the average tax rate is exogenous, predictable well in advance, and has no impact on households' marginal tax rate for an intermediate income range. This variation therefore allows us to distinguish between the rational taxpayer hypothesis and the schmeduling hypothesis.

Our empirical results show that the resulting increase in the average tax rate in year t leads to a *decrease* in the growth rate of household labor income between years t and $t+1$. We interpret this result as evidence to the contrary of taxpayers being fully rational and in favor of taxpayers schmeduling. We argue that this conclusion is robust to plausible potential effects of a binding liquidity constraint and a *positive* direct effect of a child's earlier birth date on parents' labor income. We also conduct several robustness tests which show that our result is for the most part not driven by a potential *negative* direct effect of a child's earlier birth date on parents' labor income.

It is also important to mention some limitations of our study. First, the schmeduling hypothesis, as presented in Section 4, can explain virtually any pattern of behavior, and is therefore impossible to refute. As a reflection of that, our empirical design has power against the rational taxpayer hypothesis, but not against the schmeduling hypothesis. Further research is necessary to refine various kinds of schmeduling and to distinguish between them empirically. Second, given the limitations of our dataset, the findings should be verified using a dataset covering a period before the introduction of the Child Tax Credit in order to directly control for any direct child age effects on parents' labor income. We plan to do exactly that in the immediate future.

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A Appendix A: Calculation of the Reduction in the Excess Burden of Taxation Due to Schmedul-ing

Using the constant elasticity of substitution utility function from (1), the marginal rate of substitution between leisure and consumption is given by

$$\frac{MU_{1-l}}{MU_c} = \frac{1-\alpha}{\alpha}\left(\frac{c}{1-l}\right)^{1-\rho}. \tag{A-1}$$

The budget constraint is given by

$$c = (1-t)wl + D. \tag{A-2}$$

The budget constraint implies that the true marginal price of leisure is $(1-t)w$, whereas the *perceived* marginal price of leisure, or the perceived net wage rate, is given by $(1-\widehat{t})w$, where $\widehat{t}$ is the *perceived* MTR. Substituting from (A-2) to (A-1), it follows that

$$\frac{MU_{1-l}}{MU_c} = \frac{1-\alpha}{\alpha}\left[\frac{(1-t)wl + D}{1-l}\right]^{1-\rho}. \tag{A-3}$$

Labor supply is determined by the equality between the marginal rate of substitution and the *perceived* after-tax wage rate. However, because of the demogrant, some agents may decide to supply zero labor. Taking into account this corner solution, labor supply is determined by

$$l^*(w,t,D,\widehat{t}) = \frac{\max\{A(w,\widehat{t}) - D, 0\}}{A(w,\widehat{t}) + (1-t)w}, \tag{A-4}$$

where

$$A(w,\widehat{t}) \equiv \left[(1-\widehat{t})w\frac{\alpha}{1-\alpha}\right]^{\frac{1}{1-\rho}}. \tag{A-5}$$

Subsequently, the consumption choice is given by

$$c^*(w,t,D,\widehat{t}) = (1-t)wl^*(w,t,D,\widehat{t}) + D, \tag{A-6}$$

indirect utility is given by

$$V(w,t,D,\widehat{t}) = \left\{\alpha\left[c^*(w,t,D,\widehat{t})\right]^\rho + (1-\alpha)\left[1-l^*\left(w,t,D,\widehat{t}\right)\right])^\rho\right\}^{\frac{1}{\rho}}, \tag{A-7}$$

and tax revenue is given by

$$TR(w,t,D,\widehat{t}) \equiv twl^*(w,t,D,\widehat{t}) - D. \tag{A-8}$$

In what follows, we outline the calculation of the excess burden for a rational taxpayer ($\widehat{t} = t$), and a schmeduler, i.e., a taxpayer who perceives his MTR to be equal to his ATR given by $(twl - D)/wl$.

A.1 Rational taxpayer

For a rational taxpayer, $\widehat{t} = t$. Labor supply, consumption, indirect utility, and tax revenue are then easily calculated from (A-4)-(A-8). The excess burden is defined as the difference between the maximum tax revenue that could be collected by a social planner while keeping the taxpayer's utility at $V(w,t,D,t)$ and the tax revenue $TR(w,t,D,t)$ that is actually collected. The former tax revenue, denoted by $-\overline{D}_R(w,t,D)$, is implicitly given by

$$V\left[w,0,\overline{D}_R(w,t,D),0\right] = V(w,t,D,t). \tag{A-9}$$

Note that $l^*(w,0,\overline{D}_R,0)$ is weakly decreasing and $c^*(w,0,\overline{D}_R,0)$ is strictly increasing in $\overline{D}_R$, implying that $V(w,0,\overline{D}_R,0)$ is strictly increasing in $\overline{D}_R$. In addition,

$V(w,0,D-tw,0) < V(w,t,D,t) < V(w,0,D,0)$. Hence (A-9) can be solved numerically for $\overline{D}_R$ in a straightforward way by searching on the interval $(D-tw,D)$. The excess burden for a rational taxpayer is then given by

$$EB_R = -\overline{D}_R - TR(w,t,D,t). \tag{A-10}$$

A.2 Schmeduler

For a schmeduler, $\widehat{t} = (twl - D)/wl$. Using (A-4), labor supply of a schmeduler $l_S(w,t,D)$ is implicitly given by

$$l_S(w,t,D) = l^* \{w,t,D,[twl_S(w,t,D) - D]/wl_S(w,t,D)\}. \tag{A-11}$$

Note that since $l^*(w,t,D,\widehat{t})$ is strictly decreasing in $\widehat{t}$ and $(twl_S - D)/wl_S$ is strictly increasing in l_S, the RHS of (A-11) is strictly decreasing in l_S. In addition, the value of the RHS for $l_S = 0$ is equal to 1 and for $l_S = 1$ it is strictly less than 1. Hence (A-11) can be solved numerically for l_S by searching on the interval $(0,1)$. Consumption, indirect utility, and tax revenue are then easily calculated from (A-6)-(A-8). The resulting solution then determines the average tax rate

$$\widehat{t}(w,t,D) \equiv [twl_S(w,t,D) - D]/wl_S(w,t,D). \tag{A-12}$$

The excess burden is defined as the difference between the maximum tax revenue that could be collected by a social planner while keeping the taxpayer's utility at $V\left[w,t,D,\widehat{t}(w,t,D)\right]$ and the tax revenue $TR\left[w,t,D,\widehat{t}(w,t,D)\right]$ that is actually collected. The former tax revenue, denoted by $-\overline{D}_S(w,t,D)$, is implicitly given by

$$V\left[w,0,\overline{D}_S(w,t,D),0\right] = V\left[w,t,D,\widehat{t}(w,t,D)\right]. \tag{A-13}$$

We have already established in the previous subsection that $V(w, 0, \overline{D}_S, 0)$ is strictly increasing in $\overline{D}_S$. In addition, $V(w, 0, D-tw, 0) < V\left[w, t, D, \widehat{t}\,(w, t, D)\right] < V(w, 0, D, 0)$. Hence (A-13) can be solved numerically for $\overline{D}_S$ in a straightforward way by searching on the interval $(D - tw, D)$. The excess burden for a schmeduler is then given by

$$EB_S = -\overline{D}_S - TR\left[w, t, D, \widehat{t}\,(w, t, D)\right]. \tag{A-14}$$

B Appendix B

Proof of Proposition 1. Choose an arbitrary time period $u \in \{0, ..., T\}$. Suppose that, based on the initial beliefs in period 0 and all the signals accumulated up until the end of period $u - 1$, the households beliefs about (τ_{iu}, D_{iu}) are given by $N(\mu_{iu}, \Sigma_{iu})$. Then the joint distribution of τ_{iu}, D_{iu}, and T_{iu} is given by

$$\begin{pmatrix} \tau_{iu} \\ D_{iu} \\ T_{iu} \end{pmatrix} \sim N\left\{\begin{pmatrix} \mu_{iu} \\ \mu_{iu}(y_{iu}, -1)^T \end{pmatrix}, \begin{bmatrix} \Sigma_{iu} & \Sigma_{iu}(y_{iu}, -1)^T \\ (y_{iu}, -1)\Sigma_{iu} & (y_{iu}, -1)\Sigma_{iu}(y_{iu}, -1)^T \end{bmatrix}\right\}. \tag{A-15}$$

Based on observing the realization of T_{iu}, the posterior belief about (τ_{iu}, D_{iu}) is then given by (DeGroot, 1970) $N(m_{iu}, V_{iu})$, where m_{iu} and V_{iu} are given by (9) and (11).

Likewise, given the assumptions about the stochastic structure of the signal s_{iu}, the joint distribution of ε_{iu+1} and s_{iu} is given by

$$\begin{pmatrix} \varepsilon_{iu+1} \\ s_{iu} \end{pmatrix} \sim N\left(0, \begin{bmatrix} D_i & D_i \\ D_i & D_i + S_i \end{bmatrix}\right). \tag{A-16}$$

Upon observing the signal s_{iu}, the household updates its beliefs about the tax innovation to $N\left[A_i s_{iu}, B_i\right]$, where $A_i \equiv G_i(G_i + S_i)^{-1}$ and $B_i \equiv G_i - G_i(G_i + S_i)^{-1}G_i$.

Then, given (2) and the independence assumptions, the updated beliefs about (τ_{iu+1}, D_{iu+1}) are given by $N(\mu_{iu+1}, \Sigma_{iu+1})$ as given by (8) and (10). Given that the initial prior is $(\tau_{i0}, D_{i0}) \sim N(\mu_{i0}, \Sigma_{i0})$, it follows by induction that, based on all the information available up until the end of period t, the posterior belief about (τ_{it+1}, D_{it+1}) is given by $N(\mu_{it+1}, \Sigma_{it+1})$ as recursively defined in Proposition 1. Finally, (6) and (7) then follow from this belief by a recursive use of (2) and the distributional assumptions about ϕ_{is} and ε_{is}. ■

Table 1: Summary Statistics: Household Labor Income

Year of	Turn 17 in:									
	2000		2001		2002		2003		2004	
Survey	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec	Jan-June	July-Dec
2001	53,380	52,557	52,674	49,270	52,207	50,054	51,478	48,868	53,565	52,652
	(17,286)	(18,741)	(16,773)	(18,196)	(17,796)	(18,391)	(17,306)	(16,376)	(17,018)	(18,120)
	178	190	219	216	202	214	218	210	221	207
2002	54,695	54,061	53,644	48,772	54,437	51,146	51,732	50,472	54,030	52,868
	(20,319)	(21,453)	(20,944)	(21,545)	(19,227)	(21,321)	(20,035)	(19,785)	(17,981)	(20,854)
	143	160	180	184	176	184	188	178	195	180
2003	56,119	55,772	55,185	50,979	56,598	52,751	53,267	52,298	56,373	55,625
	(25,874)	(26,482)	(23,563)	(26,329)	(24,380)	(23,633)	(22,651)	(22,916)	(22,165)	(22,684)
	133	142	169	165	156	167	185	168	182	166

Notes:

1. Source: SIPP, 2001-2003. Sample restricted to those households with at least one child who turns 17 between 2000 and 2004.
2. Unweighted means (in dollars), standard deviations (in parentheses), and number of observations.
3. There are 1,607 households and 5,476 household-years in the data. Of these, 430 belong to two, 48 to three, and 2 to four different cohorts (year when child turns 17). There are also 51 households which have more than one dependent child turning 17 in one year.

Table 2: Summary Statistics: Demographic Variables

	Mean	Std. Dev.
Married	0.85	0.36
Wife's Age	43.76	5.55
Husband's Age	45.82	6.31
Wife High School	0.90	0.30
Wife College	0.22	0.41
Husband High School	0.88	0.33
Husband College	0.24	0.43
Dependents	2.36	1.17

Notes:

1. Source: SIPP, 2001-2003. Sample restricted to those households with at least one child who turns 17 between 2000 and 2004.
2. Married: binary married couple with children household indicator. Wife (Husband) High School: binary wife (husband) high school graduation indicator. Wife (Husband) College: binary wife (husband) college graduation indicator. Dependents: children under the age of 24 living at home with parents. Married: binary indicator for a married couple household as opposed to a single-parent household.
3. Unweighted means and standard deviations.
4. Husband characteristics conditional on being married, otherwise equal to zero.
5. There are 1,607 households and 5,476 household-years in the data. Of these, 430 belong to two, 48 to three, and 2 to four different cohorts (year when child turns 17). There are also 51 households who have more than one dependent child turning 17 in one year.

Table 3: Change in ATR and MTR between 2001 and 2002

AGI_{2001}	Year	17 in 2002	MTR (%)	ATR (%)	ΔMTR_{2002}	$\Delta MTR_{2002}/MTR_{2001}$	ΔATR_{2002}	$\Delta ATR_{2002}/ATR_{2001}$	Obs.
30K-50K	2001	no	15.36	2.66					
	2002		17.09	2.48	1.73	11.26	-0.18	-6.91	146
	2001	yes	16.55	3.02					
	2002		16.93	4.47	0.37	2.26	1.45	48.03	145
50K-70K	2001	no	18.84	7.02					
	2002		19.95	6.90	1.11	5.88	-0.12	-1.66	126
	2001	yes	19.53	7.01					
	2002		20.42	8.12	0.90	4.60	1.12	15.91	122
70K-90K	2001	no	26.23	10.25					
	2002		25.25	11.28	-0.98	-3.75	1.03	10.08	65
	2001	yes	26.51	10.81					
	2002		23.46	10.76	-3.04	-11.48	-0.05	-0.50	91
30K-90K	2001	no	18.76	5.75					
	2002		19.73	5.83	0.97	5.19	0.08	1.32	337
	2001	yes	20.10	6.36					
	2002		19.78	7.31	-0.32	-1.57	0.95	14.99	358

Notes:

1. Source: SIPP, 2001-2003. Sample restricted to households with a child who turns 17 in 2002 or 2003 and that are observed in both 2001 and 2002.
2. We cannot reject at a 5% level of significance in a two-tailed t-test that the difference in the average change in MTR between the treatment and control group for each income category and the full sample, with the exception of the $70-$90K income category, is equal to zero.
3. We can reject at a 5% level of significance in a two-tailed t-test that the difference in the average change in ATR between the treatment and control group for each income category and the full sample, with the exception of the $70-$90K income category, is equal to zero.
4. Unweighted means.

Table 4: Change in ATR and MTR between 2002 and 2003

AGI_{2001}	Year	17 in 2003	MTR (%)	ATR (%)	ΔMTR_{2003}	$\Delta MTR_{2003}/MTR_{2002}$	ΔATR_{2003}	$\Delta ATR_{2003}/ATR_{2002}$	Obs.
30K-50K	2002	no	17.99	1.35					
	2003		14.65	-0.66	-3.34	-18.55	-2.00	—	112
	2002	yes	16.91	2.35					
	2003		15.18	2.50	-1.72	-10.19	0.16	6.69	150
50K-70K	2002	no	21.05	7.73					
	2003		18.39	5.91	-2.66	-12.65	-1.82	-23.58	119
	2002	yes	19.89	6.89					
	2003		18.24	6.84	-1.65	-8.31	-0.04	-0.64	126
70K-90K	2002	no	24.88	10.56					
	2003		22.03	8.31	-2.85	-11.46	-2.25	-21.31	81
	2002	yes	25.08	11.21					
	2003		22.33	10.07	-2.75	-10.97	-1.14	-10.14	61
30K-90K	2002	no	20.94	6.17					
	2003		17.99	4.18	-2.95	-14.09	-2.00	-32.37	312
	2002	yes	19.50	5.65					
	2003		17.62	5.50	-1.88	-9.64	-0.15	-2.70	337

Notes:

1. Source: SIPP, 2001-2003. Sample restricted to households with a child who turns 17 in 2003 or 2004 and that are observed in both 2002 and 2003.
2. We cannot reject at conventional levels of significance in a two-tailed t-test that the difference in the average change in MTR between the treatment and control group for each income category and the full sample is equal to zero.
3. We can reject at a 1% level of significance in a two-tailed t-test that the difference in the average change in ATR between the treatment and control group for each income category and the full sample, with the exception of the $70-$90K income category, is equal to zero. For the $70-$90K income category, we reject the same hypothesis at the 10% significance level.
4. Unweighted means.

Table 5: The Effect of Losing a CTC Eligible Child on the Growth Rate of Household Labor Income: Time Window of +/- 6 Months

	Income Class by AGI_{2001}			
	$30K-$90K	$30K-$50K	$50K-$70K	$70K-$90K
	(1)	(2)	(3)	(4)
$Treatment_t$	-0.059	-0.153	-0.015	0.001
	(0.021)***	(0.044)***	(0.025)	(0.026)
Year 2002	0.006	-0.005	0.022	0.006
	(0.021)	(0.047)	(0.025)	(0.027)
Constant	0.290	0.988	0.758	-0.293
	(0.599)	(1.095)	(0.746)	(1.009)
Demographic Controls	Yes	Yes	Yes	Yes
Observations	688	279	252	157
R^2	0.06	0.11	0.10	0.13

Notes:

1. Data source: SIPP 2001-2003.
2. Dependent variable: Growth of household labor income between years t and $t+1$ ($\Delta \ln Y_{it+1}$).
3. Timing: $t = 2001, 2002$.
4. Demographic controls (coefficients not displayed): Married, Wife's Age, Wife's Age Squared, Wife High School, Wife College, Husband's Age, Husband's Age Squared, Husband High School, Husband College, Number of Dependents.
5. Standard errors in parentheses are clustered at household level.
6. Significant at: * 10 percent level; ** 5 percent level; *** 1 percent level.

Table 6: The Effect of Losing a CTC Eligible Child on the Growth Rate of Household Labor Income: Time Window of +/- 12 Months

	Income Class by AGI_{2001}			
	\$30K-\$90K	\$30K-\$50K	\$50K-\$70K	\$70K-\$90K
	(1)	(2)	(3)	(4)
$Treatment_t$	-0.033	-0.077	-0.009	-0.012
	(0.013)**	(0.026)***	(0.017)	(0.021)
Year 2002	0.007	-0.006	0.022	0.020
	(0.013)	(0.026)	(0.019)	(0.022)
Constant	0.238	1.184	0.184	-1.137
	(0.468)	(0.816)	(0.533)	(0.704)
Demographic Controls	Yes	Yes	Yes	Yes
Observations	1,311	531	472	308
R^2	0.04	0.07	0.09	0.06

Notes:

1. Data source: SIPP 2001-2003.
2. Dependent variable: Growth of household labor income between years t and $t+1$ ($\Delta \ln Y_{it+1}$).
3. Timing: $t = 2001, 2002$.
4. Demographic controls (coefficients not displayed): Married, Wife's Age, Wife's Age Squared, Wife High School, Wife College, Husband's Age, Husband's Age Squared, Husband High School, Husband College, Number of Dependents.
5. Standard errors in parentheses are clustered at household level.
6. Significant at: * 10 percent level; ** 5 percent level; *** 1 percent level.

Table 7: The Effect of Losing a CTC Eligible Child on the Growth Rate of Household Labor Income: Time Window of +/- 3 Months

	Income Class by AGI_{2001}			
	$30K-$90K	$30K-$50K	$50K-$70K	$70K-$90K
	(1)	(2)	(3)	(4)
$Treatment_t$	-0.046	-0.117	-0.018	-0.042
	(0.028)*	(0.052)**	(0.043)	(0.035)
Year 2002	0.017	0.026	-0.016	0.090
	(0.024)	(0.042)	(0.039)	(0.035)**
Constant	-0.537	-0.142	-0.366	-0.072
	(0.829)	(1.224)	(1.367)	(1.229)
Demographic Controls	Yes	Yes	Yes	Yes
Observations	330	142	115	73
R^2	0.10	0.18	0.15	0.23

Notes:

1. Data source: SIPP 2001-2003.
2. Dependent variable: Growth of household labor income between years t and $t+1$ ($\Delta \ln Y_{it+1}$).
3. Timing: $t = 2001, 2002$.
4. Demographic controls (coefficients not displayed): Married, Wife's Age, Wife's Age Squared, Wife High School, Wife College, Husband's Age, Husband's Age Squared, Husband High School, Husband College, Number of Dependents.
5. Standard errors in parentheses are clustered at household level.
6. Significant at: * 10 percent level; ** 5 percent level; *** 1 percent level.

Table 8: The Effect of an Increase in the ATR due to Losing CTC on the Growth Rate of Household Labor Income: Time Window of +/- 6 Months

	Income Class by AGI_{2001}			
	\$30K-\$90K	\$30K-\$50K	\$50K-\$70K	\$70K-\$90K
	(1)	(2)	(3)	(4)
$100 \times \left\lvert \widehat{\Delta CTC_t} \right\rvert / AGI_{2001}$	-0.047	-0.088	-0.016	-0.001
	(0.018)***	(0.025)***	(0.025)	(0.034)
Year 2002	0.005	-0.004	0.022	0.006
	(0.021)	(0.046)	(0.025)	(0.027)
Constant	0.345	1.005	0.766	-0.296
	(0.604)	(1.097)	(0.744)	(1.010)
Demographic Controls	Yes	Yes	Yes	Yes
Observations	688	279	252	157
R^2	0.06	0.10	0.10	0.13

Notes:

1. Data source: SIPP 2001-2003.
2. Dependent variable: Growth of household labor income between years t and $t+1$ ($\Delta \ln Y_{it+1}$).
3. Timing: $t = 2001, 2002$.
4. Demographic controls (coefficients not displayed): Married, Wife's Age, Wife's Age Squared, Wife High School, Wife College, Husband's Age, Husband's Age Squared, Husband High School, Husband College, Number of Dependents.
5. Standard errors in parentheses are clustered at household level.
6. Significant at: * 10 percent level; ** 5 percent level; *** 1 percent level.

Table 9: Robustness Tests

	Turning 17	Turning 18	Turning 16
	Jan-June vs. July-Dec	+/- 6 Months	+/- 6 Months
	(1)	(2)	(3)
"Treatment"$_{t-1}$	-0.019	0.014	-0.011
	(0.021)	(0.020)	(0.019)
Year 2002	0.013	-0.002	0.005
	(0.023)	(0.019)	(0.018)
Constant	-0.486	-0.559	0.454
	(0.720)	(0.571)	(0.464)
Demographic Controls	Yes	Yes	Yes
Observations	667	644	701
R^2	0.06	0.04	0.04

Notes:

1. Data source: SIPP 2001-2003.
2. Dependent variable: Growth of household labor income between years t and $t+1$ ($\Delta \ln Y_{it+1}$).
3. Timing: $t = 2001, 2002$ in Specifications (1)-(5); $t = 2001$ in Specifications (6) and (7).
4. Demographic controls (coefficients not displayed): Wife's Age, Wife's Age Squared, Wife High School, Wife College, Husband's Age, Husband's Age Squared, Husband High School, Husband College, Number of Dependents.
5. Standard errors in parentheses are clustered at household level.
6. Significant at: * 10 percent level; ** 5 percent level; *** 1 percent level.

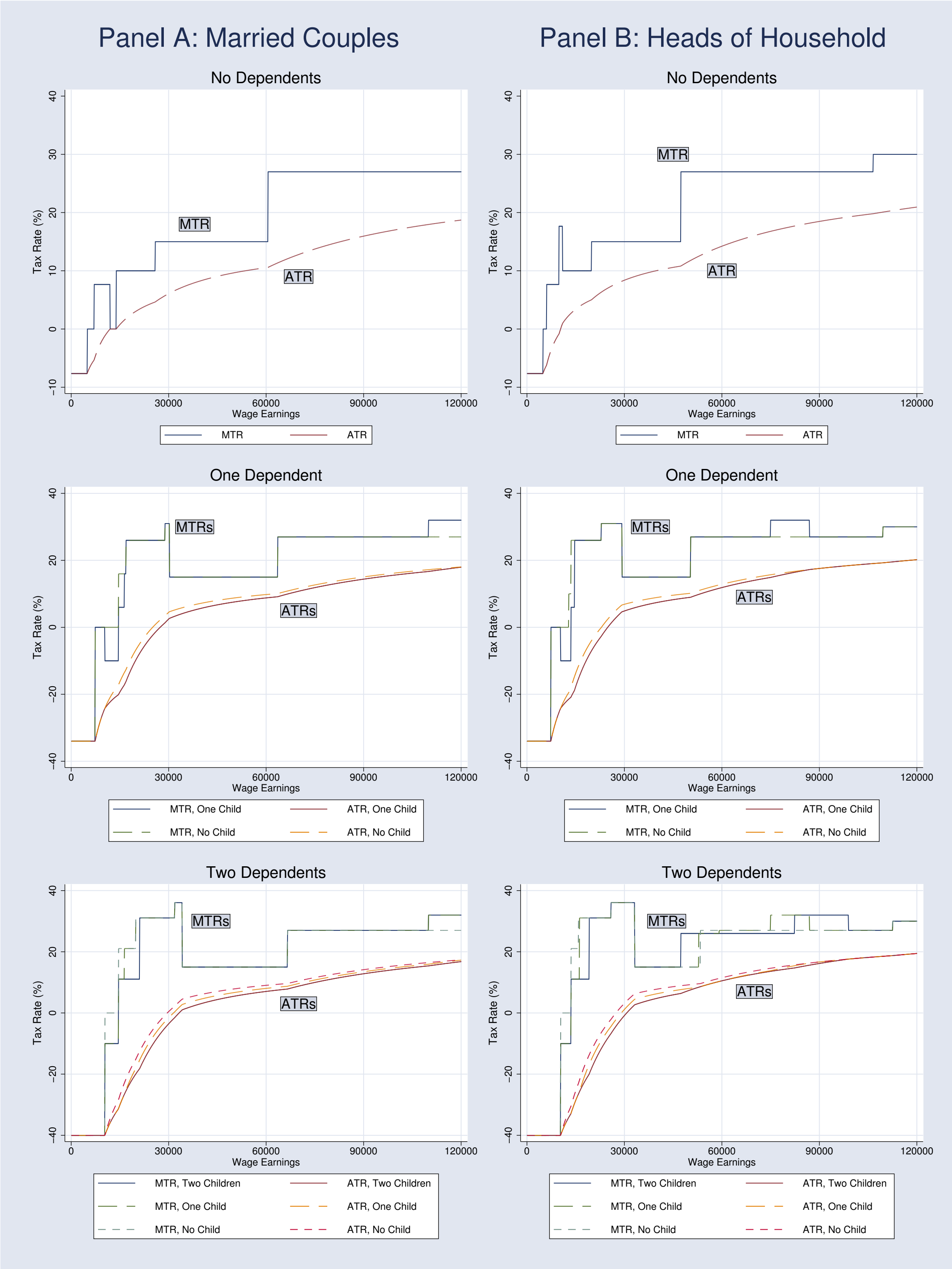

Figure 1: MTRs and ATRs for a Married Couple Filing Jointly and a Head of Household Earning Only Labor Income in 2002 by Total Number of Dependents and the Number of Children Eligible for the Child Tax Credit

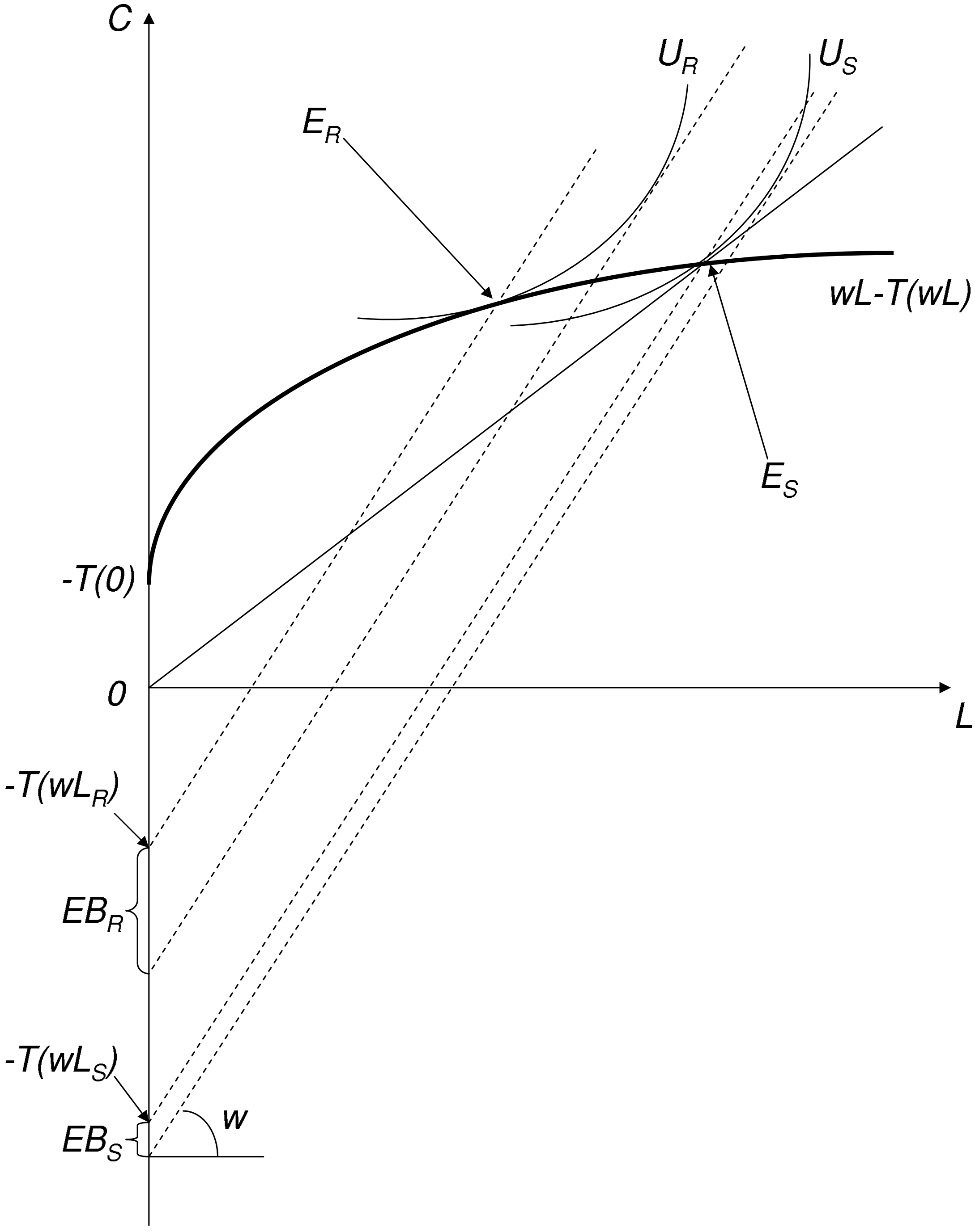

Figure 2: Welfare Impact of Using the ATR Instead of the MTR

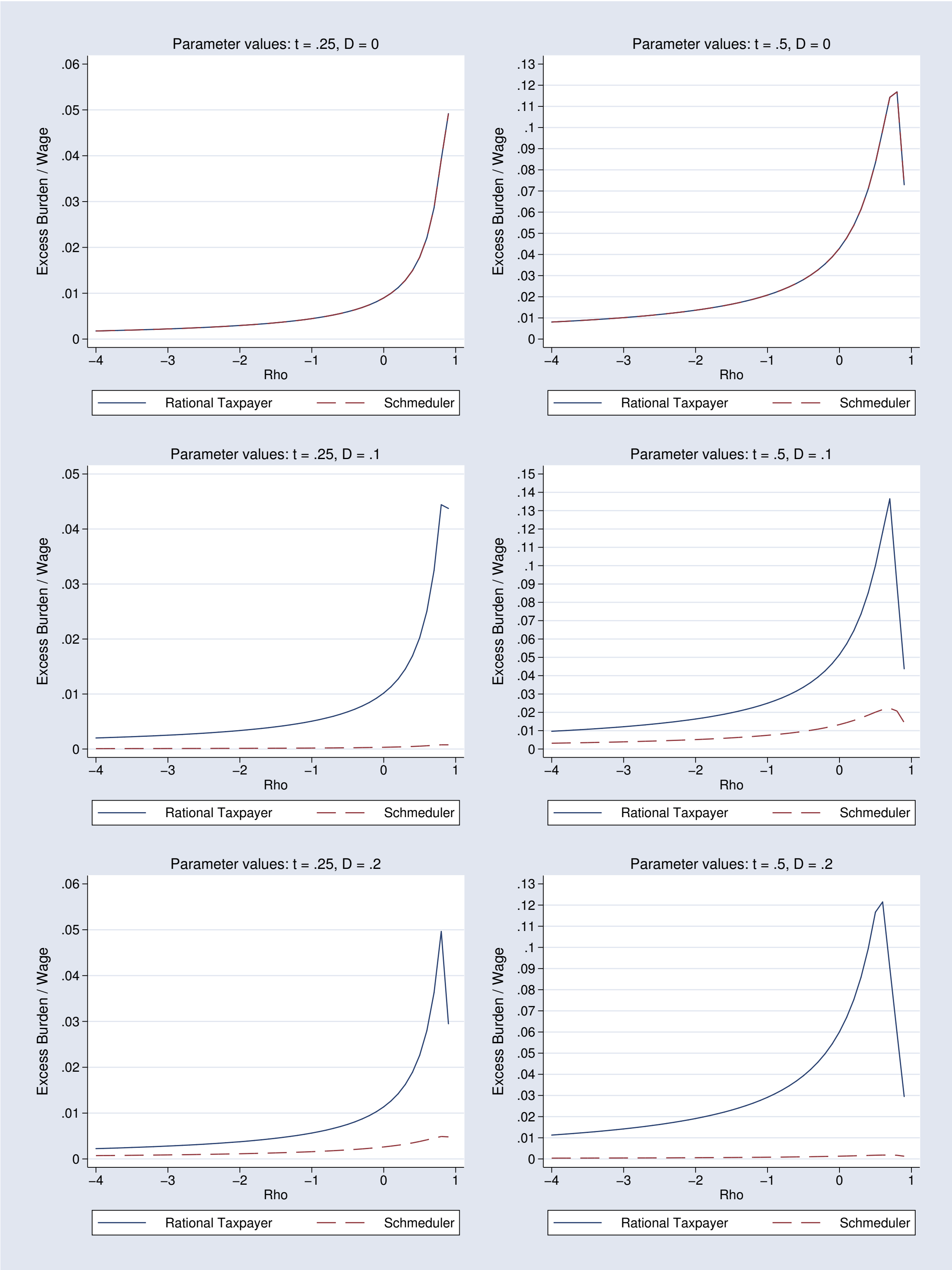

Figure 3: Excess Burden When Using the MTR and When Using the ATR

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