Schmeduling

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Abstract

Complicated pricing schedules can make it very difficult for consumers to know what price they are paying. Such schedules are in widespread use in important economic domains such as taxation, assistance to the poor, and utility pricing. When people have limited understanding of the actual schedules they face, they are likely to perceive them in a crude fashion. We define the term “schmedule” to be an inaccurately perceived schedule. We call the act of behaving as if one were facing a schmedule rather than the true schedule, “schmeduling.” Our focus is on two forms of schmeduling: ironing and spotlighting. Ironing arises when an individual facing a multipart schedule perceives and responds to the average price at the point where he consumes. Spotlighting occurs when consumers identify and respond to immediate or local prices, and ignore the full schedule, even though future prices will be affected by current consumption.

We analyze the welfare implications of ironing in three settings: a profit-maximizing monopolist, a Ramsey-pricing utility regulator, and a social-welfare maximizing tax authority. We show that with convex schedules, outcomes that are Pareto superior to the rational responders’ outcome are available in all three contexts, though a sophisticated schedule setter will not necessarily choose such outcomes. We also solve the Mirrlees optimal income tax problem under ironing and show, using micro data, that the welfare implications of the ironing variant of schmeduling are potentially very large for the personal income tax. We then identify the deadweight loss that arises from spotlighting.

We provide empirical tests of ironing using the 1998 introduction of the child tax credit and of spotlighting using data from a food stamp cash out experiment. In both cases, the data, though not conclusive, are consistent with a significant amount of schmeduling.

> "If line 11 is equal to or more than line 12, enter the amount from line 8 on line 14 and go to line 15. If line 11 is less than line 12, divide line 11 by line 12. Enter the result as a decimal (rounded to at least three places)."
>
> Internal Revenue Service (2002)

> "Beginning with your November bill and continuing through April 2001 your gas adjustment factor will be $0.68530 per therm. The local distribution adjustment factor will be $0.00820. . . .For an average customer on Rate R-3 this will amount to a $33.83 increase in your bill."
>
> Keyspan Energy Delivery (2000)

> "Roaming rates apply to calls placed and received outside this area. Long distance charges for calls received while roaming are calculated from your home area code to the location where you received the call. Due to delayed reporting between carriers, usage may be billed in a subsequent month and will be charged as if used in the month billed.. . . . Other charges, surcharges, assessments, universal connectivity charge, and federal, state and local taxes apply."
>
> AT&T Wireless (2002)

The demand curve is a bedrock concept in economics. It tells how much of something a person will buy at each price. The efficiency of the market equilibrium requires that the demand curve accurately reflect people's willingness to pay. Yet quite often, people have little or no idea what price they are paying. Few consumers, for example, know how much it would cost to run their dishwasher twice a day rather than once a day or to keep the thermostat in their home set one degree higher during the winter. Similarly, we suspect that few people know with any precision how close they are to running out of their monthly allotment of free cellular phone minutes. And, there is ample evidence that taxpayers and welfare benefit recipients often have little understanding of their marginal wages net of taxes and transfers. In all of these cases, and in many other ones, it is likely that individuals are making suboptimal choices. Interestingly, in important cases these suboptimal choices reduce deadweight loss, and thus increase collective welfare.

In this paper we undertake four tasks. First, we develop a theory that describes the circumstances under which people are unlikely to perceive the true prices that they face -- when pricing schedules are complex, when the connection between consumption and payoffs is remote, and when other features of the economic environment make it difficult to learn from past experience. We illustrate this theory with examples from five areas of economic behavior.

Second, drawing upon experimental results in psychology as well as evidence on how people perceive the incentives created by existing tax, transfer, and regulatory systems, we posit several behavioral rules for how people actually perceive and respond to schedules. We argue that when people have limited understanding of the actual schedules that they face, they are likely to perceive them in a crude fashion. They may know their price or marginal tax rate only very roughly. Or they may know some element of the true schedule, but not how it relates to their marginal cost. We define the term "schmedule" to be a misperceived schedule. Thus, schmedules exist only in the eye of the beholder. We call the act of behaving as if one were facing a schmedule rather than the true schedule, “schmeduling” and those who do it “schmedulers.”

Our focus is on two forms of schmeduling: ironing and spotlighting. Ironing in real life is intended to make fabric flat. The schmeduling variant of ironing arises when an individual facing a multipart schedule perceives only the average price to the point where he consumes. For example, an individual earning $80,000 and therefore in the 30 percent marginal tax bracket might observe that his taxes are $16,005, iron to a constant rate of 20 percent, and make decisions as if he kept 80 percent of marginal earnings. Spotlighting occurs when consumers respond to immediate or local prices and ignore the full schedule that they face. It frequently occurs when individuals make choices in response to current prices, but fail to take into account the effect of current choices on future prices. Thus, a food stamp recipient may consume more calories in the early days of the month, when, because the recipient has not yet exhausted the monthly allotment of food stamps, food appears to have a much lower cost.

Third, we analyze the welfare implications of ironing and spotlighting behavior. We study the effects of ironing in three settings: when a profit-maximizing monopolist sets prices, when a Ramsey-pricing regulator sets utility rates, and when a social-welfare-maximizing tax authority sets the tax schedule. When the optimal schedule with rational consumers is convex, ironing improves the outcomes available to the schedule setter.[1] Indeed, with convex schedules, outcomes that are Pareto superior to the rational responders' outcome are available, though the sophisticated schedule setter will not necessarily choose such outcomes. We also solve the Mirrlees optimal income tax problem under ironing and show, using micro data, that the welfare implications of the ironing variant of schmeduling are potentially very large for the personal income tax. Our analysis of the welfare effects of spotlighting focuses on the deadweight loss that such behavior produces.

Fourth, we conduct two empirical tests of rational versus schmeduling behavior. To test ironing, we use data from before and after the 1998 introduction of the child tax credit. To test

[1] Throughout this paper we refer to the standard model of fully-informed consumers who optimize subject to their exact budget constraints as the "rational model." We do not, however, mean to imply that it is necessarily irrational to schmedule is some circumstances. The costs of gathering information may make it optimal to follow a heuristic approach where schedules are approximated. We also believe, however, that there are some cases in which the true marginal prices are readily available, the stakes are high, and people nonetheless perceive an alternative price.

spotlighting, we use data from the San Diego food stamp cash out experiment. Throughout our analysis we recognize that in real life some individuals are serious schmedulers, others perceive schedules accurately and respond appropriately, and still others mix schmeduling with some element of rational response to schedules.

I. Conditions that Give Rise to Schmeduling

We identify nine conditions that can make it difficult for people to perceive the incentives -- e.g., prices or taxes – operating at the margin. We expect that schmeduling will be rare unless several of these conditions are present, and that schmeduling will arise more often and in more extreme forms when more of the conditions occur. The nine conditions fit into three broad categories:

Category A: Complexity. Complexity makes it difficult to determine marginal prices and makes it costly to calculate a person's exact location on the schedule.

1. ***Nonlinear pricing***. Schmeduling is more common when there is the potential to confuse average and marginal prices.
2. ***Schedule complexity***. Schmeduling is more common when there are more rates in the schedule or if the consumer is operating on two or more schedules simultaneously.
3. ***Frequent revisions of schedules***. Schmeduling is more common if the pricing schedule is revised frequently, implying that rates may not be known or that groping toward the optimum is less likely to be successful.

Category B: Remote Connection Between Consumption and Payoff. The next two conditions make it difficult to perceive prices from one's own market transactions, say in purchasing electricity or water.

4. ***Delayed payoffs***. Schmeduling is more common when the payoff from a decision is separated in time from the consumption choice.

5. ***Bundled consumption***. Schmeduling is more common when the payoff from each choice is bundled with many other choices. These other choices can either be different types of choices or they can be similar choices at different points in time.

Category C: Environment is not conducive to learning. The remaining four conditions make it difficult for a person to learn the marginal price he faces from personal experience or from the experience of acquaintances.

6. ***Nonstationary economic environment***. Schmeduling is more common if the environments in which people are making choices are changing so that people are operating at different points on the schedule each time they make a choice.

7. ***Heterogeneity in offered schedules.*** Schmeduling is more common when one's acquaintances face different schedules or are operating at different points on the schedule than you are. Comparing one's payoff to that received by a friend who made a different consumption choice is, therefore, not informative.

8. ***Obscure pricing units***. Schmeduling tends to arise if the units in which people consume are different from those in which they are charged. Given such differences some forms of schmeduling are likely to arise even if prices are constant.

9. ***False signals***. Schmeduling can arise when information presented to the consumer could

be misinterpreted as the marginal price. Thus, consumers may be presented with average prices along with or instead of marginal prices, or they may pay multiple charges per accounting period, but the charges early in the period are not the marginal cost conditional on expected future behavior.

II. Economic Examples of Schmeduling

We now present five examples of areas of economic behavior in which we expect to observe schmeduling. Table I shows which of the above conditions apply to each.

Tax Systems. A substantial body of research indicates that people do not understand their tax schedules. Interviews with taxpayers in the UK (Brown, 1968; Lewis, 1978), Italy (Bises, 1990), and Sweden (Brannas and Karlsson, 1996) and with EITC recipients in the U.S. (Liebman, 1996; Olson and Davis, 1994; Romich and Weisner, 2002) all suggest substantial confusion about marginal rates.[2] Fujii and Hawley (1988) compare responses to a survey question about marginal tax rates to calculated marginal tax rates using Survey of Consumer Finances data; they conclude that there are significant differences.[3] De Bartolome (1995) shows that people confuse average and marginal tax rates when asked to make calculations using a tax table similar to those published by the Internal Revenue Service with the 1040 tax form.

In addition, individuals' actual choices often reveal traces of schmeduling. For example,

[2] Rosen's (1976) evidence suggests that people do not ignore taxes altogether. Break (1957) finds that solicitors and accountants in the UK are aware of their marginal rates, but that taxes have little impact on their work hours.

[3] The Fujii and Hawley study is open to alternative interpretations. Their data set did not include itemized deductions. Hence, measurement error could contribute to the discrepancies that they present. Moreover, the paper presents average marginal tax rates using both the survey and the calculated approach but do not show the distribution of individual-level discrepancies. Therefore, their study is not as informative as it could be for our purposes.

the evidence that taxpayers generally do not bunch at kink points (Heckman, 1983; Liebman, 1998; Saez 2002) and that people locate at places on the budget constraint where theory says that they should not reside (Macurdy et al 1991) is usually interpreted as suggesting that taxable income elasticities are small (Saez 2002) or that the specification of preferences in the analysis is wrong (Heim and Meyer 2002).[4] Schmeduling offers a different explanation. Lack of bunching at concave kink points and the presence of people at convex kink points may arise because people do not know or misperceive the tax schedule.[5]

More generally, the complexity of the tax code, with seven statutory marginal rates and twenty-two provisions that "give rise to deviations between effective marginal tax rates and statutory marginal tax rates" make it unlikely that most taxpayers calculate their marginal rates accurately (Barthold et al, 1998). Other tax and transfer programs – state income taxes, food stamps, student loans, housing assistance, etc.– make the task considerably more difficult.[6]

Given the challenge of calculating marginal rates directly, it is worth considering what alternatives people might employ, short of looking up the tax tables. In theory, they could infer their true net wages by looking at their pay stubs to see how their after-tax income changes from year to year in response to changes in effort, even without referring to tax tables or trying hypotheticals in TurboTax.[7] Such first-differencing calculations seem unlikely, particularly

[4] Saez (2002) acknowledges the possibility of a behavioral explanation for the lack of bunching.

[5] The simulations in Saez (2002) suggest that uncertainty about what annual income will turn out to be is not large enough to explain the lack of bunching at kink points if elasticities are at least moderately large. Similarly, simulations of our own indicate that, in most cases, we can distinguish a rational consumer from a schmeduler unless income uncertainty is very great.

[6] Dynamic tax considerations – such as tax rates on earnings converted to future consumption, tax rates on human capital investment, and the relationship between current work and future social security benefits – add additional complexity (Auerbach and Kotlikoff 1985; Kotlikoff, 1996).

[7] The summary statistics automatically produced by TurboTax when the taxpayer has finished filling out a tax return include the taxpayer's average tax rate, but not the marginal tax rate. One must redo the tax return with an alternative income level to learn one's marginal tax rate from this software.

given rapid changes in economic environments.[8]

Table I shows that the tax system features most of the conditions we predict should foster schmeduling. Tax systems are complex, involve nonlinearities, and are revised frequently. The payoff from a decision this January may not be realized until April of the following year. Often very different decisions (labor effort of two people, sale of capital assets, degree of tax avoidance undertaken) together determine a single annual payoff. Individuals are likely to be on a very different point on the schedule than their friends or neighbors (and also hesitant to discuss their incomes). Finally, taxpayers receive pay stubs that may lead them to conclude their marginal tax rate is merely 1-(net pay/gross pay).[9] [10]

Welfare Programs. To our knowledge, income transfer systems create the most complex schedules widely faced by ordinary citizens. Many recipients receive benefits from multiple programs, each with its own schedule of how benefits fall (and occasionally rise) with increased earnings. Even when the benefit-reduction schedule from a single program is linear, the combined schedule will be highly nonlinear. Moreover, each program has complicated rules about amounts of income that are disregarded before the benefit-reduction schedule is applied. For example, in 2000 the food stamp program disregarded the first $134 dollars of income plus

[8] Even if work effort stays constant, changes in marital status, family composition, housing consumption, life-cycle earnings patterns, and tax laws mean that people will often be on different segments of the budget constraint.

[9] The withholding schedule does not account accurately for non-wage income, and the gap between gross and net pay that the taxpayer observes on his paystub often reflects non-tax payroll deductions for life insurance, dependent care accounts, medical savings accounts, parking, and the like. Thus, taxpayers may react to a number that is neither their marginal nor their average tax rate.

[10] Confusion between average and marginal prices has been offered as an explanation for the flypaper effect (that federal grants to state and local government significantly increase state and local spending) by Courant, Gramlich, and Rubinfield (1979) and Oates (1979). Hines and Thaler (1995) discuss this and other explanations for the flypaper effect.

20 percent of earnings (among a long list of other deductions) in a month. Thus, the way in which earnings are allocated across months also affects benefit payments.[11]

Even economists have a hard time computing effective marginal tax rates for welfare recipients. The complexity of the rules about what income is disregarded largely explains the wide range of estimates of effective tax rates for AFDC recipients in the empirical literature – ranging from the work of Dickert, Houser, and Scholz (1994) who find cumulative rates of 15 to 40 percent, to the work of Giannarelli and Steuerle (1995) who find rates of 75 percent or more.[12]

Both program rules and unstable economic environments make it hard for welfare recipients to know where they are on the schedule. Benefit reduction rates often vary based upon the length of time a person has been receiving benefits,[13] and recipients often experience large discrete jumps in earnings levels; so knowing the marginal rate on one additional dollar of income may be a very bad estimate of the payoff to the change (say from part-time to full-time work) that the person is actually contemplating.

Some features of welfare programs make their incentives easier to perceive than those of the tax system. Their accounting period is usually one month, rather than one year, enabling a

[11] In theory, welfare case workers could explain to their clients what the financial benefit from earning more would be. Evidence from a study of the California GAIN program suggests, however, that even when caseworkers were explicitly urged to discuss the returns to work with clients, they rarely did so (Meyers, Glaser, and MacDonald, 1998).

[12]The schedule for the Earned Income Tax Credit (EITC) is particularly complicated. The credit initially increases with earnings, is constant at its maximum value for a range of earnings, and then is phased out as earnings rise even further. Since payment is usually made as part of an annual tax refund check, the EITC component of the refund is hard to determine. Empirical research on the EITC has found that single mothers respond strongly to EITC incentives in deciding whether to work, but not in choosing how many hours to work (Eissa and Liebman, 1996; Meyer and Rosenbaum, 2001; Meyer, 2002). Liebman (1998) attributes this combination of results to the greater ease with which recipients can perceive the impact of the credit on the average return to work than on the marginal return.

[13] Time limits make the welfare recipient's decision problem into a complex dynamic programming problem of how to consume from a fixed potential-benefit stream. See Grogger and Michalopoulos (1999) on welfare time limits and Pollack and Zeckhauser (1996) on the more general problem of how to consume out of a fixed budget over multiple periods. Each paper finds that complex, nonintuitive strategies are optimal.

person to see an earnings change swiftly reflected in welfare benefits. Kling, Liebman, and Katz (2001) report that a large share of recipients of housing assistance know that their rent will go up by exactly 30 percent of any increase in their earnings, perhaps because of the monthly accounting period; whereas, EITC recipients, with an annual accounting period, generally have no concept of the EITC phaseout. A second possible explanation is that the 30 percent housing tax rate has been constant for many years, and applies nationwide to everyone in public housing.[14] Other tax or transfer programs, by contrast, place individuals at different points and slopes on the schedule, and rates vary across locales. Overall, public assistance provides examples of most of the conditions listed in Table 1.

Utility Pricing. Utility pricing schedules, though simpler than tax and transfer schedules, still have multi-tiered, nonlinear pricing. They have four additional features that make it difficult for consumers to perceive the marginal price of consuming additional water, electricity, or heating fuel. First, pricing schedules are sometimes not published on the monthly bill. Second, consumers are often located at very different points on the schedule in different seasons – say, demanding more natural gas in the winter. Third, pricing schedules often vary from season to season – utilities charge more for natural gas in winter. Fourth, and most importantly, the link between a consumer's choices (how long to stay in the shower, whether to run a half-full dishwasher, where to set the thermostat) and consumption is hard to observe. How many gallons

[14]In most cases, a public housing resident's neighbor or cousin in another city can accurately tell him or her what the effective tax rate is from housing assistance. A similar ability to learn about schedules from acquaintances may explain the clustering of elderly workers with earnings just below the threshold for the Social Security earnings test (Burtless and Moffitt,1984; Friedberg, 2000). Gruber and Orszag (1999) show, however, that the amount of such bunching that occurs is quite small – at most 4.1 percent of the working population of 62- to 69-year-olds locate just below the earnings-test threshold.

of water are used per shower, and how much does it cost to heat that water? Bills are presented in consumption units that are not directly observable (and, like therms and kilowatts, are often incomprehensible) to the consumer, and monthly payments aggregate hundreds of disparate individual decisions (e.g., turning on the light and running the dishwasher). Such factors – a nonstationary economic environment, delayed payoff, and bundled consumption (see Table I) – combine to make it almost impossible to determine one's marginal price by observing how bills vary with behavior. How then do people make their decisions relating to utility use?[15]

Nonlinear Penalties, Fines, and Insurance Contracts. In 1959, one of us (RJZ) let his roommate borrow his car early in the fall semester. His roommate returned the car, and mentioned that he had received a ticket, but that it was free. Indeed, the schedule allowed two free tickets, then $5 for the 3rd, $10 for the fourth, and $20 for any ticket thereafter. The roommate asserted he owed nothing. RJZ, believing that he would probably get four or five tickets in the year, suggested that $15 might be his expected marginal cost due to the ticket, and that they could always settle up when the cost became known at the end of the year.[16]

This sort of penalty structure is common. For example, automobile insurance rates often start rising after a person has received more than 3 points on his license from moving violations, or has made a certain number of claims under his comprehensive insurance policy. Criminal sentencing guidelines often impose higher prison sentences on convicts who have previous convictions, "three-strikes" laws being a draconian example. Medical flexible spending accounts

[15] There is some empirical support for the proposition that utility consumers engage in schmeduling. Friedman (2002) finds that the consumption behavior of natural gas consumers is better explained by a model in which consumers respond to the total bill rather than a model in which they respond to marginal cost.
[16] The roommate, who was not studying economics, did not counter with the argument that the owner would be excessively careless, not internalizing costs incurred by the roommate.

have zero out-of-pocket costs for initial units of consumption; consumers pay the full price once the accounts are exhausted. In each of these cases the true marginal cost of additional consumption early in the time period depends on expected consumption later in the time period and can be far above the immediate cost. We conjecture that confusion often arises when the within-accounting-period payoffs present false signals of the ultimate marginal price.

Nonlinear Pricing of Consumer Goods. For most consumer goods, such as milk or clothing, consumers are told the price at the time of contemplated purchase, and the per-unit price does not vary with quantity. However, even with ordinary goods, consumers are sometimes offered quantity discounts. Such pricing may lead consumers to schmedule.

Typically, the schmeduler is hurt by failing to rationally optimize. Say he uses ironing. He consumes units whose marginal cost exceed his marginal benefits if the schedule is convex, and vice versa if the schedule is concave. This assumes that the schedule setter does not change the schedule in response to the schmeduler's behavior. As we discuss further below, if the schedule setter does respond, that can help or hurt the schmeduler, depending on the schedule setter's goal, the shape of the schedule, and the particular schmeduling behavior.[17]

Sophisticated businesses may capitalize on the confusion that pricing schedules create, causing some customers to pay more or purchase more than they otherwise would for the service. Cell phone packages with prices that rise steeply if a customer uses more than his or her allocated

[17]In some cases, merchants may hurt themselves by presenting pricing in a way that produces schmeduling behavior. Shutterfly.com describes its holiday cards as costing 82 cents per card if 100 are purchased and 69 cents per card if 200 are purchased. Thus the marginal cost of the second 100 cards is only 56 cents per card. We suspect that most consumers deciding between 100 and 200 cards perceive the marginal price as 69 cents and that Shutterfly could increase both its sales and its customers' consumer surplus by describing its pricing as a two-part schedule, so as to get some additional people to respond to the schedule rather than a schmedule.

amount of monthly minutes presumably fall in this category. It is next to impossible for a customer to know how many minutes he or she has used up so far in the month. Moreover, as the quotation at the top of the paper shows, there is no necessary connection between when the customer makes the calls and which months the calls are assigned to for billing purposes.[18]

III. How People and Pigeons Respond to Schmedules

People who are fiercely rational or who face very simple pricing schemes may know exactly where they are on their various schedules. Some may use first-differencing to estimate marginal prices,[19] and other quasi-rational methods may be near optimal. Some affluent people hire people to do the calculating and optimizing for them.

Our proposition, however, is that people facing pricing schedules often engage in two prominent variants of schmeduling: ironing and spotlighting.[20] Evidence from experimental psychology – mostly with pigeons but some with humans – establishes ironing and spotlighting as plausible models of how people behave when faced with complicated schedules. Moreover, our theory makes predictions of when each type of behavior will be observed. Ironing occurs

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[18] Cell phone companies may be counting on people to consume more than they plan, and to pay high rates on extra minutes, or – like auto rental companies offering cheap full tanks – may be trying to get customers to purchase more minutes to protect against exceeding the limit. This process is complicated because cell phone companies compete fiercely, and presumably there is adverse selection – frequent callers choose flat-rate plans, for example, with schmeduling tempering adverse selection.

[19] In other words, consumers may infer marginal prices by calculating the change in payoff divided by the change in quantity consumed over subsequent accounting periods. Alternatively, they may infer marginal prices by comparing their own situation to that of a similar person who made a slightly different choice.

[20] A third, more extreme, form of schmeduling is ostriching. This occurs when people are so overwhelmed by the complexity of schedules that they ignore the schedule altogether. Examples of this include: 1) people ignoring the marginal social security benefits they receive in the future from social security payroll tax payments; 2) consumers making choices based on factors other than price when the pricing schedules are too complicated, as appears to occur frequently with purchasers of medigap insurance policies – as evidenced by the wide range of prices at which identical policies can be purchased; and 3) consumers purchasing mutual funds with 100 basis point annual fees, even though information of the fees is readily available. We do not discuss ostriching further in this paper because we think it will be very difficult to develop a general theory capable of predicting how consumers will behave in these circumstances.

when there is a single payoff for all of the bundled choices within an accounting period. Spotlighting occurs when there are multiple within-accounting-period payoffs.

With ***ironing***, people smooth over the entire range of the schedule. They perceive (or treat) the average price as the marginal price. Thus one decides whether to lower the thermostat by noting that $300 per month represents an average price of 60 cents per therm, rather than 89 cents for the last (and next) therm of natural gas.[21] With ***spotlighting***, people respond to the instantaneous payoff in the current sub-period without considering effects for the remainder of the accounting period. Thus users of medical flexible spending accounts may act as if consumption in January is free (or near free), ignoring the fact that by the end of the year they may well be paying the full cost of marginal care.[22]

These same behaviors are well documented in the experimental psychology literature for a wide range of species including pigeons, rats, monkeys, and humans. In particular, schmeduling is closely related to Richard Herrnstein's theories of melioration and distributed choice.[23] We summarize the experimental psychology evidence in appendix A.

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[21] In fact, in the home heating example we doubt that people ever do the conversion to price per therm. Nonetheless, in thinking about marginal consumption decisions, we believe people make those decisions by thinking of increments to the $300 monthly bill which, since it includes the price of inframarginal consumption, will result in behavior that is responsive to average rather than marginal prices.

[22] Keeler and Rolph (1988) show, using data from the Rand Health Experiment, that consumers who have nearly exhausted health insurance deductibles spend no more on healthcare than consumers who are far from exhausting their deductibles. However, consumers who have completely exhausted the deductibles do consume more in response to the lower price. This finding -- that people respond to their local price and fail to incorporate expected future consumption into their calculations – is consistent with spotlighting.

[23] Schmeduling also has antecedents in the behavioral economics literature. It is most closely related to the literature on calculation errors (Tversky and Kahneman, 1974), bounded rationality (Simon, 1978), and mental accounting (Thaler, 1985). The confusion between immediate and end-of-period prices that is the essence of spotlighting is related to the literature on time-inconsistent preferences and self-control (Thaler and Shefrin, 1981; Laibson, 1997; Bernheim and Rangel, 2002).

Whether these theories can in fact explain people's behavior in the applications that are our focus remains to be seen. Before turning to empirical tests of these theories in section V, we first discuss the potential welfare implications of such behavior.

IV. Welfare Implications of Ironing and Spotlighting

To illustrate how schmeduling affects welfare, we first consider simple schedules with two linear segments, and a world with two types of responders. We start with ironing, and study schmeduling in three contexts: a profit-maximizing monopolist, a Ramsey-pricing public utility, and a social-welfare-maximizing tax authority. We also illustrate the deadweight loss that arises from spotlighting. Then, for the tax authority case, we drop the simplifications, solve the Mirrlees optimal tax model under ironing, and present empirical estimates of the welfare implications of ironing for the U.S. tax system.

Ironing in Two-segment Two-type Models

For simplicity, in the monopolist and Ramsey-pricing cases, we shall assume that goods are produced at constant marginal cost and that there are no economies of scale on the consumption side (such as in delivery). Throughout, we focus on situations where the optimal schedule from the standpoint of the schedule setter is convex: prices rise with quantities consumed, and tax rates rise with income. This "rising-price" case is most relevant to the tax- and transfer- policy applications we turn to later in the paper. Convexity could arise to maximize profits in the monopolist case or to maximize efficiency in the Ramsey-pricing case, if the high demander has lower elasticity. Or it could be imposed to meet distributional concerns in the tax example, whatever elasticities might be.[24] There are, of course, situations where optimal schedules are concave, for example when there are economies of scale in production, or where large users have more elastic demand (for example, if they have lower per-unit transaction costs for switching suppliers).

Ironing: The Profit-Maximizing Monopolist. The monopolist sets a price schedule where the first k units cost p_1 each, and all subsequent units cost p_2, where convexity requires that $p_2 > p_1$. Given ironing, and but two types of responders, call them HI and LO, two-segment schedules can reproduce the results of significantly more complex schedules. Figures 2a and 2b illustrate the consumers' and profit-maximizer's decision problems. The two consumers have equal incomes, but differ in their tastes for the good.[25] At any point, consumer HI is willing to give up more of the other good to get another unit of the monopolist's good; i,e., he has less elastic demand.

As depicted in Figure 2a, for rational responders, the monopolist selects three parameters: p_1, p_2, and a kink point where the price switches. The choices are such that LO consumes at the kink (point A representing K units), and HI chooses some point on the p_2 segment of the budget constraint. (His indifference curve is tangent in this rational case.) In maximizing its profits, the

[24] Convex schedules will not be observed in situations where big users can easily make a series of small purchases to reduce their cost. Convex schedules are quite common with utility pricing or taxes, where breakup would be hard or illegal. Insurance offers an interesting case in which it is often not possible to buy half as much from two sources since there are prohibitions against insuring the same thing twice (or at least against collecting if you do). Hence, people buy all their insurance for a home through a single insurer who in turn can charge more the greater the percentage of your home's value you insure. The same holds true for mortgages. An 80 percent mortgage costs more than twice a 40 percent mortgage, but you can't buy two separate 40 percent mortgages that will behave like a single 80 percent mortgage. The Rothschild-Stiglitz insurance results, and their push for nonlinear pricing, all hinge around these issues. With life insurance, in contrast, you can buy two smaller policies that have the same impact as one larger policy, and prices tend to fall with the amount insured, due to negative correlations between income and mortality risk and because of savings in transaction costs.

[25] In this figure we assume that they have the same income because this allows us to depict them as facing the same budget constraint, but our results do not require them to have the same income.

monopolist faces several constraints that apply whether the consumers are rational or schmedulers. First, he is restricted by assumption to a pricing schedule that starts at zero and that rises with quantity consumed. Second, he must offer a segmented linear schedule, rather than two points. Third, both responders must prefer their choices to zero consumption. Fourth, there is a no-envy condition. HI must prefer some choice on the p_2 segment to point A. Finally, observe that in optimizing against LO, the monopolist has two different policy tools, the price and the length of the pricing segment. However, it turns out that it is never optimal to prevent LO from consuming as much as he wants at p_1, as we explain in conjunction with Figure 2b.

Figure 2b shows the solution to the monopolist's profit maximization problem when confronted with rational consumers and then with schmedulers. The vertical axis measures net revenue; that is, marginal cost is subtracted. We first consider the solution when consumers are rational. Look at the outcome for LO, and the Feasibility Rational LO curve. This shows how profits to the monopolist from sales to LO vary with p_1 (the slope of a line from the origin to the curve). At the right-most end, p_1 is low, quantity demanded is high, but revenues just cover costs. As we move left on the curve, p_1 is rising. LO will always consume on this feasibility frontier. In other words, the kink point – R in the figure – will always occur at the point that LO would choose if offered the opportunity to consume an unlimited quantity at a price of p_1 per unit.[26]

Point S indicates the point where net revenue is maximized, taking into account only the sales to LO. The slope of the curve from the origin through S is p_{1s}. Posit that the optimal

[26] To see this, consider interior point T as a possible kink. The monopolist would secure more from LO by offering the alternative p_1 that runs to R, the point vertically above T on the frontier. This is also the point that LO would choose at this new p_1. The monopolist also gets more from HI. Say that the best the monopolist can do against HI given a kink at T is V. With a kink instead at R, he will have a lower marginal price for any quantity-net revenue pair northeast of R. Hence he could receive greater net revenues from HI, e.g., at E.

outcome is to have LO consume at R and HI at E. The monopolist will set $p_1 > p_{1s}$ (along Feasibility Rational LO) – a level that is higher than would be optimal were he optimizing against the low type in isolation. Doing so allows him to lower p_2, thereby increasing the quantity consumed by and profits from HI. Raising the price on inframarginal units and lowering them on marginal ones is not unlike imposing a fixed cost on HI and then a lower per-unit price, thereby yielding higher profits from HI. But this comes at the cost of lower profits from LO. Point R represents the optimal balancing of profits from HI and profits from LO. It will therefore always be to the left of S, the maximum on the Feasibility Rational LO curve. This higher p_1 results in lower utility for LO than if the monopolist were optimizing against LO in isolation.

Now consider the curve labeled "Feasibility Rational HI." This curve, added from point R, shows how varying p_2 affects profits to the monopolist from sales to HI. Convexity requires that $p_2 > p_1$. Therefore the curve ends at point D, the level of consumption chosen by HI if the slope of the second segment just equals the slope of the first. When p_2 becomes sufficiently high -- steeper than the "Feasibility Rational HI" curve at point R – HI prefers the kink point to any point on the p_2 portion of the schedule and consumes at point R. Point E indicates the HI type consumer's consumption at the level of p_{2*}, the value that maximizes the monopolist's profits.

When consumers are ironing, the profit maximizer's problem takes on a different cast. The LO consumer is unaffected, since he merely responds to a single price, which is both average and marginal. HI, however, responds to his average price, not p_2. Hence, his feasibility curve assumes that a price line pivots starting at the origin. His feasibility frontier lies strictly above that for rational HI to the northwest of D (at D the average price and marginal price are equal). That is because he perceives a lower price at the margin for any amount of revenue raised. Thus, for example, if the HI ironer were offered the price schedule through R, with p_2^* beyond, he would consume at a point like G, with greater consumption than at E.

Given that HI is responding as an ironer, the location of the first segment of the schedule does not matter. Thus, it is optimal to move the first segment to S, with a caveat about envy, discussed below. HI will be offered the schedule running from S through F. He consumes at F where his indifference curve is tangent to the price line from the origin through F. The envy caveat applies if HI prefers S to F. The point S_e on the Feasibility Ironing HI curve shows the point where HI is indifferent to S. In this case, F is preferred to S. If it were not, it would be optimal to move S to the left and F to the right until envy was just eliminated.

It is readily seen that the monopolist is better off with ironing behavior. He could always offer the optimal rational schedule. Under that schedule, an ironing HI would operate at point G, which offers more net revenue than E, the point produced by the rational HI. Since the monopolist also selects S rather than R as the kink point, LO is definitely better off with ironing. HI, however, is likely to be worse off as an ironer, since at a point like F he pays more and consumes less than at E.

We have posited that the schedule setter is a shrewd maximizer who understands his consumers' psychological propensities. But this is not necessary. He can merely vary the two-part price schedule through trial and error, and will reach the same outcome as would an optimizing schedule setter.[27]

[27] In contrast, we will see that in the Ramsey pricing and optimal income tax models, the schedule setter cares about social welfare and will therefore need to know the preferences underlying the behavior he observes. He may draw erroneous inferences about preferences if he does not realize that consumers are ironing.

Ironing: A Ramsey-Pricing Utility. The Ramsey pricing model bears important similarities to the monopolist case, though the objective functions differ. Whereas the monopolist maximizes profits, a Ramsey pricer minimizes deadweight loss, subject to the constraint that profits cover fixed costs. We continue to assume a convex schedule, where the higher-volume user pays a higher per-unit charge on marginal units.[28]

Figure 3 shows the Ramsey pricer's solution. The feasibility constraints in the rational case for both consumers are identical to those in the profit maximizing example since the only thing that has changed is the producer's objective. Let points A and B represent the optima, assuming that LO and HI are rational and that HI does not envy LO. In other words, these points reflect the inverse elasticity rule. Note that point A lies to the right of the revenue maximizing point because the Ramsey pricer is trying to maximize social welfare, not revenues, and therefore takes LO's utility into account.

If HI is an ironer, it is easy to see that the Ramsey pricer can do better. He simply offers a schedule with the second segment going from A to C, where C lies on the line from the origin through B. HI will consume at C. HI is better off, since points strictly better than B – those in the triangle formed by extending horizontal and vertical lines from B to the line connecting A and C – were available to him. In this solution, there is no envy, since $U_H(C) > U_H(B) > U_H(A)$. Moreover, revenues are higher, implying that some could be given back to LO, HI, or both. This merely shows how to beat the rational outcome – in other words that a Pareto improvement exists. By adjusting the locations of A and C, the schedule setter with ironing can further reduce deadweight loss, while making sure not to adjust so far that HI prefers A to C.

[28] Today, most utilities have such schedules for several purposes: to limit demand since new capacity costs more than old, to control environmental externalities, and to achieve distributional objectives since big users tend to be richer.

Ironing: The Optimal Income Tax. We assume that the tax schedule is convex: i.e., that marginal tax rates increase somewhere and decrease nowhere. The presumed justification is not differential elasticities, but distributional concerns, i.e., a presumed declining marginal utility of money. Our analysis has both taxpayers pay positive amounts, though allowing for net negative taxes would merely involve rescaling the axes. Figure 4 shows our analysis. The scales on the two axes are drawn so that post-tax income equals pre-tax income (the usual 45 degree line) along the steep dotted line ending at F. This makes the diagram easier to read. Assume that the tax schedule depicted with the solid lines is the optimal schedule if the two taxpayers are rational. Thus the L type taxpayer chooses point A and the H type taxpayer chooses point B.[29] A superior outcome is vailable if HI is a schmeduler. We draw a straight line from the origin through point B to find a point, C, on this line that is on the schmeduler's feasibility curve (in other words, the schmeduler's indifference curve is tangent to the average tax rate line at this point), and that provides higher utility than at B. In particular, the schedule setter can get HI to choose this point, by offering a tax schedule with the same tax rate through point A as in the rational case and then setting the second tax rate so that the tax schedule beginning at A goes through point C (the lightly dotted line). With this new schedule, the schmeduler not only has higher utility, but also generates more tax revenue (he has higher pre-tax income and is paying

[29] Note that the marginal tax rate for the second, higher, bracket will be below the revenue- maximizing one, since HI's welfare counts somewhat and the loss in revenue from moving away from the revenue-maximizing point is initially zero.

the same average tax rate as at B). Given a sophisticated schedule setter, the tax scheme with schmeduling is Pareto superior to the one without.[30]

General statements about progressivity given schmedulers, as opposed to rational responders, are not possible. The answer depends on the progressivity measure employed. We are confident of one result. In comparison with the optimal tax scheme with rational responses, there exists a Pareto-superior scheme given schmeduling that simultaneously collects more taxes from HI, has a higher average tax rate imposed on HI, and leaves HI better off. This is achieved at a point slightly below C on HI's feasibility frontier. HI is still better off than he was at B, but pays more in taxes and has a higher average tax rate.[31]

One other point merits emphasis. Given any tax schedule, an individual is better off if he is rational. This can be seen most clearly by observing that the ironer who is tangent to the average tax rate curve at C would achieve higher utility by moving to the left along the second segment of the tax schedule. Ironing yields its benefits because it makes respondents less responsive to marginal rates. Given that, the schedule setter offers a more favorable tax schedule.[32] The best situation for a taxpayer is to be rational while everyone else an ironer.

The results from our geometric presentations are straightforward. Ironing behavior eliminates some of the deadweight loss from high marginal prices or taxes. This implies that when the optimal rational schedule is convex, superior outcomes are available for the monopolist, for the Ramsey pricer, and for the setter of an optimal income tax. In the latter two

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[30] Though we have shown that ironing behavior allows for a Pareto-superior outcome, the optimal outcome given ironing may not be Pareto superior. For example, if ironing gets rid of most of the deadweight loss associated with taxing HI, the optimal scheme may cut his welfare while substantially raising welfare for LO.

[31] The arguments regarding no-envy conditions and naive schedule setters in the optimal income tax case follow directly from those in the previous two models.

[32] See de Bartolome (1995) for an earlier statement of this result.

public finance contexts, outcomes that are Pareto superior to the rational-responders' outcome are available, though such an outcome will not necessarily be chosen by the sophisticated schedule setter.

Spotlighting. We turn now to the welfare implications of spotlighting. We continue to analyze a convex schedule ($p_2 > p_1$) with two linear segments, but here only one consumer is required. We present a graphical analysis of a model with two discrete sub-periods. Appendix A contains an algebraic analysis of a continuous-time model. For simplicity, we assume no discounting. We focus on the magnitude of the deadweight loss that occurs when the consumer misperceives or miscomputes prices. This contrasts with our ironing analysis, where we assumed that sophisticated schedule setters reoptimized to take account of consumers' schmeduling. Schedule setting is generally less interesting in the spotlighting context than with ironing. From the seller's standpoint, spotlighting behavior simply amplifies the demand curve in the initial price range.[33]

Figure 5 illustrates the deadweight loss that arises from spotlighting when a price schedule has two segments. The consumer pays p_1 for the first Z units, and then pays p_2 for subsequent units. This schedule is shown as segments AB and CD on the diagram. The consumer chooses consumption in each sub-period. (A sub-period could be a day, with the price schedule applying to aggregate consumption during a monthly accounting period.) Consider two sub-periods. The consumer's demand curve for the first is EF. Since the consumer is a spotlighter, he responds only to the local price and ignores the impact of this decision on the

[33] It is possible to come up with examples in which schmedule-setting opportunities analogous to those under ironing would be available given spotlighting responders. For example, if a tax authority were to withhold at different rates throughout the year, depending on where the taxpayer then was on the annual tax schedule – as opposed to the actual practice of withholding based on expected annual earnings – this would create opportunities for schmedule setting that would be quite similar to those in the optimal taxation example we analyzed under ironing.

price(s) he will face in the second sub-period. Therefore, first sub-period consumption is determined by the intersection of the segments AB and EF, and he consumes Q_{spot} of the good. The demand curve for the second sub-period, GH, begins at Q_{spot} because there is a single (two-part) price schedule for the entire accounting period. Total consumption for the two sub-periods, Q_{tot}, is determined by the intersection of GH and CD.

Spotlighting leads to overconsumption because the consumer ignores the true opportunity cost of his first-sub-period purchases; he behaves as if he is foregoing p_1 of other goods for each unit consumed, whereas the true cost is p_2. The amount of overconsumption is Q_{spot}-Q_{rat}; the deadweight loss from this overconsumption is the triangle IJK.

Empirical Magnitude of Welfare Effects Are the welfare effects of schmeduling large enough to be of policy interest? While the answer will depend on the specific application, there is one important case – the federal income tax in the presence of ironing – where the data and methodology are readily available to assess the magnitude of the welfare effects. We first examine the welfare effects under the 2000 U.S. tax code. Then we solve the Mirrlees optimal tax problem under ironing, and show how the structure of the optimal tax schedule under ironing differs from that under the standard model.

With a convex tax schedule, ironers will perceive a tax rate that is lower than the true marginal tax rate. Hence, they will earn more income (work harder), and the tax system will impose a smaller deadweight loss. To assess the quantitative importance of this effect, we conduct simulations using the 1998 IRS public use sample of tax returns and NBER's internet Taxsim model. We "age" the sample to reflect 2000 income levels and use tax schedules for that year.[34] Following Feldstein (1999), we calculate deadweight loss using the Harberger-Browning approximation as

$$DWL = \frac{1}{2} TY\varepsilon \frac{\tau^2}{1-\tau}, \qquad \textbf{(1)}$$

where TY is taxable income, ϵ is the elasticity of taxable income with respect to the after-tax share, and τ is the tax rate. We use a value of 0.4 for ϵ, based on the estimates of Gruber and Saez (2002). Since deadweight loss is linear in ϵ, readers can readily employ alternative values.

We assume that taxpayers are ironers: they mistake their average tax rates for their marginal tax rates. Then we ask what would happen if we informed these taxpayers of their true marginal rates. It is worth emphasizing that an ironer optimizes at a point where his indifference curve is tangent to the average-tax line (a line from the origin) and that is simultaneously on the frontier of the tax schedule. Point C in figure 4 represents such a point (for the tax schedule whose second segment extends from point A through point C). For a given convex tax schedule and standard preferences, this is a unique point for each individual. The Harberger-Browning approximation applies to our thought experiment because the deadweight loss effect of informing an ironer of his true marginal rate is identical to that for a rational consumer who experienced an actual change in tax schedule from the average tax line perceived by the ironer to the true tax schedule.

[34] 2000 was the most recent year covered by Taxsim at the time we did these calculations. We dropped a couple dozen observations from the sample for whom Taxsim calculated marginal tax rates below -40 percent or above 50 percent.

Table II presents our results. In the data, taxpayers have taxable income of $4.233 trillion and pay income tax of $974.7 billion. Assuming ironing, the Harberger-Browning formula yields deadweight loss of $56.7 billion, or 5.8 percent of revenue raised.[35]

We estimate that if taxpayers were informed of their true marginal tax rates, taxable income would fall by about 5 percent to $4.020 trillion, and revenue would fall by about 6 percent. Deadweight loss would rise to $109 billion, or 11.9 percent of revenue raised.[36] These differences in income, revenue, and deadweight loss are all economically significant.

The marginal excess burden of taxation can be computed similarly. Consider a 10 percent increase in all marginal tax rates (for example, a 20 percent marginal tax rate would become 22 percent). Under the schmeduling model, revenue increases by $82.5 billion and deadweight loss increases by $13.9 billion for a marginal excess burden of 17 cents per $1 of additional revenue. In the rational model, revenue increases by $68.9 billion and deadweight loss increases by $27.2 billion, representing a marginal excess burden of 39 cents.[37]

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[35] For comparability with the main results in Feldstein (1999) these results ignore the payroll tax. Treating the personal income tax as an increment on top of the payroll tax would produce larger deadweight loss estimates.

[36] Our estimates for the rational case are quite similar to Feldstein's (1999) estimates. Feldstein, using an elasticity of 1.04, estimates that DWL from the personal income tax in 1994 was 32.2 percent of revenue. Multiplying our DWL estimate by (1.04/0.4) produces an estimate of 30.9 percent. Interestingly, our estimate that DWL under schmeduling is 48 percent lower than under the rational case is very similar to that of de Bartholeme (1995) who does an illustrative calculation for a representative worker with mean earnings using parameter estimates from Hausman (1981) and finds that DWL falls by 43 percent when taxpayers substitute average rates for marginal rates.

[37] With a taxable income elasticity at Feldstein's preferred value of 1.04, the marginal excess burden is $1.89 per dollar of revenue raised under the rational model and 52 cents under the schmeduling model.

It is worth emphasizing that existing estimates of the elasticity of taxable income come from studies of behavioral responses to tax changes. These elasticities are calculated by dividing the change in behavior by the change in after-tax share. The changes in after-tax shares in these calculations are based on marginal tax rates. Changes in after-tax shares calculated based on perceived tax rates (i.e., average tax rates) would be smaller, resulting in larger elasticities relative to the perceived change in after-tax shares. Therefore, it might be appropriate to use larger elasticities in the calculations above. This would produce higher estimates for the deadweight loss. However, it would not alter the estimates of the relative amount of deadweight loss under schmeduling and the rational model (since we would simply be using higher elasticities in both calculations).

There is one piece of natural experiment evidence that is potentially inconsistent with the predictions of our ironing model. Feldstein (1995), Eissa (1995), and Auten and Carroll (1997) provide evidence that high-income taxpayers increased their incomes substantially in response to the reduction in marginal tax rates from the Tax Reform Act of 1986 (TRA86). Since TRA86 was designed to be distributionally neutral, it affected average tax rates

The Optimal Income Tax Under Ironing

The Mirrlees optimal income tax problem seeks to find the tax schedule that maximizes social welfare subject to a government budget constraint and to an incentive compatibility constraint for each worker, assuming that the government can observe workers' earnings but not their skill level. Recent papers by Diamond (1998) and Saez (2001) have significantly advanced the optimal income tax literature by reformulating the problem in a way that makes transparent the factors that determine the shape of the optimal tax schedule.

Diamond (1998) shows that with quasilinear preferences, the marginal tax rate, *T'*, at each skill level, *n*, satisfies

$$\frac{T'}{1-T'} = \left[\frac{e^{-1}+1}{n}\right] \times \left[\frac{\int_n^{\infty}\left(p - G'\right)dF}{pf}\right], \qquad \textbf{(2)}$$

where *e* is the labor supply elasticity, *p* is the multiplier on the government budget constraint (equal the average over the population of the marginal social welfare), *G(u)* is social welfare for an individual with utility, *u*, and *f* and *F* are the pdf and cdf of the skill distribution, respectively.

only slightly at most income levels. Thus, our ironing model would predict little behavioral response to this tax reform.

This evidence does not lead us to abandon our schmeduling model. First, we have argued that while many individuals schmedule, some individuals are rational. The very high-income taxpayers studied in the TRA86 literature are likely to be among the most rational of all taxpayers. Thus they are the ones whom we would least expect to observe engaging in schmeduling. Second, there is a large literature by Slemrod (1990), Goolsbee (2000), and others suggesting that the TRA86 evidence is a product of widening income inequality and the shifting of income between the corporate and individual income tax bases, not of behavioral responses to taxation. If we are able to accumulate evidence demonstrating that taxpayers often engage in ironing, this will increase the probability that these alternative interpretations of TRA86 are correct.

Saez (2001) shows that the upper tail of the income distribution for married couples in the U.S. follows a pareto distribution with a pareto parameter of about 2 and that the asymptotic tax rate (the tax rate on taxpayers with very high incomes) from the optimal tax problem is therefore $\frac{1}{1+ea}$ where e is the labor supply elasticity and a is the pareto parameter.[38] Thus with a pareto parameter of 2 and a taxable income elasticity of 0.5, the optimal asymptotic tax rate would be 0.5.

In appendix C, we derive analogous results under ironing. The main difference from the standard problem involves replacing the first order condition for individual maximization of $v' = n(1 - T')$ with the ironing first order condition $v' = n\left(1 - \frac{T}{ny}\right)$. The former (maximizing) equates the marginal disutility of effort and the marginal return to an extra hour of work, whereas the latter (ironing) equates the marginal disutility of effort and the average return to work.[39] The resulting first order condition for the Mirrlees problem given ironing – analogous to the Diamond result given in equation 2 above – shows how the average tax rate at a given skill level relates to both the labor supply elasticity and to the ratio of marginal social welfare at the skill level to the multiplier on the government's budget constraint:[40]

$$\frac{\frac{T(ny)}{ny}}{1 - \frac{T(ny)}{ny}} = \frac{1}{e}\left(1 - \frac{G'(u)}{p}\right). \qquad \textbf{(3)}$$

[38] This is the formula assuming quasilinear preferences (implying equal compensated and uncompensated elasticities) and with the social marginal utility of someone with infinite income equaling zero.

[39] We follow Diamond's notation in which y is labor supply measured as a percentage of the maximum possible labor supply, and $v(1-y)$ is the disutility of effort.

[40] We thank Emmanuel Saez who found an error in our original derivation of the Mirrlees first order condition under ironing and showed us that the first order condition has the form given here. This first order condition turns out to be identical to the first order condition for the continuous case of Saez's (2000) model of the extensive margin of labor supply, a coincidence that can be attributed to the fact that labor force participation decisions (holding hours fixed) depend on average tax rates just as the intensive margin decisions of ironers do. We also thank Erzo Luttmer for extensive coaching on the Mirrlees problem.

The asymptotic marginal (and average) tax rate in the ironing model is $\frac{1}{e+1}$. Thus with an elasticity of .5 and a pareto parameter of 2, the optimal rate on high income taxpayers is .67 under ironing compared with 0.50 under the standard model.

Figure 7a shows simulations of the optimal average tax rates implied by this first order condition for three different elasticities. To be comparable with Saez (2001), the simulations use a skill distribution taken from the 1992 earnings distribution of married U.S. taxpayers and assume a quasilinear utility function and a logarithmic social welfare function.[41] The optimal tax schedule under ironing has two interesting features. First, average tax rates at the bottom are negative. In this model it turns out to be optimal to have a fairly large EITC-like program, even without the extensive-margin considerations that underlie similar conclusions by Liebman (2001) and Saez (2002). The intuition behind this result is that the negative effects of the EITC phase-out in a standard model do not arise in a model in which people are responding to average tax rates – even as the EITC is being phased-out, average tax rates are negative. Second, average tax rates quickly become very high. Once earnings reach $50,000, average tax rates are already at 40 percent.

Figure 7b plots the optimal *marginal* tax rates under the standard Mirrlees model and the ironing version of the Mirrlees model. The results for the standard model use an elasticity of 0.5 and are indistinguishable from those with the same elasticity presented in Saez (2001) . We present results using the ironing model for two different elasticities: 0.5 and 0.8. These two ironing results allow us to conduct two different comparisons. The first comparison – using both results with the 0.5 elasticity – assumes identical preferences for ironers and for rational

[41]Appendix C describes the simulations in further detail.

taxpayers and shows how the optimal tax schedule differs under the two assumptions about how people perceive incentives. The second comparison - using the 0.5 elasticity for the standard model and the 0.8 elasticity for ironing – crudely adjusts for the fact that empirical estimates of taxable income elasticities would generally be higher if they had been calculated under the assumption that people were ironers. Since changes in tax schedules typically result in larger changes in marginal tax rates than in average tax rates, a given change in behavior implies a larger elasticity if people are responding to average tax rates. Thus to be consistent with behavior observed in the past requires an elasticity of 0.5 if people are rational but a higher elasticity if people are ironers. The figure shows that the marginal tax rate approaches the asymptotic rate much more quickly under ironing than under the standard model.

Our overall assessment from these two tax examples is that schmeduling behavior can make a major difference. When schmedulers face a convex schedule, their nonrational behavior increases efficiency. Were the schedule concave, the opposite result would apply. We have proceeded inductively thus far: assume a behavior and distill the consequences. The remainder of our paper is deductive. It presents two empirical studies that test for the presence of schmeduling behavior.

IV. Empirical Tests

This section conducts two empirical tests of schmeduling. The first uses data from before and after the 1998 introduction of the child tax credit to test for ironing. The second uses data from the San Diego food stamp cash out experiment to test for spotlighting. In addition to providing empirical evidence on whether schmeduling is occurring in these two instances, these examples illustrate the kinds of conflicting predictions that can allow one to distinguish between the rational and schmeduling models more generally.

A. 1998 Introduction of the Child Credit

Beginning in 1998, U.S. taxpayers with children could claim a $500 per child tax credit. In most cases, this credit was not refundable. Thus a taxpayer with $500 or less of tax liability could not take advantage of the full credit.[42] Figure 6 illustrates the impact of the introduction of the child credit on marginal and average tax rates at different income levels for a taxpayer in 1998. For the purpose of this figure, the taxpayer is assumed to be married with two qualifying children,[43] claim the standard deduction, and have only wage income.

Before 1998, taxpayers with incomes between about $18,000 and $25,000 owed income tax, and therefore faced a 15 percent marginal tax rate. But beginning in 1998, the child credit eliminated the entire tax liability for these taxpayers and reduced their marginal tax rate from the federal personal income tax to zero. Thus, their marginal tax rate fell by 15 percentage points. All taxpayers with income above $18,000 experienced a reduction in tax liability and therefore a reduction in average tax rates. The reduction in average tax rates grows with income from $18,000 until the point at which a taxpayer can use the entire $1000 (2 children X $500) credit. After that point the reduction in average tax rates falls gradually as the reduction in tax liability remains $1000, but the denominator in the average tax rate calculation, the person's income, rises.

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[42] The credit was partially refundable for some taxpayers with three or more children.
[43] Only children age 17 and under can qualify a taxpayer for the child credit.

The rational model would predict that the reduction in marginal tax rates would induce people with income between \$18,000 and \$25,000 to increase their earnings. We would also expect to see some bunching at \$25,000, the point at which the marginal tax rate jumps from zero to 15 percent after the reform. Because income effects are generally thought to be close to zero, we would expect to see little effect on the earnings of people with incomes above \$25,000, and any effect would be a reduction in earnings due to the income effect.

In contrast, the schmeduling model predicts increased work by anyone whose average tax rate fell – everyone with income above \$18,000. In particular, we would expect to see increased work by people with incomes above \$25,000 and no bunching at that point – two predictions that depart from those of the rational model.

To test these predictions, we use data from the 1997 and 1999 IRS public use Statistics of Income tax files. These files are based around random samples of individual tax returns, but are blurred in various ways to protect taxpayer confidentiality. Our basic approach is to examine whether the change in the distribution of taxpayers by income between 1997 and 1999 looks more like what would be predicted by the rational model or by the ironing model.

In order to be able to predict how individual behavior will change in response to the change in budget constraints, we need to model people's preferences. In particular, given our interest in the bunching of taxpayers at kink points, we cannot simply predict the change by multiplying the percentage change in the after-tax share times an elasticity. We follow Diamond (1998) and Saez (2002) in assuming that preferences take the quasilinear form

$$U = C - \frac{L^{1+K}}{1+K}, \qquad \textbf{(4)}$$

where C is consumption and L is labor effort. Under this specification, there is a single preference parameter, *K*, which is equal to $1/\epsilon$, where ϵ is the labor supply elasticity. There is no income effect in this model. We view this model as the simplest structural analog to elasticity calculations with a constant elasticity. Although the model is specified in terms of an hours of work decision, we follow Feldstein (1999) in viewing the behavioral response to taxes more broadly as any behavior (including compliance, intensity of effort, shifting of compensation into fringe benefit) that affects taxable income. Thus, ϵ should be interpreted as the elasticity of taxable income with respect to 1 minus the after tax share.

The Rational Model

With rational taxpayers, the first order condition from this model is

$$(\mathrm{L}^{*})^{K} = w(1 - t^{*}), \qquad \textbf{(5)}$$

where t^* is the tax rate on the segment of the budget constraint where the taxpayer's optimum lies and w is the taxpayer's wage. By multiplying both sides by w^K and rearranging, it is possible to express w as a function of K and of observable quantities:

$$w = \left[\frac{(wL^*)^{K}}{1-t}\right]^{\frac{1}{K+1}}. \qquad \textbf{(6)}$$

Thus given an elasticity, ϵ, and a distribution of income under a known tax schedule, we can derive the wage distribution and simulate the distribution of income under any other budget constraint (We observe pre-tax income, wL^*, in our data set; given wL^* we know t^* since we know the tax schedule that the taxpayer faces.).

This approach encounters two complications. First, if a taxpayer locates exactly at the kink point between segments with tax rates of t_a and $t_{b,}$ we do not know his exact wage, only that it lies between the two values that would occur from substituting t_a and t_b into the equation above. In practice, only a couple of people in our data set locate exactly at a kink, and we randomly assign those people to a wage between the two implied by t_a and $t_{b,}$ The second complication is more significant. Because there are almost no people exactly at the kink, the wage distribution that is implied by taking observed income and plugging it into the equation derived above from the first order condition implausibly has a noticeable gap in it – with no one (except the people exactly at the kink) at wages between the wage implied by t_a and the wage implied by $t_{b.}$.[44] Our approach is to assume *in our rational model* that taxpayers are uncertain about exactly where the kink is located and so a taxpayer near kink point, *k*, chooses hours of work, *L*, to maximize expected utility where the expectation is over the possible locations of the kink point. Appendix B derives the perceived marginal tax rate given this assumption. It is worth emphasizing that by introducing this uncertainty about the location of the kink point into the rational model we are, in essence, letting the rational taxpayers engage in a bit of schmeduling. The implication is that if we find evidence of schmeduling behavior when we test it against this lenient variant of the rational model, it will be even more powerful evidence that schmeduling is occurring.

[44] The complication is not simply that this gap is implausible. Because the gap is dependent on where the kinks are, the implied wage distribution will change when the tax schedule changes, a feature that would be inconsistent with the estimation approach we describe below.

The Ironing Model

In the ironing model we assume that taxpayers have the same preferences as they do in the rational model (equation 4). However, they respond to average tax rates rather than marginal tax rates. They therefore choose hours, *L*, to satisfy the following tangency condition

$$L^{*K} = w\left(1 - \frac{T(wL^{*})}{wL^{*}}\right) \qquad \textbf{(7)}$$

instead of the conventional one. In this equation, *T(wL*)* is total taxes due at income *wL**, and the marginal disutility of effort is equated with the average return to work rather than the marginal return. Given K and an observed income level, this equation can be used to find *w*.[45] There is no need to introduce uncertainty about the location of the kinks into the ironing model since the wage distribution implied by ironing does not have a discontinuity at each kink point as it did in the rational model.

Econometric Model

We now apply the model above to simultaneously estimate the elasticity, ϵ, and the share of taxpayers who are schmedulers, *s*. Let S be a vector in which the *ith* element equals 1 if the *ith* individual is a schmeduler and 0 if the *ith* individual is rational. The vector of pre-tax incomes in the two years is given by:

$$\begin{aligned} m_{97} &= S\mu_S(f_{97},\varepsilon,w) + (1-S)\mu_R(f_{97},\varepsilon,w,\sigma_K) + \nu_{\sigma_O} \\ m_{99} &= S\mu_S(f_{99},\varepsilon,w(1+\gamma)) + (1-S)\mu_R(f_{99},\varepsilon,w(1+\gamma),\sigma_K) + \nu_{\sigma_O} \end{aligned} \qquad \textbf{(8)} \quad .$$

[45] In the rational model there is an explicit analytical expression for *w*. In the ironing model, a simple numerical procedure is needed to solve for *w*.

Income, *m*, is determined by the functions μ_S and $\mu_{R,}$ which generate an earnings level for a schmeduler and a rational taxpayer respectively as a function of the tax schedule in each year, f_{97} and f_{99}, the elasticity, ϵ, and a vector of taxpayer wages. In the rational case, there is an extra parameter, σ_k, which reflects the amount of uncertainty about where kinks in the schedule are located. γ is a parameter that describes the amount of nominal wage growth between the two years. $\nu_{\sigma,}$ is a Gaussian random variable representing optimization error; its standard deviation is $\sigma_{O.}$

Two key assumptions identify our model. First, the wage distribution in 1999 equals the wage distribution in 1997 inflated by $1+\gamma$. This assumption is similar to the assumption that underlies most natural experiment studies of tax reforms.[46] Second, the probability that a taxpayer is a schmeduler is the same at all wage levels. While we think this assumption is unlikely to be strictly true, we think it is a reasonable approximation within the relatively narrow income range that is our focus with the expansion of the child credit. With sufficient sample sizes and variation in tax rates, our methodology can be extended to estimate a wage-varying schmeduling probability.

Our econometric procedure chooses ϵ, s, and γ along with a mean and variance for the log wage distribution and then simulates the implied income distribution in each of the two years. It then searchs over values of the five parameters to find those that minimize the distance between the simulated income distribution and the observed income distribution.[47]

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[46] We thank Alberto Abadie for suggesting this formulation of our first identifying assumption.

[47] We currently set σ_K=$4000, the minimum level that produces a reasonable wage distribution (i.e. with no sharp reduction in density at the kink points) for all elasticities under 1. We set σ_O=$2000 based on the evidence in Saez (2002). In principle one could estimate both of these parameters as well. Our minimum distance calculation separates the data into 20 bins (defined to each contain 5 percent of the true data) and minimizes the sum of the product of the fractions in each bin in the real data and the fractions in each bin in the simulated data.

Our results are preliminary. Using data generated with known parameter values, our numerical procedure for finding the parameter values that minimize the distance between the simulated and actual data frequently selects only a local minimum. We are not yet confident that we have found the global minimum in the real data.

Data and Results

We limit our sample to married couples with at least two children. For these households, the introduction of the child tax credit provided a new tax credit of at least $1000.[48] Our tax model consists of the federal income tax (including the EITC) and the OASDI and HI payroll taxes (modeled as a proportional tax of .0765). We ignore state taxes. To study the full range of behavioral responses to taxation we define income as adjusted gross income minus itemized deductions above the standard deduction. In essence, we treat the sum of the standard deduction and personal and dependent exemptions as a tax bracket with a zero tax rate, rather than subtracting these amounts from adjusted gross income to define income.

Before turning to results, it is worth asking whether this change in taxes is large enough to allow us to distinguish between the two models. Figures 6A and 6B demonstrate that the two models create noticeably different income distributions. Figure 6A takes the 1997 sample and shows how introducing the child credit in 1997 would have changed the income distribution in that year under the rational model and under the schmeduling model.[49] In particular, it shows the change in income from introducing the child tax credit plotted against 1997 income with an

[48] In claiming the child credit, taxpayers could claim only those children age 17 and below. We cannot implement this restriction in our data because we do not observe the age of the children in the 1997 data. Therefore, we simply assume that all taxpayers with dependent children living at home claim the child credit.

[49] For these simulations, the standard deviation of the kink error is set at $3000 and the optimization error is set at $2000.

elasticity of 0.40. Under the rational model, taxpayers with incomes between about $10,000 and $25,000 increase their income. But there is no change for taxpayers who are more than a few thousand dollars above the new kink at roughly $25,000 (due to uncertainty about the kink point, a few taxpayers above the kink are affected by the change even in the rational model). Under the schmeduling model, taxpayers just above the kink have relatively large responses and the dollar response remains relatively constant for the full range of the income distribution.[50] Figure 6B shows the CDF of income under the two models. There is a noticeable difference in the schmeduling and rational income distributions between roughly $18,000 and $28,000. In particular, the rational taxpayers who increase their incomes in response to the reduction in marginal tax rates produce a deficit of taxpayers between about $18,000 and $25,000 and the rational CDF is therefore below the ironing CDF over this range. Then the concentration of taxpayers around the kink point in the rational model causes a sudden jump in the CDF around $25,000. Just above this income level is where taxpayers experience the largest reductions in average tax rates. Because of this, the schmeduling CDF falls below the rational CDF as schmedulers who otherwise would have been in this range increase their incomes in response to the reduction in their average tax rates.

Table III shows our results from estimating our model on the actual data. We estimate that the elasticity of income with respect to the after-tax share is 0.38, that 54 percent of taxpayers are schmedulers, and that nominal wage growth was 4.7 percent over this period.[51]

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[50] In percentage terms, the increase in income falls with income above the kink at the start of the 15 percent bracket. Therefore, if the income growth term, γ, is multiplicative, we can separately identify income growth and schmeduling.

[51] The 1979 increase in the level of earnings subject to the OASDI payroll tax provides another natural experiment in which the predictions of the ironing model and the rational model differ and in which the methodology presented here could be applied.

B. *The Within-month Pattern of Food Consumption by Food Stamp Recipients*

Our second empirical test addresses the spotlighting model, looking at food consumption by those reeciving food stamps. Our principal hypothesis is that inframarginal food stamp recipients – those who spend more than the food stamp amount on food during the month – nonetheless view the cost of spending a dollar of food stamps on food as less than a dollar in terms of lost consumption of other goods. Before they have exhausted their food stamps, they respond, in part, to the local price of spending a dollar of food stamps, which they perceive as far less than one dollar (pure spotlighting would infer a price of zero). That is, during the early period of the month, they fail to realize that the cost of a marginal dollar of food consumption is one dollar. Then, after they have exhausted their food stamps and must spend cash for food, they perceive the true marginal cost of their food. The empirical prediction of the spotlighting model for food consumption by food stamp recipients is that food consumption should fall through the month as recipients exhaust their stamps. No such pattern would occur with rational consumers. A priori, finding evidence of such behavior might seem unlikely, since food stamp recipients get to play the game many times; every month they get food stamps.

If we had data only on food consumption by food stamp recipients, however, it would be hard to distinguish spotlighting from several other hypotheses that could also explain declining food consumption during the month after benefit payment. For example, myopic consumers might also have declining consumption throughout the month, as would consumers who consume a constant minimum level throughout the month but run out of income at the end of the month (and perhaps consume at a higher level at the beginning of the month because they are hungry from running out of income at the end of the previous month).[52]

In order to isolate the pure spotlighting effect, we use data from the 1989-1990 San Diego food stamp cash out experiment.[53] In this experiment, a random sample of the food stamp caseload had their food stamp checks replaced by an equal amount of cash benefits.[54] These data are useful for testing spotlighting because they allow us to distinguish our theory from other possible explanations for declining food consumption during the month after benefit payment. In particular, for the myopic, hyperbolic discounting, and food insecurity theories, there is no reason why the slope of consumption throughout the month should change if stamps were converted to cash. If spotlighting is occurring, in contrast, we would expect to see a greater decline in consumption throughout the month for consumers who are paid in food stamps than for consumers who are paid in cash.

Our base sample consists of all sample members for whom there is complete food consumption data (a total of 541 receiving food stamps and 537 receiving cash). However, we

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[52] We thank Jesse Shapiro for helping us with the data used in this section of the paper. Shapiro (2003) provides evidence suggesting that food consumption by food stamp recipients is consistent with hyperbolic discounting.

[53] Although we describe the cashed out recipients as receiving "cash," they actually received their payment in a check.

[54] Mathematica evaluated this experiment for the Department of Agriculture and collected data on food consumption from about 600 randomly selected food stamp recipients and from another 600 who had had their benefits cashed out. Mathematica's evaluation estimated the impact of cash out on average food use at home and concluded that it reduced food use at home by between 5 and 8 percent (Ohls et al 1992) . Whitmore (2002) reevaluated these data, focusing on the difference between marginal and inframarginal consumers as a way to estimate the deadweight loss from paying in food stamps rather than in cash. She found that inframarginal consumers do not alter their food consumption when converted to cash, but that "distorted" food stamp recipients do reduce their consumption, and that they value their stamps at only 80 percent of face value. A similar experiment occurred around the same time in Alabama. However, as Whitmore (2002) discusses, the data from this second experiment are less reliable, both because of its limited duration and because caseworkers coached cash recipients not to change their food consumption. In addition, we have been unable to learn the institutional details about AFDC payout dates in Alabama during this period and therefore cannot estimate our model on these data. We thank Jesse Shapiro for helping us with these data. Shapiro (2003) provides evidence suggesting that food consumption by food stamp recipients is consistent with hyperbolic discounting.

want to restrict the sample to inframarginal consumers – those who would consume more than their food stamps if they received their payment in food stamps.. To identify these consumers we run a probit regression in the food stamp sample with a dependent variable that is one if the household consumed more than their food stamps during the survey month.[55] The independent variables are indicators for household size and a fourth degree polynomial in food stamp benefit level (the food stamp benefit levels in this study are obtained from administrative payment records). We use this estimated equation to predict a probability of being inframarginal for households in both the cash and the food stamp group. Then we limit our sample to households with a predicted probability of 0.95 or above. This results in a sample of 349 in the cash group and 366 in the food stamp group. In this restricted sample, over 98 percent of households in each group spent more on food than they received in food stamps and the percentages are nearly identical in the two groups.

We use two dependent variables in our regressions testing our hypothesis: total dollars of food consumed during the survey week and total calories of food consumed during the survey week, both measured in natural logarithms.[56] Our OLS regression specification is:

(8) $\ln(\text{food consumption})=\beta_0+\beta_1(\text{paid in cash})+\beta_2(\text{days since last AFDC check})+\beta_3(\text{days since last AFDC check}) \times (\text{food stamps paid in cash})+\beta_4(\text{days since last food stamp check}) \times (\text{paid in food stamps}) +\gamma X +\epsilon.$

AFDC benefits were paid on the first of the month. Cash recipients received their cashed-out food stamp payment as part of the same check. In contrast, food stamp recipients received their

[55] Since food data is collected for only one week in this study we scale up the food consumption by # days in month/7.

[56] The Mathematica data set contains an elaborate set of variables measuring the nutritional value of all of the foods consumed by each household.

food stamp checks at roughly uniform intervals throughout the month. Thus, β_2 should capture the relationship between days since AFDC receipt and food consumption for the entire sample. β_3 should capture any differential relationship between days since AFDC receipt and food consumption for those in the cashed-out group who also received their food stamp payment with their AFDC check. β_4 is the key parameter for testing our hypothesis. In measures the relationship between the number of days since food stamp receipt and food consumption for those receiving food stamps. X is a set of covariates that are assumed not to be affected by the experiment: dummy variables for calendar month and household size and interactions between these variables and treatment group.[57]

Table 4 shows the results from our regressions. The dependent variable is the log of food consumption, either measured in dollars (column 1) or in calories (column 2). First, consider column 1. The point estimates for days since last AFDC check in the first column represents a 0.22 percent per day reduction in consumption or a total decline of about 7 percent over the month. The coefficients on the interaction between AFDC receipt and payment in cash are positive. However, neither the coefficient on days since AFDC check receipt or on the interaction of days since AFDC receipt with cash payment are statistically different from zero and their coefficients cancel out, suggesting no overall within-month pattern of food consumption for those receiving all of their benefits in cash.

For those paid in food stamps, the estimates suggests a fairly sharp drop off in consumption over the food stamp month. The coefficient on the interaction between "days since food stamp payment" and "payment in stamps rather than checks" is about 0.8 percent per day,

[57]We have explored the sensitivity of our results to including a more elaborate set of covariates. As would be expected given the independence between covariates and treatment assignment (due to the random assignment), the results are quite insensitive to including additional covariates.

and has a p-value of .051.   Thus, individuals receiving payments through food stamps reduce food consumption by about 24 percent over the month.

This pattern of declining food consumption for those paid in food stamps is not apparent when food consumption is measured in calories, although the difference between the two food stamp coefficients (the second and third rows) is similar in the two specifications.[58] One possible explanation for this pattern is that the nutritional content of food purchases changes over the month as food stamps and money become scarce. This interpretation of the results is consistent with Whitmore's (2002) findings for the overall effects of the cash out experiment on food consumption.

VI. Conclusion

We have argued that schmeduling is likely to be a common form of economic behavior, that it arises in substantively important areas of economic decision making, and that the welfare effects of people responding to schmedules rather than to their true schedules are likely to be large and to have significant policy implications.   Moreover, because the conditions that give rise to schmeduling are found in many economic environments, empirical evidence on how people respond to schedules in one environment will help us predict how people will react when faced by schedules in other environments. We have provided two empirical tests of schmeduling. The tests are not conclusive. However, in both cases the data are consistent with the presence of a significant amount of schmeduling.

[58] An F-test of the hypothesis that the food stamp coefficients are equal for the cash and stamp samples has a p-value of .17 in the first column and .19 in the second column.

Appendix A

Herrnstein (1961) demonstrated what he called the matching law: hungry pigeons, choosing which of two response keys to peck, peck on each lever in proportion to the amount of reinforcement (food) obtained by pecking on that lever.[59] The theory of melioration – that subjects act to equalize the average return to all choices (keys pecked) – explains matching behavior (Herrnstein and Vaughn, 1980; Herrnstein, 1982). Such behavior is suboptimal if the frequency of pecks affects payoffs (such as when there are diminishing returns to pecking on a given key).

Melioration predicts behavior that incorporates important elements of both ironing and spotlighting. First, like ironing, melioration predicts that organisms will respond to average returns. As Herrnstein (1990) explains: "It should soon be evident that the fundamental difference between matching and utility maximization is that matching is based on average returns (in utility or reinforcement) over some extended period of activity, while maximization requires a sensitivity to marginal returns at each moment . . ." Second, like spotlighting, melioration predicts that organisms will respond to local rather than global payoffs. As Herrnstein (1982) explains: "[Melioration requires] the organism to respond only to the difference between local reinforcement rates from individual behaviors. Maximization, in contrast, requires the selection of the biggest aggregation of reinforcement across behaviors." Experiments in which melioration and maximization predict different behaviors have almost always found that behavior follows the predictions of melioration.

[59] By 1976, similar results had been obtained from rats, monkeys, and humans (De Villiers and Herrnstein, 1976), and the matching law had been shown to apply to variations in the quantity of reinforcement obtained (as opposed to the frequency of reinforcement) and to the decision of how often to engage in a single activity (as opposed to the choice between two different options). The introductory essays by Rachlin and Laibson (1997) are indispensable in understanding this literature.

Pigeons Ironing. A 1981 pigeon experiment is instructive (Mazur, 1981).[60] It involved periods of darkness possibly yielding food payoffs. The darkness was available at random intervals, but could be secured only by pecking the then correct key, the two keys being equally likely. But given darkness, one key paid off with higher frequency than the other. The time to a new potential darkness interval and the key that would trigger it were then selected at random. The pigeons pecked far too often on the high payoff frequency key, selecting a ratio close to that predicted by melioration (in proportion to the frequency of payoff), and far from the more balanced maximizing ratio. (Half the time, pecking the low-payoff key was the only way to advance to the next potential darkness period). Pigeons equalized average returns, not marginal returns.

Humans Spotlighting. Spotlighting arises when current choices affect future payoffs, hence immediate and marginal payoffs diverge. Psychologists' experiments have created such schedules for both humans and pigeons, and shown that both species respond to the immediate payoffs.

In one such experiment, human subjects were asked to choose between the left and right arrows on a computer keyboard in exchange for monetary rewards (Herrnstein and Prelec, 1991). The subjects observed their monetary reward accumulate on a computer screen, which showed pennies falling. Each time a key was pressed, a penny fell, but a key could not be pressed again until the penny completed its fall. Pushing the right key caused the penny to fall two seconds faster than the left key, thus offering a higher instantaneous reward. However, the greater the fraction of right-key presses in the past 10 choices, the slower the pennies fell, regardless of the

[60] Our accounts of these studies are based upon Herrnstein (1982).

choice. The exact parameters made it optimal to press the left key exclusively. However, almost all of the subjects exclusively picked the right option after a few trials. Subjects responded to the immediate reinforcement rate, and did not come close to optimizing against the true schedule.

Pigeons Spotlighting. When subjects – be they pigeons or humans – are presented with complex schedules, it can be almost impossible to discern marginal payoffs. Figures 1a and 1b show the schedules respectively of a pigeon reward experiment (Vaughn, 1981) and of a married U.S. taxpayer with two children (Council of Economic Advisors, 2003); they look like Rorshach Test equivalents. In the pigeon experiment payoffs depended on pecks in the previous four minutes. The highest payoffs came if the right key was pecked between 12.5 percent and 25 percent of the time, the lowest if it was pecked between 75 percent and 87.5 percent of the time. However, actual delivery of the rewards occurred mostly after a peck on the right key. The three pigeons in this experiment all ended up spending between 75 and 80 percent of their time on the right key, spotlighting as they responded to instantaneous payoffs – and found, alas, the global minimum.

Our empirical section analyzes human response to complex schedules, though none as complex as the one in Figure 1b. Interestingly, even the Council of Economic Advisors – which did not have to peck or earn in real time to discover it – could not present this schedule correctly. The income level at which the phase-out of the EITC begins is mislabeled.

Appendix B. Spotlighting Losses With Continuous Consumption

We compute spotlighting's deadweight losses when consumption is continuous, as it is say for water. Let x[p(t)] be the consumer's instantaneous demand at time t, and T be the length of the accounting period. Define the cumulative demand through time t as F(t) = $\int_0^t x[p(s)]ds$.

The price at time t, p(t), equals p_1 if F(t)<k and equals p_2 if F(t)>= k (where k is the kink point – the level of cumulative demand at which the price switches from p_1 to p_2).

Total consumption under spotlighting is $F(T) = \int_0^{\hat{t}} x(p_1)dt + \int_{\hat{t}}^{T} x(p_2)dt$, where $\hat{t}$ is the amount of time it takes to exhaust the first price-segment and therefore solves $\int_0^{\hat{t}} x(p_1)dt = k$. This relationship implies that $x(p_1)\hat{t} = k$, or $\hat{t} = \frac{k}{x(p_1)}$. Therefore,

$F(T) = \int_0^{\frac{k}{x(p_1)}} x(p_1)dt + \int_{\frac{k}{x(p_1)}}^{T} x(p_2)dt$, which implies that total consumption under spotlighting is:

$$F(T) = x(p_1)\frac{k}{x(p_1)} + x(p_2)T - x(p_2)\frac{k}{x(p_1)} .$$

Total consumption for a rational consumer is simply $F(T) = \int_0^T x(p_2)dt = x(p_2)T.$

Subtracting total rational consumption from total spotlighting consumption yields the excess consumption under spotlighting: $k\left(1 - \frac{x(p_2)}{x(p_1)}\right)$. Intuitively, excessive consumption rises with *k*, because a larger *k* implies that the consumer is responding to the wrong price a greater fraction of the time. In addition, excess consumption is larger the bigger the gap between demand at p_2 to demand at p_1. In contrast if consumption is completely inelastic and $x(p_2)$ equals $x(p_1)$ there is no excess consumption.

Integrating excess consumption between the two prices yields the deadweight loss:

$DWL = \frac{k}{x(p_1)} \int_{p_1}^{p_2} [x(p_1) - x(z)] dz$, where $\frac{k}{x(p_1)}$ represents the amount of time that the individual is overconsuming, and the integral gives the instantaneous DWL during these periods of overconsumption.[61]

[61]Moving the initial $x(p_1)$ to the inside of the integral yields an expression that is quite similar to the expression for the amount of over-consumption, and, not surprisingly, demonstrates that the same conditions for when over-consumption will be high apply to deadweight loss as well – deadweight loss rises with *k* and with the elasticity of demand.

C The Mirrlees Problem when Taxpayers Respond to Average Tax Rates

We follow the notation and approach of Diamond (1998). n is the worker's skill level. $x(n)$ represents consumption by a person with skill level n. $y(n)$ is labor supply in percentage terms of a person with skill level n. Utility takes the quasilinear form

$$u(x, y) = x(n) + v(1 - y), \tag{C-1}$$

where $v(1 - y)$ is the disutility of effort. The social planner's objective is to maximize social welfare,

$$max \int_{n_0}^{n_1} G\left\{U\left[x\left(n\right), y\left(n\right)\right]\right\} f\left(n\right) dn, \tag{C-2}$$

subject to the budget constraint,

$$\int_{n_0}^{n_1} T\left[ny\left(n\right)\right] f\left(n\right) dn \geq E, \tag{C-3}$$

and to an incentive-compatability constraint for each individual. In these last two equations, $G\left\{U\right\}$ is the social welfare function, $f(n)$ is the skill distribution, E is government spending, and $T\left[ny\left(n\right)\right]$ represents taxes as a function of earnings.

With these definitions, the expression for utility can be rewritten as:

$$\begin{aligned} u(x, y) &= x + v\left(1 - y\right) & \text{(C-4)} \\ &= ny - T\left[ny(n)\right] + v(1 - y). & \text{(C-5)} \end{aligned}$$

The first order condition for individual optimization under the standard model is

$$v'\left[1 - y(n)\right] = n\left\{1 - T'\left[ny(n)\right]\right\}. \tag{C-6}$$

However when the taxpayer is an ironer and instead responds to average tax rates, the FOC becomes

$$v'\left[1 - y(n)\right] = n\left\{1 - \frac{T\left[ny(n)\right]}{ny(n)}\right\}. \tag{C-7}$$

C.1 The Mirrlees First Order Condition

To solve this problem, note that equation C-7 can be rewritten as

$$T\left[ny(n)\right] = y(n)\left[n - v'[1 - y(n)]\right] \tag{C-8}$$

and substituted for $T[ny(n)]$ in the social welfare objective. This substitution allows us to solve the Mirrlees problem by forming a simple Lagrangian rather than the Hamiltonian that is necessary in the standard version of the problem:

$$\mathcal{L} = G\left[v + yv'\right] - p\left[y(n)v'[1 - y(n)] - ny(n)\right] f(n)dn. \tag{C-9}$$

Differentiate with respect to $y(n)$ to get

$$G'(u)\left(-yv''\right) - p\left[v' - yv'' - n\right] = 0. \tag{C-10}$$

To interpret this expression, it is useful to substitute for v' and v''. We can eliminate v' using $v' = n\left[1 - \frac{T(ny)}{ny}\right]$ from equation C-7. To eliminate v'', we first derive an expression for the elasticity of labor supply with respect to 1 minus the perceived after tax wage. Note that from taking the derivative of the schmeduling FOC (equation C-7) with respect to $n\left[1 - \frac{T(ny)}{ny}\right]$ we get

$$\frac{dy}{dn(1 - \frac{T(ny)}{ny})} = \frac{-1}{v''}. \tag{C-11}$$

The elasticity therefore equals

$$e(n) = \frac{dy}{dn(1 - \frac{T(ny)}{ny})} \frac{n(1 - \frac{T(ny)}{ny})}{y} = \frac{-v'}{yv''}, \tag{C-12}$$

which is the same as in the standard case. Rearranging equation C-10 and substituting we get

$$
\begin{aligned}
G'(u) &= \frac{p\left[v' - yv'' - n\right]}{(-yv'')} && \text{(C-13)}\\
&= p\left[e + 1 + \frac{n}{yv''}\right]\\
&= p\left[e + 1 + n\frac{v'}{yv''}\frac{1}{v'}\right]\\
&= p\left[e + 1 - ne\frac{1}{n\left\{1 - \frac{T[ny]}{ny}\right\}}\right]\\
&= p\left[e + 1 - e\frac{1}{1 - ATR}\right]\\
1 - \frac{G'(u)}{p} &= -e + e\frac{1}{1 - ATR}\\
\left[1 - \frac{G'(u)}{p}\right]\frac{1}{e} &= \frac{1}{1 - ATR} - 1\\
\frac{ATR}{1 - ATR} &= \left[1 - \frac{G'(u)}{p}\right]\frac{1}{e} && \text{(C-14)}
\end{aligned}
$$

C.2 Perturbation Approach

The same result can be obtained using the perturbation approach of Saez(2001). At the optimum, the revenue gain from a small increase in taxes, weighted by the average social welfare weight, must equal the welfare loss for the people on whom the taxes were increased. Let M be the mechanical revenue effect, B be the behavioral revenue effect, p be the average welfare weight, and $G'(u)$ be the welfare weight on the people whose taxes are being increased:

$$p(M + B) = G'(u)M. \qquad \text{(C-15)}$$

Given ironing, if we raise a person's average tax rate by dt, we have the following:

Direct revenue effect: $M = nydt$.

Behavioral revenue effect: $e = \frac{dR}{d(1-ATR)}\frac{(1-ATR)}{R}$, so $B = dR = eR\frac{d(1-ATR)}{1-atr} = e(ATR)(ny)\frac{-dt}{1-atr} = -\frac{ATR}{1-ATR}(ny)edt$.

Welfare effect: $\quad -G'(u)nydt.$

Plugging these components into equation C-14, we get:

$$\begin{aligned} p\left[nydt - \frac{ATR}{1-ATR}(ny)edt\right] &= -G'(u)nydt \qquad \text{(C-16)} \\ 1 - e\frac{ATR}{1-ATR} &= -\frac{G'(u)}{p} \\ \frac{ATR}{1-ATR} &= \frac{1}{e}\left[1 - \frac{G'(u)}{p}\right]. \end{aligned}$$

C.3 Asymptotic tax rate

The asymptotic tax rate can be derived directly from the FOC under the assumption that $\frac{G'(u)}{p} \to 0$ asymptotically. This yields:

$$ATR = MTR = \frac{1}{e+1} \qquad \text{(C-17)}$$

More generally, the optimal rate above a given income level can be determined as in Saez (2001) by defining $\bar{g}$ as the ratio of the average social welfare weight on those above the given income level to the overall average. Then the optimal rate on high-income taxpayers becomes

$$ATR = MTR = \frac{1-\bar{g}}{e+1-\bar{g}} \qquad \text{(C-18)}$$

C.4 Numerical Simulations

Traditionally, empirical simulations of the optimal tax schedule have relied on numerical solution of the Mirrlees differential equations. However, Saez has proposed an alternate numerical approach based directly on the first order condition that is much easier (and appears to be more reliable) than solving the differential equations. Under the Saez method, one guesses an initial tax schedule (say a 25 percent marginal rate at all income levels), finds the optimum for each skill level under that tax schedule, and then generates a new tax schedule by calculating the value of the right hand side of the FOC at this new set of optima. One then solves for either the marginal tax rate (in the traditional Mirrlees problem) or the average tax rate (when taxpayers are responding to average tax rates). One repeats this process by using the new tax schedule in place of the initial tax schedule until the process converges.

For comparability, we follow Saez (2001) in our data construction and assumptions. We assume that utility takes the quasilinear form, $U = C + \frac{L^{1+K}}{1+K}$, and that social welfare is $\ln(u)$. We take the earnings of married couples from the 1992 Statistics of Income public use tax file and invert the first order condition to obtain the skill distribution, given the assumption that people faced a flat 25 percent tax schedule. We also impose a lower-bound on the skill level at the skill level implied by a 1992 earnings level of $5000. We assume that government (non-transfer) spending is 20 percent of actual 1992 pre-tax earnings for our sample of married taxpayers.

One subtlety in the simulations for the ironing model is the treatment of lump-sum transfers. Would providing a lump-sum transfer to all workers reduce average tax rates and increase work? Our assumption is that lump-sum transfers do not affect people's perceptions of their return to work. However, without imposing further constraints, this assumption about lump-sum transfers (along with our chosen utility function) would produce an optimum with a large lump sum tax and a hugely negative tax rate at the lowest income level corresponding to positive earnings. We avoid this unreasonable result by assuming that ten percent of the population is made up of non-workers. This produces an endogenously chosen positive level of lump-sum transfers at zero income. More generally, the simple Mirrlees model with quasi-linear preferences is not a very good model for thinking about the labor force participation decision of people at very low skill levels. Models such as Saez (2002b) and Liebman (2002) that explicitly consider the extensive margin are more appropriate.

Appendix D: The Rational Model with Uncertainty about the Location of the Kink

We assume that a taxpayer near kink point, *k*, chooses hours of work, *L*, to maximize expected utility where the expectation is over the possible locations of the kink point.

(B1) $$E[U(L)] = \int_{-\infty}^{wL} p(k)\left[wL - kt_L - t_H(wL - k)\right]dk + \int_{wL}^{\infty} p(k)\left[wL - t_L wL\right]dk - \frac{L^{1+K}}{1+K}.$$

In this equation, t_L is the tax rate on the segment of the tax schedule just below the kink point at *k*, t_H is the tax rate on the segment of the tax schedule that starts at *k*, and *p(k)* is the probability distribution function of *k*. The first term in the equation is after-tax income (consumption) when the kink point is below *wL* and the second term is after-tax income when the kink point is above *wL* . If we further assume that the uncertainty is distributed normally with mean at the true kink point and standard deviation $\sigma_{k,}$ the expression can be rewritten as:

(B2) $$E\left[U(L)\right] = \Phi(wl)wL(1 - t_H) + \int_{-\infty}^{wL} p(k)k(t_H - t_L)dk + (1 - \Phi(wl))wL(1 - t_L) - \frac{L^{1+K}}{1+K}$$

where Φ is the normal CDF. The first order condition is (surpressing the argument of Φ):

(B3) $$0 = \Phi' w^2 L(1 - t_H) + w(1 - t_H)\Phi + w(1 - t_L)\Phi - \Phi' w^2 L(1 - t_L) - w(1 - t_L)\Phi - L^K$$

Multiplying through by *L* and replacing wL with Y (the income observed in the data), we can express L as a function of observed quantities:

(B4) $$L = \left[Y(1 - t_H)\Phi + Y(1 - t_L)(1 - \Phi) + \Phi' Y^2(1 - t_H) - \Phi' Y^2(1 - t_L)\right]^{\frac{1}{K+1}}.$$

We can then determine *w* as *Y/L*. Thus, in our rational model, we have two preference parameters *K* (the inverse of the labor supply elasticity) and σ_k, *(*the amount of uncertainty around the location of kink points). It can be shown that the marginal tax rate perceived by the taxpayer near the kink point between t_a and t_b in this model is a weighted average of t_a and t_b:

(B5) $$mtr(Y) = t_a(1 - \Phi(Y)) + t_b\Phi(Y).$$

References

Auerbach, Alan J. and Laurence J. Kotlikoff (1985). The Efficiency Gains from Social Security Benefit-Tax Linkage. NBER Working Paper 1645.

Auten, Gerald, and Robert Carroll (1997). The Effects of Income Taxes on Household Behavior. Office of Tax Analysis, U.S. Department of the Treasury.

Bernheim, B. Douglas and Antonio Rangel (2002). Addiction and Cue-conditioned Cognitive Processes. NBER Working Paper 9329.

Bises, Bruno (1990). Income Tax Perception and Labour Supply in a Sample of Industry Workers, *Public Finance*, 1:3-17.

Brannas, Kurt and Niklas Karlsson (1996). Estimating the Perceived Tax Scale within a Labor Supply Model. *Economic Letters*, 52:75-79.

Break, George (1957). "Income Taxes and Incentives to Work: An Empirical Study," *American Economic Review*, 47:529-549.

Brown, C.V. (1968). Misconceptions About Income Tax and Incentives. *Scottish Journal of Political Economy*, February: pp1-12.

Burtless, Gary and Robert Moffitt (1984). The Effect of Social Security Benefits on the Labor Supply of the Aged. In Henry Aaron and Gary Burtless, editors. *Retirement and Economic Behavior*. Brookings Institution: Washington, 135-174.

Courant, Paul N., Edward M. Gramlich, and Daniel L. Rubinfeld (1979). The Stimulative Effects of Intergovernmental Grants: Or Why Money Sticks Where It Hits. In Mieszkowski, Peter, and William H. Oakland, editors, *Fiscal Federalism and Grants-in-Aid*. Washington, D.C.: Urban Institute. Pp. 5-21.

de Bartolome, Charles A.M. (1995). "Which Tax Rate Do People Use: Average or Marginal?" *Journal of Public Economics*, 56:79-96.

de Villiers, Peter A. and Richard J. Herrnstein. (1976). "Toward a Law of Response Strength," *Psychological Bulletin*, 83:1131-1153. Reprinted in Richard J. Herrnstein, *The Matching Law: Papers in Psychology and Economics* , edited by Howard Rachlin and David I. Laibson, (Cambridge, Harvard University Press), 1997.

Diamond, Peter (1998). "Optimal Income Taxation: An Example with a U-Shaped Pattern of Optimal Marginal Tax Rates," *American Economic Review*, 88, 83-95.

Dickert, S., S. Hauser, and J.K. Scholz (1994). Taxes and the Poor: A Microsimulation Study of Implict and Explicit Taxes. *National Tax Journal* 47: 76-97.

Eissa, Nada (1995). Taxation and Labor Supply of Married Women: the Tax Reform Act of 1986 as a Natural Experiment. NBER Working Paper No. 5023.

Eissa, Nada and Jeffrey Liebman (1996). The Labor Supply Impact of the Earned Income Tax Credit. *Quarterly Journal of Economics*, 111, 605-637,

Feldstein, Martin (1995). The Effect of Marginal Tax Rates on Taxable Income: A Panel Study of the 1986 Tax Reform Act. *Journal of Political Economy*, 103:551-572.

Feldstein, Martin (1999). Tax Avoidance and the Deadweight Loss of the Income Tax, *Review of Economics and Statistics*, 81: 674-680.

Friedberg, Leora (2000). The Labor Supply Effects of the Social Security Earnings Test. *Review of Economics and Statistics*, 82: 48-63.

Friedman, Lee S. (2002). Bounded Rationality versus Standard Utility-Maximization: A test of Energy Price Responsiveness. In Rajeev Gowda and Jeffrey C. Fox, editors, *Judgments, Decisions, and Public Policy*. Cambridge: Cambridge University Press.

Fujii, Edwin T. and Clifford B. Hawley (1988). On the Accuracy of Tax Perceptions, *Review of Economics and Statistics*, 344-347.

Giannarelli, L. and E. Steuerle (1995). It’s Not What You Make, It’s What You Keep: Tax Rates Faced by AFDC Recipients. Paper presented at the APPAM Annual Research Conference.

Goolsbee, Austin (2000). It’s Not About the Money: Why Natural Experiments Don’t Work On the Rich. In Slemrod, Joel (editor), *Does Atlas Shrug? The Economic Consequences of Taxing the Rich*. Cambridge University Press, Cambridge.

Grogger, Jeff and Charles Michalopoulous (1999). Welfare Dynamics Under Time Limits. NBER Working Paper 7353.

Gruber, Jonathan and Peter Orszag (1999). What to Do About the Social Security Earnings Test? Center for Retirement Research Issue Brief 1999:1.

Gruber, Jonathan and Emmanuel Saez (2002). “The Elasticity of Taxable Income: Evidence and Implications,” *Journal of Public Economics*, 84:1-32.

Hausman, Jerry (1981). “Labor Supply” in Henry Aaron and Joseph Pechman (editors) *How Taxes Affect Economic Activity* (Brookings, Washington, DC).

Heckman, James (1983). "Comment on Stochastic Problems in the Simulation of Labor Supply" in Martin Feldstein (editor) *Behavioral Simulation Methods in Tax Policy Analysis*.

Heim, Bradley T. and Bruce D. Meyer (2003). Work Costs and Nonconvex Preferences in the Estimation of Labor Supply Models. NBER Working Paper 9429.

Barthold, Thomas A., Thomas Koerner, and John F. Navratil (1998). Effective Marginal Tax Rates Under the Federal Individual Income Tax: Death by One Thousand Pin Pricks? *National Tax Journal*, 51: 553-564.

Herrnstein, Richard J. (1961). "Relative and Absolute Strength of Response as a Function of Frequency of Reinforcement." *Journal of the Experimental Analysis of Behavior*, 4: 267-272. Reprinted in Richard J. Herrnstein, *The Matching Law: Papers in Psychology and Economics* , edited by Howard Rachlin and David I. Laibson, (Cambridge, Harvard University Press), 1997.

Herrnstein, Richard J. and Heyman, G. M.(1979). "Is Matching Compatible with Reinforcement Maximization on Concurrent Variable Interval, Variable Ratio?" *Journal of the Experimental Analysis of Behavior*, 31, 209-223.

Herrnstein, Richard J. (1982). "Melioration as Behavioral Dynamism." Reprinted in Richard J. Herrnstein, *The Matching Law: Papers in Psychology and Economics* , edited by Howard Rachlin and David I. Laibson, (Cambridge, Harvard University Press), 1997.

Herrnstein, Richard J. (1990). "Rational Choice Theory: Necessary but Not Sufficient." *American Psychologist*, 45: 356-367. Reprinted in Richard J. Herrnstein, *The Matching Law: Papers in Psychology and Economics* , edited by Howard Rachlin and David I. Laibson, (Cambridge, Harvard University Press), 1997.

Herrnstein, Richard J. (1991). "Experiments on Stable Suboptimality in Individual Behavor." *American Economic Review* (May), 81: 360-364.

Herrnstein, Richard J. and Drazen Prelec (1991). "Melioration: A Theory of Distributed Choice," *Journal of Economic Perspectives*, 5:137-156.

Herrnstein, Richard J. and Vaughan, w., Jr. (1980). "Melioration and Behavioral Allocation." In J.E.R. Staddon (ed.), *Limits to Action: The Allocation of Individual Behavior* (New York: Academic Press).

Hines, James R. and Richard H. Thaler (1995). The Flypaper Effect. *Journal of Economic Perspectives*, 9: 217-226.

Keeler, Emmet and J.E. Rolph (1988). The Demand for Episodes of Treatment in the Health Insurance Experiment. *Journal of Health Economics*, 7: 337-367.

Kling, Jeffrey, Jeffrey Liebman, and Larry Katz (2003). Bullets Don't Got No Name: Consequences of Fear in the Ghetto. Forthcoming in Thomas Weisner (editor), *Discovering Successful Pathways*, University of Chicago Press

Kotlikoff, Laurence J. (1995). Privatization of Social Security: How It Works and Why It Matters, *Tax Policy and the Economy*, 10: 1-32.

Laibson, David (1997). Golden Eggs and Hyperbolic Discounting. *Quarterly Journal of Economics*, 62: 443-477.

Liebman, Jeffrey (1996). The Impact of the Earned Income Tax Credit on Labor Supply and Taxpayer Compliance. Harvard University Phd Thesis.

Liebman, Jeffrey (1998). The Impact of the Earned Income Tax Credit on Incentives and the Income Distribution, *Tax Policy and the Economy*, volume 12.

Liebman, Jeffrey (2002). The Optimal Design of the Earned Income Tax Credit in Bruce D. Meyer and Douglas Holtz-Eakin, editors, *Making Work Pay: The Earned Income Tax Credit and Its Impact on American Families* (New York: Russell Sage Foundation Press).

MaCurdy, Thomas, David Green, and Harry Paarsh (1990). "Assessing Empirical Approaches for Analyzing Taxes and Labor Supply," *Journal of Human Resources*, 25: 415-490.

Mazur, J.E. (1981). "Optimization Theory Fails to Predict Performance of Pigeons in a Two-Response Situation." *Science*, 214: 823-825.

Meyer, Bruce D. and Rosenbaum, Dan T. (2001). Welfare, the Earned Income Tax Credit, and the Labor Supply of Single Mothers. Quarterly Journal of Economics. 116: 1063-1114.

Meyer, Bruce D. (2002). Labor Supply at the Extensive and Intensive Margins: The EITC, Welfare, and Hours Worked. *American Economic Review*, May.

Meyers, Marcia K, Bonnie Glaser, and Karin MacDonald (1998). On the Front Lines of Welfare Delivery: Are Workers Implementing Policy Reforms? *Journal of Policy Analysis and Management*, 17:1-22.

Oates, Wallace (1979). Lump-sum Intergovernmental Grants Have Price Effects. In Mieszkowski, Peter, and William H. Oakland, editors, *Fiscal Federalism and Grants-in-Aid*. Washington, D.C.: Urban Institute. Pp. 23-30.

Pollack, Harold and Richard Zeckhauser (1996). Budgets as Dynamic Gatekeepers, *Management Science*, 42: 642-658.

Rachlin, Howard and David I. Laibson (1997). “Introduction,” in Richard J. Herrnstein, *The Matching Law: Papers in Psychology and Economics* , edited by Howard Rachlin and David I. Laibson, (Cambridge, Harvard University Press).

Romich, Jennifer and Thomas Weisner (2002). How Families View and Use the Earned Income Tax Credit, in Bruce Meyer and Douglas Holtz-Eakin editors, *Making Work Pay*. Russell Sage Foundation, New York.

Rosen, Harvey S. (1976). Taxes in a Labor Supply Model with Joint Wage-Hours Determination, *Econometrica*, 44:485-507.

Saez, Emmanuel (1999). The Effect of Marginal Tax Rates on Income: A Panel Study of Bracket Creep, *Journal of Public Economics*.

Saez, Emmanuel (2001). Using Elasticities to Derive Optimal Income Tax Rates. *Review of Economic Studies*, 68: 205-229.

Saez, Emmanuel (2002a). Do Taxpayers Bunch at Kink Points? Mimeo UC Berkeley.

Saez, Emmanuel (2002b). Optimal Income Transfer Programs: Intensive Versus Extensive Labor Supply Responses. *Quarterly Journal of Economics*, 117: 1039-1073.

Simon, Herbert A. (1978). Rationality as Process and as Product of Thought. *American Economic Review Papers and Proceedings*, 68:1-16.

Slemrod, Joel (1990). *Do Taxes Matter?*. MIT Press, Cambridge, MA.

Thaler, Richard H. (1985). Mental Accounting and Consumer Choice. *Marketing Science* 4: 199-214.

Thaler, Richard H. and H.M. Shefrin (1981). An Economic Theory of Self-control. *Journal of Political Economy* 89: 392-406.

Tversky, Amos and Daniel Kahneman (1974). Judgment Under Uncertainty: Heuristics and Biases. *Science*. 185: 1124-1131.

Vaughn, W., Jr. (1981). “Melioration, matching, and maximization.” *Journal of the Experimental Analysis of Behavior*, 36: 141-149.

Table I
Five Examples of Conditions that Give Rise to Schmeduling

	Non-linear pricing	Complexity	Frequent revisions	Delayed Payoffs	Bundled Consumption	Nonstationary environment	Schedule heterogeneity	Obscure units	False signals
Tax schedules	X	X	X	X	?	X	X		X
Public assistance benefit formulas	X	X	X	?	?	X	?		
Utility pricing	X	X	X	X	X	X	X	X	?
Richard's parking tickets	X			X	X				X
Non-linear pricing of consumer goods	X				X	X	?	?	X

Note: X means that the condition is usually present for that example. ? means that this condition is sometimes present and sometimes not in that example.

Table II
Deadweight Loss in the Two Models with Elasticity of 0.4
(billions of dollars)

	Taxable Income	Revenue	Deadweight Loss
Schmeduling	4233.3	974.7	56.7
Rational	4019.9	913.4	109.0

Table III

Parameter Estimates from the Econometric Model of the Introduction of the Child Credit

Elasticity	0.38
Share of sample that are schmedulers	0.54
Nominal wage growth	0.047

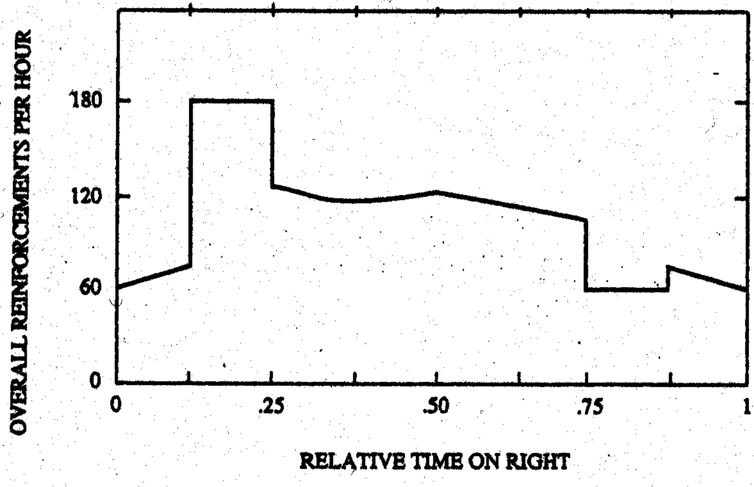
Notes. Standard deviation of optimization error is set to $2000. Standard deviation of uncertainty around the kink is set at $4000.

Table IV: Regression Results for the Within-Month Pattern of Food Consumption by Food Stamp Recipients

	Dependent Variable	
	Log of food consumption in dollars (1)	Log of food consumption in calories (2)
Days since last AFDC check	-.00216 (.00417)	-.00384 (.00424)
Days since last AFDC check interacted with Food Stamps paid in cash	.00192 (.00566)	.00733 (.00575)
Days since last Food Stamp check (for those paid in stamps)	-.00761 (.00390)	-.00205 (.00397)
R^2	0.27	0.30
Sample size	715	715

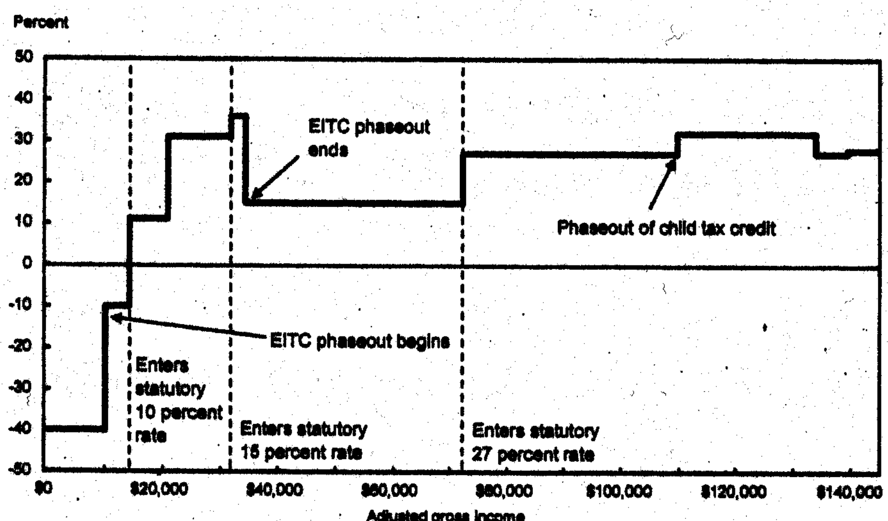
Notes: Regressions also include indicator variables for calendar month, household size, and experimental group. Robust standard errors in parentheses.

Figure 1a
Pigeons Spotlighting



Source: Vaughn (1981) as adapted by Herrnstein (1982).

Figure 1b
Marginal Federal Income Tax Rates in 2003



Note: Calculations are for joint-filer, one-earner family with two children under 14. Itemized deductions are assumed to be 18 percent of income.

Source: Council of Economic Advisers.

Figure 2a

Consumers' Budget Constraint in Monopolist Case

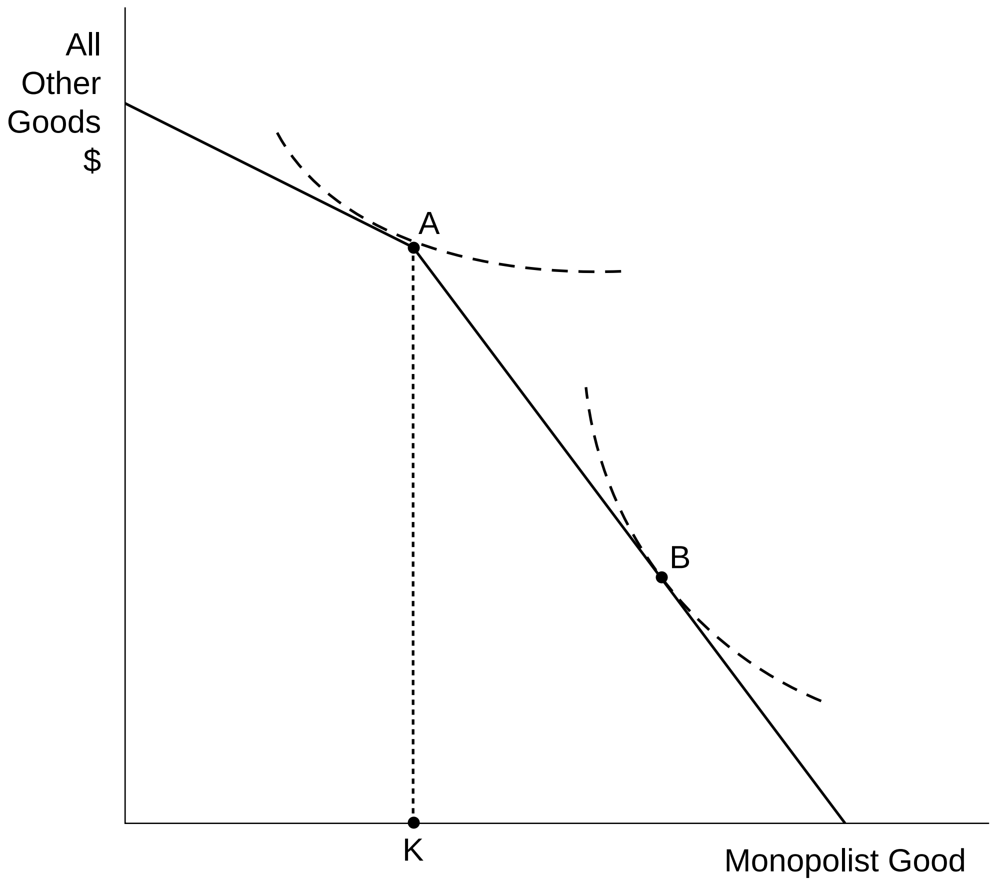


Figure 2b

Monopolist Case

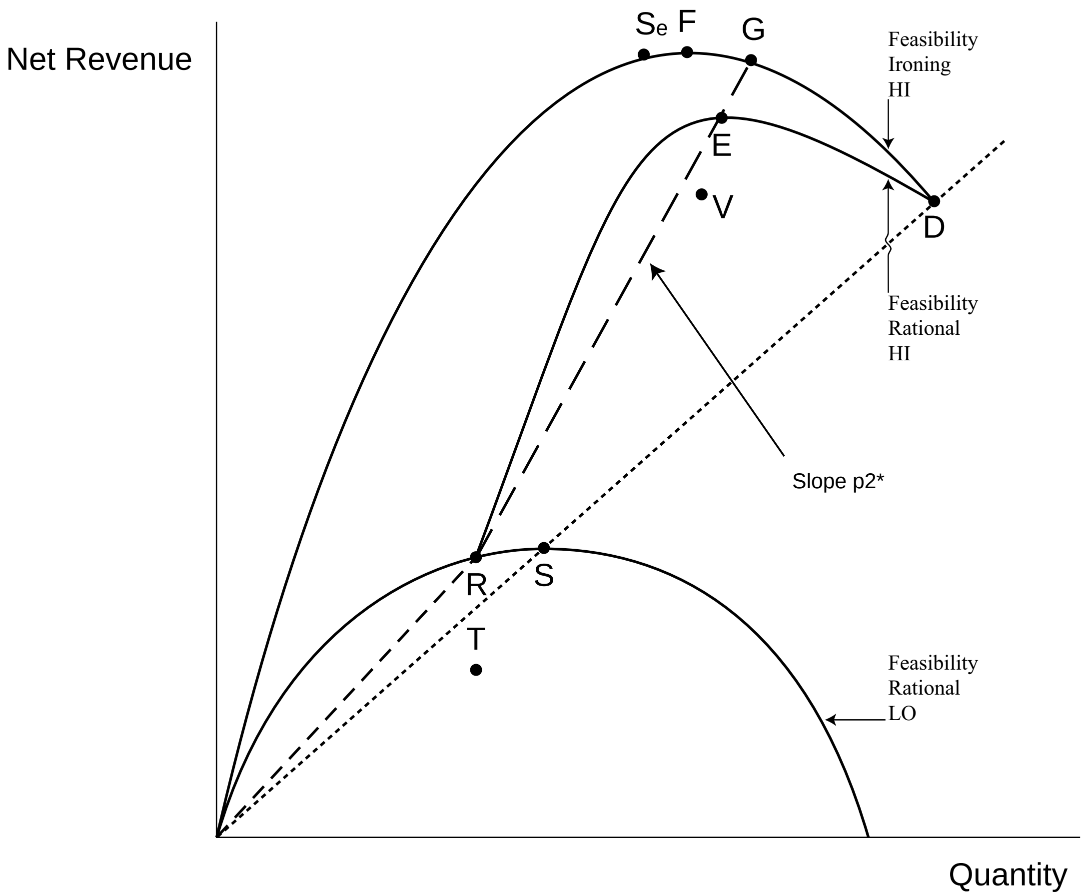


Figure 3
Ramsey Pricing

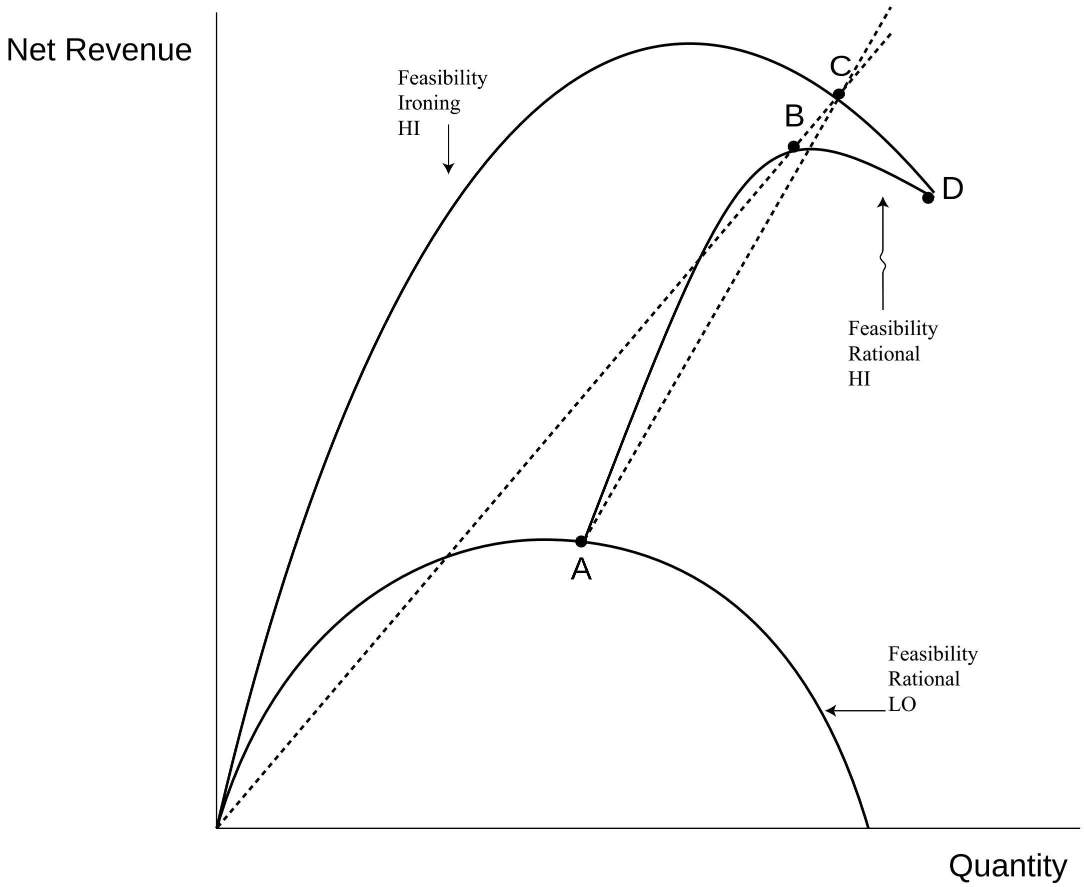


Figure 4

Schmeduling in the Optimal Income Tax

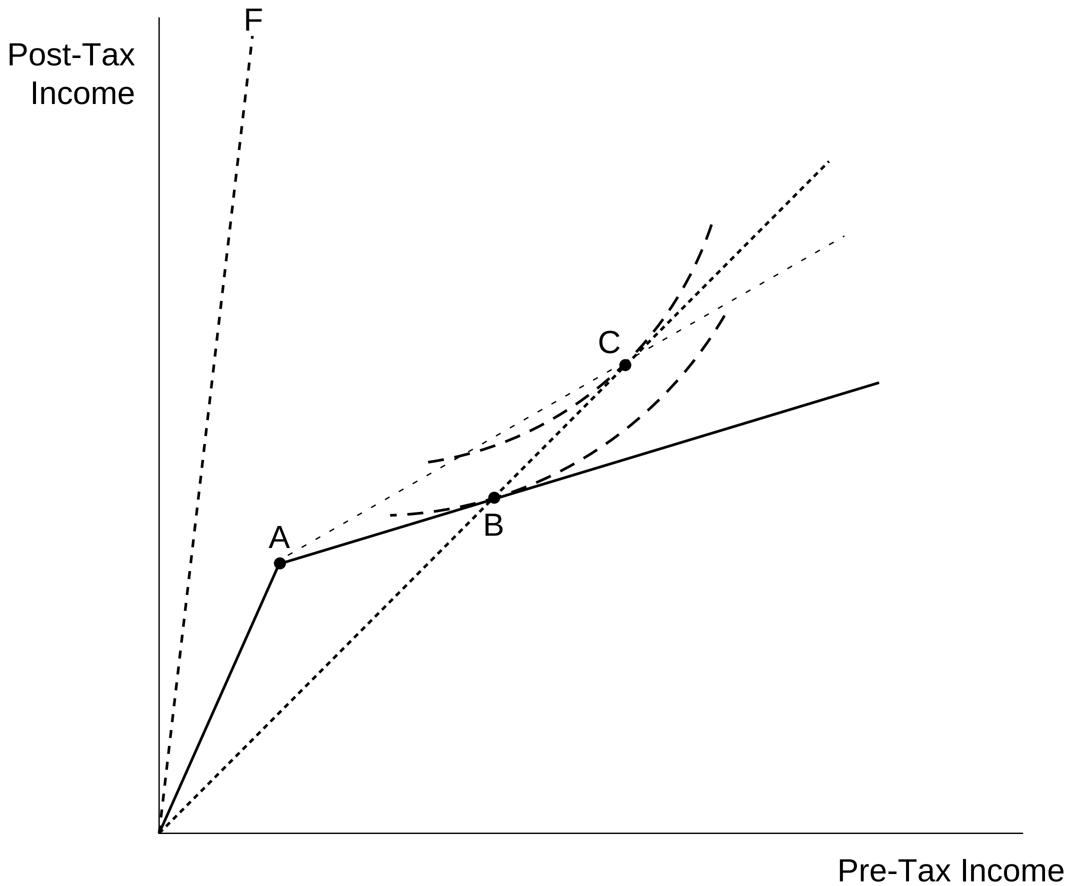


Figure 5

Deadweight Loss from Spotlighting

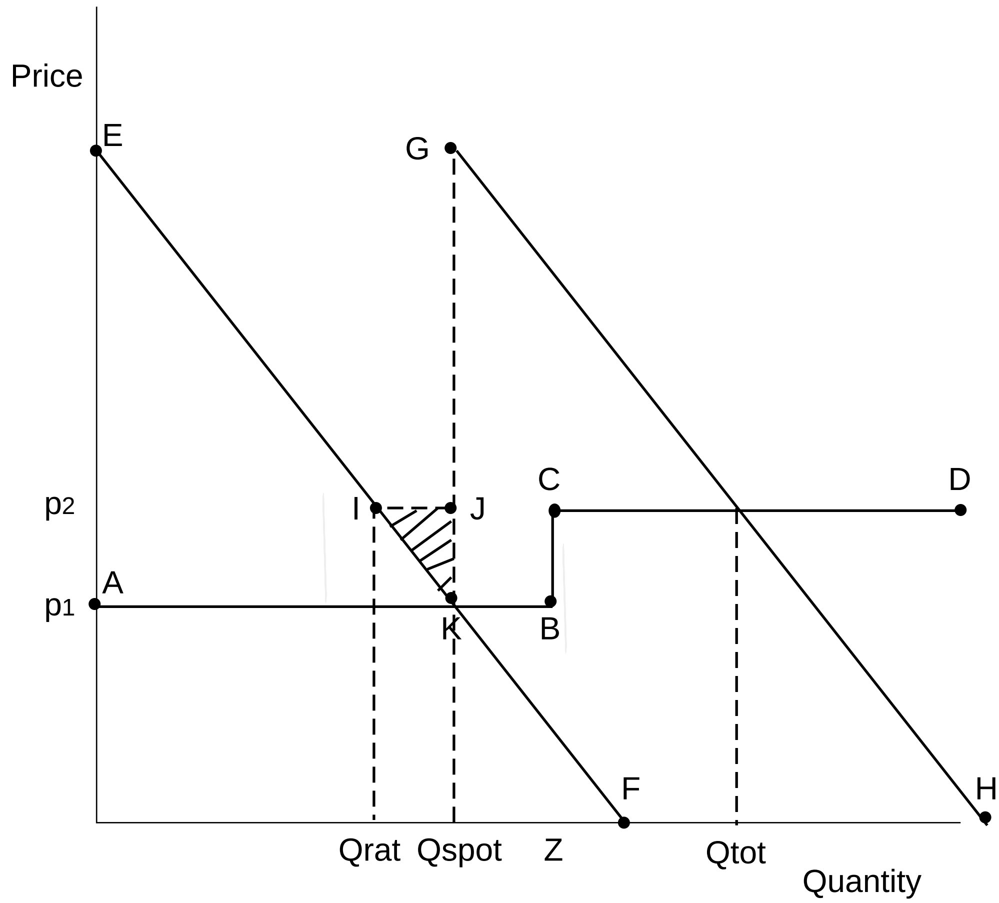
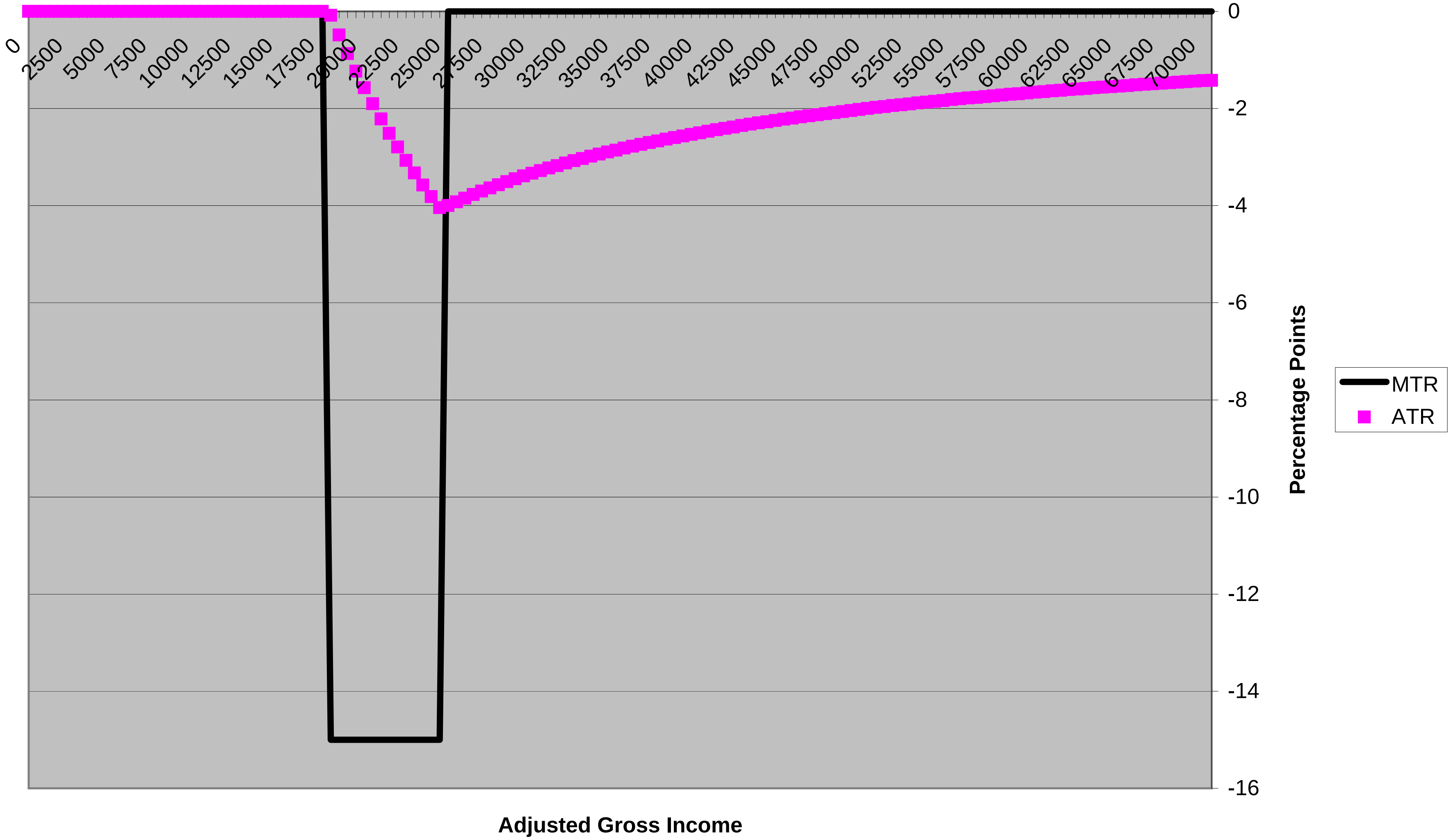


Figure 6
Change in Average and Marginal Tax Rates from Introduction of Child Credit



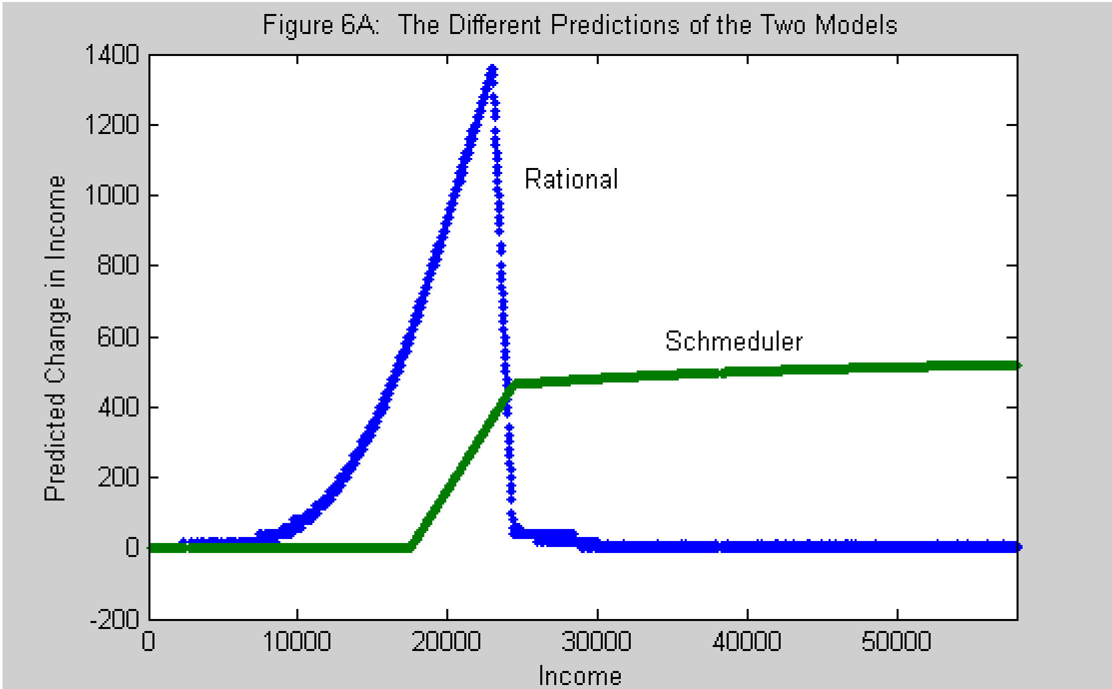


Figure 6A: The Different Predictions of the Two Models
Predicted Change in Income
Income
Rational
Schmeduler
1400
1200
1000
800
600
400
200
0
-200
0
10000
20000
30000
40000
50000

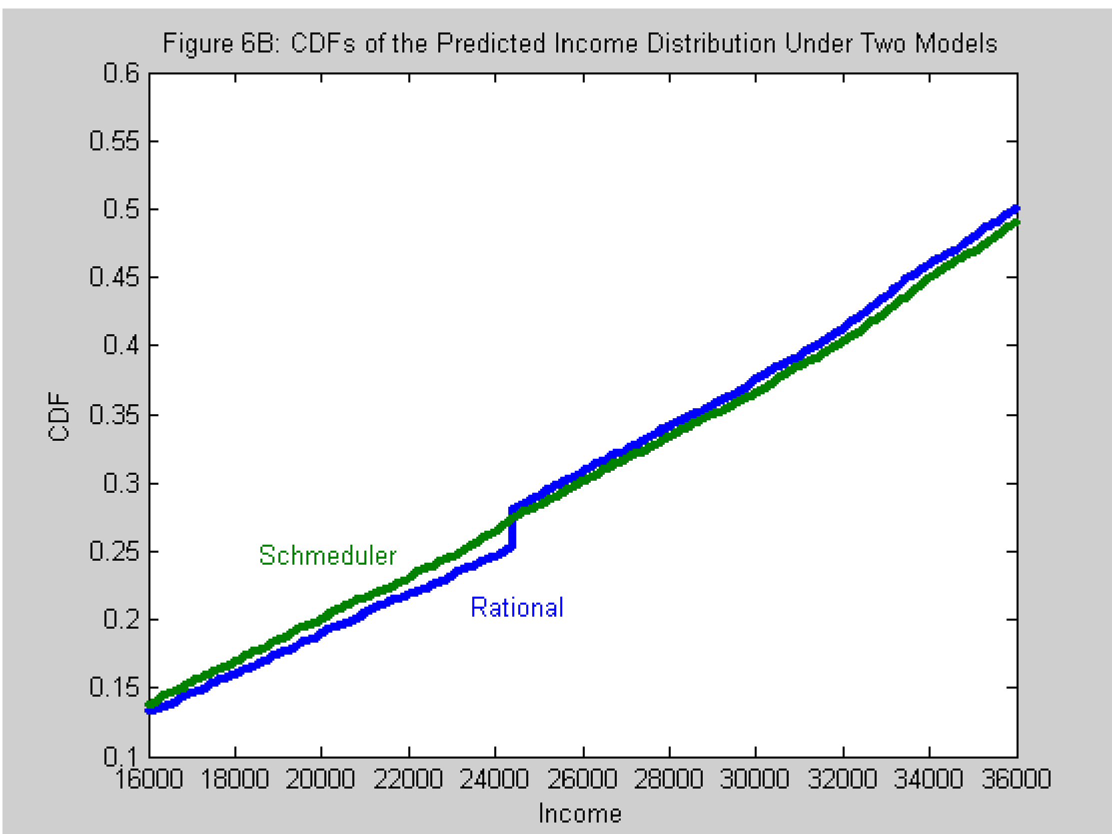


Figure 6B: CDFs of the Predicted Income Distribution Under Two Models
CDF
Income
Schmeduler
Rational
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
16000
18000
20000
22000
24000
26000
28000
30000
32000
34000
36000

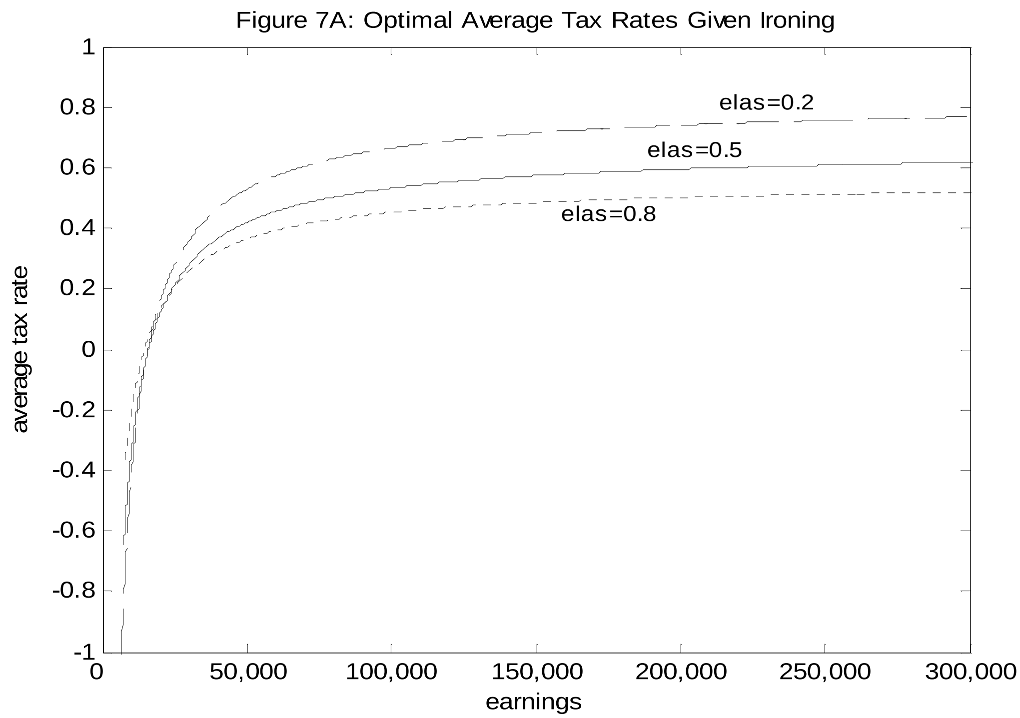


Figure 7A: Optimal Average Tax Rates Given Ironing
average tax rate
earnings
elas=0.2
elas=0.5
elas=0.8
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
50,000
100,000
150,000
200,000
250,000
300,000

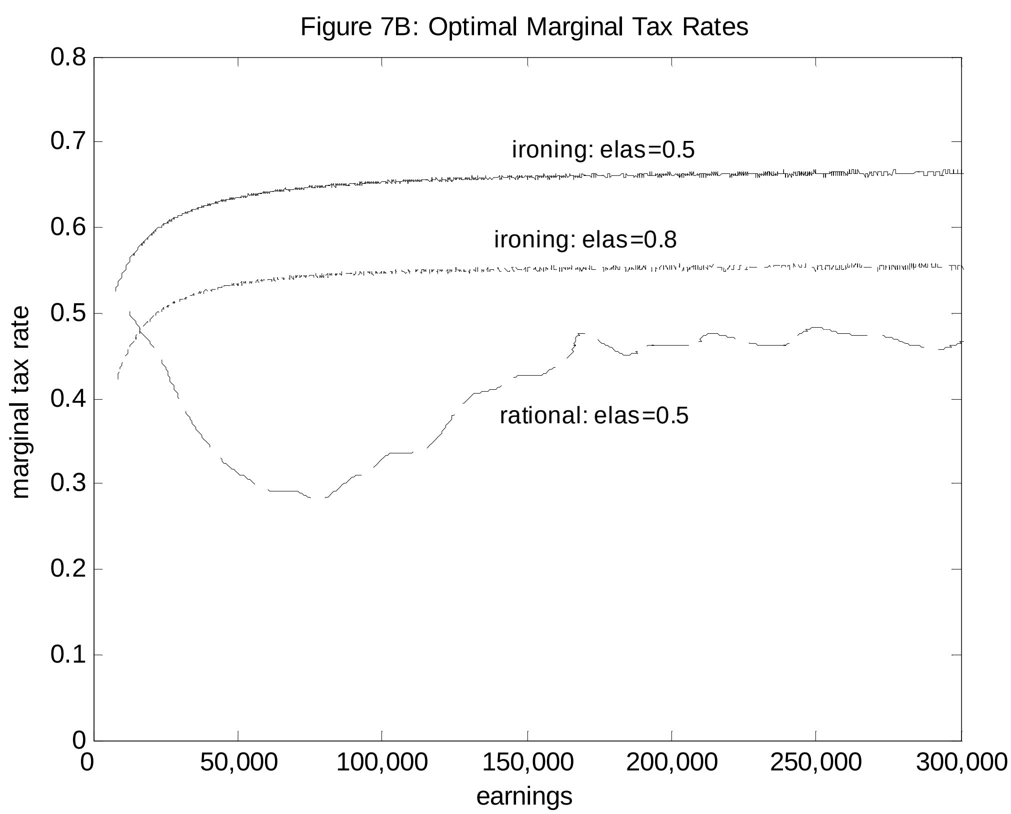


Figure 7B: Optimal Marginal Tax Rates
marginal tax rate
earnings
ironing: elas=0.5
ironing: elas=0.8
rational: elas=0.5
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50,000
100,000
150,000
200,000
250,000
300,000