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ESSAYS ON MACROECONOMICS AND EDUCATION

by

Chander Shekhar Kochar

A thesis submitted in partial fulfillment of the
requirements for the Doctor of Philosophy
degree in Economics
in the Graduate College of
The University of Iowa

August 2016

Thesis Supervisor: Associate Professor Martin Gervais

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CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

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has been approved by the Examining Committee for the thesis requirement for the Doctor of Philosophy degree in Economics at the August 2016 graduation.

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ABSTRACT

This thesis consists of three chapters. While the first chapter focuses on optimal taxation, the other two chapters address the student loan market. Specifically, I look at how student loan debt impacts search behavior of individuals in Chapter 2 and determine inefficient in the student loan market in Chapter 3.

In Chapter 1, I use a canonical model similar to that of Golosov, Tsyvinski, and Werning (2006) to highlight salient properties of the standard tax system used to decentralize constrained efficient allocations. I first show that while labor and wealth taxes are mainly used for efficiency purposes, risk-sharing is achieved through type-specific transfers. I then show through various examples that ignoring parts of the optimal tax system—a recurring theme in the literature—can lead to sizable welfare losses.

In Chapter 2, the goal is to evaluate the causal effect of student loans on labor market outcomes. In order to do so, we exploit the eligibility for the need-based Stafford loan program (subsidized Stafford loans) to implement a regression kink design. Using a nationally representative sample of students graduating with a bachelor's degree in 1993, we establish that student loan debt leads to lower earnings after graduation. Estimates show that an additional hundred dollars of Stafford loan reduces 1994 annual income by about 0.1%. Extrapolating this result, earnings for an individual with the mean level of borrowing are 5% lower than those of an individual with no debt. The impact of an additional hundred dollars of student debt on earnings

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decreases to 0.04% by 1996, and the impact of debt on earnings vanishes by 2002. Economic theory shows that there exists a simple mechanism consistent with the empirical finding, whereby more debt leads individuals to quickly find employment rather than wait for an ideal job. Crucial for this result is that student debt is not dischargeable in bankruptcy. Indeed, when debt is dischargeable, higher debt can cause individuals to search for higher paying jobs that are harder to find.

The starting point of Chapter 3 is that cross-subsidization contradicts well-functioning private lending markets: loans to all identifiable subgroup of the population should carry the same expected return. Absent government or otherwise imposed restrictions, competitive loan markets are incompatible with identifiable subsets of the population subsidizing others. We use that insight to identify and measure inefficiencies in government student loan programs using linked survey and administrative data from the Beginning Postsecondary Student (BPS) longitudinal surveys. We use loan repayment histories to compute realized returns for borrowers. We then estimate considerable heterogeneity in expected returns based on ex ante observable characteristics, which suggests inefficiencies that private lenders might exploit by cream-skimming more profitable borrowers.

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PUBLIC ABSTRACT

This dissertation examines issues related to optimal taxation and the economics of education, particularly post-secondary education in the United States. The first chapter beings by examining a canonical form of the dynamic Mirrleesian framework. The salient features of this framework are that individuals have heterogenous skills, which they can observe only at the beginning of each period and social planner can never observe an individuals sill level. The goal of this paper is then to expose the two key roles played by lump-sum taxes in tax systems emanating from such a framework. We show that lump-sum taxes support the wealth and labor income tax rates by allowing both the government and individual budgets to balance. We then show that lump-sum taxes also provide redistribution of resources in the economy.

The second chapter studies the impact of student loan debt on earnings of individuals. We determine that an average borrower makes about 5% less than an average non-borrower one year after graduation. The effect of loans on earnings tends to reduce over time and 9 years after graduation we observe the student loan debt no longer impacts earnings. We then provide a simple model to help explain the intuition behind this result and show that theory is consistent with our empirical finding. Essentially, individuals with debt are in a hurry to find a job and therefore cannot wait for their ideal job. Key to this result is the fact that student loan debt is not dischargeable in bankruptcy.

In the third chapter we identify and measure inefficiencies in government student loan programs.

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CHAPTER 1
REDISTRIBUTIVE EFFECTS OF TYPE-SPECIFIC TRANSFERS IN DYNAMIC MIRRLEESIAN OPTIMAL TAXATION

1.1 Introduction

In the Mirrleesian framework, wedges in the inter- and intra-temporal equations provide the theoretical foundation for the applicable tax functions. Because distortions are inherent in this framework, no restrictions are imposed on tax instruments. In particular, type-specific transfers can be and are extensively used. The literature has nevertheless largely ignored the role played by type-specific transfers and instead focused primarily on the nature and properties of the marginal labor and wealth tax rates that emerge from the intra- and inter-temporal wedges. Quite often, these distortionary marginal labor and wealth tax rates are determined without computing or discussing the underlying type-specific transfers necessary to support them. Saez (2001), for example derives the Mirrleesian non-linear optimal labor income tax rate using elasticities of earnings and the income distribution without determining the needed type-specific transfers. Kocherlakota (2005) determines that the optimal marginal wealth tax rates should be regressive in skill shocks. He then calculates these tax rates for a number of policy experiments without mentioning the type-specific transfers that would be required to support them.

The objective of this paper is to expose two crucial roles of type-specific transfers in optimal tax systems emanating from the dynamic Mirrleesian framework. First, they support the optimal income and wealth taxes (most importantly, ensuring that

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agents act efficiently) by enabling both the government and the agent's budgets to balance. Second, the type-specific transfers provide risk sharing in the model. The importance of this property can be understood from the fact that the efficiency-risk sharing trade-off plays a central role in the Mirrleesian framework. While the instruments associated with efficiency are discussed extensively in the literature, those associated with risk-sharing have been relatively ignored. As a consequence, this paper also provides a better understanding of a complete optimal tax system.

The approach of this paper is as follows. I start by examining a dynamic theoretical framework similar to that of Golosov, Tsyvinski, and Werning (2006) (GTW henceforth): a two period model where the utility function is separable over consumption and labor. Agents receive a skill shock in period 2, which is private information and only observed at the beginning of period 2. As GTW note, solving this class of models can become complicated very quickly due to the large number of incentive compatibility (IC) constraints. I prove that in the case of separable utility functions, not only are the local IC constraints sufficient, but only the downward local IC constraint will bind. This result helps in characterizing the constrained efficient allocation (c.e.a. henceforth) in addition to reducing the computational complexity of the model.[1] In particular, I am able to show the "no distortion at the top" result, which

[1]Both Golosov, Tsyvinski, and Werning (2006) and Kocherlakota (2005) use separable utility functions and two-period models in their numerical exercises. In both papers, the estimation strategy is to first make an initial guess as to which incentive constraints will bind, solve the model, and then check to make sure all incentive constraints are satisfied. Any violated constraints are added to the problem, which is re-solved. At this point, incentive constraints are checked again. As noted by Battaglini and Lamba (2015) this result does not hold in a more general framework.

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GTW note has not yet been analytically proven for economies with stochastically evolving skills.

I then design an optimal tax system and explicitly define every instrument. The optimal tax system consists of earnings-dependent wealth taxes, labor income taxes, and transfers. The wealth taxes take the form described by Kocherlakota (2005). The consumption-labor wedge defines the labor income tax, and transfers are obtained in the standard manner; i.e., ensuring that an agent's budget is balanced upon choosing the c.e.a. At this point, the tax rates just described are only defined at the c.e.a. However, a proper tax code needs to be defined more broadly over the tax base. One way to do so is to assign arbitrarily high punishment if individual allocation decisions differ from the c.e.a. I provide a less restrictive tax code implementing the c.e.a. whereby tax rates are a step function of the amount of labor income.[2]

The properties of this optimal tax system are similar to what is found in the literature. As in Kocherlakota (2005), the wealth tax is regressive. That is, high-skilled agents face lower wealth tax rates than low-skilled agents. In addition, the total revenue generated from wealth taxes always adds up to zero. These two properties imply that low-skilled agents are subsidizing high-skilled agents. Together

[2]Other less heavy handed alternatives in the literature include Albanesi and Sleet (2006), Kocherlakota (2005) and Golosov and Tsyvinski (2006). Some of the properties of these alternatives, however, are not well suited for the problem I wish to study. For example, Kocherlakota (2005) does not explicitly define the consumption-labor wedge. This approach involves a mapping of endogenous variables, which he notes may not always hold. In addition, he imposes a rather high penalty for agents who choose an effective labor allocation outside the c.e.a. Golosov and Tsyvinski (2006) determine an optimal tax system for a very special case of disability insurance. Their system works only if the number of possible states is limited to two, one of which has to be an absorbing state.

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with the "no distortion at the top" result alluded to above, the highest-skilled agent faces a negative wealth tax rate and pays no income taxes. Essentially, the optimal tax rates on both wealth and income are designed with one objective in mind: to ensure that agents act optimally, thereby maximizing the size of the pie. The task of redistributing the pie amongst the various agents therefore falls squarely on the type-specific transfers.[3] To summarize, type-specific transfers are needed to support the optimal income and wealth taxes and to provide risk-sharing in the model.

To illustrate the key role played by the type-specific transfers, I consider various numerical experiments. The idea behind these experiments is to contrast the welfare cost associated with implementing an incomplete optimal Mirrleesian tax system — one without type-specific transfers or with pure lump-sum transfers — relative to the costs associated with implementing a simple, though somewhat arbitrary, tax code.[4] For example, a 3.8% welfare loss is associated with the equilibrium allocation under a Mirrleesian tax system devoid of lump-sum transfers. By comparison, a simple and easily-implemented log-linear income tax function, optimized Ramsey-style, produces a relatively small welfare loss of 0.5%. These results are hardly surprising, considering that if type-specific labor income tax rates were available, their optimal profile would look drastically different from the marginal labor income tax rates that emanate from the optimal Mirrleesian tax system. Together, these results are meant

[3]Lump-sum transfers effectively depend on the labor income, as each type self selects the c.e.a.

[4]For each experiment, the welfare loss is measured in terms of consumption equivalence using the utility at the c.e.a. as the benchmark. This strategy has been used by Heathcote and Tsujiyama (2014).

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to expose the potential pitfalls of focusing narrowly on a limited set of instruments as opposed to analyzing a tax system as a whole.

The rest of the paper is as follows. In Section 1.2, I discuss the dynamic Mirrleesian problem: environment, and the planner's problem and its properties; Section 1.3 proposes the optimal tax system, decentralization, and properties of the tax system; Section 1.4 lays out the numerical setup and experiments 1 and 2; Section 1.5 explores the Ramsey experiments (experiments 3 and 4); Section 1.6 concludes.

1.2 Two-Period Mirrleesian Economy

1.2.1 Environment

In this section, I describe a two-period dynamic Mirrleesian economy with a unit measure of agents that live for both periods. This set-up is fairly standard in the literature.

1.2.1.1 Preferences

There is a single consumption good that can be produced by labor. Agents have identical preferences, and each agent maximizes her lifetime expected utility, given by

$$\mathbb{E}\left[\sum_{t=1}^{2}\beta^{t-1}\{u(c_t)-v(\ell_t)\}\right], \tag{1.1}$$

where $c_t \in \mathbb{R}_+$ is the agent's consumption in period t and $\ell_t \in [0,1]$ is the agent's labor in period t. I assume that u', $-u''$, v', and v'' all exist and are positive. $\beta \in (0,1)$ is the discount factor.

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1.2.1.2 Skills

Private idiosyncratic skill shocks, which are independent across workers, are the only source of shocks and heterogeneity in the economy. An agent with skill θ_t and labor ℓ_t produces $y_t = \theta_t \ell_t$ units of effective labor. As is standard, y_t is observable. Everyone starts off with the same skill level in period 1, denoted θ_1. The problem is dynamic in nature because an agent realizes her period 2 skill level, which is private information, only at the beginning of the second period.

There are a finite number (N) of skill levels in period 2, where higher numbers denote higher skill levels. Let $\theta_{2,i}$ for $i = 1, 2, \ldots, N$ be the realization of skill level in period 2. Denote by π_i for $i = 1, 2, \ldots, N$ the ex-ante probability distribution of skill levels, equivalent to the ex-post distribution in the population.

1.2.1.3 Technology

Production is linear in efficiency units of labor supplied and there is a linear savings technology with a constant rate of return R. The resource constraints are:

$$c_1 - y_1 + k' + G_1 = 0, \tag{1.2}$$

$$\sum_{i=1}^{N} \pi_i [c_{2,i} - y_{2,i}] - Rk' + G_2 = 0, \tag{1.3}$$

where k' is the amount saved between periods and G_t is government expenditure in period $t = 1, 2$.

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1.2.2 Planner's Problem

The constrained efficient allocation must respect incentive compatibility given that skill shocks are private information. An agent who realizes a skill level i in period 2 may choose to behave as if she has realized skill level i_r. Incentive compatibility constraints ensure that the agent has no incentive to misrepresent her type. That is, for an agent of type i and for all alternative feasible reporting strategies i_r, the following must hold:

$$IC_{i,i_r}: \qquad u(c_{2,i}) - v(y_{2,i}/\theta_{2,i}) \geq u(c_{2,i_r}) - v(y_{2,i_r}/\theta_{2,i}) \;\; \forall i, i_r. \tag{1.4}$$

I concentrate on maximizing a utilitarian social welfare function. Therefore, the constrained efficient planning problem maximizes

$$u(c_1) - v(y_1/\theta_1) + \beta \sum_{i=1}^{N} \pi_i \big[u(c_{2,i}) - v(y_{2,i}/\theta_{2,i})\big] \;, \tag{1.5}$$

subject to the resource constraints in (1.2) and (1.3) and the incentive constraints in (1.4). Let $\{c_1^*, \{c_{2,i}^*\}_{i=1}^N, y_1^*, \{y_{2,i}^*\}_{i=1}^N, k'^*\}$ denote the solution to this problem.

1.2.2.1 Properties of the Planner's Problem

In order to reduce the complexity of the problem, I now examine some properties of the c.e.a.

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Proposition 1. *The solution to the planner's problem has the following properties:*

Property 1 : $\theta_{2,i+1} > \theta_{2,i} \Rightarrow y_{2,i+1} > y_{2,i}; c_{2,i+1} > c_{2,i}$.

Property 2 : Local IC constraints are sufficient.

Property 3 : Downward IC constraints always bind.

Property 4 : Upward IC constraints never bind.

The first property says that an agent with a higher skill level will have both a higher level of consumption and higher level of effective labor. The second property tells us that if $IC_{i,i-1}$ and $IC_{i,i+1}$ are satisfied (i.e., an agent of skill type i has an incentive to mimic neither an agent of skill type $i-1$ nor of $i+1$), then $IC_{i,j}$ will always be satisfied for any j. In other words, the planner only needs to worry about the IC constraints in the immediate neighborhood of a skill level. The third and fourth properties tell us that only downward IC constraints will be binding. That is, the planner only needs to ensure that an agent cannot be better off by acting as if she belongs to the skill level just below her true skill level. The details of the proof can be found in Appendix A.1.

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1.2.2.2 Partial Characterization of Constrained Efficient Allocation

As $\{c_1^*, \{c_{2,i}^*\}_{i=1}^N, y_1^*, \{y_{2,i}^*\}_{i=1}^N, k'^*\}$ is the allocation solving the planner's problem, the following must hold:

$$c_1^* - y_1^* + k'^* + G_1 = 0, \tag{1.6}$$

$$\sum_{i=1}^{N} \pi_i [c_{2,i}^* - y_{2,i}^*] - Rk'^* + G_2 = 0, \tag{1.7}$$

$$u(c_{2,i}^*) - v(y_{2,i}^*/\theta_{2,i}) = u(c_{2,i-1}^*) - v(y_{2,i-1}^*/\theta_{2,i}) \;\; ; \text{for i} = 2, 3, ...N, \tag{1.8}$$

$$\frac{1}{u'(c_1^*)} = \frac{1}{R\beta} \sum_{i=1}^{N} \left[\frac{\pi_i}{u'(c_{2,i}^*)} \right], \tag{1.9}$$

$$u'(c_1^*) = \frac{1}{\theta_1} v'(y_1^*/\theta_1), \tag{1.10}$$

$$u'(c_{2,N}^*) = \frac{1}{\theta_{2,N}} v'(y_{2,N}^*/\theta_{2,N}). \tag{1.11}$$

(1.6) and (1.7) simply state that the c.e.a. must be feasible. (1.8) tells us that at the c.e.a. the downward IC constraints are binding. (1.9) is the inverse Euler equation (IEE) for this problem. The IEE was first determined by Diamond and Mirrlees (1978); as noted by GTW, it implies that whenever consumption remains stochastic, the standard Euler equation must be distorted.[5] (1.10) and (1.11) say that no distortions exist in the intra-temporal equation in period 1 or for the highest type in period 2. (1.11) is a result of the fact that only downward IC constraints are binding and is in accordance with the standard Mirrlees result that the marginal labor income tax rate on the highest type will be 0.

[5] Applying Jensen's inequality to this equation shows that a wedge will exist in the agent's Euler equation when evaluated at the c.e.a.

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1.3 Decentralization

In this section, I first discuss the various tax instruments that comprise the optimal tax system and then introduce the system itself. I proceed to show that the tax system can implement the planner's c.e.a, finally, I discuss some properties of the tax instruments.

1.3.1 Tax Instruments

The optimal tax system consists of three instruments: wealth taxes, labor income taxes and type-specific transfers.[6]

1.3.1.1 Wealth Taxes

Let τ_k^i, $i = 1, \ldots, N$ denote wealth taxes such that

$$u'(c_1^*) = R\beta(1 - \tau_k^i)u'(c_{2,i}^*). \tag{1.12}$$

Wealth taxes defined in this manner have a special property as outlined by Kocherlakota (2005): they remove the agent's incentive to save anything other than k'^*, so she can never be better off by saving anything other than what is recommended by the c.e.a.

1.3.1.2 Labor Income Taxes

Let τ_y^i, $i = 1, \ldots, N$ denote labor income taxes such that

[6]This is just one of many potential sets of instruments. For example, one could use state-dependent consumption taxes instead of state-dependent wealth taxes.

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$$u'(c^*_{2,i}) = \left(\frac{1}{1-\tau^i_y}\right)\left(\frac{1}{\theta_{2,i}}\right)v'\left(\frac{y^*_{2,i}}{\theta_{2,i}}\right). \tag{1.13}$$

From (1.13), $\left(\frac{1}{1-\tau^i_y}\right)$ is set to equal the wedge in the intra-temporal equation for all skill levels i. Comparing (1.11) and (1.13), τ^N_y is evidently equal to 0 because no wedge exists for the highest type.

1.3.1.3 Type-specific Transfers

Let T_i, $i = 1, \ldots, N$ denote type-specific transfers such that

$$c^*_{2,i} = Rk'^*(1-\tau^i_k) + y^*_{2,i}(1-\tau^i_y) + T_i \tag{1.14}$$

From above, T_i is set such that the budget constraints hold for each type of agent when she chooses the appropriate allocation from the c.e.a.

1.3.2 Optimal Tax System

Define the tax system, $\mathbb{T}$ as follows:

$$\mathbb{T} = \begin{cases} \{\tau^1_k, \tau^1_y, T_1\} & \text{if } y \in [0, y^*_{2,1}] \\ \{\tau^i_k, \tau^i_y, T_i\} & \text{if } y \in (y^*_{2,i-1}, y^*_{2,i}] \;\; ;\text{for } i = 2 \ldots N-1 \\ \{\tau^N_k, \tau^N_y, T_N\} & \text{if } y > y^*_{N-1} \end{cases} \tag{1.15}$$

$\mathbb{T}$ is a function of effective labor. It might seem a little strange that wealth is taxed based on one's effective labor. Given that there is no heterogeneity in period 1 and agents therefore save the same amount, one could define the tax system in terms

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of adjusted gross income, much like the US tax code. Additionally, Kitao (2010) explores the idea of taxing capital at a decreasing rate as a function of labor supply and determines the welfare gains from such a system over the standard approach of treating the two separately.

1.3.3 Implementation

Definition. *Given a tax function and prices, an allocation of consumption, effective labor, and savings* $(\{c_1, y_1\}, \{c_{2,i}, y_{2,i}\}_{i=1\ldots N}, k')$ *constitutes an equilibrium if*

1. *it solves the individual's maximization problem*
2. *it is feasible*
3. *GBC holds.*

It should be noted that by Walras' Law, if 1. and 2. hold, then 3. will automatically hold.

Proposition 2. *The tax system defined by (1.15) implements the planner's constrained efficient allocation.*

The detailed proof of the proposition is fairly mechanical and can be found in Appendix A.2.

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1.3.4 Properties of the Tax Function

1.3.4.1 Wealth Taxes

A pair of inferences can be made about wealth taxes based on (1.12). The first is that wealth taxes are regressive in nature.[7] To see this, note that $1-\tau_k^i = \frac{u'(c_1^*)}{R\beta u'(c_{2,i}^*)}$. If $c_{2,i}^* > c_{2,j}^*$, then $u'(c_{2,i}^*) < u'(c_{2,j}^*)$ because $u'(\cdot)$ is decreasing, which in turn gives us $1-\tau_k^i > 1-\tau_k^j$, and hence $\tau_k^i < \tau_k^j$.

The second property is that for any functional form of $u(\cdot)$ and any distribution of skills in period 2, the total wealth taxes add up to zero. From (1.12):

$$\begin{aligned}
&u'(c_1^*) = R\beta(1-\tau_k^i)u'(c_{2,i}^*) \quad \forall i = 1, \ldots, N,\\
\Rightarrow &\frac{(1-\tau_k^i)}{u'(c_1^*)} = \frac{1}{R\beta u'(c_{2,i}^*)} \quad \forall i = 1, \ldots, N,\\
\Rightarrow &\frac{1}{u'(c_1^*)} = \frac{\tau_k^i}{u'(c_1^*)} + \frac{1}{R\beta u'(c_{2,i}^*)} \quad \forall i = 1, \ldots, N,\\
\Rightarrow &\frac{1}{u'(c_1^*)} = \sum_{i=1}^{N} \frac{\pi_i \tau_k^i}{u'(c_1^*)} + \frac{1}{R\beta}\sum_{i=1}^{N} \frac{\pi_i}{u'(c_{2,i}^*)}.
\end{aligned}$$

From (1.9), we know that the inverse Euler equation must hold at the c.e.a., i.e., $\frac{1}{u'(c_1^*)} = \frac{1}{R\beta}\sum_{i=1}^{N} \frac{\pi_i}{u'(c_{2,i}^*)}$. This implies that the first term on the right-hand side of the above equation has to equal 0. Therefore,

$$\sum_{i=1}^{N} \frac{\pi_i \tau_k^i}{u'(c_1^*)} = 0 \Rightarrow \sum_{i=1}^{N} \pi_i \tau_k^i = 0 \Rightarrow Rk'^* \sum_{i=1}^{N} \pi_i \tau_k^i = 0 \ ,$$

because $u'(c_1^*)$ is independent of i and the total wealth tax collected is equal to $Rk'^* \sum_{i=1}^{N} \pi_i \tau_k^i$.

[7] This is not surprising given that I use the same tax function as prescribed by Kocherlakota (2005) who also reached the same conclusion.

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The fact that k'^* is the same for every agent is very useful for this result. For the more general case where k'^* might be type-dependent, it is possible to show that by mapping the wealth tax rates into their equivalent consumption tax rates and for $u(c) = \ln(c)$, the total tax collected is again 0. I do this in Appendix A.3.

This, in conjunction with the regressive nature of wealth taxes, means that the high-skilled agents actually receive a subsidy on their wealth taxes, which is funded by the low-skilled agents. Additionally, wealth taxes produce no net government revenue. Therefore, the goal of the state-dependent wealth taxes is to ensure that agents behave optimally. Such taxes are responsible for neither collecting government revenue nor providing any kind of risk sharing.

1.3.4.2 Labor Taxes

Two things can be said about the state-dependent labor taxes. First, as noted, $\tau_y^N = 0$. While this result is standard in the static framework, GTW note that it has not yet been analytically proven for economies with stochastically evolving skills. Second, from Proposition 1, we know that both $c^*_{2,i}$ and $y^*_{2,i}$ are increasing in i. Given that $v'(\cdot)$ is increasing and $u'(\cdot)$ is decreasing, this would imply that $\frac{v'(y^*_{2,i})}{u'(c^*_{2,i})}$ is increasing in i. By definition,

$$\tau_y^i = 1 - \left(\frac{1}{\theta_{2,i}}\right)\left(\frac{v'(y^*_{2,i}/\theta_{2,i})}{u'(c^*_{2,i})}\right).$$

We know from GTW that τ_y^i is increasing at low skill levels; at some point it reaches a maximum, after which it starts decreasing and eventually goes to 0. This means that, for small i, j where $i > j$, $\tau_y^i > \tau_y^j$ implies:

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$$1 - \left(\frac{1}{\theta_{2,i}}\right)\left(\frac{v'(y^*_{2,i}/\theta_{2,i})}{u'(c^*_{2,i})}\right) > 1 - \left(\frac{1}{\theta_{2,j}}\right)\left(\frac{v'(y^*_{2,j}/\theta_{2,j})}{u'(c^*_{2,j})}\right)$$
$$\Rightarrow \left(\frac{1}{\theta_{2,i}}\right)\left(\frac{v'(y^*_{2,i}/\theta_{2,i})}{u'(c^*_{2,i})}\right) < \left(\frac{1}{\theta_{2,j}}\right)\left(\frac{v'(y^*_{2,j}/\theta_{2,j})}{u'(c^*_{2,j})}\right),$$

even though $\frac{v'(y^*_{2,i})}{u'(c^*_{2,i})} > \frac{v'(y^*_{2,j})}{u'(c^*_{2,j})}$; scaling $y^*_{2,}$ by the appropriate $\theta_{2,}$ switched the inequality. While it is difficult to determine a theoretical explanation for this result, the numerical exercise in the next section will provide additional insight into the matter.

Having characterized the optimal tax function and discussed some of its properties in a theoretical setting in this section, the next two sections will attempt to answer some questions numerically. Specifically, the aim is to understand the welfare losses relative to the c.e.a. under different scenarios discussed in the Introduction.

1.4 The Role of Type-specific Transfers: A Numerical Exploration

The goal of this section is to quantify the important role played by type-specific transfers. The obvious starting point is to determine the c.e.a., which can then be used to determine and study the different instruments of the optimal tax system. Additionally, the utility derived from the c.e.a. can be used as a reference value in order to measure welfare loss stemming from optimizing the tax code in the absence of lump-sum taxes.

To set parameter values for the baseline model, set utility from consumption, $u(c)$, and disutility from labor, $v(\ell)$, such that $u(c) = \ln(c)$ and $v(\ell) = \ell^3$. The functional form for disutility of labor has a constant Frisch elasticity of substitution equal to 0.5. I assume that agents are identical in the first period with $\theta_1 = 10$ and

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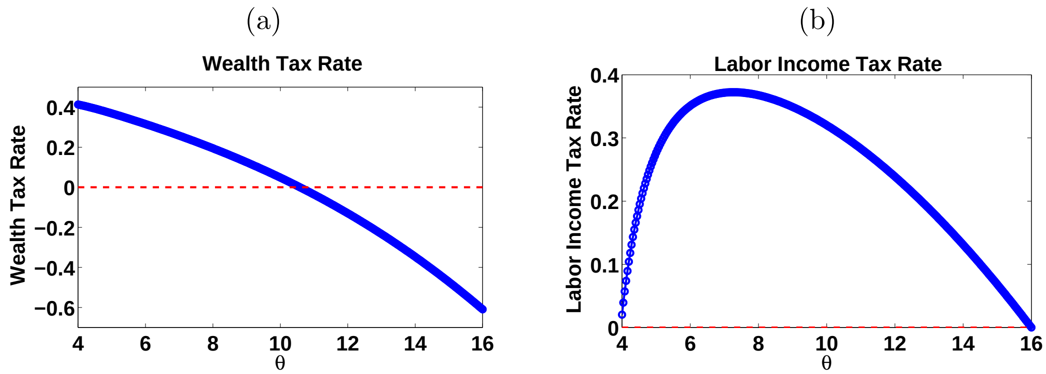
Figure 1.1: Optimal wealth and labor income tax rates implied by the constrained efficient allocation.



that there are $N = 300$ equally possible states in the second period; i.e., $\pi_i = 1/300$ and $\theta_2 \in [4, 16]$.[8] Set $R = 1$, $\beta = 1$, and $G = 0$. Because the planner wants to provide some amount of insurance, taxes collected will not be zero even given $G = 0$.

Computation Strategy: I take advantage of Property 3 for the solution of the planner's problem and assume that only the downward IC constraints are binding. I proceed to solve the corresponding system of equations derived from the FOCs to obtain the c.e.a. Optimal tax rates are then obtained using these values and (1.15).

Figures 2.3(a) and 2.3(b) show the optimal wealth labor income tax rates, respectively, as a function of skill level.[9] As expected, wealth taxes are regressive

[8]While the parameters on the utility function are fairly standard, the reason for using these skill levels is because of the log-linear tax function I will use in the next section. The standard approach has skill levels in the $(0, 1]$ range, which in turn causes consumption and effective labor to be in that same range. log takes on negative values in this range, however, which I would like to avoid.

[9]In appendix A.4, I decompose the different components of the labor income tax to get a better understanding of the hump shape.

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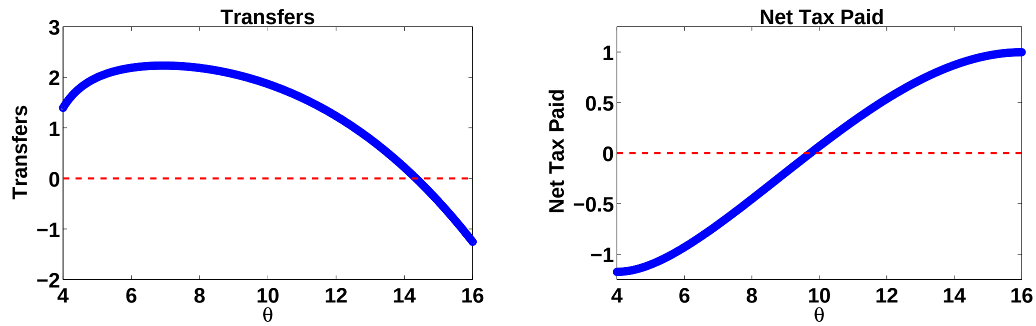
Figure 1.2: Optimal transfers and net tax paid obtained from the constrained efficient allocation.

(a) (b)



in nature; agents that realized low skill level in period 2 pay a positive wealth tax, whereas agents that realized a good skill shock receive a wealth tax subsidy (i.e., a negative wealth tax). In accordance with Mirrlees, the marginal labor income tax rate for the highest type is 0. These figures show how the optimal marginal tax rates taken at face value in the absence of the type-specific transfers might not seem as expected. For example, the highest skilled agent pays 0 labor income taxes and negative wealth taxes. On the other hand, all of the low skilled agents pay positive labor and wealth taxes.

Figure 2.4(a) shows transfers made to agents as a function of skill level. The figure shows that lower skilled agents receive net positive transfers whereas the higher skilled agents pay net positive transfers. This is why wealth and labor income taxes can take such forms. While the wealth and labor income taxes ensure efficiency, the type-specific transfers provide insurance. Finally, Figure 2.4(b) gives the complete

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picture by showing net taxes paid as a function of skill level. It shows that though low skilled agents pay positive labor and wealth taxes, the net tax paid by low-skilled agents is actually negative due to lump-sum transfers. It also shows that while the high skilled agents receive a wealth subsidy and pay little to no labor taxes, they pay a positive net tax after transfers. This final figure shows the redistributive aspect of the optimal tax function as well as the fact that the net tax paid by agents is increasing as a function of skill level.

In experiment 1, I optimize the marginal tax rates obtained above while ignoring type-specific transfers. I believe this is an important experiment because most of the literature is only interested in determining and prescribing these marginal tax rates. The experiment shows the potential pitfall of relying on just a fraction of the optimal tax code and ignoring the rest. Specifically, I let wealth tax rates be as determined in (1.12) because they do not generate any government revenue to begin with. For the labor income tax rate, I shift the entire curve by α, i.e.,

$$\hat{\tau}_y^i = \tau_y^i + \alpha, \ \forall i,$$

where $\hat{\tau}_y^i$ is the new labor income tax rate the agent faces. There are no lump-sum transfers. α is chosen such that the government budget balances and agents are allowed to choose their optimal level of allocation at these new tax rates. Because $\tau_y^i \geq 0$, labor income taxes are generating positive revenue in the presence of lump-sum transfers. Given that the current goal is, as above, to generate zero revenue, the labor income tax curve has to shift down: $\alpha < 0$. Figure 2.5 shows the shifted labor income tax rate. There is a marked decline in welfare relative to the c.e.a. at

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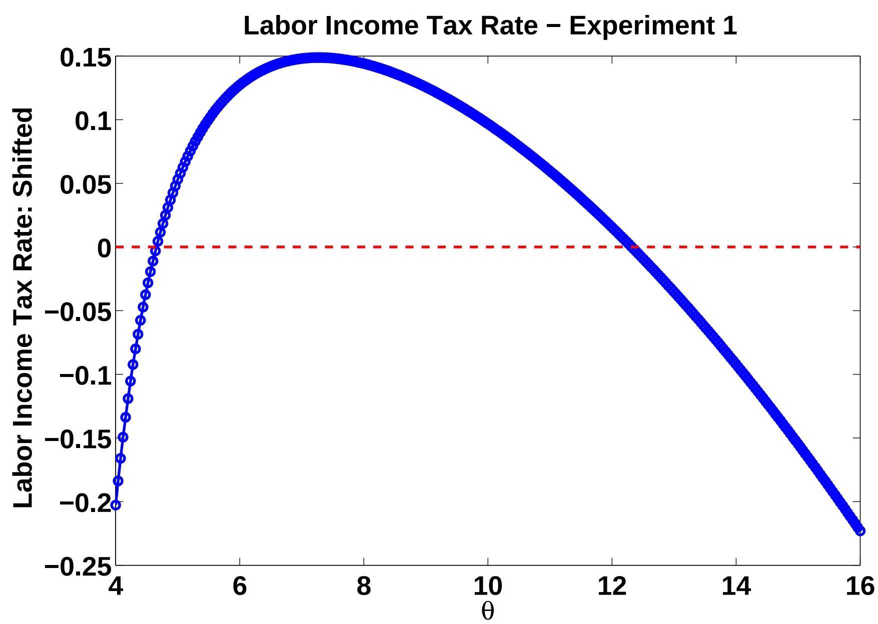
this new allocation; agents would require an additional 3.81% units of consumption in every period and state of the world to be equally well off.

Figure 1.3: Shifted labor income tax rates from Exp 1.



For experiment 2, I allow the wealth and labor taxes to be as originally defined in (1.12) and (1.13) and determine a pure lump-sum transfer such that the government budget balances and agents are allowed to choose their optimal level of allocation at these new tax rates. By not shifting the marginal labor tax curve as before, we do not change the labor decision at the margin for agents in this experiment. Because the wealth taxes were already generating zero revenue and the labor taxes generating positive revenue, a pure lump-sum transfer would be the same and positive for each agent. This would be a highly positive outcome for the high skilled agents, as they

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would receive a further subsidy through the lump-sum component. Therefore, the new tax paid is no longer increasing in skill levels. Agents would require an additional 4.5% units of consumption in every period and state of the world to maintain equal utility.

1.5 Exploring Ramsey

In this section, I use the Ramsey framework in the same environment as outlined in the previous section. I run two experiments (experiment 3 and experiment 4) in this section, the common goal being to determine how close we can get to the c.e.a. without resorting to the complicated optimal tax system. In addition, experiment 3 serves an additional purpose, explained below.

1.5.1 State-dependent Labor Taxes

In this experiment (experiment 3), the only tax instruments are earnings-dependent labor income taxes in period 2. This is an interesting experiment, in that it allows one to see what the marginal tax rates would look like as stand-alone taxes in the absence of other instruments. One can then compare these tax rates to the marginal labor income tax rates from the Mirrleesian literature, wherein the latter are often provided in isolation of other instruments.

Given the large number of tax rates to be determined, I use the primal approach to solve this problem. This requires that the tax rates in the agent's budget constraint be replaced in terms of allocations, creating a new set of constraints known as the implementability constraints. Assuming τ_y^i is the tax rate if the agent observes

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state i, the agent's problem becomes:

$$\max_{\{c\},\{y\},k'} \quad u(c_1) - v(y_1/\theta_1) + \beta \sum_{i=1}^{N} \pi_i \big[u(c_{2,i}) - v(y_{2,i}/\theta_{2,i})\big]$$

s.t.

$$c_1 + k' = y_1,$$

$$c_{2,i} = Rk' + (1-\tau_y^i)y_{2,i} \;\text{ for } i = 1, \ldots, N.$$

The first order conditions from this problem allows us to write $(1-\tau_y^i)$ in terms of allocations. Specifically, one can show that $(1-\tau_y^i) = \frac{1}{\theta_{2,i}}\left(\frac{v'(y_{2,i}/\theta_{2,i})}{u'(c_{2,i})}\right)$. Using this in the agent's budget constraints will then give the set of implementability constraints.

One then maximizes the objective function (in this case, (1.5)) subject to resource constraints (1.2) and (1.3) and the implementability constraints. Once the allocations are known, the appropriate tax rates can then be determined by inverting the process used to obtain the implementability constraint.

Figure 1.4 shows what these marginal tax rates look like. As one might expect, they are increasing in skill level and are, in fact, negative for agents realizing lower period 2 skill levels. This is not surprising because, in this case, labor income taxes are the only taxes available; they therefore play a risk-sharing role analogous to the net tax paid by agents in the optimal tax system. So, agents that realize a low skill shock receive a net tax subsidy and those that realize a good skill shock pay a positive net tax. It bears noting, however, that these results differ substantially from the labor-income tax rates in the optimal tax system. This clearly shows that taking the labor income tax rates from the optimal tax system in isolation of the other

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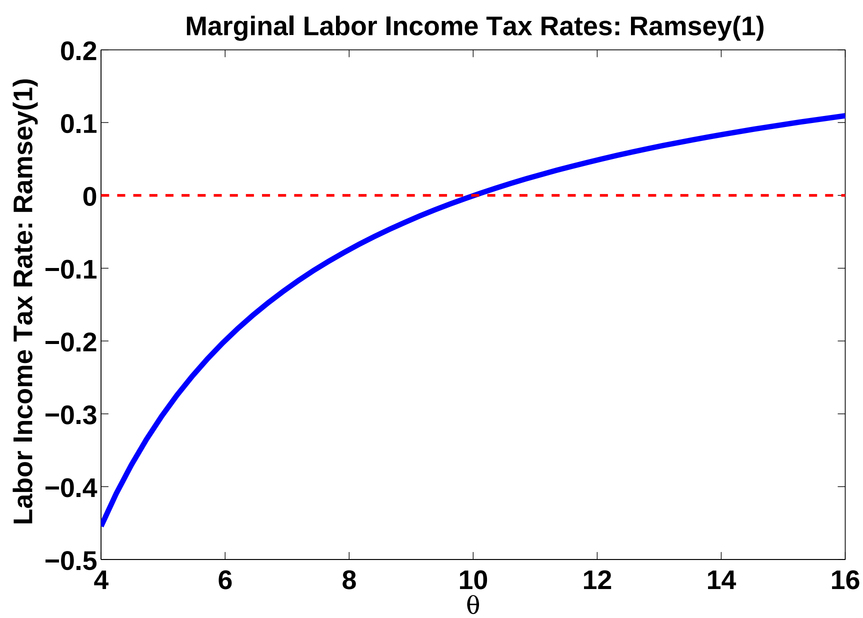
instruments is not a good idea. Additionally, agents in this case would require an additional 0.1% units of consumption in every period and state of the world to be as well of as under the optimal tax system. Relative to experiment 1, this is a significant welfare improvement, though still inferior to the c.e.a. However, this approach suffers from some of the same criticism as the Mirrleesian approach: it is complicated to implement given the number of tax instruments required. Next, in experiment 4, I consider a log-linear tax function that is much easier to implement.

Figure 1.4: Labor income tax rates obtained from Exp 3.



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1.5.2 Log-linear Taxes

There is no theory behind the tax functions used under the Ramsey framework, so they might seem arbitrarily chosen. I motivate using log-linear taxes as follows. The tax function chosen needs to share the general properties observed in the optimal tax system. That is, it must provide risk-sharing, ruling out the use of linear taxes. Additionally, we observe the need for the tax function to take on both positive and negative values, which excludes the non-linear tax function prescribed by Gouveia and Strauss (1994). As an alternative, I use the log-linear tax function, which not only meets my requirements but has also been used by Gervais (2012).[10]

I assume that agents are taxed only on labor income in period 2 and let the tax on y units of effective labor be $T(y) = y(\tilde{a} + \tilde{b} \cdot ln(y))$. The agent's problem can then be written as:

$$\max_{\{c\},\{y\},k'} \quad u(c_1) - v(y_1/\theta_1) + \beta \sum_{i=1}^{N} \pi_i \big[u(c_{2,i}) - v(y_{2,i}/\theta_{2,i})\big]$$

s.t.

$$c_1 + k' = y_1,$$

$$c_{2,i} = k'R + y_{2,i}(1 - \tilde{a} - \tilde{b} \cdot ln(y_{2,i})) \;\text{ for } i = 1, \ldots, N.$$

The tax parameters $\{\tilde{a},\, \tilde{b}\}$ need to be determined. Using $\tilde{a}$ to balance the government's budget, only $\tilde{b}$ needs to be determined. The government wants to choose

[10]In the non-linear taxation literature, Gouveia and Strauss's tax system has gained considerable popularity, having been used in the recent past by Castaneda et al. (WP); Conesa and Kreueger (2006); Conesa et al. (2009); Kitao (2010).

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$\tilde{a}$ and $\tilde{b}$ such that the agent achieves the maximum possible utility while ensuring a balanced budget; i.e., $\sum_{i=1}^{N} \pi_i c_{2,i}(\tilde{a} + \tilde{b} \cdot ln(c_{2,i})) = G$.

Unsurprisingly, the welfare losses in this case are higher than in experiment 3. This is because with log-linear taxes, the marginal and average tax rates do not overlap. This causes a wedge, and therefore, one would not expect it do as well as experiment 3.[11] As a result, agents in this case would require an additional 0.5% units of consumption in every period and state of the world to be as well of as under the optimal tax function. Table 1.1 compares the welfare losses associated with various experiments. Figure 2.6 compares the net tax paid in the optimal tax system to that paid in the two Ramsey experiments. As evidenced from the welfare losses associated with the two Ramsey experiments, the log-linear tax function provides less insurance than the state-dependent lump-sum labor tax case.

Table 1.1: Welfare losses: ramsey vs. mirrlees.

	Mirrlees		Ramsey	
	Exp. 1	Exp. 2	Exp. 3	Exp. 4
Cons. Equiv.	3.81%	4.5%	0.1%	0.52%

[11]Agents make their decision based on the marginal tax rates and the government cares about the average tax rate.

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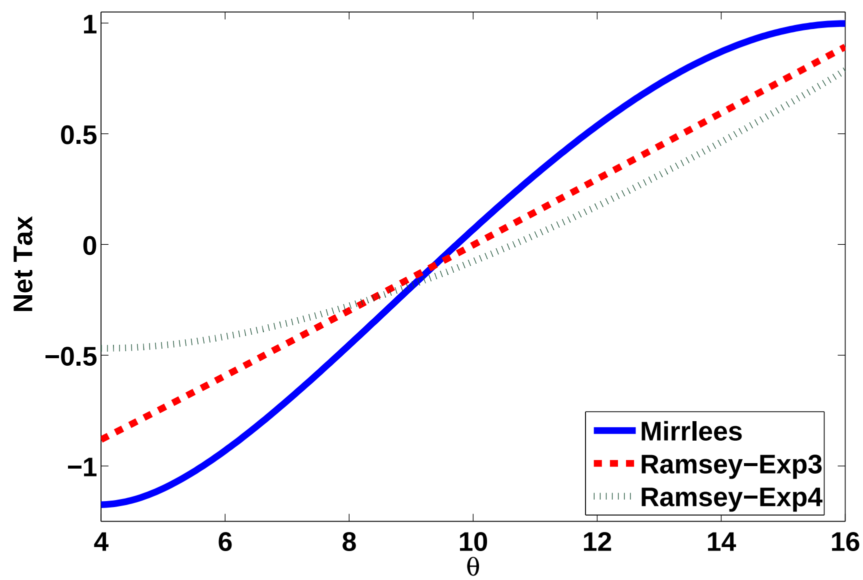
Figure 1.5: Net tax paid.



1.6 Conclusion

In this paper, I first derive a set of results in order to show that when utility is separable in consumption and labor, only the downward incentive constraint will bind. This result greatly simplifies computation and also helps in the partial characterization of the planner's problem. I then derive an optimal tax function consisting of earnings-dependent wealth, labor, and transfers. I further show that the optimal labor and wealth taxes can only be supported by transfers. Additionally, I show that most of the redistribution and risk-sharing is done through these type-specific transfers.

Then, using a simple two-period model with the Ramsey framework, I show that the respective shapes of marginal labor income tax rates are very different from what is implied by the optimal tax system. As a result, attempting to optimize

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the taxes from the Mirrleesian system in the absence of lump-sum taxes leads to significant welfare losses in the amount of 3.8% in terms of consumption equivalence. Additionally, I show that when using log-linear income taxes, an agent would require 0.5% additional units of consumption in every state and period of the economy. This shows that using a very simple parametric tax function is better than attempting to optimize an incomplete Mirrlees tax code.

Overall, one can conclude that each and every instrument of the optimal tax system plays a crucial, yet distinct, role. In the case that the optimal tax system as a whole is too complicated to implement, using a Ramsey framework is preferable to implementing only certain portions of the optimal tax system.

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CHAPTER 2
STUDENT LOAN DEBT AND LABOR MARKET OUTCOMES

2.1 Introduction

The federal student loan program has recently drawn the notice of policy groups, the media, and academia. A series of reports from the Federal Reserve Bank of New York (Haughwout et al. (2015); Lee (2013)) show that student loan debt is now the second largest source of household debt in the United States, surpassed only by home mortgages.[1] Hershbein and Hollenbeck (2014, 2015) report that 71% of bachelor's degree recipients in the class of 2012 graduated with student debt.[2] While the literature has focused primarily on studying the delinquency and default rates and designing optimal student loan programs (e.g. Lochner and Monge-Naranjo (2015), Looney and Yannelis (2015)), little is known about how student loans impact labor market outcomes: that is the focus of this paper.

Specifically, we establish empirically that student loan debt leads to lower earnings after graduation. To establish this result we use data from the Baccalaureate and Beyond Longitudinal Study: 1993/03 (B&B: 93/03). The B&B: 93/03 surveyed a representative sample of undergraduate students who received their bachelor's degree during the 1992-93 academic year, with follow-up surveys conducted in 1994, 1997

[1] According to the data, total outstanding student loan debt is currently around $1.2 trillion. This is more than total outstanding credit card debt and total outstanding car loan debt.

[2] Other papers that document the rise in student loans include Akers and Chingos (2014), Haughwout et al. (2015), Steele and Baum (2009), Woo (2014) and Arvidson et al. (2013).

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and 2003. The study collects data at the individual, institutional, and administrative levels. The administrative data are linked to the National Student Loan Data System (NSLDS), which provides information on loan types and amounts disbursed throughout an individual's undergraduate study. The institutional-level data provide the relevant information necessary to determine eligibility for need-based Stafford loans (also known as subsidized Stafford loans) during the last year of schooling for each individual in the B&B: 93/03. From the individual-level data, we have information about earnings as well as standard individual characteristics.

Unconditional means show that earnings for those eligible to borrow in their last year of schooling were approximately 8.5% lower than those who were ineligible. Because some factors that affect borrowing, such as motivation and family support, also affect income, simple regression results will be biased. There also exist valid concerns of biased results due to parental income, given the persistence of intergenerational wealth. In order to estimate unbiased results, the variation in debt used to identify the effect should be exogenous to the outcome. Our identification strategy for estimating the causal effect of cumulative debt on earnings exploits a kink in Stafford loan program eligibility, specifically for subsidized Stafford loans.[3]

Subsidized Stafford loans are need-based loans; i.e., one must demonstrate financial need in order to be eligible. Financial need for any given academic year

[3]The two main components of the federal student loan program are subsidized and unsubsidized loans. For subsidised loans, the government pays interest while the individual is in school, whereas for unsubsidized loans, interest begins to accrue the moment the loan is disbursed.

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is computed as the difference between annual cost of attendance (COA) and the sum of expected family contribution (EFC) and grants or scholarships the student receives from government or institutional sources. Students who cannot show financial need are still eligible for unsubsidized and parent PLUS loans, but will not receive subsidized loans.[4] For students with financial need, the borrowing cap increases linearly with need.[5] This results in a kink in the amount of permitted subsidized loans around the need threshold value of 0. To the left of the threshold, the slope of the amount of subsidized loans that can be borrowed is 0, to the right of the threshold, the slope for amount that can be borrowed is 1. This kink at the need threshold allows us to implement a regression kink (RK) design (Card et al. (2012)).[6]

We take advantage of the fact that dependent undergraduate students had access to only subsidized Stafford loans through the 1992-93 academic year.[7] Because all students in our sample graduated in 1993, any dependent student with positive loan amounts could only have obtained them through subsidized loans. As such, our benchmark sample consists of only dependent students.[8] While we only have

[4]Parent PLUS loans are unsubsidized loans taken out by parents of students, and they usually carry a higher interest rate than do Stafford loans.

[5] The maximum amounts allowed have varied over time and also depend on the year of enrollment. In 1992-93, students enrolled in the third year or higher were allowed a maximum of $4,000 in subsidized loans.

[6]Recently, Turner (2014) and Marx and Turner (2015) implement a RK design to study the impact of the federal Pell Grant program on educational attainment and student borrowing.

[7]While independent students always had access to unsubsidized loans, dependent students could only avail of them from the 1993-94 academic year onward.

[8]In a sample that includes both dependent and independent students 85% of all borrowers

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information on financial need in the last year of schooling, our focus is on cumulative debt. This is because we want to understand the impact that debt has on earnings. Borrowing in the last year alone need not be representative of total debt accumulated by a student. This is especially true given the transitory nature of financial need from year to year, which in turn determines eligibility for Stafford loans. As a result, the mapping between financial need and total amount borrowed (simply referred to as debt hereafter) is not a sharp mapping, but rather a "fuzzy" one: we therefore use a fuzzy RK estimation technique.

Estimates show that an additional $100 of borrowing reduces income one year after graduation by approximately 0.1%. Extrapolating this result, earnings for an individual with the mean level of borrowing are on average 5% lower than earnings of an individual with no debt. Moreover, our result is robust to various specifications. For example, in a sample that consists of both dependent and independent students, earnings for an individual with the mean level of borrowing are on average 3.8% lower than earnings of an individual with no debt. Results show that debt continues to have an impact, although of lesser magnitude, on earnings 3 years after graduation, but the effect fades away 9 years after graduation. The impact of an additional hundred dollars of student debt on earnings reduces to 0.04% by 1996. Unconditionally, the difference in earnings is persistent over time, but our identification strategy, which relies on the kink does not capture this effect. Consequently, individuals with debt

had only subsidized loans. Our results are robust to including independent students in the sample.

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not only make lower nominal wages, but also have to use part of those lower wages to make loan repayments.

We then turn to economic theory to show that there exists a simple mechanism consistent with the empirical finding, whereby more debt leads individuals to quickly find employment rather than wait for an ideal job. Specifically, we use a simple one-period directed search model, along the lines of Moen (1997), in which individuals enter the labor market with an exogenous amount of debt. The standard trade-off in such models is the inverse relationship between the target wage level and the probability of finding employment at that wage. The higher the wage an individual targets, the lower the probability of being successful and, therefore, the longer the expected duration of unemployment.

When debt is modeled along the lines of student debt; i.e., it cannot be discharged in bankruptcy, we show that individuals search for lower-wage jobs as debt increases. This is because the individual is liable for her debt regardless of the job search outcome. Failure thus becomes increasingly undesirable in the level of debt. Consequently, as debt increases, a successful job search at a lower wage is preferred over the risk involved with searching for a higher wage. Crucial to this result is that student debt is not dischargeable in bankruptcy. In fact, we show that if an individual is allowed to discharge her debt, higher debt causes her to search for higher wages at lower probabilities of success. The intuition behind this result is that as debt increases, the increase in utility from successfully finding a job at a given wage decreases due to higher debt payments. Since she knows she can declare bankruptcy

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if she is unsuccessful, default and bankruptcy puts a floor on her outside option and causes her to search for higher paying jobs with a lower probability of success – the exact opposite of our observation.

The two scenarios emphasized above are arguably very stark: either debt cannot be discharged, or, when it can, individuals automatically declare bankruptcy when their job search fails. However, there is a large literature documenting and trying to account for the relatively high frequency of loan delinquency and default on student loans (e.g. Gross et al. (2009), Lochner and Monge-Naranjo (2014), and Looney and Yannelis (2015)). Extensions of our model that explicitly allows for these phenomena suggest that what is key for our result is that individuals must eventually pay their debt, rather than the exact path that leads to that outcome. However, preliminary results suggest that the low take-up rate of income contingent repayment schemes is difficult to rationalize. Indeed, Ionescu (2011) finds that a policy allowing for income-contingent repayments that is restricted to financially constrained borrowers induces a 0.8 percent increase in welfare. Additionally, grants can also increase welfare if they lead to a reduction in student debt. Abbott et al. (2013) determine that there are significant short-run impacts of expanding tuition grants, especially of the need-based component of such grants. Our model would lead to a similar conclusion as grants along this margin would reduce the amount of debt taken up by the students.

While the literature linking student debt to economic outcomes post graduation is rather thin, there are a few notable exceptions. For example, the notion that

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individuals who graduate with student debt tend to value finding a job quickly rather than risk looking for extended periods of time is consistent with Baum (2015), who documents that student debt discourages entrepreneurship. She notes that in addition to the mechanism emphasized here, individuals with student debt may have limited access to credit. Similarly, student debt leads to delayed home ownership (Mezza et al. (2014)) as well as marriage and fertility (Gicheva (2013) and Shao (2014)).

The rest of the paper proceeds as follows: in Section 2 we describe the relevant institutional details on the federal student loan program. We describe our data and sample selection process in Section 3. In Section 4, we discuss and carry out our empirical approach. Section 5 presents the directed search model and related theoretical results, and we conclude in Section 6.

2.2 Institutional Details

In this section, we review various institutional details, including the difference between Stafford subsidized and unsubsidized loans and how eligibility for the two loan types has changed over time. This information explains why we focus initially on dependent students, and why the fortuitous timing of the B&B 93-03 survey permits us to take advantage of the regression kink design. The following institutional details are mostly obtained from a National Center of Educational Statistics (NCES) report (Berkner (2000)).

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2.2.1 Subsidized and Unsubsidized Loans

Federal student loans can be categorized into Stafford subsidized and unsubsidized loans, Perkins loans and parent PLUS loans. Of these, Stafford subsidized and unsubsidized loans are the most prominent in terms of dollar volume and number of borrowers and we therefore focus our attention on just the Stafford loan program.[9] The first serious difference between subsidized loans and unsubsidized loans is the time at which interest begins to accrue.[10] For subsidized loans, students are not charged interest while they are enrolled at least half time and during the grace period that follows (usually six months). The federal government subsidizes the cost of such loans by paying the interest over the duration. The federal government does not pay the interest on behalf of students who carry unsubsidized loans. Interest begins to accrue upon disbursal, which is then added to the principal. As a result, the amount owed on a subsidized loan will be the same as the principal borrowed when repayment begins; the amount owed on an unsubsidized loan will be the original principal borrowed plus accrued interest. The second main difference between the two loan types is the respective eligibility requirements. The requirement to qualify for subsidized loans has been consistent over time: a student must demonstrate financial need (this will be discussed in detail below). The requirements to qualify for unsubsidized loans have varied over time, however, especially with respect to dependent status. Before

[9]Perkins loans are need-based subsidized loans that are disbursed by the educational institution and carry a fixed interest rate of 5%. One has to prove exceptional need to be eligible for Perkins loans. PLUS loans are taken out by the parents of a dependent student to help cover expenses remaining after having taken out subsidized and unsubsidized loans.

[10]They sometimes carry different interest rates as well.

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proceeding further, let us first consider how the government distinguishes dependent from independent students for federal loan purposes.

Most undergraduates under the age of 24 are classified as dependent while enrolled.[11] Those undergraduates who are 24 years of age or older and all others who are married, have children or dependents for whom they provide more than half support, or are veterans, orphans or wards of the state (for example, children in foster care) are classified as independent. For dependent students, the income of the parents is a major consideration in determining the need for financial aid; for independent students, only spousal and student income is considered. Federal student loans are capped on an academic year basis. There are separate limits for subsidized loans and for unsubsidized loans and the combination of the two. These limits are also a function of the year of enrollment. Independent students are allowed to borrow more than are dependent students by combining subsidized and unsubsidized loans. The rationale for this provision is that additional loan funds are available to dependent students through their parents, while independent students are not expected to be able to rely on parental financial assistance. Having established the distinction between dependent and independent students, we move forward with how loan policies have varied over time for these groups.

The 1986 Higher Education Act (HEA), also known as the 1986 Reauthoriza-

[11]More specifically, the student must be less than 24 years of age at the start of the academic year. This means that an average high school student entering college at the age of 18 years would remain a dependent for the first six years of his undergraduate education.

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tion, established provisions for six academic years: 1987-88 to 1992-93.[12] The major federal student loan program consisted of guaranteed student loans called Stafford loans during this period. Banks and other lenders provided the funds for Stafford loans, which were guaranteed against default by the federal government through guaranty agencies. Between 1987 and 1993, all Stafford loans were subsidized and available to both dependent and independent students on the basis of financial need (*need* henceforth). Unsubsidized loans were also available through Supplemental Loans for Students (SLS), a separate federal guaranteed student loan program. SLS loans were primarily intended to allow independent students to supplement Stafford loans, though some dependent undergraduates with exceptional need could also qualify.[13]

The Reauthorization of 1992 and additional legislation made substantial changes to the structure of the federal student loan program, generally beginning with the 1993-94 academic year. The separate SLS program was phased out and replaced by unsubsidized Stafford loans, now available to both dependent and independent students. Loan limits were also increased. The existing loan program was renamed as the Federal Family Educational Loan Program (FFEL). In addition, the William D. Ford Direct Loan Program was established as an alternative system of processing

[12]Many of the changes of a Reauthorization go into effect on October 1 of that year (which is the beginning of the federal fiscal year). However, more than three-fourths of the student loans for a given academic year are processed before October, so the full effect of the changes is not evident until the following academic year.

[13]Dependent undergraduates whose parents applied, but were rejected, for federal parent PLUS loans (which require meeting creditworthiness criteria) were able to qualify for SLS loans. This provision was continued after 1993 and is still in effect, allowing some dependent students to obtain unsubsidized loans at the independent student maximum amounts.

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Stafford loans. In the direct loan program, funds are provided directly through the Department of Education. From a student perspective, the two loan programs were more or less equivalent. The 1998 Reauthorization of the Higher Education Act made no major changes to the structure of these programs, or their eligibility requirements and loan limits. FFEL ended with the enactment of the Health Care and Education Reconciliation Act of 2010. As of July 1, 2010, all FFEL loans ceased, and the direct loan program is the only source of student loans.

Figure 2.1 shows the percentage distribution of subsidized and unsubsidized loans by dependency status. Of all dependent borrowers, 97% and 96% had only subsidized loans in 1989-90 and 1992-93 respectively. This lends credence to the fact that most of the changes in the 1992 Reauthorization came into effect only with the 1993-94 academic year. This is further supported by the fact that in the 1995-96 academic year the proportion of dependent borrowers with only subsidized loans dropped to 68%; the rest had some combination of only unsubsidized loans or a mixture of subsidized and unsubsidized loans. As a result, any analysis of dependent students up to the 1992-93 academic year focusing on federal student loans will consist of subsidized loans almost exclusively. It is therefore important to understand how the government determines *need*, and how we might use variation in the *need* formula to establish a regression kink design.[14]

[14]We also note that over the years of interest, about 75% of independent students and 85% of the entire undergraduate student population only had subsidized loans. Therefore, it is conceivable that any pattern in borrowing for dependent students might still exist, though perhaps weakened somewhat, when including both dependent and independent students. We investigate the matter further when conducting robustness checks.

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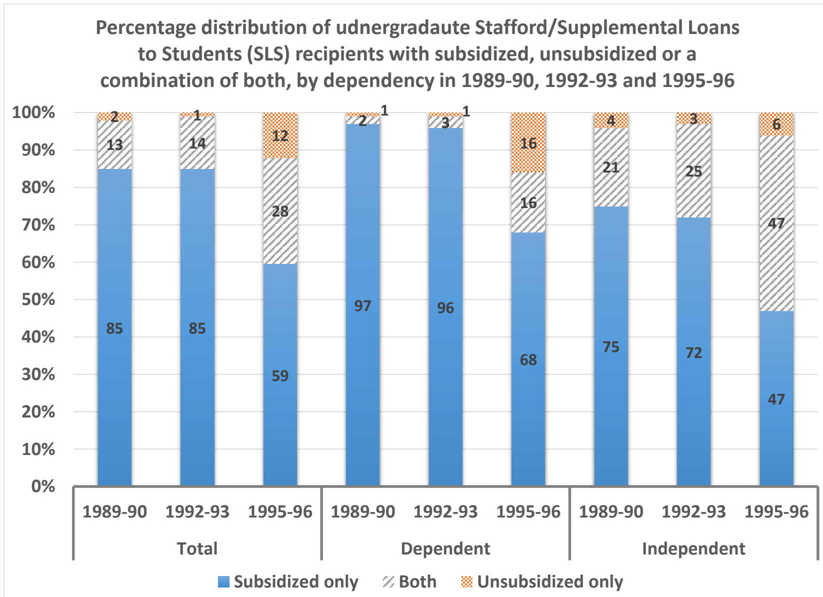
Figure 2.1: Distribution of loans.



Notes: This is Figure 4 reproduced from Berkner (2000).

Financial need is determined by comparing the cost of attendance (COA) to the ability to pay for them on the part of the student. COA is the sum of tuition, fees and other educational expenses (books, supplies, board, lodging, etc.). It is estimated for various categories of students by financial aid office at each institution based on factors such as attendance status, dependency etc.

The ability to pay is measured by an index called the expected family contribution (EFC). Students wishing to take out student loans for a given academic year fill out the Free Application for Federal Student Aid (FAFSA) in the previous spring. Since FAFSA requires tax information, it is usually filled out after filing tax returns. The federal government determines EFC and provides the number to the student's

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institution, based on the information provided in FAFSA. The EFC is a complicated formula based on income and assets, with adjustments for family size and the number of family members enrolled in postsecondary education.

Need-based federal aid eligibility and amount is determined by comparing the COA and EFC. If the EFC is greater than the COA (negative *need*), the student is not eligible for need-based aid. If the EFC is less than COA, the amount of aid for which the student qualifies is equal to COA minus EFC. If the student receives any grants or other aid, the amount is subtracted from need. Any remaining need may be covered by a subsidized Stafford loan, up to the annual limit (as explained in footnote 5). Therefore, need can be quantified as:

$$need = COA - EFC - Grants.$$

Anyone with *need* less than or equal to 0 is ineligible for subsidized Stafford loans. Anyone with positive *need* is eligible for an amount equal to *need* up to the annual limit. Hence, the change in the slope of the amount that can be borrowed around the need threshold value of 0 (the slope is 0 for those below the threshold, and 1 for those above it) will prove key in the regression kink (RK) design studied later. Figure 2.2 shows the empirical distribution of loans taken out in the last year of schooling as a function of *need*. While our analysis in Section 2.4 uses cumulative amount borrowed rather than borrowing in the last year alone, Figure 2.2 nevertheless serves as a useful illustration of the policy.

Next we discuss the repayment, delinquency and default process in some detail. Although these details are not immediately relevant to the empirical analysis, we

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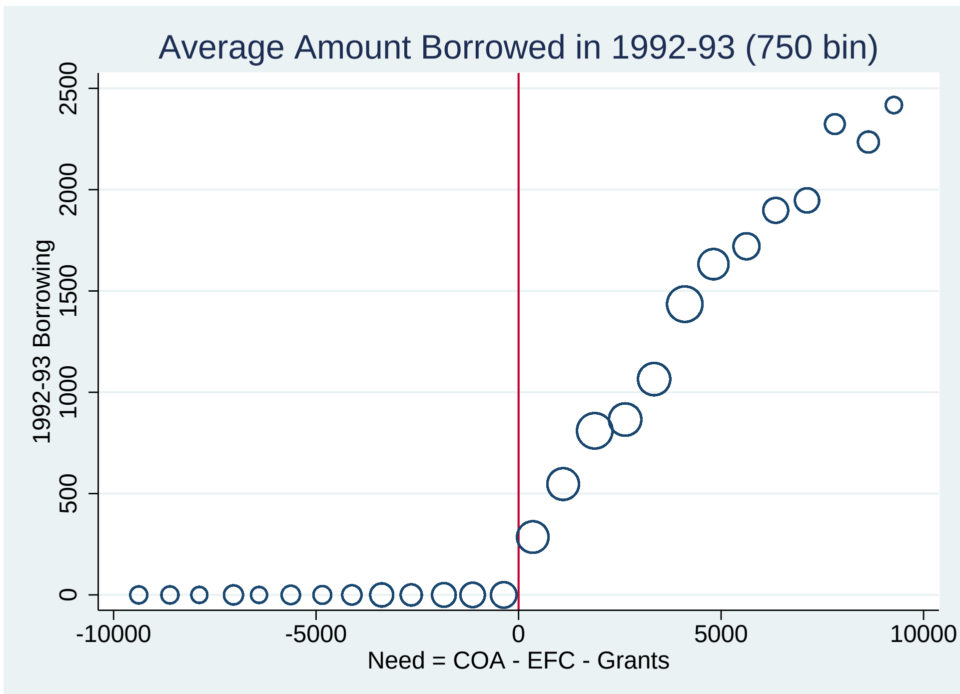
Figure 2.2: Empirical distribution of Stafford loans.



Notes: Bin size is \$750. The center of each circle represents the average amount borrowed in the bin. The size represents the number of people in the bin.

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believe that it is important to know these details in order to understand the underlying mechanism that is driving the empirical results.

2.2.2 Repayment, Delinquency and Default

Once a student graduates from school (or enrols less than half time, or drops out), she receives a six month grace period before repayments begin.[15] During this six month grace period a borrower can choose one of several repayment plans. The most popular is the ten year standard repayment plan. Under this plan, individuals make fixed monthly payments deemed actuarially fair. If the interest rate on the loans is fixed or the loans were consolidated, the monthly payments would be the same for every month. The monthly payments change annually if the interest rate is variable, but remain constant during the year (from July to the following June). Other variations of this scheme include the extended plan (for individuals who have cumulative borrowing above $35,000) and the graduated plan, under which the payment amounts increase every two years over a period of ten years. There are also a host of income-based and income-contingent plans, where an individual pays a certain fraction of her adjusted gross income (usually between 10%-20%, depending on the plan) for 20-25 years, or until the loan has been paid off. Most of these income plans cap monthly payments to the corresponding amount in the standard ten year plan. Any additional balance remaining at the end of the plan is forgiven, although it may

[15]Loans for individuals who enrol in graduate school automatically go into deferment, so no payments have to be made during this period. The grace period is nine months for Perkins loans, but they form a very small fraction of student loan program.

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be liable to taxation. Historically, loan servicing agencies have pushed the standard ten year plan, and it has been the most popular of all repayment plans by far. Only recently have income plans started to increase in popularity.[16]

An individual is deemed delinquent on her loans upon her first missed payment. At this point she must become current on her loans within nine months.[17] The cost of remaining in delinquency increases with time. From a monetary viewpoint, the longer one remains in delinquency, the more one has to pay back due to interest accumulating on unpaid capital. If the loan is 30+ days delinquent, the individual can be charged additional late fees. Credit agencies get notified once it becomes 90+ days delinquent, negatively affecting access to credit. In addition, this can cause trouble when signing up for utilities, a cell phone plan, getting approval to rent an apartment and buying homeowner's insurance.[18] Additional late fees can be added as delinquency continues. If the loan is 270 days delinquent (or more), it is termed as being in "default", and the consequences become more severe. At this point, the defaulted loans are assigned to a collection agency (collection fees are borne by the borrower); the government, moreover, has the power to garnish wages (up to 15%) or withhold tax refunds and social security benefits (up to 15%). The entire unpaid balance of the loan and any interest is immediately due and payable. In addition, one

[16]From our dataset, about 2% of respondents in repayment were in some form of income-based plan in 1994. According to the latest government data in Q2 of 2015, about 17% of individuals in repayment are in some income-based plan: `https://studentaid.ed.gov/sa/about/data-center/student/portfolio`.

[17]New government regulations are considering extending this period to twelve months.

[18]`https://studentaid.ed.gov/sa/repay-loans/default`.

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loses eligibility for additional federal student aid as well as eligibility for deferment, forbearance, and income based repayment plans when in default.

In consequence, there is almost no means of getting out of student loan debt aside from repayment. Next, we proceed to describe the B&B 1993/03 data, as well as our sample selection process. The institutional details covered in this section lay down the foundation for the choices we make when selecting the sample. For example, why our focus on dependent students leads to a clean experimental design, and why we choose to drop those enrolling into graduate school immediately after obtaining their undergraduate degree.

2.3 Data

The data source for this study is the Baccalaureate and Beyond Longitudinal Study (B&B). The sample is derived from the 1993 National Postsecondary Student Aid Survey (NPSAS), a nationally representative cross-section sample of all post-secondary students in the US. The B&B is a nationally representative sample of students who received their bachelor's degree during the 1992-93 academic year. These students were then surveyed in 1994, 1997 and 2003. Data are collected from three sources: survey data, institutional data and student loan administrative data. Institutional data, in addition to describing institutional characteristics, contains information about expected family contribution, cost of attendance and grants or scholarships received by the student during the last year of school. Student loan administrative data is obtained through the National Student Loan Data System (NSLDS): it con-

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tains information about the amount and type of loan disbursed during each year of undergraduate schooling.

2.3.1 Sample Selection

The initial data set derived from the 1993 NPSAS consists of approximately 11,200 observations.[19] First, we drop respondents with missing information related to age, race, gender or citizenship, and those who dropped out of the survey before the 1994 round; this removed about 1,300 observations. We then remove those who are non-US citizens or disabled, approximately 600 observations. Next, we drop those enrolled in graduate school (master's/PhD/professional) during the 1994 survey, reducing the count by approximately 1,500. As indicated previously, being in graduate school automatically defers repayment for those who have student loans. As a result, the mechanism that drives the model does not apply to such individuals. This leaves us with a sample of approximately 7,800 observations. Dropping individual who chose to go to graduate school in 1994 might raise some concern if student loan debt has an impact on this decision. In the Section 2.4.3 we address this concern (along with other possible extensions). Our benchmark sample consists of only dependent students. As explained earlier while discussing Figure 2.1, this allows us to exploit the kink in the Stafford loan program and conduct a well-defined experiment in order to understand the impact of student debt on income. This leaves us with about 4,700

[19]Due to data security reasons, any reference to number of observations in this document is rounded to the nearest ten.

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observations.[20] Finally, we only consider individuals who have need in the range (bandwidth) of $[-\$10,000, \$10,000]$. This is because a valid RK design considers only those values in the vicinity of the threshold value. We later conduct robustness checks to ensure that the results hold for different bandwidths. This leaves us with a sample of about 3,900 observations, all of whom graduated with a bachelor's degree in the same academic year and have similar experience (in terms of number of years in the labor force as well as the prevalent macro environment).

Given that we are trying to understand what affects income, education level, work experience, and the initial state of the economy would otherwise have to be controlled. A key feature of this data is therefore that they result in a fairly homogenous sample with amenable qualities for the question we are attempting to answer.

Given our mechanism, the primary outcome variable of interest is the respondents' annual earnings in 1994. Specifically, this is a measure of individuals annual salary at the job they held in April 1994. If it is indeed the case that individuals with student loans, knowing that they will have to start making repayments soon after graduation, have lower initial reservation wages, we should see this in the data soon after they graduate. Given that the students graduate in 1993, add the six month grace period before repayments being, repayments therefore being around the start of 1994.

[20]A 60-40 split between dependent and independent students seems to be on par with the trends during that time period. See Digest of Education Statistics 1993 (`http://nces.ed.gov/pubs93/93292.pdf`) for more details.

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2.3.1.1 Descriptive Statistics

Table 2.1 displays the characteristics of our sample. The first column shows characteristics for those respondents who were ineligible for a Stafford loan in the last year of their undergraduate degree program ($need < 0$). The second column displays characteristics for students who were eligible for Stafford loans in the last year of their undergraduate studies ($need > 0$) and column 3 reflects the entire sample. In addition, Table 2.1 is divided into three panels: student demographics and characteristics; educational related costs; annual earnings.

Under current trends, the race composition might seem highly skewed towards whites, a group accounting for 86% of the sample. This racial composition of the sample is fairly similar to the prevailing national statistic at that time however.[21] The SAT scores were out of a maximum of 1600 (800 for the math section and 800 for the verbal section). For those students who had only an ACT score, we used an ACT-SAT conversion table to determine a comparable SAT score.[22] We note that the average SAT scores of those who were eligible are not very different from those who were ineligible. To the extent that SAT score is a good proxy for ability, this strengthens our claim about the homogeneity of the sample. In addition, the average SAT score in the sample is very close to the national average, which was just over

[21] See Table 1 of the NCES report: `http://nces.ed.gov/pubs2006/2006156.pdf`.

[22] This conversion table is the outcome of a joint study by the ACT and the College Board (the College Board conducts the SAT): `http://www.act.org/aap/concordance/pdf/reference.pdf`. All results are robust to using only using actual SAT scores.

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1000 in 1992.[23]

In Panel B the Avg. Borrowed (cum.) term is the unconditional cumulative average amount borrowed by individuals while obtaining their undergraduate degree. We observe non-negative values for those who were ineligible for loans in the last year of their study because they were eligible and borrowed at some point between enrolling and graduating. Take note that not every eligible individual borrows. Finally Panel C shows the average annual incomes across groups for 1994, 1996 and 2002 respectively. The trend in the means shows that those ineligible to borrow in the last year of schooling made more than those who were eligible to borrow in the final year, on average. In 1994, those eligible to borrow made about 8.5% less than those ineligible to borrow. In the subsequent years the gap between the two groups seems to lessen, where those eligible have earnings about 4%-5% lower than those ineligible.

2.4 Empirical Framework

We use the variation induced by the kink in the Stafford loan program for the 1992-93 academic year to identify the impact of cumulative student loans on income. Because the students in our study graduate in 1993, and we focus only on dependent students, we need not worry about the type of Stafford loan; they were all subsidized Stafford loans. Additionally, given that subsidized loans are need-based loans, a kink occurs where the slope of the eligible Stafford loan amount changes from 0 to 1. Figure 2.3 displays the empirical distribution of cumulative Stafford

[23] http://www.infoplease.com/ipa/A0883611.html

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Table 2.1: Characteristics of respondents by Stafford loan eligibility.

	Ineligible	Eligible	Full sample
A. Student demographic			
Male	0.449	0.421	0.432
Age	22.17	22.13	22.15
Black	0.040	0.073	0.061
Hispanic	0.028	0.055	0.045
White	0.906	0.835	0.860
SAT	1015	980	992
Parent Income	\$60,650	\$44,640	\$50,400
Parent Education			
Less than bachelor	0.48	0.56	0.53
Bachelor	0.28	0.25	0.26
Master's and higher	0.24	0.19	0.21
Family Size	3.72	3.91	3.84
B. Education related costs			
EFC (92)	\$15,026	\$5,843	\$8,790
COA (92)	\$11,815	\$11,118	\$11,450
Grants (92)	\$876	\$1,432	\$1,216
Avg. Borrowed (cum.)	\$851	\$5,015	\$3,595
C. Average Annual Earnings			
1994	\$22,765	\$20,983	\$21,630
1996	\$28,765	\$27,532	\$27,980
2002	\$52,273	\$49,487	\$50,515
Observations	1,430	2,460	3,880

Notes: Ineligible if *need* < 0. SAT uses ACT-SAT conversion tables to compute SAT scores of students who have an ACT score but no SAT score. Parental income was in 1991. EFC is expected family contribution, and COA is cost of attendance. COA includes tuition and fees, books and supplies and living expense and is provided by the institution. Both EFC and COA are for the final academic year. All dollar values are in nominal terms. Avg. Borrowed is the unconditional cumulative average amount borrowed for undergraduate degree. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

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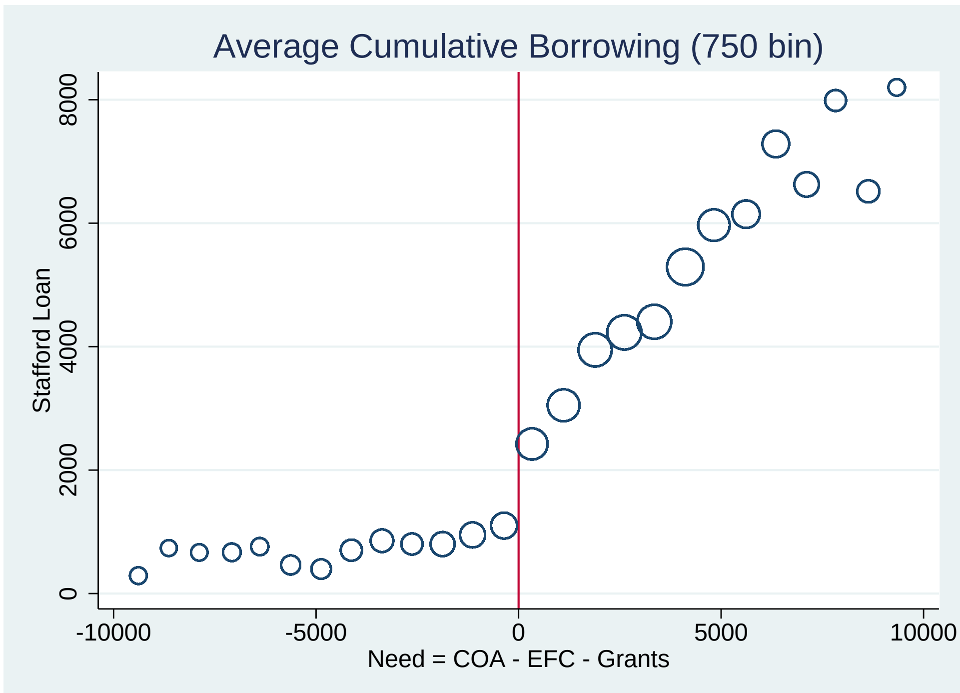
loans borrowed as a function of *need* in the final year of schooling, where *need* is calculated as discussed above. There is a clear kink about the *need* threshold value of 0. Let

Figure 2.3: Empirical distribution of cumulative Stafford loans.



Notes: Bin size is $750. The center of each circle represents the average amount borrowed in the bin. The size represents the number of people in the bin.

$$y = \tau Staf + g(need) + U$$

represent the causal relationship between the log of annual income in 1994, (y), and cumulative Stafford loans borrowed, $(Staf = Staf(need))$, where U is a random

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vector of unobservable, predetermined characteristics. The required identifying assumptions for the RK design are: (1) the direct marginal impact of *need* on y is continuous (e.g., around the eligibility threshold, there are no discontinuities in the direct relationship between *need* and y); (2) the conditional density of *need* (with respect to U) is continuously differentiable at the threshold for Stafford loan eligibility (Card et al. 2012). The monotonicity assumption needed for the estimates to describe a local average treatment effect is satisfied by the policy determining loan eligibility.[24] Provided that the relationship between unobservable factors and *need* evolves continuously across the Stafford loan eligibility threshold, the RK design approximates random assignment in the neighborhood of the kink. The second assumption, moreover, generates testable predictions concerning how the density of *need* and the distribution of observable characteristics should behave in the neighborhood of the threshold.

If these assumptions hold, and with locally constant treatment effects, the RK estimator, τ_{RK}, will identify the causal impact of cumulative Stafford loans on log earnings in 1994. Next, we provide supporting evidence for the validity of the identifying assumptions.

[24]This assumption requires that the direction of the kink be non-negative or non-positive for the entire population. In particular, it rules out situations where some individuals experience a positive kink at $need = 0$, but others experience a negative kink at $need = 0$. That the Stafford loan borrowing limit is increases in *need* ensures this holds.

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2.4.1 Evaluating the RK Identifying Assumptions

We evaluate the RK identifying assumptions through two exercises. First we test for discontinuities in the level and slope of the density of *need* at the threshold. Then, we test for discontinuities in the level and slope of the distributions of observable characteristics including age, gender, race, log parental income, parental education and family size respectively.

The first condition is that the density of *need* should be smooth. The idea here is that students, while allowed to have certain control over *need*, should not be able to manipulate it precisely. A logical argument in defense of this assumption is as follows. *need* is a function of 3 distinct components, where the value of each component is revealed separately from the others. In order to precisely manipulate *need*, therefore, the student must have the ability to manipulate the three factors while simultaneously dealing with the timing problem, making it a very difficult task. The cost of attendance is determined by the institution. Individuals, by choosing which school to attend have a level of control over COA in the first year of schooling. After this point, however, to the extent that she does not change schools, the individual takes changes in COA as given. Therefore, under the assumption that the individual did not change her school in the last year of schooling, she cannot have precise control over COA in that year. As a result, using COA in the last year of an individual's studies strengthens the argument against the ability to precisely estimate *need*. The EFC formula is an extremely complicated formula which makes manipulating it a very difficult task. Two components of EFC over which the family might exert some control are income

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in the previous year and the number of dependents in college. Because the FAFSA is filled out after parents file their tax return, precise EFC manipulation would demand that parents adjust their entire income from the previous year. Grants, the third component of *need*, are usually determined by factors directly out of the control of the student. Most grant related factors, moreover, are not known at the time of filing for FAFSA, thereby making it an instrument hard to precisely manipulate. If having precise control over any one component of *need* is difficult, having the ability to do so in a coordinated fashion between all three components is certainly very unlikely. Figure 2.4 displays the distribution of *need* as well as its various components. We do not observe bunching about any single point over the range of *need*. Panel 2.4(e) shows the distribution of *need* focussing on the range of $[-\$10000, \$10000]$, the range of need over which we will focus our attention. We notice no sudden change in the density around the threshold.

We run the following set of regressions to formally test for discontinuities in the level and slope of the distribution of observables around the threshold:

$$X_i = g(need_i) + \alpha_1 \mathbf{1}\left[need_i > 0\right] + \alpha_2\ need_i \times \mathbf{1}\left[need_i > 0\right] + \epsilon_i$$

where X_i is a predetermined covariate of individual i. $g(\cdot)$ is a polynomial function of *need*, the degree of which is determined to minimize the Akaike Information Criterion (AIC). The hypothesis we want to test is, $H_0 : \alpha_1 = 0$ for no discontinuity in the level and $H_0 : \alpha_2 = 0$ for no change in the slope. Table 2.2 shows the results for age, gender (male), race (white vs non-white), parental income, family size, parental education (college vs less than college) and SAT score. $g(\cdot)$ is defined as quadratic

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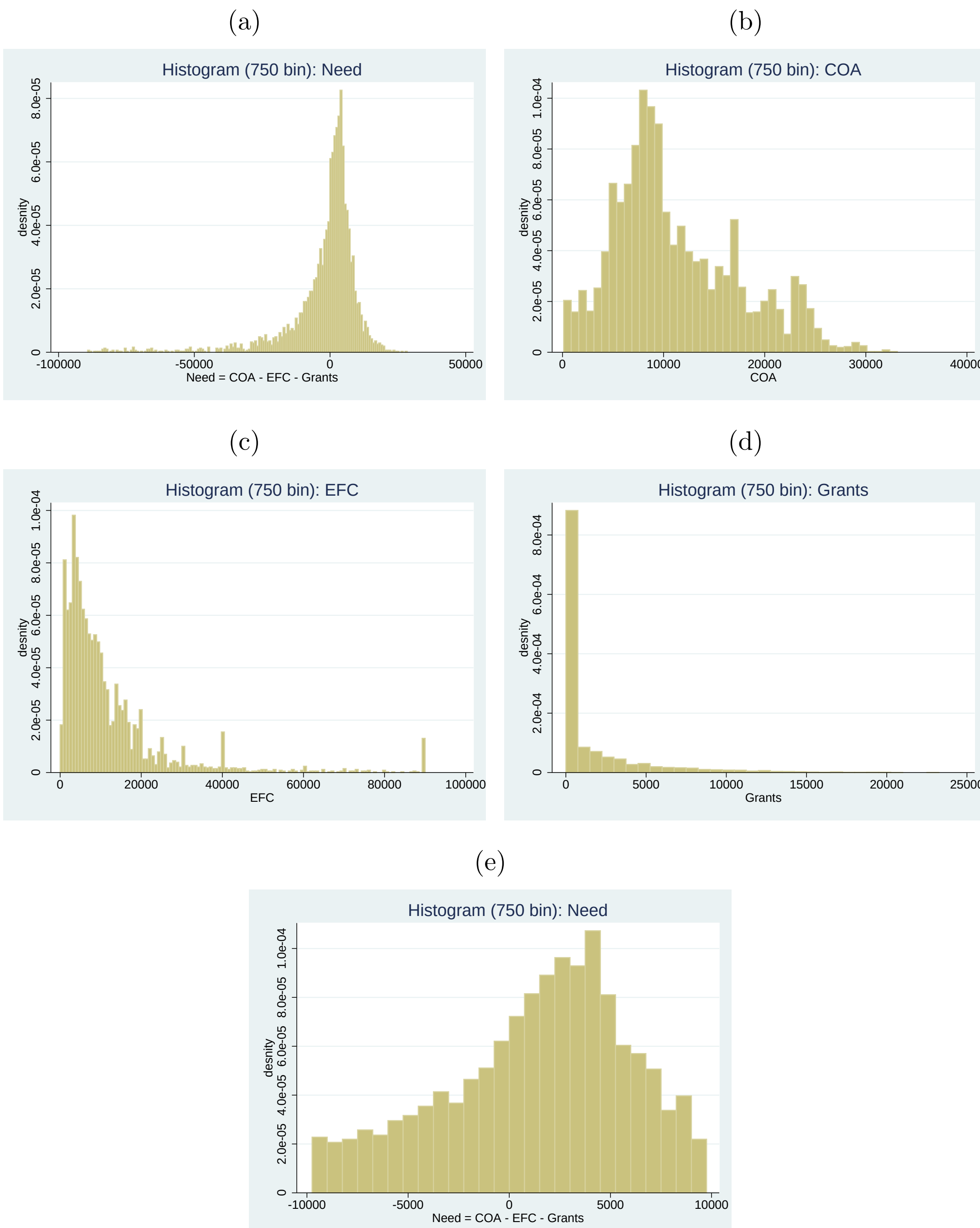
Figure 2.4: Distribution of *need* and the different components of *need*.



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in this specification, although we also test to make sure the results hold when $g(\cdot)$ is linear in robustness checks.[25] As we can see from the table, we fail to reject the null in all cases. Figure 2.5 shows the distribution of baseline characteristics as a function of *need*: we find no evidence of discontinuous changes in the level or slope of the distributions.

2.4.2 Estimation Strategy and Results

Figure 2.6 displays log annual earnings in 1994 as a function of *need*. There is a distinct downward slope to the right of the threshold point, indicating a negative relationship between amount borrowed and earnings. To the left of the threshold, the pattern is hard to discern. To help better understand the trends on either side of the threshold, the straight lines are fitted values of the raw data. To be noted is the change in slope around the threshold.

In practice, depending on the program design and associated outcomes, there are two possible estimation techniques: a sharp estimation technique and a fuzzy one. Consequently, in this section, first we explain why we use the fuzzy estimator: (τ_{RK}). After that we show how the estimator can be deduced by estimating two separate sets of regressions, known as the first stage and reduced from regression equations. Finally we discuss the results as well robustness.

We now explain the reasoning behind using a fuzzy technique in more detail.

[25] As Dong (2014) and Gelman and Imbens (2014) note, it is not ideal to use polynomials higher than two in degree. As a result we limit ourselves to only linear and quadratic polynomials.

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Table 2.2: Relationship between *need* and predetermined characteristics.

X (co-variate)	α_1	α_2 (RK)
age	0.066	-0.004
	(0.057)	(0.0417)
male	0.019	0.039
	(0.033)	(0.024)
white	-0.047	-0.011
	(0.037)	(0.017)
log parental income	-0.21	0.031
	(0.13)	(0.033)
family size	0.100	0.012
	(0.085)	(0.061)
College Ed. Parent	-0.115	0.008
	(0.077)	(0.024)
SAT	-26.37	-5.55
	(23.19)	(9.52)
Observations	3,880	3,880

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. Due to very small values in column 3, all numbers are scaled by 1000. The polynomial degree was set to 2. Each value is from a separate set of regressions. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

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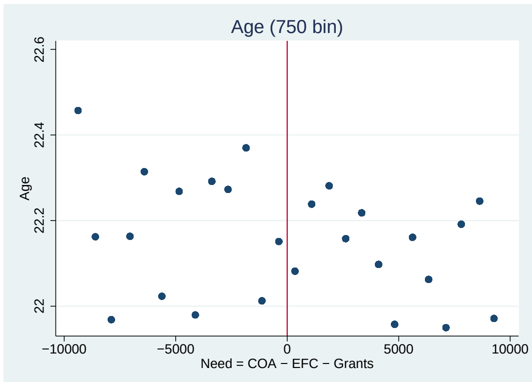
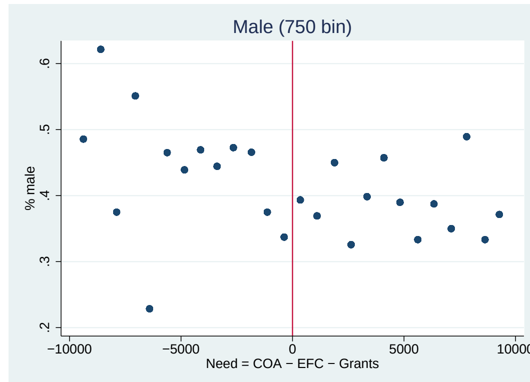
Figure 2.5: The distribution of baseline characteristics.

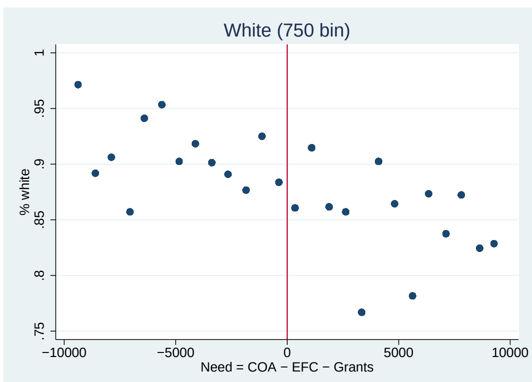
(a)



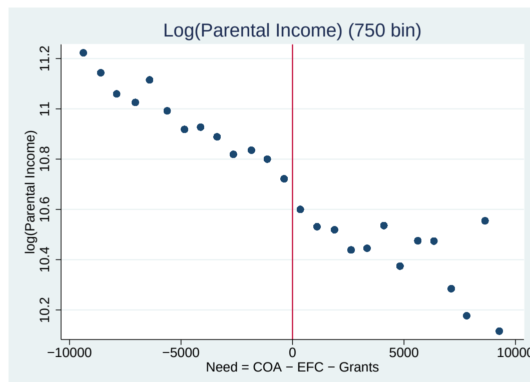
(b)



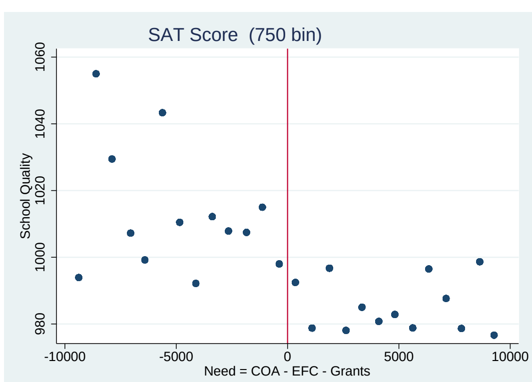
(c)



(d)



(e)



(f)

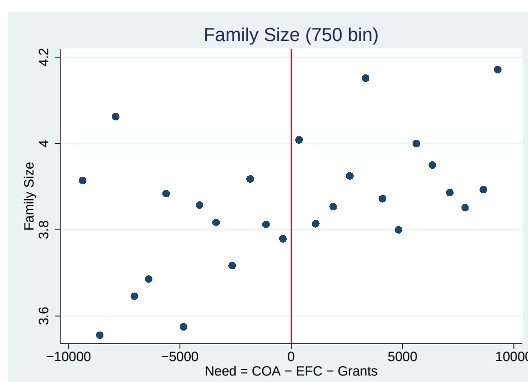


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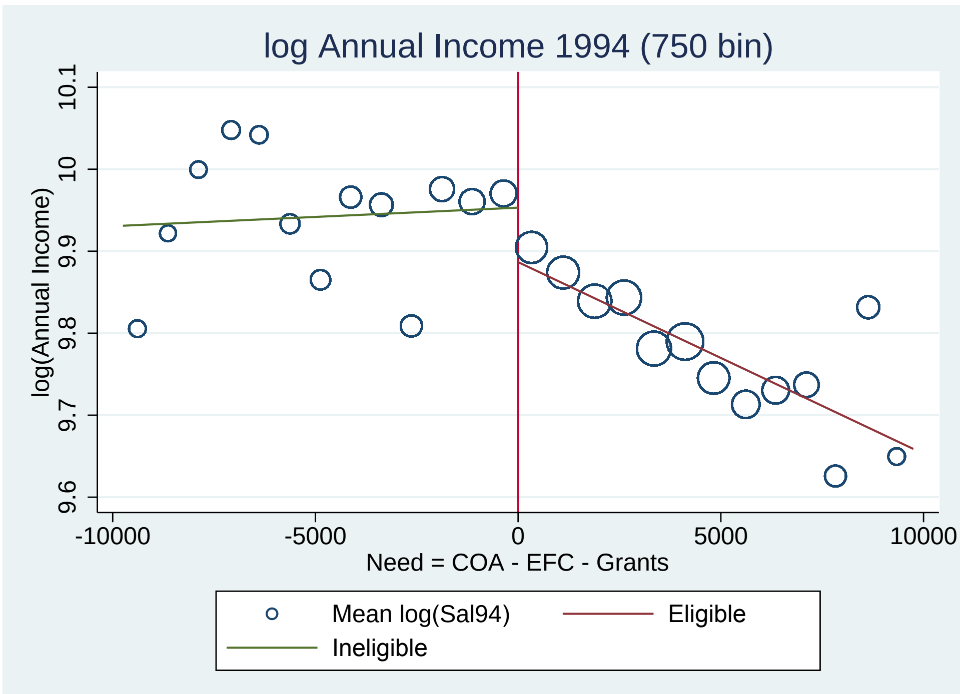
Figure 2.6: The reduced form impact of *need* on log earnings.



Notes: The center of each circle represents the average amount borrowed in the bin. The size represents the number of people in the bin.

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Although *need* is unambiguously defined, we observe that there is in some sense an imperfect compliance of the rules, as is usually so in practice.[26] Specifically, in our case we map cumulative student loans on *need* in the final year of school. The mapping to *need* for individuals may vary from year to year depending on changes in COA, parental income, grants received and number of siblings in college to name a few. This is so, despite the fact that the threshold rule does not change over time. Also, not all students eligible in the last year do borrow – the take-up rate of the program is not 100%. Finally, if the treatment is a continuous variable, as in our case – cumulative Stafford loan amount – the fuzzy estimator has intuitive interpretation analogous to an IV specification.

Now, we can define the fuzzy RK estimator (τ_{RK}) as:

$$\tau_{RK} = \frac{\lim_{\varepsilon \downarrow 0}\left[\frac{\partial y|need=need_0+\varepsilon}{\partial need}\right] - \lim_{\varepsilon \uparrow 0}\left[\frac{\partial y|need=need_0+\varepsilon}{\partial need}\right]}{\lim_{\varepsilon \downarrow 0}\left[\frac{\partial Staf|need=need_0+\varepsilon}{\partial need}\right] - \lim_{\varepsilon \uparrow 0}\left[\frac{\partial Staf|need=need_0+\varepsilon}{\partial need}\right]},$$

where $need_0$ represents the Stafford Loan eligibility threshold. Note that the RK estimator is based upon the change in slope about the threshold. The numerator measures the change in log income (y) as a function of *need*, and the denominator measures the change in cumulative loan amounts ($Staf$) as a function of *need*. Given the above definition, the next step is to estimate τ_{RK}.

The denominator can be determined by estimating what is known as the first stage equation, the numerator can be determined by estimating the reduced form

[26] In general, this occurs due to factors such as imperfect take-up of the program or the existence of factors other than the threshold rule that affect the probability of program participation.

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equation. Consider the following first stage equation (2.1) and reduced form equation (2.2):

$$Staf_i = f(need_i) + \beta_1 \mathbf{1}\big[need_i > 0\big] + \beta_2 need_i \times \mathbf{1}\big[need_i > 0\big] + \eta\ \mathbf{X}_i + \nu_i \qquad (2.1)$$

$$y_i = g(need_i) + \gamma_1 \mathbf{1}\big[need_i > 0\big] + \gamma_2 need_i \times \mathbf{1}\big[need_i > 0\big] + \phi\ \mathbf{X}_i + \upsilon_i, \qquad (2.2)$$

where i indicates an individual, and $f(\cdot)$ and $g(\cdot)$ are polynomial functions of *need*, the degree of the polynomials is chosen such that the AIC is minimized. $\mathbf{1}\big[need_i > 0\big]$ is an indicator function taking on the value of 1 if *need* is positive and 0 otherwise. $\mathbf{X}$ is a vector of predetermined demographic characteristics. β_2 measures the change in the slope of cumulative Stafford loans around the threshold. It is interpreted as the change in cumulative borrowing for every dollar increase in *need*, by an individual barely eligible for Stafford loans. Similarly, γ_2 measures the change in the slope of log earnings around the threshold. In this framework, $\hat{\tau}_{RK} = \frac{\hat{\gamma}_2}{\hat{\beta}_2}$.

Equations (2.1) and (2.2) show in a very clear manner how τ_{RK} can be estimated. In addition, they provide an understanding of how cumulative debt and log earnings are impacted by *need*. One concern with this approach, however, is that determining the standard error for $\hat{\tau}_{RK}$ is not as straightforward. Fortunately, τ_{RK} can also be estimated using standard 2SLS estimation techniques, which in turn allows us to determine robust standard errors. In order to do so we regress log earnings in 1994 on cumulative Stafford loans borrowed, and estimate 2SLS model where the second stage takes on the form:

$$y_i = \tau_{RK}\widehat{Staf}_i + g(need_i) + \lambda \mathbf{X}_i + \delta_i, \qquad (2.3)$$

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using the kink as an instrument for debt. Here, τ_{RK} represents the impact of an additional dollar of cumulative Stafford loans on log annual earnings in 1994.

Table 2.3 shows the estimation results where we use a quadratic in *need* for all specifications and Stafford loans are in 100's of dollars. Panel A shows the result for the first stage and reduced stage estimations. The interpretation of these estimates are as discussed above. For example, from $\hat{\beta}_2$ we determine that for students who are barely eligible for Stafford loans, every dollar increase in *need* increases their cumulative borrowing by 46 cents on average. Panel B displays 2SLS estimates of the impact of Stafford loan amount on log earnings. The interpretation of the 2SLS estimator is that an additional hundred dollars of Stafford loan reduces 1994 annual income by about 0.1%.[27] Extrapolating linearly, at the average level of borrowing, an individual's earnings are 5% lower than an average debt free individual in 1994.

Additional robustness checks are carried out in Appendix B.1 from which we conclude that the overall patterns and results remain qualitatively similar. The first test we conduct is to verify that our results are robust to including independent students in the sample. The experiment is not as clean, because independent students were also eligible to borrow unsubsidized federal loans. As noted earlier, however, the majority of independent students had only subsidized loans. We observe in this sample that there is more borrowing at the lower end of *need* and not as much on the higher end. The change in slope about the threshold is also not as sharp. The

[27]For small values of $\hat{\beta}$, $e^{\hat{\beta}} \approx 1 + \hat{\beta}$. That is, $\hat{\beta}$ gives the percentage change in income for a unit change in cumulative Stafford loans, where a unit is 100s of dollars.

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Table 2.3: Impact of Stafford loans on 1994 earnings.

A. OLS estimates	
$\hat{\beta}_2$	0.0046***
	(0.0011)
$\hat{\gamma}_2$	-0.00465**
	(0.00223)
B. 2SLS estimates	
Stafford Loan ($\hat{\tau}_{RK}$)	-0.00101**
	(0.00042)
Observations	3,880

Notes: $\hat{\beta}_2$ is the coefficient on the Stafford loan eligible $\times$ distance from threshold in the first stage regression equation. Stafford loans are in 100's of dollars. γ_2 is the coefficient on the Stafford loan eligible $\times$ distance from threshold in the reduced stage regression equation. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, family size and quadratic in need. $\hat{\gamma}_2$ term in Panel A are scaled by a factor of 1000. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

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estimates for this sample show that earnings for an individual with the mean level of borrowing are on average 3.8% lower than earnings of an individual with no debt.

Various other tests are conducted to determine the robustness of our estimates. For example, we determine that excluding the vector of observable characteristics has minimal impact on the magnitude of τ_{RK}. It lowers the efficiency of the estimate, but the p-value remains lower than 0.05. The estimate is also robust to other polynomial specifications as well as smaller bandwidths.

Next we will present further supporting evidence and discuss a number of possible extensions. For example, we investigate the impact of dropping individuals enrolled in graduate school in 1994, we document number of months between graduation and joining of first job as well as number of interviews until first job, as well as estimate a model using dollar earnings instead of log earnings and look at longer term impacts of debt on earnings. Having established the empirical results and tested its robustness, we will then turn to theory to provide the intuition behind out finding.

2.4.3 Discussion

The goal of this section is two fold. First, we would like to determine the impact of some sample selections decisions we made. Specifically, the decision to drop students who were in graduate school in 1994 and the decision to use log earnings instead of earnings (log earnings would automatically drop individuals that report zero earnings). Second, we would like to determine the long-term impact of student loan debt on earning, by estimating the model using earnings in 1997 and 2003.

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2.4.3.1 Individuals in Graduate School in 1994

We explained our reasoning to drop graduate students from the benchmark sample in Section 2.3.1. In this section, with the help of descriptive statistics we will attempt to establish whether: a) students that chose to go to graduate school are different from those that chose not to. If so, in what dimension? and b) did being eligible for student loans in the last year of schooling have an impact on the decision to go to graduate school?

The sample selection now is as follows. Instead of dropping individuals who were in graduate school in 1994, we keep them in the sample. Then after accounting for independent students and those outside the specified need bandwidth (students with *need* greater than \$10,000 and less than -\$10,000), we are left with 4,460 observations (i.e. original benchmark sample plus 760 individuals who went to graduate school in 1994, are dependent and within the specified need bandwidth). Therefore, in this new sample, 16.5% of the individuals were in graduate school in 1994 (in the raw sample 16.1% or 1,500 out of 9,300 individuals were in graduate school in 1994).

Table 2.4 summarizes the differences between individuals that chose to go to graduate school in 1994 (Grad94) and those that did not go to graduate school in 1994 (non-Grad94). The non-Grad94 sample is the benchmark sample outlined in Table 2.1. As the table shows, the composition of Asians in the Grad94 sample is almost twice as large as in the non-Grad94 sample. As would be expected, individuals that chose to go to graduate school had considerably higher SAT scores, came from richer households, had better educated parents and slightly bigger families. In terms

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of student loan debt, those that chose to go to graduate school had taken on slightly less debt than those who chose not to. Next we will investigate whether eligibility for student loan debt had an impact on graduate school decision.

In Table 2.5 we focus entirely on individuals that chose to go to graduate school in 1994. They are now broken into two groups, those that were ineligible for student loan debt in the last year of schooling and those who were eligible for debt in the last year of schooling. There is a significant difference in parental income between those ineligible and those eligible. This difference in parental income translates to a difference in average amount borrowed between the two groups. It is interesting to note that the difference in the average amount borrowed between eligible and ineligible students in lower for those that chose to go to graduate school than those that chose not to.

Figure 2.7 plots the probability of attending graduate school as a function of need in the last year of undergraduate study. As the figure shows, there is not much difference in the probability, especially around the threshold.

2.4.3.2 Time to First Job & Number of Interviews

Given that for each individual we know the date of graduation and date at which they started working, we can determine the number of months between graduation date and joining date.

Table 2.6 shows that while that those that borrowed seem to take about a quarter of a month less (approximately a week) to start working, we do not observe

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Table 2.4: Characteristics of respondents by 1994 graduate school enrollment.

	Grad94	non-Grad94	Full sample
A. Student demographic			
Male	0.477	0.432	0.439
Age	21.92	22.15	22.08
Asian	0.063	0.034	0.039
Black	0.056	0.061	0.060
Hispanic	0.035	0.045	0.043
White	0.842	0.860	0.855
SAT	1075	992	1007
Parent Income	$54,814	$50,400	$51,189
Parent Education			
Less than bachelor	0.42	0.53	0.49
Bachelor	0.27	0.26	0.26
Master's and higher	0.29	0.21	0.22
Family Size	4.01	3.84	3.87
B. Education related costs			
Avg. Borrowed (cum.)	$3,442	$3,595	$3,569
Observations	760	3,880	4,640

Notes: Grad94 indicates individuals who were in graduate school in 1994. non-Grad94 indicates individuals who were not in graduate school in 1994. The sample is the benchmark sample plus an additional 760 individuals who enrolled in graduate school in 1994, were dependents and within the specified need bandwidth. SAT uses ACT-SAT conversion tables to compute SAT scores of students who have an ACT score but no SAT score. Parental income was in 1991. Students with *need* greater than $10,000 and less than -$10,000 are excluded.

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Table 2.5: Characteristics of 1994 graduate school students by eligibility.

	Ineligible	Eligible	Grad94
A. Student demographic			
Male	0.517	0.455	0.477
Age	21.99	21.88	21.92
Asian	0.053	0.082	0.063
Black	0.048	0.061	0.056
Hispanic	0.031	0.037	0.035
White	0.837	0.845	0.842
SAT	1098	1062	1075
Parent Income	$67,703	$48,084	$54,814
Parent Education			
Less than bachelor	0.42	0.43	0.42
Bachelor	0.27	0.26	0.27
Master's and higher	0.30	0.28	0.29
Family Size	3.99	4.05	4.01
B. Education related costs			
Avg. Borrowed (cum.)	$1,080	$4,520	$3,442
Observations	230	530	760

Notes: Grad94 has the same definition as in Table 2.4. Ineligible if *need* < 0. The sample is the additional 760 individuals who enrolled in graduate school in 1994, were dependents and within the specified need bandwidth. SAT uses ACT-SAT conversion tables to compute SAT scores of students who have an ACT score but no SAT score. Parental income was in 1991. Students with *need* greater than $10,000 and less than -$10,000 are excluded.

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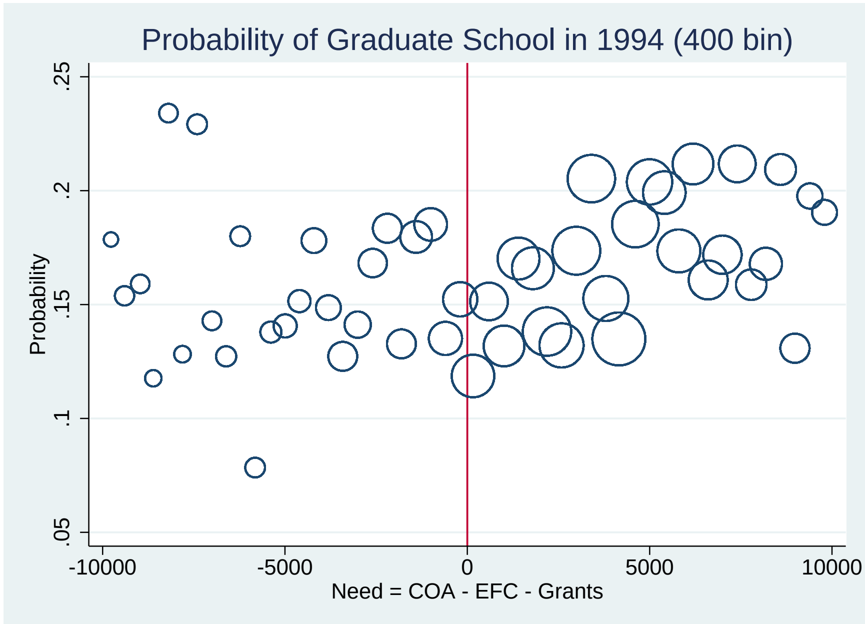
Figure 2.7: Probability of attending graduate school in 1994.



Notes: The center of each circle represents the average amount borrowed in the bin. The size represents the number of people in the bin.

Table 2.6: Months to first job.

	Non-Borrow	Borrow	Ineligible	Eligible
	2.15	1.91	1.98	2.06
Observations	1910	1970	1,430	2,460

Notes: This table presents number of months between date of graduation and joining of first job. The data is separated into 2 mutually exclusive groups using a couple of different criteria. First the data is broken down into two groups based on if the student ever borrowed (Borrow) or not (Non-Borrow). Then the data is broken down into two groups based on eligibility for student loan program in the last year of schooling. Ineligible if *need* < 0. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

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much difference in starting times when controlling for debt eligibility. This means that we will not be able to use our identification strategy to test our hypotheses that those with debt are in a hurry to find a job. Table 2.7 shows that those that never borrowed took fewer interviews than those that ever borrowed. Given that they also joined work at a later date, this would imply that non-borrowers were more selective in the type of jobs they interview for.

Table 2.7: Number of jobs interviewed for upon completion of degree.

	Non-Borrow	Borrow	Ineligible	Eligible
	5.37	5.64	5.53	5.50
Observations	1910	1970	1,430	2,460

Notes: This table presents number of interviews. The data is separated into 2 mutually exclusive groups using a couple of different criteria. First the data is broken down into two groups based on if the student ever borrowed (Borrow) not (Non-Borrow). Then the data is broken down into two groups based on eligibility for student loan program in the last year of schooling. Ineligible if *need* < 0. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

2.4.3.3 Earnings in Dollar Amounts

In this section, instead of using log of earnings in 1994, we use earnings in dollar amounts so as not to exclude individuals who reported zero earnings. Figure 2.8 shows the reduced form impact of *need* on 1994 annual earnings. As we can see from the figure, earnings to the right of the threshold maintains a downward slope similar to the case where we used log earnings.

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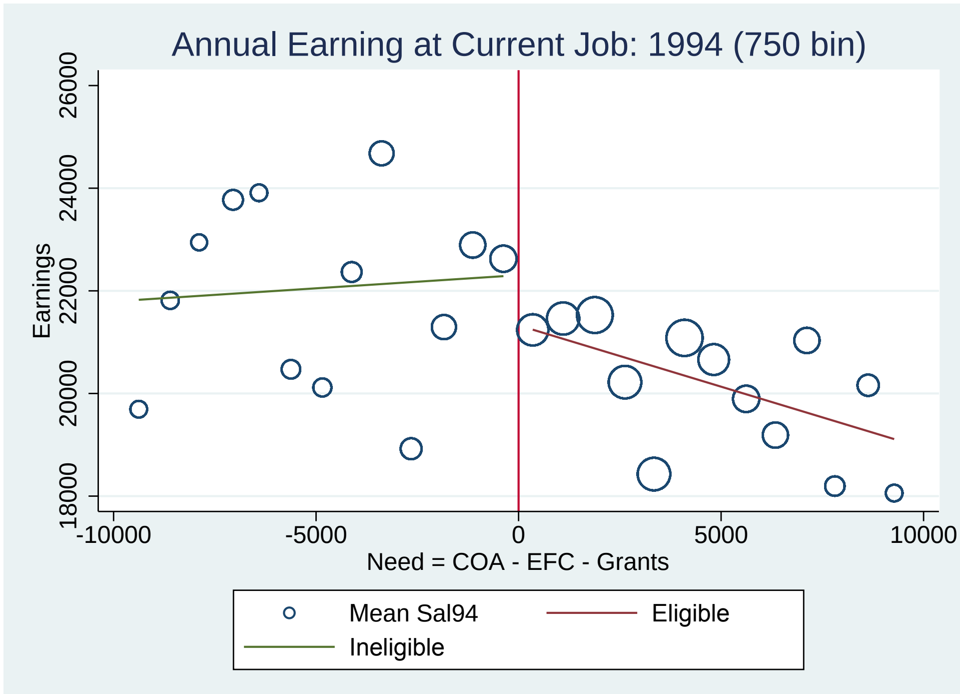
Figure 2.8: The reduced form impact of *need* on 1994 annual earnings.



Notes: The center of each circle represents the average amount borrowed in the bin. The size represents the number of people in the bin.

Table 2.8 shows the estimation results where we use a quadratic in *need* for all specifications. There are two main differences between between the model used to generate the results for Table 2.3 and the model used to generate the results for Table 2.8. The first difference, as already pointed out, is that we use earnings in dollar amounts instead of log earnings. The second difference is that for Table 2.8, Stafford loans are in dollars instead of 100's of dollars. Panel *A* shows the result for the first stage and reduced stage estimations. The interpretation of these estimates are as discussed above. For example, from $\hat{\beta}_2$ we determine that for students who are barely

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Table 2.8: Impact of Stafford loans on 1994 earnings.

A. OLS estimates	
$\hat{\beta}_2$	0.46***
	(0.11)
$\hat{\gamma}_2$	-0.078**
	(0.0379)
B. 2SLS estimates	
Stafford Loan ($\hat{\tau}_{RK}$)	-0.1696**
	(0.0915)
Observations	3,930

Notes: $\hat{\beta}_2$ is the coefficient on the Stafford loan eligible × distance from threshold in the first stage regression equation. γ_2 is the coefficient on the Stafford loan eligible × distance from threshold in the reduced stage regression equation. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, family size and quadratic in need. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

eligible for Stafford loans, every dollar increase in *need* increases their cumulative borrowing by 46 cents on average. Panel *B* displays 2SLS estimates of the impact of Stafford loan amount on earnings. The interpretation of the 2SLS estimator is that an additional dollar of Stafford loan reduces 1994 annual income by about 17 cents. Extrapolating linearly, at the average level of borrowing, an individual's earnings are 4.1% lower than an average debt free individual in 1994.

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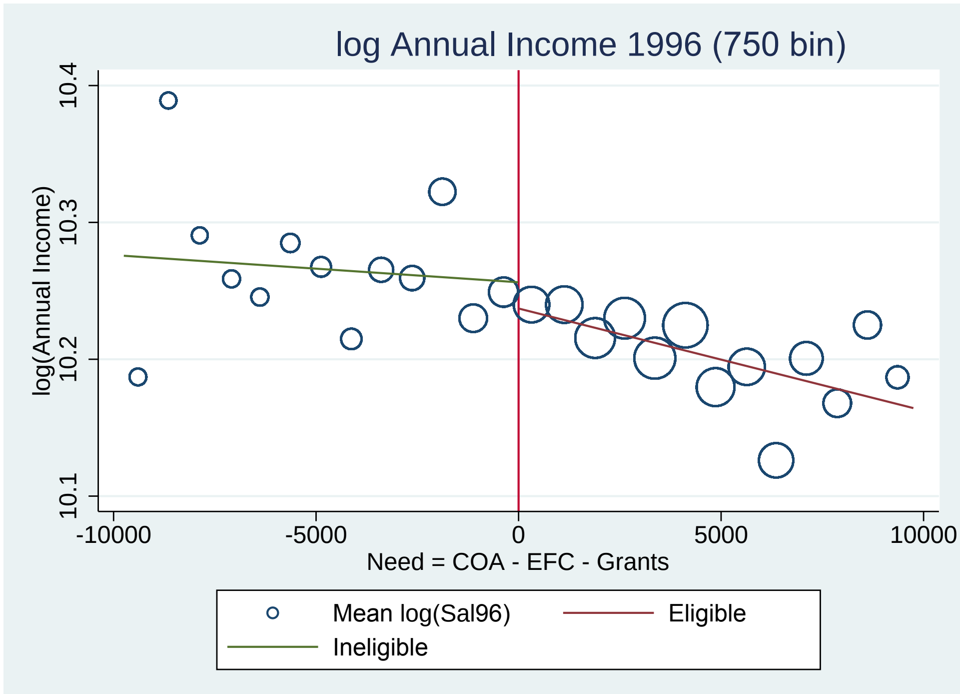
Figure 2.9: The reduced form impact of *need* on 1996 annual earnings.



Notes: The center of each circle represents the average amount borrowed in the bin. The size represents the number of people in the bin.

2.4.3.4 Impact of Debt on Later Years

Given that the survey was conducted again in 1997 and 2003, we have information on individuals earnings in 1996 and 2002. Hence, in this section we determine the impact of student loan debt on earnings 3 years and 9 years post graduation. Figure 2.9 shows the reduced form impact of need on log 1996 earnings. We notice that there is a kink at the threshold value, though it does not as sharp as what we observed in 1994. Table 2.9 shows the estimation results where we use a quadratic in *need* for all specifications and Stafford loans are in 100's of dollars. Panel A shows the result

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Table 2.9: Impact of Stafford loans on 1996 earnings.

A. OLS estimates	
$\hat{\beta}_2$	0.0046***
	(0.0011)
$\hat{\gamma}_2$	-0.00194**
	(0.00061)
B. 2SLS estimates	
Stafford Loan ($\hat{\tau}_{RK}$)	-0.00042**
	(0.000201)
Observations	3,880

Notes: $\hat{\beta}_2$ is the coefficient on the Stafford loan eligible × distance from threshold in the first stage regression equation. Stafford loans are in 100's of dollars. γ_2 is the coefficient on the Stafford loan eligible × distance from threshold in the reduced stage regression equation. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, family size and quadratic in need. $\hat{\gamma}_2$ term in Panel A are scaled by a factor of 1000. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

for the first stage and reduced stage estimations. The first stage does not change, but the results for the reduced stage change since we are using earnings in 1996 for this table. The numbers for the Panel B displays 2SLS estimates of the impact of Stafford loan amount on log earnings. The interpretation of the 2SLS estimator is that an additional hundred dollars of Stafford loan reduces 1996 annual income by about 0.042%.

Figure 2.10 show the reduced form impact of need on log 2002 earnings. We notice that there is now no longer a kink at the threshold value. Table 2.10 shows the

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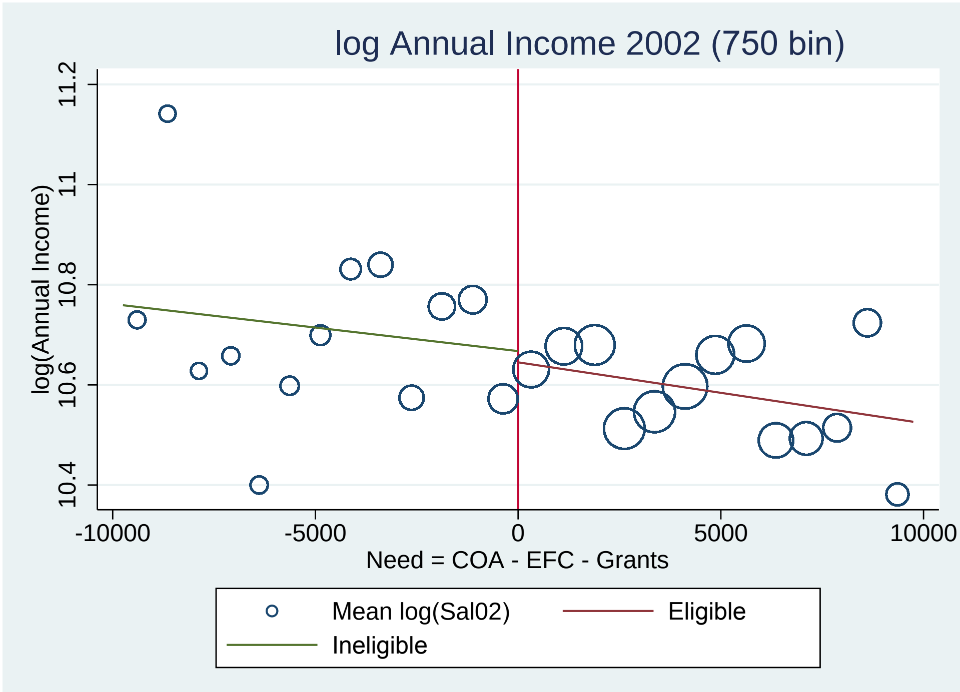
Figure 2.10: The reduced form impact of *need* on 2002 annual earnings.



Notes: The center of each circle represents the average amount borrowed in the bin. The size represents the number of people in the bin.

estimation results where we use a quadratic in *need* for all specifications and Stafford loans are in 100's of dollars. Panel *A* shows the result for the first stage and reduced stage estimations. The first stage does not change, but the results for the reduced stage change since we are using earnings in 2002 for this table. As one would expect the change in slope is no longer significant. The numbers for the Panel *B* displays 2SLS estimates of the impact of Stafford loan amount on log earnings. Since the reduced stage showed insignificant results, we do not find any significant impact of debt on earnings in 2002. These results seem to imply that while individuals with

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Table 2.10: Impact of Stafford loans on 2002 earnings.

A. OLS estimates	
$\hat{\beta}_2$	0.0046***
	(0.0011)
$\hat{\gamma}_2$	-0.00005
	(0.00497)
B. 2SLS estimates	
Stafford Loan ($\hat{\tau}_{RK}$)	-0.00002
	(0.00065)
Observations	3,880

Notes: $\hat{\beta}_2$ is the coefficient on the Stafford loan eligible $\times$ distance from threshold in the first stage regression equation. Stafford loans are in 100's of dollars. γ_2 is the coefficient on the Stafford loan eligible $\times$ distance from threshold in the reduced stage regression equation. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, family size and quadratic in need. $\hat{\gamma}_2$ term in Panel A are scaled by a factor of 1000. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

debt are initially in a hurry to find a job, once having secured the job they are able to eventually find more optimal jobs over time.

2.5 Model

We use a single-period, competitive search framework along the lines of Moen (1997) with an exogenous amount of debt at the beginning of the period. What is crucial is whether or not the debt can be discharged at the end of the period. We first show that when debt cannot be discharged (as is the case with student loans), higher

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debt causes individuals to target lower wages at higher probabilities of finding work. The opposite happens when debt is dischargeable, i.e., higher debt causes individuals to target higher wages with lower probabilities of success.

2.5.1 Environment

The labor market consists of a continuum of workers and firms. The measure of workers is normalized to 1. The measure of jobs is endogenously determined through free entry, and there is a fixed cost $\kappa > 0$ associated with opening a vacancy.

Let $m(u, v)$ denote the number of new worker-firm matches, where u is the measure of unemployed fresh graduates searching for a measure v of vacancies. The matching function $m(u, v)$ captures the frictions in the market for workers and vacancies, which cause some workers and vacancies to remain unmatched in a period.

It is standard to assume that $m(u, v)$ is continuous, differentiable, non-negative, increasing, concave in both arguments and constant returns to scale (CRS), with $m(u, 0) = m(0, v) = 0$ for all (u, v). Let $\theta = \frac{v}{u}$ denote the market tightness ratio. Due to CRS, θ is sufficient to determine job finding probabilities. Let p denote the probability that an unemployed worker finds a job, then

$$p = \frac{m(u, v)}{u} = \frac{u\ m(1, v/u)}{u} = m(1, \theta) = p(\theta).$$

Similarly, if q is the probability that a firm fills a vacancy, then

$$q = \frac{m(u, v)}{v} = \frac{m(u, v)}{u\frac{v}{u}} = \frac{p(\theta)}{\theta},$$

where $p(\theta)$ is increasing in θ and $q(\theta)$ is decreasing in θ. These conditions are also sufficient to ensure that the elasticity of $p(\theta)$, $\varepsilon_p = \frac{\theta p'(\theta)}{p(\theta)} \in (0, 1)$. In addition, we

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restrict our attention to matching functions where ε_p is either constant or decreasing in θ.[28]

As noted above, firms must pay a vacancy posting cost κ. Any match within the period produces output y, which is divided between the worker and firm according to the posted wage, w. Free entry gives us the relationship between θ and w

$$q(\theta)(y - w) = \kappa. \tag{2.4}$$

As θ increases, the probability that a firm fills a vacancy, $q(\theta)$, decreases. It follows that as θ increases, $(y - w)$ must increase for (2.4) to hold and w must therefore decrease. That is, jobs that provide a high probability of matching for the worker (high θ) offer lower wages, and vice versa. This establishes the negative relationship between θ and w, which we will use later.

Individuals enter the labor market with a debt amount d corresponding to the student loan debt accumulated. To ensure that consumption remains positive, we endow them with b. Individuals choose wages to maximize their expected utility. Matched workers receive wage w, while unmatched workers have different outcomes depending on the model specification, which will be covered in detail in the following sections. Finally, the model ends at the end of the period.

Below, we cover the case where the debt is modeled along the lines of student loan debt so that it cannot be discharged in bankruptcy. We do this by imposing that the individual must always pay off her debt at the end of period. We then model the

[28]This includes the most widely used forms of the matching function. For example, with urn ball matching functions, ε_p is decreasing and with Cobb-Douglas ($p(\theta) = \theta^\beta$ for $\beta \in (0, 1)$) ε_p is a constant.

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case where loans can be discharged in bankruptcy and show the contrasting result this produces. These two specifications show that the 'cannot discharge in bankruptcy' condition is crucial to the observed behavior.

2.5.2 Non-dischargeable Loans

In this section, we model debt along the lines of a stylized student loan repayment scheme. Specifically, the individual cannot discharge her debt in bankruptcy and must pay it off, even if she is unsuccessful in finding a job. Note the problem below:

$$\max_{\theta,w}\ p(\theta)\ u(w+b-d)+(1-p(\theta))\ u(b-d), \tag{2.5}$$

subject to the constraint

$$\frac{p(\theta)}{\theta}(y-w)=\kappa. \tag{2.6}$$

The objective function is derived from the agent's problem. The agent is successful in finding a job with probability $p(\theta)$, in which case she receives utility from consuming the wage plus her endowment, net of the debt payments. With probability $(1-p(\theta))$ she is unable to find a match, in which case she consumes her endowment net of debt payments; i.e., debt is always paid off at the end of the period irrespective of the outcome of the job search. The problem is subject to the free entry condition, where we substitute $q(\theta)$ with $\frac{p(\theta)}{\theta}$.

The first order condition (F.O.C.) for this problem is:

$$\underbrace{p'(\theta)\big[u(w+b-d)-u(b-d)\big]}_{\text{gain from higher probability}}=\underbrace{p(\theta)u'(w+b-d)}_{\text{gain from higher wage}}\ \underbrace{\frac{\kappa}{p(\theta)}\left[1-\frac{\theta p'(\theta)}{p(\theta)}\right]}_{\text{exchange rate between } w \text{ and } \theta}. \tag{2.7}$$

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This equation represents the trade-off between the gains from searching for a higher probability job and that of a higher wage. The left-hand side represents the increase in utility from searching for a job with marginally higher probability of success. The right-hand side can be divided into two parts as shown above. The first part shows the gain in utility from obtaining a marginally higher wage. The second part gives the trade-off, or exchange rate between the wage and the tightness ratio, as can be derived by totally differentiating the free entry condition.

In order to further understand the relationship between θ and w, we re-write (2.7) as

$$\underbrace{\frac{u'(w+b-d)}{u(w+b-d)-u(b-d)}}_{\text{decreasing in } w} = \frac{1}{\kappa} \underbrace{\frac{p'(\theta)}{1-\frac{\theta p'(\theta)}{p(\theta)}}}_{\text{decreasing in } \theta} . \tag{2.8}$$

First, let us focus on the left-hand side of the equation. When w increases, the term on the left-hand side decreases. This is because as w increases, the denominator increases and the numerator decreases. κ is a constant, so for equality to hold, the remaining part on the right-hand side must also decrease. Given the assumptions on $p(\theta)$, in particular, the concavity and the constant (or decreasing) elasticity assumption, it is easy to see that the term is decreasing in θ. Therefore, as w increases, the term on the left-hand side decreases, implying that the term on the right-hand side must decrease and θ must increase. This tells us that w and θ are positively sloped in the F.O.C. (2.7). We have already established in the Environment section that they are negatively sloped in the free entry condition. As shown in Figure 2.11, there exists a unique w_d^* and θ_d^*, for a given level of debt, d. Next, we establish how the

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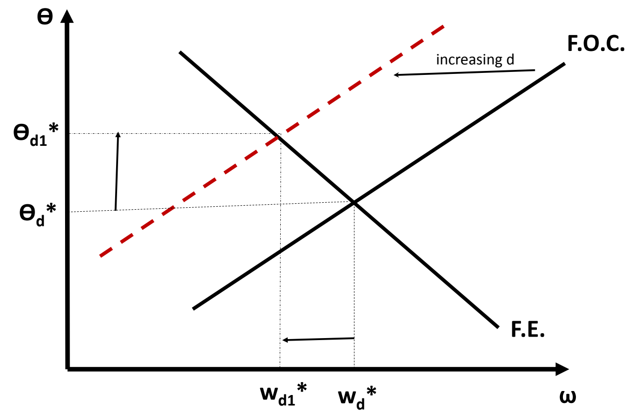
Figure 2.11: Model with non-dischargeable debt.



Notes: F.E. represents the downward sloping free entry condition, F.O.C. represents the upward sloping first order condition. w^* and θ^* are the equilibrium values at a given debt level d. w_1^* and θ_1^* show the equilibrium values at a higher debt level d_1. Individuals search for a lower wage with higher probability of success at d_1 compared to d.

level of debt impacts the search behavior.

Assumption 1. *The utility function is of the class Decreasing Absolute Risk Aversion (DARA):*

$$u(c) = \frac{1-\gamma}{\gamma}\left(\frac{\alpha c}{1-\gamma}+\beta\right)^{\gamma} \quad \text{where } \alpha > 0,\ \beta > -\frac{\alpha c}{1-\gamma},\ \gamma \in (0,1);$$

Proposition 3. *Under Assumption 1 higher debt causes individuals to search for lower wage jobs with a higher job-finding probability.*

Proof. While the proof is fairly mechanical and the details can be found in Appendix B.2, we will provide a quick outline here. The basic idea behind behind the proof is to first determine the condition under which the left hand side of (2.8) is decreasing

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in the debt level, d. As d increases, and the left hand side of (2.8) decreases, this cause the right hand side of (2.8) to decrease. Since it has already been established that the right hand side is decreasing in θ, an increase in d results in a corresponding increase in θ. As shown in Figure 2.11, when $d_1 > d$, the agent searches for a lower paying job with a higher probability of success.

Once we have determined the above condition, the next step is to determine the class of utility functions for which this is true. Finally note that both CRRA and log utility are special cases of DARA. For CRRA, set $\alpha = 1 - \gamma$ and $\beta = 0$, for log, $\gamma \to 0$ and $\beta = 0$. $\square$

The intuition behind this result is as follows. Due to the non-dischargeablity, as debt increases, the outcome of being unsuccessful becomes increasingly undesirable in the level of debt. As a result, as debt increases being successful in obtaining a job at a low wage is more desirable and provides higher utility than taking the increased risk of being unsuccessful at targeting a higher wage. In other words, it eliminates the incentive to 'gamble' on targeting higher wage jobs. Next will show the impact of allowing debt to be discharged in bankruptcy and how this changes the behavior of individuals. In the proof we also show that the commonly used utility functions, namely CRRA and log are special cases of DARA.

2.5.3 Dischargeable Loans

Note the problem below:

$$\max_{\theta,w} \; p(\theta) \; u(w + b - d) + (1 - p(\theta)) \; u(\phi b), \tag{2.9}$$

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subject to the constraints

$$\frac{p(\theta)}{\theta}(y-w)=\kappa. \tag{2.10}$$

The objective function is derived from the agent's problem. The agent is successful in finding a job with probability $p(\theta)$, in which case she receives utility from consuming the wage plus her endowment, net of the debt payments. In the case that she is unable to find a match, she files for bankruptcy instead of paying off her debt. Since filing for bankruptcy is costly, she is only able to consume a fraction $\phi \in (0,1]$ of her endowment. The magnitude of ϕ is not important for the qualitative results derived here. The problem is subject to the free entry condition, where we substitute $q(\theta)$ with $\frac{p(\theta)}{\theta}$.

The first order condition (F.O.C.) for this problem is:

$$\underbrace{p'(\theta)\big[u(w+b-d)-u(\phi b)\big]}_{\text{gain from higher probability}}=\underbrace{p(\theta)u'(w+b-d)}_{\text{gain from higher wage}}\quad\underbrace{\frac{\kappa}{p(\theta)}\left[1-\frac{\theta p'(\theta)}{p(\theta)}\right]}_{\text{exchange rate between } w \text{ and } \theta}.$$

This equation represents the trade-off between the gains from searching for a higher probability job and that of a higher wage. The left-hand side represents the increase in utility from searching for a job with marginally higher probability of success. The right-hand side can be divided into two parts as shown above. The first part shows the gain in utility from obtaining a marginally higher wage. The second part gives the trade-off, or exchange rate between the wage and the tightness ratio, as before.

Proposition 4. *Higher debt causes individuals to search for higher wage jobs with a lower job-finding probability*

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Proof. The free entry condition remains unchanged with an increase in d, as it is independent of the level of debt. The F.O.C. is a function of debt, re-write (**??**) as

$$\underbrace{\frac{u'(w+b-d)}{u(w+b-d)-u(\phi b)}}_{\text{decreasing in } w,\text{ increasing in } d} = \frac{1}{\kappa}\underbrace{\frac{p'(\theta)}{1-\frac{\theta p'(\theta)}{p(\theta)}}}_{\text{decreasing in } \theta}. \tag{2.11}$$

The left-hand side of (2.11) depends on d. As d increases, the denominator decreases and the numerator increases, causing the left-hand side to increase. In order to maintain equality, and with κ being constant, the remaining term on the right-hand side must increase. Because we have already shown that the remaining term is decreasing in θ, this means that θ must decrease. In other words, as debt goes up, the individual starts searching for higher paying jobs with lower a probability of success. This is shown in Figure 2.12. □

The intuition behind this result is that as debt increases, the increase in utility from successfully finding a job at a given wage decreases due to higher debt payments. Because she knows she can declare bankruptcy if she is unsuccessful, default and bankruptcy puts a floor on her outside option and causes her to search for higher paying jobs with a lower probability of success.

2.6 Conclusion

While the recent rise in federal student loan debt is well documented, economists are only now examining the implications of these loans on borrowers. Consequently, the goal of this paper is to understand the impact of student loan debt on labor market outcomes. In order to do so we first empirically establish the relationship between

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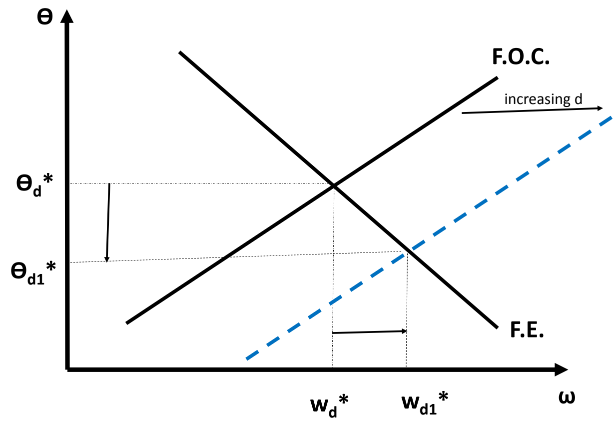
Figure 2.12: Model with dischargeable debt.



Notes: F.E. represents the downward sloping free entry condition, F.O.C. represents the upward sloping first order condition. w^* and θ^* are the equilibrium values at a given debt level d. w_1^* and θ_1^* show the equilibrium values at a higher debt level d_1. Individuals search for a higher wage with lower probability of success at d_1 compared to d.

cumulative student loan debt and earnings less than a year after graduation. Using data from the Baccalaureate and Beyond Longitudinal Study: 1993/03 (B&B: 93/03), a nationally representative sample of undergraduates that received their bachelor's in 1993, we implement a regression kink (RK) design to determine the causal impact of debt on earnings. Key to this design is that up to 1993, dependent students could only borrow need-based Stafford loans. Estimates show that an additional hundred dollars of Stafford loan reduces 1994 annual income by about 0.1%. Extrapolating this result, earnings for an individual with the mean level of borrowing are 5% lower than those of an individual with no debt. The impact of an additional hundred dollars of student debt on earnings decreases to 0.04% by 1996, and the impact of debt on

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earnings vanishes by 2002.

We then show that our empirical finding is consistent with economic theory. Specifically, using a simple one-period directed search model along the lines of Moen (1997) with exogenous amounts of debt, we show that as the level of debt increases, individuals will search for lower-wage jobs, with the accompanying higher probability of success. Crucial to this result is the fact that debt is modeled along the lines of student debt; i.e. it cannot be discharged in bankruptcy and therefore the individual is liable for her debts irrespective of the outcome of the job search. Once this condition is removed so the debt can be discharged in bankruptcy, the complete opposite result is observed. Individuals now search for higher-wage jobs with the accompanying lower probability of success.

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CHAPTER 3
CROSS-SUBSIDIZATION IN THE STUDENT LOAN MARKET

3.1 Introduction

The federal student loan market is inherently inefficient – every student eligible for federal student loans is allowed the same amount of loans at the same interest rate as every other eligible student.[1] The maximum loan amounts and interest rates are independent of any school or student characteristic such as major, gpa, age, etc. Given that one would expect returns on loans to be a function of these heterogenous characteristics (school and individual), one would therefore also expect heterogeneity in expected returns. Consequently, this results in cross-subsidization in the federal student loan market, where individuals with high expected returns subsidize those with low expected returns. Understanding the relationship between individual characteristics and expected returns is one of the main objectives of this paper.

The student loan market is fundamentally different from typical private markets, where lenders take into account an individual's characteristics such as credit history and earnings before determining the amount and terms of any loan.[2] The lack of cross-subsidization in private markets is a topic that has been explored in the literature. One early example is Puelz and Snow (1994) who use the fact that

[1]The eligibility requirements are very lenient. One needs to be enrolled in a school eligible for federal funding and should not have borrowed the cumulative maximum.

[2]Typically, lenders must nevertheless comply with the rules established by the Federal Deposit Insurance Corp. (FDIC) as well as the Community Reinvestment Act, which bans various types of discriminatory credit practices.

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incentive-compatible contracts should be free from cross-subsidization to characterize such contracts.[3] It should be noted that cross-subsidization need not always have a negative connotation. For example, in the case of regulated monopolies cross-subsidization is deemed desirable from the government's stand-point: for example, local calls subsidized by long-distance calls—see Parsons (1998).[4] More recently, Glover and Corbae (2016) explore the role of cross-subsidization in the context of a dynamic environment with adverse selection and show that high credit score individuals subsidizing low credit score individuals may actually lead to a Pareto improvement. In their framework, however, both credit limits and interest rates are function of credit score.

It is well understood that designing an efficient student loan program is not the main objective of the government. In fact, the Higher Education Act of 1965, which laid the foundation of the Federal Student Loan program, proposed to "strengthen the educational resources of our colleges and universities and to provide financial assistance for students in postsecondary and higher education." The act was intended to encourage greater social mobility and equality of opportunity (Glater (2011); Simikovic (2013)). Nevertheless, we believe that understanding the extent of cross-subsidization in the federal student loan system is an important and worthwhile exercise to execute. In addition, this will highlight the possibilities of cream-skimming by

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[3]Gale (1996) studies the implications of imposing the absence of cross-subsidization across contracts in the context of a model with adverse selection.

[4]There is also some evidence that 'special' checking accounts used to be subsidized by checking accounts—see Shaffer (1984)

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the private sector—a phenomenon already underway, as exemplified by the growing loans originated by companies such as SoFi.[5] Better understanding of the shortcomings of the current system will allow deeper insight into possible ways to improve the student loan system without compromising on its objectives.

There are several papers discussing the cost to the government associated with the growing student loan program in the U.S.: Haughwout et al. (2015); Lee (2013); Akers and Chingos (2014); Looney and Yannelis (2015); Deming et al. (2012) to name a few. Rather than trying to assess the cost of the program, our aim here is to evaluate the extent of cross-subsidization in individual loan disbursement. The idea is simple: private competitive markets necessarily imply no cross-subsidies across returns of loans issued to individuals with various observable individual characteristics. As such, the extent of cross-subsidization provides a measure of the departures of the student loan program from competitive markets.

Our methodology, in principle, is quite simple. Given a set of loans issued in a particular time period and a complete history for each loan, one simply has to compute the return to each loan and evaluate the extent to which expected returns—or the distribution of returns—differs across various segments of the student borrower population. For example, loans issued to individuals pursuing different majors in their first year of study should carry the same expected return, and so on.

Clearly, the data requirement to implement our methodology are quite strin-

[5]Because of its financing strategy—it does not take deposits—SoFi does not fall under the jurisdiction of the FDIC, but is instead monitored by the Consumer Financial Protection Bureau.

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gent, as a complete history of loans is required. While not ideal (we will get back to this point below), the Department of Education does have some datasets that do provide loan histories for a subset of post-secondary students, know as the Beginning Post-Secondary (BPS) survey.[6] Because BPS data can be linked to the National Student Loan Data System (NSLDS), we have access to the history of every student loan issued to individuals in the BPS. One key aspect of the BPS that we take advantage of (and will be discussed in more detail later) is that it allows us to focus on individuals that either enrolled or obtained a post-secondary degree different from a bachelor's degree as well as individuals who attend a for-profit institution. This is important since many recent studies (Akers and Chingos (2014); Looney and Yannelis (2015)) show that despite what the popular media would have us believe, it is not individuals with a bachelor's degree that are having problems repaying loans. Instead, it is individuals with student loans that either went to a for-profit school or have a certificate degree, associate degree or some level of college that constitute the vast majority of individuals struggling to repay their loans.

However, at this point NSLDS data is known to be flawed, along dimensions that aren't immediately detectable.[7] As such, the results in Section 3.4 should be

[6]The Baccalaureate and Beyond Longitudinal Study (B&B), also from the Department of Education, provides similar histories on loans of individuals graduating from 4-year degrees. However, this dataset is not as ideal, as characteristics of individuals at the time loans were issued are not directly observable: individuals are followed from graduation on. Furthermore, and precisely because individuals are followed from the time they graduate, individuals who did not finish their degree—a significant fraction—are by construction left out of the data.

[7]Various conversations with individuals in charge of this dataset confirmed that as of this date, there are several issues with the individual history files.

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taken as suggestive of the type of results that our methodology can deliver, and should not be taken as the final word on the extent of cross-subsidization involved in the student loan program at large, nor for that particular set of students.

The rest of this paper is as follows: in Section 3.2 we discuss how to determine returns on loans, in Section 3.3 we detail the BPS dataset used as well as outline interesting trends in the data, in Section 3.4 we give some preliminary results and offer a brief conclusion in Section 3.5.

3.2 Methodology

Our starting point is that a competitive private market is incompatible with subsets of the population subsidizing others. Now there are potentially many ways to interpret what absence of cross-subsidization means. The most prominent one, which assumes risk neutral lenders, is equality of expected rate of return on loans to any identifiable subset of the population. The interpretation is clear: if the expected yield on loans to a subset of the population exceeds the cost of funds, then financial institutions will compete away these profits by offering a lower interest rate. On the other hand, no financial institution will offer loans to a subset of the population with a yield lower than the cost of funds. In other words, the interest rate on loans to any identifiable subset of the population should carry the same expected rate of return.

By design, the student loan program involves a certain degree of cross subsidization, simply because the interest rate on student loans is fixed for the entire student population. Our methodology is designed to evaluate the extent to which

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the student loan program departs from zero cross-subsidization, and to characterize which sub-groups subsidize others.

3.2.1 Computing Basic Returns

Computing the return on a loan is in principle very straightforward. Given some initial loan amount L_0, a sequence of payments $\{P_t\}_{t=1}^{T}$, and a constant interest rate r, the return is simply given by

$$R = 1/L_0 \sum_{t=1}^{T} (1+r)^{T-t} P_t - 1. \tag{3.1}$$

Since typical student loans have standard amortization schedule with constant payments (at least yearly, as the interest rate is updated on a yearly basis, more on this below), (3.1) is useful even if we do not observe actual payments made, as long as we observe loan status changes over time—this will become clear below. Standard payments can be computed at any point in time: if the current interest rate is r, the current balance is L, and there are T payments remaining, then the constant payment over the remaining horizon (from some date 0 until date T) of the loan is given by

$$\begin{aligned} P &= \frac{(1+r)^T}{\sum_{t=0}^{T-1}(1+r)^t} L, \\ &= \frac{r}{1-(1+r)^{-T}} L. \end{aligned} \tag{3.2}$$

We can also compute the sequence of loan balances $\{L_t\}_{t=1}^{T}$ recursively (from some $L = L_0$) as follows:

$$L_t = (1+r)L_{t-1} - P. \tag{3.3}$$

As such, we can easily keep track of payments and balances as long as we know the status of the loan at all dates. Furthermore, since the amortization schedule is

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actuarially fair, the value of the loan at any point in time is simply the balance of the loan at that time. As such, if we observe the status of the loan for T periods while the horizon of the loan is longer than T, we can still use (3.1) simply by replacing the last payment with the balance of the loan for date T, i.e. set $P_T = L_T$.[8] To make returns comparable across loans with different number of observed time periods, we use annual percentage rates, labeled r^a, defined in the obvious way from the monthly percentage rate r^m:

$$\begin{aligned} r^m &= (R+1)^{1/(T-t_0)} - 1; \\ r^a &= (1+r^m)^{12} - 1, \end{aligned} \tag{3.4}$$

where t_0 represent the origination date of a loan.

3.2.2 Adjusting Payments According to Loan Status

In practice, the stream of payments can deviate from the above schedule for several reasons. For one thing, students do not make payments while they are enrolled in school, nor during a grace period equal to 6 months after last enrollment. We will refer to this status simply as 'the grace period,' whether the individual is still in school or has recently stopped being enrolled. While interest does not accrue for subsidized loans during that grace period, interest gets added to the principal for unsubsidized loans. Accordingly, for subsidized loans, we impute a payment equal to the interest payment for each month over which a loan is in its grace period. As such, the loan balance remains constant over the grace period, following equation (3.3). The idea

[8]To accommodate the idea that the actual value of a loans may not reflect its face value at date T, one can set $P_T = \delta L_T$ for some $\delta \in [0, 1]$.

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is that we treat this subsidy as a payment made to the lender by the government on behalf of the student. For unsubsidized loans, no (implicit) payment is made and so the loan balance evolves according to (3.3).

Similarly, students who have been out of school can go back to school, in which case loans previously issued enter a deferment period.[9] As for the grace period, interest accrues the principal for unsubsidized loans while in deferment, but implicit payments are made by the government on behalf of the student for subsidized loans, so that the balance of the loan remains constant.

Another frequently observed status is forbearance. A forbearance period is granted to individuals going through a period of financial hardship or illness. Unlike deferment periods, interest accrues on all loans (subsidized or not) while in forbearance. Accordingly, payments are set to zero and the balance of the loan evolves according to (3.3).

Two more loan status need to be discussed. This first one is straightforward: individuals always have the option of paying off their entire loan balance. In this case, we simply set the payment in that month equal to the balance of the loan. The second, default, is discussed in details below.

A loan must be delinquent for 9 months prior to being given a default status. In other words, when a default status is observed, payments equal to zero must be imputed for the previous 9 months, and the balance of the loan updated according

[9]While deferment periods are mainly granted to go back to school, they can also be granted during a period of economic hardship. See https://studentaid.ed.gov/sa/repay-loans/deferment-forbearance#what-is-deferment.

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to equation (3.3) over these 9 months. Since we typically do not observe complete loan histories, we must impute the value of a loan at the date of default. In other words, the payment that enters the return calculation in (3.1) for that period is set to $P_t = \gamma L_t$. The value of γ reflects the ability of the government to later recoup money out of loans that ever enter default. Following the work of Lucas (2010) we set $\gamma = 0.5$.

Before discussing our data, we note that we also follow loans that become consolidated, simply by following consolidated loans themselves. As we will see below, among other things, consolidation allows an individual to lock in the current interest rate for the (rest of the) duration of a loan.

3.3 Description of the Data

Detailed payment history would in principle be required in order to compute returns on student loans (see equation (3.1)). As emphasized in the previous section, however, one can go a long way by observing loan status histories. Since each loan taken out by individuals in the Beginning Postsecondary Students (BPS) is linked to the National Student Loan Data System (NSLDS), a partial history of the status of each loan in the BPS96/01 is available. At the moment, history files are only available for the 96/01 sample of the BPS.[10]

[10]The Department of Education's Institute of Education Sciences (IES) also produces the Baccalaureate and Beyond (B&B) survey, which is also linked to NSLDS data. The advantage of the BPS is that it surveys students during their education. As such, it allows us to identify characteristics of individuals at the time of loan origination. In addition, while the B&B only surveys individuals graduating from 4-year college degree, the BPS follows entering students regardless of degrees pursued, and whether or not they ever finish their degree.

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3.3.1 National Student Loan Data System (NSLDS)

We use the NSLDS to derive loan status indicators for every loan taken out by every individual in the BPS Survey. For every loan issued to a student, the database provides the most recent status of the loan (typically over the Summer 2001), as well as the balance of the loan at that date. In addition, the database provides changes in the status of any loan taken out by a student over the course of the survey, that is, from the 1995/96 school year until 2001. Using this information, we can determine when a loan was taken out, and identify (1) its grace period; (2) all deferment periods, if any; (3) all forbearance periods, if any; (4) if a loan was paid in full during a particular month; and (5) the date the loan went into default, if at all.

3.3.2 Beginning Postsecondary Students (BPS)

The BPS is a longitudinal study which follows a cohort of students who are enrolling in postsecondary education for the first time. The BPS surveys a sample of students as they are first enrolled in postsecondary education, and whether they pursue a college (Bachelor's or Associate) degree or any types of certificate. The BPS draws its initial sample from the National Postsecondary Student Aid Study (NPSAS), which consists of a large, nationally representative, sample of postsecondary students. Because of data availability, we consider a cohort that was first surveyed in 1996 (at the end of the 1995/96 academic year, in which they entered postsecondary education). Subsequently, follow-up surveys were conducted 3 and 6 years after entry into postsecondary education (in 1998 and 2001).

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The study collects data on student persistence in, and completion of, postsecondary education programs, their transition to employment, demographic characteristics, and changes over time in their goals, marital status, income, and debt, among other indicators. In addition, it offers institutional records on grades and SAT scores, as well as loan administrative snapshots in 2001.

3.3.3 Sample Selection

The original sample contains 12,280 respondents, around 60% of which contracted at least one loan to attend a post-secondary institution over the sample period, i.e. from the 1995/96 academic year to the 2000/01 academic year. In order to focus on typical American students, we remove respondents who are not U.S. citizen, have a disability, or have missing values for these characteristics or their age. Of the remaining 10,430 observations, we remove the 1,770 respondents who were still enrolled in school (some in graduate school) as of the last survey, leaving us with 8,660 observations. The fraction of borrowers in that sample, at 58%, is close to that of the original sample. Finally, since individuals enrolled in 4-year degrees will have at best very few months of potential loan repayments by the end of the survey, we concentrate on respondents who were not initially enrolled in 4-year bachelor degrees. This leaves us with 2,570, of which 1,280 (50%) contracted at least one student loan over the sample period. Our benchmark sample consists of these 1,280 respondents. A more restrictive sample, with respondents available for the last interview, brings the sample size of borrowers to 1,080: we will sometimes use this more restrictive

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Table 3.1: Number of loans, average amount borrowed and fraction subsidized loans by year.

Loan Year	Number of loans	Average Amount	Percent Sub.
1	1,520	$ 4,576	66.62%
2	810	$ 4,643	66.58%
3	510	$ 4,692	70.42%
4	460	$ 5,724	62.63%
5	350	$ 5,886	62.85%
6	190	$ 6,401	59.67%
7	20	$ 3,747	69.56%
Total	3,860	$ 4,944	69.98%

Notes: Loan Year is the year the loan was taken out (1995-96 being Year 1). Number of loans indicates how many loans were taken out in a specific year. Average amount is the average amount borrowed that year, conditional on borrowing. Percent Sub. is the fraction of loans that are subsidized.

sample when answers to the last round of interviews are considered.

From our benchmark sample, 14,120 individual-loan-history (or status) observations emerge from NSLDS data. Of those, we concentrate on Stafford loans, both subsidized and unsubsidized, thus removing Perkins and Plus loans (see below for consolidation loans). In addition, we remove loans for which the last status is either death, disability, or closed school discharge, loans that were cancelled before disbursement, loans with disbursement amounts equal to zero, and loans that were issued prior to the 1995/96 academic year, leaving us with 11,490 individual-loan-history observations. Note that several loans are eventually consolidated: as much as the data allows, we continue tracking Stafford loans for which we can identify

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the corresponding consolidated loan. All in all, after deleting histories that contain obvious coding mistakes, we have 3,860 individual-loan observations for which the history is available. These observations come from 1,240 unique individuals from our benchmark sample, i.e. we lose about 40 individuals through this process.

Table 3.1 shows the breakdown of total loans by year, i.e. number of first, second, and other year loans. 40% of the loans were taken out in the first year itself, which is consistent with our sample selection. Loans taken out each following year tend to decrease, but do not drop to zero after year two. This is because some individuals decide to pursue further studies including enrolling in a bachelor's degree. As a result, the average amount borrowed is also higher in the later years. The fraction of loans that are subsidized remains fairly constant throughout the years.

Table 3.2 shows summary statistics at the individual level. One thing that stands out is that the average age of individuals as of 12/31/1995 in the sample is almost 22 years. This seems to indicate that most individuals in our sample are older than what one would expect for first time post-secondary enrolling individuals to be aged in their first year. In the sample, men borrow more, earn more, have a lower GPA at the end of the first year and are younger than women. Racially, Asians and Whites earn more and have higher GPA's than Blacks and Hispanics, while Asians and Hispanics borrow less than Whites and Blacks. In terms of age, whites seem to be older than the other three groups all of whom seem to be similarly aged. 82% of individuals come from families where the highest parental education is less than a bachelor's degree. These individuals, earn less, borrow less and tend to be older.

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Table 3.2: Summary statistics: individual characteristics.

	# Obs	Inc.	UG loan	Frac. owed	GPA	Age
full sample	1,240	26,907	7,691	.753	2.76	21.69
male	500	32,274	8,155	.727	2.61	21.12
female	740	23,280	7,380	.772	2.89	22.07
asian	30	29,929	6,811	.630	3.20	20.84
black	200	23,647	7,546	.878	2.48	20.80
hispanic	190	24,178	5,503	.695	2.68	20.70
white	810	28,083	8,268	.739	2.84	22.17
Par Master	60	30,816	8,420	.745	2.87	20.78
Par Bach	160	27,637	9,216	.786	2.76	20.19
Par ltBach	1,020	26,527	7,412	.749	2.75	21.97
no maj	140	26,304	9,405	.810	2.46	19.59
humanities	80	27,017	8,721	.823	2.46	19.31
soc/behv sc	40	25,717	12,265	.850	2.80	21.48
life/phy sc	20	27,294	10,590	.798	2.68	19.23
engr/csc/math	140	34,208	8,793	.707	2.82	22.32
education	40	27,055	8,458	.825	2.76	19.36
business	240	24,403	5,986	.714	2.81	22.44
health	140	24,883	8,811	.805	2.87	22.59
voc/tech	90	34,645	6,767	.662	2.90	23.50
other	320	24,362	6,423	.742	2.83	21.88

Notes: Income is income in 2001 conditional on working; UG loan is the total amount of loans taken out; Fraction owed is the remaining fraction of the loans in 2001; GPA is at the end of the 1995-96 academic year. Age is as of 12/31/1995. Majors are the initial major in 1995-96. Par Master indicates individuals whose parents have a master's degree or higher, Par Bach is for individuals whose parents have a bachelor's degree and Par ltBach for individuals whose parents have less than a bachelor's degree.

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Table 3.3: Summary statistics: school characteristics.

	# Obs	Inc.	UG loan	Frac. owed	GPA	Age
Public	450	26,804	9,001	.798	2.57	20.70
Private NFP	240	28,492	9,068	.755	2.68	20.40
Private FP	550	26,033	6,043	.717	3.01	23.04
4-yr	260	28,556	9,645	.761	2.48	19.86
2-yr	640	27,140	8,324	.774	2.79	21.20
lt 2-yr	340	25,030	5,033	.708	3.05	23.99

Notes: Income is income in 2001 conditional on working; UG loan is the total amount of loans taken out; Fraction owed is the remaining fraction of the loans in 2001; GPA is at the end of the 1995-96 academic year. Age is as of 12/31/1995. Two types of institutional classifications are used. In the first group, institutions are classified into public, not-got-profit private and for-profit private institutions. In the second group they are classified as 4 year, 2 year or less than 2 year institutions.

Individuals who were enrolled in a technical or vocational course in the first year tend to earn considerably more than their peers and at the same time are on the lower end of the borrowing spectrum. The age distribution in terms of major seems to be bimodal. For one group of majors the average age seems to be around 19 years, for another group the average age is 22–23 years.

Table 3.3 shows summary statistics at the institutional level. Two types of institutional classifications are used. In the first group, institutions are classified into public, not-for-profit private and for-profit private institutions. In the second group they are classified as 4-year, 2-year or less than 2-year institutions. Individuals enrolled in for-profit private schools tend to borrow considerably less and are older than those in other types of schools. Similarly, those enrolled in less than 2-year

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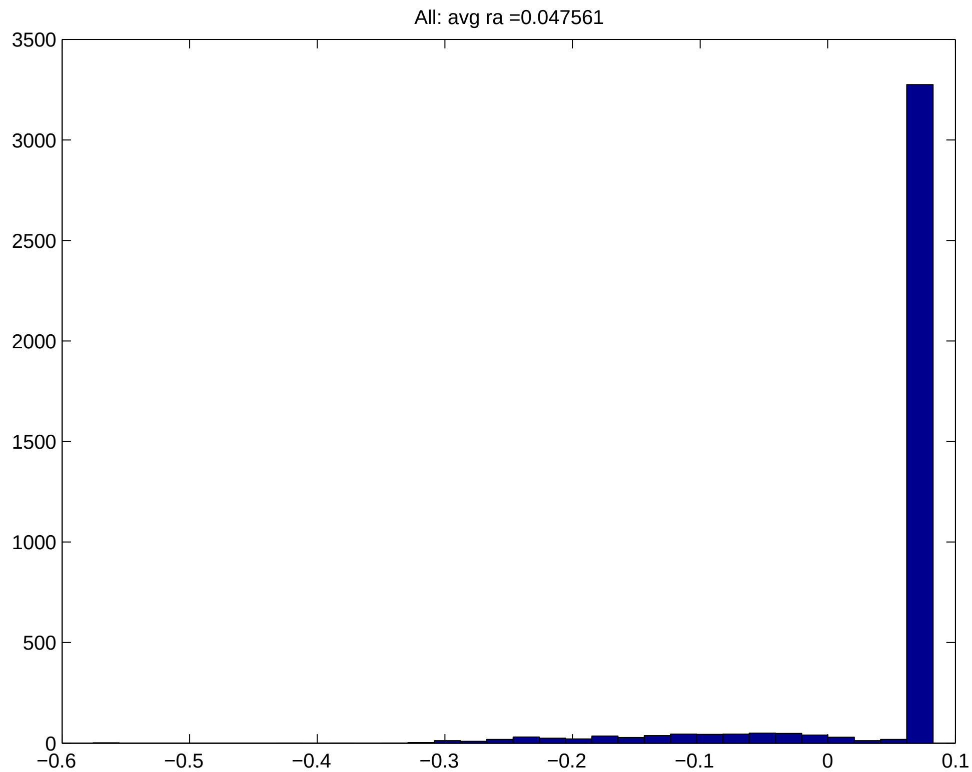
Figure 3.1: Return histogram.



Notes: Original data from BPS and NSLDS. The sample consists of all loans issued.

programs borrow considerably less and are older. Both, students in for-profit private schools and less than 2-years schools have higher GPA's, but earn less on average. They also tend to be 2–3 years older than their peers.

3.4 Results

As indicated in the Introduction, due to errors with the data, this section will only provide an illustration of the type of results that can be generated with the data.

The first thing that needs to be calculated is expected returns for each loan.

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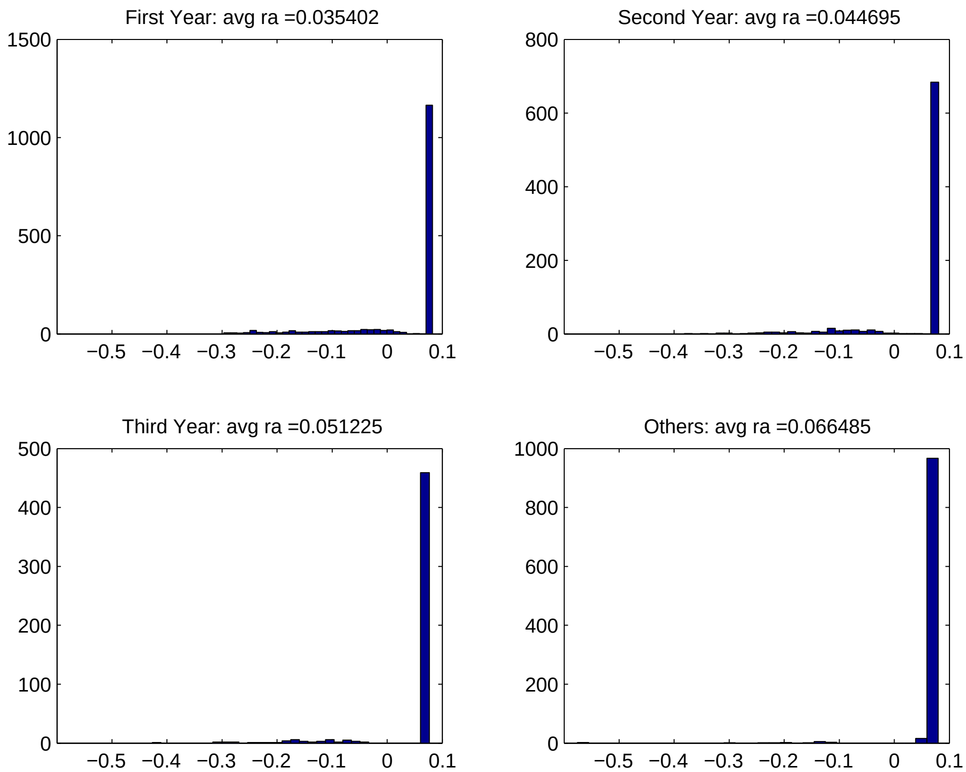
Figure 3.2: Return histograms by year.



Notes: Original data from BPS and NSLDS. The sample consists of all loans issued in a given year.

Figure 3.1 shows the histogram of returns for all loans. This shows that by and large, most loans seem to have a positive return, while there are some loans which are performing very poorly. It might be more informative to break up loans by the year in which they were disbursed, since the history of loans is time-dependent, so loans disbursed in the same year have had a similar amount of time to evolve. The break down by year appear on Figure 3.2, where the average return is part of the title of each sub-picture. As expected, there is more heterogeneity in returns for loans that were disbursed in the first year compared to loans that were disbursed in later years.

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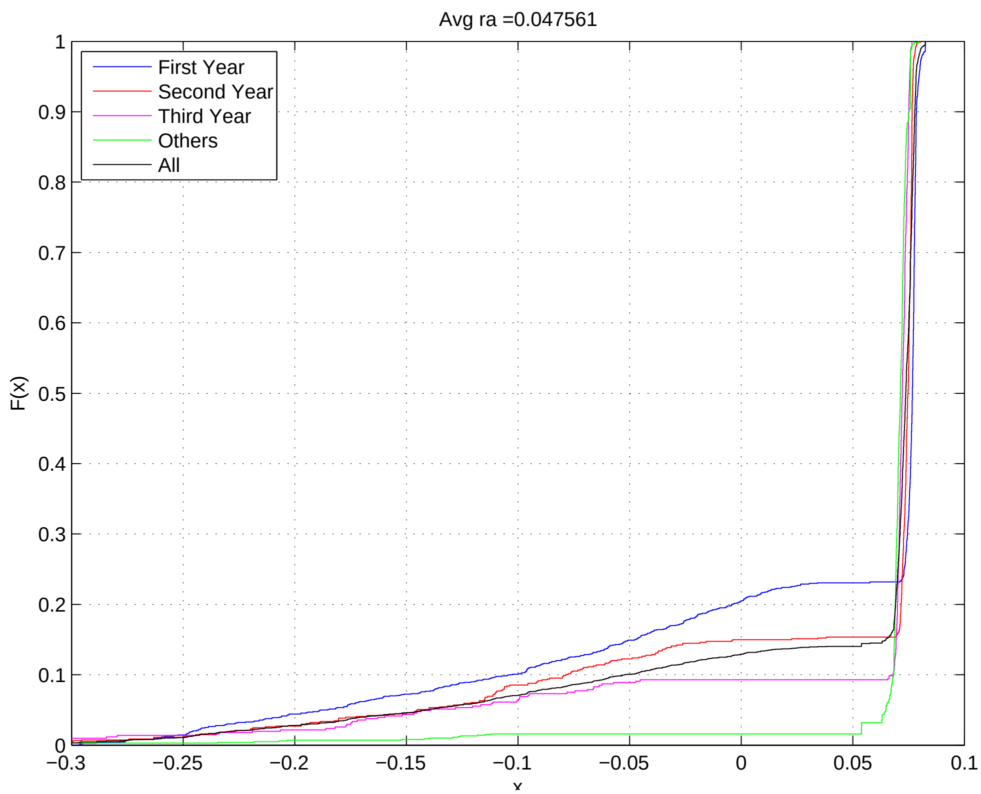
Figure 3.3: Return cdf's by year.



Notes: Original data from BPS and NSLDS. The sample consists of all loans issued in a given year.

Finally, one can plot cdf of returns which is shown in Figure 3.3. This allows us to evaluate the returns on loans disbursed in different year using a single graph. There is a 10 percentage point increase in loans with negative returns when comparing loans disbursed in the third year to loans disbursed in the first year. One main cause for this would be that loans disbursed in the first year had 2 extra years to evolve and therefore have a higher chance of ever going into default.

Additionally, we can plot conditional expected return. For example Figure 3.4 plots expected returns on first year loans for individuals enrolled in public, not-for-

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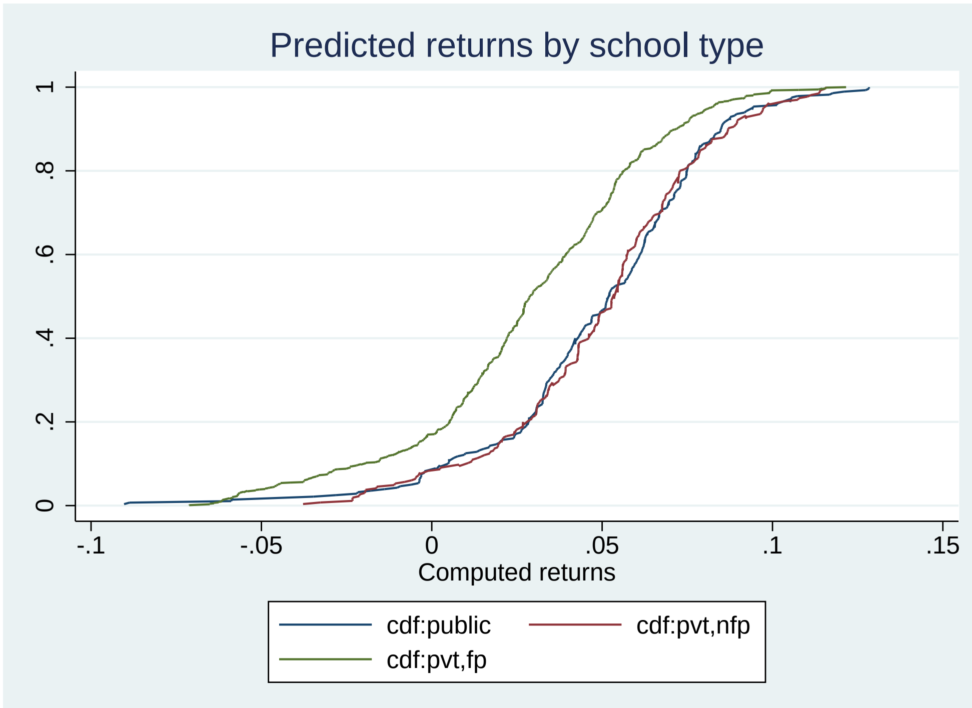
Figure 3.4: First year loan returns by characteristics.



Notes: Original data from BPS and NSLDS. The sample consists loans issued in the first year.

profit private and for-profit private schools. The figure clearly shows that the returns at for-profit private schools are lower than those at the other two types of schools. One could generate similar plots based on other characteristics such as race, gender, major as well as plots for loans disbursed in other years.

Having calculated expected returns, we can now answer the question: which individual characteristics help predict expected returns. The most straightforward way to go about answering this question is to estimate a linear model:

$$r^a_{i,t} = \alpha_{i,t} X_{i,t} + \epsilon_{i,t}, \tag{3.5}$$

where $r^a_{i,t}$ is the return on loan i disbursed in year t and $X_{i,t}$ is a vector of year

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t observable individual characteristics for the individual who took out loan i. The characteristics of the individual can be time varying, as long as the lending agency is able to observe the information at the time the loan is originated. For example, for second year loans, the lending agency should be able to see information on GPA at the end of the first year.

Table 3.4 shows some results when estimating the model in equation (3.5). For loans that were disbursed in the first year, school type (for-profit private school), gender (males), race (black) and number of dependents all have a negative impact on returns. On the other hand, individuals from well to do families have higher returns. For loans that were disbursed in the second year, we observe a similar pattern, however as shown in column (3), we can now use GPA at the end of the first year. This seems to have a big impact on R^2 and predicts that individuals with higher GPA are likely to have higher returns.

3.5 Conclusion

The starting point of this paper is that cross-subsidization contradicts well-functioning private lending markets: loans to all identifiable subgroup of the population should carry the same expected return. We use data from the BPS to evaluate the prevalence of cross-subsidization in the student loan market, which, by design, is not expected to be efficient. Because the NSLDS data can be linked to BPS data, we can estimate the rate of return on every student loan issued to each respondents in the BPS. Using these returns, we can compute expected returns as of the date of

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origination for various identifiable subsets of the student population. This allows us to identify, for example, that students who attend private for-profit institutions are cross-subsidized. However, due to serious data issues recently discoved by the NSLDS, we are unable to present concrete results in this paper, i.e. our results should be seen as potential implications of our methodology as opposed to the actual implications.

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Table 3.4: BPS 1996/01: expected returns - initial degree non-bachelor's

	(1) year 1	(2) year 2	(3) year 2 (GPA)
pvt.,nfp	-0.00383	0.0257***	0.0112
pvt.,fp	-0.0258***	-0.0264***	-0.0318***
Age as of 12/31/95	-0.000168	-0.00113	0.000637
agesq	0.0000389	0.0000488	0.0000183
Male	-0.0173***	-0.00238	-0.00278
asian	0.0219*	0.0190***	0.0169*
black	-0.0465***	-0.0198**	-0.00478
hispanic	-0.00678	-0.00678	-0.00895
SingPar	-0.00277	-0.0358***	-0.0411***
NumDepend	-0.00697**	-0.00132	-0.00763*
dependent	0.0107	0.0181	0.0235
depfamInc	0.000284***	0.0000316	0.0000114
ind_ParB	-0.00485	0.00158	-0.00916
ind_ParM	-0.00172	0.0102	0.00191
major95:no maj	-0.0126	0.00666	-0.00559
major95:social/behav. sc.	-0.00340	0.0128	-0.0226*
major95:life/phy. sc.	-0.00256	0.0563**	0.0274
major95:engr./csc/math	0.00733	0.0264*	-0.00424
major95:education	-0.0344*	0.00107	-0.0168
major95:business/mgmt.	-0.00927	0.00849	-0.0153
major95:health	-0.0161	0.0209	-0.00399
major95:vocational/tech	-0.00754	0.00939	-0.0146
major95:other tech/prof	-0.00255	0.0338**	0.0101
lntuition	0.00485	-0.00386	-0.00203
gpa			0.0205***
Constant	0.0300	0.0710	-0.0228
State f.e.	Yes	Yes	Yes
Observations	1450	790	680
R^2	0.173	0.275	0.324

$^{+}$ $p < 0.105$, * $p < 0.100$, ** $p < 0.05$, *** $p < 0.01$

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APPENDIX A
APPENDIX TO CHAPTER 1

A.1 Proof of Proposition 1

The proofs of these results are fairly mechanical and once I have the proved Property 1, the proofs for Property 2 and 3 are very similar to the ones given by Thomas and Worrall (1990) (reproduced in Ljungqvist and Sargent (2012)). The main reason why the proof for Property 1 differs is that in Thomas and Worrall, the private information appears additively inside a concave function. Here, $\theta_{2,i}$ appears non-linearly inside a convex function ($v(\frac{y_{2,i}}{\theta_{2,i}})$), so this complicates things a little bit. The proof to Property 4 is then a simple extension.

Proof:

Property 1:

Consider the following IC constraints:

$$IC_{s,s+1} : u(c_{2,s}) - v\left(\frac{y_{2,s}}{\theta_{2,s}}\right) \geq u(c_{2,s+1}) - v\left(\frac{y_{2,s+1}}{\theta_s}\right)$$
$$IC_{s+1,s} : u(c_{2,s+1}) - v\left(\frac{y_{2,s+1}}{\theta_{2,s+1}}\right) \geq u(c_{2,s}) - v\left(\frac{y_{2,s}}{\theta_{2,s+1}}\right)$$

Adding the above two equations we get:

$$v\left(\frac{y_{2,s}}{\theta_{2,s}}\right) - v\left(\frac{y_{2,s}}{\theta_{2,s+1}}\right) \leq v\left(\frac{y_{2,s+1}}{\theta_{2,s}}\right) - v\left(\frac{y_{2,s+1}}{\theta_{2,s+1}}\right) \tag{A.1}$$

Let

$$\theta_{2,s+1} = k\theta_{2,s},\ \frac{y_{2,s}}{\theta_{2,s}} = x,\ \frac{y_{2,s+1}}{\theta_{2,s}} = \tilde{x}$$

so that $k > 1$

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Now equation (A.1) can be written as:

$$v(x) - v(x/k) \leq v(\tilde{x}) - v(\tilde{x}/k)$$

In order to show that $\tilde{x} > x$, it is sufficient to show that $v(x) - v(x/k)$ is increasing in x, i.e.

$$\frac{d}{dx}(v(x) - v(x/k)) = v'(x) - \frac{1}{k}v'(x/k) > 0 \tag{A.2}$$

Since v is convex (its derivative is non-decreasing) and $k > 1$,

$$v'(x) \geq v'(x/k) > \frac{1}{k}v'(x/k)$$

Hence (A.2) holds and $y_{2,s+1} > y_{2,s}$. From $IC_{s+1,s}$ this implies that $c_{2,s+1} > c_{2,s}$.

Property 2:

Suppose we know that $IC_{s,k} \geq 0$ for some $s > k$, i.e.

$$u(c_{2,s}) - v(y_{2,s}/\theta_{2,s}) \geq u(c_{2,k}) - v(y_{2,k}/\theta_{2,s}) \tag{A.3}$$

From Property 1 we know that this implies $y_{2,s} > y_{2,k}$ and from the convexity of v

$$v\left(\frac{y_{2,s}}{\theta_{2,s}}\right) - v\left(\frac{y_{2,s}}{\theta_{2,s+1}}\right) \geq v\left(\frac{y_{2,k}}{\theta_{2,s}}\right) - v\left(\frac{y_{2,k}}{\theta_{2,s+1}}\right) \tag{A.4}$$

Adding equations (A.3) and (A.4) we get

$$u(c_{2,s}) - v\left(\frac{y_{2,s}}{\theta_{2,s+1}}\right) \geq u(c_{2,k}) - v\left(\frac{y_{2,k}}{\theta_{2,s+1}}\right) \tag{A.5}$$

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Note that the local downward IC, $IC_{s+1,s}$

$$u(c_{2,s+1}) - v\left(\frac{y_{2,s+1}}{\theta_{2,s+1}}\right) \geq u(c_{2,s}) - v\left(\frac{y_{2,s}}{\theta_{2,s+1}}\right) \tag{A.6}$$

From equations (A.5) and (A.6), it is easy to conclude that

$$u(c_{2,s+1}) - v\left(\frac{y_{2,s+1}}{\theta_{2,s+1}}\right) \geq u(c_{2,k}) - v\left(\frac{y_{2,k}}{\theta_{2,s+1}}\right)$$

In other words, $IC_{s+1,k}$ holds whenever $IC_{s+1,s}$ holds $\forall k < s$. In this recursive manner we can show that all global downward IC constraints are satisfied when local constraints are satisfied. The same approach can be applied to show that all global upward IC constraints are satisfied when local constraints are satisfied.

Property 3:

First note that the two resource constraints 1.2 and 1.3 can be collapsed into a single present value condition by solving out for k_2. That is:

$$G + c_1 - y_1 + \frac{1}{R}\sum_{i=1}^{N} \pi_i[c_{2,i} - y_{2,i}] = 0 \tag{A.7}$$

Let's simplify this problem initially and assume that there are only two possible states in the second period

$$IC_{1,2} : u(c_{2,1}) - v\left(\frac{y_{2,1}}{\theta_{2,1}}\right) \geq u(c_{2,2}) - v\left(\frac{y_{2,2}}{\theta_{2,1}}\right) \tag{A.8}$$

$$IC_{2,1} : u(c_{2,2}) - v\left(\frac{y_{2,2}}{\theta_{2,2}}\right) \geq u(c_{2,1}) - v\left(\frac{y_{2,1}}{\theta_{2,2}}\right) \tag{A.9}$$

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Let us assume that $IC_{2,1}$ does not bind. From Property 1 we know that $c_{2,2} > c_{2,1}$ and $y_{2,2} > y_{2,1}$

Let $\tilde{c}_{2,1} = c_{2,1}$, lower $c_{2,2}$ to $\tilde{c}_{2,2}$ such that

$$u(\tilde{c}_{2,2}) - v\left(\frac{y_{2,2}}{\theta_{2,2}}\right) = u(\tilde{c}_{2,1}) - v\left(\frac{y_{2,1}}{\theta_{2,1}}\right)$$

Note that this would imply that $IC_{1,2}$ can no longer be binding (if at all it was before). Also, lowering $c_{2,2}$ means that feasibility (equation A.7) no longer holds. Let α such that $\hat{c}_{2,i} = \tilde{c}_{2,i} + \alpha$ and

$$G + c_1 - y_1 + \frac{1}{R}\sum \pi_i[\hat{c}_{2,i} - y_{2,i}] = 0$$

We now have a feasible allocation for which no IC is violated and there is more risk sharing than before. Since the planner's preferences are concave, he would prefer this allocation over the original allocation. Since the planner did not choose this allocation, it means that our initial assumption that $IC_{2,1}$ did not bind was incorrect.

Now that I have shown in detail how this works for a simple case, it can be generalized to a case with more than 2 states using the same approach as used by Ljungqvist and Sargent Ljungqvist and Sargent (2012).

<u>Property 4:</u>

Similar to the proof for Property 3, let us assume that there are only two states in period 2. We have already proved that $IC_{2,1}$ is binding. Let us also assume that $IC_{1,2}$ is binding as well, i.e.

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$$IC_{1,2} : u(c_{2,1}) - v\left(\frac{y_{2,1}}{\theta_{2,1}}\right) = u(c_{2,2}) - v\left(\frac{y_{2,2}}{\theta_{2,1}}\right)$$
$$IC_{2,1} : u(c_{2,2}) - v\left(\frac{y_{2,2}}{\theta_{2,2}}\right) = u(c_{2,1}) - v\left(\frac{y_{2,1}}{\theta_{2,2}}\right)$$

Add the two equations above, we get

$$v\left(\frac{y_{2,1}}{\theta_{2,1}}\right) - v\left(\frac{y_{2,1}}{\theta_{2,2}}\right) = v\left(\frac{y_{2,2}}{\theta_{2,1}}\right) - v\left(\frac{y_{2,2}}{\theta_{2,2}}\right)$$

We know from the proof of Property 1 that this cannot be true since the right hand side of the equation is always greater than the left hand side of the equation. Hence our assumption that $IC_{1,2}$ is binding was incorrect.

A.2 Proof of Proposition 2

In this section I provide the proof for Proposition 2. Given that the tax system is a function of effective labor, the agent needs to determine which level of effective labor to choose in period 2 that would maximize her lifetime expected utility. The agent's decision can be grouped into 4 general categories. The first one is when the agent decides to impart effective labor that reflects her true skill level. In this case an agent of type i chooses effective labor in the range of $(y^*_{2,i-1}, y^*_{2,i}]$ and faces tax rates of $\{\tau^i_k, \tau^i_y, T_i\}$ for $i = 1, \ldots, N$.

In the second category, the agent decides that at certain realizations of skill level, she will impart effective labor that reflects a skill level lower than her true skill level. For example, an agent who realizes skill level j might decide to choose effective labor from the range $(y^*_{2,p-1}, y^*_{2,p}]$ and face tax rates of $\{\tau^p_k, \tau^p_y, T_p\}$ for some $p < j$.

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For any other realization of skill level $i \neq j$ she chooses effective labor in the range of $(y^*_{2,i-1}, y^*_{2,i}]$. This is just one specific example of possible cases under the second category and the proof will cover all possible permutations.

In the third category, the agent decides that at certain realizations of skill level, she will impart effective labor that reflects a skill level above her true skill level. For example, an agent who realizes skill level j might decide to choose effective labor from the range $(y^*_{2,p-1}, y^*_{2,p}]$ and face tax rates of $\{\tau^p_k, \tau^p_y, T_p\}$ for some $p > j$. For any other realization of skill level $i \neq j$ she chooses effective labor in the range of $(y^*_{2,i-1}, y^*_{2,i}]$. Again, this is just one specific example of possible cases under the third category and the proof will cover all possible permutations.

Finally, the fourth category is a combination of the second and third categories. That is, upon realization of certain skill levels the agent might decide to impart effective labor below her true skill level and upon realization of other skill levels she might decide to impart effective labor above her true skill level. The idea behind the proof is that the c.e.a. solves the agent problem for category one and the agent cannot be better off in the other categories. I break up the proof into 4 parts to show this.

A.2.1 Category I

As described above, in this case the agent decides to impart effective labor that reflects her true skill level. Therefore, the agent's problem can be written as:

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$$\max_{c,y,k'} \; u(c_1) - v(y_1/\theta_1) + \beta \sum_{i=1}^{N} \pi_i [u(c_{2,i}) - v(y_{2,i}/\theta_{2,i})]$$

$$\text{s.t.} \quad c_1 + k' = y_1$$

$$c_{2,i} = Rk'(1-\tau_k^i) + y_{2,i}(1-\tau_y^i) + T_i \quad ;\text{if } s = i \;\&\; y_{2,i} \in (y^*_{2,i-1}, y^*_{2,i}]$$

The Lagrangian to the problem can be written as:

$$\mathcal{L} = u(c_1) - v\left(\frac{c_1 + k'}{\theta_1}\right) + \beta \sum_{i=1}^{N} \left[\pi_i \left\{ u(c_{2,i}) - v\left(\frac{c_{2,i} - Rk'(1-\tau_k^i) - T_i}{(1-\tau_y^i)\theta_{2,i}}\right) \right\} \right]$$

This problem has $2N+3$ variables $(c_1, y_1, k', \{c_{2,i}\}_{i=1}^N, \{y_{2,i}\}_{i=1}^N)$ and so we need that many equations. There are $N+1$ budget constraints noted above, and below I note $N+1$ intra-temporal equations plus 1 Euler equation.

$$\begin{aligned} u'(c_1) &= \left(\frac{1}{\theta_1}\right) v'\left(\frac{y_1}{\theta_1}\right) \\ u'(c_{2,i}) &= \left(\frac{1}{1-\tau_y^i}\right)\left(\frac{1}{\theta_{2,i}}\right) v'\left(\frac{y_{2,i}}{\theta_{2,i}}\right) \quad \text{for } i = 1, \ldots, N \\ u'(c_1) &= R\beta \sum_{i=1}^{N} \pi_i (1-\tau_k^i) u'(c_{2,i}) \end{aligned}$$

Clearly, given the definition of the tax functions from (1.15) the c.e.a. satisfies the budget constraints, the intra-temporal equations and the Euler equation.

In general, the Euler equation ensures that it is optimal for the agent to choose c_1^*.[1] Showing this will be useful for later parts of the proof. If the agent does not

[1]and therefore y_1^* and k'^*

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choose c_1^*, there are two other possible alternatives, either the agent can consume more than c_1^* or less than it. If she chooses $c_1 > c_1^*$, then from the intra-temporal equation for the first period, $y_1 < y_1^*$ which leads to the result $k' < k'^*$ (the agent consumes more and works less than the c.e.a.). Also, now since $u'(c_1) < u'(c_1^*)$, from the Euler equation we must have at least one $i \in [1, N]$ such that $u'(c_{2,i}) < u'(c_{2,i}^*)$. This means that $c_{2,i} > c_{2,i}^*$, but for the intra-temporal equation to hold, it would also require $y_{2,i} < y_{2,i}^*$. That is the agent should consume more while both working and saving less than before, the budget constraint in this case will most definitely not be satisfied. If $c_1 < c_1^*$ then $u'(c_1) > u'(c_1^*)$ and from the Euler equation this would require at least one $i \in [1, N]$ such that $u'(c_{2,i}) > u'(c_{2,i}^*)$. Applying this condition to the intra-temporal equation would cause $y_{2,i} > y_{2,i}^*$, which is out of the permissible range of $y_{2,i}$. In addition, from the first period intra-temporal equation, $c_1 < c_1^*$ would result in $y_1 > y_1^*$ and therefore $k' > k'^*$ (the agent consumes less and works more than the c.e.a.). $u'(c_{2,i}) > u'(c_{2,i}^*)$ implies that $c_{2,i} < c_{2,i}^*$, therefore in the second period the agent should consume less even though he has saved more in the first period and is expected to work more in the second period. Clearly, this too will not satisfy her budget constraint.

The rest of the proof is to show that the agent cannot do better.

A.2.2 Category II

In this section we consider the case where the agent might decide to impart effective labor below her true skill level. This case is interesting because as we observed

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from the planner's problem high types have the incentive to act like low types. In this class of models, generally a high type agent has the incentive to report himself as a low type since low types pay lower taxes and impart less labor. In order to make up for the loss in consumption that would accompany a low type agent in period 2, the agent deviates from the optimal savings amount, reducing consumption in period 1 and thus saving more. Therefore, the design of wealth taxes is key here because they are designed such that the agent never has the incentive to deviate from k'^*.[2]

The simplest case here, as outlined earlier, is when an agent decides to impart her true level of effective labor in all possible states but one. Once we analyze this case, it is easy to generalize the result to any number of states where the agent may try to misrepresent her true type. WLOG assume that an agent who if she realizes a skill level $j \in [2, N]$ decides to impart effective labor in the range $(y^*_{2,p-1}, y^*_{2,p}]$ for any $p < j$. If the agent realizes any other skill level $i \neq j$, then she will choose to impart from skill level $(y^*_{2,i-1}, y^*_{2,i}]$. In this case the agent's budget constraints are:

$$c_1 + k' = y_1$$

$$c_{2,i} = Rk'(1-\tau_k^i) + y_{2,i}(1-\tau_y^i) + T_i \quad \text{;if } s = i \neq j \ \& \ y_{2,i} \in (y^*_{2,i-1}, y^*_{2,i}]$$

$$c_{2,j} = Rk'(1-\tau_k^p) + y_{2,j}(1-\tau_y^p) + T_p \quad \text{;if } s = j \ \& \ y_{2,j} \in (y^*_{2,p-1}, y^*_{2,p}]$$

[2] See Kocherlakota (2005) for details.

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and the first order conditions are

$$u'(c_1) = \left(\frac{1}{\theta_1}\right) v'\left(\frac{y_1}{\theta_1}\right) \tag{A.10}$$

$$u'(c_{2,i}) = \left(\frac{1}{1-\tau_y^i}\right)\left(\frac{1}{\theta_{2,i}}\right) v'\left(\frac{y_{2,i}}{\theta_{2,i}}\right) \quad \text{for } i = 1, \ldots, N \ \&\ i \neq j \tag{A.11}$$

$$u'(c_{2,j}) = \left(\frac{1}{1-\tau_y^p}\right)\left(\frac{1}{\theta_{2,j}}\right) v'\left(\frac{y_{2,j}}{\theta_{2,j}}\right) \tag{A.12}$$

$$u'(c_1) = R\beta\left[\sum_{i=1}^{j-1}\pi_i(1-\tau_k^i)u'(c_{2,i}) + \pi_j(1-\tau_k^p)u'(c_{2,j}) + \sum_{i=j+1}^{N}\pi_i(1-\tau_k^i)u'(c_{2,i})\right] \tag{A.13}$$

Before proceeding further, it is important to note that in period 1 the intra-temporal equation for the planner (equation 1.10) and for the agent (equation A.10) are the same. The first period budget constraint for the planner and the agent are also same. As noted above, the wealth taxes are setup such that the agent has no incentive to save anything other than k'^*. Moreover, given the fact that $u'(\cdot)$ is monotonically decreasing and $v'(\cdot)$ is monotonically increasing (single crossing property), if $\{c_1^*, y_1^*, k'^*\}$ are part of the planner's solution, they must also be part of the agent's solution. Also note that the c.e.a. is not a solution to this problem as $y_{2,j}$ cannot be higher than $y_{2,p}^*$. Alternatively, one could follow a process similar to Category I to show that the agent will always find it optimal to choose c_1^*. Using this strategy shows that the agent's labor decision in state j only exacerbates the problems that we observed earlier.

I now show that for any $i \neq j$, the agent must choose $y_{2,i}^*$. $y_{2,i}^*$ satisfies both the budget constraint and the intra-temporal equation for the agent. On the other hand, if the agent chooses from $(y_{2,i-1}^*, y_{2,i}^*)$, it is not possible for the agent to satisfy both

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the budget constraint and the intra-temporal equation. This is because by working less the budget constraint will force the agent to consume less than $c^*_{2,i}$, whereas the intra-temporal equation will require the agent to consume more than $c^*_{2,i}$.

The mathematical statement below highlights the contradiction:

$$\left(\frac{1}{\theta_{2,i}}\right)\left(\frac{v'(y^*_{2,i}/\theta_{2,i})}{u'(c^*_{2,i})}\right) = 1 - \tau^i_y > \left(\frac{1}{\theta_{2,i}}\right)\left(\frac{v'(y_{2,i}/\theta_{2,i})}{u'(c_{2,i})}\right)$$

The equality holds by definition of τ^i_y. The inequality shows that the intra-temporal equation cannot hold for $y_{2,i} < y^*_{2,i}$ and $c_{2,i} < c^*_{2,i}$. This is because from the convexity of $v(\cdot)$, $v'\left(\frac{y^*_{2,i}}{\theta_{2,i}}\right) > v'\left(\frac{y_{2,i}}{\theta_{2,i}}\right)$ and from the concavity of $u(\cdot)$, $u'(c^*_{2,i}) < u'(c_{2,i})$. Therefore the fraction on the extreme right has to be smaller than the fraction on the extreme left.

Now that it has been established that for $i \neq j$, the agent must choose $y^*_{2,i}$, the remaining question to be answered is what value of $y_{2,j} \in (y^*_{2,p-1}, y^*_{2,p}]$ is optimal for the agent. The answer is that any value of y_j in the given range will not solve both the agent's budget constraint and her intra-temporal equation. The mathematical statement below highlights the contradiction:

$$\left(\frac{1}{\theta_{2,p}}\right)\left(\frac{v'(y^*_{2,p}/\theta_{2,p})}{u'(c^*_{2,p})}\right) = 1 - \tau^p_y > \left(\frac{1}{\theta_{2,j}}\right)\left(\frac{v'(y_{2,j}/\theta_{2,j}}{u'(c_{2,j})}\right)$$

The equality holds by definition of τ^p_y and the inequality shows that the intra-temporal equation cannot hold for possible values of $y_{2,j}$ and $c_{2,j}$. This is because since $\theta_{2,p} < \theta_{2,j}$ and from the convexity of $v(\cdot)$, $\frac{1}{\theta_{2,p}}v'\left(\frac{y^*_{2,p}}{\theta_{2,p}}\right) > \frac{1}{\theta_{2,j}}v'\left(\frac{y_{2,j}}{\theta_{2,j}}\right)$ for any allowable values of $y_{2,j}$. The intra-temporal equation can only hold if $u'(c^*_{2,p}) > u'(c_{2,j})$, and from the

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concavity of $u(\cdot)$, this is possible only if $c^*_{2,p} < c_{2,j}$, which cannot be true given the budget constraint.

We can now generalize this result to any number of states where the agent might decide to impart effective labor to reflect her skill level lower than it actually is. For example, consider the other extreme where the agent chooses from the appropriate effective labor range if she realizes the lowest state, in any other realization she will impart the effective labor to reflect an effective labor of a skill level just below her true level. As noted above the agent will find it optimal to choose $y^*_{2,1}$ if she realizes the lowest state and in all other cases, no solution exists.

A.2.3 Category III

In this section we consider the case where the agent might decide to impart effective labor above her true skill level. This case is not very interesting interesting because as we observed from the planner's problem low types do not have the incentive to act like high types. Still for the sake of completeness this case needs to be ruled out as well.

The simplest case here, as above, is when an agent decides to impart her true level of effective labor in all possible states but 1. Once we analyze this case, it is easy to generalize the result to any number of states where the agent may try to misrepresent her true type. WLOG assume that an agent who if she realizes a skill level $j \in [1, N-1]$ decides to impart effective labor in the range $(y^*_{2,p-1}, y^*_{2,p}]$ for any $p > j$. If the agent realizes any other skill level $i \neq j$, then she will choose to impart

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from skill level $(y^*_{2,i-1}, y^*_{2,i}]$. In this case the agent's budget constraints are:

$$c_1 + k' = y_1$$

$$c_{2,i} = Rk'(1-\tau_k^i) + y_{2,i}(1-\tau_y^i) + T_i \quad ;\text{if } s = i \neq j \ \&\ y_{2,i} \in (y^*_{2,i-1}, y^*_{2,i}]$$

$$c_{2,j} = Rk'(1-\tau_k^p) + y_{2,j}(1-\tau_y^p) + T_p \quad ;\text{if } s = j \ \&\ y_{2,j} \in (y^*_{2,p-1}, y^*_{2,p}]$$

and the first order conditions are

$$u'(c_1) = \left(\frac{1}{\theta_1}\right) v'\left(\frac{y_1}{\theta_1}\right) \tag{A.14}$$

$$u'(c_{2,i}) = \left(\frac{1}{1-\tau_y^i}\right)\left(\frac{1}{\theta_{2,i}}\right) v'\left(\frac{y_{2,i}}{\theta_{2,i}}\right) \quad \text{for } i = 1, \ldots, N \ \&\ i \neq j \tag{A.15}$$

$$u'(c_{2,j}) = \left(\frac{1}{1-\tau_y^p}\right)\left(\frac{1}{\theta_{2,j}}\right) v'\left(\frac{y_{2,j}}{\theta_{2,j}}\right) \tag{A.16}$$

$$u'(c_1) = R\beta\left[\sum_{i=1}^{j-1} \pi_i(1-\tau_k^i)u'(c_{2,i}) + \pi_j(1-\tau_k^p)u'(c_{2,j}) + \sum_{i=j+1}^{N} \pi_i(1-\tau_k^i)u'(c_{2,i})\right] \tag{A.17}$$

As above for any $i \neq j$, the agent must choose $y^*_{2,i}$. The question then remains if there exists a feasible option for $y_{2,j} \in (y^*_{2,p-1}, y^*_{2,p}]$. It is quite straightforward to show that $y_{2,j} \neq y^*_{2,p}$. The mathematical statement below highlights the contradiction:

$$\left(\frac{1}{\theta_{2,p}}\right)\left(\frac{v'(y^*_{2,p}/\theta_{2,p})}{u'(c^*_{2,p})}\right) = 1 - \tau_y^p < \left(\frac{1}{\theta_{2,j}}\right)\left(\frac{v'(y^*_{2,p}/\theta_{2,j})}{u'(c^*_{2,p})}\right)$$

The equality holds by definition of τ_y^p and the inequality shows that the intra-temporal equation cannot hold for this case. When $y_{2,j} = y^*_{2,p}$, then from the budget constraint $c_{2,j} = c^*_{2,p}$, but because $\theta_{2,p} > \theta_{2,j}$ the two fractions cannot be equal.

Because of the sign of the inequality, it is a little more complicated to show that no solution exists for $y_{2,j} \in (y^*_{2,p-1}, y^*_{2,p})$. In this range however, from the budget

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constraint we can conclude that $c_{2,j} > c^*_{2,j}$ because $y^*_{2,p-1} \geq y^*_{2,j}$. From the concavity of $u(\cdot)$, this implies that $u'(c_{2,j}) < u'(c^*_{2,j})$. Therefore, for the Euler equation to still hold, there must exist at least one $i \neq j$ such that $u'(c_{2,i}) > u'(c^*_{2,i})$, or, $c_{2,i} < c^*_{2,i}$. This will lead to a contradiction in the intra-temporal equation of i as noted below:

$$\left(\frac{1}{\theta_{2,i}}\right)\left(\frac{v'(y^*_{2,i}/\theta_{2,i})}{u'(c^*_{2,i})}\right) = 1 - \tau^i_y > \left(\frac{1}{\theta_{2,i}}\right)\left(\frac{v'(y_{2,i}/\theta_{2,i})}{u'(c_{2,i})}\right)$$

The equality holds by definition of τ^i_y and the inequality shows that the intra-temporal equation cannot hold for this case. For the intra-temporal equation to hold with equality we wold need the numerator to also increase as the denominator increased. However, increasing the numerator will push it out of the acceptable range for $y_{2,i}$.

Now generalizing this result is quite straightforward. If the agent decides to misreport her true type for more than 1 state, one only needs to apply the above logic. For the states he decides to report her true type, her only option is to choose from the c.e.a. and for state where he misreports her type no solution exists.

A.2.4 Category IV

As discussed earlier, this is a combination of the above two categories. As a result, the strategy here is to use the results derived above to show that the agent cannot be better off than choosing the c.e.a..The simplest case in this category would take on the form as follows. WLOG assume that an agent who if she realizes a skill level $j_1 \in [2, N]$ decides to impart effective labor in the range $(y^*_{2,p_1-1}, y^*_{2,p_1}]$ for any $p_1 < j_1$ and if she realizes a skill level $j_2 \in [1, N-1]$, she decides to impart effective

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labor in the range $(y^*_{2,p_2-1}, y^*_{2,p_2}]$ for any $p_2 > j_2$. If the agent realizes any other skill level $i \neq \{j_1, j_2\}$, then she will choose to impart from skill level $(y^*_{2,i-1}, y^*_{2,i}]$. In this case the agent's budget constraints are:

$$c_1 + k' = y_1$$

$$c_{2,i} = Rk'(1-\tau_k^i) + y_{2,i}(1-\tau_y^i) + T_i \quad ;\text{if } s = i \neq \{j_1, j_2\} \ \&\ y_{2,i} \in (y^*_{2,i-1}, y^*_{2,i}]$$

$$c_{2,j_1} = Rk'(1-\tau_k^{p_1}) + y_{2,j_1}(1-\tau_y^{p_1}) + T_{p_1} \quad ;\text{if } s = j_1 \ \&\ y_{2,j_1} \in (y^*_{2,p_1-1}, y^*_{2,p_1}]$$

$$c_{2,j_2} = Rk'(1-\tau_k^{p_2}) + y_{2,j_2}(1-\tau_y^{p_2}) + T_{p_2} \quad ;\text{if } s = j_2 \ \&\ y_{2,j_2} \in (y^*_{2,p_2-1}, y^*_{2,p_2}]$$

with out loss of generality and for the sake of convenience, assuming that j_2 is the skill level, right after j_1. The first order conditions can then be written as:

$$\begin{aligned}
u'(c_1) &= \left(\frac{1}{\theta_1}\right) v'\left(\frac{y_1}{\theta_1}\right) \\
u'(c_{2,i}) &= \left(\frac{1}{1-\tau_y^i}\right)\left(\frac{1}{\theta_{2,i}}\right) v'\left(\frac{y_{2,i}}{\theta_{2,i}}\right) \quad \text{for } i = 1, \ldots, N \ \&\ i \neq \{j_1, j_2\} \\
u'(c_{2,j_1}) &= \left(\frac{1}{1-\tau_y^{p_1}}\right)\left(\frac{1}{\theta_{2,j_1}}\right) v'\left(\frac{y_{2,j_1}}{\theta_{2,j_1}}\right) \\
u'(c_{2,j_2}) &= \left(\frac{1}{1-\tau_y^{p_2}}\right)\left(\frac{1}{\theta_{2,j_2}}\right) v'\left(\frac{y_{2,j_2}}{\theta_{2,j_2}}\right) \\
u'(c_1) &= R\beta\Bigg[\sum_{i=1}^{j_1-1} \pi_i(1-\tau_k^i)u'(c_{2,i}) + \pi_{j_1}(1-\tau_k^{p_1})u'(c_{2,j_1}) \\
&\qquad + \pi_{j_2}(1-\tau_k^{p_2})u'(c_{2,j_2}) + \sum_{i=j_2+1}^{N} \pi_i(1-\tau_k^i)u'(c_{2,i})\Bigg]
\end{aligned}$$

Given the arguments above, the approach is simple. For $i \neq \{j_1, j_2\}$ the agent must choose from the c.e.a. for both the intra-temporal and the budget constraint to be satisfied. For $i = \{j_1, j_2\}$, there exists no value that will satisfy the budget

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constraint, the intra-temporal equation and the Euler equation for allowed values of y_{j_1} and y_{j_2}. Further, any other general form of this category would make use of these same arguments.

A.3 Mapping into Consumption Taxes

Here I derive another version of the property that the total wealth tax collected sums to zero. In this case I I map the wealth tax into consumption taxes (the two taxes are equivalent in the Euler equation). For $u(c) = \ln(c)$ there exist a unique mapping of $\tau_k^i \to \hat{\tau}_k^i$ such that total wealth taxes add up to zero. To see this, note that from equation 1.12 we have,

$$\begin{aligned} \frac{1}{u'(c_1^*)} &= \frac{1}{R\beta(1-\tau_k^i)u'(c_{2,i}^*)} \qquad \forall i = 1,\ldots,N \\ \Rightarrow \frac{1}{u'(c_1^*)} &= \frac{1}{R\beta}\sum_{i=1}^{N}\frac{\pi_i}{(1-\tau_k^i)u'(c_{2,i}^*)} \end{aligned} \tag{A.18}$$

Now, let $\hat{\tau}_k^i$ be such that $1+\hat{\tau}_k^i = \frac{1}{1-\tau_k^i}$. Equation A.18 now becomes

$$\begin{aligned} \frac{1}{u'(c_1^*)} &= \frac{1}{R\beta}\sum_{i=1}^{N}\frac{\pi_i(1+\hat{\tau}_k^i)}{u'(c_{2,i}^*)} \\ &= \frac{1}{R\beta}\sum_{i=1}^{N}\frac{\pi_i}{u'(c_{2,i}^*)} + \frac{1}{R\beta}\sum_{i=1}^{N}\frac{\pi_i\hat{\tau}_k^i}{u'(c_{2,i}^*)} \end{aligned}$$

From equation 1.9 we know that the inverse euler equation must hold at the c.e.a. and using $u(c) = \ln(c)$ we get

$$\sum_{i=1}^{N}\frac{\pi_i\hat{\tau}_k^i}{u'(c_{2,i}^*)} = 0 \Rightarrow \sum_{i=1}^{N}\pi_i\hat{\tau}_k^i c_{2,i}^* = 0$$

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A.4 Decomposing the Marginal Labor Tax Rates

As the title suggests, in this section I decompose the different components of the labor income tax rate in order to understand what causes the hump shape. Figure B.1(a) shows the actual labor supplied by agents in period 2 as a function of realized kill levels. This term is obtained by $\ell_2 = \frac{y_2}{\theta_2}$. As one can see, even though y_2 is increasing in θ_2 (from Proposition 1), ℓ_2 is not monotone in θ_2.

Figure B.1(b) plots $\frac{\partial}{\partial y_2}\left(\frac{y_2}{\theta_2}\right)^{\gamma} = \gamma\left(\frac{1}{\theta_2}\right)\left(\frac{y_2}{\theta_2}\right)^{(\gamma-1)}$ as a function of θ_2. This can essentially be seen as the numerator in $1-\tau_y$. Clearly it is decreasing in θ_2 even though y_2 and therefore $v'(y_2)$ are increasing in theta. Figure B.1(c) plots $\frac{1}{u'(c_2)}$, and as determined earlier it is increasing in θ_2. Finally B.1(d) plots $1-\tau_y = \frac{\gamma}{u'(c_2)}\left(\frac{1}{\theta_2}\right)\left(\frac{y_2}{\theta_2}\right)^{(\gamma-1)}$. These figures help explain the hump shape. Initially at low skill levels $\gamma\left(\frac{1}{\theta_2}\right)\left(\frac{y_2}{\theta_2}\right)^{(\gamma-1)}$ is decreasing much faster than $\frac{1}{u'(c_2)}$ is increasing and therefore the product of the two terms is decreasing. At some point the rate at which $\gamma\left(\frac{1}{\theta_2}\right)\left(\frac{y_2}{\theta_2}\right)^{(\gamma-1)}$ is decreasing slows down considerably such that $\frac{1}{u'(c_2)}$ has a stronger impact and therefore $1-\tau_y$ is increasing again.

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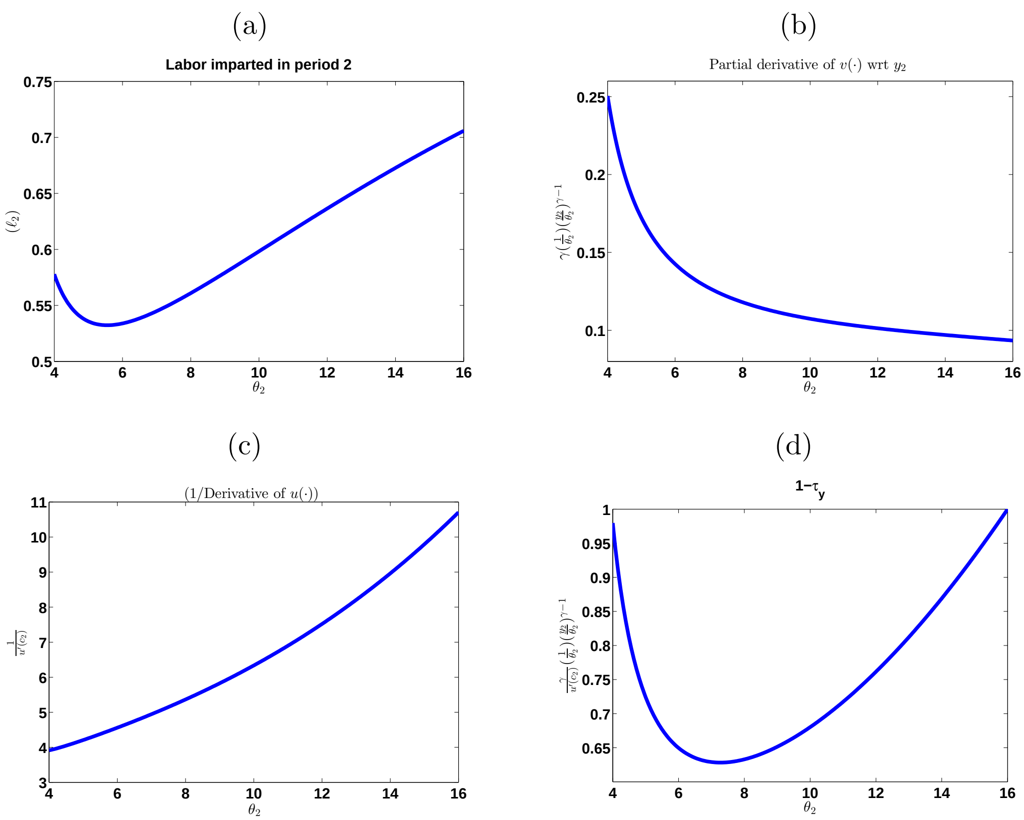
Figure A.1: Various components of the marginal labor income tax rate



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APPENDIX B
APPENDIX TO CHAPTER 2

B.1 Robustness Checks

B.1.1 Including Independent Students

The first robustness check we conduct is to determine what happens when we include independent students as part of the sample. Given that independent students were also eligible for SLS loans, which were unsubsidized, a concern might be that we do not observe the kink in the data when considering the impact of total federal student loans. When one refers to Figure 2.1, we note that even among independent students, about 75% had only subsidized loans. Figure B.1(a) displays the empirical distribution of cumulative Stafford loans borrowed as a function of *need* in the final year of school when we include independent students in the sample.[1] We notice that qualitatively it is very similar to Figure 2.3: there exists a kink at $need = 0$ even when we include independent students to the sample. Quantitatively, the figures differ in terms of average amounts borrowed on either side of the threshold. To the left of the threshold, the average amount borrowed is higher in Figure B.1(a) than in Figure 2.3, but to the right of the threshold, it is does not go as high in Figure B.1(a) as it does in Figure 2.3.

Table B.1 checks for discontinuities and kinks in the observable characteristics at the kinks using a quadratic in *need*. As can be seen, we can safely reject the null

[1]Of the 7,800 observations, about 5,900 observations fit into the *need* $\in$ $(-\$10,000, \$10,000)$ range.

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for all observable characteristics. Figure B.1(b) plots log of 1994 annual income as a function of *need* for this sample. We notice that for Figure B.1(b), the change in the slope around the threshold seems less than what we observed for the case with just dependent students in Figure 2.6. Table B.2 shows the first stage results and Table B.3 shows the second stage results and the IV RK estimate. In general the results still hold, though the magnitude is lower.

B.1.2 Standard Checks

Next we conduct a standard series of robustness checks. First we make sure that the results are robust to the linear specification, then we check for robustness when excluding exogenous parameters from the regression analysis. In theory the exogenous parameters should only affect the efficiency of the RK estimator. Finally we check to make sure the results are robust to various bandwidth values. Overall, the results seem to hold across the various robustness checks.

B.2 Proof for Proposition 3

Proof. From equation (2.8), we know that the right-hand side of the equation is decreasing in θ. For a higher θ, we need the term on the right-hand side to decrease, which means the term on the left-hand side should be decreasing in d. Therefore, we need to determine the conditions under which the term on the left hand side is decreasing in d. Define

$$F(d) = u'(w+b-d)\big[u(w+b-d) - u(b-d)\big]^{-1},$$

then:

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$$
\begin{aligned}
F'(d) = u''(w+b-d)\big[u(w+b-d)-u(b-d)\big]^{-1} \\
- u'(w+b-d)\big[u(w+b-d)-u(b-d)\big]^{-2}\big[-u'(w+b-d)+u'(b-d)\big] \\
= -\big[u(w+b-d)-u(b-d)\big]^{-1} \\
\times \left[u''(w+b-d) - \frac{u'(w+b-d)\big[u'(w+b-d)-u'(b-d)\big]}{u(w+b-d)-u(b-d)}\right] \\
= -\big[u(w+b-d)-u(b-d)\big]^{-1}u'(w+b-d) \\
\times \left[\frac{u''(w+b-d)}{u'(w+b-d)} - \frac{u'(w+b-d)-u'(b-d)}{u(w+b-d)-u(b-d)}\right]
\end{aligned}
$$

Given the assumptions, both of the terms outside of the big square brackets are positive. This means that for $F'(d) < 0$, the term inside the big square bracket must be positive, since there is already a minus side at the front of the expression. That is,

$$\frac{u'(w+b-d)-u'(b-d)}{u(w+b-d)-u(b-d)} < \frac{u''(w+b-d)}{u'(w+b-d)}$$

Now consider the class of utility functions with Decreasing Absolute Risk Aversion (DARA):

$$u(c) = \frac{1-\gamma}{\gamma}\left(\frac{\alpha c}{1-\gamma}+\beta\right)^{\gamma} \quad \text{where } \alpha > 0,\ \beta > -\frac{\alpha c}{1-\gamma},\ \gamma \in (0,1);$$

First, note that

$$u'(c) = \alpha\left(\frac{\alpha c}{1-\gamma}+\beta\right)^{\gamma-1}, \quad u''(c) = -\alpha^2\left(\frac{\alpha c}{1-\gamma}+\beta\right)^{\gamma-2}.$$

Let $c_w = w+b-d$, $c_a = b-d$ and $\beta > -\frac{\alpha c_a}{1-\gamma}$;

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then

$$\frac{u'(w+b-d)-u'(b-d)}{u(w+b-d)-u(b-d)} < \frac{u''(w+b-d)}{u'(w+b-d)}$$

can be written as

$$\Rightarrow u'(c_w)\big[u'(c_w)-u'(c_a)\big] < u''(c_w)\big[u(c_w)-u(c_a)\big]$$

$$\Rightarrow \alpha\left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{\gamma-1}\left[\alpha\left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{\gamma-1}-\alpha\left(\frac{\alpha c_a}{1-\gamma}+\beta\right)^{\gamma-1}\right]$$
$$< -\alpha^2\left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{\gamma-2}\left[\frac{1-\gamma}{\gamma}\left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{\gamma}-\frac{1-\gamma}{\gamma}\left(\frac{\alpha c_a}{1-\gamma}+\beta\right)^{\gamma}\right]$$

dividing both sides by α^2 and expanding the term

$$\Rightarrow \left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{2\gamma-2}-\left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{\gamma-1}\left(\frac{\alpha c_a}{1-\gamma}+\beta\right)^{\gamma-1}$$
$$< -\frac{1-\gamma}{\gamma}\left[\left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{2\gamma-2}-\left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{\gamma-2}\left(\frac{\alpha c_a}{1-\gamma}+\beta\right)^{\gamma}\right],$$

dividing both sides by $\left(\frac{\alpha c_w}{1-\gamma}+\beta\right)^{2\gamma-2}$

$$1-\left(\frac{\frac{\alpha c_a}{1-\gamma}+\beta}{\frac{\alpha c_w}{1-\gamma}+\beta}\right)^{\gamma-1} < -\frac{1-\gamma}{\gamma}\left[1-\left(\frac{\frac{\alpha c_a}{1-\gamma}+\beta}{\frac{\alpha c_w}{1-\gamma}+\beta}\right)^{\gamma}\right],$$

let $\frac{\frac{\alpha c_a}{1-\gamma}+\beta}{\frac{\alpha c_w}{1-\gamma}+\beta}=x$. Given our assumptions, $x\in(0,1)$ and the inequality can be written as:

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$$\Rightarrow 1 - x^{\gamma-1} < -\frac{1-\gamma}{\gamma}[1 - x^{\gamma}]$$

$$\Rightarrow \gamma(1 - x^{\gamma-1}) < -(1-\gamma)(1 - x^{\gamma})$$

$$\Rightarrow \gamma - \gamma x^{\gamma-1} < -(1 - x^{\gamma}) + \gamma(1 - x^{\gamma})$$

$$\Rightarrow 1 - \gamma x^{\gamma-1} - (1-\gamma)x^{\gamma} < 0;$$

multiply both sides by $x^{1-\gamma}$

$$\Rightarrow x^{1-\gamma} - \gamma - (1-\gamma)x < 0$$

$$\Rightarrow x^{1-\gamma} - (\gamma = (1-\gamma)x) < 0$$

$$\Rightarrow G(\gamma) - H(\gamma) < 0.$$

Note that $H(0) = G(0)$ and $H(1) = G(1)$. That is, G and H cross at 0 and 1. Also, $G'(\gamma) = -x^{1-\gamma}\log(x)$, $H'(\gamma) = 1 - x$, $G''(\gamma) = x^{1-\gamma}\big(\log(x)\big)^2 > 0$, and $H''(\gamma) = 0$. This shows that $G(\gamma)$ is convex, while $H(\gamma)$ is linear. As a result, the inequality holds for $\gamma \in (0, 1)$

Also, note that CRRA is DARA where $\alpha = 1 - \gamma$, $\beta = 0$ and $\gamma \in (0, 1)$ and log utility is DARA with $\gamma \to 0$ and $\beta = 0$.

$\square$

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Table B.1: Relationship between *need* and predetermined characteristics: dependent and independent students.

X (co-variate)	α_1	α_2 (RK)
age	0.207	-0.035
	(0.55)	(0.023)
male	0.027	0.019
	(0.026)	(0.018)
white	-0.027	0.006
	(0.020)	(0.013)
log parental income	-0.21	0.031
	(0.14)	(0.033)
family size	0.150	0.021
	(0.114)	(0.051)
College Ed. Parent	-0.029	0.004
	(0.025)	(0.018)
SAT	-27.59	-4.39
	(21.43)	(7.82)
Observations	5,910	5,910

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. Due to very small values in column 3, all numbers are scaled by 1000. Standard errors in parenthesis. The polynomial degree was set to 2. Each value is from a separate set of regressions. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

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Table B.2: Impact of Stafford loan eligibility on loans borrowed: dependent and independent students.

β_2	0.0035***
	(0.0016)
Observations	5,910

Notes: β_2 is the coefficient on the Stafford loan eligible × distance from threshold. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, indicator for dependent, interaction term between dependent and parental income, quadratic in need. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

Table B.3: Impact of Stafford loans on 1994 earnings: dependent and independent students

A. OLS estimates	
γ_2	-0.00266**
	(0.00136)
B. 2SLS estimates	
Stafford Loan (RK)	-0.00076**
	(0.00037)
Observations	5,910

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, indicator for dependent, interaction term between dependent and parental income, quadratic in need. *RK* terms in Panel *A* are scaled by a factor of 1000. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

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Table B.4: Relationship between *need* and predetermined characteristics: linear.

X (co-variate)	α_1	α_2 (RK)
age	0.077	-0.014
	(0.056)	(0.011)
male	0.016	0.004
	(0.032)	(0.006)
white	-0.052	0.005
	(0.045)	(0.004)
log parental income	-0.243	0.04*
	(0.201)	(0.025)
family size	0.091	0.005
	(0.082)	(0.017)
College Ed. Parent	-0.121*	0.020
	(0.068)	(0.031)
SAT	-34.75	-1.91
	(30.14)	(2.66)
Observations	3,880	3,880

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. Due to very small values in column 3, all numbers are scaled by 1000. The polynomial degree was set to 1. Each value is from a separate set of regressions. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

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Table B.5: Impact of Stafford loan eligibility on loans borrowed: linear.

β_2	0.0052***
	(0.0025)
Observations	3,880

Notes: β_2 is the coefficient on the Stafford loan eligible × distance from threshold. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, indicator for dependent, interaction term between dependent and parental income, quadratic in need. Students with *need* greater than $10,000 and less than -$10,000 are excluded.

Table B.6: Impact of Stafford loans on 1994 earnings: linear.

A. OLS estimates	
γ_2	-0.00385**
	(0.00192)
B. 2SLS estimates	
Stafford Loan (RK)	-0.00074**
	(0.00036)
Observations	3,880

Notes: γ_2 is the coefficient on the Stafford loan eligible × distance from threshold. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, indicator for dependent, interaction term between dependent and parental income, quadratic in need. *RK* terms in Panel *A* are scaled by a factor of 1000. Students with *need* greater than $10,000 and less than -$10,000 are excluded.

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Table B.7: Impact of Stafford loan eligibility on loans borrowed: excluding exogenous regressors.

β_2	0.0051***
	(0.0018)
Observations	3,880

Notes: β_2 is the coefficient on the Stafford loan eligible $\times$ distance from threshold. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, indicator for dependent, interaction term between dependent and parental income, quadratic in need. Students with *need* greater than $10,000 and less than -$10,000 are excluded.

Table B.8: Impact of Stafford loans on 1994 earnings: excluding exogenous regressors.

A. OLS estimates	
γ_2	-0.0055**
	(0.00268)
B. 2SLS estimates	
Stafford Loan (RK)	-0.00107**
	(0.00052)
Observations	3,880

Notes: γ_2 is the coefficient on the Stafford loan eligible $\times$ distance from threshold. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, indicator for dependent, interaction term between dependent and parental income, quadratic in need. *RK* terms in Panel *A* are scaled by a factor of 1000. Students with *need* greater than $10,000 and less than -$10,000 are excluded.

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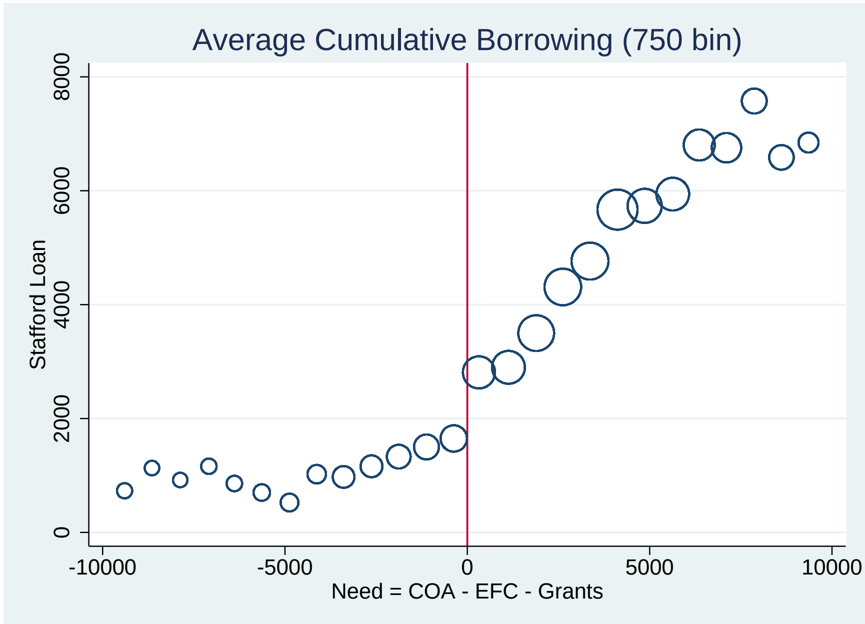
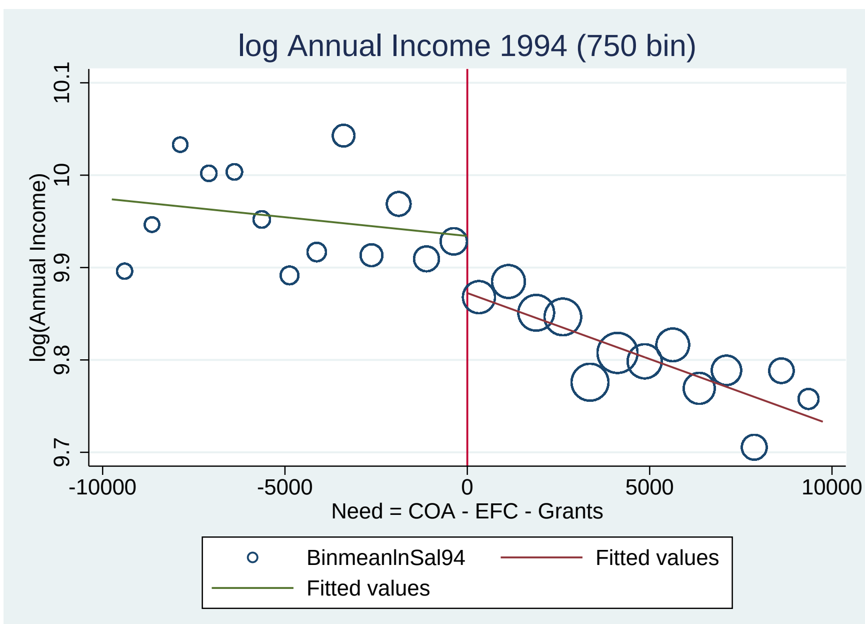
Figure B.1: Sample consisting of dependent and independent students.

(a)



(b)



Notes: (a)Empirical distribution of Stafford loans as a function of *need*; (b)The reduced form impact of *need* on log 1994 annual earnings. The center of each circle represents the average amount borrowed in the bin. The size represents the number of people in the bin.

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Table B.9: Robustness check: varying bandwidth.

Bandwidth	(1) \$8,000	(2) \$5,000
A. 2SLS estimates (polynomial order 1)		
Stafford Loan (RK)	-0.0009**	-0.0011**
	(0.00044)	(0.00053)
B. 2SLS estimates (polynomial order 2)		
Stafford Loan (RK)	-0.0012**	-0.0015**
	(0.00061)	(0.00076)
Observations	3,110	2,360

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. All regressions also include controls for age, gender, race, SAT score, major, parental education level, parental income, quadratic in *need*. Students with *need* greater than \$10,000 and less than -\$10,000 are excluded.

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REFERENCES

Abbott, B., G. Gallipoli, C. Meghir, and G. L. Violante (2013). Education policy and intergenerational transfers in equilibrium. Working Paper 18782, National Bureau of Economic Research.

Akers, B. and M. M. Chingos (2014). Is a student loan crisis on the horizon? Report, Brown Center on Education Policy at Brookings.

Albanesi, S. and C. Sleet (2006). Dynamic optimal taxation with private information. *Review of Economic Studies 73*, 1–30.

Arvidson, D., D. Feshbach, R. Parikh, and J. Weinstein (2013). The measureone private student loan report. Report, http://www.measureone.com/reports.

Athreya, K., J. Sanchez, X. Tam, and E. Young (2014). Bankruptcy and delinquency in a model of unsecured debt. Working paper.

Athreya, K. B. and N. B. Simpson (2006, May). Unsecured debt with public insurance: From bad to worse. *Journal of Monetary Economics 53*(4), 797–825.

Auerbach, A., L. Kotlikoff, and J. Skinner (1983). The efficienct gains from dynamic tax reform. *International Economic Review 24*, 81–100.

Battaglini, M. and S. Coate (2008). Pareto efficient income taxation with stochastic abilities. *Journal of Public Economics 92*, 844–868.

Battaglini, M. and R. Lamba (2015). Optimal dynamic contracting: The first-order approach and beyond. *Wprking Paper*.

Baum, S. (2015). Does increasing reliance on student debt explain declines in entrepreneurial activity? posing the question, gathering evidence, considering policy options. Research report, Urban Institute.

Berkner, L. (2000). Trends in undergraduate borrowing: Federal student loans in 1989-90, 1992-93, and 1995-96. Technical report, U.S. Department of Education. National Center for Education Statistics, Washington, D.C. Project Officer: Larry Bobbitt.

Bleemer, Z., M. Brown, D. Lee, and W. van der Klaauw (2015). Debts, jobs, or housing: What's keeping millennials at home? Staff Reports 700, Federal Reserve Bank of New York.

Card, D., D. Lee, Z. Pei, and A. Weber (2012, November). Nonlinear policy rules and the identification and estimation of causal effects in a generalized regression kink design. Working Paper 18564, National Bureau of Economic Research.

المنارة للاستشارات

www.manaraa.com

Castaneda, A., J. Diaz-Gimenez, and J. Rios Rull (WP). Earnings and wealth inequality and income taxation: Quantifying the tradeoffs of switching to a proportional income tax in the us. *Unpublished*.

Chari, V. and P. Kehoe (1999). *Optimal Fiscal and Monetary Policy.* ed. Taylor, J. and Woodford, M., Elsevier.

Chatterjee, S. and F. Ionescu (2012). Insuring student loans against the risk of college failure. *Quantitative Economics 3*(3), 393 – 420.

Chen, D. (2012). The impact of personal bankruptcy on labor supply decisions. Working paper.

Cohen-Cole, E., K. Herkenhoff, and G. Phillips (2015). How credit constraints impact job finding rates, sorting and aggregate output. Working paper.

Conesa, C., S. Kitao, and D. Krueger (2009). Taxing captial? not a bad idea after all! *American Econimc Review 91*, 25–48.

Conesa, C. and D. Kreueger (2006). On the optimal progressivity of the income tax code. *Journal of Monetary Economics 53*, 1425–1450.

Crossley, T. and H. Low (2005). Borrowing constraints, the cost of precautionary saving and unemployment insurance. Working paper.

da Costa, C. and I. Werning (2008). On the optimality of the friedman rule with heterogeneous agents and nonlinear income taxation. *Journal of Political Economy 116*, 82–112.

Deming, D. J., C. Goldin, and L. F. Katz (2012, February). The for-profit postsecondary school sector: Nimble critters or agile predators? *Journal of Economic Perspectives 26*(1), 139–64.

den Haan, W. J., G. Ramey, and J. Watson (2000). Job destruction and propagation of shocks. *American Economic Review 90*(3), 482–498.

Diamond, P. and J. Mirrlees (1978). A model of social insurance with variable retirement. *Journal of Public Economics 10(3)*, 295–336.

Dobbie, W. and J. Song (2014). Debt relief and debtors outcomes: measuring the effects of consumer bankruptcy protection. Working paper, National Bureau of Economic Research.

Dong, Y. (2014). Jump or kink? identification of binary treatment regression discontinuity design without the discontinuity. Working paper.

Farhi, E. and I. Werning (2007). Inequality and social discounting. *Journal of Political Economy 115*, 365–402.

المنارة للاستشارات
www.manaraa.com

Field, E. (2009). Educational debt burden and career choice: Evidence from a financial aid experiment at nyu law school. *American Economic Journal: Applied Economics 1*(1), 1–21.

Findeisen, S. and D. Sachs (2013). Education and optimal dynamic taxation: The role of income-contingent student loans. Working paper.

Findeisen, S. and D. Sachs (2014). Designing efficient college and tax policies. Working paper.

Gale, D. (1996). Equilibria and pareto optima of markets with adverse selection. *Economic Theory 7*(2), 207–235.

Gary-Bobo, R. J. and A. Trannoy (2014). Optimal student loans and graduate tax under moral hazard and adverse selection. CESifo Working Paper Series 4279, CESifo Group Munich.

Gelman, A. and G. Imbens (2014, August). Why High-order Polynomials Should not be Used in Regression Discontinuity Designs. NBER Working Papers 20405, National Bureau of Economic Research, Inc.

Genda, Y., A. Kondo, and S. Ohta (2010). Long-Term Effects of a Recession at Labor Market Entry in Japan and the United States. *Journal of Human Resources 45*(1).

Gervais, M. (2012). On the optimality of age dependent taxes and the progressive u.s. tax system. *Journal of Economic Dynamics and Control 36*, 682–691.

Gicheva, D. (2013). In debt and alone? examining the causal link between student loans and marriage. Working paper.

Glater, J. (2011). The other big test: Why congress should allow college students to borrow more through federal aid programs. *New York University Journal of Legislation and Public Policy 14*.

Glover, A. and D. Corbae (2016). A Simple Dynamic Theory of Credit Scores Under Adverse Selection. Technical report.

Golosov, M., N. Kocherlakota, and A. Tsyvinski (2003). Optimal indirect and captial taxation. *Review of Economic Studies 70*, 569–587.

Golosov, M. and A. Tsyvinski (2006). Designing optimal disability insurance: A case for asset testing. *Journal of Political Economy 114*, 257–279.

Golosov, M., A. Tsyvinski, and I. Werning (2006). New dynamic public finance: A user's guide. *NBER Macroeconomics Annual 21*, 317–388.

Gouveia, M. and R. Strauss (1994). Effective federal individual income tax functions: An exploratory empericial analysis. *National Tax Journal 47*, 317–339.

www.manaraa.com

Gross, J., D. Cekic, and N. Hillman (2009). What matters in student loan default: A review of the research literature. *Journal of Student Financial Aid 39*(1), 19–29.

Hahn, J., P. Todd, and W. van der Klaauw (2001). Identification and estimation of treatment effects with a regression-discontinuity design. *Econometrica 69*(1), 201–09.

Hall, R. and A. Rabushka (1995). The flat tax. *2nd ed. Hoover Institution Press*.

Hanushek, E. A., C. K. Y. Leung, and K. Yilmaz (2014). Borrowing Constraints, College Aid, and Intergenerational Mobility. *Journal of Human Capital 8*(1), 1 – 41.

Haughwout, A., D. Lee, J. Scally, and W. van der Klaauw (2015). Student loan borrowing and repayment trends. Report, Federal Reserve Bank of New York.

Heathcote, J. and H. Tsujiyama (2014). Optimal income taxation: Mirrlees meets ramsey. *Working Paper*.

Herkenhoff, K. (2014). The Impact of Consumer Credit Access on Unemployment. Technical report.

Hershbein, B. and K. Hollenbeck (2014). The distribution of college graduate debt, 1990-2008; a decomposition approach - updated web tables and figures. W.E. Upjohn Institute Working Paper.

Hershbein, B. and K. Hollenbeck (2015). *The distribution of college graduate debt, 1990-2008; A decomposition approach.* Student Loans and the Dynamics of Debt. Chapter 4, W.E. Upjohn Institute for Employment Research.

Ionescu, F. (2008). Consolidation of Student Loan Repayments and Default Incentives. *The B.E. Journal of Macroeconomics 8*(1), 1–37.

Ionescu, F. (2009). The federal student loan program: Quantitative implications for college enrollment and default rates. *Review of Economic Dynamics 12*(1), 205–231.

Ionescu, F. (2011). Risky Human Capital and Alternative Bankruptcy Regimes for Student Loans. *Journal of Human Capital 5*(2), 153 – 206.

Kahn, L. B. (2010, April). The long-term labor market consequences of graduating from college in a bad economy. *Labour Economics 17*(2), 303–316.

Karahan, F. and S. Rhee (2013). Geographical reallocation and unemployment during the great recession: The role of the housing bust. Staff reports, Federal Reserve Bank of New York.

Kitao, S. (2010). Labor-dependent capital income taxation. *Journal of Monetary Economics 57(8)*, 959–974.

المنارة للاستشارات

www.manaraa.com

Kocherlakota, N. (2005). Zero expected wealth taxes: A mirrlees approach to dynamic optimal taxation. *Econometrica 73*, 1587–1621.

Kocherlakota, N. (2006). *Advances in Dynamic Optimal Taxation*, Volume I. Advances in Economics and Econometrics: Theory and Applications, Ninth World Congress, Eds. Richard Blundell, Whitney K. Newey and Torsten Persson, Cambridge University Press.

Krueger, D. and A. Ludwig (2013a). Optimal capital and progressive labor income taxation with endogenous schooling decisions and intergenerational transfers. Working paper.

Krueger, D. and A. Ludwig (2013b). Optimal progressive labor income taxation and education subsidies when education decisions and intergenerational transfers are endogenous. *American Economic Review 103*(3), 496–501.

Lee, D. (2013). Household debt and credit: Student debt. Technical report, Federal Reserve Bank of New York.

Ljungqvist, L. and T. J. Sargent (2012, June). *Recursive Macroeconomic Theory, Third Edition*, Volume 1 of *MIT Press Books*. The MIT Press.

Lochner, L. and A. Monge-Naranjo (2015). Student loans and repayment: Theory, evidence and policy. Working Paper 20849, National Bureau of Economic Research.

Lochner, L. J. and A. Monge-Naranjo (2014). Default and repayment among baccalaureate degree earners. Working Paper 19882, National Bureau of Economic Research.

Looney, A. and C. Yannelis (2015). A crisis in student loans? how changes in the characterstics of borrowers and in the institutions they attend constributed to rising loan defaults. Bpea conference draft, Brookings papers on Economic Activity.

Lucas, D. (2010). *Measuring and Managing Federal Financial Risk*. University of Chicago Press.

Marx, B. M. and L. J. Turner (2015, January). Borrowing trouble? student loans, the cost of borrowing, and implications for the effectiveness of need-based grant aid. Working Paper 20850, National Bureau of Economic Research.

Menzio, G. and S. Shi (2010a). Block recursive equilibria for stochastic models of search on the job. *Journal of Economic Theory 145*(4), 1453 – 1494. Search Theory and Applications.

Menzio, G. and S. Shi (2010b, July). Block recursive equilibria for stochastic models of search on the job. *Journal of Economic Theory 145*(4), 1453–1494.

المنارة للاستشارات

www.manaraa.com

Menzio, G., I. Telyukova, and L. Visschers (2012). Directed search over the life cycle. Working paper, National Bureau of Economic Research.

Mezza, A., K. Sommer, and S. Sherlund (2014). Student loans and homeownership trends. Feds notes, Board of Governors of the Federal Reserve System.

Mirrlees, J. (1971). An exploration in the theory of optimum income taxation. *Review of Economic Studies 38*, 175–208.

Mirrlees, J. (1976). Optimal tax theory: A synthesis. *Journal of Public Economics 6*, 327–358.

Moen, E. R. (1997). Competitive search equilibrium. *Journal of Political Economy 105*(2), pp. 385–411.

Oreopoulos, P., T. von Wachter, and A. Heisz (2012). The short- and long-term career effects of graduating in a recession. *American Economic Journal: Applied Economics 4*(1), 1–29.

Parsons, S. G. (1998). Cross-subsidization in telecommunications. *Journal of Regulatory Economics 13*(2), 157–182.

Piketty, T. and E. Saez (2012). Optimal labor income taxation. *NBER Working Paper: Working Paper 18521*.

Puelz, R. and A. Snow (1994). Evidence on adverse selection: Equilibrium signaling and cross-subsidization in the insurance market. *Journal of Political Economy 102*(2), 236–57.

Rendon, S. (2006). Job search and asset accumulation under borrowing constraints. *International Economic Review 47*(1), 233–263.

Rogerson, R., R. Shimer, and R. Wright (2005). Search-theoretic models of the labor market: A survey. *Journal of Economic Literature 43*(4), 959–988.

Rothstein, J. and C. E. Rouse (2011). Constrained after college: Student loans and early-career occupational choices. *Journal of Public Economics 95*(1), 149–163.

Saez, E. (2001). Using elasticities to derive optimal income tax rates. *Review of Economic Studies 68*, 205–229.

Shaffer, S. (1984). Cross-subsidization in checking accounts: Note. *Journal of Money, Credit and Banking 16*(1), 100–109.

Shao, L. (2014). Debt, marriage, and children: The impact of student loans on marriage and fertility. Working paper.

Simikovic, M. (2013). Risk-based student loans. *Washington and Lee Law Review 70*(1), 527.

المنارة للاستشارات
www.manaraa.com

Stantcheva, S. (2014). Optimal taxation and human capital policies over the life cycle. Working paper.

Steele, P. and S. Baum (2009). How much are college students borrowing? NY: College Board Publications.

Thomas, J. and T. Worrall (1990). Income fluctuations and assymetric information: An example of a repeated principal-agent problem. *Journal of Economic Theory 51*, 367–390.

Turner, L. (2014). The road to pell is paved with good intentions: The economics incidence of fedearl student grant aid. Working paper.

Ventura, G. (1999). Flat tax reform: A quantitative exploration. *Journal of Economic Dynamics and Control 23*, 1425–1458.

von Watcher, T. (2006). In the right place at the wrong time: The role of firms and luck in young workers' careers. *The American Economic Review 95*(5), 1697–1705.

Woo, J. (2014). Degrees of debt – student borrowing and loan repayment of bachelor's degree recpients 1 year after graduating: 1994, 2001, and 2009. Report, National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, DC.

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