ESSAYS ON TAX CREDITS, JOB MOBILITY, AND PERSONAL BANKRUPTCY

by

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Abstract

This dissertation is composed of three chapters. In the first chapter, I build and estimate a dynamic labor supply model that takes into account human capital accumulation, borrowing constraints and unobserved heterogeneity in skills and preferences in order to understand the impact of the EITC on life-cycle wage paths of single women. In the model, the EITC has an impact on women's decisions through two main channels. First, it alters the rewards from work by shifting the per-period budget constraint. This in turn causes the women to make different hours of work and saving decisions. Second, through the change in the experience stock, the EITC also alters future rewards from work. This channel leads to a further change in the current hours of work and saving decisions of women. The results indicate that EITC is effective in promoting wage growth for single women over the life-cycle. Further analysis reveals that the change in the experience stock, rather than the immediate effect of the EITC on the per-period budget constraint, plays the prominent role in generating wage growth. Moreover, the change in net worth as a result of the tax credit indicates that EITC provides debt relief for women with negative net worth while it leads to an increase in the consumption expenditures for those with positive net worth. Using the estimated model, I conduct three distinct counterfactual experiments. First, I analyze the impact of imposing an asset test with a value that is similar to the asset limits in other federal cash transfer programs for low-income individuals. Second, I examine how single women without children respond to the adjustments in the credit schedule that are proposed by President Obama. Finally, I evaluate alternative designs for

the EITC, such as different cutoffs for the payment regions or different subsidy amounts, with respect to their effectiveness in promoting wage growth.

The second chapter constructs a job search model with wage renegotiations that takes into account the strategic behavior on the firm side. Workers search both when unemployed and employed while firms decide whether to target their vacancies to unemployed or employed workers and whether to match the offers coming to their employees. The novel feature of the model is to make use of the superior information the incumbent firm has over the poaching firm with respect to employees' skills. This channel captures a firm's discrimination between its workers as it matches only the outside offers that come to the high-skilled workers and lets the low-skilled workers go. In this setup, lemons problem does not exist because workers have idiosyncratic preference types. The existence of idiosyncratic preferences allows for the possibility of recruiting high-skilled workers even when the incumbent firm matches their outside offers. The result is that in equilibrium firms post their vacancies in both markets. In addition, more skilled workers have lower job-to-job mobility compared to workers with skills from the lower tail of the distribution.

In the last chapter, my coauthors and I build a structural model of Chapter 13 bankruptcy that captures the salient features of personal bankruptcy under Chapter 13. We estimate our model using a novel data set we construct from bankruptcy court dockets recorded in Delaware between 2001 and 2002. Our estimation results highlight the importance of debtor's choice of repayment plan length on Chapter 13 outcomes under the restrictions imposed by

the bankruptcy law. We use the estimated model to conduct policy experiments to evaluate the impact of more stringent provisions of Chapter 13 that impose additional restrictions on the length of repayment plans. We find that these provisions would not materially affect creditor recovery rates and would not necessarily make discharge more likely for debtors with income above the state median income.

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for being my best friend,
for holding my hand every step of the way,
and for being the sunshine of my life.

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Chapter 1

Does the Earned Income Tax Credit Help Single Women Climb the Wage Ladder?

1.1 Introduction

Earned Income Tax Credit (EITC), the dominant tax-based cash assistance program in the U.S., is commonly credited for causing taxpayers to choose work over welfare dependency. This pro-work effect is found to be more pronounced particularly for single women with children[1], as several studies find EITC expansions to be the prime reason why employment rose among single women with children during the 1990s (Eissa and Liebman, 1996; Meyer and Rosenbaum, 2001). However, without promoting wage growth in the long run, EITC can create dependency on another form of government transfer - tax-credits. A key question to ask, then, is: What is the impact of the EITC on wage growth?

The objective of this paper is to take a first step at evaluating whether

[1]The EITC did not offer any credit to childless women until 1994.

the EITC helps single women climb the wage ladder. To provide an answer to whether the EITC promotes wage growth, I first develop and estimate a dynamic labor supply model. I then use the estimated model to simulate life-cycle labor supply, employment, wage and net asset paths of women with and without the tax credit. This allows me to assess the impact of the EITC on wage growth by comparing the magnitude of the dynamic, long-term effects of the EITC to its immediate impact through easing the budget constraint on the life-cycle profiles of single women. Next, I conduct three distinct counterfactual experiments. First, I consider the consequences of an expansion in the credit schedule for childless workers as proposed by President Obama. Second, I assess the significance of imposing an assets test with a value similar to the asset limits in other federal cash transfer programs for low-income individuals. Finally, I evaluate whether it is possible strengthen the impact of the EITC on wage growth by altering the parameters of the credit schedule such as the cutoffs for payment regions or the amount of the subsidy.

The analysis in this paper is based on the estimation of a life-cycle labor supply model in which forward-looking single women make joint work and saving (or borrowing) decisions. Specifically, starting from the year they complete education and enter the labor market, single women decide on annual hours of work and the level of net savings under borrowing constraints. Based on these decisions, the amount of the EITC a woman receives is determined as the level of the tax credit depends on her labor market earnings in the previous year. In the model, I also allow for participation in other government transfer programs such as the Temporary Assistance to Needy Families (TANF) and Supplemental

Nutrition Assistance Program (SNAP). I do not model participation in these programs as endogenous decisions, rather I specify the probability of receiving any benefit as exogenous stochastic processes that depend on women's observable characteristics. The model also takes into account any changes in the family composition over the life cycle, in the form of arrival and departure of a child. In addition, by incorporating observed and unobserved heterogeneity in skills and preferences, I try to match the rich dynamics that are observed in the data.

The theoretical and empirical framework in this paper focuses on three dynamic mechanisms that have significant impact on the wage growth of single women. The first one is human capital accumulation[2] which is exploited by several studies in the literature, e.g., Eckstein and Wolpin (1989a); Van der Klaauw (1996); Altuğ and Miller (1998); Francesconi (2002); Keane and Wolpin (2010); Keane, Todd, and Wolpin (2011). Human capital accumulation creates a link between the work choice and future wages. In particular, a woman's work choice adds to the stock of work experience, which in turn affects future wages and thus, future work choices. This feature of the model creates an 'investment return' to the current choice of work hours. Second, the model imposes borrowing constraints by setting a lower bound on the level of assets that depends on women's characteristics such as age and educational attainment, similar to Keane and Wolpin (2001). By limiting the extent to which women can transfer resources across periods, this borrowing constraint alters the work choices

[2]In this paper, when I use the term human capital accumulation I refer to experience accumulation. Moreover, the fact that higher experience leads to wage growth does not necessarily imply skill formation. Experience in the labor market is valuable because it may convey information on a worker's unobserved characteristics such as punctuality, reliability or motivation.

of women, and thus modifies the wage growth path as well as human capital accumulation over the life cycle. Nevertheless, the existence of borrowing constraints does not eliminate the consumption smoothing motives created by a positively sloped age-earnings profile over the life cycle. Finally, the credit schedule of the EITC creates one other dynamic channel. The amount of tax credit, determined by annual earnings, is received in the following year as a tax refund. Therefore, the current work choice of a woman can alter her monetary resources for the following period through the level of tax credit she receives. By easing the budget constraint, the tax credit creates an additional channel through which current work hours affect future labor supply decisions.

My analysis focuses on single women for three main reasons. First and foremost, single women form the prime population for tax-based cash assistance along with welfare programs as they are generally characterized with low levels of education, low income and high poverty (see Blundell, Dias, Meghir, and Shaw (2013)). Furthermore, as Gladden and Taber (2000) point out, learning-by-doing or human capital accumulation is crucial for workers with low income and low levels of education since wage growth differences between the low and moderately skilled workers stem mainly from differences in the level of work experience. Since any change in the work experience would be translated into a different path of wage growth, low-income women form the prime group to evaluate whether a tax-credit helps climbing the wage-ladder. Finally, I restrict my analysis to single women as they lack the safety net created by spousal earnings. This implies that external factors such as household bargaining or spousal preferences over women's leisure do not affect the labor supply decisions

made by single women.

For the empirical analysis, I use data from the Panel Study of Income Dynamics (PSID). This data set is well suited for the analysis for two main reasons. First, it collects detailed information on annual hours of work, annual earnings, the level of education, number of children, cost of childcare, participation in welfare programs as well as on the assets and debt of single women. Moreover, the PSID provides data over a significantly long time frame, contrary to other similar data sets such as the Survey of Income and Program Participation (SIPP). One drawback of PSID, however, is that it doesn't present any information on the level of the EITC individuals receive. I resolve this issue by calculating the amount of credit each woman receives using the actual policy parameters set by the federal and the state governments, depending on annual earnings and size of the family.[3]

I estimate the parameters of the model using a two-step method. In the first step, I estimate the parameters of the exogenous processes in the model, such as child care costs, participation in other government programs and the change in family composition. In the second step, I estimate the remaining parameters using method of simulated moments (MSM). Specifically, I simulate a data set using the parameters from the model, and I match the moments from the simulated data to the moments from the observed data. The choice of the estimation method is dictated mainly by the data structure provided by the PSID. Although PSID gives detailed information on the variables that are key

[3]With this calculation I am assuming every EITC eligible individual claims tax credit. Given that the EITC participation rates vary between 80-86% (Scholz (1994)) implies that this assumption is reasonable.

to the model, it only does so at a few points in time. Furthermore, it doesn't give information on women's work experience stocks[4] as developed in the model. As a result, by using a simulation-based estimation approach, I am able to fill the gaps in the data on assets and work experience. The identification of the impact of the EITC comes from the variation in the policy parameters across time and states.

The results of the estimation display significant returns to experience for low-income single women. In particular, a one percent increase in the experience stock constructed based on annual work hours, leads to a 0.22% increase in the wage rate of a woman. The parameter estimates from the wage equation further highlight the importance the detrimental effect of career breaks on women's life-cycle earnings. In particular, a woman who worked full-time in the previous year earns an average wage almost 6.7% higher than a woman who took a career break in the previous period. Using the parameter estimates from the model, I then assess the impact of the EITC on labor supply, wage and net worth paths of single women over the life cycle. Using the 2002 schedule for the tax credit, I show that employment rate increases by 4 percentage points as a result of the EITC. Moreover, I find that the EITC generates significant intensive-margin responses[5], contrary to what previous literature has argued, once the dynamic effects of the EITC are taken into consideration. This result is in line with the findings of Imai and Keane (2004); Keane (2009, 2011); Keane

[4]I construct a woman's experience stock as the total hours of work she has worked since she entered the labor market. Because the PSID switched to biennial interviewing, I cannot observe the experience stock of some women from the data.

[5]Intensive-margin responses refer to the change in hours of work conditional on employment. Extensive-margin responses, on the other hand, refer to the change in the employment decisions.

and Rogerson (2012) which argue intensive-margin responses might be underestimated if human capital accumulation is not explicitly taken into account. Furthermore, I show that as a result of the labor supply responses to the tax credit, the average wage rate of a single women increase by 5% as a result of the EITC. Further analysis proves that this increase in the wages is actually generated by the additional human capital accumulation created by the tax credit. I then consider the heterogeneity in the responses to the EITC and find that high school dropouts along with women who have two or more children are the two groups that benefit the most from the tax credit. Additionally, I show that receiving the tax credit early in the life cycle generates a higher wage growth.

The counterfactual experiments in the paper analyze adjustments to the design of the credit schedule for the EITC. Specifically, I first consider an expansion of the tax credit received by childless women as recently proposed by President Obama[6]. The results show that the expansion is successful in generating an increase in the employment rate and average wages without disincentivizing work hours and savings. Next, I investigate the impact of introduction of an asset limit as part of the eligibility requirements for the tax credit. Such asset limits exist in major public benefit programs, e.g., Temporary Assistance to Needy Families (TANF), Supplemental Nutrition Assistance Program (SNAP), and Supplemental Security Income (SSI). The results show that this additional restriction for eligibility might inhibit single women's ability to move along the path to financial security and self-sufficiency. Specifically, the asset test causes significant declines in the employment rate and the average net worth compared to their values under the current EITC schedule. The decline in net assets is

[6]See www.whitehouse.gov/sites/default/files/docs/eitc_report.pdf

especially disturbing as the sample in consideration consists of single women who lack the safety net provided by spousal earnings. This result also implies that an asset test possibly makes these women more vulnerable to the labor market shocks they may face, by eliminating the protection created by their asset stocks. This finding on the detrimental impact of an asset test may provide insight to the recent discussions in the policy circles[7] that argue imposing asset limits as a requirement for eligibility might be hindering the effectiveness of government cash-transfer programs.

The rest of the paper is organized as follows. Section 2 presents the literature this paper contributes to and Section 3 explains the details on the credit schedule as well as the eligibility requirements of the EITC. Section 4 describes the sample used in the empirical analysis and displays some key facts from the data. In Section 5, I introduce the life-cycle labor supply model developed in this paper and discuss the solution method. Section 6 presents the empirical analysis by describing the estimation method, identification arguments and then, by interpreting the parameter estimates. In Section 7, I explore the impact of the EITC on the extensive and intensive margin responses along with wage growth and net asset accumulation. Section 8 looks at policy experiments in which the credit is expanded for childless women and the eligibility for the tax credit requires an asset test in addition to the requirements concerning labor market earnings. Section 9 concludes.

[7]For example, see http://goo.gl/Fgs3fc or http://goo.gl/KZtt9b.

1.2 Related Literature

There is a large literature on the static labor supply effects of the EITC. Blundell (2006); Eissa and Hoynes (2006, 2011); Hotz and Scholz (2003); Hoynes (2009); Liebman (1998) are a few examples of excellent surveys that provide vast evidence on how EITC payments increase the labor force participation in the population. Nevertheless, comparatively little research has connected life-cycle decisions and EITC payments[8]. One notable exception comes from Heckman, Lochner, and Cossa (2002), who study the potential effects of wage subsidies on skill formulation by comparing on-the-job training models with learning-by-doing models and argue that the learning-by-doing models, which are favored by provisional evidence, indicate that wage subsidies promote skill formation. Even though the paper does not take into account the potential endogenous labor market entry effects of the EITC, it quantifies the change in the average human capital stock of single women with low levels of education. The results show that EITC may reduced the long-term wages, even though the skill levels do not decline. Blank (2012), is an other example that constructs a dynamic-discrete choice model of employment and welfare participation, and estimates it using a sample of single women from PSID. Without taking into account the saving or borrowing decisions or heterogeneity in skills or preferences, she finds that the EITC only leads to an increase in part-time employment. However, the paper does not explicitly consider the effect of the tax credit on life-cycle wage

[8] Ben-Shalom, Moffitt, and Scholz (2011); Hotz and Scholz (2003) both consider the dynamic impact of EITC payments in the form of human capital accumulation and they argue that EITC should theoretically decrease the returns to human capital accumulation in the phase-out region by taxing both current and future income, whereas it should have an opposite effect in the subsidy region. Neither of these papers provides any empirical analysis.

paths of individuals. The most recent study on this topic is by Athreya, Reilly, and Simpson (2014). In a setting where wages are exogenous, they find that the EITC reduces consumption volatility along with an increase in the labor supply of unskilled single mothers, especially at the extensive margin. In sum, to the best of my knowledge, none of the papers in the literature considers the impact of the EITC on life-cycle wage paths of women through the changes in their optimal behavior concerning employment, hours of work and saving/borrowing.

One other related literature this paper contributes to studies the dynamic structural links created by welfare or earnings subsidy programs that are similar to the EITC. One example is the seminal paper by Miller and Sanders (1997) that estimates a dynamic model to conduct an empirical analysis on how AFDC affects the educational attainment and subsequent labor market performance of young women. Their results show that negative duration dependence in welfare overwhelms the human capital effect. A more recent example is a paper by Blundell, Dias, Meghir, and Shaw (2013), which sets up a dynamic model of education, labor supply and saving decisions of women in order to understand the ramifications of the reform on Working Families Tax Credit, the dominant earnings subsidy program in UK. In particular, they consider the insurance value created by the tax credit and analyze whether women with different levels of educational attainment prefer increases in income support or tax cuts that are equally costly.

Finally, this paper contributes to the literature on structural estimation of dynamic models of female labor supply. A number of studies emphasized the link

between women's labor force participation and human capital accumulation, often examining how marriage, fertility and participation interact (Keane, Todd, and Wolpin, 2011). Examples include Eckstein and Wolpin (1989a); Van der Klaauw (1996); Altuğ and Miller (1998); Francesconi (2002); Keane and Wolpin (2010). However, almost all papers in the literature ignore the saving or borrowing decisions of women. Blundell, Dias, Meghir, and Shaw (2013) is one exception, though they only allow for borrowing for the schooling investment. To the best of my knowledge, this paper is the first to develop and estimate a dynamic female labor supply model that incorporates the saving and borrowing decisions of women along with the effect of credit constraints.

1.3 Institutional Background

EITC, which was enacted in 1975 primarily as a temporary credit to offset Social Security taxes, is a refundable tax credit for low-income individuals. Congress made the credit permanent in 1978 and repeatedly increased its value until 1987. After that, EITC has undergone three major expansions; with the Tax Reform Act (TRA) of 1986, the Omnibus Reconciliation Act (OBRA) of 1990 and with OBRA of 1993. OBRA 1993 was the largest among these expansions as it almost doubled the payments to eligible individuals along with sharply increasing the benefits to families with two or more children (Eissa and Hoynes, 2006).

1.3.1 Eligibility

In order to claim EITC, an individual must file an annual income tax return. Among the individuals who file their tax returns, those who have a Social Security number and who are U.S. citizens or resident aliens all year or are married to U.S. citizens or resident aliens are considered for the tax credit. Furthermore, before 1994 a taxpayer had to have a "qualifying child" subject to certain age, relationship and residency tests in order to be eligible. Since 1994, childless adults may also claim EITC, as long as they are older than 25. Finally, EITC has special rules for members of the military, ministers, members of the clergy and those receiving disability benefits[9].

EITC is a means-tested cash transfer program and thus, the most important eligibility rule for the program is concerned with labor market earnings of individuals. In particular, individuals or families must have positive earnings in order to be eligible. The labor market earnings is formally defined as "the sum of wage, salary and self-employment income" by the IRS[10]. The restriction of positive earned income implies that at least one individual in a family must be working in order to claim EITC. One other condition for receiving the tax credit is to have earned income and adjusted gross income (AGI)[11] less than the EITC limit which varies by the number of children and marital status for certain years. Although EITC did not include an asset test originally, starting with 1996 limitations on investment income came into effect. In terms of tax

[9] http://goo.gl/Q4JJCe

[10] http://www.irs.gov/Individuals/What-is-Earned-Income%3F

[11] AGI is an individual's total gross income minus allowances for personal exemptions and itemized deductions.

credit purposes, the definition of investment or asset income includes earned interest, dividends, capital gains, royalties and rent from personal property, and returns from passive activities such as business pursuits in which the person is not actively involved[12]. Specifically, the investment income limit was $2,350 for the first year it came into effect while it increased slightly to $2,800 in 2006.

1.3.2 The Credit Schedule

There are three important factors that define the credit schedule for the EITC. First and foremost, the credit schedule depends on earned income. Specifically, the schedule consists of three regions: subsidy (phase-in), flat (plateau) and phase-out. At the lowest level of earnings, or in the subsidy region, EITC benefit equals to a fixed percentage of earnings and an individual with a level of earnings that is equal to the subsidy region threshold receives the maximum credit. Taxpayers with earnings above the subsidy region threshold continue receiving the maximum credit for a small interval of earnings. However, once the level of earnings reaches the flat region threshold, EITC benefits are taxed away at the phase-out rate. Therefore, the subsidy rate, phase-out rate, and two earnings thresholds, which determine the end of the subsidy and the flat regions, define the credit schedule. Table 1.1 presents the credit schedule for the tax year 2013. In the table, credit rate represents the subsidy rate and the minimum income for maximum credit represents the threshold that defines the end of the subsidy region.

Second, as can be seen from Table 1.1, there are separate credit schedules for different family sizes. In particular, the credit rate and the phase-out rate

[12]http://www.cbo.gov/budget-options/2013/44810

increase with the number of children. However, the increase in the phase-out rate is much lower than the increase in the credit rate. Moreover, the maximum credit varies significantly with the number of children. As an example, while the maximum credit is $487 for taxpayers with no child, it increases to $6,044 for taxpayers with three or more children. The eligibility range for earnings is also considerably larger for families with more children. Since more generous payments are offered to taxpayers with more children, EITC is generally considered as a pro-natal policy. On the other hand, the EITC has been criticized for imposing substantial marriage penalties as single and married individuals faced the same earnings thresholds until 2002. This means that, if a single parent receiving the EITC got married before 2002, the addition of the spouse's earnings may have reduced or eliminated the credit, even though the spouse was also eligible for the credit. To address this issue, the Economic Growth and Tax Relief Reconciliation Act of 2001 raised the level of beginning income for the phase-out region for couples to $3,000 above the level of beginning income for single individuals. Moreover, the American Recovery and Reinvestment Act of 2009 (ARRA) has increased that amount to $5,000 in 2009 and indexed the threshold to inflation.

Finally, the EITC is defined as a refundable transfer program, which means that if the credit exceeds a taxpayer's income tax liability, the excess amount is paid as a tax refund. This refundable portion on the EITC is usually referred to as the outlay component. Eissa and Hoynes (2006) show that the outlay component of the EITC amounts to a significant portion of the total payments. In particular, in 2004 $35 billion out of a total cost of $40 billion was due to the

outlay component. This fact is crucial for the analysis in this paper as I focus on the outlay component of the EITC in the empirical analysis and assume the tax credit payments determined by labor market earnings are received as a tax refund in the following year.

1.3.3 State-level EITC Programs

Starting in late 1980s, states began to enact their own EITC schedules as add-in programs to the federal EITC. The first state to approve an EITC program as a supplement to the federal EITC was Maryland in 1987. These state EITC rules are usually simpler than the federal schedule as they are mostly defined as a fixed percentage of the federal EITC. As an example, for the tax year 2001 the EITC rate in Maryland was 16%, which implied that Maryland residents were to receive an additional supplement that amounted to 16% of the federal EITC.

State EITC rates vary a lot across years and across states. In 1996, the only states that provided EITC supplements were Iowa, Maryland, Minnesota, New York, Rhode Island, Vermont and Wisconsin. However, as of 2013 the number of states with EITC programs increased to 22. Moreover, the generosity of these programs range from 3.5% in Louisiana to 40% in the District of Columbia for the tax year 2013. Another difference in the state-level EITC schedules across states comes from the refundability of the benefits. Although most of the states that provide EITC supplements offer refundable benefits, there are still some states such as Delaware, Maine and Virginia with a non-refundable benefit system. In these states, EITC supplements act only to decrease the

state tax liability of individuals and families.

1.4 Data

I utilize the Panel Study of Income Dynamics (PSID) to create the sample I use in the empirical analysis. The PSID is a longitudinal study that began in 1968 with a core nationally representative sample called the Survey Research Center (SRC) sample, and an oversample that mainly represents low-income and black families, called the Survey of Economic Opportunity (SEO) sample. The PSID added an additional Latino sample in 1990 but dropped the individuals in this sample after 1995, due to missing out on the full range of post-1968 immigrants. Still, in order to continue its nationally representative sample, the PSID included a sample of post-1968 immigrants after 1997.

Until 1997, the PSID collected annual data on demographic characteristics, labor market earnings, annual work hours, childcare expenditures, receipts from welfare and other government programs every year. However, after 1997 PSID switched to biennial interviewing due to insufficient funding which makes tracking individuals' labor market histories harder[13]. In the analysis, I use PSID waves from 1993 to 2007, which provide demographic information for the years between 1993 and 2007. However the labor market information obtained from these waves refer to the years 1992-2006. Furthermore, I include both the SRC and the SEO samples in order to create a sample of low-income individuals. I drop the observations that belong to the Latino and the immigrant samples due to two main factors. First, these samples do not represent the full range of

[13]PSID continues to collect data on Supplemental Nutrition Assistance Program benefits for each year, even after switching to biennial interviewing.

post-1968 immigrants. Secondly, the PSID stopped interviewing the majority of the individuals that belong to these samples after 1995 due to insufficient funding. Information on demographic characteristics, labor market status, earnings, annual work hours, childcare costs along with welfare and food stamp benefits come from the individual and family files of the PSID. Making use of the Supplemental Wealth Files the PSID provides, I construct net asset[14] profiles. The PSID collected wealth information every 5 years until 1999, and every 2 years after that. In construction my net asset measure, I use the wealth files from 1994, 1999, 2001, 2003, and 2005. The asset information provided by the PSID is very comprehensive as it includes the values of real estates, farms or businesses, vehicles, stocks, mutual funds, bonds, and liquid assets. The wealth files also specify the value of home equity and other debts.

I restrict the sample I use for the empirical analysis to single women who are classified as never married for the years I observe them in the data. Moreover, I include observations for a given woman only if she is between ages 16 and 70, is not self-employed, has valid data on education, race, state of residence, number of children, annual work hours and labor market earnings. I also exclude observations from women who change their state of residence as well as women who are students, who are in the military, who are retired or disabled. Finally, I drop the observations of women who are interviewed only once during the years 1992 to 2006. The remaining sample consists of 1,407 women with 7,090 observations over 15 years[15]. Out of these 1,407 women, 50%

[14]Throughout the paper, I use the term net assets to refer to the net worth of individuals. Net worth or net assets is defined as assets minus the liabilities an individual has.

[15]Out of these 7,090 observations I observe labor market information such as earnings or annual work hours for 4,593 and the value of assets for 2,573 observations

are observed for at most 8 years and 21% over the whole period. For this sample of women, I use information on age, years of education, state of residence, number of children, age of youngest child, annual earnings[16], annual work hours, child care expenditures, welfare benefits, food stamp benefits and net worth. Although the PSID does not provide information on the amount EITC benefits a woman is entitled to, I use federal and state EITC policy rules to calculate the annual tax credit a woman receives[17]. Furthermore, in order to remove the effect of outliers, I censor earnings, annual work hours, child care expenditures and net worth at the top and bottom 5 percentiles for each wave of the data I'm using. Finally, in constructing the net worth measure I use in the rest of the paper, I exclude the value of home equity. The reasons for excluding the value of home equity are twofold. First, in the data only 102 observations have a value of home equity different from 0. Second, these 102 observations form a considerably wide range of home equity values, from $-121,000 to $143,000. One explanation for this observation might be the housing bubble that emerged around 2001.

Table 1.2 provides summary statistics for the sample. As can be seen from the table, women are on average around 33 years old and mostly black. The fraction of black women in the sample is high due to including observations from the SEO sample that overrepresents blacks. In terms of the level of education, the sample consists mainly of high school graduates. On average, these women

[16] All monetary variables are adjusted to 2006 dollars.

[17] I am not using information on asset income from the PSID. This is mainly because the asset income information is not consistent with the asset levels reported in the Supplemental Wealth Files. In addition, since the asset information is provided only for 5 years out of the whole observation period, I cannot impose the asset income restrictions to the data while calculating the EITC amount each woman receives.

have one child and the age of youngest child is around 3 years old[18]. The fact that women on average have only one or no child might be the result of having a young sample of women. As for the labor market status, more than 85% of the women in this sample are employed and these women who are employed, on average, work a little less than full-time. Full-time jobs usually necessitate working 8 hours a week and 50 weeks a year, which add up to around 2,000 work hours per year. Since the women in this sample work around 1,800 hours on average, the average working hours is less than the hours a full time job necessitates. Furthermore, this sample can be described as consisting of low-income women as the annual earnings of the average woman is a little more than $25,000. Due to the low levels of labor market earnings, 38% of the total observations fall in the eligibility range of the EITC based on labor market earnings. More specifically, the average federal EITC received is about $1,900 while the maximum credit can be as high as $4,645. The average of the state EITC, however, is very low mostly even among the women who are eligible for the EITC mostly because only a few states offered state EITC programs until the early 2000s. The fraction of TANF and SNAP recipients in the sample is significantly lower than the fraction of EITC recipients. However, even though the fraction of TANF and SNAP recipients are low, the average benefits for the eligible women are considerably higher than the average benefits the EITC provides. The final key variable for the analysis is net worth, which is defined as the value of checking accounts, stocks, and vehicles less any debt. The most striking aspect of net worth in the sample is its wide range, from around -$33,032

[18]The number of children is capped at 2 as for tax credit purposes having more than 2 children is not different from having 2 children. Imposing this restriction decreases the average number of children from 1.01 to 0.88 in the sample.

to $72,133. Still, even though some women have high levels of net worth, the average in the sample is only $3,249. Moreover, 26% of the sample has negative net worth, while 20% has zero and 54% has positive net worth. The distribution of the net worth in the sample is displayed in Figure 1.2.

Since the sample in consideration consists of low-income women, the age-earnings profile is flatter than the education-earnings profile. The top panel in Table 1.3 presents how average earnings and annual work hours vary across age groups. As expected, average annual earnings increase with age even though the increase is not significant. Moreover, earnings rise with age, even though older women tend to work fewer hours annually. In particular, the women in the sample work the most between ages 25 and 30. Since the average earnings of older women are higher even though they are working less, it can be inferred that the wage rate increases as women get older. With respect to the tax credit, the table shows that more than 40% of the women who are younger than 40 receive EITC. The percentage of EITC recipients is slightly lower for women who are younger than 25, mainly because of the eligibility rule that states childless individuals can receive EITC only if they are 25 years old or older. Since the average level of earnings rise as women age, it is not surprising to see that the EITC recipiency rate declines with age. Furthermore, this trend in the percentage of EITC recipients across age groups is reflected in the average EITC payments. For this reason, the average amount of tax credit is the highest for the women who are aged between 25 and 30.

The bottom panel of Table 1.3 displays the trends for average earnings, work hours and EITC receipts across education groups. Most significantly,

average earnings increase with the level of educational attainment of women. Furthermore, more educated women work for considerably more hours than less educated women. These two observations lead to a steep decline in the EITC recipiency rates as women get more educated. Furthermore, not only the fraction but also the average tax credit the eligible women receive declines as the education level of the women gets higher.

In order to understand the group of women who receive the EITC a little better, Table 1.4 provides information on the age, education and annual work hours of EITC recipients. According to the table, half of the recipients are above age 30, while most of them are between ages 30 and 40. As for education, almost half of the women who receive the tax credit are high school graduates. Interestingly, high school dropouts are less likely to receive the tax credit than high school graduates in the sample. Further analysis of the data reveals that this is because high school dropouts are less likely to work than the high school graduates. Finally, the last column of the table shows how much EITC recipients work annually. Since EITC recipients have low labor market earnings, one might think that they also have short working hours. However contrary to this belief, the table provides evidence that in fact more than 65% of the women who receive the EITC work either full time or have more than one part time job. Note that, a part time job requires about 1,000 annual work hours while a full time job requires about 2,000 annual work hours. With these definitions, the last column of the table reveals that the majority of EITC recipients work more than 1,300 hours. In order to have more than 1,300 annual work hours, these women must either work full-time or have more than one part-time job. The

fact that these women have long working hours but low earnings leads to the conclusion that they suffer from low wages. Figure 1.3 provides evidence for this argument by comparing the average wage of EITC recipients with that of non-recipients across ages. This figure also shows the extent of an OLS bias. More specifically, if the wage level is regressed on EITC eligibility along with some controls, this OLS regression would reveal that being eligible for the EITC is correlated with receiving low wages. This might lead to the wrong conclusion that EITC actually leads to women receiving low wage rates. However, the fact that EITC eligibility requires having low earnings should also be taken into consideration.

To sum up, women in the sample I construct for the empirical analysis tend to have noticeably low labor market earnings and net worth. In addition, almost 40% of the observations are coupled with earnings that fall in the eligibility region of the EITC. Further analysis reveals that EITC recipients are mostly high-school graduates and are between ages 30 and 40. Most notably, the women who receive tax credit have long working hours and low earnings. This leads to the conclusion that these women suffer from low wages. A natural question is: how much does EITC help these low-wage women over their labor market careers in terms of human capital accumulation and wage growth? To answer this question, the next section presents a life-cycle labor supply model.

1.5 Model

In this section, I provide a life-cycle model for single women who rationally choose their optimal life-cycle paths for net savings (or borrowing and

consequently consumption) and annual hours of work. In the model, I allow for participation in welfare and food stamp programs as well as family composition changes over the life-cycle in the form of arrival and departure of a child. However, these dynamics are exogenously determined in the model.

I start modelling women's decisions as they complete their education and enter the labor market. The age at which a woman enters the labor market, thus, depends on her education level and is denoted by t_{0i}. Specfically, I assume that high school dropouts start working at age 16, high school graduates at age 18, college dropouts at age 20, and finally college graduates and those with post-college education enter the labor market at age 22. After entering the labor market, women make annual decisions concerning their work hours and levels of net saving. Working life is assumed to end deterministically at age 60, but I assume women live for 10 more years and consumer their accumulated assets.

The model accounts for three important dynamic mechanisms, first and foremost being human capital accumulation. By working more hours, women accumulate experience which have long lasting effects on their earnings. Specifically, the wage rate a woman faces depend on the experience stock, persistent unobserved heterogeneity, previous and current work hours choices as well as the market skill rental price. The impact of the previous work hours choice on the wage rate is crucial for incorporating the detrimental effect of taking time out of the labor market for single women. Even though having a career break does not cause a decline in the experience stock in the model, by allowing the wage rate to depend on previous hours choice, the model captures the detrimental impact of taking time out of the labor market and thus, the dynamic

links in the earnings processes of women.

Secondly, the model allows for saving and borrowing. By deciding on how much to save, women in fact determine the amount of funds to transfer across different stages of their life-cycle. Since I focus on low-income women in this paper, I also incorporate borrowing constraints to the model. In particular, the model imposes a lower-bound for the level of assets which depend on women's age and schooling level. However, I allow this lower bound to be negative, which implies that women can borrow even when their net worth is negative. In addition to the borrowing constraint, the model imposes a lower bound for consumption. In particular, women's saving or borrowing choices are feasible only if the level of consumption exceeds a consumption floor, $\underline{c}$.

The final intertemporal link comes from the structure of the EITC. By deciding on how many hours to work, a woman essentially determines the amount of tax credit she receives next period, taking as given the policy parameters[19]. In addition, I assume that women have static expectations concerning the tax system, which implies that any change in the tax credit or tax policy comes unexpectedly. This assumption is motivated by previous work in the literature documenting the lack of knowledge of the tax policies[20].

In addition to these dynamics, the model also accounts for participation in

[19] As mentioned earlier, EITC payments are received as a tax refund. A tax refund based on the earnings from the current year is generally received between January and May of the following year. Since I am modelling the annual decisions of women, I assume the EITC payment based on the labor market earnings from the current period is received in the following period.

[20] See for example Olson and Davis (1994) and Romich and Weisner (2000)

government transfer programs such as the Temporary Assistance to Needy Families (TANF) and Supplemental Nutrition Assistance Program (SNAP). However, rather than explicitly modelling the decisions to participate in these programs, I model the probabilities of receiving any benefits that capture both eligibility and the participation decision as stochastic processes.

In the remaining of this section, I describe the details of the model with specific parametrizations, provide a discussion on the predictions of the model and explain the solution method.

1.5.1 The Choice Set

At each age t, a single woman i chooses a pair $d_{it} = \left(d_{it}^h, d_{it}^s\right)$, where $d_{it}^h \in \mathcal{D}^h$ represents the choice for annual hours of work and $d_{it}^s \in \mathcal{D}^s$ represents the level of savings (or borrowing) net of interest income. The alternative choices each of these decisions entail are described as:

$$d_{it}^h = \begin{cases} 0 & \text{No work,} \\ 1 & \text{Less than 1300 hours,} \\ 2 & \text{Between 1300 and 1950 hours,} \\ 3 & \text{Between 1950 and 2200 hours,} \\ 4 & \text{More than 2200 hours,} \end{cases} \tag{1.1}$$

$$d_{it}^s = A_{i,t+1} - (1+r)A_{it} \in \{a_1, \ldots, a_{10}\}, \tag{1.2}$$

where A_{it} is woman's level of assets.

The annual hours of work choice includes 5 alternatives: no work, working less than 1300 hours, between 1300 and 1950 hours, between 1950 and 2200 hours and more than 2200 hours. If a woman chooses an alternative that requires work, I assume the woman's annual work hours is equal to the midpoint of

each bin. For example, if a woman chooses alternative 2 which implies that she chooses to work less than 1300 hours, I assume she works for 650 in that period[21]. The net saving decision[22], on the other hand, involves choosing from one of the 10 discrete alternatives between -$5,000 and $15,000. Note that, through the choice of net savings, a woman also decides on her level of consumption conditional on the receipts and expenditures defining her budget constraint. The model also allows for borrowing which implies that d^s_{it} can take on negative values. I discretize annual work hours and net saving in order to make a women's choice set entirely discrete. This specification is crucial for the analysis as it increases the tractability of the problem.

1.5.2 Preferences

Period utility, given in equation (1.3), defines a woman's preferences over the choice variables, d^h_{it} and d^s_{it}, conditional on observed state variables X_{it} and the preference shock, ϵ^h_{it}.

$$\begin{aligned} U(c_{it}, d^h_{it}, d^h_{i,t-1}; X_{it}, \epsilon^h_{it}, k) = \lambda_c(X_{it}, k)\frac{c_{it}^{\theta_c}}{\theta_c} + \lambda_h(X_{it}, \epsilon^h_{it}, k)\big[\mathbb{1}\{d^h_{it}=1\} \\ + \alpha^u_2\mathbb{1}\{d^h_{it}=2\} + \alpha^u_3\mathbb{1}\{d^h_{it}=3\} + \alpha^u_4\mathbb{1}\{d^h_{it}=4\}\big] \\ + \alpha^u_5\mathbb{1}\{d^h_{it}=1\}\mathbb{1}\{d^h_{i,t-1}=1\} \\ + \alpha^u_6\mathbb{1}\{d^h_{it}=2\}\mathbb{1}\{d^h_{i,t-1}=2\} \\ + \alpha^u_7\mathbb{1}\{d^h_{it}=3\}\mathbb{1}\{d^h_{i,t-1}=3\} \\ + \alpha^u_8\mathbb{1}\{d^h_{it}=4\}\mathbb{1}\{d^h_{i,t-1}=4\}. \end{aligned} \tag{1.3}$$

[21] The intervals determining the alternatives for the hours of work choice are constructed so that the mean and the standard deviation of work hours based on this definition is approximately equal to the annual hours of work distribution in the data.

[22] I follow Keane and Wolpin (2001) in this particular formulation for the saving decision.

The period utility is seperable between consumption and leisure. Furthermore, the first component of the period utility defines the value of consumption while the second component represents the value of leisure, or equivalently the disutility from work. The utility from consumption has an augmented CRRA form with the constant relative risk-aversion parameter, $1-\theta_c$. To ensure the concavity of flow utility with respect to consumption, I assume $\theta_c < 1$. The function, $\lambda_c(.)$ captures the differences in the marginal utility of consumption resulting from observed and unobserved heterogeneity. More specifically, this function is defined as

$$\lambda_c(X_{it},k) = \sum_{j=1}^{K} \alpha_{0j}^c \mathbb{1}\{k=j\} \exp\big(\alpha_1^c \mathbb{1}\{y_{it} \leq 25\} + \alpha_2^c \{y_{it} \leq 30\} + \alpha_3^c \mathbb{1}\{y_{it} \geq 40\} + \alpha_4^c \mathbb{1}\{y_{it} \geq 50\} + \alpha_5^c N_{it}\big), \tag{1.4}$$

where X_{it} represents observed characteristics of the woman such as the number of children, N_{it}; the education level and age[23], y_{it}. In this formulation, the parameters α_2^u, α_3^u, and α_4^u represent the varying disutility a woman gets from choosing different work alternatives as well as the fixed psychic cost from work. The remaining parameters α_5^u-α_8^u capture the decrease in the disutility from work if the woman chooses the same work alternative as she did the last period. Permanent unobserved heterogeneity enters the model through the woman's latent type[24], $k \in \{0,1,\ldots,K\}$, which captures the persistence in preferences for saving and leisure and its correlation with the observed characteristics of a woman.

Similarly, $\lambda_h(.)$ refers to a function that shifts the marginal disutility of

[23] I use both t and y_{it} to denote age. However, t refers to the periods of the model which can also be defined as a year.

[24] Although the woman knows her own type, it cannot be observed by the econometrician.

work based on observable and unobservable characteristics of a woman.

$$\lambda_h(X_{it}, k) = \alpha_0^h + \sum_{j=2}^{K} \alpha_{1j}^h \mathbb{1}\{k = j\} + \alpha_2^h \{y_{it} \leq 25\} + \alpha_3^h \mathbb{1}\{y_{it} \leq 30\} \\ + \alpha_4^h \mathbb{1}\{y_{it} \geq 40\} + \alpha_5^h \mathbb{1}\{y_{it} \geq 50\} + \epsilon_{it}^h. \tag{1.5}$$

According to the specification given by equation (1.5), marginal disutility of work depends on a woman's latent type, age, along with a random preference shock, ϵ_{it}^h which follows a normal distribution.

1.5.3 The Woman's Problem

Given the preferences and the choice set, I now define a woman's life-cycle problem formally. A woman maximizes her present discounted lifetime utility from age t_{0i} to the terminal age T_i, both determined by the woman's educational attainment. The choice set $\mathcal{D}$ in each period, t, is constructed by the Cartesian product of the sets of discrete alternatives $\mathcal{D}^h \times \mathcal{D}^s$. Let $\mathfrak{d}_{it}$ denote a vector of dummy variables $\mathfrak{d}_{it}^j$, $j = 1, \ldots, 50$ such that $\mathfrak{d}_{it}^j$ is equal to 1 if the woman chooses jth element of $\mathcal{D}$. In addition, let U_{it}^j be the utility associated with this choice. Then, the maximized utility at any period t is given by:

$$V(X_{it}) = \max_{\mathfrak{d}_{it}} \mathbb{E}\Big[\sum_{\tau=t}^{60} \sum_{j=1}^{50} \beta^{\tau-t} U_{i\tau}^j \mathfrak{d}_{i\tau}^j | X_{it} \Big], \tag{1.6}$$

where X_{it} is the state space at period t, which represents the information set of the woman at that period. The state variables at period t include the age of the woman y_{it}, the level of her assets A_{it}, schooling level S_i, the state she resides in SR_i, her race R_i, experience stock H_{it}, the federal and state earned income tax credit to be received at that period $EITC_{it}$, the number of children N_{it}, the age of her youngest child N_{it}^k, the calendar year v_{it} and the contemporaneous shock

vector $\epsilon_{it} = \left[\epsilon_{it}^{h}, \epsilon_{it}^{w}, \epsilon_{it}^{cc}, \epsilon_{it}^{tanf}, \epsilon_{it}^{snap}\right]$. Next, I define the transitions for each of these state variables in detail.

1.5.4 Constraints

A woman's annual income is composed of her earnings, $w_{it}h_{it}$; federal and state EITC payments received, $EITC_{it}$; the amount of SNAP benefits the woman receives, $SNAP_{it}$; as well as the amount of TANF benefits, $TANF_{it}$. Out of this annual income, the woman pays federal and state income taxes T_{it}, child care costs CC_{it} if she has a child, and makes consumption expenditures. The remaining amount earns interest and is transferred to future periods to determine the level of assets for the next period, $A_{i,t+1}$. I further assume that there exists a consumption floor, so that a choice pair (d_{it}^{s}, d_{it}^{h}) is feasible only if consumption is above the minimum consumption threshold, $\underline{c}$. Even though the budget constraint defines the transition for the woman's assets, the model also imposes a borrowing constraint that is determined by woman's age and educational attainment. This borrowing constraint requires the level of assets to stay above some nonpositive threshold every period. In sum, the intertemporal budget constraint a woman faces can be summarized by the following three equations:

$$\begin{aligned} A_{i,t+1} = (1+r)A_{it} + w_{it}h_{it} + EITC_{it} - T_{it} - CC_{it}\mathbb{1}\{N_{it} > 0\} \\ + \mathbb{1}\{P^{SNAP} = 1\}SNAP_{it} + \mathbb{1}\{P^{TANF} = 1\}TANF_{it} - C_{it}, \end{aligned} \tag{1.7}$$

$$c_{it}(d_{it}^{s}) \geq \underline{c}, \tag{1.8}$$

$$A_{i,t+1} \geq \underline{a}_{i,t+1} = -\exp\left(\alpha_0^b + \alpha_1^b y_{i,t+1} + \alpha_2^b y_{i,t+1}^2 + \alpha_3^b S_i\right). \tag{1.9}$$

Next, I explain each component of the budget constraint in detail.

As mentioned in the preceeding section, I define annual work hours h_{it} based on the annual work hours choice of the woman

$$h_{it} = \begin{cases} 0 & \text{if } d_{it}^h = 0, \\ 650 & \text{if } d_{it}^h = 1, \\ 1625 & \text{if } d_{it}^h = 2, \\ 2075 & \text{if } d_{it}^h = 3, \\ 2600 & \text{if } d_{it}^h = 4, \end{cases} \tag{1.10}$$

and given this definition, I calculate woman's annual labor market earnings by multiplying the annual work hours h_{it} with the wage she earns, w_{it}.

The wage process is determined as an exponential function of the woman's latent type, hours of work choice, age, race, schooling level, experience stock, previous hours of work choice, and the calendar year as in the following equation.

$$\begin{aligned} \ln w_{it} = \alpha_0^w &+ \sum_{j=1}^{K-1} \alpha_{1j}^w \mathbb{1}\{k = j+1\} + \sum_{j=1}^{3} \alpha_{2j}^w \mathbb{1}\{d_{it} = j+1\} + \alpha_3^w y_{it} \\ &+ \alpha_4^w R_i + \alpha_5^w S_i + \alpha_6^w \ln(H_{it}+1) + \sum_{j=1}^{4} \alpha_{7j}^w \mathbb{1}\{d_{i,t-1}^h = j\} + \alpha_{8j}^w v_{it} \\ &+ \alpha_{9j}^w SR_i + \epsilon_{it}^w, \end{aligned} \tag{1.11}$$

where k is the latent type of the woman, y_{it} is the age, R_i is the race, S_i is the educational attainment, SR_i is the state of residence and H_{it} is the accumulated hours of work. The existence of the latent type in the wage equation captures the impact of the unobserved skill endowment of a woman on the wage level. Furthermore, the third term in equation (2.2) reflects the varying returns to different hours of work choices. More specifically, the parameters α_{2j}^w for $j = 1, 2, 3$ represent the differences in the wage offers a woman faces when she chooses different annual work hours. The parameter α_4^w measures the difference in the

skill rental prices between the black and white women due to discrimination against black women in the labor market. In order to measure the discrimination, the variable R_i is defined as a dummy that takes on a value of 1 if the woman is black. In addition, the dynamic wage process allows for endogenous state dependence through experience accumulation and a change in the current wage offer depending on the previous hours of work choice of the woman. The following equation defines the process for experience accumulation.

$$H_{i,t+1} = H_{it} + h_{it}. \tag{1.12}$$

Finally, I assume that the idiosyncratic wage shock ϵ_{it}^w is serially independent. In particular, the random wage shock and the preference shock are assumed to be jointly normally distributed such that

$$\begin{bmatrix} \epsilon_{it}^h \\ \epsilon_{it}^w \end{bmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_h^2 & \sigma_{hw} \\ \sigma_{hw} & \sigma_w^2 \end{pmatrix} \right). \tag{1.13}$$

The federal and state EITC payments received by the woman depends on previous period's earnings. As previously mentioned, in this analysis I only consider the outlay component of the EITC which implies that a woman receives federal and state EITC in the form of a tax refund[25]. Note that, in this formulation, I am implicitly assuming that a woman makes all necessary tax payments during the year. For this reason, when she files for taxes she will not be liable for any additional taxes and she will not receive any tax refund. Therefore, the only posibility for a woman to receive a payment in the form of

[25]Since I assume the decision period of the model to be a year and that all the decisions are made at the beginning of a year, even if the tax refund is received in January, the credit will be a part of next period's income and thus, enter next period's budget constraint.

a tax refund is to be eligible for federal and thus, state EITC if she lives in a state that offers a state EITC program.

The federal tax credit that a woman is going to receive in the next period is determined based on her earnings for the current period and is described in equation (1.14).

$$FEITC_{i,t+1} = \begin{cases} r_{1it}E_{it} & \text{if } E_{it} \leq b_{1it}, \\ r_{1it}b_{1it} & \text{if } b_{1it} < E_{it} \leq b_{2it}, \\ \max\{r_{1it}b_{1it} - r_{2it}(E_{it} - b_{2it})\} & \text{if } E_{it} > b_{2it}, \end{cases} \tag{1.14}$$

Each component of this piecewise function defines a particular payment region of the EITC schedule. If the earnings of the woman is less than b_{1it}, then the woman is in the subsidy region and the tax credit is equal to a percentage r_{1it} of her earnings E_{it}. However, if the woman's earnings fall between b_{1it} and b_{2it}, then she is in the flat region and receives the maximum level of the tax credit possible, which equals to $r_{1it}b_{1it}$. Finally, if the woman's earnings are above the threshold b_{2it}, then the woman is either in the phase-out region or she is not eligible for the tax credit at all. In the phase-out region, the amount of credit is taxed away depending on how far the level of the woman's earnings is compared to the threshold b_{2it} whereas the amount of credit simply equals to zero if the woman is not eligible for EITC. The policy parameters r_{1it}, r_{2it}, b_{1it} and b_{2it} depend on the number of children, marital status and the calendar year.

If a woman is eligible for federal EITC and if she resides in a state that offers a state EITC program, then she also receives tax credit from the state. The level of tax credit the woman receives from the state is determined as a percentage of the federal EITC she is entitled to. More specifically,

$$SEITC_{i,t+1} = r_{3it}FEITC_{i,t+1}, \tag{1.15}$$

where the policy parameter r_{3it} is set by the state and varies with the calendar year and for some states, with the number of children. Finally, the total EITC payments a woman receives is simply the sum of the federal and state EITC benefits.

$$EITC_{i,t+1} = FEITC_{i,t+1} + SEITC_{i,t+1} \tag{1.16}$$

Due to the complicated structure of the tax system, I assume women have static expectations concerning the evolution of the federal and state EITC schedule parameters so that $\mathbb{E}(r_{ji,t+1}) = r_{jit}$, $\forall j \in \{1,2,3\}$ and $\mathbb{E}(b_{ji,t+1}) = b_{jit}$, $\forall j \in \{1,2\}$. Therefore, any change in the policy rule comes as a surpise. Moreover, I assume that women can face up to four policy regimes over their life-cycles. In particular, I adopt the 1990, 1993, 1996 and 2002 regimes and assume they operate over the periods prior to 1990, between 1991 to 1995, between 1996 to 2001 and 2002 onwards, respectively.

The federal and state income tax a woman pays enter the budget constraint through T_{it}. In order to calculate the amount of the federal tax liability, I use the actual tax brackets and the marginal tax rates for a given calendar year. In these calculations, I assume women pay taxes as the head of the household and use the appropriate tax policy parameters for that status. In order to find the state income tax a woman needs to pay given the level of her earnings and the state she resides in, I use the tax simulator, TAXSIM, developed by the National Bureau of Economic Research.

A woman incurs child care costs only when she has a child. The child care cost depends on the number of children the woman has, the age of her youngest child, and her hours of work choice. In particular, I assume the child

care costs vary depending on whether the youngest child is an infant, a toddler, a child or a teenager. A woman might pay child care costs even when she is not working. This means that the child care costs might involve the expenditures a woman makes for her child's care and that these expenditures do not necessarily only include the costs of day care or schooling. However, in the data, there are also several mothers who don't make any child care expenditures. Therefore, I consider the child care costs to be a truncated version of a latent variable process. In particular, I assume the latent process to have the following structure.

$$\begin{aligned} CC^*_{it} = \alpha^{cc}_0 + \alpha^{cc}_1 N_{it} + \alpha^{cc}_2 \mathbb{1}\{3 \leq N^y_{it} \leq 5\} + \alpha^{cc}_3 \mathbb{1}\{6 \leq N^y_{it} \leq 10\} \\ + \alpha^{cc}_4 \mathbb{1}\{11 \leq N^y_{it} \leq 17\} + \alpha^{cc}_5 d^h_{it} + \epsilon^{cc}_{it} \end{aligned} \tag{1.17}$$

where the random child care expenditure shocks are normally distributed, $\epsilon^{cc}_{it} \sim N(0, \sigma^2_{cc})$. Furthermore, the actual child care cost process is given by

$$CC_{it} = \max\{0, CC^*_{it}\}. \tag{1.18}$$

In the model, TANF and SNAP participation decisions are not endogenous but rather defined as stochastic processes. Still, according to the model a woman makes her life-cycle decisions conditional on TANF and SNAP participation and receipts. More specifically, I model the probabilities of receiving any TANF or SNAP benefits as seperate logistic functions. The rules for the welfare program state that a woman is eligible for TANF benefits if she passes an income eligibility test. Moreover, the thresholds for this income eligibility test vary with the state of residence and the family size. In terms of the welfare participation decision, previous work in the literature shows that the stigma from welfare participation depends on observable characteristics such as the

level of educational attainment, age and race. For these reasons, I model the TANF participation probability as a logistic function that is determined by the earnings of the woman, her education level, how many children she has, her race, her age, the calendar year, and the state she resides in. Note that this probability captures the eligibility for the program as well as the participation decision.

$$\Pr(P_{it}^{TANF} = 1) = \frac{\exp(\mathbf{X}_{it}^{pt}\alpha^{pt})}{1 + \exp(\mathbf{X}_{it}^{pt}\alpha^{pt})}, \tag{1.19}$$

where $\mathbf{X}_{it}^{pt} = [E_{it}, E_{it}\mathbb{1}\{v_{it} > 1996\}, S_i, R_i, y_{it}, v_{it}, SR_i]$. If the woman participates in welfare, the actual benefits are determined based on earnings and a policy rule that is state and family-size dependent. For this reason, I approximate the benefit determination function as an exponential function given by

$$\ln TANF_{it} = \alpha_0^{tanf} + \alpha_1^{tanf} SR_i + \alpha_2^{tanf} v_{it} + \alpha_3^{tanf} E_{it} + \alpha_4^{tanf} N_{it} + \epsilon_{it}^{tanf}, \tag{1.20}$$

where ϵ_{it}^{tanf} is a normally distributed random shock with zero mean, $\epsilon_{it}^{tanf} \sim N(0, \sigma_{tanf}^2)$.

Similar to welfare, eligibility for SNAP is determined by an income test for which the thresholds are specific to state of residence and the family size. In addition, net income test for SNAP also takes into account the amount of welfare receipts a woman is entitled to. Taking the eligibility rules into account, the probability of participating in SNAP is approximated as

$$\Pr(P_{it}^{SNAP} = 1) = \frac{\exp(\mathbf{X}_{it}^{ps}\alpha^{ps})}{1 + \exp(\mathbf{X}_{it}^{ps}\alpha^{ps})}, \tag{1.21}$$

where $\mathbf{X}_{it}^{ps} = [E_{it}, S_i, TANF_{it}, v_{it}, y_{it}, R_i, SR_i]$. Once again, the inclusion of woman's age, race and schooling level is meant to capture the varying stigma

from the participation decision based on the observable characteristics of the woman.

If eligible, a woman's actual SNAP benefits are determined by a policy rule that takes into account her earnings and welfare benefits. This policy rule changes according to state policies, calendar year and the family size. Therefore, I model the amount of SNAP benefits of an eligible woman as an exponential function that depends on these variables.

$$\ln SNAP_{it} = \alpha_0^{snap} + \alpha_1^{snap} SR_i + \alpha_2^{snap} v_{it} + \alpha_3^{snap} E_{it} + \alpha_4 TANF_{it} + \alpha_5^{snap} N_{it} + \epsilon_{it}^{snap}, \tag{1.22}$$

where $\epsilon_{it}^{snap} \sim N(0, \sigma_{snap}^2)$.

The transition in the number of children and the age of the yougest child are modeled so as to match the dynamics in the data. First, in order to limit the size of the state space I cap the number of children, so that a women can at most have 2 children[26]. Secondly, from the data I observe that the change in the number of children does not only happen through birth or the child exceeding the age of 17. Adoption, taking custody of an existing child, the death of a child or the child leaving the house to live with another family member are also common events. This means, the number of children a woman has can increase or decrease at any age. For these reasons, I specify the transition in the number of children as follows.

$$\Pr(N_{i,t+1} = m) = \frac{\exp\left(\mathbf{X}_{it}^n \alpha_m^n\right)}{1 + \sum_{j=1}^{2} \exp\left(\mathbf{X}_{it}^n \alpha_j^n\right)} \quad \forall m \in \{1, 2\}, \tag{1.23}$$

[26]Having more than two children matters only for the state EITC policy of Minnesota.

$$\Pr(N_{i,t+1}=0) = 1 - \sum_{m=1}^{2} \Pr(N_{i,t+1}=m), \tag{1.24}$$

where $\mathbf{X}_{it}^{n} = [y_{it}, S_i, N_{it}^{y}\mathbb{1}\{N_{it}>0\}, N_{it}]$. In this specification, the probability of a change in the number of children varies with the woman's age, her schooling level, age of her youngest child if she has a child, and the number of children she already has.

For the reasons explained above, the age of the youngest child is not deterministically changing in the data. In order to deal with this, I construct four groups for the age of the youngest child and calculate the transition matrix for the age of a woman's youngest child so that the probability of a change in the age of the youngest child is determined by the age of the woman and how many children she has according to the following process.

$$\Pr(N_{i,t+1}^{y}=m) = \frac{\exp\left(\mathbf{X}_{it}^{k}\alpha_{m}^{k}\right)}{1+\sum_{j=2}^{4}\exp\left(\mathbf{X}_{it}^{k}\alpha_{j}^{k}\right)} \quad \forall m \in \{2,3,4\}, \tag{1.25}$$

$$\Pr(N_{i,t+1}^{y}=1) = 1 - \sum_{m=2}^{4} \Pr(N_{i,t+1}^{y}=m), \tag{1.26}$$

where $\mathbf{X}_{it}^{k} = [y_{it}, N_{it}, N_{it}^{y}]$.

1.5.5 The Solution Method

The life-cycle maximization problem of a woman can be reformulated in a dynamic programming framework. Specifically, the value function can be written as the maximum over alternative-specific value functions denoted as V^j for $j = 1, \ldots, 50$ that satisfy the Bellman equation:

$$V(X_{it}) = \max\left\{V^1(X_{it}), \ldots, V^j(X_{it})\right\}, \tag{1.27}$$

$$V^j(X_{it}) = U^j_{it} + \beta \mathbb{E}\left(V(X_{i,t+1})|\mathfrak{d}^j_{it} = 1, X_{it}\right). \tag{1.28}$$

The expectation in equation (1.28) is taken over the joint distribution of the random shocks as well as the future values of the state variables. Furthermore, the terminal-period alternative-specific value functions consist only of the contemporaneous utilities. In particular, I assume there is no value for death and that there is no bequest motives. Therefore, for all values of $X_{i,T+1}$ and $j = 1, \ldots, 50$, I set $V^j(X_{i,T+1}) = 0$.

Due to the finite-horizon structure of the model, I use backward recursion as the solution method. Backward recursion entails solving the model as a function of the entire state space for each period. More importantly, the solution of this optimization problem necessitates finding the values of $\mathbb{E}\left(V(X_{i,t+1})|\mathfrak{d}^j_{it} = 1, X_{it}\right)$ for all points in the state space. Given the continuation value in period t, the optimal saving decision conditional on each hours of work alternative is calculated for by comparing the remaining discounted utility on a grid of possible consumption levels implied by the different saving/borrowing decisions, for each of the five alternatives for the hours of work choices.

In order to reduce the computational burden created by evaluating the value functions over the entire state space, I utilize two methods. First, I reduce the size of the state space by discretizing the continuous state variables. If, however, a value outside the grid of an element of the state space needs to be computed, I use linear interpolation and extrapolation. Secondly, I use an approximation method developed by Keane and Wolpin (1994) which requires the calculation of the function $\mathbb{E}\left(V(X_{i,t+1})|\mathfrak{d}^j_{it} = 1, X_{it}\right)$ for a subset of the state

space at each t and estimating a regression function as a polynomial in those state space elements. The values from the fitted polynomial are used to pinpoint the value of this function for the remaining points in the state space. Finally, in order to calculate the multivariate integrals when taking expectations, I use Monte Carlo integration.

1.5.6 Theoretical Predictions on the Impact of the EITC

The static labor supply theory predicts that the EITC will encourage employment among single women as the program gives incentives that decrease the disutility from work for those people who are unemployed without the credit[27]. However, the impact of the tax credit on hours of work of single women depends on which region the women's earnings fall into before the credit is introduced. In particular, in the subsidy (phase-in) region EITC acts as a wage subsidy, which leads to a negative income effect and a positive substitution effect due to leisure becoming more expensive. Still, without further assumptions on the preferences, it is not possible to determine theoretically whether the income effect or the subsidy effect dominates. Consequently, the direction of the intensive-margin responses of the women who are in the subsidy region is theoretically ambiguous. In the flat region, the budget constraint of a woman shifts out by an amount that is equal to the level of the maximum credit. Therefore, in this region the EITC creates a negative income effect that leads to a reduction in the work hours. Since the amount of the tax credit declines with each dollar

[27]This prediction is actually concerned with labor force participation. The tax credit provides incentives to those women who choose to remain out of the labor force. Nevertheless, the model does not take into account labor force participation decision of the women. Therefore, the predictions on labor force participation are fully reflected in employment decisions

earned when a woman is in the phase-out region, the EITC acts as a tax that decreases the net wage earned by the single woman. For this reason, the EITC produces a negative income effect along with a negative substitution effect as labor becomes less rewarding. Accordingly, the overall impact of the EITC on work hours depends on the distribution of women across the payment regions. Although the theoretical prediction of the static labor supply model on the impact of the EITC on work hours is ambiguous, as more EITC recipients have earnings in the flat and phase-out regions the expectation is for the EITC to reduce the work hours of eligible single women.

On the other hand, the model in this paper takes into consideration another channel through which the EITC has an effect on employment and hours of work, i.e., human capital accumulation. Human capital accumulation in this model works in a way to increase the rewards from work as it takes into account the impact of current hours of work decisions on future wages. More specifically, by working more in a given period, a woman increases her experience stock and thus, faces higher wage offers in the future.

The dynamic model predicts positive employment effects similar to the static labor supply model. As before, the tax credit provides incentives that decrease the disutility from work and thus, leads some of the women who choose to remain unemployed without the credit to start working. In addition to this, the dynamic model also takes into account that the introduction of the credit increases the future rewards from work for women who are unemployed without the credit. Therefore, the expectation is to have a higher change in the employment rate resulting from the introduction of the tax credit in the dynamic

model.

In order to understand the prediction of the model on hours of work, once again the behavioral responses of the women in each region need to be separately evaluated. Note that, in all payment regions the human capital effect works in the same direction. Essentially, no matter in which region a woman's earnings fall, due to human capital accumulation she always has a motive to work more in order to achieve a higher wage level. Whether this human capital effect dominates the income and substitution effects that are created by each payment region, however, requires more elaboration. As mentioned above, in the subsidy region the credit creates a substitution and an income effect that operates in the opposite directions. The dynamics of the model adds the human capital effect into the picture, which works in the same direction of the substitution effect. In other words, the human capital effect leads to an increase in the hours of work similar to the substitution effect that operates on the women in this region. Still, it is not possible to theoretically identify whether the income effect cancels out the favorable intensive-region responses created by the substitution and human capital effects. Even so, it is possible to compare the prediction of the dynamic model to that of the static model. Due to human capital accumulation, in the dynamic model the intensive-margin responses are expected to be higher, i.e. the change in the work hours of the women in this region should either be less negative or more positive in the dynamic model. The same argument follows for the flat and phase-out regions as well. Even though the EITC taxes both the current and future rewards from work in the phase-out

region, the dynamic model introduces a link through which women are incentivized to work more in order to increase the future rewards from work. In both of these regions, the human capital effect counteracts the negative income or substitution effects created by the credit. However, it is not possible to provide a statement whether this human capital accumulation channel completely cancels out the incentives created by the program to decrease hours of work in these regions. Moreover, the strength of the human capital channel depends on the age of the woman, marginal disutility she gets from work based on her observed and unobserved characteristics and the experience stock she currently has. Nevertheless, contrary to the static model, the impact of the EITC on work hours of single women is theoretically ambiguous in the flat and phase-out regions in the dynamic model. Consequently, estimating the model will provide further insight on the magnitudes of these individual effects as well as the net impact of the EITC on intensive-margin responses. Note that, the above analysis is made by ignoring the changes in the asset stocks of these individuals. If the borrowing or saving motives of individuals are also taken into account, it gets even harder to determine the direction of the change in work hours. In that setting, the marginal utility of consumption based on the woman's observed and unobserved characteristics, her current asset stock as well as her impatience are also crucial for understanding the net impact.

The impact of the EITC on asset accumulation can not be analyzed through the static labor supply model. One contribution of the model in this paper is to allow for such an evaluation. In this model, the EITC might have an effect on the net asset stock, which is defined as assets minus liabilities, through

two main channels. First of all, the tax credit increases the resources available to a woman in each period as long as she remains eligible. This means that, if the woman were to spend the same amount on consumption expenditures, EITC leads to asset accumulation. However, due to human capital accumulation, the woman adjusts her consumption expenditures as well. More specifically, human capital accumulation implies that the woman expects to experience an increase in her earnings as she grows older. This is simply due to an increase in her experience stock with every year she works. The expectation of a positive age-earnings relation implies that the woman has consumption smoothing motives in order to achieve a stable path of consumption over the life cycle. If the EITC is increasing the slope of this age-earnings profile, or in other words if the EITC is helping women to achieve higher wage levels over the life-cycle, then the women will have stronger desires for consumption smoothing which implies that the level of consumption expenditures especially in younger ages will rise. Once again, the EITC creates two competing forces. Whether the income effect or the human wealth effect dominates depend on the discount factor, the coefficient of relative risk aversion, the interest rate and the degree of disutility a woman gets from working. For this reason, the model's prediction for the impact of the tax credit on asset accumulation is also ambiguous.

In sum, even though the model in this paper predicts that the EITC leads to an increase in the employment rate, it fails to provide a definite conclusion on the direction of intensive-margin responses and asset accumulation. This creates the need for an empirical analysis through which the forces mentioned in this section, such as the human wealth effect, are identified and the net effect can

be evaluated. The rest of the paper is an attempt to provide such an analysis.

1.6 Estimation and Results

In this section I first describe the estimation method I use in this paper. Next, I explain the identification arguments and discuss the parameter estimates. Finally, I assess the success of the model in terms of fitting the patterns observed in the data. The parameter estimates presented in this section are used in the rest of the paper to perform counterfactual experiments.

1.6.1 Estimation Method

I estimate the parameters of the model following a two-step procedure. In the first step I estimate the exogenous transitions in the state variables, such as the number of children, the age of the youngest child, the child care cost, TANF participation and benefits along with SNAP participation and benefits. In addition, I set the discount factor β to 0.96 and the risk-free interest rate r to 0.02. The predetermined values for the risk-free interest rate and the discount factor imply that women have some degree of impatience, since the interest rate is slightly lower than the discount rate. In the second step, I estimate the remaining parameters of the model using the method of simulated moments (MSM). More specifically, the estimation procedure follows an iterative process. First, I estimate the exogenous elements of the model from the data and set the values for the discount factor and the interest rate. Then, I calculate the moments from the data. In the third step, given an initial guess of the parameter vector, I solve the life-cycle optimization problem of single women conditional

on the estimated exognous elements from the first step. Next, I simulate 7 paths for each woman reproducing the age and time structure of the data. Simulating 7 paths for each woman leads to a total of 9,849 paths. Finally, I calculate the moments from the simulated data and calculate the weighted average distance between the sample moments and the simulated moments from the model. The iterative process continues until this distance is minimized.

More formally, let Ω denote the parameter vector, $\widetilde{M}^S(\Omega)$ denote the vector of moments from the simulated data and $M_N(\Omega)$ denote the vector of moments from the observed data. Then, the estimated parameter vector $\hat{\Omega}$ solves the following objective function:

$$\hat{\Omega} = \arg\min_{\Omega}(M_N - \widetilde{M}_S(\Omega))' W_N (M_N - \widetilde{M}_S(\Omega)), \tag{1.29}$$

where W_N is a symmetric, positive-definite weighting matrix. Following Del Boca, Flinn, and Wiswall (2014), I construct this weighting matrix as the inverse of the covariance matrix of M_N, which is estimated by resampling the data[28]. In particular, I compute the vector M_N^g for each of the Q resamples from the original N data points which leads to the following covariance matrix for M_N:

$$W_N = \left(Q^{-1} \sum_{g=1}^{G} (M_N^g - M_N)(M_N^g - M_N)' \right)^{-1}, \tag{1.30}$$

where the number of draws, Q is set to 200.

The moments that form M_N and consequently $\widetilde{M}_S(\Omega)$ include the mean and the standard deviation of annual work hours by age, education, and the

[28] Del Boca, Flinn, and Wiswall (2014) show that the estimator $\hat{\Omega}$ is consistent for any given positive-definite weight matrix given that the model is identified. Note that the weight matrix W_N is positive-definite by construction.

number of children; employment rate by age,education, and the number of children; mean wage by age,education, and the number of children; the mean net assets by age and eduation groups; along with the 10^{th}, 25^{th}, 75^{th} percentiles of net assets. I also calculate the correlations between wage and work hours, contemporaneous wage and lagged hours, as well as the correlation between the contemporaneous and lagged hours choices.

1.6.1.1 Type Probabilities and Initial Conditions

The initial conditions for the model consist of the values for schooling, race, the state a woman resides in, the number of children she has, the age of her youngest child, previous period's choice of work hours, the level of net assets and the amount of EITC she is entitled to at t_{0i}, the initial period of the model. I take the values of the woman's schooling, race, state of residence and the level of net assets as given in the data. For the women whose initial net worth is missing in the data, I draw a value of net assets from the distribution of initial assets conditional on these women's educational attainment. Note that, in the model a woman starts her working career at an age determined by her educational attainment. For this reason, I assume that a woman has no experience and no children at the time she starts her working career[29]. The assumption that the initial level of experience is zero implies that any experience a woman gains during school years is not effective enough to increase her human capital stock. In addition, since t_{0i} marks the first period a woman works, I further assume that previous period's work hours choice and the level of EITC a woman receives

[29]In the data, if the woman has no child, the age of the youngest child is coded as 1. Therefore, the transition probabilities given in equations (23) and (24) can be calculated even if the woman has no child in a given period

is zero in this period.

Although the schooling level of a woman is taken as given in the data, it is unlikely that this variable is exogenous. The schooling choice a woman makes earlier in life, or the decision to stop schooling and to start working may reflect skill endowments or innate ability that I cannot observe. Moreover, these skill endowments would further affect the work choices of the woman later in the life cycle. In sum, the educational attainment of a woman might be the outcome of an endogenous process that is not taken into account by my model. In order to tackle with the possible bias this endogeneity might entail, I assume that the educational attainment of a woman is exogenous conditional on her latent type, k. In turn, the type probability is specified as a logistic function of the schooling level of a woman.

$$\pi_k = \frac{\exp\left(\alpha_{0j}^t + \alpha_{1j}^t \mathbb{1}\{S_i = 1\} + \alpha_{2j}^t \mathbb{1}\{S_i > 2\}\right)}{1 + \sum_{l=2}^{K} \exp\left(\alpha_{0l}^t + \alpha_{1l}^t \mathbb{1}\{S_i = 1\} + \alpha_{2l}^t \mathbb{1}\{S_i > 2\}\right),} \quad \forall k \in \{2, \ldots, K\}, \quad (1.31)$$

$$\pi_1 = 1 - \sum_{k=2}^{K} \pi_k. \quad (1.32)$$

According to equation (1.31), the latent type of a woman is determined based on whether the woman is a high school drop out and whether she has at least some college education.

1.6.1.2 Measurement Error

The measurement error in the observed wage and asset data is crucial, as the wage and asset outliers significantly affect work and net saving choices and thus, the parameters of the model. In order to diminish this influence, I assume both wages and assets are subject to measurement errors. In particular,

I assume the measurement error on wages have a multiplicative structure so that,

$$w_{it}^{observed} = w_{it} \exp(\eta_{it}^{w}), \tag{1.33}$$

where η_{it}^{w} is normally distributed as $\eta_{it}^{w} \sim N(0, \sigma_{mw}^2)$. The measurement error on assets, on the other hand, is assumed to follow an additive process.

$$A_{it}^{observed} = A_{it} + \eta_{it}^{a}, \tag{1.34}$$

with $\eta_{it}^{a} \sim N(0, \sigma_{ma}^2)$ and $\sigma_{ma} = \sigma_{ma,0} + \sigma_{ma,1} A_{it}$. With this additive structure for the measurement error, the variance of the measurement error varies with the level of assets. I further assume that the measurement errors on assets and wages are independent of each other and of the other error terms in the model, in addition to being serially independent.

1.6.2 Identification

The identification of the parameters of the model rely on a combination of functional form and distributional assumptions as well as two sets of exclusion restrictions. The first set of exclusion restrictions necessitates the existence of at least one variable that affects the selection of individuals into certain states while not changing the outcome equation. In the context of this paper, an example of the selection equation is the marginal utility of leisure while the outcome is the wage equation. In this setting, the number of children a woman has, serves the role of an exclusion restriction as it shifts the marginal utility of leisure even though it does not enter the wage equation. The second exclusion restriction requires at least one variable to shift the outcome equation while not altering the

selection equation. Experience that enters the wage equation serves the role of this type of an exclusion restriction. A similar argument follows for the marginal utility of consumption and the borrowing constraint equations. The number of children a woman has, for example, shifts the marginal utility of consumption even though it does not have an impact on the borrowing constraint. Schooling level, on the other hand, is one of the determinants of the lowest asset threshold although it does not alter the marginal utility of consumption.

The coefficient of relative risk aversion, θ_c, which determines the curvature of the utility function and the intertemporal elasticity of substitution, $1 - \theta_c$ is identified through the differences in the net saving-age profiles of women with similar observable and unobservable characteristics. Furthermore, the marginal utility of consumption is specified as an exponential function in order to make the identification less challenging.

Next, the distribution of the latent types and type-specific parameters are identified through the panel structure of the data. Repeatedly observing the choices of the same woman conditional on the observable characteristics allow me to separate the persistent unobserved heterogeneity from transitory unobserved shocks. However, as types cannot be identified without a normalization, I impose a ranking on the skill endowments in estimation. I assume type 1 women have the lowest skill endowments while type 4 women have the highest.

Finally, the impact of the EITC is identified through the variation in the policy parameters across time and states. The number of states with state-level EITC programs varies a lot across years. For example, in 1986, only Maryland was offering state EITC while in 2001 the number of states with

state EITC programs increased to 15. Moreover, the level of the tax credit differs substantially across states. In 2001, while EITC eligible individuals in Maine were receiving state-level tax credit that was equal to 5% of their federal EITC, in Vermont the state-level EITC was equal to 32% of the federal credit. This difference across states considerably varies across time which helps with the identification of the impact of the EITC on work hours, employment and asset accumulation.

1.6.3 Parameter Estimates

I first present the results from the first step of the estimation procedure which are used as an input in solving the life-cycle optimization problem of a woman. Next, I report the parameter estimates from the second step that utilizes MSM.

Table 1.5 presents the estimates for the cost of child care equation. The estimates show that childcare cost increases as the number of children increase, as expected. However, an additional child raises the cost of childcare only by 3 percent. This tells us that even though having more children necessitates higher childcare costs, the women also benefit from economies of scale when they have more children. One reason for this might be due to older child taking care of the younger one when a woman has more than one child, which can eliminate the need for a baby-sitter. Moreover, younger children may use the clothes, toys and other belongings of the older children. Among the women with the same number of children, those whose youngest child is an infant pay the highest child care costs. Although the cost of a toddler is not significantly different from an

infant, the childcare cost considerably decreases when the youngest child is older than 6.

As mentioned before, the probability for TANF participation captures both eligibility and the participation decision. Table 1.6 reports that there is no significant difference between black and white women in terms of welfare participation. Moreover, even though states impose their own earnings thresholds, participation in welfare for women who live in different states is not significantly different. With regards to the TANF benefits observed in the data, the results display that a woman's earnings is the most important determinant. As expected, welfare receipts decline as annual earnings increase.

Similar to TANF participation, the black and white women do not differ in terms of the probability of SNAP participation as well. Nevertheless, SNAP participation is lower among women who are older, who have higher annual earnings and who are more educated. On the other hand, women with higher TANF benefits have higher SNAP participation. As for the benefits, having more children lead to a rise in the benefits while higher annual earnings and higher TANF benefits received lead to a decline. The reason for this is that the women's earnings and welfare receipts add to the eligibility income used for the calculation for benefits. As a woman's income increases, benefits are taxed away.

Finally, tables 1.8 and 1.9 present the estimates used in calculating the transition matrix for the number of children and the age of the youngest child.

The remaining parameters are estimated using MSM and tables 1.10-1.12 report the results. Note that, the parameter estimates themselves are not of

key interest for the purposes of this paper. Rather, the behavioral patterns indicated by the model are the focus of the empirical analysis. Nevertheless, I next discuss the important findings based on the parameter estimates.

First, the CRRA parameter measured by θ_c is 0.5123 which implies a coefficient of relative risk aversion of $1 - \theta_c = 0.4877$. This estimate is in line with the findings of several papers in the literature such as Keane and Wolpin (2001), Gooree et al. (2003), Imai and Keane (2004), and Sauer (2004). In contrast, the CRRA parameter I estimate is considerably high compared to the typical value used in the life-cycle consumption literature. The value of θ_c commonly accepted in this literature is around -2 (Hubbard et al., 1994), which implies a lower willingness to substitute consumption intertemporally and a higher level of prudence. Keane and Wolpin (2001), who also include borrowing constraints in their analysis, argue that in models without borrowing constraints a high degree of prudence is needed in order to justify the observed pattern of young people with steep earnings profiles not to borrow heavily. That being said, the sample of women this paper focuses on are subject to income uncertainty and have a high willingness to substitute intertemporally as they are single low-income women. The fact that these women are single plays a crucial role for this argument, as they do not have a spousal income that serves the role of a safety net.

The lower bound for net assets shows the lowest amount of assets (or the highest amount of debt) held by the women in the sample before taking into account the measurement error in assets. To give an example, the highest level of debt allowed for a 25-year-old woman who is a high school dropout is around

$3,264 while it is $64 for a 45-year-old high school dropout. On the other hand, schooling has a more significant impact on the amount of the highest amount of debt permitted, as for a 25-year-old woman who has a college degree or more, the bound becomes $1,776. In addition to the borrowing constraint, I estimate a consumption floor and find that it is around $2,118 for this sample of women.

The parameters of the wage equation are consistent with the literature. For example, the parameter of the educational attainment implies that an additional year of schooling increases the wage the woman faces by 4.1%. Moreover, the results display significant returns to experience. In particular, a 1% increase in the experience stock leads to a 0.14% increase in the wage rate. Consider a woman who worked part-time for 15 years. She would have 1,500 hours of experience stock. Next, consider a woman who worked full-time for 15 years. This woman would have 3,000 hours of experience. The estimated returns to experience indicates that the woman who worked full-time would face a wage rate that is 14% higher than the wage rate of the woman who worked part-time. The estimates further show that the wages of black women are 17% lower than the wages of white women. This estimate might reflect the discrimination in the labor market in terms of lower skill rental prices for black women or that black women have lower skill endowments independent of the type, which cannot be captured by model. Finally, the wage equation estimates also show the importance of career breaks. For instance, a woman who worked between 1950 and 2200 hours last period receives a wage rate that is 6.7% higher than the wage rate of a woman who had a career break in the previous period.

In terms of the latent types of the women, I find that unobserved heterogeneity plays an important role in explaining differences in the outcomes. In particular, I estimated the model with four latent types and in the estimation I imposed a ranking on the skill endowments ascending from type 1. The estimates suggest that types differ substantially. For example, in the log wage equation, types 3 and 4 are estimated to earn wages about 6% higher than either type 1 or 2. Although types 1 and 2 have similar skill endowments, type 1 women get a greater utility from consumption and less disutility from non-leisure time. Type 3 and type 4 women have high skill endowments and include most of the women with college education. Type 4 women have lower utility from consumption and a slightly higher disutility from work. Furthermore, the type probability equations imply that women with more education are much more likely to be of high skill types.

Figure 1.4 displays the within sample fit of the simulated model to the life-cycle profiles of mean log wage, mean asset, employment and mean annual hours of work. In general, the model is able to fit the shape of the life-cycle profiles for mean wage, employment rate and mean work hours well. The figure shows that the model underestimates the mean net assets between ages 50 and 60. At the same time, it slightly underestimates the mean log wage before age 30. A comparison of data moments and the simulated moments also show that the model does a good job in predicting the employment rates, work hours choices and wage rates across demographic groups[30]

[30]The tables that compare the simulated moments with the moments from the data are provided in the online appendix.

1.7 The Impact of the EITC on Single Women

I now examine the predictions of the model with regards to the impact of the EITC on women's wage growth over the life-cycle. I first consider the differences in women's behavior with and without the EITC. The simulations with the EITC assume that the 2002 tax schedule is in effect. Next, I consider the life-cycle effects of an EITC introduction. More specifically, I first simulate the consequences of an EITC introduction early in the working life and compare the results life-cycle profiles generated by an EITC introduction later in the life cycle.

Table 1.13 displays the impact of the tax credit on mean employment, annual hours of work, log wage, and net assets. The first two columns present the average of these variables when the human capital accumulation channel is closed. In particular, these simulations assume that the experience stock or the choice of previous work hours have not effect on the wage rate. The change in the employment rate and in the intensive-margin responses or in other words, the change in the average work hours of the women conditional on employment is consistent with the findings of the previous studies. In particular, the change in the employment rate without allowing for human capital accumulation is 2.6% or 2 percentage points. The change in the average work hours of employed women is -0.15% which is not significantly different than zero. Unfortunately, it is not possible to compare the change in average wages and average net assets to any studies as to the best of my knowledge there is no paper in the literature that present any evidence on those. However, Table 1.13 indicates that the average wage rate increases by 0.27% with the EITC, which is due to the rise in

the employment rate. Net assets on the other hand increase more significantly than the other key variables. This is due to the debt relief the EITC provides as it is directly increasing the period income of the single women.

The last three columns of Table 1.13 provides evidence on the importance of the human capital accumulation channel for the impact of the EITC. More specifically, once the wage rate reacts to the experience stock as well as the previous work choices of women, the EITC has an additional effect of increasing the future rewards from work. Therefore, both the extensive and the intensive-margin responses become stronger with EITC once human capital accumulation channel becomes functional. As a result of the stronger employment and hours of work responses, the EITC significantly raises the average wages in the population. Note that, the percentage changes reported in this table are for the whole sample, while only 38% of the women are eligible for the EITC. As a result, the 5% increase in the average wages in fact corresponds to a 20% increase in the average wages of the women who are EITC eligible. For this reason, it is clear that EITC is influential in helping single women in climbing the wage ladder.

Figure 5 presents the distribution of the change in the work hours for the EITC target group. For this simulation, I mark the women who are eligible for EITC at least once over their life-cycles in a setting where EITC is not offered. Then I track their intensive-margin responses under EITC. The table shows the distribution of the change in the average work hours over the life-cycle as a result of the EITC. The resulting average change in the work hours of these women is around 5%. However, the figure provides evidence that almost 70% of

the women in this target group respond to tax credit by increasing their work hours. Even though the theoretical predictions of the dynamic model on the change in hours of work is ambiguous, this exercise indicates that the human wealth effect is in fact stronger than the income effect in the payment regions of the credit schedule.

The life-cycle wage path of women who are in the target group is displayed in Figure 6. In fact, the figure shows how successful EITC is in helping women climb the wage ladder. Evidently, EITC leads to a significant rise in the wages for women at all ages. The main reason for this is the rise in the employment and annual hours of work as a result of the EITC. Since women work more under the tax credit, they accumulate a higher experience stock, which leads to higher wages. Furthermore, as the impact on the wage profile is generated from the accumulation of the experience stock, the wage growth is higher for older woman, even though their average annual work hours is lower than the average without the EITC. The increase in wages can go as high as 25% which means that the work incentives provided by the EITC are effective in generating wage growth for single women. Note that, the EITC leads to a wage growth even though for some women the intensive-margin responses are negative.

Table 1.14 decomposes the percent change in the wage rate across different age and education groups as well as with respect to the number of children a woman has. As can be seen from the table, women who are above 50, who are high school dropouts and who have two children or more benefit the most from the tax credit. Since the wage growth is almost entirely due to the additional human capital accumulation created by the credit, it is expected the older women

to have a higher percentage change in the average wage rate. Moreover, high school dropout are the group with the lowest wages on average and therefore, they form the group that experiences the highest wage growth. Finally, women with two children or more receive the highest tax credit according to the EITC schedule. In addition, they are the women who work for the shortest hours. For this reason, the effect of the EITC is stronger on this group. The primary reason for the lack of any the small EITC impact on the group of childless women is the age restriction the EITC eligibility imposes on taxpayers without a qualifying child. More specifically, women without a child cannot benefit from the tax credit until age 25, and even after age 25, because the amount of the credit they are entitled to is not very high we see a relatively insignificant impact on these women's wage growth. The same argument applies for the small wage changes for the group of women who are younger than 25. These women are less likely to have a child and thus, face the least generous credit schedule.

Although Table 1.14 indicates that older women benefit more from receiving the EITC, if the tax credit is introduced at different ages over life-cycle the end result might be different. In order to investigate this, I next consider whether introducing EITC at different stages of the life cycle has varying impact on the wage growth profiles. In doing so, I first simulate the wage paths of single women with an unanticipated EITC introduction at age 25. Then, I simulate the wage paths of the same women once again, but this time the introduction of the tax credit happens at age 45. In both cases, I use the 2002 tax credit schedule for the simulations. Figure 1.7 shows that in both cases, the introduction of the EITC promotes wage growth. However, if the women

experience the EITC introduction at an early age, then the impact on wage growth is more significant. Receiving tax credit later in life considerably shifts the wage profile as well. Nevertheless, the average wage level stays lower than the average wage level simulated with an early EITC introduction. The reasons for that are twofold. First, at later stages in the life cycle, women have higher average earnings and thus, are less likely to receive EITC. Second, as the tax credit promotes wage growth through human capital accumulation, the impact of a higher experience stock in early ages in the life cycle leads to a more considerable shift in the wage profile.

EITC can influence the net worth of women in two particular ways. First, the tax credit helps the women who are having a hard time in making ends meet. These women are highly indebted and due to credit constraints, they fail to make the expenditures they need. By providing cash transfers, the EITC offers debt relief to these women. More specifically, these credit-constrained women use the tax credit mostly to make expenditures such as paying the credit card debt or bills that are past due (Smeeding, Phillips, and O'Connor (2000) and Mendenhall, Edin, Crowley, Sykes, Tach, Kriz, and Kling (2012)). Second, because the tax credit generates human capital accumulation, it is increasing the slope of the age-earnings profile for the eligible women. The steeper age-earnings profile in turn creates stronger consumption smoothing motives, which lead to an increase in consumption especially in early ages. Whether the increase in the lifetime wealth or the increase in consumption dominates cannot be determined theoretically. However, the last row of Table 1.13 shows that without the human capital accumulation channel, the EITC leads to a 1.72% increase in the average

net assets for the whole sample. Once again, considering the fact that only 40% of the women in this sample are eligible for the EITC, the change in the average net worth of the eligible women is almost 4.5%. The rise in net assets due to the tax credit is not surprising, because without human capital accumulation the consumption-smoothing motives are either very weak or non-existent. Once I allow for human capital accumulation in the model, however, the rise in the net assets falls significantly. The reason for that is the wage growth the EITC generates. As a result of the stronger wage growth over the life-cycle, age-earnings profiles of the women gets steeper and thus, their consumption smoothing-motives cancel out a higher percentage of the increase in the life-time wealth due to the tax credit. Note that, the less significant rise in the net assets implies that the women who are eligible for the EITC are actually using the tax-credit for consumption purposes. This is in line with the findings of Mendenhall et al. (2012) who interviewed the EITC recipients in Chicago and asked how they are using the credit. Their findings indicate that only 38% of the recipients use the credit for saving while others use the credit on consumption expenditures such as going to fancy restaurants, repairing their cars, moving to better school districts for their children, or even by taking their children to Disney World.

Figure 8 shows the distribution of the change in average of the net assets over the life-cycle for women who are eligible for EITC at least once in their life times. The resulting distribution shows that while the mean percent change in net assets is not different than zero, there is actually a significant increase in the net assets of the women who belong to the target group. Since net assets is

a measure of both a woman's liabilities and assets, this result suggests that the effect of the debt relief provided by the tax credit is dominant for the majority of the women. A further investigation reveals that the women who experience a decline in their net assets have an average net worth of over $8,500. Evidently, for these women with relatively higher levels of net worth, the consumption-smoothing motive dominates the increase in the lifetime wealth as a result of the EITC.

1.8 Policy Analysis

Recently, the EITC has been the focus of the budget negotiations as well as the proposals concerning the cash transfer programs. Most notably, the recent proposals by President Obama and Congressman Ryan involve expansions in the credit for childless workers. In this section, I first analyze the long-term benefits and provide an estimate of the cost of such an expansion. Next, I consider imposing an asset test for the EITC similar to the asset limits in SNAP and TANF. Public benefit programs have historically included asset tests that prevent eligible individuals to accumulate assets and thus, move along the path to financial security. Even though the EITC does not have a formal asset test, in a counterfactual experiment, I analyze the impact of such a limit on women's behaviors in hope of shedding some light on the possible programs these asset tests create for the other public programs' recipients.

1.8.1 Expanding the Tax Credit for Childless Women

Since its implementation, the EITC has undergone major expansions that increased the generosity of the credit as well as the range of eligibility. However, childless taxpayers have benefited the least from these expansions. To give an example, a childless single women who works full time at the minimum wage is not eligible for the tax credit as the level of her labor market earnings is above the eligibility threshold that childless taxpayers face. As a result, the credit fails to provide cash assistance to many low-wage childless taxpayers.

Recently several proposals have been made to expand the credit schedule for the childless workers. Most notably, both President Obama and Congressman Ryan proposed to lower the eligibility age for this group to 21, to double the maximum credit to $1,000, and to raise the ending income for the tax credit to $18,000. These changes imply that both the credit rate and the phase-out rate are doubled to 15.3% for the childless workers. Moreover, this proposal is estimated to have a cost around $60 billion.

Table 15 presents the estimated change in the employment, hours of work, average wages and net assets for single women under the proposed EITC expansion. The results show that under the new credit schedule, the employment rate for single women is expected to rise by 2.2%. However, conditional on employment, the responses in work hours are less responsive to the expansion in the credit schedule. There are two main reasons that generate this result. First, in the sample that I'm using for the empirical analysis, only 30% of the single women have earnings less than $18,000 which is the threshold for eligibility. Thus, the change in the hours of work for eligible women is in fact 3.13%.

Second, among the payment regions of the credit schedule, the subsidy region provides the strongest work incentives. However, even with the EITC expansion for the end income for the subsidy region is quite low. More specifically, for a childless woman to be in the subsidy region, the level of her earnings needs to be lower than $6,570 under the proposed credit schedule. That being said, only 6% of the childless women in my sample have earnings that fall in the subsidy region. As a result, only a few women are subject to the full extent of the work incentives the tax credit provides. Nevertheless, the average wage rate still rises by 1.41% for single childless women. This means that the EITC eligible women experience an increase in the average wage rate by 4.7%. Even though the credit cannot extend the work incentives to the majority of eligible women, because the eligibility age is lowered to 21 with the proposed expansion the effect of human capital accumulation is significant. Finally, the eligible women increase the average net assets by %1.53 (= 0.46/0.3). This result suggests that the consumption smoothing motives for childless women is dominated by the wealth effect created by the EITC.

1.8.2 Imposing an Asset Test

The second policy analysis I consider in this paper is imposing an asset test as one of the eligibility requirement for the EITC. Recent discussions on the effectiveness government transfer programs focus on eliminating the asset tests on SNAP and TANF. The advocates of eliminating the asset limits for government programs argue that these limits provide incentives to drive down assets or to not save at all. However, considering the target population for cash transfer programs, it is evident that helping these individuals in reaching

financial security is a key component for eliminating dependency on government transfers and thus, for promoting self-sufficiency. In line with these arguments, recently several states have eliminated the asset limits for SNAP.

In order to assess whether these asset tests in fact decrease the effectiveness of the government programs, in this section I analyze the responses of single women to an introduction of an asset limit for EITC eligibility. For the analysis I first use the 2002 tax and credit schedule and simulate life-cycle paths for single women. Next, I again use the 2002 tax and credit schedule with an additional requirement for EITC eligibility. More specifically, I impose an asset limit of \$5,000 and simulate the life-cycle paths of single women to see if there is any change in their responses. The results from this exercise are presented in Table 16.

As can be seen from the table due to the asset test, the work incentives provided by the EITC reach out to fewer women and thus the extensive-margin responses to EITC are weaker. In particular, the employment rate fall by 1.5 percentage points or 1.7% as a result of the asset test. The decline in the employment rate is generated by the behavior of women who are not working but living off of their assets. The intensive-margin responses on the other hand are not significantly altered by the introduction of an asset test. This is due to two main factors. First, with the introduction of the asset test, fewer women are now eligible for the EITC. More specifically, the fraction of EITC-eligible women falls from 39% to 34%. Second, the women who are eligible for the EITC work more than they do without the asset test. Since the incentives created by the tax credit discourage saving, these women use their labor market experience

as an insurance that replaces the insurance provided by assets. The change in the wage growth is also negative but insignificant. The decline in the wage growth with the asset test stems from the decline in the employment rate. As mentioned before, career breaks have a detrimental impact on the wage rate a single woman faces. However, due to the asset test, some women cannot benefit from the work incentives the EITC provides and thus, remain unemployed. This, in turn, leads to a decline in their future wages. Finally, the last row of the table indicates that the average net assets of single women fall with the introduction of an asset test. There are two main channels that generate this result. First, the women who remain unemployed as a result of the introduction of an asset test miss on labor market earnings for that period and thus, fail to accumulate assets. In fact, some of these women even dissave as they live off of their assets. Second, low-income women whose assets are slightly above the asset limit decumulate their asset stock in order to be eligible for the tax credit. Third, the women who are eligible for the EITC even with the asset limit cannot accumulate assets unless their earnings are far above the income limit for the tax credit. Therefore, the asset accumulation process slows down considerably. Considering the fact that these women lack the safety net provided by spousal earnings, this decline in the average net assets is quite dangerous. If there is a labor market shock that leaves these women unemployed, they'd be dependent on the government programs as they wouldn't have the necessary savings that would act as a buffer in the periods they remain unemployed.

1.9 Conclusion

This paper develops and estimates a female life-cycle labor supply model with human capital accumulation, borrowing constraints and unobserved heterogeneity in skills and preferences to assess whether the work incentives provided by the EITC is sufficient to promote wage growth. In the analysis, I study the changes in the behavior of single women primarily because they lack the safety net created by spousal earnings. Estimates of the structural parameters, derived using the Panel Study of Income Dynamics shed light on the importance of human capital accumulation and career breaks on wage growth. Comparing the life-cycle profiles simulated under the 2002 tax credit schedule to those without the EITC, I find that EITC is successful in helping single women climb the wage ladder. Further analysis reveals that this wage growth mostly results from the human capital accumulation generated by the tax credit, rather than its immediate effect on the per-period budget constraint.

Using the parameter estimates from the model, I first show that the expansion of the credit for childless workers promotes further wage growth. However, unless the eligibility range of the credit is increased even further, the impact of the EITC would be constrained. In particular, a flatter but longer subsidy region might be more influential in helping childless single women climb the wage ladder. Next, I investigate whether asset tests limit the benefits of government transfers. In particular, I impose an asset limit of $5,000 as an eligibility requirement for the EITC and find that both the work incentives and the wage growth created by the EITC is hindered. More significantly, the asset test slows down the asset accumulation process considerably and thus, leaves single women

more vulnerable to labor market shocks.

A task for future research is to account for partnering and fertility decisions in the model. By doing so, both the marriage penalties and the pro-natal features of the EITC can be better understood. Moreover, as I am only focusing on single women in this paper, the data I am using is not nationally representative. By utilizing a more representative data and a model that can replicate the coupling and fertility dynamics in the data, it would be possible to make a sound cost-benefit analysis for possible reforms on the tax credit. Further research could also extend the model by endogenizing participation in welfare and food stamp programs. This would enable an analysis on whether EITC expansion crowds out welfare dependency. One final extension to this paper could be to add the firm side to the model and to analyze the general equilibrium effects of the EITC. Such an examination would allow an understanding of the complementarities between minimum wage policies and the EITC as both policy instruments target the same group of people. Moreover, by adding the firm side to the analysis, one can investigate the role of the EITC in protecting individuals during recession times against macroeconomic shocks.

1.10 Tables

Table 1.1: The Credit Schedule for 2013

	Credit rate (%)	Minimum income for maximum credit	Maximum credit	Phase-out rate (%)	Phase-out Range	
					Beginning income	Ending income
No child	7.65	6,370	487	7.65	7,970	14,340
One child	34	9,560	3,250	15.98	17,530	37,870
Two children	40	13,430	5,372	21.06	17,530	43,038
Three children	45	13,430	6,044	21.06	17,530	46,227

Table 1.2: Summary Statistics

	Mean	Std. Dev.	Min.	Max.
Age	33.06	9.59	16	66
Fraction of blacks	0.65	0.48	0	1
Fraction of high school dropouts	0.15	0.36	0	1
Fraction of high school graduates	0.4	0.49	0	1
Fraction of college dropouts	0.25	0.44	0	1
Fraction of college graduate	0.19	0.39	0	1
Number of children	0.87	0.88	0	2
Age of youngest child	3.3	4.21	1	17
Fraction employed	0.86	0.34	0	1
Annual work hours among employed	1,819	682.9	10	3,576
Annual earnings among employed ($)	26,836	17,661	123	69,756
Fraction receiving EITC	0.38	0.49	0	1
Federal EITC among EITC recipients ($)	1,900	1,338	1	4,645
State EITC ($)	29.95	134.95	0	1,587.6
Fraction receiving TANF	0.12	0.33	0	1
Average TANF among recipients ($)	3,063	1,721	23	6,494
Fraction receiving SNAP	0.26	0.44	0	1
Average SNAP among recipients ($)	3,467	2,197	45	6,782
Net worth	3,545	12,347	-33,032	72,133

Note: All monetary values are in 2006 dollars.

Table 1.3: Earnings and EITC Recipients by Age and Education Groups

	Avg. Earnings	Avg. Hours	% of EITC Recipients	Avg. EITC	Number of Observations
Age≤25	17,680	1,500	36.3	1,966	1,110
25<Age≤30	24,224	1,667	41.7	2,043	1.043
30<Age≤40	24,584	1,594	41.9	1,968	1,448
* 40<Age≤50	25,495	1,562	34.6	1,808	719 *
50<Age≤60	28,266	1,447	25.3	1,110	273
High School Dropouts	10,212	1,058	56.6	2,074	710
High School Graduates	18,571	1,483	47.6	1,997	1,843
College Dropouts	27,070	1,789	35.2	1,724	1,158
College Graduates	38,316	1,897	8.5	1,503	882

Note: Number of observations refer to the number of observations with non-missing labor market status. The average EITC amount reflects the average of the tax credit amont EITC recipients.

Table 1.4: Age, Education, and Hours Decomposition for EITC Recipients

Age		Education		Annual Work Hours	
Age≤25	22.87	HS Dropout	22.81	Hours<350	8.75
25<Age≤30	24.69	HS Grad.	49.77	350≤Hours<1300	23.85
30<Age≤40	34.39	Coll. Dropout	23.16	1300≤Hours<1950	27.65
40<Age≤50	14.13	Coll. Grad.	4.26	1950≤Hours<2200	27.31
50<Age≤60	3.92			Hours>2200	12.44

Note: The numbers refer to the percentage of EITC recipients that belong to each relevant group.

Table 1.5: Estimates for the Cost of Child Care

Parameter	Variable	Estimate
α_0^{cc}	Constant	15.641^{***}
		(0.1763)
α_1^{cc}	Number of children	3.01^{***}
		(0.5848)
α_2^{cc}	If youngest child is between the age of 3 & 5	0.198
		(0.7695)
α_3^{cc}	If youngest child is between the age of 6 & 10	-3.704^{***}
		(0.778)
α_4^{cc}	If youngest child is between the age of 11 & 17	-9.227^{***}
		(0.8838)
α_5^{cc}	Hours of work choice	0.412^{***}
		(0.0296)
σ_{cc}	Standard deviation of the child care expenditure shock	14.007

Notes: Standard errors in paranthesis. * indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; and *** indicates statistical significance at the 1 percent level. Child care cost is divided by 100.

Table 1.6: Estimates for TANF Participation and Benefits

Parameter	Variable	Estimate
	Participation	
α_0^{pt}	Constant	189.108***
		(31.8729)
α_1^{pt}	Annual earnings	−0.01***
		(0.0008)
α_2^{pt}	Education	−0.186*
		(0.0965)
α_3^{pt}	Whether the woman is black	0.278
		(0.2239)
α_4^{pt}	Age	−0.058***
		(0.0102)
α_5^{pt}	Year	−0.095***
		(0.0159)
α_6^{pt}	State of residence	−0.01
		(0.0462)
	Benefits	
α_0^{tanf}	Constant	31.082
		(23.9887)
α_1^{tanf}	State of residence	−0.051
		(0.0353)
α_2^{tanf}	Year	0.149
		(0.0946)
α_3^{tanf}	Annual earnings	−0.001**
		(0.0006)
α_4^{tanf}	Number of children	0.149
		(0.0946)
σ_{tanf}	Standard deviation of the TANF benefit shock	0.8794

Notes: Standard errors in paranthesis. * indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; and *** indicates statistical significance at the 1 percent level. All monetary variables including the benefits are divided by 100.

Table 1.7: Estimates for SNAP Participation and Benefits

Parameter	Variable	Estimate
	Participation	
α_0^{ps}	Constant	-75.315^{***}
		(21.2609)
α_1^{ps}	Annual earnings	-0.009^{***}
		(0.0005)
α_2^{ps}	Education	-0.22^{***}
		(0.0658)
α_3^{ps}	TANF benefits	0.038^{***}
		(0.005)
α_4^{ps}	Age	-0.03^{***}
		(0.0062)
α_5^{ps}	Year	0.0372^{***}
		(0.0106)
α_6^{ps}	Whether the woman is black	0.7
		(0.1477)
α_7^{ps}	State of residence	0.101
		(0.0336)
	Benefits	
α_0^{snap}	Constant	-20.698^{**}
		(10.3586)
α_1^{snap}	State of residence	-0.028
		(0.0175)
α_2^{snap}	Year	0.014
		(0.0052)
α_3^{snap}	Annual earnings	-0.002^{***}
		(0.0003)
α_4^{snap}	TANF benefits	-0.004^{***}
		(0.0011)
α_5^{snap}	Number of children	0.409^{***}
		(0.0362)
σ_{snap}	Standard deviation of the SNAP benefit shock	0.7309

Notes: Standard errors in paranthesis. * indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; and *** indicates statistical significance at the 1 percent level. All monetary variables including the benefits are divided by 100.

Table 1.8: Estimates of the Transition in the Number of Children

Parameter	Variable	Estimate
	$\Pr(N_{i,t+1} = 1)$	
α^n_{01}	Constant	-1.742^{***}
		(0.2935)
α^n_{11}	Age	-0.055^{***}
		(0.0094)
α^n_{21}	Education	-0.194^{**}
		(0.0888)
α^n_{31}	Age of youngest child if there is a child	0.077
		(0.1162)
α^n_{41}	Number of children	5.544^{***}
		(0.3521)
	$\Pr(N_{i,t+1} = 2)$	
α^n_{02}	Constant	-7.011^{***}
		(0.4397)
α^n_{12}	Age	-0.077^{***}
		(0.0138)
α^n_{22}	Education	-0.388^{***}
		(0.1265)
α^n_{32}	Age of youngest child if there is a child	-0.359^{***}
		(0.1378)
α^n_{42}	Number of children	10.556^{***}
		(0.3924)

Notes: Standard errors in paranthesis. * indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; and *** indicates statistical significance at the 1 percent level. The probability of not having child is calculated using the above probabilities, as having no child is the base group in the estimation.

Table 1.9: Estimates of the Transition in Age of the Youngest Child

Parameter	Variable	Estimate
	$\Pr(N^k_{i,t+1} = 2)$	
α^k_{02}	Constant	-1.21^{***}
		(0.3039)
α^k_{12}	Age	-0.022^{***}
		(0.0072)
α^k_{22}	Education	0.269^{***}
		(0.0679)
α^k_{32}	Number of children	0.208^{*}
		(0.1188)
α^k_{42}	Age of the youngest child	0.3864^{***}
		(0.081)
	$\Pr(N^k_{i,t+1} = 3)$	
α^k_{03}	Constant	-6.281^{***}
		(0.4078)
α^k_{13}	Age	-0.012
		(0.009)
α^k_{23}	Education	0.424^{***}
		(0.0836)
α^k_{33}	Number of children	0.594^{***}
		(0.1439)
α^k_{43}	Age of the youngest child	2.229^{***}
		(0.0994)
	$\Pr(N^k_{i,t+1} = 4)$	
α^k_{04}	Constant	-16.518^{***}
		(0.8201)
α^k_{14}	Age	0.035^{***}
		(0.0132)
α^k_{24}	Education	0.469^{***}
		(0.1189)
α^k_{34}	Number of children	0.682^{***}
		(0.2049)
α^k_{44}	Age of the youngest child	4.827^{***}
		(0.1862)

Notes: Standard errors in paranthesis. * indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; and *** indicates statistical significance at the 1 percent level. The probability of the age of youngest child being less than 2 is calculated using the above probabilities, as it is the base group in the estimation.

Table 1.10: Estimates of the Flow Utility Parameters

Parameter	Variable	Estimate	Std. Error
θ_c	CRRA parameter	0.5123	0.0057
α_2^u	If the woman chooses to work between 1300 and 1950 hours ($d_{it}^h = 2$)	2.1522	0.0452
α_3^u	If the woman chooses to work between 1950 and 2200 hours ($d_{it}^h = 3$)	5.7481	0.0374
α_4^u	If the woman chooses to work more than 2200 hours ($d_{it}^h = 4$)	5.8303	0.0396
α_5^u	$d_{it}^h = 1$ and $d_{i,t-1}^h = 1$	0.1472	0.0591
α_6^u	$d_{it}^h = 2$ and $d_{i,t-1}^h = 2$	0.2031	0.0348
α_7^u	$d_{it}^h = 3$ and $d_{i,t-1}^h = 3$	0.8412	0.0913
α_8^u	$d_{it}^h = 4$ and $d_{i,t-1}^h = 4$	0.8532	0.0901
Marginal Utility of Consumption Shifters			
α_{01}^c	If the woman belongs to type 1	4.1033	1.4820
α_{02}^c	If the woman belongs to type 2	2.105	0.4361
α_{03}^c	If the woman belongs to type 3	3.915	0.2182
α_{04}^c	If the woman belongs to type 4	2.082	0.1421
α_1^c	If the woman is younger than 25	-0.467	0.0902
α_2^c	If the woman is younger than 30	-0.168	0.1203
α_3^c	If the woman is older than 40	-1.279	0.2035
α_4^c	If the woman is older than 50	0.6	0.4783
α_5^c	Number of children	1.038	0.2917
Marginal Disutility of Work Shifters			
α_0^h	Constant	-1.2675	0.0394
α_{12}^h	If the woman is of type 2	-0.057	0.0487
α_{13}^h	If the woman is of type 3	0.134	0.0213
α_{14}^h	If the woman is of type 4	0.192	0.0349
α_2^h	If the woman is younger than 25	-1.2881	0.0183
α_3^h	If the woman is younger than 30	-1.2564	0.0304
α_4^h	If the woman is older than 40	-0.2708	0.0151
α_5^h	If the woman is older than 50	-1.3569	0.0428

Table 1.11: Estimates of the Wage Equation and the Net Asset Lower Bound Parameters

Parameter	Variable	Estimate	Std. Error
Wage Parameters			
α_0^w	Constant	3.1791	1.2451
α_{12}^w	If the woman belongs to type 2	0.11	0.0385
α_{13}^w	If the woman belongs to type 3	6.42	0.9412
α_{14}^w	If the woman belongs to type 4	6.93	0.8463
α_{22}^w	If the woman chooses to work between 1300 & 1950 hours	0.4995	0.2739
α_{23}^w	If the woman chooses to work between 1950 & 2200 hours	0.8246	0.1826
α_{24}^w	If the woman chooses to work more than 2200 hours	0.894	0.1731
α_3^w	Woman's age	0.012	0.0247
α_4^w	If the woman is black	-0.1664	0.0318
α_5^w	Educational attainment	0.041	0.0129
α_6^w	Experience stock	0.135	0.0379
α_{71}^w	If the woman worked less than 1300 hours last year	0.0086	0.0403
α_{72}^w	If the woman worked between 1300 & 1950 hours last year	0.0452	0.0178
α_{73}^w	If the woman worked between 1950 & 2200 hours last year	0.0673	0.0225
α_{74}^w	If the woman worked more than 2200 hours last year	0.0668	0.0289
α_8^w	Calendar year	0.0035	0.0120
α_9^w	State of Residence	0.0921	0.0311
Asset Bound Parameters			
α_0^b	Constant	12.1543	0.9131
α_1^b	Age	-0.131	0.0126
α_2^b	Age-squared	-0.093	0.0899
α_3^b	Schooling	-0.2029	0.0244
$\underline{c}$	Minimum consumption floor	2,118	371

Table 1.12: Estimates of the Type Probabilities and the Error Distributions

Parameter	Variable	Estimate	Std. Error
Prob. of Being a Type 2 Woman			
α_{02}^t	Constant	1.953	0.7121
α_{12}^t	If the woman is a high school dropout	1.723	0.5234
α_{22}^t	If the woman has at least some college education	-0.261	0.1041
Prob. of Being a Type 3 Woman			
α_{03}^t	Constant	2.254	0.4551
α_{13}^t	If the woman is a high school dropout	-0.712	0.2717
α_{23}^t	If the woman has at least some college education	0.683	0.1903
Prob. of Being a Type 4 Woman			
α_{04}^t	Constant	0.879	0.2041
α_{14}^t	If the woman is a high school dropout	-0.547	0.1031
α_{24}^t	If the woman has at least some college education	1.426	0.1923
Error Distributions			
σ_h	Standard deviation of the preference shock	1.1979	0.1923
σ_w	Standard deviation of the wage shock	0.9897	0.0842
ρ_{hw}	Correlation between the preference and the wage shock	-0.5948	0.0679
σ_{mw}	Standard deviation of the measurement error in wages	0.262	0.0213
$\sigma_{ma,0}$	Constant of the standard deviation of the measurement error in assets	1.324	0.1387
$\sigma_{ma,1}$	Slope of the standard deviation of the measurement error in assets	0.141	0.0171

Table 1.13: The Impact of the EITC on Employment, Hours of Work, Wages and Net Assets

	Without HC Accumulation			With HC Accumulation		
	No EITC	With EITC	% Change	No EITC	With EITC	% Change
Employment	0.78	0.80	+2.6	0.84	0.88	+4.8
Hours of Work (cond. on employment)	1,310	1,308	-0.15	1,802	1,835	+1.84
Wage	11.12	11.15	+0.27	13.14	13.8	+5.02
Net Assets	3,143	3,197	+1.72	3,482	3,495	+0.37

Notes: The first two columns of the table show the simulations from the model when the human capital accumulation channel is closed. This means the experience stock and the work hours choice from the previous period has no effect on the wage level. The numbers in the 3rd and the 6th columns show the percent changes between the responses with and without the EITC.

Table 1.14: Percent Change in Wage under EITC (Target Group)

Age groups	% Change	Education Groups	% Change	Nr. of Children	% Change
Age<25	+4	HS dropouts	+16	No child	+4
25<Age<40	+13	HS grads	+14	One child	+9
40<Age<50	+20	Coll. dropouts	+8	Two children	+16
50<Age<60	+23	Coll. grads	+3		

Notes: The numbers show the percent change in the wage rate as between the simulation with and without the EITC.

Table 1.15: The Impact of an EITC Expansion for Childless Women on Employment, Hours of Work, Wages, and Net Assets

	Current EITC Schedule	With EITC Expansion	% Change
Employment	0.91	0.93	+2.2
Hours of Work (cond. on employment)	1,819	1,836	+0.94
Wage	15.01	15.43	+1.41
Net Assets	5,604	5,630	+0.46

Notes: The first column of the table reports the averages of the corresponding variables for single women from the simulations of the model using the current EITC schedule. The second column does the same using the simulations under an EITC expansion for childless workers. The numbers in the 3rd column shows the percent changes between the responses with and without the EITC expansion.

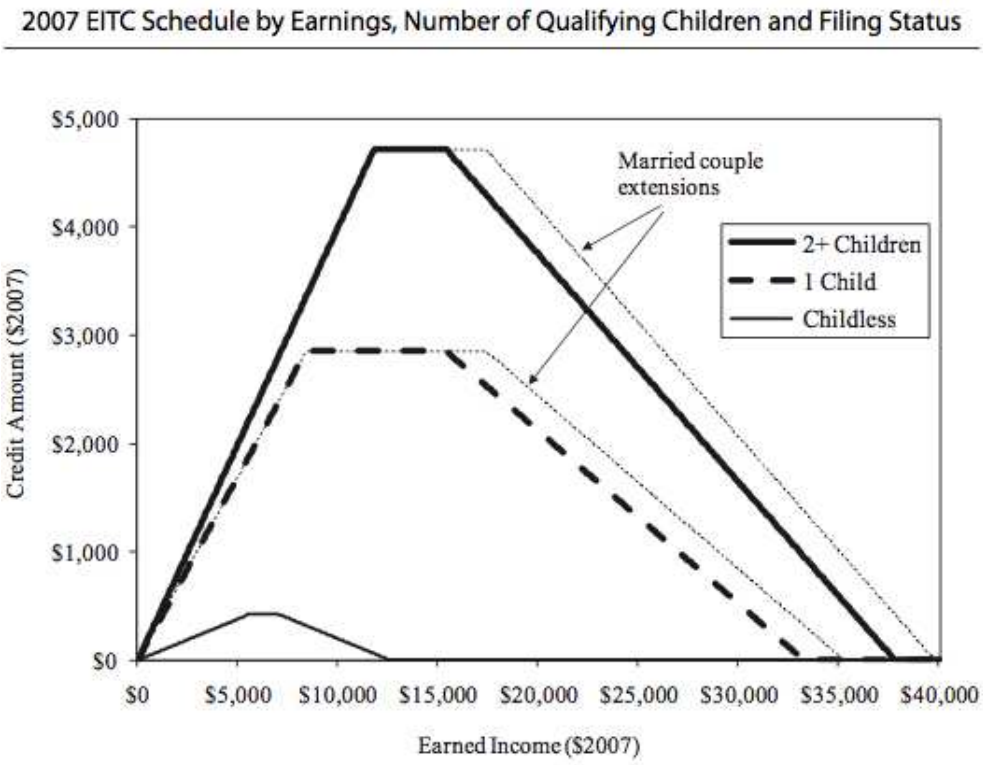
Table 1.16: The Impact of an Asset Limit on Employment, Hours of Work, Wages, and Net Assets

	Current EITC Schedule	With Asset Test	% Change
Employment	0.88	0.865	-1.7
Hours of Work (cond. on employment)	1,835	1,820	-0.82
Wage	13.8	13.4	-0.29
Net Assets	3,495	3,425	-2.01

Notes: The first column of the table reports the averages of the corresponding variables for single women from the simulations of the model using the current EITC schedule. The second column does the same using the simulations under an EITC expansion for childless workers. The numbers in the 3rd column shows the percent changes between the responses with and without the EITC expansion.

1.11 Figures

Figure 1.1: EITC Schedule



Source:Eissa and Hoynes (2006)

Figure 1.2: The Distribution of Net Worth in the Sample

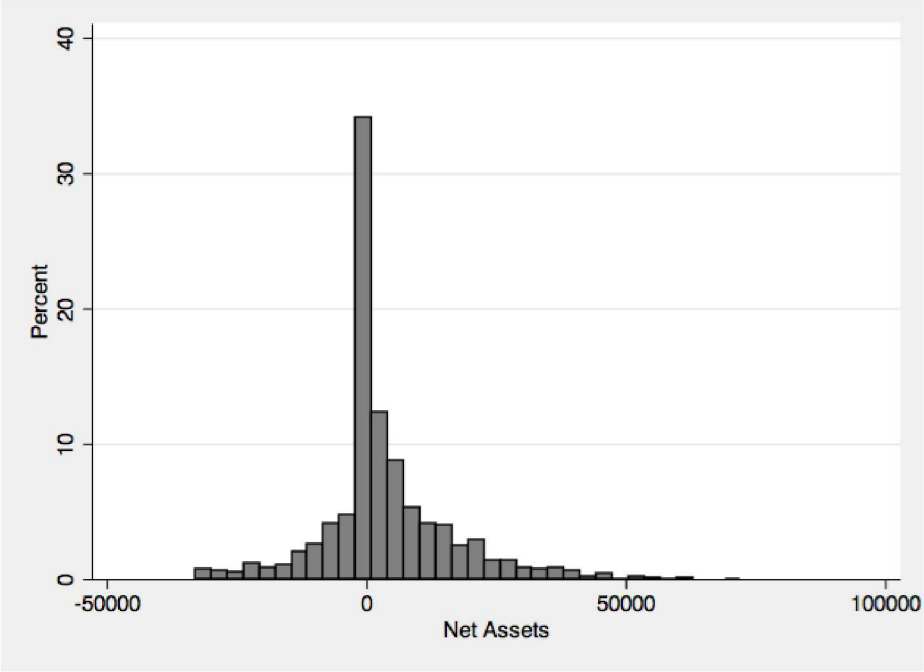


Figure 1.3: Average Wages by EITC Recipiency

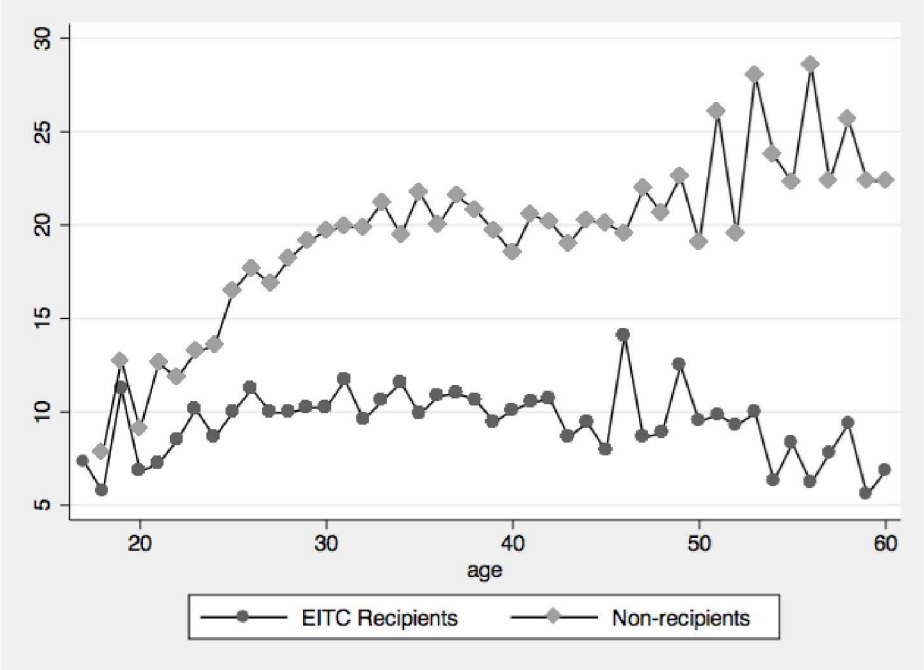
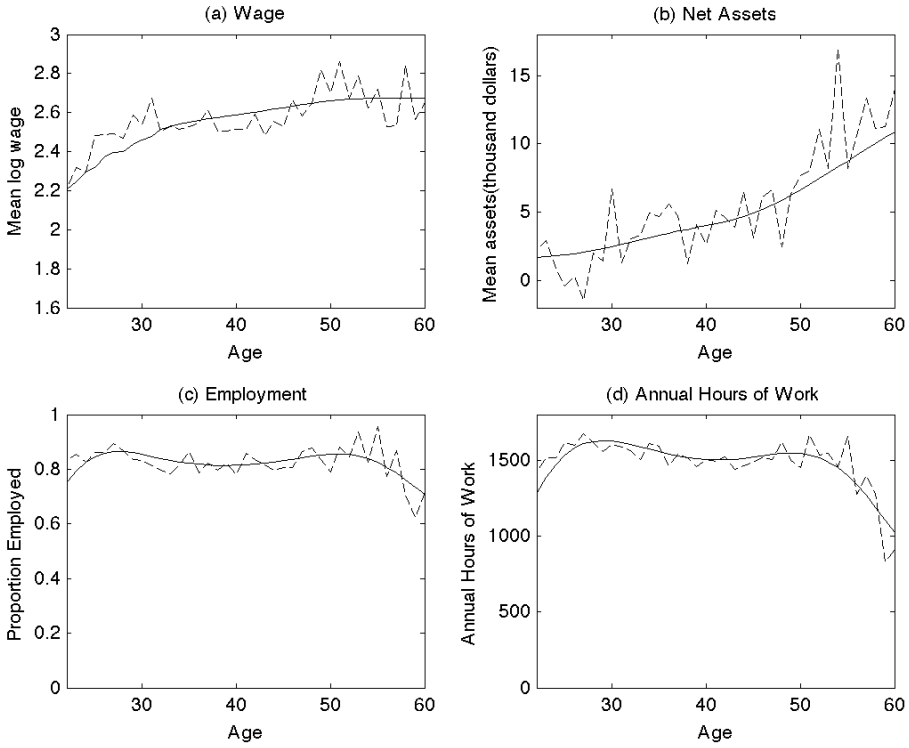
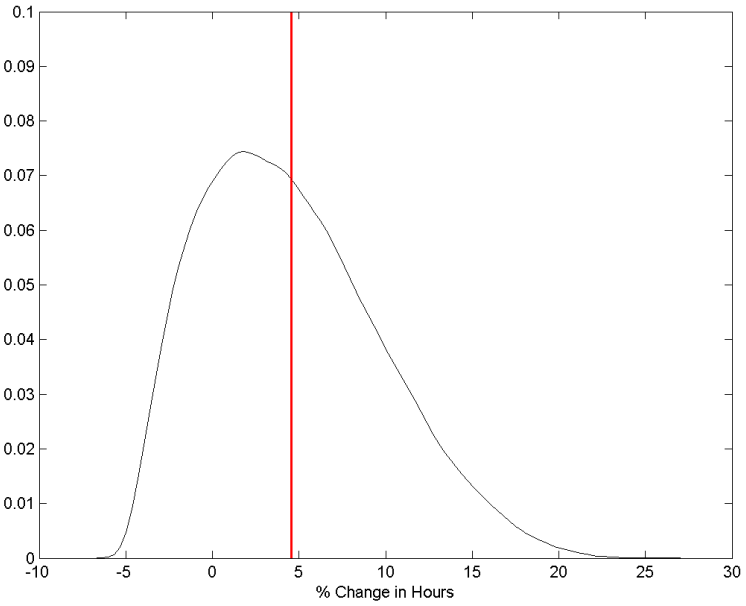


Figure 1.4: Within Sample Fit for Wage, Asset, Employment, and Hours of Work



Note: Dashed lines represent data and solid lines represent simulations.

Figure 1.5: The Distribution of the Change in Work Hours for the EITC Target Group



Note: The red line is the mean of the distribution.

Figure 1.6: The Life-Cycle Wage Path of the Women in the Target Group

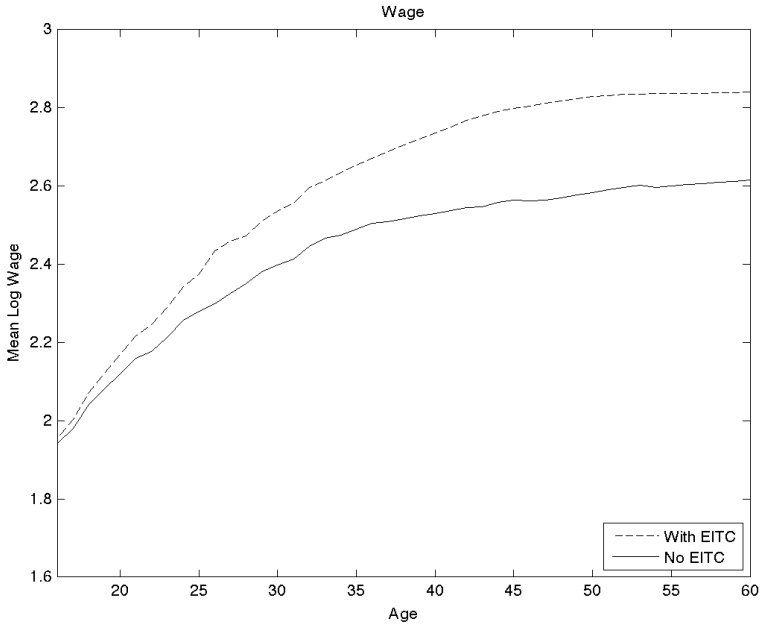


Figure 1.7: Introducing the EITC at Different Stages of the Life-cyce

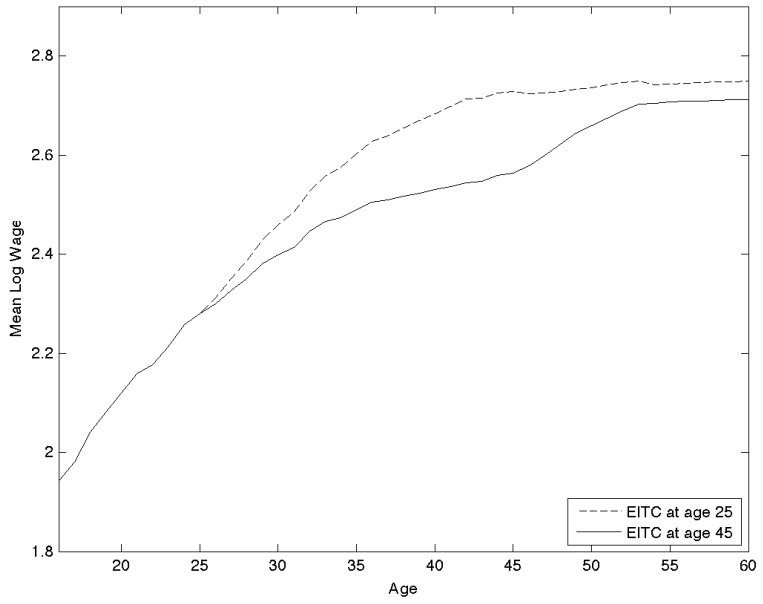
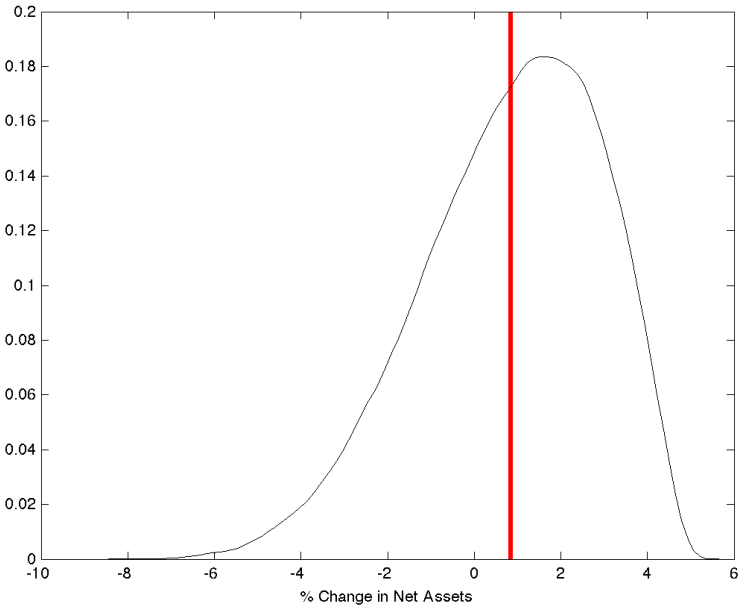


Figure 1.8: The Distribution of the Change in Net Assets for the EITC Target Group



Note: The red line is the mean of the distribution.

Chapter 2

Wage Renegotiations with Labor Market Frictions

2.1 Introduction

One of the distinguishing aspects of workers' labor market experiences is the amount of turnover they face. The reason is that job-to-job transitions are very frequent in a worker's career. Topel and Ward (1992) show that the average number of full time jobs held in the first 10 years of a working career is around 7. Even though some researchers, like Stern, Finkelstein, Stone, Latting, and Dornsife (1994), believe that this turnover is inefficient and lead to wage stagnations, the majority agrees on the fact that the job-to-job movements a worker faces promote wage growth. Mortensen and Pissarides (1999), for example, argue that employed workers move up the wage ladder thanks to the employer-to-employer flows without intervening spells of unemployment. In addition, Heckman (1993) asserts that "Job shopping promotes wage growth. Turnover is another form of investment not demonstrably less efficient than youth apprenticeships.".

Recent research have been using search theoretic models in order to explain wage ladders, job-to-job mobility, and wage inequality of seemingly identical workers in the labor market. These studies use two opposite descriptions to characterize the labor market. The first and most commonly used description is called the random search model. In these models, workers and firms are randomly paired together. Regardless of whether the wage is determined through wage posting or bargaining, the worker does not know anything about the wage before she is matched with that firm (Mortensen, 1970; Burdett and Mortensen, 1998; Postel-Vinay and Robin, 2002). In directed search models, on the other hand, firms post wage offers and workers direct their search to the most attractive alternative for them (Moen, 1997; Shimer, 1996). Random search models are commonly used for analyzing unemployment spells, the consequences of worker heterogeneity, and on-the-job search while directed search models are used for examining the matching processes and wage determination.

Although random and directed search models try to explain the labor market from two different perspectives, the labor market in real life falls somewhere in between these two polar descriptions. In reality, firms are not completely clueless regarding with which worker they are matched as argued by random search models. They also do not post their wages and wait for workers to make applications to fill their vacancies as dictated by directed search models. In fact, labor markets comprise the main components of both of these models. Specifically, firms do target a group of workers when posting their vacancies like in directed search and in return some of the prospects of these job openings are hidden from the workers until a match is formed between a worker and a firm

similar to the random search models.

In this paper, I attempt to incorporate both random search and targeted search by constructing a job search model with wage renegotiations that takes into account the strategic behavior on the firm side. Workers search both when unemployed and employed while firms decide whether to target their vacancies to unemployed or employed workers and whether to match the offers coming to their employees. There is asymmetric information in two dimensions in the model. First, workers' skills are only known to their current employers. Second, workers have idiosyncratic preferences over different jobs and these preferences are unobserved to the firms. Due to the asymmetric information over workers' skill levels, the probability of successfully recruiting an employed worker is lower for a vacant firm. This is because a worker with higher productivity receives matching offers from her current employer in the event of an outside offer, and the only reason she would ever leave her current employer is due to her idiosyncratic preferences that are unobserved to the firms. In equilibrium, however, there is search in both markets because firms with vacancies are indifferent between searching in the unemployed workers' and in the employed workers' markets. In the unemployed workers' market, the average worker productivity is lower but the probability of a successful recruit is higher than in the employed workers' market. The result is that less skilled workers have higher job-to-job mobility than high skilled workers.

The contribution of this paper to the search theory literature is threefold. First, the model incorporates both random and directed search in the labor market. Specifically, firms decide in which market to search, a feature that

makes the model closer to a directed search model. However at the same time firms and workers are matched randomly and thus, the model in the paper also resembles a random search model. To the best of my knowledge, this is the first paper to combine these two different aspects of search theory. Second, the model generates search in multiple markets in equilibrium. The studies in the literature so far has only examined a firm's decision as to whether to enter the labor market or not. After the entry decision, firms are matched with an employed or unemployed worker randomly. For this reason, there has been no research that takes into account search in multiple markets.[1] Finally, this paper analyzes wage renegotiations with multiple firms using a non-cooperative model of bargaining and asymmetric information. Even though there are a few papers that consider a non-cooperative bargaining model for wage negotiations under search frictions, there has been no research in the literature so far that incorporates asymmetric information to this setup.

The rest of the paper is organized as follows. Section 2 presents the literature this paper contributes to. In Section 3, I explain the details of the labor market analyzed in the paper as well as define and characterize the equilibrium in each subgame. In Section 4, I analyze the comparative statics regarding the equilibrium in the employed workers' market by imposing parametric assumptions on the model. Section 5 concludes.

[1]Searching in multiple markets is especially important in a general equilibrium setting since the characteristics of the firms in each market are going to be determined endogenously through firms' decisions in such a setting. Even though in this paper I don't consider a general equilibrium set up, one can consider this paper as the first step in this research agenda.

2.2 Literature Review

This paper mainly contributes to the literature on job search and wage negotiations. There are several studies that consider labor market frictions with and without wage bargaining, including Burdett and Mortensen (1998); Dey and Flinn (2005), and Shephard (2012). However, there are considerably fewer examples of papers that incorporate both search frictions and wage renegotiations (Postel-Vinay and Robin, 2002; Cahuc, Postel-Vinay, and Robin, 2006). Still, even in these papers there is no information asymmetry. Moreover, the equilibra generated by these models state that the incumbent firms match all outside offers up to the marginal productivity of their existing match, without discriminating between workers. For this reason, how the number of job-to-job movers change across skill groups depends on the productivity of the firm that makes the outside offer.

Even though none of the papers in the labor literature incorporate both random and directed search in their analyses, there is one study that has a similar objective. Menzio (2007) studies a search model in which firms have private information about their vacancies and they costlessly communicate this information with unemployed workers. This kind of a setup differs from both random and directed search models because the workers receive some information about the vacancy before the match occurs and because the firms do not post their wages to attract workers but rather they choose messages to advertise their openings. Menzio finds that in equilibrium when the firm posts a more optimistic message, workers demand a higher wage leading to a higher wage outcome in equilibrium.

Private information setting is not common in the analysis of random search models but there are a few papers which focus on asymmetric information in directed search models and in search models that consider auctions. Lauermann and Wolinsky (2015), for example, analyze a sequential search model with adverse selection and study how close the equilibrium prices are to the full-information prices when search frictions are small. Guerrieri, Shimer, and Wright (2010), on the other hand, study a directed search equilibrium where workers have private information about the potential gains from trade. In this setup, firms post contracts while agents observe these contracts and decide where to apply. Guerrieri, Shimer and Wright show that firms offer separating contracts to attract different types of agents in equilibrium.

2.3 The Model

In this section, I first describe the labor market and the characteristics of the workers and firms that I analyze in this paper. Then, I explain the details of the matching and wage barganining processes in this labor market.

2.3.1 The Environment

Consider a labor market in which a measure 1 of atomistic workers face a continuum of competitive firms with a mass normalized to 1. There is no heterogeneity in firm productivities while workers have different levels of skills. A worker's skill level is measured by the amount of efficiency units of labor, ε, she supplies per unit time. The distribution of workers' skills is exogenously

determined. Specifically, the skills of unemployed workers follow a cumulative distribution function $G_u(\varepsilon)$ over the support $[\underline{\varepsilon}, \overline{\varepsilon}]$ and this distribution is assumed to be continuous with density g_u. Similarly, the skill distribution of employed workers has a cumulative distribution function $G_e(\varepsilon)$ over the support $[\underline{\varepsilon}, \overline{\varepsilon}]$. In addition, $G_e(\varepsilon)$ first order stochastically dominates $G_u(\varepsilon)$.

In this labor market, employed workers are also heterogenous with respect to their idiosyncratic match qualities. The match quality is unobserved to the firms and it captures the preferences of the worker concerning the location of the job, company culture, etc. Moreover, the match quality affects the utility of the worker and thus, her decision on whether to stay with the incumbent firm or to accept the job offer of the poaching firm. The difference in the match qualities between the current employer and the firm that makes an outside wage offer to the already employed worker is denoted by d and it follows a uniform distribution with support $[-x, x]$.

Workers maximize their expected payoffs and firms maximize their expected profits. The utility a worker who is employed with a wage offer w and a match quality q receives is

$$u(w, q) = w + q. \tag{2.1}$$

An unemployed worker's utility is determined by the income flow she receives in the form of unemployment benefits. An unemployed worker receives an income flow b, with b being a positive constant.[2]

[2]In U.S., benefits are generally paid by state governments and eligible workers receive around $40 - 50\%$ of their previous pay depending on the state. In this specification, I ignore this fact and assume that all workers receive the same benefits. It is possible to assume the benefits are determined based on workers' skills but that would require assuming the skill level of a worker reflects her previous pay perfectly.

The marginal productivity of a match between a worker with skill level ε and a firm is $h(\varepsilon)$ where $h(.)$ is a strictly increasing, continuous, concave function with $h(\varepsilon) > 0$, $\forall\, \varepsilon \in [\underline{\varepsilon}, \bar{\varepsilon}]$. A firm which employs a type-ε worker from a wage level w receives

$$\pi(\varepsilon, w) = h(\varepsilon) - w. \tag{2.2}$$

On the other hand, a vacant firm receives a flow profit of π_0. This flow profit captures the firm's valuation of a vacant job slot. However, note that this value can potentially be negative to indicate a cost of remaining vacant. Throughout this paper I assume that $\pi_0 = 0$, which can be generated as a result of free entry and exit for the firms in the search market.

2.3.2 Matching and Wage Bargaining

Before any matching occurs, firms with vacant positions choose to post their vacancies either to the pool of unemployed or to the pool of employed workers. In this paper, I assume that these two submarkets are already formed during the period of analysis. The firms and workers are brought together pairwise through a sequential, random and time-consuming search process. Unemployed workers sample job offers with probability λ_u. Employed workers may also search for other jobs and the offer arrival probability of offers for on-the-job searchers is λ_e. I do not impose any restrictions on the relative magnitudes of offer arrival probabilities in the employed and unemployed workers' markets at this point.

Wage bargaining occurs in an incomplete information setting. This is because firms cannot observe the types of workers they are matched with before

the wage is settled. In the unemployed workers' market, firms make take-it-or-leave-it wage offers to the workers after a match is formed. After observing this wage offer, an unemployed worker then decides whether to take the job offer or to stay unemployed. Correspondingly, once a vacant firm is matched with an already employed worker in the employed workers' market, the poaching firm makes a take-it-or-leave-it wage offer and the incumbent firm which currently employes the worker makes a counter-offer after observing the poaching firm's wage offer. Seeing both of these wage offers and taking her current wage into consideration, an already employed worker then decides whether to stay at the incumbent firm or to leave to work at the poaching firm. In this set up, the incumbent firm has superior information over the poaching firm as the poaching firm cannot observe the skill level of the worker, while the incumbent firm can. However, note that neither of these firms know about what the worker thinks about the match qualities. Therefore, a worker can have a lower wage once she changes jobs even though she gets a greater payoff from working at her new job due to a higher match quality. However, if the worker stays with the incumbent after she receives an outside offer, the incumbent cannot impose a lower wage than the worker's wage before she received the outside offer. In addition, I assume that there are no renegotiation costs.[3]

[3]This paper in fact considers a given period of a labor market that has existed since the beginning of time. However in this setup workers and firms only consider their static payoffs and do not take into account the continuation values from their actions. For this reason, it might be more appropriate to characterize the model in this paper as one, that considers the final period of a labor market. Even though this is a very restrictive specification, it is suitable for the main goal of this paper.

2.3.3 Unemployed Workers' Market

In this section I define and characterize the equilibrium in the unemployed workers' market.

2.3.3.1 Equilibrium Definition

An equilibrium for the unemployed workers' market consists of a wage offer $w_u^* \in \mathbb{R}_+$ by the firm and an acceptance strategy $a_u^*:[\underline{\varepsilon}, \overline{\varepsilon}] \times \mathbb{R}_+ \to [0,1]$ for the worker, where $a_u^*(\varepsilon, w_u)$ denotes the probability that a type ε worker accepts the wage offer w_u, such that:

(i) For each ε and w_u, the probability $a_u^*(\varepsilon, w_u)$ maximizes worker's expected payoff:

$$a_u^*(\varepsilon, w_u) \in \underset{a \in [0,1]}{\arg\max} \;\; aw_u + (1-a)b, \tag{2.3}$$

(ii) Given $a_u^*(\varepsilon, w_u)$, firm's wage offer w_u^* maximizes its expected profits:

$$w_u^* \in \underset{w \in \mathbb{R}_+}{\arg\max} \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} a_u^*(\varepsilon, w)\,[h(\varepsilon) - w]\,dG_u(\varepsilon). \tag{2.4}$$

The above definition states that when a vacant firm and an unemployed worker is matched, the vacant firm makes a wage offer that maximizes its expected profits. The firm considers its expected profits in making this decision because it cannot observe the skill level of the worker. The worker, on the other hand, compares her payoff from remaining unemployed and working for the firm.

2.3.3.2 Equilibrium Characterization

I characterize the equilibrium of this subgame using backward induction. Therefore, I start with analyzing the worker's strategy.

The worker gets b from remaining unemployed, while her payoff is w_u if she accepts the job offer. For this reason, the worker accepts the offer as long as $w_u > b$. This implies

$$a_u^*(\varepsilon, w_u) = \begin{cases} 1 & \text{if } w_u > b, \\ 0 & \text{if } w_u < b, \\ \overline{a} & \text{if } w_u = b, \end{cases} \tag{2.5}$$

for some $\overline{a} \in [0, 1]$. However, I assume $\overline{a} = 1$, which means that even if the worker gets equal payoff from remaining unemployed and accepting the firm's job offer, she chooses to accept the firm's offer.

The firm does not observe the worker's skill. However, it knows that for a given w_u, the worker accepts the wage offer if and only if $w_u \geq b$. Therefore, if the firm offers $w_u \geq b$, all unemployed workers, regardless of their skills, accept the firm's wage offer. Note that, offering $w_u = b$ strictly dominates offering $w_u > b$. This is because making a wage offer that is greater than b does not change the worker's probability of accepting the wage offer and only decreases the profit the firm gets from hiring a worker with any given skill level. On the other hand, when $w_u < b$ all unemployed workers reject the wage offer since staying unemployed brings a higher payoff. Then, offering $w_u = b$ strictly dominates offering $w_u < b$ if and only if

$$\mathbb{E}\left[h(\varepsilon)\right] - b > 0, \tag{2.6}$$

or in other words, if only if the expected marginal productivity of a worker is higher than the unemployment benefits which is equal to the mininum marginal cost of hiring a worker from the unemployed workers' market. In order to have an equilibrium in which firms can hire workers from the unemployed workers' market, I assume that $\mathbb{E}\left[h(\varepsilon)\right] - b > 0$ for the remainder of this paper. With this assumption, it follows that the equilibrium wage offer by the firm is $w_u^* = b$. Morever, in equilibrium all unemployed workers who are matched with a firm accept the wage offers they receive.

Now that the equilibrium strategies of unemployed workers and the vacant firms which post their vacancies to the unemployed workers' market are determined, I continue the analysis with comparative statics. Since whether the firm offers $w_u = b$ or does not make an offer at all depends on equation (2.6) being satisfied, I start with the impact of the level of unemployment benefits on the equilibrium. Let $\bar{b}$ be the level of unemployment benefits that is equal to the mean marginal productivity of the workers in this labor market. That is,

$$\mathbb{E}[h(\varepsilon)] - \bar{b} = 0. \tag{2.7}$$

Then, it is possible to infer that $\forall b > \bar{b}$, there is no hiring in equilibrium in the unemployed workers' market and $\forall b < \bar{b}$, all firms offer $w_u^* = b$ and all unemployed workers who are matched with a firm accept their wage offers in equilibrium. If $b = \bar{b}$, then a firm receives equal expected profit from offering b and from not making a wage offer at all. In that case, the firm randomizes.

Second, I analyze how the equilibrium changes with respect to the skill distribution of the workers in the unemployed workers' market $G_u(\varepsilon)$. Consider

two distribution functions, $F(\varepsilon)$ and $G(\varepsilon)$, that describe the skill distribution in this market. Moreover, suppose $F(\varepsilon)$ first order stochastically dominates $G(\varepsilon)$. The definition of first order stochastic dominance implies that

$$\mathbb{E}_F[h(\varepsilon)] > \mathbb{E}_G[h(\varepsilon)], \tag{2.8}$$

as long as $h(\varepsilon)$ is strictly increasing. This means that the expected marginal productivity in the unemployed workers' market is higher if the distribution of skills in this market is defined by $F(\varepsilon)$ rather than by $G(\varepsilon)$. Next, let $\bar{b}_F$ and $\bar{b}_G$ be the levels of unemployment benefits that are equal to the mean marginal productivities of unemployed workers under the skill distributions $F(.)$ and $G(.)$, respectively. Equation (2.8) implies that

$$\bar{b}_F > \bar{b}_G. \tag{2.9}$$

Therefore, in equilibrium there is hiring in the unemployed workers' market for a larger interval of b values if the skills in this market are distributed with $F(\varepsilon)$ rather than with $G(\varepsilon)$. In other words, if the firms have a greater probability of matching with workers with higher skills, there is hiring in equilibrium even for higher levels of unemployment benefits.

Finally, let us consider how the equilibrium changes with respect to the changes in the marginal productivity function $h(\varepsilon)$ in this market. Specifically, consider $c(\varepsilon)$ to be a concave transformation of the baseline marginal productivity function $h(\varepsilon)$. This means that when $c(\varepsilon)$ defines marginal productivity, the incremental increase in the marginal productivity of a worker with an incremental increase in the skill level is smaller compared to the increase when

$h(\epsilon)$ defines the marginal productivity of the workers in this market. Note that, a concave transformation of a strictly increasing concave function need not be strictly increasing. Moreover depending on the specific function choice for the concave transformation, the way equlibrium outcomes change is affected drastically. I show this with two specific examples. First, let the strictly increasing function $h(\varepsilon)$ be defined as

$$h(\varepsilon) = \varepsilon^{\frac{1}{2}}. \tag{2.10}$$

Next, consider two strictly increasing concave transformations of this function, $c_1(\varepsilon)$ and $c_2(\varepsilon)$, such that

$$\begin{aligned} c_1(\varepsilon) &= \varepsilon^{\frac{1}{3}}, \\ c_2(\varepsilon) &= \frac{1}{2}\ln(\varepsilon). \end{aligned} \tag{2.11}$$

Moreover, suppose the distribution of skills in the unemployed workers' market follows a uniform distribution over the support $[\frac{1}{2}, 1]$. Whether the marginal productivity in this market is defined by $h(.)$, $c_1(.)$, or $c_2(.)$ does not change the equilibrium strategies of the unemployed workers or the firms that post their vacancies to the unemployed workers' market. However, these specifications matter for the level of unemployment benefits for there to be hiring in this market. The expected marginal productivities in this market under these parametric assumptions are as follows:

$$\begin{aligned} \mathbb{E}[h(\varepsilon)] &= 0.43, \\ \mathbb{E}[c_1(\varepsilon)] &= 0.45, \\ \mathbb{E}[c_2(\varepsilon)] &= -0.08. \end{aligned} \tag{2.12}$$

These results imply that when $c_1(\varepsilon)$ defines the marginal productivity in this market instead of $h(\varepsilon)$, in equilibrium these is hiring for higher levels of unemployment benefits. However if we compare the expected marginal productivities under $h(\varepsilon)$ and $c_2(\varepsilon)$, the result is the opposite. In fact for any $b \geq 0$, there is no hiring in this market when $c_2(\varepsilon)$ specifies how the skills of a worker impact her marginal productivity in a given firm. For this reason, it is not possible to make a generalization about how changes in the function $h(\varepsilon)$ affects equilibrium outcomes.

2.3.4 Employed Workers' Market

This section defines and characterizes the equilibrium in the employed workers' market. I first explain the worker's decision, then consider the incumbent firm's strategy and finally, analyze the poaching firm's strategy.

Before moving on to defining the equilibrium in the employed workers' market, let me clarify why I use the difference in match qualities rather than using the individual match qualities for both the incumbent and the poaching firms in the following analysis. First, let q_{inc} and q_{pf} be the match qualities the worker gets from working at the incumbent and the poaching firms, respectively. In order to decide which firm to choose the worker compares the payoffs she gets from working at these two firms. In other words, the worker compares $\max\{w_{inc}, \overline{w}\} + q_{inc}$ to $w_{pf} + q_{pf}$ when making her decision. If we denote worker's probability of staying at the incumbent firm as $a_e(\varepsilon, q_{inc}, q_{pf}, w_{inc}, w_{pf})$, then the

worker's maximization problem can be written as

$$a_e(\varepsilon, q_{inc}, q_{pf}, w_{inc}, w_{pf}) \in \underset{a\in[0,1]}{\arg\max}\ a\left[\max\{w_{inc}, \overline{w}\} + q_{inc}\right] + (1-a)\left[w_{pf} + q_{pf}\right], \tag{2.13}$$

Equation (2.13) can also be written in the following form

$$a_e(\varepsilon, q_{inc}, q_{pf}, w_{inc}, w_{pf}) \in \underset{a\in[0,1]}{\arg\max}\ a\left[\max\{w_{inc}, \overline{w}\} - w_{pf} + q_{pf} - q_{inc}\right] + w_{pf} + q_{pf}, \tag{2.14}$$

which is equivalent to

$$a_e(\varepsilon, d, w_{inc}, w_{pf}) \in \underset{a\in[0,1]}{\arg\max}\ a\left[\max\{w_{inc}, \overline{w}\} - w_{pf} + d\right]. \tag{2.15}$$

For this reason, in the following analysis I work with the difference in the match qualities between the poaching and the incumbent firms rather than working with the individual match qualities for these two firms.

2.3.4.1 Equilibrium Definition

An equilibrium for the employed workers' market consists of a wage offer w^*_{pf} by the poaching firm, a wage offer $w^*_{inc} : [\underline{\varepsilon}, \overline{\varepsilon}] \times \mathbb{R}_+ \to \mathbb{R}_+$ by the incumbent firm, and a staying strategy $a^*_e : [\underline{\varepsilon}, \overline{\varepsilon}] \times [-x, x] \times \mathbb{R}_+ \times \mathbb{R}_+ \to [0, 1]$ for the worker, where $a^*_e(\varepsilon, d, w_{inc}, w_{pf})$ denotes the probability that a type ε worker who sees the difference between the match qualities of the two firms as d and receives wage offers w_{inc} and w_{pf} from the incumbent and the poaching firms respectively stays at the incumbent firm, such that:

(i) For each ε, d, $w_{inc}(\varepsilon, w_{pf})$, and w_{pf}, the probability $a^*_e(\varepsilon, d, w_{inc}(\varepsilon, w_{pf}), w_{pf})$

maximizes worker's payoff:

$$a_e(\varepsilon, d, w_{inc}(\varepsilon, w_{pf}), w_{pf}) \in \underset{a\in[0,1]}{\arg\max}\ a\left[\max\{w_{inc}(\varepsilon, w_{pf}), \overline{w}\} - w_{pf} + d\right], \tag{2.16}$$

(ii) Given $a_e^*(\varepsilon, d, w_{inc}(\varepsilon, w_{pf}), w_{pf})$, the incumbent firm's wage offer $w_{inc}^*(\varepsilon, w_{pf})$ maximizes incumbent firm's expected profits for each ε and w_{pf}:

$$w_{inc}^*(\varepsilon, w_{pf}) \in \underset{w\in\mathbb{R}_+}{\arg\max} \int_{-x}^{x} a_e^*(\varepsilon, d, w, w_{pf})\left[h(\varepsilon) - w\right] dF(d) \tag{2.17}$$

(iii) Given $a_e^*(\varepsilon, d, w_{inc}(\varepsilon, w_{pf}), w_{pf})$ and $w_{inc}^*(\varepsilon, w_{pf})$, the poaching firm's wage offer w_{pf}^* maximizes poaching firm's expected profits:

$$w_{pf}^* \in \underset{w\in\mathbb{R}_+}{\arg\max} \int_{-x}^{x}\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} a_e^*(\varepsilon, d, w_{inc}^*(\varepsilon, w), w)[h(\varepsilon) - w] dG_e(\varepsilon)\, dF(d) \tag{2.18}$$

According to this equilibrium definition, the poaching firm chooses the wage offer that maximizes its expected profits by incorporating the workers with different skills, who face different match qualities have different staying strategies and incumbent firms that employ workers with different skills offer different wages to their current employees after these workers receive outside offers. After observing the wage offer by the poaching firm, the incumbent decides on its counter-offer based on the skill level of its curent employee. The incumbent also considers its expected profit when deciding on the level of the wage it's going to offer. This is because the incumbent cannot observe what the workers think of the difference in the match qualities between the poaching and the incumbent firms. Finally, after observing the wage offers by the poaching firm and the incumbent, the worker chooses its staying strategy by comparing

her payoff from staying at her current job to her payoff from working at the poaching firm.

2.3.4.2 Equilibrium Characterization

In order to characterize the equilibrium, I use backward induction which necessitates starting with an analysis of the worker's staying strategy.

The worker stays at the incumbent firm as long as the payoff she gets from the incumbent is at least as high as the payoff she gets from the poaching firm.[4] Then, the worker's best response can be defined as:

$$a_e^*(\varepsilon, d, w_{inc}(\varepsilon, w_{pf}), w_{pf}) = \begin{cases} 1 & \text{if } \max\{w_{inc}, \overline{w}\} \geq w_{pf} + d, \\ 0 & \text{if } \max\{w_{inc}, \overline{w}\} < w_{pf} + d. \end{cases} \tag{2.19}$$

Before moving on to the equilibrium strategy of the incumbent firm, let me first talk about the current wage $\overline{w}$ of the workers. In this paper, I consider only one period of a dynamic labor market. However, because the current wage of a worker $\overline{w}$ in any given period is determined through the events of the previous periods, I assume $\overline{w}$ is exognous and I don't specify how it is determined. Just to give an idea, consider an employed worker who entered the employed workers' market last period. From the analysis of the unemployed workers' market, we know that her current wage should be equal to the level of unemployment benefits b. On the other hand, if we consider another worker who has been employed for several periods, it is not possible to determine her current wage by only knowing the equilibrium strategies of the incumbent and

[4] With this statement, I am ignoring the possibility that the worker randomizes when the payoffs from the two firms are equal. I assume the worker stays at the incumbent firm even if leaving gives her the same payoff. This assumption is without loss of generality because the random variable d is continuous. Due to the definition of d, $\max\{w_{inc}, \overline{w}\}$ being equal to w_{pf} is actually a zero-probability event.

the poaching firms. The number of outside offers this worker has received so far and the realizations of d in each of these events are important in order to understand whether the worker changes jobs or stays with the incumbent. For all these reasons, I treat $\overline{w}$ as an exogenous variable. In doing so, I also make the following assumption

$$\mathbb{E}_e[h(\varepsilon)] \geq \overline{w} + 3x, \tag{2.20}$$

which tells that the mean marginal productivity in the employed workers market is significantly great than the current wage. This assumption is important for the analysis because it implies that the poaching firm never offers a wage level that is smaller than $\overline{w} + x$. If that is the case, the incumbent need to make a counter wage offer rather than keeping the wage at the current level in order to keep its employee. Therefore, assuming the inequality in (2.20) holds in fact implies that

$$\max\{w_{inc}, \overline{w}\} = w_{inc}. \tag{2.21}$$

Now that we know more about the current wage the incumbent pays, it is possible to move on to characterize the equilibrium strategy of the incumbent. The incumbent firm observes the type of the worker but not the match quality differences between the two firms. Moreover, the incumbent infers that the worker stays at her current job if and only if

$$w^*_{inc}(\varepsilon, w_{pf}) \geq w_{pf} + d. \tag{2.22}$$

Since d is uniformly distributed over the support $[-x, x]$, $\Pr(d \leq w^*_{inc}(\varepsilon, w_{pf}) - w_{pf})$ is equal to $\dfrac{w^*_{inc}(\varepsilon, w_{pf}) - w_{pf} + x}{2x}$. Therefore, the optimization problem of

the incumbent can be written as

$$w^*_{inc}(\varepsilon, w_{pf}) \in \arg\max_{w \in \mathbb{R}_+} \left(\frac{w - w_{pf} + x}{2x} \right) (h(\varepsilon) - w) . \tag{2.23}$$

Assuming an interior solution, the first order condition leads to the following solution for the incumbent's wage offer.

$$w^*_{inc}(\varepsilon, w_{pf}) = \frac{h(\varepsilon) + w_{pf} - x}{2} \tag{2.24}$$

This solution tells that the incumbent's wage offer is equal to the arithmetic average of the worker's marginal productivity $h(\varepsilon)$, which is the highest possible wage the incumbent ever offers, and the lowest possible wage offer with which the incumbent can keep its worker, $w_{pf} - x$.[5] Note that, the incumbent never makes a wage offer that is higher than the marginal productivity of the worker because such a wage offer brings negative profits.[6] However, this interior solution does not take into account the fact that the incumbent never makes a wage offer higher than $h(\varepsilon)$. In fact, when the poaching firm's wage offer w_{pf} is great than $h(\varepsilon) + x$, the incumbent is indifferent between offering any wage taht falls in the interval $[0, h(\varepsilon)]$. Therefore, I assume without loss of generality that the incumbent offers $w_{inc} = 0$ when $w_{pf} > h(\varepsilon) + x$. The following function, then,

[5] As mentioned before, the worker compares $w_{pf} - d$ and w_{inc} in order to decide which offer to accept. Therefore, the incumbent needs to offer at least $w_{pf} - x$ if it wants to have a chance of keeping its employee.

[6] In a dynamic settng, the incumbent may offer a wage that is higher than the marginal productivity of the worker in order to reach a higher level of profit in the future. This is not possible in the static model this paper considers because the agents in the labor market do not take into account the continuation values of their actions.

defines the incumbent's equilibrium strategy:

$$w^*_{inc}(\varepsilon, w_{pf}) = \begin{cases} 0 & \text{if } w_{pf} > h(\varepsilon) + x, \\ \dfrac{h(\varepsilon) + w_{pf} - x}{2} & \text{otherwise.} \end{cases} \tag{2.25}$$

The definition in (2.25) implies that when $w_{pf} > h(\varepsilon) + x$, the incumbent loses its worker to the poaching firm because $\max\{w_{inc}, \overline{w}\} < w_{pf} + d$ for all $d \in [-x, x]$. Moreover, losing its worker means that the incumbent receives zero profit. However, when $w_{pf} \leq h(\varepsilon) + x$, the incumbent gets to keep the worker as long as $d \leq \dfrac{h(\varepsilon) - w_{pf} - x}{2}$. In that case the incumbent's profit is equal to $\dfrac{h(\varepsilon) - w_{pf} + x}{2}$.

The poaching firm cannot observe the type of the worker or the match qualities. However, it can infer that the equilibrium strategy of the incumbent is defined by the function in (2.25). First, let us consider the case where $w_{pf} \leq h(\varepsilon) + x$. Figure 2.1 depicts the relation between w_{pf}, w_{inc}, and $h(\varepsilon)$ when $w_{pf} \geq h(\varepsilon) + x$. The length of the interval labelled as A in Figure 2.1 is equal to $\dfrac{h(\varepsilon) - w_{pf} + x}{2}$. If this interval A is larger than 2x, it implies that $w_{pf} + d < w_{inc}$ for all $d \in [-x, x]$. Therefore when $\dfrac{h(\varepsilon) - w_{pf} + x}{2} > 2x$ or $h(\varepsilon) - 3x > w_{pf}$, the worker stays at her current job and the poaching firm gets zero profit. In addition, this means that for a given w_{pf}, the poaching firm can never capture the workers whose skill levels satisfy

$$\varepsilon > h^{-1}(w_{pf} + 3x) \tag{2.26}$$

However if A is smaller than or equal to 2x, or $h(\varepsilon) - 3x \leq w_{pf}$, the poaching firm gets the worker depending on the realization of the difference in the match qualities, d. In order for the poaching firm to capture the worker,

the sum of its wage offer and the match quality difference needs to be greater than the wage offer by the incumbent firm. This inequality defines the interval for d that leads to the worker to switch to the poaching firm.

$$\begin{aligned} w_{pf} + d &> w_{inc}, \\ w_{pf} + d &> \frac{h(\varepsilon) + w_{pf} - x}{2}, \\ d &> \frac{h(\varepsilon) - w_{pf} - x}{2}. \end{aligned} \tag{2.27}$$

Therefore for a given w_{pf}, the poaching firm captures the workers with skill levels that satisfy

$$\varepsilon \leq h^{-1}(w_{pf} + 3x) \tag{2.28}$$

if only if $d > \frac{h(\varepsilon) - w_{pf} - x}{2}$. When that happens, the poaching firm's profit is $h(\varepsilon) - w_{pf}$.

Next, consider the case where $w_{pf} > h(\varepsilon) + x$. In this case, the worker always switches to the poaching firm regardless of the realization of d. This is because for all $d \in [-x, x]$, $w_{pf} + d > \max\{w_{inc}, \overline{w}\} = \overline{w}$. This implies that for any given w_{pf}, workers with skill levels

$$\varepsilon < h^{-1}(w_{pf} - x) \tag{2.29}$$

always switch to the poaching firm. However, the poaching firm makes a loss from hiring these workers as their marginal productivity is low.

Putting all these facts together, the poaching firm chooses the wage level it is going to offer to the employed workers by maximizing its expected profit

which is defined as follows

$$w_{pf}^{*} \in \arg\max_{w \geq \overline{w}+x} \int_{\underline{\varepsilon}}^{h^{-1}(w-x)} [h(\varepsilon)-w]\, dG_e(\varepsilon) + \int_{h^{-1}(w-x)}^{h^{-1}(w+3x)} \left[1 - F\left(\frac{h(\varepsilon)-w-x}{2}\right)\right] [h(\varepsilon)-w]\, dG_e(\varepsilon). \tag{2.30}$$

The first order condition for this maximization problem leads to the following implicit definition of w_{pf}^{*}:

$$\begin{aligned}(-2w_{pf}^{*} - 3x)G_e\left(h^{-1}(w_{pf}^{*}+3x)\right) + (2w_{pf}^{*} - x)G_e\left(h^{-1}(w_{pf}^{*}-x)\right) \\ + 2\int_{h^{-1}(w_{pf}^{*}-x)}^{h^{-1}(w_{pf}^{*}+3x)} h(\varepsilon)\, dG_e(\varepsilon) = 0\end{aligned} \tag{2.31}$$

Once again, the implicit definition of w_{pf}^{*} in equation (2.31) assumes that the solution is an interior solution. However, as I have established before, the poaching firm never offers a wage that is lower than $\overline{w}+x$. For this reason, the equilibrium strategy of the poaching firm can be written as in equation (2.32), where w^{*} is the wage level that satisfies equation (2.31):

$$w_{pf}^{*} = \max\{w^{*}, \overline{w}+x\}. \tag{2.32}$$

Unfortunately, it is not possible to examine whether the wage level that satisfies equation (2.31) is greater than $\overline{w}+x$. Therefore in order to talk about comparative statics, I impose parametric assumptions on the model in the following sections.

2.3.5 Firm's Market Choice

2.3.5.1 Equilibrium Definition

An equilibrium for this subgame consists of a market choosing startegy $a_f^* \in [0,1]$ for a vacant firm, where a_f^* denotes the probability that a firm posts its vacancy to the unemployed workers' market, such that:
Given $a_u^*(\varepsilon, w_u)$, w_u^*, $a_e^*(\varepsilon, d, w_{inc}(\varepsilon, w_{pf}), w_{pf})$, $w_{inc}^*(\varepsilon, w_{pf})$, and w_{pf}^*, the probability a_f^* maximizes the vacant firm's expected payoff:[7]

$$a_f^* \in \underset{a\in[0,1]}{\arg\max}\ a\left\{\lambda_u \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} a_u^*(\varepsilon, w_u^*)[h(\varepsilon) - w_u^*]\, dG_u(\varepsilon)\right\}$$

$$+(1-a)\left\{\lambda_e \int_{-x}^{x}\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \left(1 - a_e(\varepsilon, d, w_{inc}^*(\varepsilon, w_{pf}^*), w_{pf}^*)\right)[h(\varepsilon) - w_{pf}^*]\, dG_e(\varepsilon)\, dF(d)\right\}. \tag{2.33}$$

This equilibrium definition states that a vacant firm decides whether to post its vacancy to the employed workers' market or to the unemployed workers' market by comparing the expected profits it is going to receive from these two choices. If it chooses to post its vacancy to the unemployed workers' market, with probability λ_u it's going to get matched to an unemployed worker and it is going to offer a wage w_u^* defined by its equilibrium strategy in the unemployed workers' market. In that case, the unemployed worker this firm is matched with decides whether to accept the wage offer w_u^* based on her equilibrium strategy $a_u^*(\varepsilon, w_u^*)$. If the firm is not matched with any workers, which happens with probability $1 - \lambda_u$, it stays vacant and receives zero profit this period.

[7] In a more realistic scenario, many of the objects such as λ_u, λ_e, $G_u(\varepsilon)$, $G_e(\varepsilon)$ are endogenous and are determined by the firm's market choice, but in this setup I am assuming away their endogeneity.

On the other hand, if the vacant firm decides to post its vacancy to the employed workers' market, it's going to be matched with an employed worker with probability λ_e. Then, the worker follows her equilibrium strategy $a_e(\varepsilon, d, w^*_{inc}(\varepsilon, w^*_{pf}), w^*_{pf})$, based on the realization of the difference in match qualities d and the wage offers she receives from both her current employer and the vacant firm, to decide whether to stay at the incumbent firm or not. If the firm is not matched with any workers in the employed workers' market, which happens with probability $1 - \lambda_e$, it stays vacant and receives zero profit.

2.3.5.2 Equilibrium Characterization with an Example

Following the equilibrium definition above, a vacant firm decides to post its vacancy to the unemployed worker's market when its expected profit from doing so is higher than the expected profit from posting its vacancy to the employed workers' market. Since there is no heterogeneity in firms' productivities, all firms make the same decision regardless of the realizations of the random variables. That being said, the only case where there is search[8] in both markets is when the vacant firms randomize. In order for this to happen, a vacant firm must get equal expected profits from entering the unemployed workers' market and the employed workers' market.

To assess whether it is possible for a vacant firm to randomize posting its vacancy between the two markets in equilibrium, more specific assumptions are needed regarding the functional forms of $h(\varepsilon)$, $G_u(\varepsilon)$, $G_e(\varepsilon)$ as well as the values of the parameters such as λ_e, λ_u, x, and θ. However even with these assumptions, closed form solutions for the equilibrium wages in the employed workers' market

[8]Here with search I refer to the existence of a market with both firms and workers.

may not emerge. Thus, I use numerical solutions of the equilibrium strategies for the discussions in the rest of the paper.

One concern for the vacant firm's posting decision is whether the lemons problem exists. The reasoning is as follows. In any given point in time, the average skill level of the workers in the employed workers' market is higher than the average skill level of those in the unemployed workers' market. Even though a vacant firm cannot observe the skill levels of these workers before actually employing them, it knows that the distribution of skills in the employed workers' market first order stochastically dominates the skill distribution in the unemployed workers' market. Knowing that the unemployed workers are more likely to be "lemons", the vacant firm therefore might opt for posting in the employed workers' market regardless of the specific functional forms and parameter values. Moreover, knowing that the incumbent firm will match the offers coming to its high-skilled workers, the vacant firm might not choose to make an offer to an employed worker. These problems, however, are resolved in this model due to the match quality parameter that captures the idiosyncratic preferences of workers. The fact that the average skill level in the employed group is higher than that in the unemployed group makes it more attractive to approach employed workers. However, conditional on making an offer to a worker with a higher skill level, the probability that it will be accepted is lower in the employed group as the incumbent firms will match the offer coming to their skilled workers and the poaching firms, thus, end up hiring only the skilled workers that are discontent with their existing match. These costs and benefits balance each other in the equilibrium leading to a case where posting

in the unemployed workers' market or in the employed workers' market doesn't dominate one another at all times. In fact, with the baseline specification in Table 2.1, it is possible to show that there is search in both markets.[9] In addition, it can be shown that the vacant firm randomizes between posting in the employed and unemployed workers' market not only at these parameter values but also at a differnet combination of other parameters within a neighborhood of these values. I leave the explanation of the functional forms and an analysis of comparative statics to the next section.

2.4 Numerical Example

As mentioned in the previous section, I make use of the numerical solution of the model in the following comparative static analyses.[10] Table 2.1 shows the baseline specification I use in calculating the equilibrium. The marginal productivity of a worker is defined as $h(\varepsilon) = \varepsilon^{\alpha}$, where ε represents the skill level of the worker and α is the parameter that determines how much a given skill is productive at any job. In this analysis, I assume $\alpha = 0.5$ to ensure the marginal productivity function is strictly concave and differentiable. The skill distribution in both the unemployed and the employed workers' markets are

[9] So far, I have assumed the skill distribution in the employed workers' market and in the unemployed workers' market have the same support. However, in the baseline specification the skill distribution in the employed workers' market has a different support than that of the unemployed workers' market. Assuming the two distributions are defined over the same support is a an assumption without loss of generality because assuming these two distributions have different supports do not change any of the theoretical analysis.

[10] In all the numerical exercises I consider in this section, I randomly draw 1000 values from the distribution of the match quality difference for each skill level. Next, I calculate the equilibrium wage levels and the decision of the workers. The fraction of job-to-job movers for each skill level is the fraction of the workers who decide to take the poaching firm's job offer among these 1000 cases.

assumed to be uniform. However, the range of the skill levels in the employed workers' market is wider since I initially assumed that the skill distribution in the employed workers' market first order stochastically dominates the skill distribution in the unemployed workers' market. The parameter values for the arrival rates of job offers in both markets are assumed to be equal in order to make sure the difference in the expected profits from entering these two markets do not result from a difference in the arrival rates. The unemployment benefit parameter as well as the value of the match quality to the worker is set arbitrarily in order to make sure it is possible for a firm to get equal expected profits from entering these two markets. However, later in this section I also show how the model's predictions change with respect to a change in these variables.

First, I analyze how the wage offers by the incumbent and the poaching firms change across skill levels. Figure 2.2 displays the patterns. The poaching firm's wage offer does not change with respect to the skill level, because the poaching firm cannot observe the worker's skills. However, the superior information the incumbent firm has over the worker's skill level allows it to offer a different wage offer for workers with different skill levels. Specifically, the incumbent's wage offer increase with the worker's skill level, consistent with its equilibrium strategy. Notice that, until the skill level is around 3 the poaching firm's wage offer is always higher than the incumbent's wage offer. Moreover, for workers with skill level $\varepsilon < 1.6$, the poaching firm actually makes a loss from hiring the worker. This is because for these skill levels, the marginal productivity of the worker is lower than the poaching firm's wage offer.

Even though the poaching firm's wage offer is greater than the incumbent's

wage offer for the workers with skill levels that are lower than 3, it doesn't necessarily mean that these workers change jobs whenever they receive an outside wage offer. In fact, Figure 2.3 shows that fraction of job-to-job movers are considerably lower than one for the workers with skill levels lower than 3. The reason for this pattern is the workers' idiosyncratic preferences about match quality. Similarly, when the incumbent's wage offer is greater than that of the poaching firm, it does not mean that the worker is going to stay at her current job. As can be seen from the figure, the fraction of job-to-job movers stay well above 0.3 for the workers with higher skill levels. Therefore, even though the poaching firm knows that the incumbent matches the offers coming to its skilled workers, posting a vacancy to the employed workers' market might enable the poaching firm to hire skilled workers depending on the realization of the difference in match qualities between the two firms. Nonetheless, this result certainly changes with respect to the range over which the distribution of the match quality parameter is defined. For this reason, I look at how the equilibrium outcomes change with respect to x in the remainder of this section.

Figure 2.4 demonstrates the equilibrium wage offers by the incumbent for workers with different skill levels at different levels of x. First, the fact that the incumbent's wage offer increases as the worker is more skilled does not change across different levels of x. Next, the figure shows that as the level of x increases, the equilibrium wage curves of the incumbent initially shifts down and after a threshold they shift back up, thought not to the level of the initial wage curve. The increase in x means an increase in the variance of the match quality difference distribution without a change in the mean. The equilibrium wage

offer strategy of the incumbent tells that the firm offers a wage that is equal to the average of the marginal productivity of the worker and the poaching firm's wage offer minus x. This means that the incumbent offers a wage that is in the middle of the highest wage it would pay for that worker and the lowest wage with which it can hire the worker. When the variance of the distribution increases, the highest wage the incumbent would pay for the worker does not change as the marginal productivity of this worker stays the same. On the other hand, when x increases, the lowest wage with which the incumbent can hire this worker decreases for a given level of w_{pf}. Therefore, for low levels of x, when x increases the incumbent's equilibrium wage offer declines. However when $x > 0.6$, the rise in the poaching firm's equilibrium wage offer dominates the rise in x and leads to an increase in the incumbent's wage offer. As a result, the incumbent's wage offer has a non-monotonic relation with the level of x, or in other words the variance of the match quality distribution.

The change in the wage offer by the poaching firm with respect to x is shown in Figure 2.5. Unlike the incumbent's equilibrium wage offer, the wage offer by the poaching firm monotonically increases as x increases. Nevertheless, note that the increase in the wage level is higher for higher levels of x. This fact also explains the reason why we see a non-monotonic relation between the incumbent's wage offer and x. The poaching firm's equilibrium wage strategy given by Equation (2.31) tells that as x increases, the interval of skill levels from which the poaching firm is going to make a loss, if the worker accepts its offer, declines. Moreover, again as x increases, the interval of the skill levels from which the poaching firm can potentially hire considerably gets larger. For this

reason, the wage offer by the poaching firm increases with x. Also, notice that the rise in the poaching firm's wage offer is higher than the rise in x for $x > 0.6$.

Finally, Figure 2.6 displays how the fraction of job-to-job movers vary with respect to changes in x. As expected, the fraction of job-to-job movers rise with x. This is mostly generated by the increase in the poaching firm's wage offer. However, the interesting thing is the fact that the increase in job-to-job movers gets smaller for higher values of x. This is because initially the poaching firm's wage offer increases while the incumbent's wage offer decreases. Adding the increase in x on top of the rising difference between the two firms' wage offers explains the increase in the fraction of job-to-job movers for all skill levels. Still, the change in the probability of moving becomes smaller for higher levels of x. It is true that the increase in the poaching firm's wage offer is higher for these values of x, but at the same time the variance of the match quality is also higher. Therefore, even though the difference between the wage offers between the two firms rise, the probability of receiving a very low match quality rises as well. For this reason, the change in the fraction of movers is lower for higher values of x.

2.5 Conclusion

This paper constructs a job search model with wage negotiations and renegotiations in which targeted and random search happens at the same time. In the model, firms choose whether to post their vacancies in the employed or unemployed workers' market and whether to match to offers coming to their employees. Workers on the other hand decide whether to accept a job offer

when they are unemployed and whether to stay at the incumbent firm or switch to poaching firm after they receive an offer when they are employed. Workers also have idiosyncratic preferences over different jobs which is unobserved to the employers. This extra dimension of asymmetric information eliminates the lemons problem and leads to an equilibrium with search in both employed workers' and unemployed workers' markets. In addition, the model predicts that workers who switch to the poaching firm are less skilled on average. This is because, the workers who are switching to the poaching firm mainly change jobs because the incumbent chooses not to match their wage offer. For this reason, the model generates a negative relation between the skill level of the worker and the rate of job-to-job mobility.

As mentioned earlier, this paper is a first step in achieving a dynamic general equilibrium search model in which firms' strategic decisions determine the job offer rates as well as the firm productivity distributions in both markets. In this paper, I try to characterize the equilibrium strategies by ignoring the continuation values of the agents' and by only taking into account the static payoffs. However, when the workers' and firms' decisions change their future prospects of finding a job, wage growth and hiring, the model may well generate different equilibria. Moreover, in such a setup, the model's predictions regarding the steady state job-to-job mobility rates can be tested from the data. Finally, in this paper I have assumed the current wage of a worker is determined exogenously as I do not model the previous periods of this labor market. However, the current wage has significant impact on both incumbent's and poaching firm's equilibrium strategies. Therefore, the next step in this research agenda would

be to endogenize this variable by analyzing a dynamic labor market in the same setup.

2.6 Tables and Figures

Table 2.1: The Baseline Specification for the Numerical Solution

The marginal productivity of a worker	$h(\varepsilon) = \varepsilon^{\alpha}$
Skill distribution in the unenmployed workers' market	$G_u(\varepsilon) \sim U[0.5, 2]$
Skill distribution in the enmployed workers' market	$G_e(\varepsilon) \sim U[1, 4]$
Arrival rate of offers in the unemployed workers' market	$\lambda_u = 0.7$
Arrival rate of offers in the employed workers' market	$\lambda_e = 0.7$
The utility a worker gets from high match quality	$x = 0.5$
Parameter defining worker's productivity	$\alpha = 0.5$
Unemployment benefits	$b = 0.9868$

Figure 2.1: Incumbent's and Poaching Firm's Wage Offers When $w_{pf} + x \leq \varepsilon$

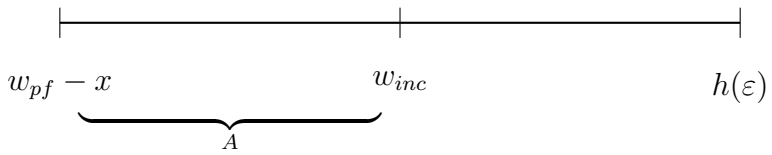


Figure 2.2: Incumbent's and Poaching Firm's Wage Offers Across Skill Levels

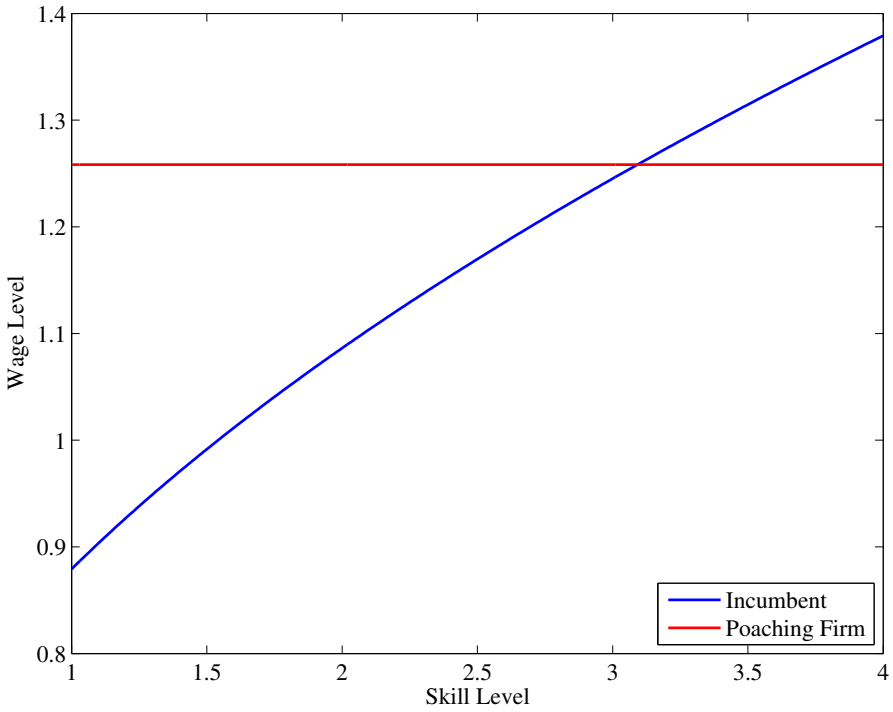


Figure 2.3: Fraction of Job-to-Job Movers Across Skill Groups

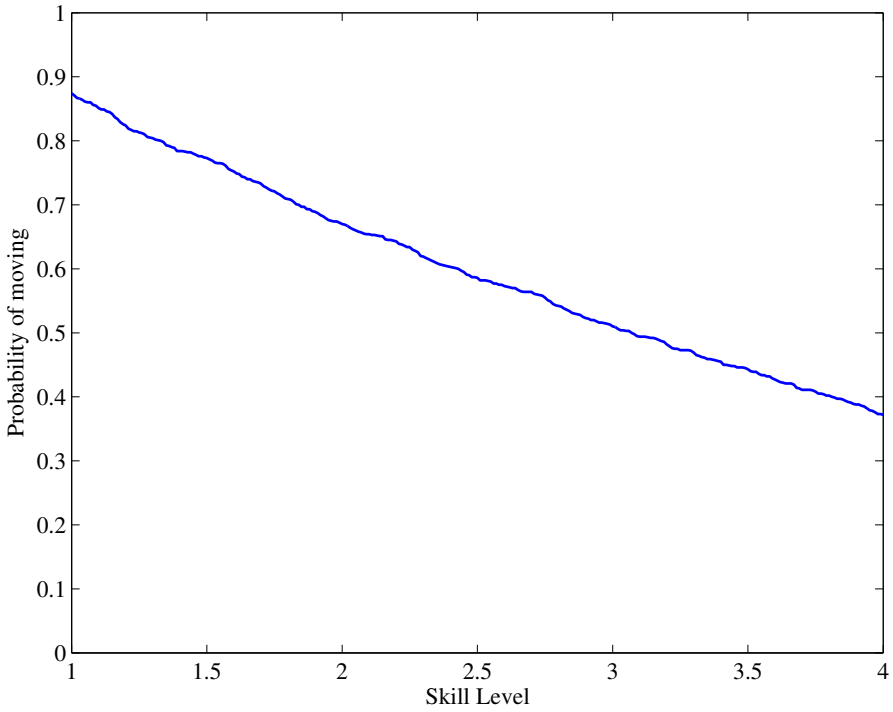


Figure 2.4: Incumbent's Wage Across Different Levels of x

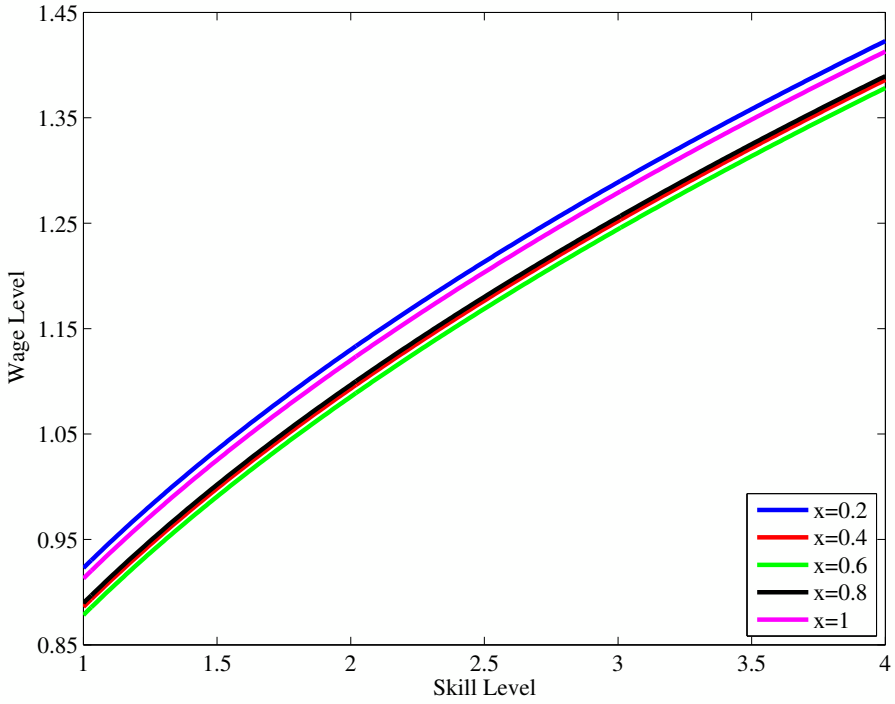


Figure 2.5: Poaching Firm's Wage Across Different Levels of x

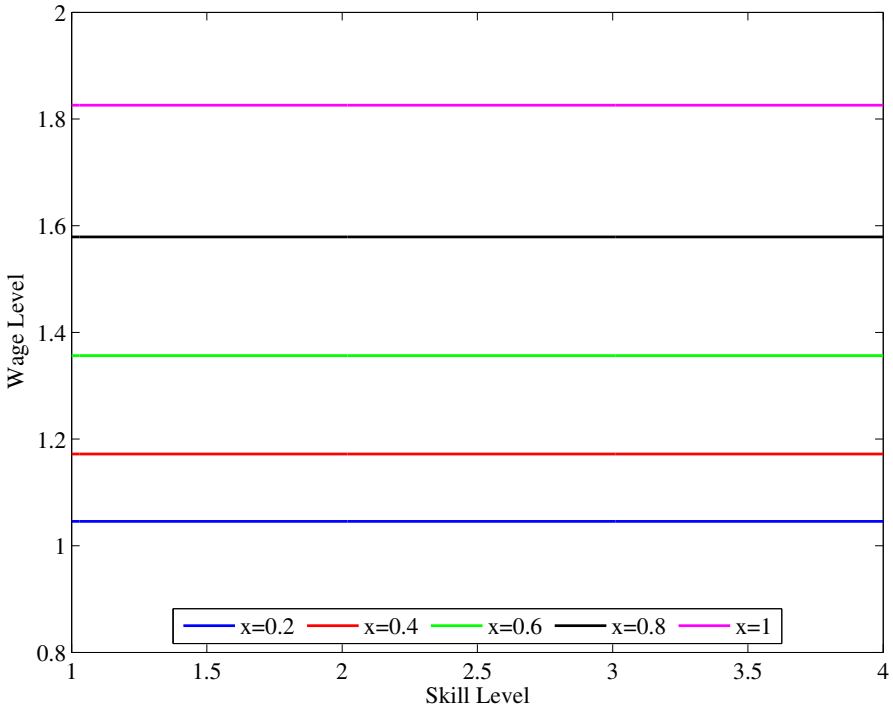
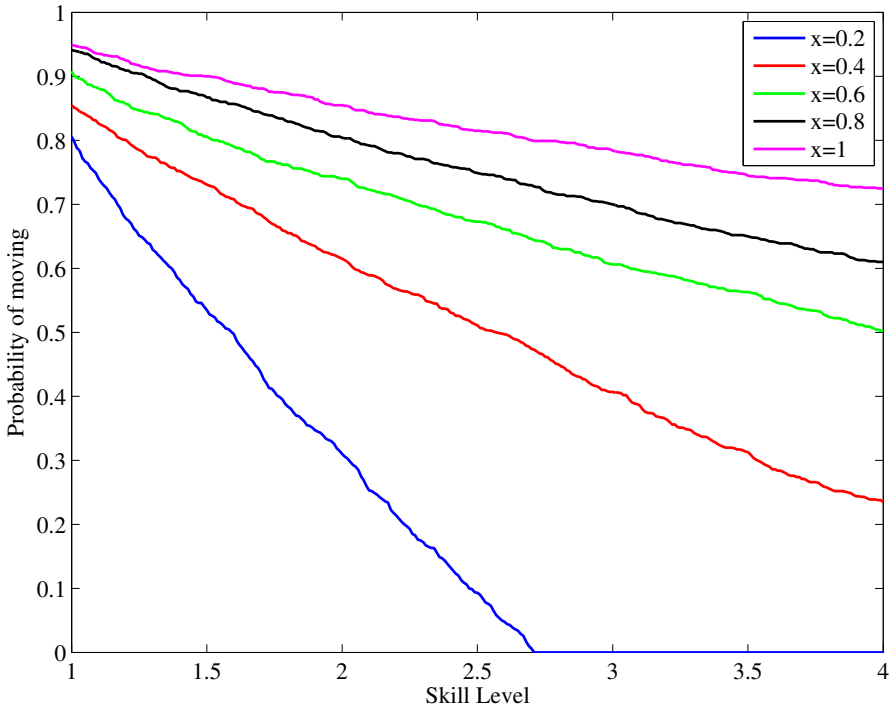


Figure 2.6: Fraction of Job-to-Job Movers Across Different Levels of x



Chapter 3

An Anatomy of U.S. Personal Bankruptcy under Chapter 13

This chapter is joint work with Hülya Eraslan, Wenli Li, and Pierre-Daniel Sarte.

3.1 Introduction

On April 20, 2005, the Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA) was signed into law and ended a comprehensive legislative effort that began under the Clinton administration. The most significant (and controversial) change introduced by the new personal bankruptcy law was to impose a "means test" on debtors contemplating a bankruptcy filing. The aim was to ensure that debtors with sufficient income would file under Chapter 13 and complete a repayment plan out of future income. The key presumption

underlying this provision was that a large number of households did not repay as much as their income allowed. In particular, it was thought that Chapter 13 would perform better, both as a collection device for creditors and as a means to provide debtors with a financial fresh start, if stricter rules were imposed on repayment plans.[1]

The objective of our paper is to take a first step at evaluating the impact of these stricter rules. Specifically, we aim to assess the effect of section 1325, paragraph 4, which was added to the U.S. Bankruptcy Code under BAPCPA and imposes additional restrictions on the length of repayment plans for debtors with income above the state median. In order to do so, we build and estimate a structural model of Chapter 13 bankruptcy using a novel data set we construct. For a side contribution, we provide empirical evidence regarding the outcomes under Chapter 13 and its performance both as a collection device for creditors and as a means to provide debtors with a financial fresh start.

Our model captures the salient features of personal bankruptcy under Chapter 13. In our model, a debtor first makes decisions regarding whether or not to file under Chapter 13 and, if so, what repayment plan to propose. Since the law requires that all of a debtor's excess income be applied to his repayment plan, the debtor's choice of repayment plan boils down to its length. In choosing what plan to propose, the debtor recognizes that its duration has a bearing on the confirmation outcome that is determined by the recommendations of a bankruptcy trustee appointed to oversee the bankruptcy process. Under the bankruptcy law, in deciding whether to confirm a plan or not, the trustee must

[1] See, for example, https://www.tinyurl.com/bapcpa2005.

form an opinion as to the fairness and feasibility of the plan. The fairness condition is satisfied as long as the debtor contributes all excess income into the plan payments. The feasibility condition requires that the debtor's excess income is sufficient to pay the unsecured creditors over a three- to five-year period an amount no less than they can recover under liquidation of the debtor's assets. To capture the idea that the trustee has some leeway in the interpretation of the bankruptcy law, in our model, whether the trustee views a given plan as fair and feasible or not is random from the perspective of the debtor. Specifically, whether the trustee views a plan as fair and feasible depends on the debtor's characteristics and the plan length.

Even if a plan is initially confirmed, it may nonetheless become unfair or infeasible due to fluctuations in the debtor's financial condition. We model this possibility by introducing shocks to income or expenses of the debtor at a random date. Following the shocks, the trustee reevaluates the feasibility of the plan under the new debtor characteristics. If the case is not dismissed, the debtor decides whether to continue or voluntarily default on his plan.

Overall, our model highlights a basic trade-off debtors face in proposing long repayment plans versus short ones. Long repayment plans are costly in that they impose restraints on debtors for longer periods, but these plans may also be more likely to be confirmed by the court and, ultimately, to result in a financial fresh start. In addition, our model highlights the importance of shocks to excess income during the bankruptcy process. In particular, even though a plan may be fair and feasible at the time a debtor files for Chapter 13 bankruptcy, it may cease to be so later on before the repayment plan is complete.

We estimate our model using newly collected data contained in court files on all Chapter 13 personal bankruptcies recorded by the United States Bankruptcy Court for the District of Delaware between August 2001 and August 2002. From the court documents, we extract information concerning the filers' financial and demographic information at the time of filing and the final outcome of their cases. Specifically, we collect data on the outcomes predicted by our model: the choice of plan length, whether the plan is confirmed or not, whether the case is successfully completed or not, and the recovery rate of the creditors. In addition to these endogenous outcomes, in our model the decision to file for Chapter 13 in the first place is also endogenous. Although all the debtors in our sample have chosen to file for Chapter 13, we identify the parameters associated with this decision through the variation in the decision to continue or voluntarily default on the plan following the shocks to financial conditions.

We estimate our model using the maximum likelihood approach. Our estimates confirm that the debtor's choice of plan length indeed affects the trustee's opinions on the fairness and feasibility of the plan. In particular, after controlling for exogenous debtor characteristics, we find that longer plans are more likely to be confirmed in the first place and less likely to be dismissed after the original plan becomes infeasible. However, whether a debtor's income is above the state median level does not play a significant role in the confirmation of the plan.[2] As such, the means test established under BAPCPA appears inconsequential. In addition, we find that changes in debtors' conditions during

[2]Whether income is above the state median appears immaterial for the confirmation of the plan; however, income plays an important role through the determination of excess income (income minus necessary expenses) and therefore the required plan payments.

bankruptcy play a significant role in governing Chapter 13 outcomes, including the ability of debtors to obtain a financial fresh start. In particular, negative shocks to excess income, especially when experienced early in the program, raise the probability of dismissal significantly.

We next conduct policy experiments to assess the effect of section 1325, paragraph 4, that was added to the U.S. Bankruptcy Code under BAPCPA. This policy imposes additional restrictions on the length of payment plans for debtors with income above the state median. Our results predict that this new policy would not materially affect creditor recovery rates and would not necessarily make discharge more likely for debtors with income above the state median. This finding is robust to alternative policy experiments that require bankruptcy plans to meet stricter standards in other ways, such as proposing a higher recovery rate. In fact, in these alternative experiments, some Chapter 13 filers no longer choose to file, with the result that recovery rates and discharge rates even decline. It appears, therefore, that a stricter bankruptcy code can make it more difficult for debtors to obtain a fresh start but without necessarily helping to raise creditor recovery rates.

The remainder of this paper is organized as follows. Section 2 the discusses related literature. Section 3 presents institutional details associated with U.S. personal bankruptcy law as well as a summary of creditors' options outside bankruptcy. Section 4 provides a description of the data. Section 5 presents a structural model of Chapter 13 bankruptcy. Section 6 presents econometric specification. Section 7 presents our estimation results. Section 8 assesses the effects of policy experiments directly related to BAPCPA as well as hypothetical

ones. Section 9 offers some concluding remarks.

3.2 Related Literature

Our paper contributes to a growing literature on households' bankruptcy decisions. With some exceptions, this literature has largely focused on households' bankruptcy decisions under Chapter 7. In early work, Domowitz and Sartain (1999) combine a sample of households who filed for bankruptcy in the early 1980s with data from the Survey of Consumer Finances for 1983. They find that households with more credit card debt are more likely to file for bankruptcy. Gross and Souleles (2002) study individuals' credit card account data and conclude that a decrease in stigma associated with bankruptcy is partly responsible for the increase in bankruptcy filing rates between 1995 and 1997. Using data from the Panel Study of Income Dynamics, Fay, Hurst, and White (2002) test the role of financial benefits in households' bankruptcy decisions and find support for underlying strategic considerations. In particular, households are more likely to file when their financial benefit from filing is higher.[3]

More recently, given the debates that surrounded the proposal and eventual passage of BAPCPA, attention has shifted toward consumer bankruptcy

[3] Sullivan, Warren, and Westbrook (1989, 2000) and Himmelstein, Warren, Thorne, and Woolhandler (2005) provide vivid narratives of debtors and creditors who end up in bankruptcy court. Conclusions underscore that bankruptcy is often caused by crises in debtors' lives, including divorce, job loss, and medical problems. There is also a separate empirical literature that examines the effects of personal bankruptcy law on the supply and demand for credit (Gropp, Scholz, and White (1997) and Lin and White (2001)), on the ability of households to insure against labor income risk (Athreya, Tam, and Young, 2012), on consumption behavior (Filer and Fisher (2005) and Grant (2004)), on labor supply (Han and Li, 2007), and on mobility (Elul and Subramanian, 2002).

under Chapter 13. Similarly to our methods, Sullivan, Warren, and Westbrook (2003) and Norberg and Velkey (2006) construct data on Chapter 13 bankruptcy filers using U.S. bankruptcy court files. However, their focus is entirely descriptive. By contrast, we estimate a structural model and conduct policy experiments to evaluate stricter rules imposed under BAPCPA.[4]

Our paper also informs a literature in macroeconomics that has provided tractable models relating documented empirical facts on consumer bankruptcy to aggregate considerations. A number of studies have used calibration and simulation exercises to explain observed aggregate U.S. consumer bankruptcy filing rates and have evaluated the effects of information, financial innovation, and changes in bankruptcy laws on these rates and other economic aggregates. Examples include Athreya (2002); Chatterjee, Corbae, Nakajima, and Ríos-Rull (2007); Drozd and Nosal (2008); Li and Sarte (2006); Livshits, MacGee, and Tertilt (2007, 2011), and Sanchez (2010). These papers abstract from the details of the personal bankruptcy laws, and do not distinguish between Chapter 7 and Chapter 13 personal bankruptcies.

3.3 Legal Background

This section first briefly reviews creditors' legal remedies outside bankruptcy. It then addresses the main features of U.S. personal bankruptcy law focusing in detail on Chapter 13 court procedures.

[4]See Eckstein and Wolpin (1989b); Rust (1996); Aguirregabiria and Mira (2010), and Keane, Todd, and Wolpin (2011) for surveys of structural dynamic choice models.

3.3.1 Creditors' Legal Remedies Outside of Bankruptcy

When a debtor defaults on his debt obligations without explicitly filing for bankruptcy, secured creditors, such as mortgage lenders or car loan lenders, seize property to recover what they are owed. Unsecured creditors, such as credit card issuers, often start with making calls and writing letters soliciting payments. They then typically sell their debts to collecting agencies. Unsecured creditors also have the option to sue the debtor and obtain a court judgment against him. They collect on the judgment by having the court order that the debtor's employer take a portion of his paycheck and remit that money to the sheriff, who then forwards the payment appropriately. This process is known as "wage garnishment." Unsecured creditors can also potentially seize a debtor's bank account and/or foreclose on his home. State laws typically restrict the amount and type of assets that can be seized to different degrees. Therefore, the process of seizing an account or foreclosing on a property can be costly and, in practice, unsecured creditors rarely do so.

3.3.2 Main Features of U.S. Personal Bankruptcy Law Prior to BAPCPA

U.S. personal bankruptcy law features two distinct procedures: Chapter 7 and Chapter 13. Prior to BAPCPA, debtors had the right to choose between the two chapters.[5] Chapter 7 is often referred to as "liquidation."Under Chapter 7, the debtor surrenders all assets above an exemption level that varies across

[5]Given the time span covered by our data set and the objectives of this paper, the basic features of personal bankruptcy law we provide below predate the passage of the 2005 Bankruptcy Reform Act.

states. In exchange, he obtains the discharge of most of his unsecured debt such as credit card debt, medical bills, personal loans, utility bills, etc.[6] A debtor cannot file again for Chapter 7 during the six years that follow the last filing. In contrast, Chapter 13 is formally known as "adjustment of debts of consumers with regular income."Under Chapter 13, a portion of a debtor's future earnings are used to meet part of his debt obligations. The repayment plan can last for a period of up to five years. While the debtor's assets are unaffected under Chapter 13, at the end of the payment plan, any remaining debt is discharged. A debtor is prevented from filing again under Chapter 13 for a period of 180 days following his last filing.

3.3.3 Bankruptcy Procedure under Chapter 13

A Chapter 13 case begins when a debtor files a petition with the bankruptcy court. This petition gives a description of, among other information, the debtor's assets, debts, income, and expenditures. In the petition, the debtor also proposes a repayment plan that devotes all of his *excess income* to the payment of unmet claims. Bankruptcy law defines excess income as any income net of necessary living expenses including housing expenses, which is in the form of mortgage payments for most of the debtors. In order to be confirmed by the court, the proposed plan must provide to repay the debt over a three- to five-year period. It must also be filed in good faith.[7] In particular, the debtor must

[6]Discharge prevents the creditors who are owed the discharged debts from taking any action against the debtor, including any communication with the debtor regarding unpaid debts.

[7]Trustees typically ask Chapter 13 filers to start submitting periodic payments according to the plan as soon as the plan is filed. Payments are distributed to creditors only if the plan is confirmed and are otherwise refunded. This practice, together with other court rules,

propose to pay at least as much as the value of the assets creditors would have otherwise received under Chapter 7. Finally, the plan must cure any default on secured debt at the time of filing before providing for payments to unsecured creditors. Because the law requires debtors to devote all of their disposable income to the payment plan, the key element of the repayment plan is the proposed plan length.

Upon the filing of a petition, a trustee is appointed by the bankruptcy court. The trustee is responsible for evaluating and recommending whether or not to confirm a proposed plan. He also works as a disbursing agent during the implementation of the plan, collecting payments from debtors and distributing them to creditors. Within a month of the petition filing, the trustee schedules a section 341 meeting. At this meeting, creditors are given an opportunity to ask any questions regarding the debtor's financial situation that may affect the plan. Ultimately, the trustee recommends to the court that a proposed plan either be confirmed, along with the implied repayment schedule, or be dismissed.

If the plan is dismissed, the case ends. Creditors can resume legal remedies outside bankruptcy, as described above, to pursue the repayment of their loans. If a repayment plan is confirmed, the debtor starts making payments as specified in that plan.[8] Once plan payments are completed, any remaining debt is discharged. It is possible for a plan that is initially confirmed to be subsequently altered. In particular, the debtor is free to prepay his debts in the

discourages debtors from staying in Chapter 13 bankruptcy without a confirmed plan for too long.

[8]In Delaware, the trustee receives 6% of total payments made under a confirmed plan.

event that his assets appreciate or he receives additional income from an unexpected source, such as an inheritance. The debtor can also potentially convert the case to a Chapter 7 filing, even after confirmation of the Chapter 13 plan, or voluntarily default on the confirmed plan and have the case dismissed. When a debtor benefits from a substantial increase in income after confirmation of a repayment plan, the law requires the debtor to increase his payments by the amount of additional income received (unless expenses for basic maintenance have also changed). Ultimately, the final plan that is carried out can look very different from the proposed and confirmed plan.

3.4 The Data

3.4.1 Data Collection

The data collected in this paper are obtained using an electronic public access service to case and docket information from Federal Bankruptcy courts and the U.S. Party/Case Index. This service is known as Public Access to Court Electronic Records (PACER) and offers bankruptcy court information including i) a listing of all parties and participants including judges, attorneys, and trustees, ii) a chronology of the dates of case events entered in the case record, iii) a claims registry, and iv) the types of documents filed for specific cases and imaged copies of these documents.

The docket sheet together with the court files it contains allow us to extract information concerning important dates that mark the Chapter 13 bankruptcy procedure, including the filing date, the confirmation date, and the dismissal or

discharge date, as well as filers' financial and income information at the time of filing and the final outcome of the case. The court files include debtor petitions, attorney disclosure forms, statements of financial affairs, Chapter 13 plans, and the trustee report. The debtor petitions contain different schedules, labeled A through J, that set forth the financial situation of the debtor, including real property that is owned, other personal assets in the form of furniture, cash, or insurance, liabilities such as secured debt and unsecured priority debt (taxes), and maintenance expenses for food, clothes, and transportation, among other basic expenses.

The court files are mostly PDF images from which information cannot be directly extracted using software. We manually collected all of our data by downloading these images and coding them into a database. The data were entered twice and the corresponding entries were cross-checked. The data were also checked against different sources where the same information was reported. For instance, the summary of schedules provides headline numbers on filers' assets, debts, income, and expenditures, while petition schedules A through J provide the same information in greater detail.

There were $1,085$ Chapter 13 bankruptcy cases filed in Delaware over our sample period (August 2001 to August 2002). Of the $1,085$ cases, we deleted from our sample 134 cases that have incomplete information resulting from either court recording or filing errors, and that were therefore trivially dismissed. In addition, 130 cases were omitted from the data due to inconsistent information filed by the debtors. Our final sample contains 821 cases, of which 364 (or 44%) resulted in a discharge upon successful completion of the repayment plans

while 457 cases were dismissed under Chapter 13. Of the dismissed cases, 52 were later converted to Chapter 7 filings. Table 1 summarizes this information.

3.4.2 Data Description

3.4.2.1 Selected Characteristics of Chapter 13 Debtors

Most of the variables we use in our analysis are directly available from the court files. Others are constructed on the basis of these original variables. For comparison, demographics, employment status, and income information are obtained for the State of Delaware from the 2000 Census and the Mortgage Bankers Association. We also report data on expenditures from the northeast region of the 2001 Consumer Expenditure Survey. Balance sheet information at the national level is obtained from the 2001 Survey of Consumer Finances.

The debtors in our sample are somewhat less likely to be unemployed than the average Delaware resident, with approximately 4% of the filers being unemployed compared to 5% in Delaware. This is not surprising since Chapter 13 bankruptcy is designed for curing the debts of individuals with regular income. What is more surprising is that about 5% of the filers are self-employed. Average monthly household income for the debtors in our sample is $\$2,938$, which falls short of Delaware's average adjusted gross income by about 30%. Filers for whom we have income data for both the current and previous year experience a nearly 20% average decline in income prior to filing.

The court files also provide information regarding debtors' monthly expenses that define basic maintenance under Chapter 13. Debtors in our sample

spend on average $1,164 on housing expenses (mortgage or rent). While housing expenses are shielded by law, a provision prohibits debtors from boosting these expenses prior to filing. In our sample, housing expenses, including expenses for home maintenance, account on average for 40% of total monthly expenses.[9] Debtors in Chapter 13 spend about $442 a month on average for food and clothing, which is considerably less than the $600 monthly average reported for the northeast region of the Consumer Expenditure Survey. Food and clothing represent 19% of debtors' monthly expenses in our sample. The remaining categories that define maintenance expenses include alimony payments,[10] insurance premia, medical expenditures, transportation expenses, and discretionary expenses. Discretionary expenses include recreation and entertainment. These expenses are arguably the least related to basic necessities and the most subject to interpretation by the trustee. In our sample, however, discretionary expenses account for approximately 2.5% of total monthly expenses on average.

We refer to a debtor as a *repeat filer* if he has filed for either Chapter 7 or Chapter 13 bankruptcy at least once prior to the current filing, since 1980. In our sample, about 24% of the debtors are repeat filers and thus have already been exposed to the experience of bankruptcy.

As expected, the most striking aspect of Chapter 13 filers relates to their level of indebtedness. Specifically, their median total debt, including mortgages,

[9] About 87% of the debtors in our sample own their homes, which exceeds the 70% state homeownership rate. That said, over one-fifth of homeowners who file for bankruptcy have pending foreclosure lawsuits, much higher than the state average foreclosure rate of 0.35%.

[10] Compared to their peers, Chapter 13 filers in our sample are less likely to be married, with 46% of the sample being recorded as married versus 54% for the state of Delaware. Approximately 6% of the filers listed alimony as part of either their monthly income or monthly expenses, thus suggesting a recent divorce.

car loans, and credit card debt, is about $121,852, around six times the national median, while their median total assets are $104,000, less than half of the corresponding national median. Their median unsecured debt is $14,737, compared to a national median of zero. Median arrears[11] amount to $12,517. Together, total debt in default (henceforth, total debt) for the median filer - arrears as well as unsecured debt - amounts to approximately to the debtor's annual gross income. Specifically, the debtor with the median income earns $31,284 and the debtor with the median total debt in default owes $30,834 in past-due debt. By contrast, the debtor with the median total debt, including mortgages, car loans, and credit card debt, owes about $121,852. The large difference is due to the fact that some of the debt is not in default.

Table 2 provides summary statistics for the debtor characteristics we use in our analysis. As can be seen from this table, monthly rent or mortgage payments average a little under $850 a month, which amounts to about 31% of monthly income. For about 8.5% of filers, medical debt constitutes over 10% of their total debt in default.[12] About a quarter of filers have above-state-median-income at the time of filing. Moreover, on average, the debtors in our sample have been in their current job for about five months. A little over 1% of the filers did not hire an attorney. Those who did hired experienced attorneys in the sense that their attorneys handled, on average, 94 cases in our sample. Finally, the majority of the filers proposed long repayment plans (over four years), with the proposed recovery rates over 65%.

[11] Arrears are missed payments that are past due on a (secured) loan. This is particularly relevant for mortgage debt in the case of consumer bankruptcy. For secured debt, the part of the debt that is in default is only the arrears.

[12] We calculate medical debts by flagging keywords such as "health," "medical," or "Labcorp," that are listed for either the debt type or the associated creditor.

To sum up, Chapter 13 filers in our sample tend to earn noticeably less than average and are very heavily indebted. These observations are broadly consistent with previous findings in the literature (see, for example, Domowitz and Sartain (1999); Nelson (1999), and Fay, Hurst, and White (2002)).

3.4.2.2 Outcomes under Chapter 13

Two of the key outcomes of the personal bankruptcy process are creditors' *recovery rate* and debtors' ability to obtain a *discharge*. These outcomes depend crucially on the *length of plans* that are chosen by debtors and whether these plans are *confirmed*[13] by the trustee. Hence, this paper focuses on these four quantifiable aspects of Chapter 13.

Figures 3.1 and 3.2 illustrate noteworthy aspects of proposed Chapter 13 plans in our sample. First, proposed plan lengths in Figure 1 are nearly bimodal, with the majority of filers proposing either three-year or five-year plans. In what follows, we will refer to plans shorter than four years as three-year plans and the plans longer than four years as five-year plans.

The fact that a large fraction (84%) of the debtors propose five-year plans is not surprising given that it often takes at least three years for filers to repay arrears in full.

Second, there exists considerable variation in proposed creditor recovery rates. As shown in Figure 3.2a, the majority of filers propose to repay at least half of their total debt. The mean and median proposed recovery rates are

[13]Cases that are not confirmed are either converted to Chapter 7 or dismissed. Given the small number of Chapter 7 conversions in our sample, we do not formally distinguish between dismissal and chapter conversion in our analysis, even though a case that is converted to Chapter 7 may eventually be discharged under that chapter.

close to 66 cents and 60 cents on the dollar, respectively. Around 20% of filers propose to pay their creditors back in full.

Third, as illustrated in Figure 3.2b, these recovery rates are strikingly lower than those implied by the proposed plans. An important reason for the discrepancy is that many debtors in bankruptcy end up not carrying out their plans in full, either because they are dismissed by the trustee at a later stage or because they voluntarily exit Chapter 13 before completing their plans. Accordingly, the distribution of actual recovery rates looks very different, depending on whether debtors completed Chapter 13 and were successfully discharged or not. This is shown in Figure 3.3a. Furthermore, Figure 3.3b illustrates that the proposed plan length also matters somewhat for the distribution of recovery rates. Interestingly, although their average recovery rates are similar, debtors that propose five-year plans are associated with a lower median recovery rate than those that propose three-year plans. Specifically, the actual median recovery rates are 15% for the debtors with five-year plans versus 19% for the debtors with three-year plans. One possible reason is that debtors who seek to smooth their payments over longer periods could be the ones in greater financial distress.

The average recovery rate for the creditors is 29%, with a median recovery rate of 14%. The mean and median recovery rates conditional on the debtor being discharged are 59% and 55%, respectively.[14] This recovery rate is the weighted average of the recovery rates of the unsecured and secured creditors.

[14]Chapter 13 recovery rates are necessarily zero for cases that are dismissed without confirmation.

The mean recovery rate on unsecured debt is 17% while the median is 0%. Conditional on discharge, the mean and median recovery rates on unsecured debt are 38% and 25%, respectively. By contrast, the mean recovery rate on secured debt is 49% while the median is 39%. By law, the recovery rate on secured debt conditional on discharge must be 100%. The unconditional recovery rate on secured claims is, however, lower than 100% for two reasons. First, when the debtor does not obtain a discharge in Chapter 13, he does not necessarily pay his secured creditors in full. Second, for secured debt other than mortgages (for example, car loans), it is possible that the value of the claim is reduced during the bankruptcy proceedings through cram-down. Although we do not have the data on cram-down, we do not expect the recovery rates we report to be too different from the actual recovery rates since most of the secured debt is mortgage debt, which cannot be crammed down.

The descriptive statistics for the variables we just discussed as well as the remaining outcomes are summarized in Table 3.3. As can be seen, close to 20% of the cases in our sample are dismissed without ever obtaining the confirmation of a plan, and only 55% of the confirmed plans are carried out to completion. In summary, creditor recovery rates are considerably lower than those that are first proposed. In addition, more than half of the debtors fail to obtain the financial fresh start potentially afforded by the bankruptcy law. A natural question is this: what debtor characteristics, or other aspects of Chapter 13, are associated with these outcomes? To answer this question, the next section builds a structural model of Chapter 13 bankruptcy.

3.5 The Model

In this section, we model the behavior of debtors while they are in Chapter 13 bankruptcy, taking as given trustees' decision rules. We do not explicitly model the creditors' problem since they don't actively participate in the bankruptcy process.

Our analysis begins with a debtor's decision to file for bankruptcy under Chapter 13. We let $F \in \{0, 1\}$ denote the debtor's decision to file for Chapter 13 bankruptcy, where $F = 1$ if and only if the debtor files for Chapter 13. In order to be able to discharge his debts, the debtor must propose a repayment plan, have it confirmed by the court, and carry it out in full. The payoff of the debtor depends on the payments P he makes in Chapter 13 and whether or not he obtains a discharge. We let $D \in \{0, 1\}$ denote the discharge outcome, where $D = 1$ if and only if a discharge in Chapter 13 is obtained. The payoff from discharge is normalized to zero, and the payoff from exiting Chapter 13 without a discharge is given by $\overline{V}(Z)$, where Z denotes the predetermined debtor characteristics at the time of filing for bankruptcy.[15] We assume that the payoff of the debtor is additively separable over payments and the discharge outcome and that it is given by $u(P, D) = -P + (1 - D)\overline{V}(Z)$.

Since the law requires all of the debtor's excess income to be applied to the repayment plan, he has little say over per-period plan payments, and these are treated as exogenous. As discussed in the previous section, discretionary expenses account for a negligible fraction of the monthly expenses. As such, we

[15] Since payments (if any) made outside Chapter 13 are not available, the payoff from options that do not involve Chapter 13 must be estimated.

assume the monthly payment amount is exogenously given by the excess income, denoted by X, and the debtor's choice regarding the plan consists solely of its length. We assume the debtor can propose either a three-year (short-term) plan or a five-year (long-term) plans and we denote the plan length by L.[16]

Once a plan is proposed, a trustee must decide whether or not to confirm the proposed plan. We assume that the trustee is nonstrategic and that his decision rule is exogenous, which the debtor takes as given. In addition, we assume that the decision rule is stochastic. This captures the idea that the interpretation of the bankruptcy law is not entirely unambiguous, and the trustee has some leeway in the interpretation of its provisions. How the trustee interprets the ambiguous provisions is unobservable to the debtor. We let $C \in \{0, 1\}$ denote the confirmation outcome, where $C = 1$ if and only if the plan is confirmed. At the time the trustee makes the decision to confirm the case or not, he observes the plan length L and the debtor characteristics Z, and his confirmation decision rule is characterized by the probability $\Pr(C|L)$.[17]

If the plan is confirmed, then the debtor starts making payments according to the plan. In particular, he is expected to pay his excess income X in each period $t \in \{1, \ldots, L\}$. However, his excess income may change during bankruptcy due to unexpected shocks.[18] Specifically, we assume the existence of an additive shock $\eta \in \mathbb{R}$ to excess income. In addition, we assume the timing

[16] While this assumption is made for simplicity, it is consistent with the observed distribution of proposed plan lengths being highly bimodal around these two values (recall Figure 3.1).

[17] In our estimation, we allow this probability to depend on the debtor characteristics Z as well. We suppress this dependency in our notation.

[18] For example, once a plan is confirmed, a debtor may switch employment, gain additional income in the form of inheritance, or obtain access to refinancing on secured debt. These changes can in principle be observed by the trustee, but they are not documented and therefore are unavailable to us.

of this shock is random and given by $\tau \in [0, L]$.

We assume that once the shocks to excess income are realized, the trustee reevaluates the plan in light of the changes to the excess income and thus to the per-period payment amount and therefore to the total payments. Specifically, the total plan payments are now given by $X\tau + (L - \tau)(X + \eta)$. As before, we take the trustee's decision rule as exogenous and stochastic. We let $S \in \{0, 1\}$ denote the trustee's reevaluation outcome, where $S = 1$ if and only if the trustee dismisses the case. At the time the trustee makes the decision to dismiss the case or not, he observes the shock η to excess income and its timing τ in addition to the plan length L and the debtor characteristics Z. We let $\Pr(S|L, \eta, \tau)$ denote the probability that characterizes the dismissal decision rule by the trustee.[19]

Even if a plan is not dismissed by the trustee at τ, the debtor may decide to voluntarily exit Chapter 13 bankruptcy without a discharge. We let $E \in \{0, 1\}$ denote the debtor's decision to exit Chapter 13, where $E = 1$ if and only if the debtor voluntarily exits Chapter 13 following the realization of the shock to his excess income.[20]

Figure 3.4 summarizes the timing of events. First, the debtor chooses F. If $F = 1$, then the debtor chooses L. Given L, the confirmation outcome C is realized. If $C = 1$, the shocks η and τ are realized followed by the realization of the dismissal outcome S. If $S = 0$, then the debtor chooses E. The decisions F, L, and E together with the realizations of random variables C, S, η, and τ

[19] As before, in our estimation, we allow this probability to depend on the debtor characteristics Z as well.

[20] Note that this decision resembles the decision to file for Chapter 13 bankruptcy in the first place. Since in our data set we observe only people who chose to file for Chapter 13 bankruptcy, the debtor's decision to exit Chapter 13 or plays an important role in our identification.

determine whether the debtor obtains a discharge D, as well as the payments P made in Chapter 13 bankruptcy. We explain this next.

3.5.1 Discharge and Payment Outcomes under Chapter 13

If $F = 0$, then the debtor obtains no discharge, and the payments in Chapter 13 are zero, i.e., $D = 0$ and $P = 0$. If $F = 1$, then there are four cases:

(i) If $C = 0$, then the plan is not confirmed, the case is terminated without a discharge, and the creditors do not collect anything in Chapter 13. Consequently $D = 0$ and $P = 0$ in this case.

(ii) If $C = 1$ and $S = 1$, then the case is dismissed after the shocks to debtor's excess income are realized, and again the debtor fails to obtain a discharge $D = 0$. In this case, the payments in Chapter 13 consist of the payments made up to the realization of the shock to excess income at time τ, that is, $P = X\tau$.

(iii) If $C = 1$, $S = 0$, and $E = 1$, then the case is not dismissed at time τ but the debtor decides to exit the bankruptcy voluntarily. In this case, too, we have $D = 0$ and $P = X\tau$.

(iv) If $C = 1$, $S = 0$, and $E = 0$, then the debtor decides to remain in bankruptcy and his payments are modified to $X + \eta$. Because he already paid X per year until time τ, and he pays $X + \eta$ per year from τ to L, and because he does not need to pay more than what he owes, the total

payment in this case is $P = \min\{X\tau + (X+\eta)(L-\tau), B\}$, where B is the total debt at the time of filing for bankruptcy.[21] In this case, the debtor obtains a discharge, and so $D = 1$.

Note that, the variables F, L and E are determined as the solution to the debtor's dynamic optimization problem. We next discuss how these variables are determined.

3.5.2 The Debtor's Problem

In this section, we characterize the debtor's optimal choices $\widehat{F}$, $\widehat{L}$, and $\widehat{E}$ using backward induction. First, consider the debtor's choice of $\widehat{E}$ at time τ after his excess income becomes $X + \eta$. If the debtor decides to exit bankruptcy, his utility is given by $-X\tau + \overline{V}(Z')$, where Z' reflects the debtor's new characteristics at time τ, after taking into account the reduction in his debt due to the payments he has already made, and his new excess income, taking into account the shock η it received. If the debtor decides to remain in bankruptcy, his utility is given by $-\min\{X\tau + (X+\eta)(L-\tau), B\}$. As such, $\widehat{E} = 0$ if and only if $-\min\{X\tau + (X+\eta)(L-\tau), B\} \geq -X\tau + \overline{V}(Z')$.[22]

Next consider the debtor's choice of plan length. This choice has two consequences. First, it affects the probability that the plan will be confirmed. Second, it affects the payoff conditional on the plan being confirmed. Let $V(L)$

[21] As mentioned earlier, the trustee collects a 6% fee from the total payments. To account for this, we adjust the total debt amount.

[22] We assume that the debtor remains in bankruptcy when indifferent. Under the assumptions we make on the distribution of η in the next section, this is a zero probability event.

denote this conditional payoff.[23] Formally, we have

$$V(L) = \mathbb{E}_{\eta,\tau}[\Pr(S=1|L,\eta,\tau)[-X\tau + \overline{V}(Z')]$$

$$+ Pr(S=0|L,\eta,\tau)[\max\{-\min\{X\tau + (X+\eta)(L-\tau), B\}, -X\tau + \overline{V}(Z')\}]. \tag{3.1}$$

The debtor's choice of plan length must maximize his expected utility, i.e.,

$$\widehat{L} \in \underset{L\in\{3,5\}}{\arg\max}\ \Pr(C=1|L)V(L) + (1-\Pr(C=1|L))\overline{V}(Z). \tag{3.2}$$

Finally, the debtor's choice of filing must be optimal. Assuming that the debtor files for Chapter 13 when indifferent, we have $\widehat{F} = 1$ if and only if $\Pr(C=1|\widehat{L})V(\widehat{L}) + (1-\Pr(C=1|\widehat{L}))\overline{V}(Z) \geq \overline{V}(Z)$ or, equivalently, if and only if $V(\widehat{L}) \geq \overline{V}(Z)$.

We now turn to our empirical specification.

3.6 Econometric Specification

3.6.1 Likelihood Function

The solution of the optimization problem just discussed serves as the input into estimating the parameters of the model given data on choices made by the debtors and the confirmation and discharge outcomes. As mentioned earlier, for each individual in the data, we observe the choice of plan length $\widehat{L}$,

[23] Of course, this payoff depends on the debtor characteristics Z as well, which we suppress.

discharge outcome D, confirmation outcome C, and the recovery rate of their creditors, which is equivalent to observing the payments P. The contribution to the likelihood function of each debtor in our sample is therefore equal to the probability of observing $(\widehat{L}, C, P, D)$ conditional on the vector of (exogenous) debtor characteristics Z, and the model's parameters β.[24] Given the optimization decisions faced by debtors under Chapter 13, the likelihood of each debtor can be written as

$$\Pr(\widehat{L}, C, P, D|Z, \beta) = \Pr(\widehat{L}|Z, \beta) \Pr(C|\widehat{L}; Z, \beta) \Pr(P, D|C, \widehat{L}; Z, \beta). \tag{3.3}$$

The sample likelihood is the product of the probabilities in (3.3) over all the debtors in the data set. The remainder of this section addresses each of the components on the right-hand side of (3.3), suppressing the conditioning on Z and β.

Although the choice of plan length is deterministic for the debtor, it is probabilistic from our view since we do not have the same information the debtor has. A debtor's health or educational status, for instance, may affect the probability of a plan being confirmed, which in turn affects the choice of plan length. To reconcile any potential discrepancy between the model's predictions and observed plan length choices, we allow for the fact that the debtor evaluates the probability $\Pr(C = 1|L)$ of confirmation of the proposed plan L using information that is unavailable to us. We let ε_L denote a multiplicative error term that lets us differentiate between the debtors' probability assessment of

[24] The expected payoff from filing under Chapter 13 is also endogenous in the model. As explained later in this section, the vector of endogenous events therefore implicitly takes into account the fact that all debtors in our sample have chosen to file under that chapter.

initial plan confirmation and the analogous evaluation made by us. Hence, the true conditional probability of confirmation is given by

$$\Pr(C = 1|L, \varepsilon_L) = Q(C = 1|L)\varepsilon_L, \tag{3.4}$$

where $Q(C = 1|L)$ reflects our assessment of initial plan confirmation and is parameterized below. We assume that ε_L is distributed with a cumulative distribution function $G(\varepsilon_L|L)$ with support $\mathcal{E}_L$. (The fact that the probability of confirmation lies in $[0, 1]$ imposes restrictions on $\mathcal{E}_L$. We discuss these restrictions explicitly in the next section.) Although the debtor's estimate of the confirmation probability of his proposed plan uses more information than is available to us, there is no *a priori* reason why our estimate of $\Pr(C = 1|L)$ should be biased. Therefore, we require that $\mathbb{E}(\varepsilon_L) = 1\ \forall L$, which immediately implies that

$$\Pr(C = 1|L) = \mathbb{E}[\Pr(C = 1|L, \varepsilon_L)] = Q(C = 1|L). \tag{3.5}$$

From (3.2) and (3.5), it follows that

$$\begin{aligned} &Q(C = 1|\widehat{L})\varepsilon_{\widehat{L}}V(\widehat{L}) \ + \ (1 - Q(C = 1|\widehat{L}))\varepsilon_{\widehat{L}}\overline{V}(Z) \\ &\qquad \geq \ Q(C = 1|L)\varepsilon_L V(L) \ + \ (1 - Q(C = 1|L)\varepsilon_L)\overline{V}(Z) \end{aligned} \tag{3.6}$$

for all $L \neq \widehat{L}$. Since this is trivially satisfied when $L = \widehat{L}$. There are three cases to consider:

(i) If $V(\widehat{L}) < \overline{V}(Z)$, then $\Pr(\widehat{L}) = 0$. This is because the expected payoff

$V(\widehat{L})$ from filing under Chapter 13 is endogenous in the model, and for the debtor to be observed in the data set, we must have $V(\widehat{L}) \geq \overline{V}(Z)$.

(ii) If $V(L) < \overline{V}(Z)$ and $V(\widehat{L}) \geq \overline{V}(Z)$, the left-hand side of (3.6) is at least as large as $\overline{V}(Z)$ and the right-hand side of (3.6) is less than $\overline{V}(Z)$. Thus (3.6) is always satisfied regardless of $\varepsilon_{\widehat{L}}$ and ε_L, implying $\Pr(\widehat{L}) = 1$.

(iii) If $V(L) \geq \overline{V}(Z)$, then (3.6) implies that

$$\begin{aligned} \Pr(\widehat{L}|\varepsilon_{\widehat{L}}) &= \Pr\left(\varepsilon_L \leq \frac{Q(C=1|\widehat{L})\varepsilon_{\widehat{L}}(V(\widehat{L}) - \overline{V}(Z))}{Q(C=1|L)(V(L) - \overline{V}(Z))}\middle| \varepsilon_{\widehat{L}}\right), \\ &= G\left(\frac{Q(C=1|\widehat{L})\varepsilon_{\widehat{L}}(V(\widehat{L}) - \overline{V}(Z))}{Q(C=1|L)(V(L) - \overline{V}(Z))}\middle| L\right), \end{aligned} \tag{3.7}$$

and therefore

$$\Pr(\widehat{L}) = \int_{\mathcal{E}_{\widehat{L}}} G\left(\frac{Q(C=1|\widehat{L})\varepsilon_{\widehat{L}}(V(\widehat{L}) - \overline{V}(Z))}{Q(C=1|L)(V(L) - \overline{V}(Z))}\middle| L\right) dG(\varepsilon_{\widehat{L}}|\widehat{L}). \tag{3.8}$$

This completes the derivation of $\Pr(C|\widehat{L})$ and $\Pr(\widehat{L})$, the first two terms on the right-hand side of (3.3). We now turn to the derivation of the last term, i.e., the derivation of $\Pr(P, D|C, \widehat{L})$, making use of the discussion in Section 3.5.1.

First, consider the case when $C = 0$. In this case, we have

$$\Pr(P, D|C=0, \widehat{L}) = \begin{cases} 1 & \text{if } P = 0 \text{ and } D = 0, \\ 0 & \text{otherwise.} \end{cases} \tag{3.9}$$

Next, consider the case $C = 1$. Note that, in this case, the payment P and

the discharge outcome D depend on the realization of the random variables η and τ. Since we do not observe the realization of these variables, we integrate them out:

$$\Pr(P, D|C = 1, \widehat{L}) = \mathbb{E}_{\eta,\tau}\{\Pr(P, D|C = 1, \widehat{L}, \eta, \tau)\}. \tag{3.10}$$

When $C = 1$ and $D = 0$, there are two possibilities. Either $S = 1$, which happens with probability $\Pr(S = 1|\widehat{L}, \eta, \tau)$, or $S = 0$ and $E = 1$, which happens with probability $\Pr(S = 0|\widehat{L}, \eta, \tau)$ when

$$-\min\{X\tau + (X + \eta)(\widehat{L} - \tau), B\} < -X\tau + \overline{V}(Z'). \tag{3.11}$$

Although we do not observe S and E per se, in both of these cases, we must have $P = X\tau$ and $D = 0$. Since we know the excess income X, observing the total payment P allows us to infer the realized value of τ. Substituting it in (3.11), we obtain

$$\begin{aligned}\Pr(P, D = 0|C = 1, \widehat{L}) = f_\tau\left(\frac{P}{X}\right)\frac{B}{X}\mathbb{E}_\eta\Bigg\{&\Pr(S = 1|\widehat{L}, \eta, \frac{P}{X}) \\ &+ \Pr(S = 0|\widehat{L}, \eta, \frac{P}{X})\mathbb{1}\left(-\min\{P + (X + \eta)(\widehat{L} - \frac{P}{X}), B\} < -P + \overline{V}(Z')\right)\Bigg\}.\end{aligned} \tag{3.12}$$

where f_τ denotes the density function of τ and $\mathbb{1}(.)$ is an indicator function that takes the value 1 when the statement in parentheses is true.[25]

Finally, when $C = 1$ and $D = 1$, we must have $S = 0$ and $E = 0$, which

[25]Note that, as discussed earlier, Z' depends on η and τ.

happens with probability $\Pr(S=0|\widehat{L},\eta,\tau)$ when

$$-\min\{X\tau+(X+\eta)(\widehat{L}-\tau),B\}\geq -X\tau+\overline{V}(Z'). \tag{3.13}$$

In this case, we observe full debt repayment if and only if $X\tau+(X+\eta)(\widehat{L}-\tau)\geq B$ or, alternatively, $\eta\geq\frac{B-X\widehat{L}}{(\widehat{L}-\tau)}$. Therefore,

$$\begin{aligned}\Pr(P=B,&D=1|C=1,\widehat{L}) \;=\; \mathbb{E}_{\eta,\tau}\Bigg\{\Pr(S=0|\widehat{L},\eta,\tau)\\ &\mathbb{1}\left(-\min\{X\tau+(X+\eta)(\widehat{L}-\tau),B\}\geq -X\tau+\overline{V}(Z')\right)\Bigg|\,\eta\geq\frac{B-X\widehat{L}}{(\widehat{L}-\tau)}\Bigg\}.\end{aligned} \tag{3.14}$$

By contrast, when we observe less than full payment, i.e., for $P<B$, we must have $P=X\tau+(X+\eta)(\widehat{L}-\tau)$ and consequently $\eta=\frac{P-X\widehat{L}}{\widehat{L}-\tau}$. Therefore, for $P<B$, we have

$$\begin{aligned}\Pr(P,D=1|C=1,\widehat{L}) \;=\; \mathbb{E}_{\tau}\Bigg\{&f_{\eta}\left(\frac{P-X\widehat{L}}{(\widehat{L}-\tau)}\right)\frac{1}{(\widehat{L}-\tau)}\\ &\left[1-\Pr(S=0|\widehat{L},\frac{P-X\widehat{L}}{(\widehat{L}-\tau)},\tau)\right]\mathbb{1}\left\{P\geq -X\tau+\overline{V}(Z')\right\}.\end{aligned} \tag{3.15}$$

3.6.2 Parametrization

In order to maximize the likelihood function (3.3), several objects must first be parameterized, taking into account the restrictions implied by both our

model and the econometric specification. These objects relate to the conditional probability of initial plan confirmation, $Q(C|L,Z)$, the probability of dismissal after the shocks η and τ are realized, $\Pr(S=1|L,\eta,\tau,Z)$, the payoff associated with options outside Chapter 13, $\overline{V}(Z)$, the density functions that govern the shocks η and τ, $f_\eta(\eta|L,Z)$ and $f_\tau(\tau|L,Z)$, respectively, and the distribution of ε_L, $G(\varepsilon_L|L,Z)$.

We assume $Q(C|L,Z)$ is specified as a logistic function:

$$Q(C=1|L;Z) = \frac{e^{q(L,Z)}}{1+e^{q(L,Z)}}, \tag{3.16}$$

where

$$\begin{aligned} q(L,Z) &= \beta_0^c + \beta_1^c L + \beta_2^c ratio\_asset\_debt \\ &+ \beta_3^c ratio\_arrears\_debt + \beta_4^c ratio\_rent\_mortgage\_inc \\ &+ \beta_5^c medical\_debt + \beta_6^c job\_tenure \\ &+ \beta_7^c inc\_above\_med + \beta_8^c repeat\_filer \\ &+ \beta_9^c attorney\_exp + \beta_{10}^c p\_recovery\_rate, \end{aligned}$$

and the β_i^C's are parameters to be estimated.[26]

We next discuss the parametrization of $G(\varepsilon_L|L,Z)$. We assume $G(\varepsilon_L|L,Z)$

[26] All the observed variables are defined in Table 3.4.

is specified by a power distribution, i.e.,

$$G(\varepsilon_L|L,Z) = [\varepsilon_L Q(C=1|L,Z)]^{\varphi(L,Z)}. \tag{3.17}$$

for $\varepsilon_L \in \mathcal{E}_L$. To ensure that the conditional probability $P(C=1|L,Z)$ of plan confirmation lies in $[0,1]$, the support of ε_L must be bounded. In addition, recall that we assume $E(\varepsilon_L) = 1 \ \forall L$. Thus, we require that $\mathcal{E}_L = [0, \frac{1}{Q(C=1|L,Z)}]$ and $\varphi(L,Z) = \frac{Q(C=1|L,Z)}{[1-Q(C=1|L,Z)]}$. These restrictions, therefore, tie down both the shape and the support of $G(\varepsilon_L|L,Z)$.

We assume $\Pr(S=1|L,\eta,\tau,Z)$ is also specified as a logistic function,

$$\Pr(S=1|L,\eta,\tau,Z) = \frac{e^{d(L,Z,\eta,\tau)}}{1+e^{d(L,Z,\eta,\tau)}}, \tag{3.18}$$

where

$$\begin{aligned} d(L,Z,\eta,\tau) &= \beta_0^d + \beta_1^d L + \beta_2^d ratio\_asset\_debt + \beta_3^d ratio\_arrears\_debt \\ &+ \beta_4^d ratio\_rent\_mortgage\_inc + \beta_5^d medical\_debt + \beta_6^d job\_tenure \\ &+ \beta_7^d inc\_above\_med + \beta_8^d repeat\_filer \\ &+ \beta_9^d attorney\_exp + \beta_{10}^d discharge\_recovery\_rate \\ &+ \beta_{11}^d dismiss\_recovery\_rate + \beta_{12}^d \eta + \beta_{13}^d \tau. \end{aligned}$$

We estimate the payoff associated with options that do not involve Chapter 13

as

$$\overline{V}(Z) = \beta_1^D arrears + \beta_2^D unsecured\_debt + \beta_3^D assets. \tag{3.19}$$

This specification allows for the possibility that debtors' payoff outside Chapter 13 decreases with both the amount of debt they carry and the amount of assets that would have otherwise been protected under Chapter 13.

We assume that τ has a power distribution with density

$$f_\tau(\tau|L,Z) = \frac{\beta_L^\tau \tau^{\beta_L^\tau - 1}}{L^\beta} \text{ for } \tau \in [0,L]. \tag{3.20}$$

Finally, we assume η is normally distributed with density

$$f_\eta(\eta|L,Z) = \frac{1}{\sqrt{2\pi\left(\beta_{1,L}^\eta\right)^2}} \exp\left(-\frac{(\eta - \beta_{0,L}^\eta)^2}{2(\beta_{1,L}^\eta)^2}\right). \tag{3.21}$$

The family of distribution functions we choose has enough flexibility to capture any potential effects of a debtor's plan length choice and characteristics on the likelihood that his case will be confirmed and discharged, as well as the determination of his implied recovery rate.

3.7 Results

Tables 3.5, 3.6, and 3.7 present the maximum likelihood estimates of the model's parameters. Specifically, Table 3.5 presents the maximum likelihood estimates of the parameters of the confirmation probability $Q(C = 1|L,Z)$ given by (3.16), Table 3.6 presents the estimates of the parameters of the dismissal

probability $\Pr(S = 1|L, \eta, \tau, Z)$ given by equation (3.18), and Table 3.7 presents the estimates of the parameters of the outside payoff $\overline{V}(Z)$ given by (3.19), the distribution of the shock η given by (3.21), and the distribution of its timing τ given by (3.20).

These estimates allow us to directly answer two questions of interest. First, what debtor characteristics significantly influence the likelihood that a Chapter 13 bankruptcy plan will be confirmed by the bankruptcy court? In a related vein, do these characteristics still matter at a later bankruptcy stage as the debtor's circumstances have changed and the trustee reevaluates the plan? With the answers to these questions, we can indirectly infer how particular debtor attributes affect creditor recovery rates.

Table 3.5 indicates that, all else equal, long-term plans are more likely to be initially approved by the trustee than are short-term plans. Longer plans typically imply higher proposed recovery rates in our sample. Even after controlling for the proposed recovery rate, the probability of a proposed plan being confirmed is higher when the proposed plan length is longer.

In addition, as can be seen from Table 3.6, longer plans make it less likely that the plan will be dismissed later on in the bankruptcy.

Recall that a Chapter 13 plan must propose to pay all arrears in order for a plan to be confirmed and must be able to pay them all in order to be discharged. As a result, having considerable arrears in relation to total debt in default decreases the confirmation probability and increases the dismissal probability.

Having a high housing expense relative to monthly income decreases the

confirmation probability and increases the dismissal probability. This is consistent with our conversations with the Chapter 13 Trustee for the District of Delaware, who emphasized the importance of fairness and feasibility as the most important criteria for confirming plans and allowing them to continue. Recall that the bankruptcy law requires the debtors to pay all of their excess income to the Chapter 13 plan, and excess income is calculated after taking out all expenses, including the housing expense. A high housing expense relative to monthly income may be viewed as a luxurious consumption at the expense of creditors and thus not fair. In addition, a high housing expense makes the debtor more vulnerable to negative shocks to excess income, making it more difficult for him to pay the arrears in full and therefore less likely to pass the feasibility test.

A longer job tenure suggests some degree of stability in the debtor's financial situation. As a result, the plan is more likely to be feasible when the debtor has a longer job tenure. Consistent with this, longer job tenure increases the probability that the trustee will confirm the plan and decreases the dismissal probability.

The fact that a debtor is a repeat filer decreases the probability that his plan will be confirmed. There are two main reasons for why a debtor might be a repeat filer. First, a debtor whose case is not initially confirmed has little chance of seeing his financial situation improve without outside help and, by law, he must wait at least 180 days before attempting a new filing. A repeat filer, therefore, could simply be someone who is unable to extricate himself from a dire financial situation on his own. Second, a repeat filer might be someone

who abuses the bankruptcy system by periodically filing for bankruptcy and discharging his debt. One would think that a debtor who is in the first category is more likely to file for bankruptcy as soon as that option becomes available to him, whereas a debtor in the second category is more likely to strategically acquire debt first and delay bankruptcy filing. In our data set, 88% of repeat filers had their previous filings around 180 days prior to the current bankruptcy filing and hence fall in the first category. For the rest of the filers, we are unable to identify the reasons for their repeat filing behavior. It is possible that the same nonstrategic cause (for example, health problems) is the reason for multiple bankruptcy filings. Although we do not observe the cause for the repeat filing, the trustee has access to much more information. Regardless of the cause, being a repeat filer reduces the likelihood of confirmation. One possibility is that debtors in the first category are unlikely to propose feasible plans, whereas debtors in the second category are unlikely to propose fair plans.

Having an experienced attorney helps to have a plan confirmed, but it also increases the probability of dismissal after the debtor's financial situation changes. Recall that we measure attorney experience by the number of cases in the sample associated with the attorney representing the debtor. One would expect that more experienced attorneys have higher demand for their services and better bargaining power regarding their fee structure. In the U.S. Bankruptcy Court for the District of Delaware, the fee charged by an attorney for a Chapter 13 case must be approved by the bankruptcy court. The structure of the fee, however, is not defined by the law. In particular, the attorneys can ask to be paid prior to or after filing the case and can stipulate whether the fee is to be

paid directly by the debtor or by the Chapter 13 trustee. The court then approves a fee it finds to be reasonable. If more experienced attorneys charge fees that are mostly front-loaded, then they may prefer to devote less of their time to cases that are already confirmed and have less time to finish, since less fees can then be collected. As such, it is not surprising that having an experienced attorney is helpful initially but may backfire later on in the case.

Notably, Table 3.6 also indicates that the trustee puts significant weight on information regarding changes in the debtor's conditions after initial confirmation of his plan. The likelihood of dismissal falls with τ, since the longer a debtor has stuck by his initial plan before facing a change in circumstances, the more he has already contributed to this plan. Similarly, the likelihood of dismissal falls with η, since increases in excess disposable income raise creditors' recovery rate.

The parameters governing the distributions of η and τ are reported in Table 3.7 and are all statistically significant at the 1% level. We estimate that, on average, debtors who file for short-term plans are less likely to experience a negative shock to their excess incomes during bankruptcy, although the variation in experiences for those debtors is considerable. Specifically, the excess income of debtors with short-term plans reduces by \$464 while the excess income of debtors with long-term plans reduces by \$704, on average. While these amounts are small, they do not imply that the actual recovery rate will be close to the proposed recovery rate. The standard deviation of η conditional on a short-term plan is \$3,217, while the standard deviation conditional on a long-term plan is \$3,395; as a result, there is considerable variation in shocks to excess income.

Many debtors for whom there is a substantial negative shock to excess income see their plans dismissed by the trustee in the second stage. Thus, for those debtors, the recovery rate is in fact close to zero.

Finally, Table 3.7 indicates that the payoff obtained outside Chapter 13 decreases with the updated level of arrears and assets held at the time of exit, while it does not depend on the level of unsecured debt at the time of exit. This is because once a filer is no longer eligible under Chapter 13, his assets are no longer protected and thus secured creditors can seize property to recover what they are owed. Secured creditors are more likely to aggressively seek a filer's assets when the assets are more valuable and the secured debt (i.e., arrears) is higher. By contrast, unsecured creditors have little power outside the bankruptcy system.

3.7.1 Effects of Debtor Characteristics on the Distribution of Recovery Rates

The second question of interest in this section relates to the effects of specific debtor characteristics on Chapter 13 outcomes and, in particular, on the distribution of creditor recovery rates.[27] For example, given that we have identified being a repeat filer as a significant variable in the trustee's confirmation and dismissal decisions, what are the implications for the distribution of recovery rates? In answering this question, the lens provided by the particular model at hand is crucial since the distribution of the recovery rates depends not only on

[27] In our model and in our empirical specification, we focused on the payment P. We present our results below in terms of the recovery rates to make them comparable across debtors with different levels of debt.

the exogenous characteristics of debtors, but also on the endogenous decisions they make. The model allows us to create a data set of artificial debtors that resembles the raw data in all dimensions but one, say, being a repeat filer, by bootstrapping from observed debtor characteristics (outside of being a repeat filer). Having created these artificial debtors, we can then explore, using the estimated model, how the distribution of recovery rates changes depending on whether, in addition, these debtors are assumed to be repeat filers.[28]

Figure 3.5a illustrates how the distribution of creditor recovery rates changes depending on one's experience with bankruptcy. We can see that repeat filers are generally associated with lower recovery rates, with 50% of debtors repaying between 0% to 20% of their debt. In contrast, only 41% of debtors are associated with the lowest recovery rates among first-time filers. More generally, creditors recover 38% of what they are owed on average from first-time filers, but only 31% from repeat filers. Similarly, Figure 3.5b depicts changes in the distribution of recovery rates depending on the amount of arrears debtors hold as a fraction of their total debt in default. Debtors for whom arrears constitute 25% of their debt (arrears being equal to 25% of debt corresponds to the 25^{th} percentile in the raw data) are associated with a 35% average recovery rate, and 44% of those debtors repay between 0% and 20% of their debt. In contrast, when debtors hold arrears equal to 69% of their debt (arrears being equal to 69% of debt corresponds to the 75^{th} percentile in the raw data), the average recovery rate falls to 25%, while the measure of debtors repaying less than 20% increases by 16 percentage points.[29]

[28] See Diermeier, Eraslan, and Merlo (2003) for alternative applications of this procedure in a political economy context and in a Chapter 11 bankruptcy environment, respectively.

[29] More specifically, we first calculate the 25^{th} percentile and the 75^{th} percentile of the

Finally, Figure 3.5c illustrates the extent to which the distribution of recovery rates changes conditional on debtors having a given ratio of excess (annual) income to debt. This measure essentially determines what debtors can potentially repay depending on the plan length they choose. Debtors in the lowest 25^{th} percentile, those with excess income representing 8% of their debt, repay 23% of what they owe on average. Debtors in the highest 25^{th} percentile, those whose excess income represents 19% of their debt, are associated with a significantly higher 42% average recovery rate.[30]

Figure 3.6 provides lower and upper bounds in terms of what creditors can expect to recover in Chapter 13 by considering extreme debtor types based on the experiments carried out in Figure 3.5. The distribution of recovery rates related to "bad types" conditions on being a repeat filer, having high arrears, and having low excess income relative to debt. This "worst case" scenario generates an average recovery rate of only 15%, with a substantial 74% of debtors repaying less than 20% of their debt and only 3% repaying more than 80%. At the other extreme, the distribution of recovery rates for "good types" is conditional on being a first-time filer, having low arrears, and having high excess income relative to debt. This distribution is associated with a much higher 51% average recovery rate, with only 31% of the debtors repaying between 0% and 20% of their debt and 34% of debtors repaying at least 80%.

distribution for the ratio of arrears to debt in default. We then bootstrap a data set of artificial debtors from the raw data such that all characteristics of debtors resemble the raw data while the values for the ratio of arrears to debt is set to the 25^{th} percentile of the distribution in the raw data. Next, we repeat this procedure and construct another data set of artificial debtors, where the values for the ratio of arrears to debt are set to the 75^{th} percentile of the distribution in the raw data.

[30]The method for constructing the data with artificial debtors is similar to that used in creating Figures 3.5a and 3.5b.

3.7.2 Importance of Shocks in Bankruptcy

We saw in Table 3.6 that the shock η and its timing τ play a significant role in the trustee's reevaluation of previously confirmed cases.

To quantify their importance, we provide in Table 3.8 a comparison of Chapter 13 outcomes between our benchmark model and the model estimated without latent variables η and τ. In the absence of shocks after a plan confirmation, we find that debtors are less willing to commit to long-term plans. Debtors with unfavorable characteristics tend to file for longer plans to increase their chances of confirmation and decrease the probability of dismissal. However, with the elimination of the dismissal process later in the plan, fewer debtors feel the need to file for long plans. The confirmation rate stays unchanged even if the ratio of debtors who file for longer plans declines. The reason is that the composition of debtor characteristics conditional on plan length is different compared to the benchmark model. Without shocks, the negative effect on confirmation rates coming from the fact that fewer debtors file for long plans counteracts the positive effect resulting from the more favorable characteristics of short-plan filers. Furthermore, without being affected by changing circumstances while in bankruptcy, all debtors with confirmed plans are eventually discharged. We find that 81% of debtors in our sample are discharged absent shocks as opposed to only 46% in the benchmark model. Furthermore, absent any income shocks, debtors are able to repay on average 48% of their debt as opposed to 29% in the benchmark model. This finding arises, because without shocks, all plans are carried out to completion. Therefore, aside from debtor

characteristics that are observable at the time of filing, changes in debtors' conditions after the start of a bankruptcy procedure play a key role in governing Chapter 13 outcomes.

3.7.3 Goodness of Fit

In order to gauge the fit of our model, we present figures that compare its predictions for the distributions of endogenous variables with the analogous empirical distributions in the data. Each figure focuses on a key aspect of Chapter 13 bankruptcy: the distribution of plan length chosen by debtors, the confirmation rate, the discharge rate, and the distribution of recovery rates. We assess how well our model fits the data using Pearson's χ^2 test,

$$N \sum_{j=1}^{K} \frac{\left[f(j) - \widehat{f}(j) \right]}{f(j)} \sim \chi^2_{K-1},$$

where $f(.)$ denotes the empirical density function, or histogram, of a given endogenous variable and $\widehat{f}(.)$ is the corresponding maximum likelihood estimate of the density function of that variable. N is the number of observations, and K is the number of bins used in the histogram.

Figure 3.7, panel a shows a comparison of the distribution of plan length chosen by debtors generated by the model (left columns) with the corresponding distribution in the data (right columns). As indicated in the figure, the χ^2 goodness-of-fit test does not reject the model at conventional significance levels. Panels b and c of Figure 3.7 illustrate similar comparisons with respect to the confirmation rate and the discharge rate. In both cases, the model is capable

of reproducing the empirical distributions quite well, and the χ^2 goodness-of-fit tests cannot reject the model at conventional significance levels. Finally, we can see from Figure 3.7, panel d, that the shape of the distribution of recovery rates produced by the model closely matches that of the corresponding empirical distribution. The model slightly under-predicts the fraction of debtors associated with relatively higher recovery rates, which implies a slightly lower average recovery rate than observed in the data. As in the other cases, however, the χ^2 goodness-of-fit test does not reject the model at standard significance levels.

3.8 Policy Analysis

Recent changes in the bankruptcy law embodied in BAPCPA were primarily intended to raise creditor recovery rates for subsets of debtors perceived to be benefiting from too lenient a bankruptcy code. One such change now prohibits all debtors with income above the state median from filing for short-term plans. Specifically, the law states that "the applicable commitment period shall be (...) not less than five years, if the current monthly income of the debtor and the debtor's spouse combined, when multiplied by 12, is not less than (...) the median family income of the applicable state."[31] Using the structural model we estimated, we now explore the quantitative effects of such a change on Chapter 13 outcomes.

[31] See 11 U.S.C § 1325(b)(4)(A)(ii).

3.8.1 Requiring Five-Year Plans for Above-Median-Income Debtors

Table 3.9 summarizes the effects of requiring debtors with above-state-median-income to file for five-year plans. Note that, following the policy change, debtors who had initially filed for three-term plans, but who no longer have that option, may well decide not to file Chapter 13 altogether, rather than filing for Chapter 13 and proposing a five-year plan. Put another way, and recalling equation (3.1), debtors for whom $V(L) \geq \overline{V}(Z)$ when $L = 3$ in the benchmark model may well have $V(L) < \overline{V}(Z)$ when $L = 5$ if forced to make the higher payments implied by a five-year plan. We find that this effect is somewhat muted in this policy experiment, as only 1% of above-median-income debtors choose to exit Chapter 13 following the policy change.

Interestingly, for the set of debtors targeted by the policy change, the main finding is a minimal increase in creditor recovery rates without considerably changing the discharge and confirmation rates. In other words, requiring the above-median-income debtors to file for five-year plans makes neither a financial fresh start more likely for that subset of debtors nor the creditors materially better off. At first look, it is puzzling that the confirmation rates and the discharge rates go down when these debtors are required to file five-year plans in light of our estimation results, which indicate that five-year plans are more likely to be confirmed and less likely to be dismissed. However, two additional effects need to be taken into consideration. First, the debtors who opt out of Chapter 13 as a result of this policy are likely to be the ones who are in better financial condition and therefore, more likely to have confirmed plans

prior to the implementation of the new policy. Once these debtors drop out of Chapter 13, confirmation rates go down. Second, the debtors who file for five-year plans are more likely to receive negative shocks to their excess income, making dismissal more likely, and therefore discharge less likely.

We should also note that, although the policy change lowers the Chapter 13 filing rate by 1%for above-median-income debtors, the outcomes in the overall sample are not materially affected. This follows from the fact that debtors whose income exceeds the state median represent only 23% of the filers in our sample.

An important consideration under this policy provision is that, while more debtors are being pushed into five-year plans, the analysis assumes that their other characteristics remain unchanged. This simplifying assumption reflects a limitation of our data. As a direction for future research, it would be ideal to sample the general population and, given this sample, consider both bankruptcy and chapter choices explicitly.[32]

[32]For now, this more challenging exercise remains beyond the scope of this paper. While some existing data sets such as the Survey of Consumer Finances, the Panel Study of Income Dynamics, and the National Longitudinal Survey of Young Men provide us with financial and income statements pertaining to the general U.S. population, the challenge lies in the collection of data on bankruptcy filers, and more precisely Chapter 7 and Chapter 13 filers separately, within that general population, as well as the resolution of their respective bankruptcy cases. For this reason, the different policy experiments in this paper are conditional on the observed distribution of the debtor characteristics.

3.8.2 Imposing a Minimum Proposed Recovery Threshold

Because the BAPCPA policy change targeted at above-median-income debtors proved ineffective in raising their recovery rates, we explore an alternative policy experiment that instead requires these debtors to propose at least a 30% recovery rate in order to have their plan confirmed by the court. In other words, we impose that all debtors with above-state-median-income propose at least the observed mean recovery rate in our sample.

Table 3.10 suggests that, when confronted with this alternative policy change, a considerable fraction of debtors (13%) now find it optimal not to file under Chapter 13 in the first place. Accordingly, substantially fewer debtors ultimately obtain a financial fresh start under Chapter 13; the discharge rate falls, from 0.48 to 0.41, for this group of affected filers.

The average creditor recovery rate under this policy experiment falls slightly, from 0.31 to 0.29, for the affected debtors. The latter result can be understood in the following way. First, above-state-median-income debtors who were already proposing to repay at least 30 cents on the dollar see their fate (confirmation, discharge, and repayment rates) essentially unchanged by the new policy. Hence, any effect of the policy change on bankruptcy outcomes must come from debtors who were initially proposing less than a 30% recovery rate. Second, the latter debtors are precisely those associated with low Chapter 13 recovery rates in the benchmark model; they tend to have high levels of arrears and high levels of debt more generally (and therefore low ratios of excess income to debt). Consequently, the fact that they are now opting out of Chapter 13 and

are assigned zero (rather than small but positive) recovery rates, has very little effect on overall repayment rates. Stated differently, the analysis suggests that debtors associated with low proposed recovery rates simply opt out of Chapter 13 if required to propose a higher recovery rate. However, since these debtors repay very little in the benchmark model, recovery rates for the overall targeted population are left virtually unchanged. In the end, the model suggests that the hypothetical minimum recovery rate policy studied here makes it more difficult for debtors to obtain a financial fresh start without necessarily increasing creditor recovery rates.

3.8.3 Implications for Overall Recovery Rates

Thus far, our policy experiments have tracked bankruptcy outcomes, and in particular creditor recovery rates, within Chapter 13 bankruptcy only. In computing recovery rates, therefore, we did not particularly focus on debtors who wound up outside Chapter 13 for one reason or another. For some policy experiments, this is not necessarily a problem since the fraction of debtors who opt out of Chapter 13 following a given policy change is small, as in the case of BAPCPA. In other cases, however, as in the experiment that imposes a minimum proposed recovery threshold to obtain confirmation of a case, the fraction of debtors who chose not to file for Chapter 13 is sizable. In addition, recall that some debtors are also dismissed out of Chapter 13 at a later bankruptcy stage. In such cases, debtors may be able to file under Chapter 7 or simply default on their loans. Since our focus in this paper is on Chapter 13, we model the payoff outside Chapter 13 as an indirect utility.

A question remains as to how overall recovery rates are affected by the recovery rates outside Chapter 13. To be able to answer this question, we would need to model what happens outside Chapter 13. Unfortunately, we do not have the data to be able to estimate such a richer model, and to the best of our knowledge, such micro data is not available. At a more aggregated level, Flynn, Bermant, and Bakewell (2002) document that during the year ended June 30, 2002, in approximately 96% of Chapter 7 filings, the case closed without any funds being collected by the trustee and distributed to creditors. In general, studies report a 0% average return to creditors from Chapter 7 filers. Indeed, this is what motivated BAPCPA to push debtors into Chapter 13 in the first place.

Taking into account the possibility that the debtors in our data set can be in better financial shape than those debtors considered in the above statistics, Table 3.11 presents overall recovery rate calculations based on the assumption that debtors outside Chapter 13 repay either 10% or 20% of their debts. The table considers the experiment where above-state-median-income debtors must propose at least a 30% recovery rate in order to have their case confirmed by the court. Recall that in contrast to the BAPCPA experiment we considered, this policy experiment was associated with a sizable fraction of debtors no longer choosing to file under Chapter 13. The benchmark model in Table 3.11 refers to the situation without the policy change, but is nevertheless relevant since, even in that case, some debtors are either dismissed by the trustee or voluntarily exit Chapter 13 after initial confirmation. As expected, overall recovery rates increase, both in the benchmark model and in the policy experiment,

when debtors outside Chapter 13 repay positive amounts on their debts. This increase, however, remains somewhat contained, even at the extreme where debtors outside Chapter 13 repay 20 cents on the dollar. More importantly, as in Table 3.10, the policy change is unable to yield a substantive increase, and may even yield a decrease, relative to the higher recovery rates generated in the benchmark model. As before, this result is driven by the fact that debtors who opt out of Chapter 13 were repaying very little in the benchmark model.

3.9 Conclusion

From court dockets recorded in the state of Delaware between 2001 and 2002, we built and estimated a structural model of Chapter 13 bankruptcy. We find that several factors significantly affect the distribution of creditor recovery rates: whether debtors are first-time filers, their arrears at the time of filing, and their income in excess of that required for basic maintenance. The analysis further underscores the importance of changes in debtors' conditions while in bankruptcy in governing Chapter 13 outcomes, including debtors' ability to obtain a financial fresh start. Our model predicts that the more stringent provisions of Chapter 13 in BAPCPA, in particular those that force subsets of debtors to file for long-term plans, would not materially affect creditor recovery rates and would not make discharge materially more likely for that subset of debtors. The results are also true in the context of alternative policy experiments that required bankruptcy plans to meet stricter standards in order to be confirmed by the court.

The analysis has an important caveat. Because of data limitations, we do not model simultaneously households' bankruptcy and chapter choice decisions. At this point, the payoff that debtors achieve outside of Chapter 13 is captured by way of an estimated indirect utility. However, this modeling strategy precludes a more detailed study of policy reforms that directly target chapter choice decisions. We leave this work to future research.

3.10 Tables

Table 3.1: Data Summary

Total Filings	821
Terminated	821
Discharged	364
Dismissed	457
Converted to Chapter 7	52

Table 3.2: Descriptive Statistics

	Mean	Standard Deviation	Median	Min	Max
Assets ($)	117,739	98,797	104,000	295	1,239,220
Assets/debt	4.42	4.79	3.28	0.02	55.46
Arrears ($)	15,492	12,517	11,000	30.43	132,012
Arrears/debt	0.48	0.29	0.46	0.001	1
Unsecured debt ($)	25,767	42,289	14,737	0	642,642
Excess income ($)	4,550	3,425.7	3,708	600	34,932
Medical debt (if exceeds 10% of total debt)*	0.08	0.28	0	0	1
Job tenure (years)	4.91	7.61	1	0	40
Income above median*	0.23	0.42	0	0	1
Repeat filer*	0.24	0.42	0	0	1
Attorney experience* (number of cases)	94.05	51.67	108	0	165
Monthly rent or mortgage payments ($)	845.75	431.25	760	2.5	4,299
Monthly rent or mortgage payment/monthly income	0.31	0.13	0.29	0.0009	1.06

Note: * indicates dummy variables; zero attorney experience indicates that the filer did not hire an attorney.

Table 3.3: Descriptive Statistics

Fraction of Three-Year Plans*	0.16
Confirmation Rate	0.81
Discharge Rate	0.44
Recovery Rate for Total Debt	
Mean	0.29
Standard Deviation	0.34
Median	0.14
Proposed Recovery Rate for Total Debt	
Mean	0.66
Standard Deviation	0.4
Median	0.6

*Three-year plans are defined as plans less than or equal to 48 Months

Table 3.4: Variable Definitions

Variable	Definition
L	The debtor's choice of plan length: 3 or 5 years.
ratio_asset_debt	Total assets as a fraction of debt in default at the time of filing.
ratio_arrears_debt	Arrears accumulated on secured debt as a fraction of debt in default at the time of filing.
ratio_rent_mortgage_inc	Monthly rent or mortgage payments as a fraction of monthly income.
medical_debt	Whether medical debts exceed 10% of total debt in default.
job_tenure	The debtor's tenure in years in his current job. (If the debtor is unemployed, this variable is equal to zero.)
inc_above_med	Whether the debtor's most recent annual income at the time of filing is above the state median.
repeat_filer	Whether the debtor has previously filed for bankruptcy.
attorney_exp	Attorney experience in handling bankruptcy cases, measured as the in-sample frequency.
eligible_7	Whether the debtor is eligible for Chapter 7 bankruptcy.
p_recovery_rate	The proposed recovery rate defined as total proposed payments over total debt in default.
discharge_recovery_rate	The recovery rate obtained upon discharge. It is calculated as total payments over total debt in default, conditional on the trustee not dismissing the debtor after the realization of shocks to excess income.
dismiss_recovery_rate	The recovery rate obtained upon dismissal. It is calculated as the ratio of total payments made by the debtor under the plan, prior to the realization of the shocks to excess income, to total debt in default.
η	Excess income shock.
τ	Timing of the excess income shock.

Table 3.5: Maximum Likelihood Estimates - Confirmation Probability

	$Q(C\|L,Z)$	
Parameter	Estimate	Definition
β_0^c	0.079	constant.
	(0.391)	
β_1^c	0.471***	plan length.
	(0.071)	
β_2^c	-0.015	assets as a fraction of debt in default at the time of filing.
	(0.013)	
β_3^c	-1.696***	arrears accumulated on secured debt.
	(0.276)	
β_4^c	-1.042**	rent or mortgage payments as a fraction of monthly income.
	(0.492)	
β_5^c	0.011	whether medical debt exceeds 10% of total debt in default.
	(0.277)	
β_6^c	0.028***	job tenure.
	(0.01)	
β_7^c	0.237	whether the debtor's annual income is above the state median.
	(0.181)	
β_8^c	-0.388**	whether the debtor has previously filed for bankruptcy.
	(0.165)	
β_9^c	0.005***	attorney experience in handling bankruptcy cases.
	(0.001)	
β_{10}^c	0.083	proposed recovery rate.
	(0.140)	

* indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; and *** indicates statistical significance at the 1% level.

Table 3.6: Maximum Likelihood Estimates - Dismissal Probability

	$\Pr(S=1\|L,\eta,\tau,Z)$	
Parameter	Estimate	Definition
β_0^d	-2.366***	constant.
	(0.303)	
β_1^d	-0.291***	plan length.
	(0.044)	
β_2^d	0.065***	assets as a fraction of debt in default at the time of filing.
	(0.020)	
β_3^d	3.916***	arrears accumulated on secured debt.
	(0.447)	
β_4^d	4.046***	rent or mortgage payments as a fraction of monthly income.
	(0.830)	
β_5^d	-6.326***	whether medical debt exceeds 10% of total debt in default.
	(1.845)	
β_6^d	-0.019***	job tenure.
	(0.007)	
β_7^d	-0.814***	whether the debtor's annual income is above the state median.
	(0.263)	
β_8^d	1.458***	whether the debtor has previously filed for bankruptcy.
	(0.287)	
β_9^d	0.006***	attorney experience in handling bankruptcy cases.
	(0.002)	
β_{10}^d	0.006	recovery rates to be obtained upon discharge.
	(0.007)	
β_{11}^d	-0.856**	recovery rates to be obtained upon dismissal.
	(0.376)	
β_{12}^d	-0.980***	dollar amount of the shock to excess income.
	(0.337)	
β_{13}^d	-1.078***	timing of the shock to excess income.
	(0.090)	

* indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; and *** indicates statistical significance at the 1% level.

Table 3.7: Maximum Likelihood Estimates

Parameter	Estimate	Definition
Utility from Dismissal		
β_1^D	-5.875**	arrears accumulated on secured debt.
	(2.463)	
β_2^D	-4.470***	assets.
	(1.662)	
β_3^D	-0.669	unsecured debt.
	(0.427)	
$f_\tau(\tau\|L)$		
β_3^τ	0.546***	parameter of the distribution of τ when proposed pay length is 3.
	(0.027)	
β_5^τ	0.315***	parameter of the distribution of τ when proposed pay length is 5.
	(0.014)	
$f_\eta(\eta\|L)$		
$\beta_{0,3}^\eta$	-464.039***	mean of the distribution of η when proposed pay length is 3.
	(31.036)	
$\beta_{1,3}^\eta$	3217.090***	standard deviation of the distribution of η when proposed pay length is 3.
	(81.360)	
$\beta_{0,5}^\eta$	-703.762***	mean of the distribution of η when proposed pay length is 5.
	(20.572)	
$\beta_{1,5}^\eta$	3395.419***	standard deviation of the distribution of η when proposed pay length is 5.
	(47.959)	

* indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; and *** indicates statistical significance at the 1% level.

Table 3.8: Effects of Changes in Debtors' Conditions

	Model	Model Without η and τ
Whole Sample		
Plan Length		
Fraction Proposing $L = 3$	0.22	0.32
Fraction Proposing $L = 5$	0.78	0.68
Confirmation Rate	0.81	0.81
Discharge Rate	0.42	0.81
Mean Recovery Rate	0.29	0.48

Table 3.9: Implementing BAPCPA-Required 5-year Plans

	Benchmark Model	Experiment
Above-Median-Income Debtors		
Fractions No Longer Filing	0	0.01
Plan Length		
Fraction Proposing $L = 3$	0.24	0.00
Fraction Proposing $L = 5$	0.76	1.00
Confirmation Rate	0.85	0.84
Discharge Rate	0.48	0.47
Mean Recovery Rate	0.31	0.33
Whole Sample		
Confirmation Rate	0.82	0.82
Discharge Rate	0.42	0.41
Mean Recovery Rate	0.28	0.29

Table 3.10: Imposing a 30% Recovery Rate Threshold

	Benchmark Model	Experiment
Above-Median-Income Debtors		
Fraction No Longer Filing	0	0.13
Plan Length		
Fraction Proposing $L = 3$	0.24	0.14
Fraction Proposing $L = 5$	0.76	0.73
Confirmation Rate	0.85	0.73
Discharge Rate	0.48	0.41
Mean Recovery Rate	0.31	0.29
Whole Sample		
Confirmation Rate	0.82	0.80
Discharge Rate	0.42	0.40
Mean Recovery Rate	0.28	0.27

Table 3.11: Imposing a 30% Recovery Rate Threshold - Outside Recovery

	Outside Recovery Rate: *0.10*		Outside Recovery Rate: *0.20*	
	Benchmark Model	Experiment	Benchmark Model	Experiment
Above-Median-Income Debtors				
Fraction No Longer Filing	0	0.13	0	0.13
Initial Dismissal Rate	0.15	0.14	0.15	0.14
Dismissed after Confirmation	0.37	0.32	0.37	0.32
Mean Recovery Rate				
Under Chapter 13	0.31	0.29	0.31	0.29
Overall	0.35	0.35	0.40	0.40
Whole Sample				
Mean Recovery Rate	0.34	0.33	0.39	0.39

3.11 Figures

Figure 3.1: Distribution of Plan Length in Months

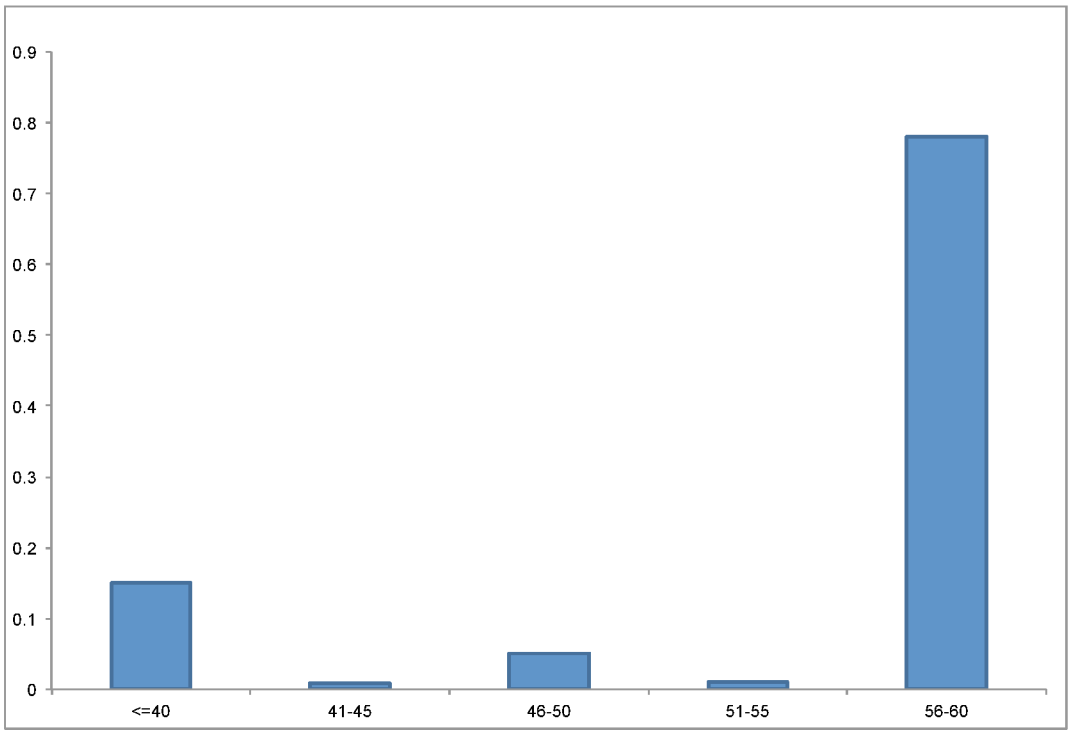
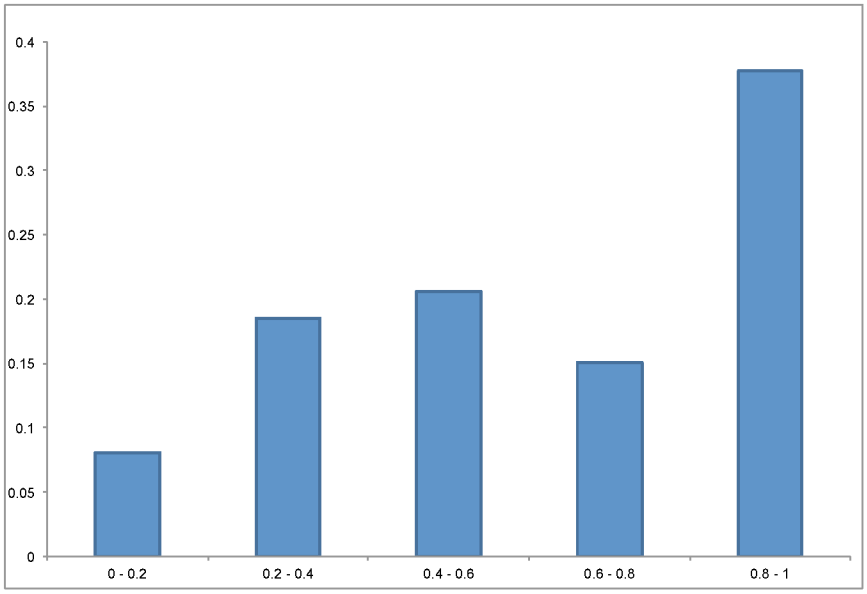
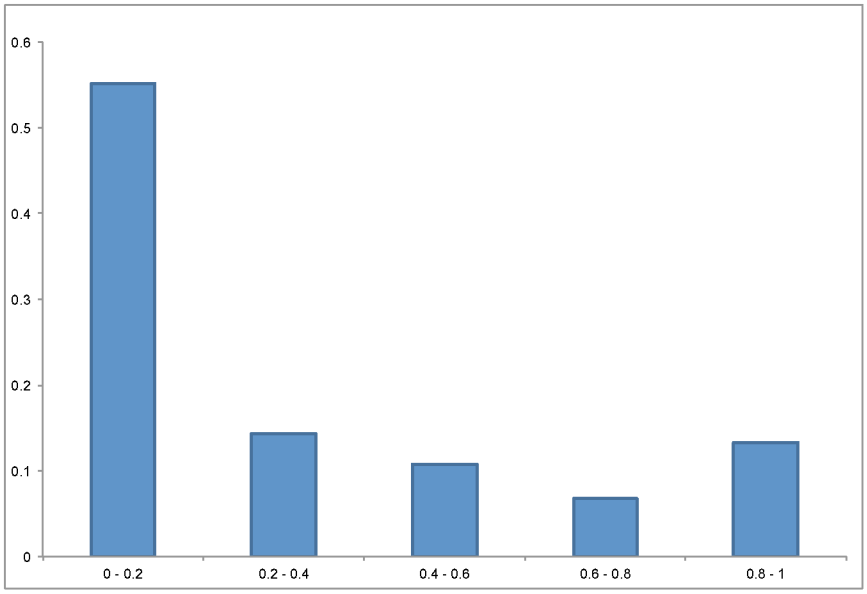


Figure 3.2: Distributions of Proposed and Actual Credit Recovery Rates

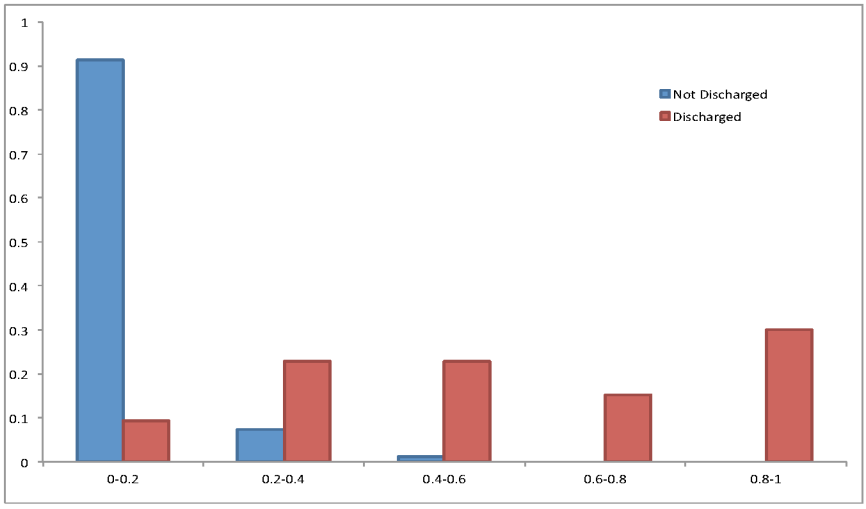


(a) Proposed

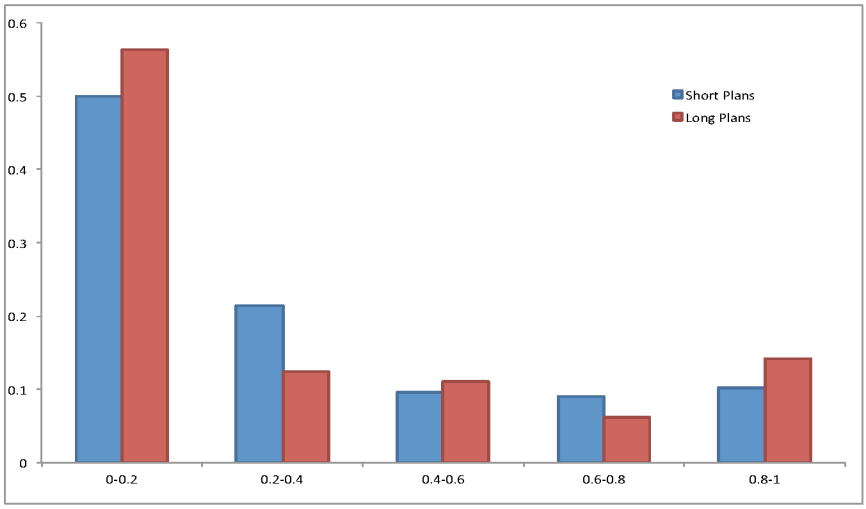


(b) Actual

Figure 3.3: Conditional Distributions of Recovery Rates



(a) Recovery Rate Conditional on Discharge



(b) Recovery Rate Conditional on Plan Length

Figure 3.4: Timing of Events

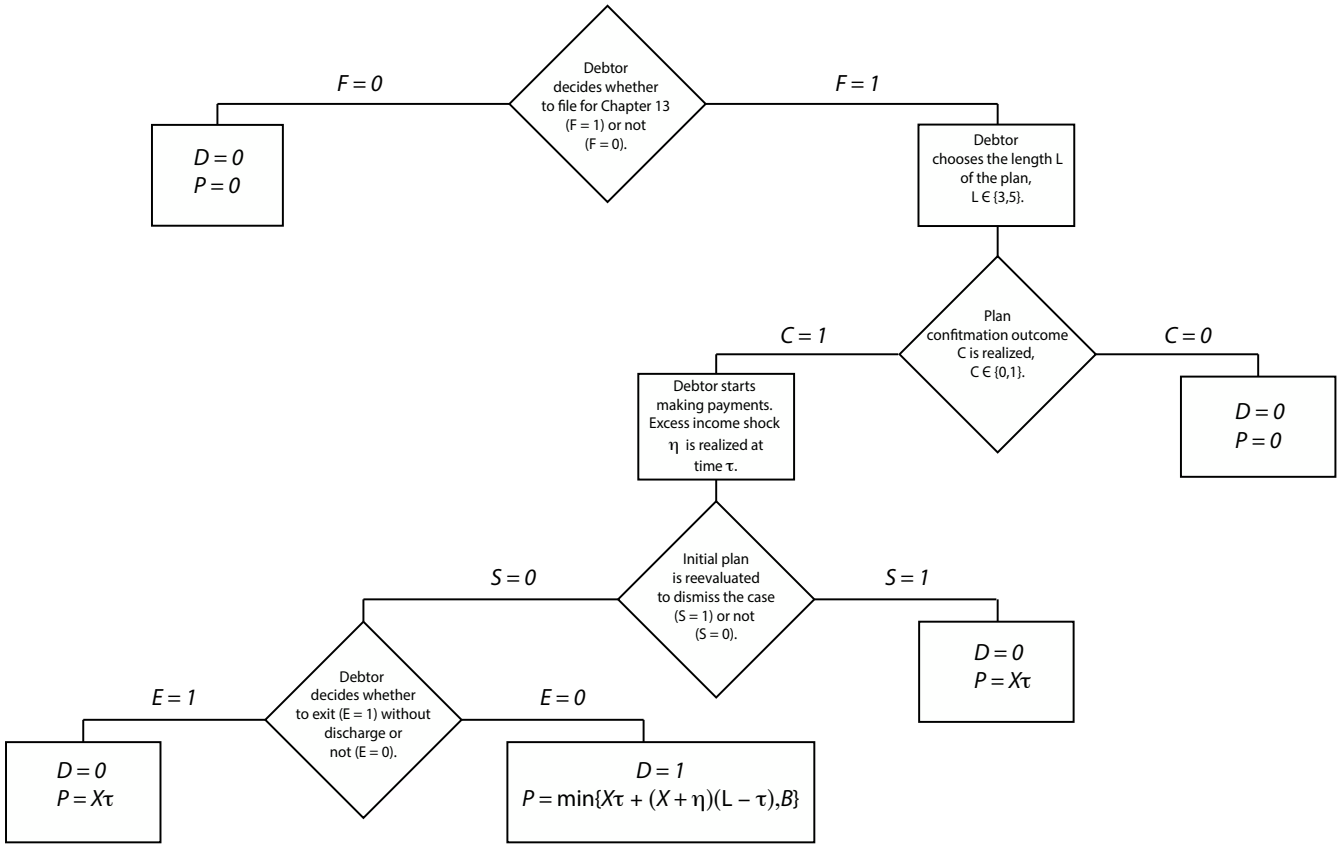
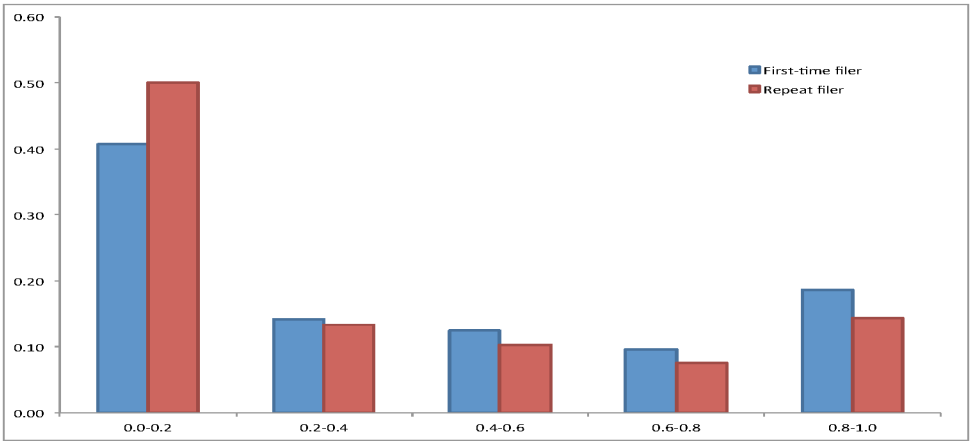
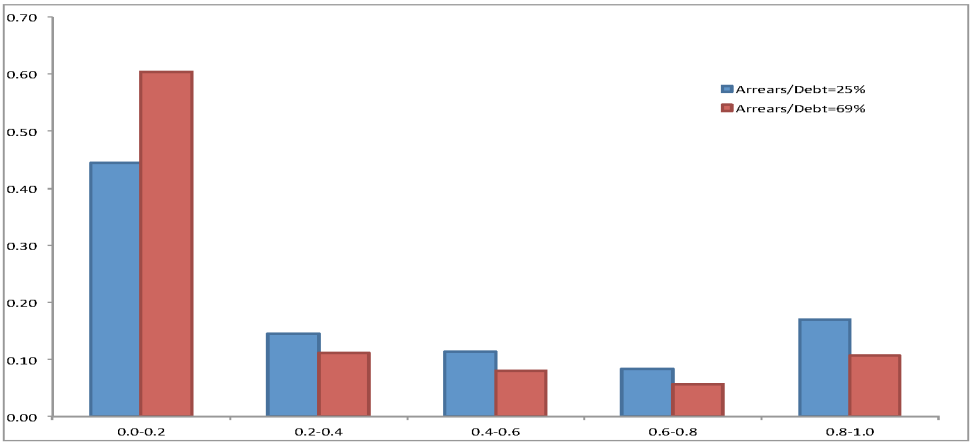


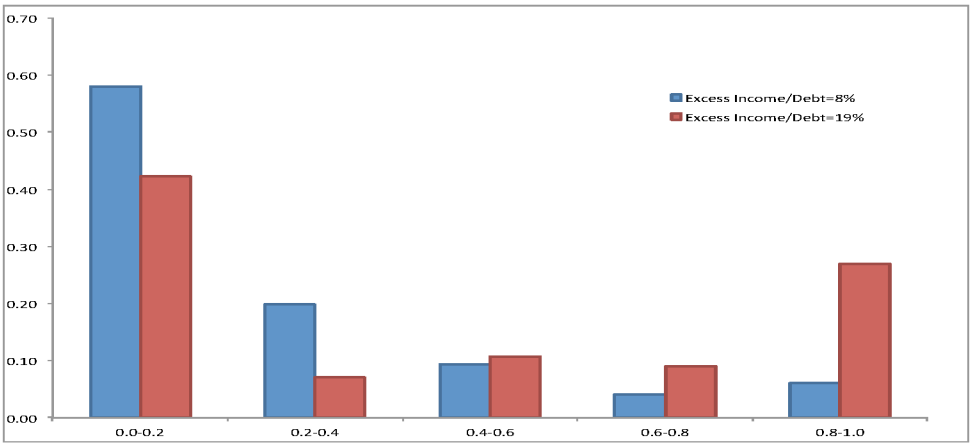
Figure 3.5: Model-Generated Conditional Distributions of Recovery Rates



(a) Recovery Rate Conditional on Bankruptcy Experience



(b) Recovery Rate Conditional on Arrears Burden



(c) Recovery Rate Conditional on Ability to Pay

Figure 3.6: Distributions of Recovery Rates for Extreme Debtor Types

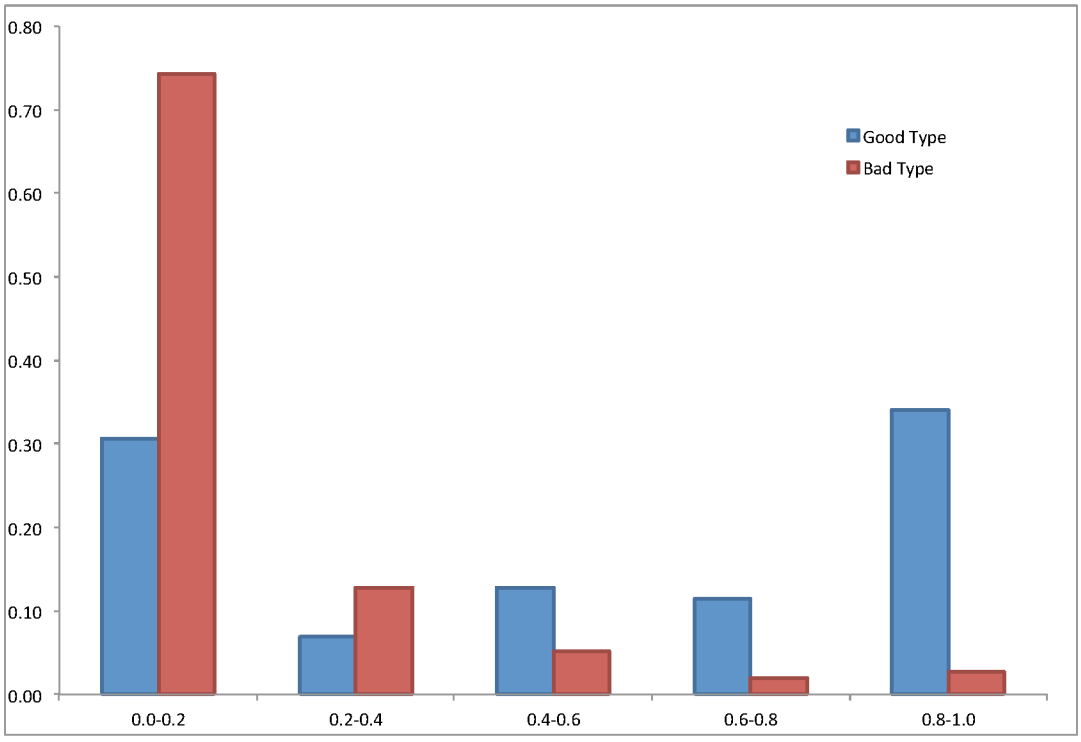
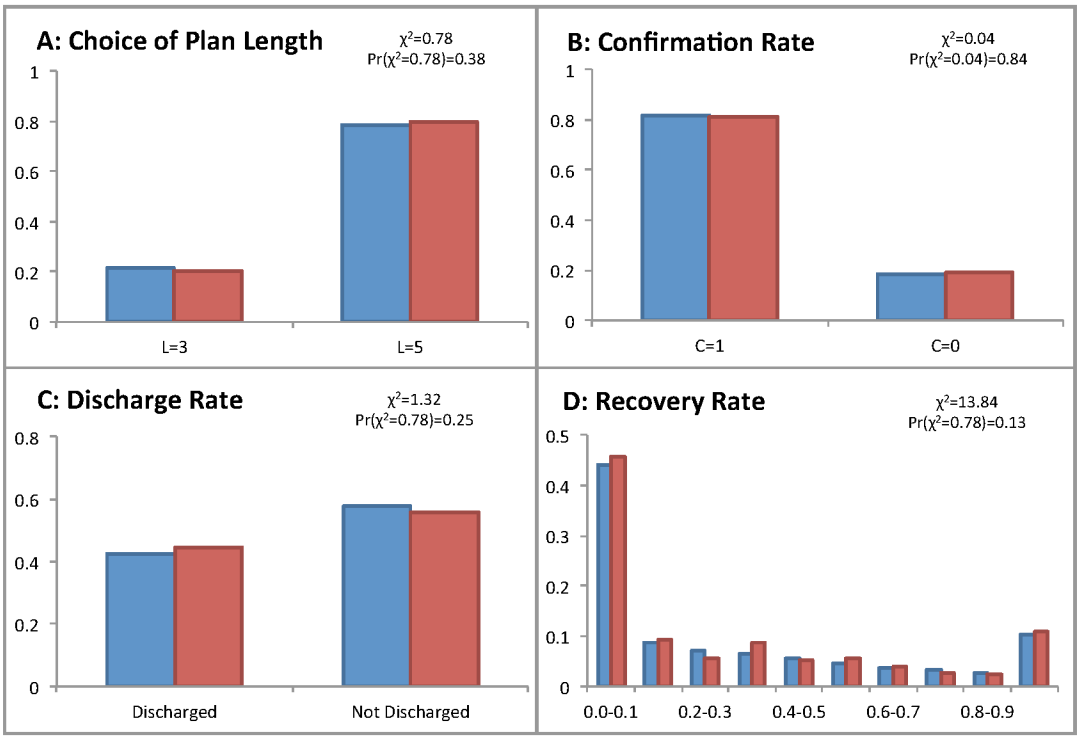


Figure 3.7: Model Fit (left columns: model; right columns: data)



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Gizem Koşar Karaca received her B.Sc and M.Sc degrees in Economics from the Middle East Technical University, Turkey in 2003 and 2007, respectively. She later started the Ph.D program in Economics at Johns Hopkins University. Her research interests lie in the field of labor and public economics with a focus on welfare programs, job search theory, and consumer bankruptcy. While she mostly utilizes applied microeconometrics in her research, she is also interested in understanding the mechanisms implied by the empirical results by means of applied economic theory.

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