

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

**A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600**

Job Search and Asset Accumulation under Borrowing Constraints

Silvio Rendón

A Dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

Department of Economics
New York University

September, 1997

Approved



UMI Number: 9808329

**Copyright 1997 by
Rendon, Silvio Roberto**

All rights reserved.

**UMI Microform 9808329
Copyright 1997, by UMI Company. All rights reserved.**

**This microform edition is protected against unauthorized
copying under Title 17, United States Code.**

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

© Silvio Rendón
All Rights Reserved 1997

To Jorge and Perla

To New York City

ACKNOWLEDGMENTS

I want to express my gratitude to Ken Wolpin, Chris Flinn and Wilbert van der Klaauw for their encouragement and advice.

W. Baumol, R. Bénabou, A. Caplin, J. Cummins, M. Gertler, B. Jovanovic, R. Kinnunen, Y. Nyarko, F. Peracchi, S. Pratap, G. Rabault, G. Topa, A. Velasco, C. Wilson and E. Wolff provided helpful comments and suggestions. All errors and omissions are mine.

Table of Contents

Table of Contents	v
List of Tables	viii
List of Figures	ix
1 Introduction	1
2 Literature Review	9
2.1 Job Search	10
2.2 Asset Accumulation and Borrowing Constraints	11
2.3 Job Search and Asset Accumulation	13
3 The Model	16
3.1 Job Market Transitions	17
3.2 Notation and Assumptions	20
3.3 Laws of Motion and Borrowing Constraint	21
3.4 Value Functions	23
3.5 Reservation Wage and Assets	24

3.6	Asset Accumulation and Employment Status	26
3.7	Numerical Simulations	30
3.8	Transition Probabilities	37
4	Data	40
4.1	Sample Selection	40
4.2	Descriptive Statistics	45
4.2.1	Home ownership	51
4.2.2	Marital Status	54
4.3	Reduced Form Estimations	56
5	Estimation Method	62
5.1	Construction of the Likelihood Function	64
5.2	Work Experience	72
5.3	Unobserved Heterogeneity	75
6	Estimation Results: Baseline Model	77
6.1	Parameter Estimates	77
6.2	Accuracy of the Model	81
6.2.1	Graphical Comparisons	81
6.2.2	Goodness of Fit Tests	86
7	Estimation Results: Extended Model	102
7.1	Parameter Estimates	103
7.2	Accuracy of the Model	110
7.2.1	Graphical Comparisons	110

7.2.2	Goodness of Fit Tests	115
8	Policy Experiments	129
8.1	Change in Transfers while Unemployed	129
8.2	Change in Initial Assets	134
8.3	Change in the Initial Asset Distribution	137
8.4	Change in Arrival Rates and Wage Offer Distribution	139
9	Conclusions	142
	Appendices	145
A	Proof of Theorem 1	145
B	Proofs of Propositions	150
C	Numerical Solution Algorithm	156
	Bibliography	159

List of Tables

1.1	Assets, Unemployment and Wages by Race and Years after Graduation. Male High School Graduates between 1978 and 1993	3
1.2	Average Quarterly Savings according to Employment Transitions for Blacks and Whites	5
3.1	Notation	19
3.2	First Unemployment Spell. Duration, Wages and Assets	31
3.3	First Unemployment Spell with Heterogeneous Agents. Duration, Wages and Assets	36
3.4	Model predicted Transition Probabilities	38
4.1	Summary Statistics	46
4.2	Composition of Net Assets according to Asset level, Race, and Years after Graduation	49
4.3	Current Net Asset holdings, Wages and Years after Graduation in 1985 dollars	50

4.4	Assets, Wages and Unemployment rate according to Home Ownership	52
4.5	Assets, Wages and Unemployment rate according to Marital Status	55
4.6	Reduced Form Decision Rules when Unemployed	57
4.7	Reduced Form Decision Rules when Employed	59
6.1	Parameter Estimates for the Baseline Model	78
6.2	Baseline Model. Actual and Predicted Choice Distribution for Employment by Year after Graduation: Blacks	88
6.3	Baseline Model. Actual and Predicted Choice Distribution for Employment by Year after Graduation: Whites	89
6.4	Baseline Model. Actual and Predicted Choice Distribution by Employment Transitions by Year after Graduation: Blacks	91
6.5	Baseline Model. Actual and Predicted Choice Distribution by Employment Transitions by Year after Graduation: Whites	92
6.6	Baseline Model. Actual and Predicted Choice Distribution for Assets by Year after Graduation: Blacks	94
6.7	Baseline Model. Actual and Predicted Choice Distribution for Assets by Year after Graduation: Whites	95
6.8	Baseline Model. Actual and Predicted Choice Distribution for Wages by Year after Graduation: Blacks	98
6.9	Baseline Model. Actual and Predicted Choice Distribution for Wages by Year after Graduation: Whites	99
7.1	Common Parameter Estimates for the Extended Model	104

7.2	Type-dependent Parameter Estimates for the Extended Model	107
7.3	Extended Model. Actual and Predicted Choice Distribution for Employment by Year after Graduation: Blacks	116
7.4	Extended Model. Actual and Predicted Choice Distribution for Employment by Year after Graduation: Whites	117
7.5	Extended Model. Actual and Predicted Choice Distribution by Employment Transitions by Year after Graduation: Blacks	119
7.6	Extended Model. Actual and Predicted Choice Distribution by Employment Transitions by Year after Graduation: Whites	120
7.7	Extended Model. Actual and Predicted Choice Distribution for Assets by Year after Graduation: Blacks	122
7.8	Extended Model. Actual and Predicted Choice Distribution for Assets by Year after Graduation: Whites	123
7.9	Extended Model. Actual and Predicted Choice Distribution for Wages by Year after Graduation: Blacks	126
7.10	Extended Model. Actual and Predicted Choice Distribution for Wages by Year after Graduation: Whites	127
8.1	Effect of Regime Change using the Extended Model. 10% Decrease in Transfers while Unemployed	130
8.2	Effect of Regime Change using the Baseline Model. 10% Decrease in Transfers while Unemployed	133
8.3	Effect of Regime Change using the Baseline Model. Initial Assets: Before= No Assets; After:\$2000	136

8.4	Effect of Regime Change. Blacks have the Initial Asset Distribution of Whites. Whites have the Initial Asset Distribution of Blacks . . .	138
8.5	Effect of Regime Change. Blacks have the Arrival Rates and Wage Offer Distribution of Whites. Whites have the Arrival Rates and Wage Offer Distribution of Blacks	141

List of Figures

3.1	Asset Accumulation and Job Acceptance	28
3.2	Assets, Wages, Unemployment and Consumption	34
6.1	Actual and Predicted Variables. Unemployed, Assets, and Wages by Quarter after Graduation. Baseline Model	82
6.2	Actual and Predicted Variables. Employment Transitions by Quarter after Graduation. Baseline Model	85
7.1	Actual and Predicted Variables. Unemployed, Assets, and Wages by Quarter after Graduation. Extended Model	111
7.2	Actual and Predicted Variables. Employment Transitions by Quarter after Graduation. Extended Model	114

Chapter 1

Introduction

The main purpose of this thesis is to establish an explicit relationship between asset accumulation and employment dynamics under imperfect capital markets. I provide empirical evidence for this link and estimate a behavioral model which is shown to replicate the main observed trends.

These two processes, traditionally analyzed separately, influence each other. Under borrowing constraints, assets can affect job search outcomes by allowing wealthier people to be more selective and obtain higher wages. Thus, the role of inherited assets and family background in the job search process becomes critical. Differences in initial wealth can imply differences in success in the labor market.

On the other hand, employment dynamics, as the main source of income uncertainty, have an impact on savings. While the unemployed maintain their consumption by running down their assets, employed agents save to buffer against future unemployment spells and future lower wages. Consequently, changes in the labor market environment affect decisions on asset accumulation. An important labor

market variable is the net amount of transfers a person receives while unemployed. It can include family transfers as well as unemployment compensation, minus the out-of-pocket cost of searching for a job. These net transfers while unemployed can have a significant effect on asset accumulation.

The asset data used in this analysis come from the National Longitudinal Survey (youth cohort). They consist of residential property, financial assets, business assets, vehicles and other assets (like jewelry or furniture) net of debts on each of these items.¹ Although they are clearly measured with errors, these data have systematic features. As seen in Table 1.1, both black and white male high school graduates (who did not attend college), accumulate assets after leaving school. From year 3 to year 9 after graduation, blacks increase their assets from \$1,521 to \$4,210 and whites increase their assets from \$6,627 to \$19,757. The percentage of people with more than \$10,000 increases from 2% to 11% for blacks, and from 17% to 40% for whites. In the same period, the fraction of blacks who are unemployed or working part time decreases from 42% to 31%. The corresponding percentage for whites decreases from 24% to 13%. Average wages increase from \$2,967 to \$3,469 for blacks, and from \$3,376 to \$ 4,622 for whites. Asset accumulation does accompany the increase in labor market activity that occurs after these individuals leave high school.

The standard job search model can account for the increase in labor market activity, but not for the increase in asset holdings. Consumption theory provides several reasons for saving, mainly life-cycle effects, purchase of indivisible goods and precautionary reasons. People save while they are young because they want to

¹Details about the construction of the asset variable are given in Chapter 6.

Table 1.1: Assets, Unemployment and Wages by Race and Years after Graduation.
Male High School Graduates between 1978 and 1993

Variable	Blacks			Whites		
	Year 3	Year 6	Year 9	Year 3	Year 6	Year 9
Average Assets	1,521	4,339	4,219	6,627	13,448	19,757
Percentage of people with:						
Assets < 0	11.02	8.24	7.50	4.00	11.40	14.67
Assets=0	39.83	29.12	32.50	8.00	4.82	6.67
$0 < \text{Assets} \leq 10,000$	46.61	52.20	49.00	71.00	51.31	38.67
$10,000 < \text{Assets} \leq 20,000$	0.85	6.59	4.50	9.00	10.67	16.00
$20,000 < \text{Assets} \leq 30,000$	0.85	1.65	3.50	4.00	6.14	8.44
Assets > 30,000	0.85	2.20	3.00	4.00	9.65	15.56
Percentage of Unemployed	42.42	30.19	31.26	23.94	15.92	12.70
Average Quarterly Wage	2,967	3,368	3,469	3,376	4,288	4,622

Note: The amounts are given in dollars of 1985. An individual is considered unemployed if he works less than 20 hours a week or earns less than \$1,000 in a quarter.
Source: NLSY.

maintain their consumption when they become older and possibly leave something to their children. They save to buy a house, a good whose purchase requires a minimum amount of money. They also save because they face uncertainty about earnings, medical expenses or their length of life. These explanations generally assume an exogenous income stream.

Table 1.2 shows the relationship between savings behavior and employment transitions. Becoming or staying unemployed is associated with a decumulation of assets, while becoming or staying employed (or switching from one employer to another) is associated with an increase in asset holdings. Black (white) individuals who remain unemployed between two calendar quarters run down their assets by \$83 (\$142), while those who remain working for the same employer increase their assets by \$362 (\$876) per quarter. These comovements, while not surprising, are systematic and informative about the credibility of the asset data. They also give evidence that that asset accumulation and employment transitions are closely related. Neither a standard search model, which ignores asset accumulation, nor a standard life cycle consumption model, which ignores employment transitions, offers an explicit explanation for these trends.

In the model proposed in this thesis, given current asset holdings, whether unemployed or employed, an agent determines an optimal job acceptance policy as well as an optimal level of consumption in each period. The model is characterized by the following features: 1) while employed a worker can always quit or be laid off, so that the individual work history is conceived of as a sequence of employment and unemployment states; 2) while the unemployed decumulate assets, employed agents can accumulate assets to maintain consumption during future periods of un-

Table 1.2: Average Quarterly Savings according to Employment Transitions for Blacks and Whites

Employment Status	$t + \Delta$			Total
	Un-employment	Same Employment	New Employment	
t				
Un-employment	-83/-142 (359)/(120)		1,104/1,295 (209)/(162)	354/683 (568)/(282)
Employment	-414/-1,353 (180)/(155)	362/876 (565)/(1214)	698/340 (367)/(345)	347/567 (1112)/(1714)
Total	-194/-825 (539)/(275)	362/876 (565)/(1214)	845/645 (576)/(507)	349/583 (1680)/(1996)

Note: The first number refers to savings of blacks; the number after the slash corresponds to savings of whites. The first number in parentheses is the number of blacks who make the corresponding transition; the number in parentheses after the slash is the respective number of whites. Assets are observed annually. Consequently, savings are defined as the average quarterly variation of assets between periods when asset holdings are observed. The employment status in the first period, t , is described in the first column. The employment status in the next period when assets are observed, $t + \Delta$, is reported in the first row.

Source: NLSY.

employment and lower wages: 3) agents use asset accumulation as a way of moving to better paid jobs;² 4) Borrowing constraints induce asset accumulation and the attainment of lower wages at the beginning of the employment career, but higher wages in later years.

Since the model does not produce closed forms for the policy rules on asset accumulation and job acceptance, I compute them numerically. Borrowing constraints can be binding, so an interior solution may not be attained. Therefore, estimation techniques based on the Euler equation are not applicable to this case. To estimate the behavioral parameters of the model, I apply the method surveyed by Rust (1988) and Eckstein & Wolpin (1989). Using the numerical solution of the dynamic programming problem as an input, I construct probability statements for observed assets, wages and employment transitions and integrate them into a maximum likelihood estimation procedure.

The data for estimation of the model come from the National Longitudinal Survey of Labor Market Experience Youth Cohort (NLSY). The NLSY is a national stratified sample of 12,686 individuals between 14 to 21 years of age as of January, 1979, who have been surveyed annually from 1979. It contains data on assets, accepted wages, length of unemployment, and personal characteristics like schooling and family background. In the estimation, separate samples of black and white high school graduates are used.

Accounting for differences in individuals' characteristics and initial asset condi-

²Unlike dynamic models of consumption and labor supply, where individuals directly decide on their income by choosing hours of work (Heckman & MaCurdy 1980, MaCurdy 1981), here they decide on a stopping rule. The way to decide on their income is to accept a wage offer or keep searching, if they are unemployed; or to switch employers, stay on the current job or quit to unemployment, if they are employed.

tions, assuming a specific utility function and an explicit distribution function for wage offers, I recover the parameters of the search model. With the recovered structural parameters I study four regime changes: a 10% decrease in net transfers while unemployed; increasing initial assets from zero to \$2,000 assets; blacks start off with the same initial asset distribution of whites and whites start off with the initial asset distribution of blacks; and blacks have the arrival rates and wage offer distributions of whites, and whites have the arrival rates and wage offer distribution of blacks.

A decrease in unemployment net transfers reduces asset holdings, unemployment and the wages of both groups. This effect is opposite to the one described by Gruber (1994), Engen & Gruber (1995) and by Hubbard, Skinner & Zeldes (1995), which only considers the insurance effect of unemployment transfers. In my model transfers while unemployed are family or government transfers net of search costs. They are, therefore, not equivalent to unemployment insurance. Yet, since these transfers support job search and individuals' ability to reject low wage offers, their reduction has the effect of lowering average accepted wages. It is this reduction in wages what ultimately reduces average asset holdings. Using the estimated parameters of the baseline model, I find out that a permanent decrease of \$100 in unemployment net transfers reduces asset holdings of blacks by \$17 and of whites by \$183 20 quarters after high school graduation.

The result of the second policy simulation is that blacks who start off with \$2,000 worth of initial assets have a first quarterly wage that is \$100 higher than blacks who start off with no assets. 20 quarters after graduation, this difference reduces to \$50. Among whites, the average wage of those who start their employment careers

with \$2,000 initial wealth exceeds in \$25 that of those whites who start off with no assets. However, 20 quarter after graduation this effect vanishes.

Through comparative statics experiments, I show that most of the differences in labor market performance between blacks and whites are accounted for by differences in their wage offer distributions and arrival rates. If blacks had the labor market environment of whites, their wage twenty quarters after graduation would be \$3,974 and not \$3,384. This would be still below the \$4,048 of whites.

This thesis is organized as follows. Chapter 2 present a discussion of the current literature on job search and asset accumulation. Chapter 3 describes the model and its main implications for asset accumulation and employment. In Chapter 4, I explain the selection of the sample and the descriptive statistics. Chapter 5 discusses maximum likelihood estimation procedure. Chapter 6 presents the results of the baseline estimation. Chapter 7 reports the results of estimating the extended model. Chapter 8 shows policy experiments based on the results of the estimations. Chapter 9 concludes.

Chapter 2

Literature Review

This chapter briefly presents the literature on job search and asset accumulation. Job search theory views the time in which an individual is looking for a job as productive, inasmuch as it permits the individual to be selective in taking a job. This is especially the case for individuals who leave high school and start looking for a job. If individuals cannot finance job search with their future expected income, they have to use their assets. Initial differences in initial assets can lead to differences in job search outcomes.

Consumption theory has shed light on the effect of income fluctuations on consumption and saving. Since people face uncertain future incomes, they find it optimal to create a buffer-stock to hedge against adverse income shocks. To the extent that labor income is the most important source of income for most people, labor market uncertainty is a potentially key determinant of people's consumption and saving.

In this context, this thesis explains how people accumulate assets to gain access to

better paid jobs and how borrowing constraints affect employment careers. It also presents descriptive evidence that asset accumulation and employment dynamics are linked, and fits the theoretical model to the data.

2.1 Job Search

In standard job search models¹ people are conceived of as wealth maximizers residing in world of perfect capital markets. In that framework, job search is independent of any decision on consumption and saving. Imperfect capital markets, however, have played a role in the literature on job search as a motivation for a finite horizon of search. This version of the search model generates decreasing reservation wages, and therefore decreasing accepted wages over an unemployment spell, which is precisely what is observed in the data over an unemployment spell. The working life of an individual is an exceedingly long period of time to explain these patterns. Other factors, like aging, can explain why wages are decreasing over longer periods of time. This means that a finite horizon of search must be motivated on other grounds. In the literature, those have been the limited duration of unemployment benefits, and a limited amount of initial assets (Mortensen 1986). Both explanations assume that the duration of search is exogenously given to the individual. Empirical studies of the job search process are based on the assumptions of an infinite search horizon with perfect capital markets or an exogenously given search horizon (Flinn & Heckman 1982*a*, Flinn & Heckman 1982*b*, Kiefer & Neumann 1979, Meyer 1990, Wolpin 1987, Wolpin 1992).

¹See the models surveyed by Lippman & McCall (1976) and Mortensen (1986).

If people are not able to borrow freely in the credit market, they can only self-finance the out-of-pocket cost of search for a finite period of time. Since individuals maximize present discounted value of income, they pay the cost of search until the borrowing constraint becomes binding. At that point, there is no other choice than dropping out of the labor force. In this explanation, initial asset holdings and borrowing constraints affect the job search strategy through their influence on the search horizon. In a standard job search model, people do not control the speed of their asset decumulation while unemployed. Consumption theory analyzes precisely how people make decisions on asset accumulation. To analyze how people make these decisions simultaneously, a combination of job search and consumption theory is necessary.

2.2 Asset Accumulation and Borrowing Constraints

Consumption theory has been mainly concerned with the effect of current income on consumption and, more generally, with the motivations of people to save. The permanent income hypothesis postulated that people's current consumption reacts only to a change in their permanent income. When confronted with data, the permanent income hypothesis has been generally rejected (Flavin 1981, Hall & Mishkin 1982, Hayashi 1985, Campbell & Mankiw 1989, Zeldes 1989, Deaton 1991), which indicated the presence of borrowing constraints. As people are unable to spend on account of their future income, consumption becomes sensitive to current income.

On the other hand, consumption theory provides several reasons for saving,

mainly life-cycle effects, purchase of indivisible goods and precautionary reasons. People save while they are young because they want to maintain their consumption when they become older and possibly leave something to their children. They save to buy a house, an indivisible good whose purchase requires to make a substantial up front payment. Since they also face uncertainty about earnings, medical expenses or their length of life, people save for precautionary reasons. They create a buffer stock against these exogenous adverse income shocks. (Schechtman & Escudero 1977, Grossman, Levhari & Mirman 1979, Hall 1978, Skinner 1985, Zeldes 1989, Deaton 1991, Hubbard et al. 1995).

Since for most people most of their income is labor income, employment dynamics are an important source of earnings uncertainty. For example, being laid off and receiving a good wage offer and accepting it while unemployed would be regarded by consumption theory as an adverse and as a favorable income shock respectively. Strictly speaking, these transitions, widely studied by job search theory, are, to some extent, the result of individuals' decisions. Thus, an exogenous shock does not capture the fact that individuals, conditional on their assets, are selective in accepting jobs. The unemployment state is not just a persistent bad shock. Job offers may have been made to an unemployed individual, but he may have rejected them hoping to find a better paid job. Current assets support consumption while unemployed and allow him to reject low wage offers. His decision about how much to decumulate each period has to be linked to his selectivity in accepting wage offers. It is in this sense that integrating job search and consumption theory would also shed light on specific aspects of consumption and saving dynamics.

2.3 Job Search and Asset Accumulation

Danforth (1974) was the first to formulate a model of utility-maximizing job search. He analyzed in detail the role of asset endowments on an individual's optimal job search strategy, summarizing his conclusions in three testable hypotheses: there exists a positive correlation between initial assets and reservation wages ("the rich are more selective"); there is a positive relationship between initial assets and duration of unemployment ("the rich search longer"); and there is a positive correlation between initial assets and discounted future income ("the rich get richer"). Lippman and McCall (Lippman & McCall 1976) noted that poorer people were unemployed for longer periods. They suggested other factors that could explain a negative correlation between wealth and duration of unemployment. For instance, wealthier searchers may search more intensively or have a higher probability of getting a job offer than poorer agents.

More generally, utility-maximizing job search models have been proposed as a generalization of job search theory (Hall, Lippman & McCall 1979, Whipple 1973), as an integrated theory of job search and individual labor supply (Burdett 1979, Burdett, Kiefer & Sharma 1985, Burdett & Mortensen 1977) and as a theory of job search and consumption (Danforth 1974, Danforth 1979, Flemming 1978, Hansen & Imrohoroglu 1992, Blundell, Magnac & Meghir 1994, Costain 1995). Despite these well-known attempts (done mainly in the seventies) of establishing explicit links between job search and consumption theory, these approaches have maintained clearly separate traditions. In the nineties, however, there is an increasing number of studies that show the importance of these links for understanding employment and savings dynamics, even as separate problems.

Bloemen & Stancanelli (1997) tested Danforth's propositions empirically. They used self-reported data on minimum acceptable wage earnings, which they use as a proxy for reservation wages. They postulate a non-linear relationship between reservation wages and assets, which they integrate in a likelihood procedure. They find that assets have a positive effect on reservation wages and a negative effect on the probability of becoming employed.

Utility-maximizing job search models made clear the effect of assets on job search. The reciprocal effect is also important. Employment dynamics, as the main source of income uncertainty, are an important determinant of savings. While the unemployed maintain their consumption by running down their assets, employed agents save to buffer against future unemployment spells and future lower wages (Dynarski & Sheffrin 1987). Consequently, changes in the labor market environment affect decisions on asset accumulation. For example, unemployment benefits increase the duration of unemployment, but also sustain consumption of the unemployed (Hamermesh 1982). Recently, Andolfatto (1996) and Gomes, Greenwood & Rebelo (1997) formulated models of consumption and savings which explicitly represent employment dynamics under a search-theoretic framework. An exogenous income stream, a standard assumption in models of consumption, ignores the fact that employment transitions as well as consumption and savings are the outcome of individual decisions.

In the context of the literature, this thesis' contribution is both theoretical and empirical. Theoretically, it extends Danforth's model for the case of on-the-job search and borrowing constraints. I show that people can take badly paid jobs to accumulate assets and, at some point, quit to search while unemployed. Asset

accumulation is therefore used as a means to gain wage mobility. I also show the effect of borrowing constraints on employment careers. People with tight borrowing constraints start being less selective than people with access to credit. As time passes, people who can borrow have to pay their debt, so that their ability to reject low wage offers deteriorates. As a result of this, it can be shown that constrained agents end up with higher wages than unconstrained ones. Empirically, this thesis provides descriptive evidence for the relationship between assets accumulation and employment. It also estimates the theoretical model showing a fairly good fit to the data.

Chapter 3

The Model

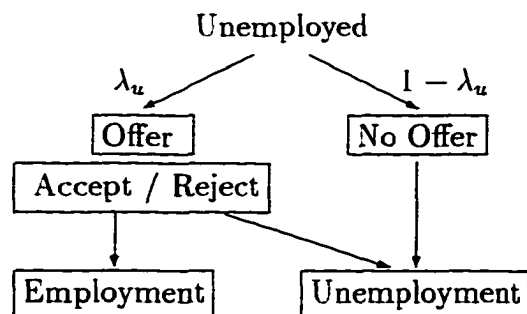
Consider an individual who lives forever (or, alternatively, faces a constant probability of death) and seeks to maximize expected lifetime utility. In each period, given his employment state, he has to determine a level of consumption. He only derives utility from consumption above some minimum level, which is guaranteed to him over his lifetime by the minimum income he receives while unemployed or while employed. Deciding on consumption in the current period is equivalent to choose a level of assets for the next period. The individual is allowed to borrow up to an exogenously given amount, i.e., the amount of admissible debt is bounded and constant in every period. There is no restriction for transferring resources across periods through savings. The rate of return for saving and borrowing is the same and constant. Initial assets are inherited, so they are not the product of any earlier asset accumulation.

3.1 Job Market Transitions

The agent can be either employed or unemployed. In both employment states he can receive a wage offer. He can only receive one wage offer in each period. While employed, he can be laid off. The wage offer distribution, the probabilities of receiving a wage offer while employed and while unemployed, and the layoff probability are known. The individual can neither affect them by any kind of decision, nor recall rejected wage offers.

If he is unemployed, the possible transitions he can have are shown in the following scheme:

Transitions from Unemployment

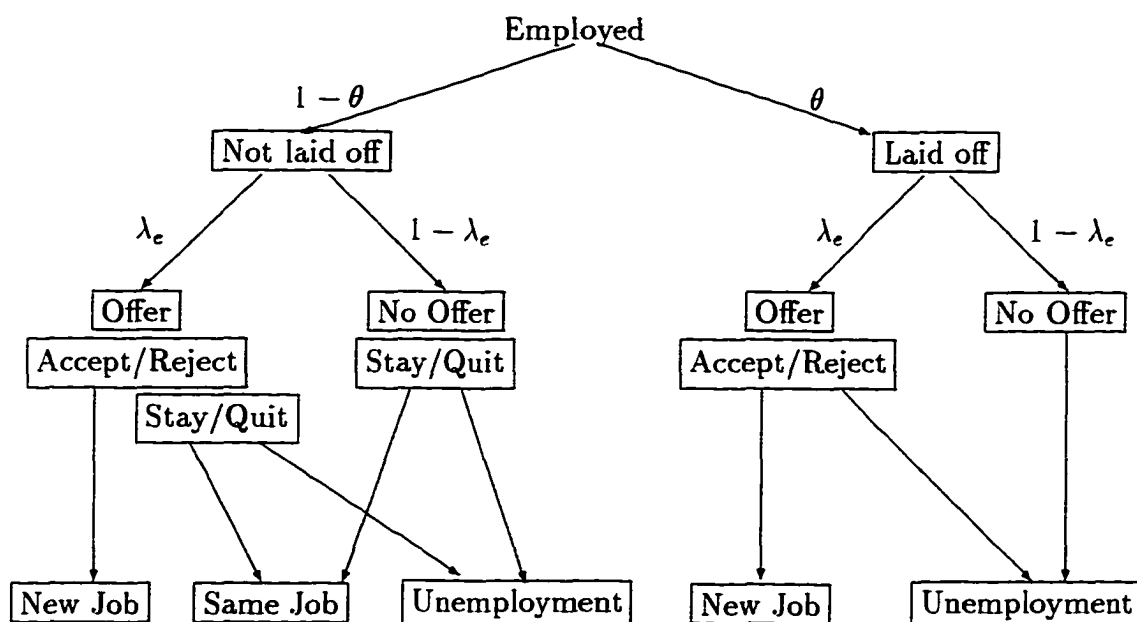


While unemployed, the agent can receive a wage offer with probability λ_u . He will take any wage offer which makes the lifetime utility of being employed higher than the lifetime utility of being unemployed. In other words, he determines the lowest wage offer he will accept to start working. Any offer higher than this wage will be accepted as well, that is, as I show below, the reservation wage property holds. If the agent rejects a wage offer or does not receive any offer at all, he remains unemployed. Whenever the individual is unemployed, he is given some amount of

transfers, which exceeds an exogenously given consumption floor. These transfers are constant over the unemployment spell and can be conceived of as exogenously given. They include family transfers plus unemployment compensation net of search costs. The individual becomes employed only if he receives and accepts a wage offer. Once employed, the accepted wage remains constant while working for that employer.

The possible transitions from being employed are shown below.

Transitions from Employment



While employed, he can receive a wage offer with probability λ_e and be laid off with probability θ . If he is not laid off and receives a job offer, he can accept it and switch to a new job, reject it and stay in the current job or reject it and quit to unemployment. If he is not laid off and does not receive a job offer, he has to decide between staying in the job or quitting to unemployment.

Table 3.1: Notation

A	: asset level in current period;
A_u	: asset level in next period if unemployed in current period;
A_e	: asset level in next period if employed in current period;
B	: minimum asset level ($B \leq 0$);
C	: consumption in current period;
C_u	: consumption if unemployed in current period;
C_e	: consumption if employed in current period;
C_{min}	: consumption floor;
$U(C)$	$= (1 - \gamma)^{-1} ((C - C_{min})^{1-\gamma} - 1), \quad \text{if } \gamma \neq 1,$ $= \ln(C - C_{min}), \quad \text{if } \gamma = 1;$
r	: rate of return ($r > 0$);
β	: discount factor ($0 < \beta < 1$);
b	: net transfers while unemployed ($b > C_{min}$);
w	: wage;
$F(x)$	wage offer distribution, $\ln w \sim N(\mu, \sigma^2 \mid \underline{w}, \bar{w})$; $0 < C_{min} < \underline{w} < \bar{w} < \infty$
λ_u	: offer probability when unemployed;
λ_e	: offer probability when employed,
θ	: layoff rate;
$V_u(A)$: lifetime utility of being unemployed with asset level A ,
$V_e(A, w)$: lifetime utility of being employed with asset level A , and wage w .

If he is laid off, he can still receive a job offer.¹ Accepting it means switching to a new job; rejecting it means becoming unemployed. If a person is laid off and does not receive any offer, he does not have any other option than to become unemployed.

¹In the quarterly data used in the estimation, some people can be reported as moving directly from one employer to another. These data include people who have been laid off and took another job in the same quarter. This transition cannot be mixed up with the transition of people who have not been laid off and accepted an offer.

3.2 Notation and Assumptions

The notation is shown in Table 3.1. The utility function assumed in this model is a Stone-Geary version of the constant relative risk aversion (CRRA) type. It satisfies the Inada conditions, in particular $U'(C_{min}) = \infty$. γ is the coefficient of risk-aversion. b is defined as unemployment transfers net of search costs.² These transfers are assumed to be non-labor income like family transfers. They exceed the consumption floor. The wage offer distribution is assumed to be bounded above and below, because the numerical solution of the model employs a discretization of the state variables. The lowest possible wage offer is assumed to exceed the minimum level C_{min} . This ensures that consumption above the minimum is always positive as the utility function assumed here requires. For purpose of estimation, a lognormal wage offer function is used.

Assumption 1 : $\lambda_u > \lambda_e$.

This assumption is based on the fact that an unemployed person can devote more time to search for a job than an employed one (Burdett & Mortensen 1977). It recognizes the productive character of being unemployed in that it permits to have a high intensity of search (Flinn & Heckman 1983). However, it does not take into account reputation effects. For example, employers may take as a bad signal that an individual is unemployed for a long time. It can be also the case that employed individuals, as insiders of an industry, are more informed about employment opportunities than unemployed ones. These effects may not be as

²Search costs and choice of search intensity can be explicitly included in the theoretical model. The identification of these additional parameters would, however, not be feasible given the available data.

important for high school graduates as for more educated segments of the labor force. This assumption creates a trade-off. By accepting an offer, an unemployed agent increases his income, but decreases the probability of receiving future wage offers. If Assumption 1 did not hold, it would always be optimal for an individual to take any wage offer greater than net transfers and there would be no returns to searching while unemployed.

Assumption 2 : $\beta(1 + r) \leq 1$.

As in standard models of consumption allocation, the pattern of asset accumulation or decumulation depends crucially on the relationship between r and β . Assumption 2 says that consumers are relatively impatient: their rate of time preference is higher than the rate of return on assets. This is a sufficient condition to generate asset decumulation while unemployed.

3.3 Laws of Motion and Borrowing Constraint

The laws of motion for assets will be given by:

$$A_u = (1 + r)(A + b - C_u), \text{ when unemployed;}$$

$$A_e = (1 + r)(A + w - C_e), \text{ when employed;}$$

$$\text{where: } C_u \geq C_{min};$$

$$\text{and: } C_e \geq C_{min}.$$

Under a Hakansson-Miller (Hakansson 1970, Miller 1974) borrowing limit, i.e, if

an agent can borrow up to the level of lifetime income he will receive with probability one, the lower bound on assets is given by

$$\tilde{B} = -\left(\frac{1+r}{r}\right)(b - C_{min}).$$

As shown below, the individual will only be employed at wages which exceed transfers while unemployed. Therefore, the minimum possible level of income is the net transfers while unemployed. As discussed by Grossman et al. (1979), if the borrowing limit were the expected lifetime income, there would be the possibility of bankruptcy. However, this could not happen with utility functions satisfying the Inada condition. An unemployed agent with asset holdings \tilde{B} , not being able to decrease his assets, will consume only his minimum requirement,

$$C = \tilde{B} + b - \left(\frac{\tilde{B}}{1+r}\right) = C_{min}.$$

Since the utility function satisfies the Inada conditions, $U'(C_{min}) = \infty$, a positive probability, no matter how small, of not having income at least above the consumption floor, will discourage the agent of taking that chance. Even if the individual can formally borrow as much as he wants, he will not run down his assets below \tilde{B} ; so $B < \tilde{B}$ will not be a binding constraint. Under this setup, a partial analysis with a fixed interest rate, \tilde{B} represents perfect capital markets. This behavior ensures that the transversality condition,

$$\lim_{T \rightarrow \infty} \frac{A^T}{(1+r)^T} = 0,$$

holds.

The individual faces borrowing constraints whenever he is only allowed to borrow below his certain capacity of repayment, i.e., $B > \tilde{B}$. Paying back with certainty can be caused by lenders being fully risk averse and unwilling to share risks with borrowers. Incorporating the full set of Arrow-Debreu contingent contracts would require allowing for default and dealing with problems of adverse selection or moral hazard. That is beyond the scope of this thesis.

3.4 Value Functions

The value functions are defined in Equations (3.1) and (3.2). Expected discounted utility differs according to the current employment state, asset holdings, and wages. Expected lifetime utility in the unemployment state, V_u , is characterized by asset holdings A . In the employment state, expected lifetime utility V_e , depends on asset holdings A , and wage w .

$$V_u(A) = \max_{A_u \geq \tilde{B}} \left\{ U \left(A + b - \frac{A_u}{1+r} \right) + \beta \left[\lambda_u \int \max [V_e(A_u, x), V_u(A_u)] dF(x) + (1 - \lambda_u) V_u(A_u) \right] \right\} \quad (3.1)$$

$$V_e(A, w) = \max_{A_e \geq \tilde{B}} \left\{ U \left(A + w - \frac{A_e}{1+r} \right) + \beta \left[(1 - \theta) (\lambda_e \int \max [V_e(A_e, x), V_e(A_e, w), V_u(A_e)] dF(x) + (1 - \lambda_e) \max [V_e(A_e, w), V_u(A_e)]) + \theta \left(\lambda^e \int \max [V_e(A_e, x), V_u(A_e)] dF(x) + (1 - \lambda_e) V_u(A_e) \right) \right] \right\} \quad (3.2)$$

Theorem 1 : (i) V_u is strictly increasing in A ; V_e is strictly increasing in A and in w . Consequently, the reservation wage property exists;

(ii) A unique bounded and continuous solution for (V_u, V_e) holds.

Proof: See Appendix.

These two stationary functions imply the existence of stationary policy rules as solution of the dynamic programming problem, that is, $A_u(A)$ when unemployed and $A_e(A, w)$ when employed.

For every state, whether the individual is employed or unemployed, there exists a reservation wage $w^*(A)$ defined by $V_e(A, w^*) = V_u(A)$. When the agent is unemployed, the reservation wage, $w^*(A)$, indicates the lowest wage offer which will induce the individual to start working. While employed, if he is not laid off, he will switch to a new job whenever he receives a wage offer higher than $\max\{w, w^*(A)\}$. If the wage offer is lower than this value or if he does not receive any offer at all, he has to decide between quitting to unemployment and staying on the job at the current wage. If his current wage is higher than $w^*(A)$, he will stay on the job; otherwise he will quit, because A is rising and thus so is $w^*(A)$. If the individual is laid off, $w^*(A)$ indicates the lowest wage an individual will accept to work for another employer.

3.5 Reservation Wage and Assets

Proposition 1 : i) $w^*(A) > b$; and ii) $\frac{\partial w^*}{\partial A} > 0$, for all $A \geq B$.

Proof: See Appendix.

Proposition 1 asserts that an individual's reservation wage is always higher than net transfers while the person is unemployed and increasing in current asset holdings. Danforth (1979) proved this result by considering the search process as a "generalized lottery." If $U(\cdot)$ satisfies decreasing absolute risk aversion, which is also the case of the utility function I assume, richer people will be willing to accept riskier activities. In the context of the job search model, this means that wealthier people are more selective and reject offers which other people accept. In Danforth's model once a job is accepted the wage is constant, so the reservation wage indicates the certainly value of searching. In the present model, people search on the job, but the probability of receiving an offer is higher while unemployed than while employed. This means that higher wealth makes people more willing to take the risk of searching while unemployed rather than employed. Given the difference in arrival rates, an additional dollar of assets will increase the value of searching more while unemployed than while employed. The reservation wage has to increase accordingly.

Notice that this effect of wealth in making people more selective can also be obtained under risk-neutrality, if people drop out of the labor force or go bankrupt once they attain the lowest possible level of assets. In the model presented here, people never leave the labor force nor do they go bankrupt. They do not face the trade off between consuming and searching longer, as would be the case if assets only serve to endogenize the finite search horizon.

3.6 Asset Accumulation and Employment Status

Proposition 2 $A_u < A$, for $A > B$; $A_u = B$, for $A = B$.

Proof: *See Appendix.*

This proposition claims that the individual tends to decumulate while unemployed. This will be so because he wants to maintain consumption, expecting that his future income will grow. Optimal behavior then consists in decumulating assets until reaching the lower bound B .³ Propositions 1 and 2 underlie Danforth's statement that wealthier people will be unemployed longer and will end up with higher accepted wages. Under asset decumulation and decreasing reservation wages over time, initial assets play a key role in job search outcomes. Once this lower bound, $B \leq 0$, is attained, the agent consumes $\bar{C} = b + B(\frac{r}{1+r})$, that is, he consumes what is left after providing for interest rate payments. Notice that this level of consumption depends on the lower bound on assets. People with tighter borrowing constraints, i.e., with less admissible debt, will end up consuming more than people who are allowed to borrow more.

Proposition 3 *There can be asset accumulation while employed only if there is a positive probability of being laid off.*

Proof: *See Appendix.*

³As explained in Section 3.3, the agent faces borrowing constraints if $B > \bar{B}$, i.e if he can only borrow below his capacity of repayment. In this case, he will attain the lower bound on assets, B , in finite time. If the agent does not face borrowing constraints, that is, if his lower bound on asset is \bar{B} , he will never attain that bound in finite time, because of the Inada conditions.

While employed at a relatively high wage an individual has an incentive to accumulate assets as a precaution to cushion possible future unemployment spells. He understands that his current job may not last forever and that future employment can be at a lower wage.⁴ This would not be so if the layoff rate were zero or if his current wage were relatively low. He will accumulate until reaching an amount sufficiently high to buffer against future unemployment and lower wages. This steady state will be a function of current wages: $\bar{A} = \bar{A}(w)$. If the individual starts off with an asset level lower than the steady state, he will accumulate; otherwise he will decumulate. If his current wage is relatively low, he will decumulate until reaching the lower bound on assets.

While employed, depending on his current asset holdings, an agent will take a new job only if it pays more than the reservation wage. Since reservation wages are increasing in assets, he can accumulate assets until reaching a reservation wage higher than his current wage. In that case, he will quit and become unemployed. The incentive to do so is also given by Assumption 1. Unemployment will be attractive if the probability of getting an offer while unemployed is relatively high. For an individual to quit a job, it has to be true that

$$w^*(A_e(A, w^*(A))) > w^*(A),$$

which means that the reservation wage has to allow him to accumulate, i.e.,

$$A_e(A, w^*(A)) > A.$$

In this case, he can take a job at the reservation wage and accumulate, so that in a later period his reservation wage will exceed his current wage. In Figure 3.1

⁴This is also true if there is a fixed retirement age.

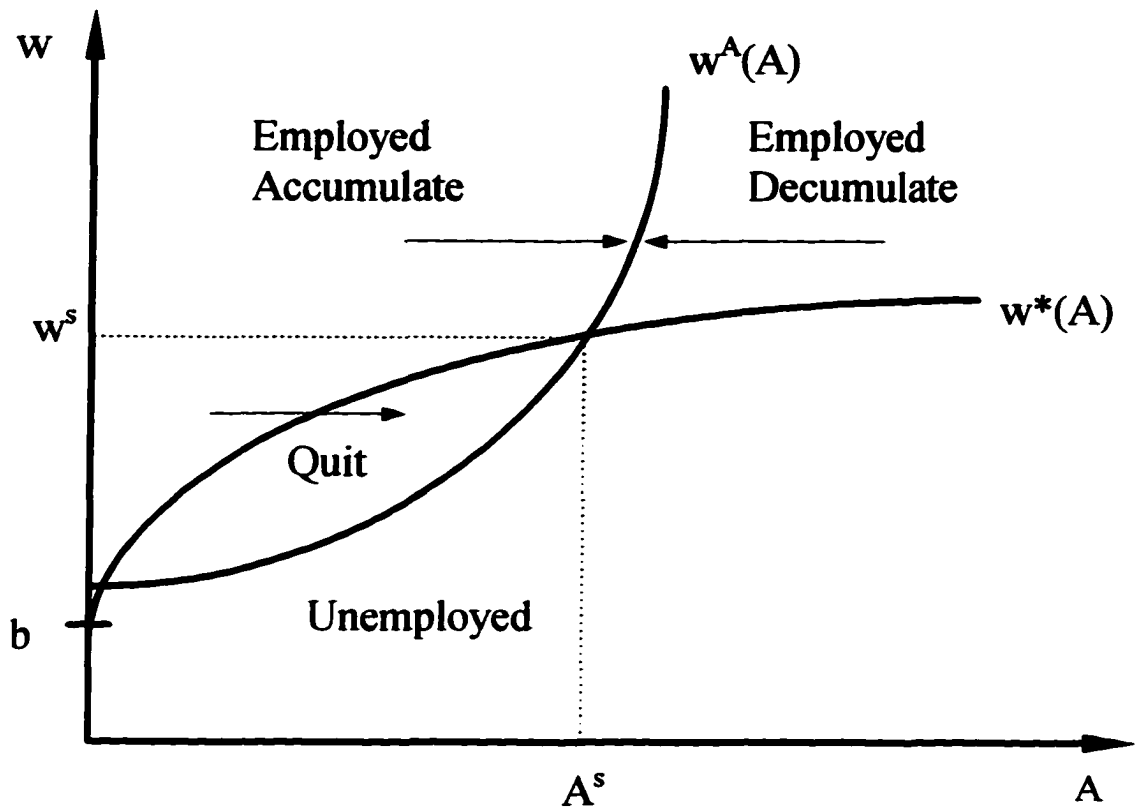


Figure 3.1: Asset Accumulation and Job Acceptance

the reservation wage function, $w^*(A)$, and the inverse of the assets steady state function,

$$w^A = \overline{A}^{-1}(A),$$

are described. The area above $w^*(A)$ indicates that wage offers will be accepted; the area below this curve represents the rejection region. The area above $w^A(A)$ shows the assets and wages combinations at which the individual will accumulate; the area below, those at which he will decumulate. Figure 3.1 shows the interaction of asset accumulation and job acceptance decisions. In this model income determination is endogenous, but unlike models of labor supply, the agent can not choose an amount of income, but can *search* for it. As in other models,⁵ quitting is part of a search strategy to reach higher wages. When the individual confronts layoff risk, this will lead him to accumulate assets, but also to search for a higher wage, even if he has to become unemployed to do so. Notice that quitting will only occur if the individual is employed at a wage lower than w^* , **and** with assets lower than A^* . People who accumulate at their current wage have an incentive to quit and become unemployed, if they have not reached yet a level of wages to ensure some security. After reaching that level of wages and of wealth, it is not optimal to quit. In this model the wealthiest people who reached a desired level of wages do not quit.

⁵The existing literature has explained in different ways that people quit to become unemployed. Workers may take jobs without knowing their true wage. Once they learn about it, they quit jobs where their true wage is revealed to be low (Jovanovic 1979). An economic boom may change wage offer distributions or arrival rates such that a worker finds profitable to quit to search while unemployed (Jovanovic 1987, Lippman & Mamer 1989). This explains the observed trend that quits are procyclical. With a finite horizon and accumulation of work experience, people quit because the value of investing in working decreases over time (Wolpin 1992).

This model accounts for some features of employment transitions and asset accumulation. At the beginning of his employment career an individual may take a very badly paid job because he wants to accumulate assets and thereby improve future wages and buffer future unemployment. Once on the job, the individual will continue searching, which reflects his permanent desire to move to jobs with higher wages (Burdett 1978). While employed, the individual can increase his current reservation wage which no longer coincides with his current wage. If he is not successful in moving to a new job, he will quit to unemployment.

Once unemployed, voluntarily or not, the agent will decumulate assets and decrease his reservation wage. When he finds a job again, he can end up with a wage lower than the one he had before becoming unemployed. Asset decumulation while unemployed can lead to a reduction in accepted wages after an unemployment spell.

3.7 Numerical Simulations

To illustrate the dynamics implied by this model, I perform numerical simulations for different groups of people. Because the optimal solution of the dynamic programming problem does not admit an analytical expression, I computed a numerical solution by discretizing the continuous state variables.⁶ The solution procedure consists of iterating the time dependent V_u and V_e functions until they converge to stationary functions. This procedure is described in greater detail in the Appendix.

⁶This simplifies both the solution of the dynamic programming problem as well as the computation of the likelihood function. It has, however, two effects in the continuous original variables. First, it collapses the continuous values of an interval into the midpoint of it. Second, it imposes upper and lower bounds in originally unconstrained variables. It is not clear the type of biases that these two problems can cause in the estimated parameters.

Table 3.2: First Unemployment Spell. Duration, Wages and Assets

Lower Bound on Assets Initial Assets	0		-50,500	
	0	5,000	0	5,000
Duration of Unemployment	2.67	2.98	3.48	3.48
Average First Accepted Wage	3084	3210	3375	3375
Assets at first job	148	3747	-8080	-3647
Average Wages at period 50	3367	3367	3304	3304
Average Assets at period 50	2111	2112	-47908	-47904

The basic parameter values in these simulations are: $b = 1,500$, $\mu = 7.3$, $\sigma = 0.6$, $\lambda_u = 0.9$, $\lambda_e = 0.2$, $\theta = 0.15$, $r = 0.01$, $\beta = 0.95$, $\gamma = 1.3$.⁷ I simulate the employment, wages and assets trajectories for 3,000 individuals who start off at the same level of assets and have the same borrowing restriction.

There are two extreme cases: one where borrowing is not allowed at all (constrained individuals), and one where people can borrow up the present discounted value of the minimum possible income, \$ 50,500 (unconstrained individuals). Wages and assets after the first unemployment spell for different initial assets and different borrowing limits are reported in Table 3.2. In the first case, people with \$5,000 worth initial assets stay unemployed 2.98 quarters on average, and start working for \$3,210. People who started searching with no assets stay unemployed 2.67 quarters and have an average first accepted wage of \$3,084. In the second case, however, neither duration of unemployment nor initial wages are affected by initial wealth. For both levels of initial assets the duration of search is 3.48 and the average first accepted wage is \$3,375. This suggests that only under perfect capital market ini-

⁷My choice of these values is based in the parameter estimates (Table 6.1).

tial assets play a role in search outcomes. In Danforth's model a worker maintained their job forever, so the effect of initial assets on people's wages was permanent. Since in this model individuals search on the job and are subject to layoffs, their employment state, wages and asset position can change permanently. Thereby, initial assets become less important for later states. 50 periods after having entered the labor market, regardless of credit market conditions, initial assets do not play any role in wages and assets. This result depends crucially on parameter values. If the layoff rate and the probability of receiving an offer while employed are very low, the effect of initial wealth may last for more periods.

Unlike initial assets, borrowing constraints have a more permanent effect. Notice that wages of people who are allowed to borrow are lower than those of people who do not. People who can borrow up to \$50,500 have quarterly wages of \$3,304 50 quarters after graduation, whereas people who cannot borrow at all earn \$3,367 per quarter. At a first glance, this seems counterintuitive. This does not only suggest that agents facing tight borrowing constraints eventually have higher wages than unconstrained agents. It also means that the former, who started off with lower wages increase their wages while the latter decrease theirs. The behavior of assets is the key to understand this result. While the constrained group accumulates and keeps \$2,111, the unconstrained group decumulates until having a debt of \$47,904. Reservation wages may be increasing over time in the first case and decreasing over time in the second. This is an infinite horizon model with no other source of uncertainty than wage offers which are accepted or rejected. Agents know that they are not required to pay the full amount of their debt, but only to bound it at a certain amount. On the other hand, the rate of time preference is assumed to be

higher than the rate of return ($\beta(1+r) = 0.9595 < 1$). With these assumptions and these parameters people will run down their assets monotonically.

To have a better assessment of this behavior, it is instructive to compare the infinite with the finite horizon case. The new parameters used are $r = 0.05263$ and $b = 2,000$.⁸ Figure 3.2 shows the time paths for assets, wages, unemployment rate and consumption. In the infinite horizon case, assets of people who can have debt go down until reaching some negative level close to the lower bound. Constrained individuals accumulate until reaching a steady state level. With a finite horizon, constrained individuals accumulate at the beginning of their life, and decumulate when the end is near. For unconstrained agents the borrowing limit is time dependent. It critically affects their asset accumulation decisions. They borrow and run down their assets, but at some point in time, as the lower bound on assets increases, assets holdings increase as well and become positive.

At the beginning of the employment career wages, unemployment and consumption are higher for unconstrained agents. This situation changes over time until constrained individuals have higher wages, unemployment and consumption. With a finite horizon there is overtaking as well, though wages, unemployment and consumption fall at the end of life.

An explanation for this puzzling behavior is the following. Unconstrained people are accumulating debt and have to make interest payments. By contrast, constrained individuals accumulate assets and receive interest gains. Unconstrained people can be very selective at the beginning of their careers, relying on debt to

⁸The first change allows that $\beta(1+r) = 1$. The reason for the second change is that with these parameters in a finite horizon people will not borrow with $b = 1,500$.

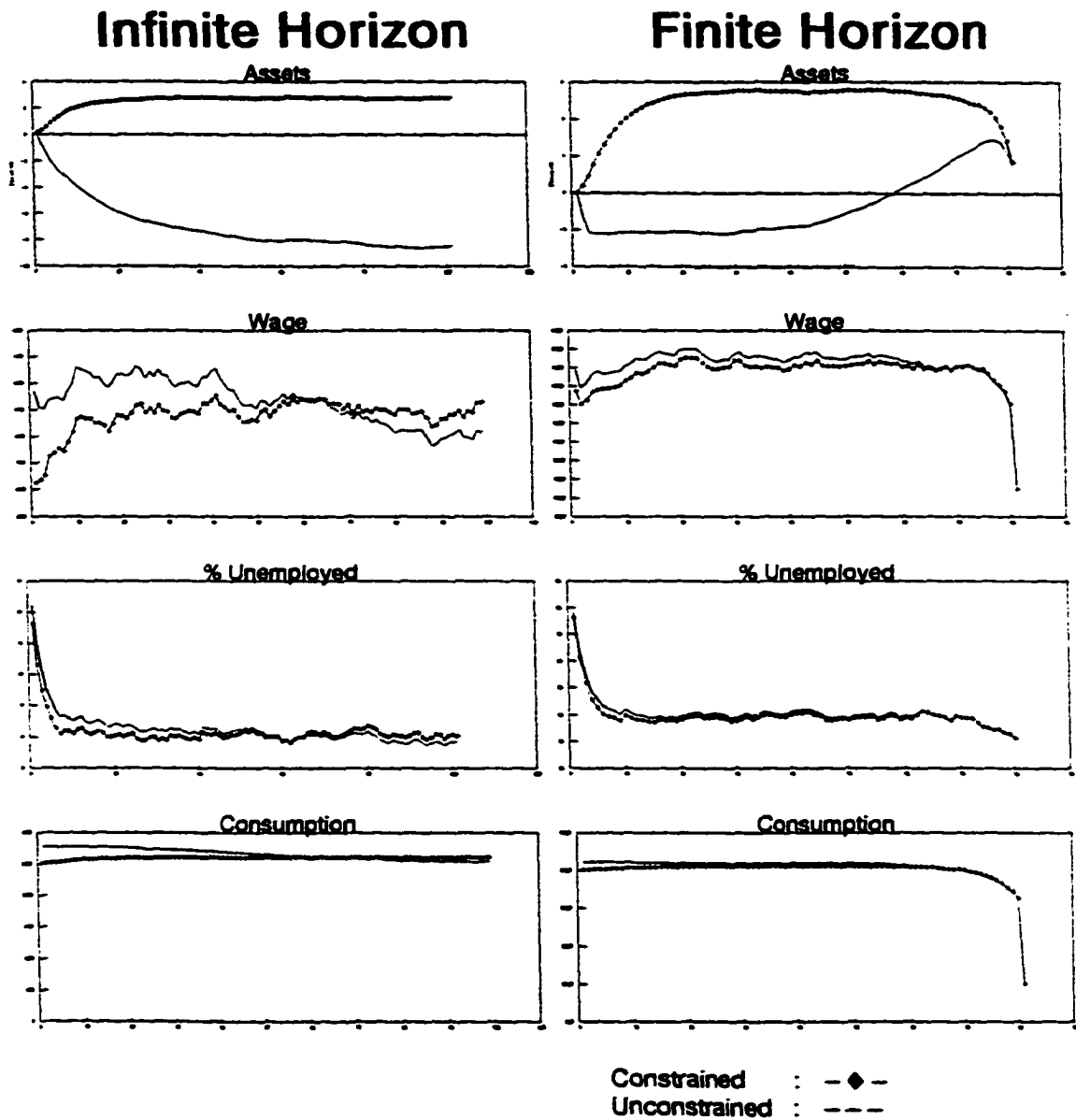


Figure 3.2: Assets, Wages, Unemployment and Consumption

finance their consumption. However, as time passes and debt grows, their ability to reject bad wage offers deteriorates and, accordingly, their consumption decreases. For constrained people the opposite is true. By accumulating assets they can afford to increase their consumption and their selectivity in job acceptance decisions. After some time, constrained people have both higher wages and higher consumption than people with debt. Nonetheless, the present discounted utility of unconstrained agents is always higher than the one of constrained ones. It is optimal for the former to obtain high utility at the beginning of their employment careers, even if they end up with a relatively low utility. Constrained people do not have this choice. The fact that they can overtake unconstrained agents in current utility, does not mean that they overtake them in terms of cumulative discounted utility.

Since these are two extreme versions of credit market constraints, there has to exist some intermediate case with capability of replicating the actual trends of the main variables. The model, however, produces other results which may not be observed. In the data, it may not be the case that wealthier people stay unemployed longer, even if they can afford to. Since in the model arrival rates are fixed, having more wealth only extends the duration of unemployment. In spite of that, people who start off with more wealth may have permanent differences with poorer ones. For example, a prosperous family background can be associated with a higher quality of schooling. Initially wealthier people may have, thereby, a higher mean wage offer than poorer agents. In other words, the presence of heterogeneous agents in the sample can significantly affect the assessment of the model. An example is given by Table 3.3. It is a comparison of the main variables after the first unemployment spell, for different levels of initial assets and of borrowing limits. Wealthier agents

Table 3.3: First Unemployment Spell with Heterogeneous Agents. Duration, Wages and Assets

Lower Bound on Assets	0			-50,500		
	0	5,000	8.03	0	5,000	8.03
Initial Assets	0	5,000	8.03	0	5,000	8.03
Mean Wage Offer	7.3	7.373	8.03	7.3	7.373	8.03
Duration of Unemployment	2.67	2.86	2.07	3.48	3.35	2.42
First Accepted Wage	3084	3346	5191	3375	3532	5556
Average Assets	148	3802	3964	-8080	-3335	-1135

may stay shorter unemployed and have higher wages, if their wage offer distribution dominates the distribution of poorer agents. Notice that the effect of heterogeneity is stronger in the unconstrained case. Compare the length of unemployment of poor and rich people according to their borrowing position. Unconstrained people with \$5,000 initial assets and with a mean wage offer of 7.373 have an unemployment spell shorter than people with no assets. Constrained people with \$5,000 initial assets and with a mean wage offer of 7.373 have a shorter unemployment spell than people with no assets. Thus, heterogeneity can have an important effect depending on the tightness of the borrowing constraint.

A similar effect can happen with quit behavior. The model predicts that agents can accumulate while employed and that they can quit to become unemployed. One way of testing this in the data is to see if people report savings before quitting and becoming unemployed. However, the existence of heterogeneous populations can cloud this prediction. For wealthier people reputation effects may be important, so that their arrival rates while employed may be higher for them than for people with less wealth. They may gain access to higher wages by switching directly to another

employer, rather than voluntarily quitting to become unemployed.

3.8 Transition Probabilities

Since the numerical solution of the model is explicitly used in the estimation, it is important to describe how the model accounts for the various possible transitions from one state to another. This is shown in Table 3.4. The state is characterized by the employment status, assets A , and the wage w if the individual is employed. The state at time t is shown vertically, whereas the state at time $t + 1$ is shown horizontally. The first line of each transition shows the probability for a change in employment status only. Whenever the individual moves from unemployment to employment or from one employer to another, he is accepting a new offer and this is shown in the second line of the corresponding boxes. The statement expresses the probability of doing the transition and attaining a specific wage w if becoming employed, or w' if changing employer. This is a joint probability and its validity is conditional on receiving a wage offer which exceeds the reservation wage. The third line gives the policy rule for assets, conditional on the current employment state. Once the individual knows his employment status, say, at t , he can determine his level of asset holdings tomorrow in a deterministic way. For this determination, he will take into account the uncertainty of next period's employment state and possibly attained wage.

While employed, the individual will know if his reservation wage next period exceeds his current wage. In that case, there will probability 0 that he stays employed at his current job. If he does not receive an acceptable wage offer, he will quit.

Table 3.4: Model predicted Transition Probabilities

t	t+1		
	Unemployed with A'	Employed with (A', w) (same employer)	Employed with (A', w') (new employer)
Un- employed with A	$\lambda_u F(w^*(A_u))$ $+(1 - \lambda_u)$ $A' = A_u(A)$	0	$\lambda_u [1 - F(w^*(A_u))]$ at wage w : $\lambda_u f(w), w \geq w^*(A_u)$ $A' = A_u(A)$
Employed	if $w^*(A_e) \geq w$		
	$\lambda_e F(w^*(A_e))$ $+(1 - \lambda_e)$ $A' = A_e(A, w)$	0	$\lambda_e [1 - F(w^*(A_e))]$ at wage w' : $\lambda_e f(w'), w' \geq w^*(A_e)$ $A' = A_e(A, w)$
with (A, w)	if $w > w^*(A_e)$:		
	$\theta[\lambda_e F(w^*(A_e))$ $+(1 - \lambda_e)]$ $A' = A_e(A, w)$	$(1 - \theta)[\lambda_e F(w) + (1 - \lambda_e)]$ $A' = A_e(A, w)$	$(1 - \theta)\lambda_e [1 - F(w)]$ $+ \theta\lambda_e [1 - F(w^*(A_e))]$, at wage w' : $\lambda_e f(w'), w' \geq w$ $\theta\lambda_e f(w'), w > w' \geq w^*(A_e)$ $A' = A_e(A, w)$

This is shown in the top part of the transition from employed to other employment states. If his current wage makes is higher than the reservation wage, he will move to unemployment only if he is laid off.

It is clear that these transition probabilities are determined by the policy rules obtained as solution for the dynamic programming problem. The trends presented in Table 1.2 are accounted by the model. Apart from showing the statements used in the computation of the likelihood function, this table shows the link between employment transitions and asset accumulation. Assets influence employment transitions to the extent that the reservation wage is a function of assets. Reciprocally, asset accumulation rules, obtained taking into account the possible employment transitions, are conditional on employment states.

Chapter 4

Data

The data come from the National Longitudinal Survey of Labor Market Experience - Youth Cohort (NLSY). This survey is a national stratified sample of 12,686 individuals between 14 to 21 years old in January, 1979, who have been interviewed annually from 1979 to 1993. It provides data on personal characteristics, household composition, educational status and attainment, military experience, labor market activity and transitions, detailed work histories, income and assets.

4.1 Sample Selection

Out of the total number of respondents, I have selected those white and black high school male graduates born after December 31 1960, who never went to college nor had any type of military experience. White males were taken from the core sample; black males were selected from the core and from the supplemental sample.

This selection is similar to that of Wolpin (1992). It was chosen for several reasons. Black and white high school graduates are the modal group in the NLSY. Only males are considered because a search-theoretic framework like that of my study corresponds more closely to a male labor force. Since the decision to join the military is not explicitly included in the model, respondents who served in the army are not included.

The NLSY contains data on school enrollment and a week by week accounting of employment status, hourly wages, hours worked, and employers. A complete weekly work history of an individual from 1978 until 1993 can be constructed. In 1979, the first year of interview, information was collected on employment history starting in January 1, 1978. Respondents whose employment histories started before 1978, i.e., those born before 1961, are dropped from the sample, because it is impossible to construct a complete employment history for them. The final sample consists of 686 individuals, 312 blacks and 374 whites.

For tractability, the data have been aggregated to quarters based on the calendar quarter in which the individual starts his employment history. So, instead of using calendar time, this study uses quarters after graduation as its time unit. Along with attrition and missing data, this implies that not all people are observed through 1993.

The last week that the individual reports having being enrolled in school is assigned to its corresponding calendar quarter. Employment history is defined to start in the quarter thereafter.

The inevitable consequence of the aggregation to quarterly data is some definitional arbitrariness. An individual is considered to be working if he is employed

during the first week of the quarter. He is reported as “unemployed” for that quarter otherwise. The job corresponding to that quarter is also the first job of the quarter. Any other job held during the quarter is ignored.¹ The quarterly wage related to that job is the wage of the first week of the quarter in 1985 dollars times 13.

Since the NLSY provides information on multiple jobs held at the same period by a person, the main job is taken to be the one with the most hours of work. A person is given the status of employed if he works 20 or more hours per week, and earns more than 1,000 1985 dollars in a quarter. The Consumer Price Index is used to transform the monetary values into real amounts.

Since the model does not incorporate temporary layoffs, individuals returning to work for their old employers are considered as having taken new jobs.

The survey includes a question on the reason for leaving a given employer. The various reasons reported for leaving the current job are classified into voluntary or involuntary reasons. It is considered a layoff when the respondent reports having been laid off, fired or discharged, that the program ended or that the plant closed. Other reasons such as family reasons, spouse changing jobs, finding a better job, quits to look for another jobs and other reasons are classed as quits.

Unfortunately, because of many missing values, this information covers only a small percentage of the transitions from a given employer. Out of the total number of transitions from employment to unemployment there is information on quits and layoffs for only 35.28% of blacks and for 38.45% of whites. The corresponding percentages for the transitions from one employer to another are 31.82% for blacks

¹Unfortunately, this construction of quarterly data implies missing transitions for high turnover groups, like blacks.

and 29.35% for whites.

The NLSY includes questions about financial characteristics of the household. Data on the market value of assets are only available for years 1985 until 1993, with exception of year 1991. This information is only available annually. Since the questions on assets refer to the market value of assets at the moment of the interview, this information is assigned to its particular calendar quarter. All other quarters are not assigned any value.

Since the model does not incorporate explicitly the existence of heterogeneous assets, they are treated as equally liquid.² This definition corresponds to the notion of wealth as a store of value used in the standard national accounting framework (Wolff 1990). Accordingly, the net value reported for total assets is the sum of the components.

The asset variable is constructed in this way only if there is information available for all of the components. If the respondent does not report at least one of them, the assets variable is reported as not available. The five components of assets are residential property, financial assets, business assets, vehicles and other. All these components are computed at their "market value" which the NLSY defines as the amount the respondent would reasonably expect someone else to pay if the particular asset were sold today in its present condition.

²An important reason for saving is the down payment of home purchasing (Engelhardt 1994). It does not seem plausible to assume that people sell their illiquid assets to finance job search. Apparently, this calls for using only the liquid components of assets in the estimation. This means to assume a priori no substitution between different types of assets. Consequently, the interaction between buying a house and employment decisions is not captured by this assumption either. Extending the model to allow for home purchasing is the consistent way of solving this omission. However, it would also make both the optimization problem and in the estimation more complicated. Not being the immediate purpose of this paper, this extension is left for future research.

Residential property refers to the net value of the respondent's house or apartment owned or being bought by the individual. That is the market value of the property, net of liabilities such as mortgages, back taxes, home improvement loans, or debts such as assessments, unpaid amounts of home improvement loans, or home repair bills.

Financial assets include money in savings or checking accounts, savings and loan companies, money market funds, credit unions, US savings bonds, individual retirement accounts (IRA or KEOGH), or certificates of deposit, common stock, stock options, bonds, mutual funds, rights to an estate or investment trust, or personal loans to others or mortgages held by respondent. This concept also includes money owed to the respondent by other people.

Business assets refer to the net market value of a farm, business or other property. Examples of this category are investment in a farm operation, a business or professional practice, or any other real estate. It does not count the property on which respondent is living. It is defined as the total market value of all of the real estate, or assets in the business, including tools and equipment, or farm operation, including value of land, buildings, house, and the equipment, livestock, stored crops, and other assets. If the property is a farm, crops held under commodity credit loans are not included. Debts or liabilities owned on this operation or property are subtracted. Any unpaid mortgages are included. Any commodity credit loans are excluded.

As vehicles it is included the market value of vehicles, including cars, motorcycles, trucks, a motor home or trailer, net of debts.

"Other" assets refer to the difference of the value of other assets worth more

than \$500 minus the amount of other debts over \$500. Examples of the property considered under this category are a piece of furniture, an appliance, stereo, boat, a piece of jewelry, a valuable collection for investment purposes, etc. Examples of debts are those owed to any stores, doctors, hospitals, banks, or anyone else, excluding 30-day charge accounts.

4.2 Descriptive Statistics

Table 4.1 presents summary statistics for the duration of the first unemployment spell, employment transitions, quits, wages and assets of both racial groups. These statistics are averages across people and over time. Therefore, they do not exploit the longitudinal character of the sample. In spite of this, they give an idea about some features of the data, and serve in the estimation as initial values for some of the parameters.

The employment variables show that on average it is less likely for unemployed blacks as compared with unemployed whites to become employed. The first unemployment spell of blacks lasts on average 4.1 quarters, whereas for whites it lasts 2.6 quarters. Out of the total unemployed blacks, 20% become employed in the next quarter, while the corresponding number for whites is 35%. It is also less likely that blacks stay at their current job. 11% of employed blacks become unemployed in the next quarter, and about 13% change employers in the next quarter. The

Table 4.1: Summary Statistics

Variable	Blacks	Whites
Employment		
Average duration of first unemployment spell (quarters)	4.10	2.60
% of unemployed becoming employed	20.45	34.94
% of employed becoming unemployed	11.32	7.31
% thereof quit	24.47	28.17
% thereof are laid off	10.81	10.28
% of employed changing employer	12.93	9.00
% thereof quit	20.69	17.99
% thereof are laid off	11.13	11.36
Wages		
Average first accepted wage	2,449	2,847
Average accepted wage	3,362	4,239
Average wage growth per quarter (%)	3.27	3.80
Average wage growth when changing employer (%)	19.93	29.33
Mean of log(wage)	8.02	8.24
Standard Deviation of log(wage)	0.44	0.48
Mean of log(wage) during first 3 years	7.89	7.99
St. Deviation of log(wage) during first 3 years	0.42	0.43
Assets		
Average assets	27,219	39,698
Average asset growth per quarter (%)	13.87	9.46
Mean of log(asset+5000)	10.01	10.26
St. Deviation of log(asset+5000)	1.019	0.951
Mean of log(asset+5000) during first 3 years	9.598	9.936
St. Deviation of log(asset+5000) during first 3 years	0.619	0.594

corresponding numbers for white individuals are 7% and 9%.³

As mentioned above, the information on the reason for leaving the current employer only covers about 30% of the transitions. Nevertheless, it is clear that an important proportion of people voluntarily abandon their current job to work for another employer or to become unemployed. At least 25% of blacks and 28% of whites who become unemployed did so because of voluntary reasons.

In this table, information on average levels, dispersion and growth of wages is also presented. Comparing the average first accepted wage with the sample average gives an idea about wage growth for both groups. Blacks, on average, have a starting wage of \$2,500 and an average wage of \$3,362; whites start on average with \$2,850 and have a wage average of \$4,240. Average wage growth is 3.3% per quarter for blacks and 3.8% per quarter for whites. It is, however, clear that changing employers is one of the main sources of wage increase: Blacks increase their wages by 20% when changing employers, whereas whites obtain a 29% increase. There are no substantial differences in dispersion of the accepted wage distribution of blacks and whites.

Assets data convey information on asset growth per quarter and on the initial asset distribution. If people consumed all their income, the average asset growth

³This transition probability is capturing a higher rate of job turnover for blacks. It can be also expressing that blacks have to move to other jobs because they are more likely to lose their current jobs.

per quarter would coincide with the rate of return. Thus, this statistic provides an idea about the rate of return: 14% for blacks and 9% for whites. The information on distribution of assets for the first three years after leaving school gives also some idea, though imperfect, about the initial distribution of assets for each group.

The composition of assets according to asset level, race and years of working experience is presented in Table 4.2. It shows the relationship between the level and the composition of wealth. Wealthier people in both groups tend to have a higher proportion of their assets in the form of residential property, business, farms or other form of property. Among the people with no more than 6 years after graduation, those with no more than \$10,000 have only 4% (blacks) and 8% (whites) of their wealth in residential property. The corresponding numbers for people with more than \$30,000 are 39% and 27%. This relationship between wealth and proportion of wealth held as residential property is maintained 6 years after graduation. Blacks with no more than \$10,000 hold about 8% of their wealth in residential property. The corresponding number for whites is 20%. Among the people with more than \$30,000, around 31% of their assets is held as residential property. There is also a fairly clear positive correlation between the percentage of business property and wealth.⁴ People with more than \$30,000 in asset holdings have more than 20% of them in business property.

⁴Using a static framework, Evans & Jovanovic (1989) find that having more assets under borrowing constraints increases the probability that a worker starts a business.

Table 4.2: Composition of Net Assets according to Asset level, Race, and Years after Graduation

Years	Blacks				Whites			
	Asset Bracket				Asset Bracket			
	1	2	3	4	1	2	3	4
Years ≤ 6								
Residential	3.96	21.80	38.27	39.12	7.79	21.47	36.12	27.33
Financial	16.72	13.82	20.39	13.01	19.57	21.68	14.41	22.53
Business	0.43	1.10	2.64	16.33	5.60	2.05	7.10	28.88
Vehicles	50.56	36.03	17.60	15.15	53.96	31.81	25.74	10.98
Other	28.32	27.25	21.10	16.39	13.07	22.98	16.63	10.29
Mean	2,235	13,693	25,638	56,462	31,278	14,433	24,950	88,546
Years > 6								
Residential	7.54	29.36	28.78	30.31	19.63	36.28	41.29	31.83
Financial	19.47	16.03	21.28	35.46	22.27	18.84	20.44	27.60
Business	0.75	1.88	5.26	24.35	4.18	3.12	4.64	27.68
Vehicles	49.46	31.37	23.63	4.83	46.99	28.04	21.00	6.35
Other	22.80	21.36	21.04	5.05	6.92	13.73	12.61	6.55
Mean	3,465	14,011	24,179	140,719	4,095	14,491	24,369	135,416

Asset Brackets:

- 1 : 0 < Assets ≤ 10,000
- 2 : 10,000 < Assets ≤ 20,000
- 3 : 20,000 < Assets ≤ 30,000
- 4 : 30,000

Table 4.3: Current Net Asset holdings, Wages and Years after Graduation in 1985 dollars

Wages	Blacks		Whites	
	Years ≤ 6	Years > 6	Years ≤ 6	Years > 6
$w \leq 2,000$	1,655	2,772	4,010	5,528
$2,000 < w \leq 4000$	2,563	4,106	5,357	8,600
$4,000 < w \leq 6000$	5,209	10,395	12,435	16,661
$w > 6000$	10,400	18,658	12,948	21,373

Vehicles is the component the proportion of which shows a very clear negative correlation with wealth. This trend is similar for both race groups and does not seem to change significantly with years after graduation. Around half of the wealth of people with less than \$10,000 is represented by the car. Financial assets are the most liquid component of wealth. Its relationship with the level of wealth is not clear.

Although the averages presented in Table 4.2 show big standard deviations, the patterns in the composition of assets are also shown in other studies like Sobol (1979), Jianakoplos, Menchik & Irvine (1989), and Blau (1990).

As shown in Table 4.3, there is a positive correlation between current assets,

wages and years after graduation for both race groups. People with higher wages tend to have a higher level of current asset holdings. With wages lower than \$2,000, people have assets of at most \$5,500. With wages higher than \$6,000 asset levels are at least \$10,400. Notice that individuals with more years after graduation but in the same wage bracket tend to hold more assets. With more than 6 years after graduation people hold around 80% more assets than people of the same wage bracket with no more than 6 years after graduation. This is indicative of the asset accumulation over time, abstracting from the wage growth.

These descriptive statistics show the existence of a link between labor market aspects and asset accumulation. There are important variables which affect this link, notably home ownership and marital status.

4.2.1 Home ownership

Since the purchase of a house is an important motivation for asset accumulation, it is instructive to compare asset levels according to home ownership. In Table 4.4, summary statistics for assets for black and white individuals are presented. Judging from the higher means and medians of homeowners' assets, it is clear that people who own a house at some point of their working careers have a higher distribution of assets. However, people who own a house also exhibit a higher level of negative assets than those who do not. While blacks who own a house report a lowest

Table 4.4: Assets, Wages and Unemployment rate according to Home Ownership

House	Blacks		Whites	
	With	Without	With	Without
Lowest Asset Level	-49,261	-26,809	-392,906	-22,967
25%	135	0	2,685	0
Median	3,270	270	11,413	1,603
75%	12,097	1,880	27,109	5,443
Highest Asset Level	8,651,996	8,695,649	8,657,300	8,504,274
Average Assets	92,097	7,929	56,541	19,809
Average Wages	3,476	2,788	4,227	3,578
% Unemployed	19.78	37.89	9.72	19.89
Observations	468	1,574	1,312	1,111

Note: "With House" refers to people who had a house at some point of their careers. "Without House" refers to people who never had a house.

observed level of assets of -\$49,261; blacks without a house have -\$26,809. Whites who own a house have -\$392,906 as the lowest observed level of assets; whereas whites without a house have -\$22,967. As an order statistic, the lowest observed asset level can be conceived of as an indicator of the highest admissible level of debt. The logic for this is the same used by Flinn & Heckman (1982*b*) to demonstrate that the lowest observed wage is a consistent estimator of the reservation wage.

While a link between home ownership and asset accumulation seems to be present in this information, at this level of disaggregation it is not possible to determine

if owning a house allows individuals to assume a higher level of debt, or if they contract a debt in order to buy the house. Since my purpose is to inquire on the link between asset accumulation and job market behavior, home ownership may be important to the extent that it affects job market outcomes.

Table 4.4 also shows average assets, average wages and the unemployment rate for the whole sample, according to race and home ownership. It is clear that higher wages and lower unemployment rates are associated with owning a house. Again the direction of the link is not clear. On the one hand, people with better job market outcomes will tend to be in a position to buy a house. In this respect, the ownership of a house is the result of the process of asset accumulation. The reciprocal effect is more interesting. To what extent does owning a house help people find (better) jobs? People who do not own a house, and are trying to accumulate to buy one, will not fully use their assets in their job search. Thus, they will not be very selective in their job search. Depending on the burden of mortgage debt, people who already bought a house will be more or less selective than those who do not own one. However, as mentioned above, since neither the decision nor the mechanism to buy a house are modelled explicitly, I estimate the model with total assets. Whatever advantage people who own a house as opposed to other assets may enjoy will be not considered in the estimation.

4.2.2 Marital Status

Marital status, like home ownership, is an important variable for the link between assets and employment. Table 4.5 shows asset holdings for both race groups according to home ownership. People who have been ever married have higher median and mean levels of assets. As with home ownership, people who have been ever married tend to have higher levels of debt. Blacks who have been ever married exhibit a lowest observed asset level of -\$49,261; whereas blacks who never married report -\$26,809 for the same variable. While whites who have been ever married have -\$392,906 as the lowest observed level of assets, whites who never married have -\$22,967.

Table 4.5 also illustrates that higher wages and lower unemployment are associated with being married. Once again, the direction of the causality is not clear. People with better job outcomes, who therefore save more, may be those more likely to get married. The opposite effect can be easily identified. The spouse of a married individual may receive another wage and contribute to asset accumulation. In terms of the theoretical model this would mean including the marriage decision as part of the search model. Moreover, if the worker's wife is a wage earner, assets can increase without an increase in the male worker's wage. While it would be insightful to do this extension, this is beyond the scope of the current research.

Table 4.5: Assets, Wages and Unemployment rate according to Marital Status

House	Blacks		Whites	
	Ever	Never	Ever	Never
Lowest Asset Level	-49,261	-26,809	-392,906	-22,967
25%	11	0	1,015	49
Median	1,813	0	6,367	2,237
75%	6261	1,576	19,873	9,261
Highest Asset Level	8,695,649	8,647,822	8,657,300	8,504,274
Average Assets	54,016	10,380	43,585	30,807
Average Wages	3,659	2,873	4,526	3,744
% Unemployed	21.18	41.78	11.58	20.76
Observations	788	1,254	1,686	737

Note: "Ever" refers to people who were ever married between 1978 and 1993. "Never" to people who were never married between 1978 and 1993.

4.3 Reduced Form Estimations

As a first assessment of the predictions of the model in terms of asset accumulation, accepted wages and employment transitions, I perform two sets of OLS and logit estimations, one for each employment status. The interpretation of these regressions is of a reduced form version of the policy functions, $A_u = A_u(A)$ and $A_e = A_e(A, w)$, and $w^* = w^*(A)$. Since the last one cannot be estimated directly, performing a logit regression of employment transitions as a function of the state variables will give information on the underlying reservation wage function along with the arrival rates. The theoretical transitions probabilities shown in Table 3.4 correspond to the following relationships:

Probability	Assets	Wages
$\Pr(\text{employed at } t + 1 \mid \text{unemployed at } t)$	-	-
$\Pr(\text{unemployed at } t + 1 \mid \text{employed at } t)$	+/0	-/0/+
$\Pr(\text{new employment at } t + 1 \mid \text{employed at } t)$	-/0	-

These reduced form estimations do not correspond to a joint decision of employment status and wages. Consequently, this is a marginal analysis of the policy rules. Table 4.6 presents OLS regressions for assets next period⁵ and logit regressions of employment status next period as functions of the state variables when unemployed.

⁵Given that the information on assets is available only for some quarters, these estimations refer to those periods when all variables are observed. Therefore, “next period” refers to the next observation for which all variables are observed. These estimations are done using total assets.

Table 4.6: Reduced Form Decision Rules when Unemployed

Variable	Assets Next Period		Employment Status Next Period	
	Blacks	Whites	Blacks	Whites
Assets	.351 (.044) 7.967	.771 (.060) 12.816	.0000539 (.0000213) 2.532	.0000402 (.0000197) 2.043
constant	939.819 (199.581) 4.709	2002.921 (502.840) 3.983	-.6452943 (.0944653) -6.831	.125976 (.1433046) 0.879
F	63.47	164.26		
R_2	0.1041	0.3975		
χ^2			6.96	13.38
$\log \mathcal{L}$			-353.09	-168.04
Obs	548	251	545	249

(Standard Errors are in parentheses and t-Statistics below)

For both race groups, assets in the current period have a strong positive impact on assets next period. Roughly speaking, one dollar worth of assets in the current period means 35 cents worth of assets in the next period for blacks. The corresponding amount for whites is 77 cents. These numbers should be interpreted, however, cautiously, because they refer to different time periods after people left high school. They cannot be interpreted as a stationary pattern of asset accumulation.

The choice of an unemployed individual, staying unemployed or moving to unemployment, is introduced in a logit framework with the state variables of the model

and their respective square terms as regressors. The results are also presented in Table 4.6. The coefficient for assets has a positive and significant sign, implying that it is more likely that wealthier unemployed people become employed.

Table 4.7 presents OLS and logit regressions for assets and employment transitions, respectively, when people are employed. Assets next period show a fairly clear positive correlation with assets and wages in the current period. One dollar worth of assets in the current period produces 43 cents of assets in the next period for blacks, and 63 cents for whites. One additional dollar in wages means a 74 cents increase in assets next period for blacks, and 71 cents for whites. These simple regressions show a tendency toward asset accumulation while employed, if wages are high enough. It can also happen, especially for blacks, that people decumulate if wages are low.

When an individual is employed, he can move to unemployment, stay in the same job or accept to work for another employer. This decision can be estimated using a multinomial logit with the state variables for employed individuals as regressors. The transition from employment to unemployment shows a negative dependence on assets. This suggests that wealthier employed people are less likely to move to unemployment. Likewise, moving from one employer to another seems to show a weak negative relationship with total assets. This is consistent with the prediction of the model that wealthier people are less likely to change employer. Wages do

Table 4.7: Reduced Form Decision Rules when Employed

Variable	Assets Next Period		Employment Status Next Period			
			Un- employed	New Employer	Un- employed	New Employer
	Blacks	Whites	Blacks		Whites	
Assets	.433 (.030) 14.32	.631 (.025) 25.01	-.0000487 (.0000188) -2.595	-3.14e-06 (9.87e-06) -0.319	-.0000387 (.0000128) -3.018	-.0000293 (8.36e-06) -3.499
wage	.743 (.123) 6.06	.705 (.126) 5.62	-6.65e-06 (.0000523) -0.127	-.0000354 (.0000439) -0.807	-.0000239 (.0000532) -0.449	-.0000479 (.0000387) -1.238
const.	133.59 (440.28) 0.30	1507.37 (545.02) 2.77	-.964 (.187) -5.15	-.318 (.155) -2.06	-1.694 (.223) -7.59	-.818 (.160) -5.100
<i>F</i>	150.35	396.16				
<i>R</i> ₂	0.23	0.37				
χ^2				10.15		4.72
<i>logL</i>				-1008.09		-1045.36
Obs	1012	1347		1008		1342

(Standard Errors are in parentheses and t-statistics below)

not seem to have a significant impact on any employment transition, except on the transition from one employer to another for blacks, where the impact is negative. This is compatible with the model which allows for negative or no impact of current wages on the employment transition. Higher current wages will decrease the range of wages acceptable to work for another employer, and, consequently, the probability of switching.

There are two important discrepancies between the predictions of the model and these reduced form estimations. The first one is that if a person is unemployed the model predicts a negative relationship between assets and the probability of becoming employed. The estimates have a positive sign. The second one is that according to the model, the higher the level of assets the more likely the transition for employment to unemployment. The reduced form estimates indicate that the correlation is negative.

As shown in Chapter 3, these discrepancies can arise because permanent differences in individuals' search environments are not taken into account. The existence of heterogeneous agents, who are assumed identical in these reduced form estimations, can be the reason for not finding what the model predicts. Relatively wealthy people, who can afford to search longer, may not actually do so, because they may have higher wage offer distributions than poorer agents. In a similar fashion, the probability that richer people become unemployed may be lower than for poorer

people, because the former may have higher arrival rates. In consequence, these reduced form results, while supporting some of the predictions of the models, also suggest the presence of permanent idiosyncratic differences in agents, which will have to be included in the structural estimation.

Chapter 5

Estimation Method

This chapter describes the method used to estimate the model presented in Chapter 3. The estimation strategy is designed to recover the parameters of the theoretical model. The procedure consists of using the policy rules of the dynamic programming problem as inputs in the computation of the likelihood function. This means that the probability statements shown in Table 3.4 are explicitly used to account for observed transitions in employment status, assets and wages. The first section of this chapter describes how the likelihood function is constructed.

A common problem in this type of estimation is the existence of unobserved idiosyncratic differences, i.e., people may have different parameters of the model. For example, individuals analyzed in the sample have the same level of formal schooling, but the quality of education is likely to differ across them. This omitted

variable plays an important role not only in initial but also in future conditions. Wage offer distributions as well as arrival rates can be affected by this circumstance (Orazem 1987, Lazear 1979). Individuals may differ also in their attitudes toward risk, tightness of their borrowing constraints, rates of return, or net transfers while unemployed.

Estimating the model without accounting for unobserved heterogeneity can lead to wrong inferences (Flinn & Heckman 1982*b*). It is, however, important, before introducing any type of heterogeneity, to have a baseline estimation with the smallest possible number of parameters. This means that it is sensible to start estimating the model assuming that all individuals have common behavioral parameters. The results of this estimation can be revealing about the type of heterogeneity needed to account for the trends in the data.

Similarly, extensions of the theoretical model are subject to an assessment of the results of this baseline estimation. This model can be extended in many different directions, which include endogenous wage growth as in Wolpin (1992), introducing explicitly the choice of search intensity, accounting for leisure in the utility function, or assuming a shock in the rate of return or in tastes. These extensions would clearly allow a better fit of the data. The strategy followed in this thesis is to estimate first the model presented in Chapter 3 and then estimate and extended model with wage growth and unobserved heterogeneity. The second section presents the extensions

to the theoretical model and the way unobserved heterogeneity is introduced.

5.1 Construction of the Likelihood Function

In this estimation only a subset of the model's parameters is estimated. Those are

$$\Theta_D = \{b, \mu, \sigma, \lambda_u, \lambda_e, \theta, r, \beta, \gamma\}.$$

The parameters which are not estimated are B , \underline{w} and \bar{w} . For the purposes of the likelihood function, the following values of these parameters are assumed: $B = -5,500$, $\underline{w} = 1,000$, $\bar{w} = 20,000$. The maximum value of assets is assumed to be \$45,500. The existence of this upper bound on assets is imposed by the discretization of the state space. In general, these bounds were chosen after making sure that most of the observed values for assets and for wages were not excluded from the estimation. Less than 11% of the assets observations lie outside the admissible range defined by these bounds. The corresponding percentage for wages is around 6%. The number of gridpoints used for assets and for wages are, respectively, 50 and 51.

The available data allow the identification of the parameters of the wage offer distribution, arrival rates, rate of return and the measurement errors. To the extent that risk averse behavior can be produced by borrowing constraints, B and the

coefficient of risk aversion may not be identified separately. That is why in this estimation B is assumed fixed. Therefore, γ may not just capture risk aversion, but also the existence of borrowing constraints. Unemployment net transfers is principally identified by data on wages and by the length of unemployment. To facilitate its identification the consumption floor \bar{c} is assumed fixed.

Given the state variables, it is possible to account for the several transitions observed in the data. However, since the model does not have any other source of randomness but wage draws, it is unlikely that it accounts simultaneously for the employment transitions and for the observed values of assets and wages. The simplest way to make the estimation feasible without introducing any other stochastic variable in the dynamic programming problem is to assume measurement errors. Apart from facilitating the estimation, there are justified reasons to believe that assets and wages are measured with errors.¹

Observed assets are defined as the model's predicted level of assets plus a measurement error:

$$A_t^{obs} = A_t + \varepsilon_A,$$

where ε_A is normally distributed with zero mean and standard deviation σ_A .

¹Rust (1990) discusses the severity of measurement errors in assets data from the Retirement History Survey (RHS). As already shown, the NLSY asset data have plausible trends.

Similarly, observed wages are defined as

$$\ln w_t^{obs} = \ln w_t + \varepsilon_w,$$

where ε_w is normally distributed with zero mean and standard deviation σ_w . Although the model does not predict a true wage level, it gives admissible values for true wages, and, with this, admissible values for measurement errors. This is, the measurement error has to be such that true wages are not below the reservation wage predicted by the model.

Since the state space has been discretized, the densities of the measurement errors have also been discretized. They are actually discrete probabilities approximated by a normal density function. The principle for discretizing measurement errors is the same as the one for discretizing assets and wages. A continuous variable is divided into equally spaced intervals. The size of these intervals is the gridsize. The midpoint value of each interval is considered as the value for the whole interval. Each discretized measurement error has the same gridsize as its corresponding variable. Assets' gridsize is 1,000, so their corresponding measurement error has also a gridsize of 1,000. Each of these intervals has a probability mass, which is calculated as the difference between two normalized cumulative distribution functions. As mentioned above, since assets are only observed annually, very few observations are available

for assets. The formal expressions of these probability masses are:

$$h_A^* = \begin{cases} \Phi\left(\frac{\varepsilon_A(k) + \Delta_A/2}{\sigma_A}\right) - \Phi\left(\frac{\varepsilon_A(k) - \Delta_A/2}{\sigma_A}\right) & \text{if assets are observed;} \\ 1 & \text{if assets are not observed;} \end{cases}$$

$$h_w^* = \begin{cases} \Phi\left(\frac{\varepsilon_w(j) + \Delta_w/2}{\sigma_w}\right) - \Phi\left(\frac{\varepsilon_w(j) - \Delta_w/2}{\sigma_w}\right) & \text{if wages are observed;} \\ 1 & \text{if wages are not observed.} \end{cases}$$

Δ_A and Δ_w are the gridsizes used for the discretization of assets and wages respectively. Each discretized level of assets is denoted with the ordinal k . N_A is the number of gridpoints for assets. In a similar fashion, each wage interval is assigned an ordinal j . The number of gridpoints for wages is N_w . So: $k = 1, \dots, N_A$, $j = 1, \dots, N_w$. As mentioned above, $N_A = 50$ and $N_w = 51$.

This discretization of variables that are originally continuous has, unfortunately, the problem of imposing bounds on the measurement errors as well. For example, if the lowest possible interval of assets is observed, the admissible measurement error will only account for values which are higher than that observation. All those values which are lower will not be admissible. The expected true value of assets will not be the observed amount of assets, or, in other words, the mean of the measurement error will not be zero. Consequently, the estimation will have biases caused by the

discretization of continuous variables. This problem can be alleviated by conditioning the distribution of the measurement errors on admitting as true values of assets and wages only those that lie within their respective supports. However, the fact that the measurement error has non-zero mean will not be eliminated by this.

The individual likelihood contribution conditional on the initial level of assets, A_0 , can be expressed as:

$$\mathcal{L}^i(\Theta_D, \sigma_A, \sigma_w | A_0) = \Pr(\mathbf{A}, \mathbf{ES}, \mathbf{w}, \mathbf{f} | \Theta_D, \sigma_A, \sigma_w, A_0).$$

The observed variables are assets, \mathbf{A} , employment status, \mathbf{ES} , wages, \mathbf{w} , and layoffs \mathbf{f} .

The model does not predict a true initial level of asset. Assuming a functional form on initial conditions can lead to biased estimates of the structural parameters (Heckman & Singer 1984). An alternative way of conditioning on assets is to start the estimation when assets are first observed. In this specification, the first asset observation could be used to condition the whole individual likelihood computation. Given that assets in the NLSY are observed only since 1985, many observed values of employment status and wages would be lost. Confronted with this trade-off, I opt for starting the estimation assuming that initial assets follow a displaced lognormal

distribution:

$$\ln(A_0 - B) \sim N(\mu_0, \sigma_0^2).$$

I add B to each unobservable initial value of assets to make the term inside the logarithm positive. The identification of the parameters of this function is not only given by assets data, but also by employment transitions and wages. Unfortunately, because of scarcity of asset observations for the first quarters after leaving high school, these parameters are mainly identified by the latter.

In the theoretical model the true level of assets when people are unemployed depends on their past wages. This complicates the computation of the likelihood function, because multiple integrations, actually sums, over wages and assets are required and must be carried over for the whole career of the individual. The type of complication introduced by this serial dependence is shown by Wolpin (1995), which solved a problem where the employment cycles were serially dependent only when people were employed. The introduction of assets in this model means that this serial dependence is prolonged to unemployment spells.

This difficulty is overcome by computing the likelihood function as a Markov chain. Continuous variables, like assets and wages, have been discretized to solve the dynamic program. They are assumed to be bounded and have an equally sized and constant number of intervals. A transition matrix, based on the probability statements of Table 3.4, can be formed to account for the observed values. Each

element of this matrix is a combination of an employment state, a level of assets and (if employed) of wages. The process can be thought of as the iteration of a matrix or array which describes at any point in time the probability that an individual has a particular state.

When an individual is employed, define the likelihood of having reached an asset level $A(k)$ and a wage $w(j)$ at time t as $\Lambda(k, j)^t$. In this case, $j \geq 1$. When an individual is unemployed $\Lambda(k, j)^t$ is the likelihood of having reached an asset level $A(k)$. In this second case $j = 0$. Since employment status and layoffs are not observed with error, this array can account for all possible true values of assets, employment status and wages.

All individuals are assumed to be unemployed when they leave school and start searching for a job. This means that in period 0 the probability that an individual has assets of $A(k)$ is

$$\Lambda(k, 0)^0 = \Phi \left(\frac{\ln(A(k) - B + \Delta_A/2) - \mu_0}{\sigma_0} \right) - \Phi \left(\frac{\ln(A(k) - B - \Delta_A/2) - \mu_0}{\sigma_0} \right).$$

This is, the likelihood of having reached that state is just given by the initial asset distribution. Now the likelihood function can be computed iteratively using

the expression

$$\Lambda(k', j')^{t+1} = \sum_k \sum_j \Lambda(k, j)^t \times \Pr(k', j' | k, j) \times h_A^* \times h_w^*,$$

where $\Pr(k', j' | k, j)$ is a discretized version of the transition probabilities for employment states, assets and wages described in Table 3.4.

The likelihood contribution of individual i is computed in this way until T^i is reached. At that point

$$\mathcal{L}_i = \sum_k \sum_j \Lambda(k, j)^{T^i}$$

The likelihood function is then the product of the individual likelihood contributions,

$$\mathcal{L}(\Theta) = \prod_{i=1}^N \mathcal{L}^i(\Theta),$$

where $\Theta = \{\Theta_D, \sigma_A, \sigma_w, \mu_0, \sigma_0\}$.

The computation the likelihood function, including the solution of the dynamic programming problem, takes approximately 30-35 CPU seconds in an IBM RISC-6000 machine. The iteration algorithm used to maximize the this likelihood function is the downhill simplex method (Press, Teutolsky, Vetterling & Flannery 1992). It requires only function evaluations, not derivatives.

5.2 Work Experience

The model presented in Chapter 3 is tractable enough to establish basic relations between asset accumulation and employment dynamics. It has, however, the limitation of assuming that the wage is fixed while a individual works for the same employer. Since this is not what it is observed in the data, the way the model captures on-the-job wage growth is by the measurement error. An important extension of this model, therefore, is to allow for endogenous wage growth. As in Wolpin (1992), wages are assumed to depend on the number of periods worked, H . The wage offer distribution, $F(x)$, refers now to the wage an individual with no experience will receive. So, the wage at an initial wage draw ω and H_t periods of working experience is

$$w(\omega, H_t) = \omega \exp(\alpha_1 H_t + \alpha_2 H_t^2) \quad (5.1)$$

Expected discounted utility differs according to the current employment state. asset holdings, work experience, wages, and the number of periods being non-employed. Expected lifetime utility in the non-employment state, V , is characterized by asset holdings A_t , and the number of periods of working experience H_t , which determines the level of the wage offer. In the employment state, expected lifetime utility W , depends on asset holdings A_t , the wage draw ω , and the number

of periods of working experience, H_t . This last two variables determine the current wage $w(\omega, H_t)$; only H_t , determines the level of the wage offer distribution. The lifetime utility of an unemployed individual, with H_t periods of working experience is:

$$\begin{aligned}
V_u(A, H_t) = \max_{A_u \geq B} \{ & U(A + b - \frac{A_u}{1+r}) \\
& + \beta \left[\lambda_u \int \max[V_e(A_u, x, H_t), V_u(A_u, H_t)] dF(x) \right. \\
& \left. + (1 - \lambda_u)V_u(A_u, H_t) \right] \}. \tag{5.2}
\end{aligned}$$

Similarly, the lifetime utility of an employed individual with asset level A_t , initial wage draw ω , and H_t periods of working experience is:

$$\begin{aligned}
V_e(A, \omega, H_t) = \max_{A_e \geq B} \{ & U(A + w(\omega, H_t) - \frac{A_e}{1+r}) \\
& + \beta [(1 - \theta)((1 - \lambda_e) \max[V_e(A_e, \omega, H_{t+1}), V_u(A_e, H_{t+1})] \\
& + \lambda_e \int \max[V_e(A_e, \omega, H_{t+1}), V_e(A_e, x, H_{t+1}), V_u(A_e, H_{t+1})] dF(x)) \\
& + \theta(\lambda^e \int \max[V_e(A_e, x, H_{t+1}), V_u(A_e, H_{t+1})] dF(x) \\
& + (1 - \lambda_e)V_u(A_e, H_{t+1})) \} \}. \tag{5.3}
\end{aligned}$$

The simple law of motion of cumulative working experience is:

$$H_{t+1} = H_t + 1, \text{ if } H_t < \bar{H},$$

where \bar{H} is a limit for acquiring working experience.

Since the introduction of cumulative working experience does not affect the monotonicity of the value functions on the other states, the reservation wage property in the extended model is preserved. It is not clear, once on the job wage growth is introduced if the propositions of Chapter 3 will persist. Work experience undermines the need for asset accumulation. People know that their wages will be higher in the future, so they can afford to consume more in the present. Work experience also allows employed people to increase their wages without the need to change employers. People can be less selective at the beginning of their careers and increase their cumulative work experience. In this respect the introduction of work experience weakens the link between job search and asset accumulation.

In terms of the estimation, work experience does not affect the construction of the likelihood function. At each iteration of the likelihood function, the wage gain produced by cumulative working experience is discounted from observed wages (Wolpin 1992).

5.3 Unobserved Heterogeneity

People do not only differ in their initial assets, but also in their other aspects that have a permanent effect all over their workhistory. For example, some people may have higher wage offer probabilities and higher means for their wage offer distributions. The minimum number of types that can be introduced to account for unobserved heterogeneity are two. So, two types of agents will be assumed in the estimation, which will have the following expression:

$$\mathcal{L}_i(\Theta) = \pi \mathcal{L}_i(\Theta^1) + (1 - \pi) \mathcal{L}_i(\Theta^2)$$

where: $\Theta = \{\Theta^1, \Theta^2, \pi\}$

In the estimation heterogeneity will be assumed in the parameters of the wage offer distribution and of the initial asset distribution, and in arrival rates: $\lambda_e, \lambda_u, \theta$. The introduction of heterogeneous agents has the consequence of having to solve the dynamic programming problem as many times as types of agents is assumed.

Redefine Θ be the vector for all parameters of the model. The likelihood function is the product of the individual likelihood contributions:

$$\mathcal{L}(\Theta) = \prod_{i=1}^N \mathcal{L}^i(\Theta)$$

As in the stripped-down model, in addition to unobserved heterogeneity in assets
I assume observed heterogeneity according to race.

Chapter 6

Estimation Results: Baseline

Model

This chapter presents the results of estimating the model of Chapter 3. The first section contains the parameter estimates of the baseline model, that is, the model where individuals are identical within each race group and do not accumulate work experience. The second section discusses the accuracy of the model by comparing the actual and the predicted variables and performing goodness of fit tests.

6.1 Parameter Estimates

The two sets of maximum likelihood estimates and the corresponding asymptotic standard errors are reported in Table 6.1. Transfers while unemployed, the

Table 6.1: Parameter Estimates for the Baseline Model

Parameters	Blacks		Whites	
	Estimates	ASE	Estimates	ASE
b	1959.936	7.442319	2124.687	372.4632
μ	7.433582	0.247731	7.599444	0.003907
σ	0.441520	0.007657	0.453725	0.003167
λ_u	0.745149	0.026741	0.836838	0.014688
λ_e	0.499975	0.020889	0.511647	0.013360
θ	0.088888	0.002693	0.060826	0.002094
r	0.091364	0.001804	0.083730	0.002371
β	0.995221	0.006665	0.991560	0.000584
γ	1.371827	0.002477	1.302130	0.009176
μ_0	8.717085	0.160303	9.107641	0.221954
σ_0	0.454774	0.067441	1.044581	0.387250
σ_A	6615.457	125.0980	10790.16	213.9432
σ_w	0.255273	0.000504	0.294351	0.000548
Loglikelihood	-31415.56		-45037.20	
Individuals	312		374	

mean, and the standard deviation of the wage offer distribution are lower for blacks than for whites. These estimates show that the wage offer distribution of whites stochastically dominates that of blacks. The probability of getting a wage offer while unemployed and the probability of getting an offer while employed are higher for whites than for blacks. The layoff rate is higher for blacks than for whites. These estimates characterize the labor market environment in which individuals make decisions on employment transitions. A more favorable labor market envi-

ronment for whites than for blacks is implied by these estimates. Similar values for these parameters have been found in Wolpin (1992). They are compatible, as it will be clearer in the next section, with the observed trends of labor turnover and accepted wages.

The parameters traditionally more related to asset accumulation are the rate of return, the discount rate and the coefficient of risk aversion. The rate of return, r , is higher for blacks than for whites. In the descriptive statistics, asset growth, which suggests an upper bound for the rate of return, is also higher for blacks than for whites. For both race groups the rate of return is high relative to the discount rate β , which is higher for whites than for blacks. In this estimation, the restriction that $\beta(1+r) \leq 1$, on which the theoretical model is based, is not imposed. That the estimates violate this assumption means that accumulation is produced to some extent by a relatively high interest rate. As explained in Chapter 3, the only reason for asset accumulation in the model is the existence of a positive layoff rate. Since this parameter is well identified by the observed involuntary transitions from employment to unemployment, it cannot be sufficiently high to account for the observed trend of asset accumulation. In the absence of other sources of savings, the estimation tends then to raise the rate of return.

The coefficient of risk-aversion γ is higher for blacks than for whites. Since a tight borrowing constraint can induce a risk-averse behavior, these estimates may

not necessarily reflect the attitude of these groups toward risk. For example, if blacks face a lower borrowing limit than whites, they may be acting as more risk-averse individuals. Since the estimation has been done assuming a fixed borrowing limit, differences in the borrowing limit are captured by the coefficients of risk-aversion. In other words, B and γ may not be identified separately. It remains, however, to be studied, the effect of B on the likelihood function.

The median and the dispersion of the initial asset distribution is lower for blacks than for whites. This means that the initial distribution of assets of whites dominates the one of blacks. Initial conditions, summarized in initial asset holdings, as well as current labor market conditions are better for whites than for blacks. It remains to be seen which of them is more important in determining the differences in career paths between the race groups.

As seen in the descriptive statistics these data, especially asset data, are very noisy. Accordingly, the measurement errors in both wages and assets are high. For assets the standard deviation of the measurement error is 6615 for blacks and 10790 for whites. For log-wages the standard deviation is 0.26 for blacks and 0.29 for whites.

Asymptotic standard errors are in general small. For both race groups, a two standard error deviation in all parameters would not change estimated parameters very much, exception for μ_0 , the median of the initial asset distribution and σ_0 ,

the standard deviation of log-assets. This result is not surprising because these distributions are estimated in most cases without asset data for the first quarter after leaving high school. Identification for these parameters comes mainly from the observations of assets several quarters after graduation.

6.2 Accuracy of the Model

To assess if these parameters capture the essential features of the data, I compare the observed and the predicted choice distributions of employment, assets, and wages. The dynamic programming problem is solved using the maximum likelihood parameter estimates. With the obtained policy rules, I generate simulated career paths for 1000 individuals and build a period-specific predicted choice distribution. Subsection 6.2.1 presents a visual inspection of the predicted and the observed averages for the employment status, employment transitions, assets and wages. Subsection 6.2.2 shows formal goodness of fit tests.

6.2.1 Graphical Comparisons

Figure 6.1 reports the paths for actual and predicted employment states, wages and assets. The model's predicted path of the unemployment rate converges to the actual one over time. The model, however, overpredicts the unemployment rate for

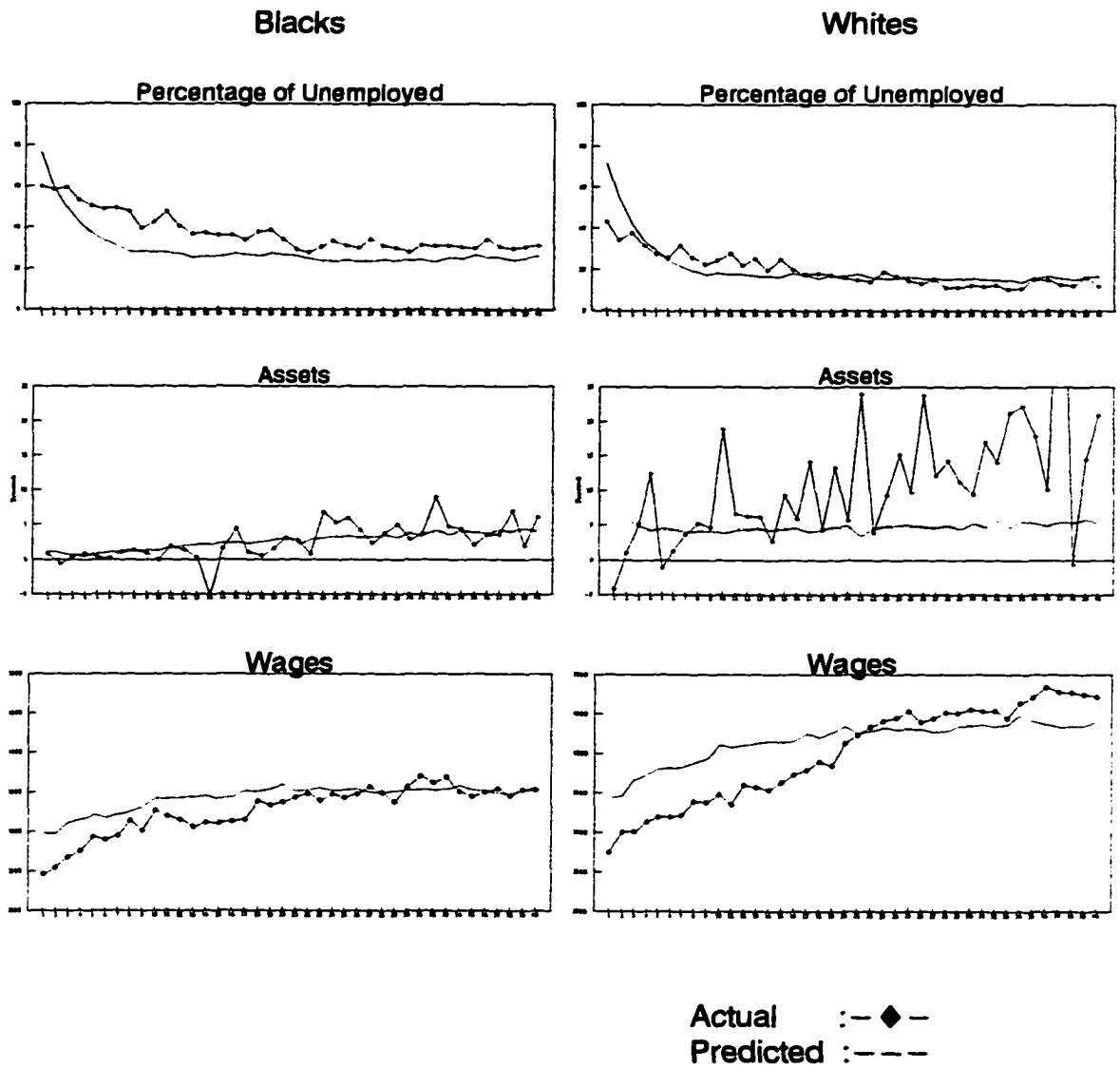


Figure 6.1: Actual and Predicted Variables. Unemployed, Assets, and Wages by Quarter after Graduation. Baseline Model

blacks and whites during the first few years after leaving school. While this high predicted unemployment rate goes down very rapidly, the actual unemployment rate goes down slowly. For whites the predicted rate of unemployment falls below the actual one six quarter after graduation and stabilizes at a slightly higher level than the actual one. For blacks the predicted unemployment rate is lower than the actual one since the third quarter after graduation.

The basic trends in asset evolution are replicated by the the model. For both groups there is a clear trend to asset accumulation. The actual data, however, show fluctuations which are not present in the predicted trajectories. Without a stochastic component other than the wage offers received each period, the model is unable to produce sufficiently large fluctuations in assets. It is also clear that the model overpredicts the average level of assets of blacks; while it underpredicts the average level of assets for whites. A more accurate assessment of the success of the model in reproducing the path for assets would need goodness of fit tests.

The actual trajectory of average wages over time is replicated in its main trends and levels for both groups. Predicted average wages for both race groups start higher than actual ones. The predicted variable grows slower than the actual for whites, so that ten years after graduation the model underpredicts the actual level of wages. For blacks the predicted average converges to the actual level. One important reason for this discrepancy could be that in the theoretical model, wage

growth is achieved only by switching to better paid jobs, whereas in the data, wages can increase while on the job. While it is true that the main increases in actual wages occur when people change employers, the data also register increases while working for the same employer, which the model does not account for. These wage increases are accounted only as a measurement error which may produce a bias in the estimation.

Figure 6.2 depicts employment transitions by quarter after graduation for both groups. They display general replication of the actual trends, especially for the transition from unemployment to employment. The predicted transitions from employment to unemployment start with a substantial discrepancy with the actual transitions, but tend to converge to the actual ones. The predicted transitions of people who change employers tend to converge to the actual ones, especially for whites. In both cases, the model underpredicts the change of employment status experienced by employed people, especially during the first quarters after leaving school. In addition, these figures show that actual employment transitions fluctuate more than those predicted by the model. The percentage of employed blacks who change employer is particularly erratic in the actual data. This means that the model generates high stability in the current job. The turnover of people is smaller in the model than in the data.

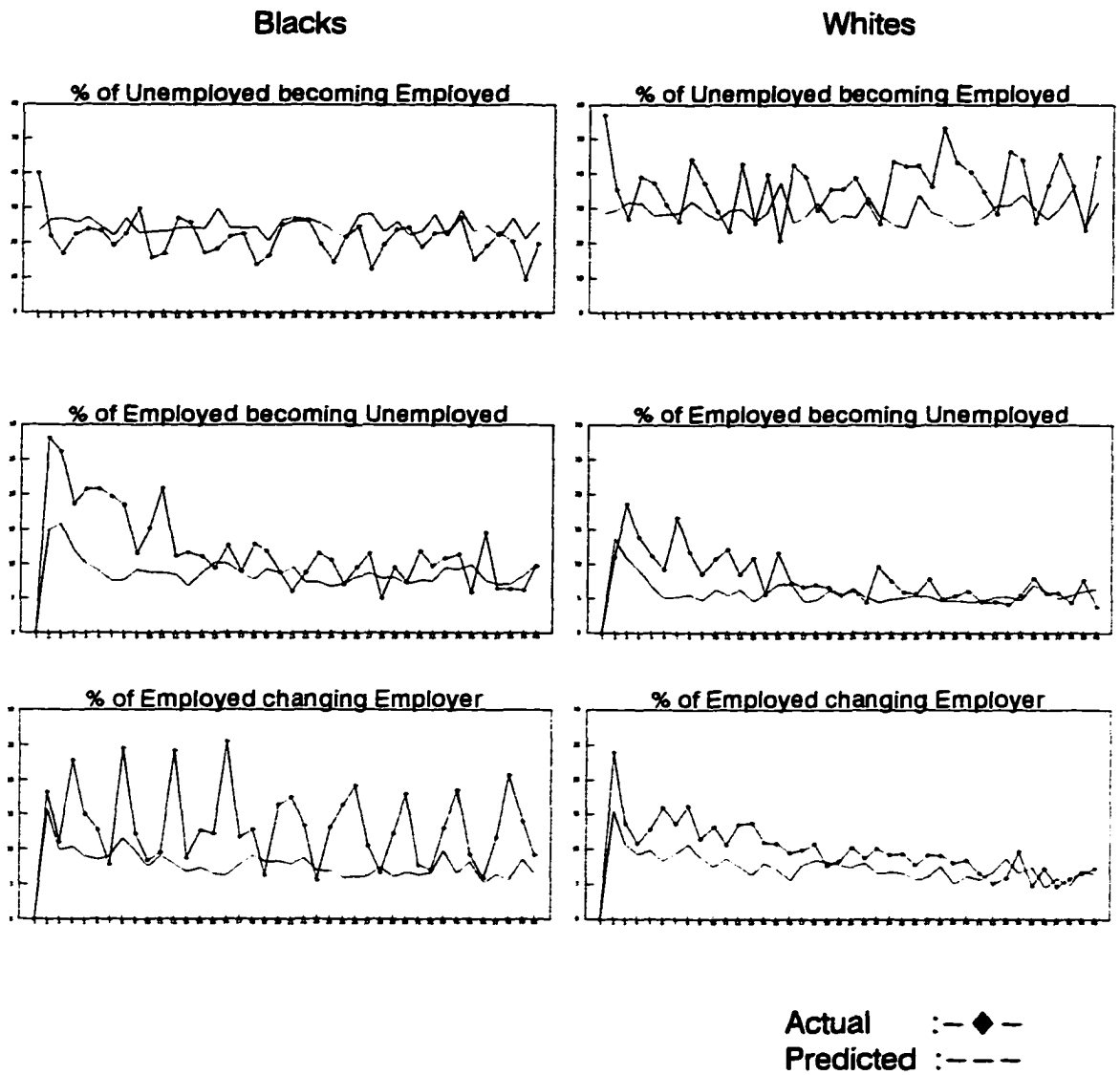


Figure 6.2: Actual and Predicted Variables. Employment Transitions by Quarter after Graduation. Baseline Model

6.2.2 Goodness of Fit Tests

In order to assess the success of the model in fitting the data formally, I perform goodness of fit tests to measure the distance between the observed choice distribution and the predicted one. A χ^2 statistic provides cell-by-cell information on whether the observed data come from the probability distribution implied by the theoretical model. Let n_{kt} be the actual number of observations of choice k at time t , and \hat{n}_{kt} the predicted corresponding number. The test statistic across choices at a particular period, t , is defined as

$$L_t = \sum_{k=1}^K \frac{(n_{kt} - \hat{n}_{kt})^2}{\hat{n}_{kt}}, \quad (6.1)$$

and the test statistic for a choice k over time after graduation is

$$L_k = \sum_{t=1}^T \frac{(n_{kt} - \hat{n}_{kt})^2}{\hat{n}_{kt}}, \quad (6.2)$$

K is the total number of possible alternatives, and T is the number of years after graduation for which the estimation is done ($T = 10$). L_t and L_k have an asymptotic χ^2 distribution with $K - 1$ and $T - 1$ degrees of freedom, respectively (Heckman & Walker 1990).¹

¹These tests may have some cells which are not predicted by the model. In that case, the

Table 6.2 and Table 6.3 compare the actual and predicted percentage of unemployment and employment by year after graduation for blacks and whites, respectively. They also present χ^2 tests for employment status at each year after graduation and by employment state for the whole time period. Considering the behavior of the entire populations, the χ^2 statistic is 404.69 and 2.36 for blacks and whites respectively. The hypothesis that the observed and predicted probabilities come from the same distribution can be rejected at the 5% significance level for blacks; it cannot be rejected for whites.

χ^2 tests by choice are reported in the last row of each table. For both groups, they reject the null hypothesis that predicted and actual proportions are the same during the first ten years after graduation at the 5% significance level.

At each row, these tables indicate actual and predicted proportions of unemployed and employed per year after graduation. This statistic is constructed for each row to test that these two proportions are the same at each year. The critical value for this test is $\chi_{(1)}^2(0.05) = 3.84$. The null hypothesis that the distribution of the population and of the model are the same cannot be rejected only at year 1 after graduation for blacks and at years 5 and 6 for whites. As in the graphical comparisons, higher distances between the model and the data are attained for both groups at the beginning of the employment career. Ten years after graduation, the

statistic is not computed and the evaluation of the significance is restricted to the remaining number of cells.

Table 6.2: Baseline Model. Actual and Predicted Choice Distribution for Employment by Year after Graduation: Blacks

Years after Grad	Unemployed		Employed		χ^2 (row)	Obs
	A	P	A	P		
1	57.67	57.22	42.33	42.78	0.10*	1212
2	48.91	32.38	51.09	67.63	148.85	1192
3	42.42	27.75	57.58	72.25	126.00	1174
4	36.55	25.95	63.45	74.05	66.68	1141
5	36.01	26.58	63.99	73.43	51.16	1122
6	30.19	24.50	69.81	75.50	19.31	1103
7	31.42	23.70	68.58	76.30	36.05	1095
8	29.95	23.80	70.05	76.20	22.66	1085
9	31.26	25.48	68.74	74.53	18.73	1062
10	30.34	25.00	69.66	75.00	15.46	1015
Total	37.88	29.24	62.12	70.76	404.69	11201
χ^2 (column)	649.95		895.72			

Note: A=actual; P=predicted.

Critical values: $\chi^2_{(1)}(.05) = 3.84$, $\chi^2_{(9)}(.05) = 16.92$.

"*" denotes that actual and predicted rates are statistically equal.

Table 6.3: Baseline Model. Actual and Predicted Choice Distribution for Employment by Year after Graduation: Whites

Years after Grad	Unemployed		Employed		χ^2 (row)	Obs
	A	P	A	P		
1	36.53	50.50	63.47	49.50	114.76	1470
2	27.47	23.52	72.53	76.47	12.52	1449
3	23.94	17.48	76.06	82.53	41.48	1433
4	22.14	16.88	77.86	83.13	27.88	1409
5	17.00	16.40	83.00	83.60	0.37*	1394
6	15.92	16.08	84.08	83.93	0.02*	1382
7	13.38	15.45	86.62	84.55	4.45	1360
8	11.82	15.07	88.18	84.93	10.97	1328
9	12.70	15.18	87.30	84.82	6.17	1299
10	13.14	15.77	86.86	84.22	6.58	1263
Total	19.71	20.23	80.29	79.77	2.36*	13787
χ^2 (column)	149.85		289.90			

Note: A=actual; P=predicted.

Critical values: $\chi^2_{(1)}(.05) = 3.84$, $\chi^2_{(9)}(.05) = 16.92$.

"*" denotes that actual and predicted rates are statistically equal.

model does a better job in approximating the actual distribution of employment status. In neither case, however, does the L statistic fall below the χ^2 critical value at a 5 % of significance.

Individuals do not, however, decide directly on their unconditional employment status. They make choices on their next employment status conditional on their current employment status. Table 6.4 and Table 6.5 show the transitions from each employment status for both race groups. Unemployed individuals, who receive a job offer, decide between staying unemployed and becoming employed. This is shown on the left hand side of the tables. For both groups the χ^2 statistics for choices over time are significant at the 5% level for all years, except for years 7 and 10. For whites the statistics are only significant for years 3 and 4.

The panel on the right in the table shows the transitions from employment to unemployment, to the same employer and to a new employer. For blacks, the null hypothesis is clearly rejected for all ten years after graduation. For whites, the null hypothesis is not rejected for years five, eight, nine and ten. The χ^2 statistics for columns are presented in the last row of the tables. They show the inability of the model to mimic the employment choices over time, except for the unemployment rate for blacks. The common problem in both race groups is that the model generates high permanence with the current employer and understates the transition to unemployment and to other employer.

Table 6.4: Baseline Model. Actual and Predicted Choice Distribution by Employment Transitions by Year after Graduation: Blacks

Years after Grad	Unemployed					Employed						
	Un employed		Employed		χ^2 (row)	Un employed		Same employer		New employer		χ^2 (row)
	A	P	A	P		A	P	A	P	A	P	
1	72.33	74.48	27.67	25.52	2.10*	24.32	13.95	58.38	74.74	17.30	11.32	77.36
2	77.63	74.65	22.37	25.35	2.01*	19.90	8.49	65.09	81.92	15.01	9.59	179.70
3	77.26	76.68	22.74	23.32	0.06*	14.81	8.75	71.91	82.71	13.28	8.54	78.40
4	79.11	74.42	20.89	25.58	3.42*	11.19	8.92	73.99	84.39	14.83	6.69	128.62
5	80.39	76.03	19.61	23.97	3.13*	10.64	8.56	77.59	83.08	11.76	8.36	22.76
6	78.21	74.26	21.79	25.74	2.27*	9.24	7.69	78.52	84.72	12.24	7.59	37.71
7	80.34	74.81	19.66	25.19	4.18	8.33	7.98	78.49	85.62	13.17	6.41	83.30
8	77.54	75.05	22.46	24.95	0.86*	9.61	7.57	79.21	86.01	11.18	6.42	47.32
9	78.82	75.10	21.18	24.90	1.95*	10.66	9.02	77.73	83.56	11.61	7.42	30.64
10	81.65	76.06	18.35	23.94	4.33	7.15	8.12	78.97	85.10	13.88	6.79	79.43
Total	77.60	75.05	22.40	24.95	12.07	11.78	8.57	75.06	83.78	13.17	7.65	609.33
χ^2 (col)	9.07*		27.32			291.23		154.40		928.94		

Note: A=actual; P=predicted.

Critical values: $\chi^2_{(1)}(.05) = 3.84$, $\chi^2_{(2)}(.05) = 5.99$, $\chi^2_{(9)}(.05) = 16.92$.

*** denotes that actual and predicted rates are statistically equal.

Table 6.5: Baseline Model. Actual and Predicted Choice Distribution by Employment Transitions by Year after Graduation: Whites

Years after Grad	Unemployed					Employed						
	Un employed		Employed		χ^2 (row)	Un employed		Same employer		New employer		χ^2 (row)
	A	P	A	P		A	P	A	P	A	P	
1	55.25	70.14	44.75	29.86	104.24	14.73	10.67	69.37	78.20	15.91	11.13	42.47
2	64.76	71.06	35.24	28.94	7.64	12.24	5.67	73.08	84.73	14.67	9.59	136.02
3	66.38	71.37	33.62	28.63	3.12*	10.01	5.72	77.76	86.11	12.23	8.16	76.40
4	66.98	70.51	33.02	29.49	1.41*	8.92	6.12	79.78	87.09	11.31	6.78	64.65
5	64.94	71.64	35.06	28.36	5.16	6.47	5.29	84.34	86.64	9.19	8.08	5.93*
6	64.35	71.52	35.65	28.48	5.68	6.95	5.26	83.45	87.54	9.61	7.20	19.58
7	56.35	71.31	43.65	28.69	23.24	6.10	5.12	85.04	88.36	8.86	6.52	15.01
8	63.40	72.89	36.60	27.11	9.16	5.11	4.77	87.83	89.31	7.06	5.92	3.47*
9	61.64	69.66	38.36	30.34	5.84	5.88	5.75	87.19	87.42	6.93	6.83	0.06*
10	61.49	69.30	38.51	30.70	5.72	5.42	5.73	88.52	88.24	6.06	6.03	0.19*
Total	61.73	70.77	38.27	29.23	121.67	7.84	5.71	82.28	86.93	9.88	7.36	230.58
χ^2 (col)	85.97		206.91			237.55		69.75		287.07		

Note: A=actual; P=predicted. $\chi^2_{(1)}(.05) = 3.84$, $\chi^2_{(2)}(.05) = 5.99$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

Table 6.6 and Table 6.7 show the yearly asset distribution for blacks and for whites, respectively. Given that asset holdings are a continuous variable, the distributions are presented, as in Table 1.1, in the form of asset brackets. These brackets are also used to build the χ^2 statistic for each year after graduation and for each bracket. As detailed in Chapter 5, in the computation of the model assets have been discretized into 51 intervals from \$-5,500 to \$45,000. These asset brackets are basically a contracted version of this discretization of the state space.

Judging from the χ^2 test, the model is able to mimic the asset distribution at the first two years after graduation for blacks and at the first year after graduation for whites. For these years, the hypothesis that actual and predicted asset levels come the same distribution cannot be rejected. For all other years after graduation for both race groups, the χ^2 coefficients are not significant. This suggests that the log-normal initial asset distribution assumed in the estimation represents a fairly good approximation to the actual initial distribution of assets. The discrepancy in the later years shows that the model does not produce enough asset accumulation and more fluctuations. As mentioned above, people only save in this model to protect themselves from layoffs and from having to accept lower wages. The interest rate and the subjective discount rate tend to be overestimated in that they are capturing the effect of other reasons for people to save. Similarly, arrival rates, wage draws and measurement errors are the only source of randomness in this model. It is not

Table 6.6: Baseline Model. Actual and Predicted Choice Distribution for Assets by Year after Graduation: Blacks

Years after Grad	Asset Brackets										χ^2 (row)	Average		Obs
	$A_{it} \leq 0$		$0 < A_{it} \leq 10000$		$10000 < A_{it} \leq 20000$		$20000 < A_{it} \leq 30000$		$A_{it} > 30000$			A	P	
	A	P	A	P	A	P	A	P	A	P				
1	58.33	48.92	41.67	41.67	.00	8.97	.00	.40	.00	.03	2.69*	476	826	24
2	42.11	47.38	57.89	43.35	.00	8.75	.00	.53	.00	.00	8.40*	1097	1031	57
3	50.85	44.67	46.61	43.92	.85	10.72	.85	.68	.85	.00	11.99	1521	1610	118
4	41.73	41.45	53.96	45.30	2.16	12.28	.00	.97	2.16	.00	15.25	1973	2286	139
5	33.94	38.90	61.21	46.67	3.64	13.12	1.21	1.23	.00	.07	19.96	2021	2646	165
6	37.36	38.48	52.20	45.88	6.59	13.88	1.65	1.65	2.20	.12	71.16	4339	2898	182
7	35.00	36.75	54.00	46.10	4.00	15.20	2.50	1.68	4.50	.28	150.01	4535	3340	200
8	37.69	34.58	48.74	47.23	3.52	16.27	4.02	1.75	6.03	.17	416.26	5233	3666	199
9	40.00	33.33	49.00	48.52	4.50	16.18	3.50	1.73	3.00	.25	83.69	4219	3846	200
10	42.86	31.80	45.81	48.33	6.40	18.07	.99	1.62	3.94	.17	188.39	4497	4135	203
Total	39.81	39.62	51.45	45.70	3.97	13.35	1.88	1.22	2.89	.11	1160.09	3602	2629	1487
$\chi^2(\text{col})$	14.10*		28.16		214.28		17.95		1853.40					

Note: A_{it} = Assets of individual i at year t .

A=actual; P=predicted.

Critical values: $\chi^2_{(4)}(.05) = 9.49$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

Table 6.7: Baseline Model. Actual and Predicted Choice Distribution for Assets by Year after Graduation: Whites

Years after Grad	Asset Brackets										χ^2 (row)	Average		Obs
	$A_{it} \leq 0$		$0 < A_{it} \leq 10000$		$10000 < A_{it} \leq 20000$		$20000 < A_{it} \leq 30000$		$A_{it} > 30000$			A	P	
	A	P	A	P	A	P	A	P	A	P				
1	38.10	39.75	47.62	27.35	4.76	17.30	4.76	10.55	4.76	5.05	5.75*	3071	5381	21
2	38.64	40.15	52.27	30.30	6.82	18.48	.00	7.62	2.27	3.45	13.80	3047	4249	44
3	12.00	39.15	71.00	30.85	9.00	20.07	4.00	7.53	4.00	2.40	79.91	6627	4156	100
4	17.76	37.58	63.82	31.98	8.55	21.43	6.58	7.33	3.29	1.70	78.20	7818	4452	152
5	23.72	37.23	53.95	32.40	10.23	21.12	5.58	7.25	6.51	2.00	76.14	10107	4490	215
6	16.23	37.75	51.32	31.88	16.67	20.55	6.14	7.88	9.65	1.95	126.86	13448	4442	228
7	20.15	36.92	50.95	31.65	15.59	21.48	4.18	7.72	9.13	2.23	115.79	13757	4790	263
8	18.06	36.05	50.66	32.02	11.89	22.62	6.61	7.40	12.78	1.90	198.04	12284	5010	227
9	21.33	34.90	38.67	33.83	16.00	21.35	8.44	7.88	15.56	2.05	216.73	19757	5095	225
10	17.23	34.20	39.92	32.83	15.55	23.23	6.72	7.80	20.59	1.95	454.08	37315	5404	238
Total	19.56	37.37	50.50	31.51	13.25	20.76	5.95	7.89	10.74	2.47	871.42	15774	4747	1713
χ^2 (col)	291.01		425.29		108.16		20.57		1391.71					

Note: A_{it} = Assets of individual i at year t .

A=actual; P=predicted.

Critical values: $\chi^2_{(4)}(.05) = 9.49$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

to be expected that fluctuations in assets can be replicated in this environment. A taste or an interest rate shock in the theoretical model may be able to account for fluctuations in assets.

For blacks, it can not be rejected that the predicted distribution of choosing the asset bracket of people with debt or no assets coincides with the corresponding actual distribution. For whites, this hypothesis is rejected. These results should be interpreted with caution. As shown in Table 1.1, in the actual distribution of assets there is an important mass of people which report zero assets. The model understates this proportion and overstates the proportion of people with debt, implying that the composition of the first bracket is different in the model and in the data. People may misreport their true level of assets if they have debt or if their level of assets is very low. The model can generate a higher proportion of people with zero assets if at least some people are assumed to be unable to borrow at all.

The second asset bracket corresponds to people with positive assets below \$10,000 worth. The χ^2 value for this bracket, presented in the last row is not significant. It is, however, noteworthy that ten years after graduation the model generates a similar proportion of people in this bracket. For blacks, the actual proportion of people with positive assets less than \$10,000 is 46%, while the predicted proportion is 48%. For whites, the corresponding actual proportion is 40% and the predicted one is 33%.

The model overpredicts the proportion of people at higher levels of assets for both race groups. The χ^2 test rejects the hypothesis that the actual and the predicted brackets came from the same probability distribution.

Table 6.8 and Table 6.9 show the actual and the predicted accepted wage distributions. The wage brackets are the same as those in Table 4.3. The criterion for choosing these brackets is the same as the one used for the asset brackets. These brackets are a short version of the discretized wage variable used for the model and for the estimation. As seen in the graphical comparisons, the model can replicate the trend of increasing average wages. It is, however, clear that the model is not producing enough people with low wages, especially in the estimation of black individuals. The data show that more than 32% of blacks and 23% of whites earn less than \$2,000 in their first year after graduation. The model predicts that these proportions are 13% and 8%, respectively. After 10 years these proportions decrease respectively to 11% and to 3% in the data, whereas the model generates 8% and 3%. Thus, the underprediction diminishes over time and practically disappears for whites, while it remains important for blacks. These results are linked to the fact that transfers while unemployed, b in the model, are \$1960 for blacks and \$2124 for whites. This means that the first wage bracket in the model is practically generated by the measurement error. In addition, the model generates too much stability for the employed. Once people are employed their transition to unemployment is less

Table 6.8: Baseline Model. Actual and Predicted Choice Distribution for Wages by Year after Graduation: Blacks

Years after Grad	Wage Brackets								χ^2 (row)	Average		Obs
	$w_{it} \leq 2000$		$2000 < w_{it} \leq 3000$		$3000 < w_{it} \leq 4000$		$w_{it} > 4000$			A	P	
	A	P	A	P	A	P	A	P				
1	31.83	12.74	59.57	71.36	6.02	14.20	2.58	1.69	166.08	2615	3053	465
2	22.63	10.87	64.21	70.13	10.18	16.49	2.98	2.51	89.68	2978	3174	570
3	20.63	7.99	62.66	69.79	14.06	18.20	2.66	4.01	141.39	3153	3352	640
4	21.40	7.19	58.52	68.43	16.59	20.19	3.49	4.19	207.87	3101	3400	687
5	15.42	6.71	60.06	66.63	19.97	22.06	4.55	4.60	82.81	3308	3491	681
6	14.61	7.15	60.76	66.09	17.59	22.15	7.04	4.60	77.17	3444	3487	739
7	13.70	6.85	59.59	67.79	19.73	20.90	6.99	4.46	68.25	3490	3460	730
8	12.79	6.46	60.80	67.26	17.19	21.92	9.22	4.36	96.19	3565	3480	727
9	12.41	7.15	59.94	65.48	17.91	22.74	9.73	4.63	78.00	3535	3496	709
10	11.39	7.23	62.04	66.77	17.66	21.70	8.91	4.30	57.55	3513	3457	685
Total	17.01	7.79	60.77	67.79	16.18	20.37	6.05	4.05	893.64	3303	3402	6633
$\chi^2(\text{col})$	1522.82		99.63		131.88		204.31					

Note: w_{it} = wage of individual i at year t .

A=actual; P=predicted.

Critical values: $\chi^2_{(3)}(.05) = 7.82$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

Table 6.9: Baseline Model. Actual and Predicted Choice Distribution for Wages by Year after Graduation: Whites

Years after Grad	Wage Brackets								χ^2 (row)	Average		Obs
	$w_{it} \leq 2000$		$2000 < w_{it} \leq 3000$		$3000 < w_{it} \leq 4000$		$w_{it} > 4000$			A	P	
	A	P	A	P	A	P	A	P				
1	22.86	7.68	60.88	63.59	11.98	23.18	4.28	5.56	293.28	2981	3582	818
2	15.59	5.33	62.37	59.73	15.70	27.39	6.34	7.55	241.24	3249	3788	962
3	15.15	4.45	58.62	56.04	18.74	28.51	7.48	11.00	303.95	3451	4000	1003
4	13.46	3.58	54.23	55.34	23.27	28.45	9.04	12.63	304.48	3616	4096	1040
5	8.89	3.77	53.89	51.70	24.81	31.07	12.41	13.46	90.65	3912	4202	1080
6	9.88	3.57	46.87	50.40	28.65	32.26	14.60	13.76	130.51	4353	4233	1103
7	8.36	3.08	43.42	51.18	32.56	32.08	15.66	13.66	118.82	4469	4229	1124
8	8.92	3.33	42.93	49.51	30.12	32.59	18.02	14.57	127.81	4531	4284	1132
9	6.83	3.57	37.55	48.22	36.07	32.33	19.56	15.89	71.80	4651	4349	1084
10	3.24	3.32	37.20	50.04	38.34	32.15	21.22	14.49	80.11	4753	4291	1051
Total	10.94	4.00	49.25	53.07	26.58	30.33	13.22	12.60	1328.71	4040	4132	10397
$\chi^2(\text{col})$	2665.50		119.07		221.31		85.48					

Note: w_{it} = wage of individual i at year t .

A=actual; P=predicted.

Critical values: $\chi^2_{(3)}(.05) = 7.82$, $\chi^2_{(9)}(.05) = 16.92$.

“**” denotes that actual and predicted rates are statistically equal.

frequent than in the actual data. This understates the number of unemployed people, who are more inclined to accept low paid jobs and become part of the low wage bracket.

On the other hand, the model does not produce enough people in the high wage bracket either. This problem is especially severe for whites, for which the model predicts that 15% of workers earn more than \$4,000 ten years after graduation, while there are actually 21% in that segment. For this group, this underestimation of the high level of wages is reflected well in the average wages over time. In general, the model overpredicts wages at the beginning of the employment career and underpredicts them ten years later. As discussed in Section 6.2.1, in this baseline model on-the-job search alone is responsible for all wage increases. Without wage growth as a function of work experience in the theoretical model, in the estimation those people who stay at the same job and experience wage growth show an increase in their measurement error in wages.

Considering the simplicity of the model and the different variables it is trying to approximate, it is delivering a fairly good approximation to the actual data. It must be noted that the aim of the estimation has been to provide a first confrontation of this model to actual data. This is the simplest possible search model with asset accumulation, so the results can be taken to suggest the areas where extensions are needed or different ways of accounting for initial conditions have to be introduced.

In this estimation I have assumed homogeneous individuals. It is, however, possible that this assumption means the omission of relevant unobserved variables. The introduction of heterogeneity can significantly change the parameters estimates and allow a better fit of the data.

Chapter 7

Estimation Results: Extended

Model

This chapter presents the results of estimating the model with endogenous work experience and heterogeneity in the wage offer distribution, arrival rates, and the initial asset distribution. Section 7.1 presents the parameter estimates of this extended model. Section 7.2 discusses the accuracy of the model by comparing the graphs of the actual and the predicted variables and performing goodness of fit tests.

7.1 Parameter Estimates

Within each race group, I assume two types of individuals which share all parameters with the exception their wage offer distribution, arrival rates, and initial asset distribution. Although heterogeneity can arise in all parameters of the model, it will be restricted in this estimation to those parameters that represent initial conditions and the labor market environment. Since the number of parameter has increased, I divide them in common and type-dependent parameters, and report them in two different tables.

Table 7.1 presents the common parameter estimates for the two types within each race group and their corresponding standard errors. These are the parameters of the wage equation, α_1 and α_2 , transfers while unemployed, the rate of rate of return, the discount factor, the coefficient of risk aversion, and the standard deviations of the measurement errors of assets and log-wages.

An important extension of the basic model is that wage increases while working for the same employer are accounted for in the wage equation. On-the-job wage increases are found to be important. 40 quarters after graduation blacks will experience a wage increase of 24% with respect to their first wage. The corresponding increase for whites is 44%. In the theoretical model these increases are related to other variables. In particular, wage growth diminishes the incentive for on-the-job search and for asset accumulation noticeably. In the basic model, the only way for

Table 7.1: Common Parameter Estimates for the Extended Model

Parameters	Blacks Estimates	Whites Estimates
$\alpha_1 \times 10^3$	5.624093 (0.02803)	9.221371 (0.06379)
$\alpha_2 \times 10^4$	-0.086034 (0.0062)	-0.041327 (3.1625)
b	1659.936 (3.2840)	1591.686 (2.8550)
r	0.092348 (0.013866)	0.099382 (0.00232)
β	0.995184 (0.012601)	0.993550 (0.00169)
γ	1.300039 (0.033484)	1.199317 (0.06040)
σ_A	4675.342 (49.17646)	12108.419921 (380.65684)
σ_w	0.275595 (0.001507)	0.341491 (0.001248)
$\log \mathcal{L}$	-30,335.01	-43,670.01
Individuals	312	374

Note: Asymptotic standard errors are in parentheses.

an individual to increase wages is to move the better paid jobs. In this extended model, an individual can just wait to accumulate work experience and enjoy the corresponding wage increases. Similarly, the need for asset accumulation, as discussed in Section 5.2, is undermined. The individual can consume more now on account of the augmented future expected income generated by wage growth. This extensions implies that in the estimation, other parameters suffer substantial variations to compensate for these effects. Given the observed data, other parameters will change to generate more on-the-job search and more asset accumulation.

Transfers while unemployed have lower values than those reported in Table 6.1 for the basic model. As discussed below, wage growth also pushes down the wage offer distributions, which determine the opportunity cost of being unemployed. The transfers people receive while unemployed are also reduced to match this change. This means that unemployment is relatively more attractive at the beginning of the employment career, when wage offers are relatively low, than years later, when individuals have already accumulated work experience and wage offers are higher. It is to be expected that as a consequence of wage growth people tend to stay longer in their current jobs at later years of their careers.

Two parameters that change to generate more asset accumulation are the rate of return and the coefficient of risk aversion. Compared with their values in the baseline estimation, the rate of return increases both for whites and for blacks, while

the coefficient of risk aversion shows a notable decrease. Asset accumulation is then clearly induced by the higher rate of return and by the lower risk aversion. Whites, who have important increases in wages, have a bigger increase in the rate of return and a bigger decrease in the coefficient of risk aversion than blacks. The subjective discount factor increases for whites, which also boosts savings. The change is not meaningful for blacks, though.

The standard deviations of the measurement errors are still relatively big, when compared with those obtained from the basic model. This is explained by the noisy data, especially for assets. The asymptotic standard errors for most of these parameters are very small. Parameter α_2 for whites, which means decreasing wage increases as a function of cumulative work experience, presents a high standard error. This can show a problem of identification for this component of the wage equation.

Table 7.2 reports the type-dependent maximum likelihood estimates and their corresponding standard errors for both race groups. For blacks, Type 1 represents 31% of the sample; for whites, it corresponds to 22% of the sample. The parameter estimates shown in this table convey information about the labor market environment and about the initial asset distribution.

As mentioned above, the introduction of wage growth pushes down the mean of the log-wage offer distribution for both blacks and whites. Consequently, they

Table 7.2: Type-dependent Parameter Estimates for the Extended Model

Parameters	Blacks Estimates		Whites Estimates	
	Type 1	Type 2	Type 1	Type 2
μ	6.118 (0.206)	7.004 (0.020)	6.750 (0.052)	7.114 (0.126)
σ	0.590 (0.025)	0.612 (0.007)	0.545 (0.014)	0.610 (0.173)
λ_u	0.665 (0.080)	0.688 (0.042)	0.791 (0.013)	0.906 (0.025)
λ_e	0.504 (0.107)	0.601 (0.012)	0.644 (0.005)	0.570 (0.004)
θ	0.160 (0.011)	0.121 (0.003)	0.134 (0.016)	0.085 (0.002)
μ_0	7.611 (0.411)	9.342 (0.116)	7.753 (2.326)	9.814 (0.126)
σ_0	0.326 (0.434)	0.396 (0.056)	0.363 (1.675)	0.307 (0.173)
p	0.306 (0.060)	0.694 [†]	0.219 (0.057)	0.781 [†]
$\log \mathcal{L}$	-30,335.01		-43,670.01	
Individuals	312		374	

Note: Asymptotic standard errors are in parentheses.

should be compared cautiously with the values reported in Table ?? of the basic model. These parameters, namely μ and σ , refer now to initial wage draws rather than to current wage offers.

As in the first estimation, the wage offer distribution of whites dominates the one of blacks. The values of μ , exhibit substantial differences over race groups. For Type 1, the value is 6.118 for blacks and 6.750 for whites. For Type 2, it is 7.004 and 7.114, respectively. This dominance is even bigger, because there is a higher proportion of whites of Type 2 than of blacks of Type 2.¹ The dispersion of wage offers, expressed in the σ 's is similar for both race groups. They are also clearly bigger than the corresponding values in the stripped-down model. This increase is also related to the introduction of wage growth in the theoretical model. Since wage increases are guaranteed to the individual, his incentives for on-the-job search are reduced. To stimulate turnover, the estimation compensates for this by increasing the variance of the wage offer distribution.

The arrival rates also depict a better labor market for whites. While the probabilities of getting a wage offer while unemployed for whites of both types are higher than those for blacks, the layoff rates of blacks are higher than those of whites. The probabilities of getting an offer while employed are higher than the corresponding

¹Comparing parameters of the "same type" across race groups gives a rough idea about the differences in labor market environment and initial asset distribution over race groups. Since the proportion of types is different for each race group, this comparison should be made with caution.

values in the basic estimation. It is not clear, however, for which race group these arrival rates are larger.

Layoff rates are significantly high for both groups and types. They are 15% for Type 1 and 12% for Type 2 of blacks. For whites, they are 13% and 8.5%, respectively. The reason for their high values is that the layoff rate is crucially related to asset accumulation. This is a variable which is also affected by the introduction of cumulative working experience. It increases to generate more turnover and more asset accumulation.

The distribution of initial assets of whites dominates that of blacks. While the standard deviations do not exhibit substantial differences across race groups, the medians of initial assets of whites for both types are clearly bigger than those of blacks. It is, however, noteworthy that the asymptotic standard errors for both race groups are relatively high, especially those of the standard deviation of log-assets. This suggests a problem of identification for these parameters. As explained in Chapter 5, the identification of the parameterized initial asset distribution is determined by the asset observations, especially those in the first few years after graduation. Since asset data are only available since 1985, there are not many of these observations.

The distribution of initial assets of Type 2 dominates the one of Type 1 for both race groups. Since Type 1 has worse conditions both in terms of initial assets and

labor market conditions for both race groups, it can be called the type of the “poor.” There is a higher proportion of this type among blacks than among whites. The introduction of heterogeneity has the consequence of improving the goodness of fit of the model, as it will be clear in the next section. It will be also clear that it weakens the relationship between asset accumulation and job acceptance decisions.

7.2 Accuracy of the Model

This section evaluates if the predictions based on the estimated parameters mimic the actual data. As in the previous chapter, I generate simulated career paths for 1000 individuals using the policy rules implied by the parameter estimates and build predicted choice distributions. Subsection 7.2.1 presents graphical comparisons of the predicted and the observed averages for the employment status, employment transitions, assets and wages. Subsection 7.2.2 shows formal goodness of fit tests.

7.2.1 Graphical Comparisons

Figure 7.1 displays the paths for actual and predicted employment states, wages and assets. Compared with the graphical comparison of the previous chapter, the predicted trajectories show, in general, a closer replication of the observed ones. The model’s predicted paths for the unemployment rate not only converge to the

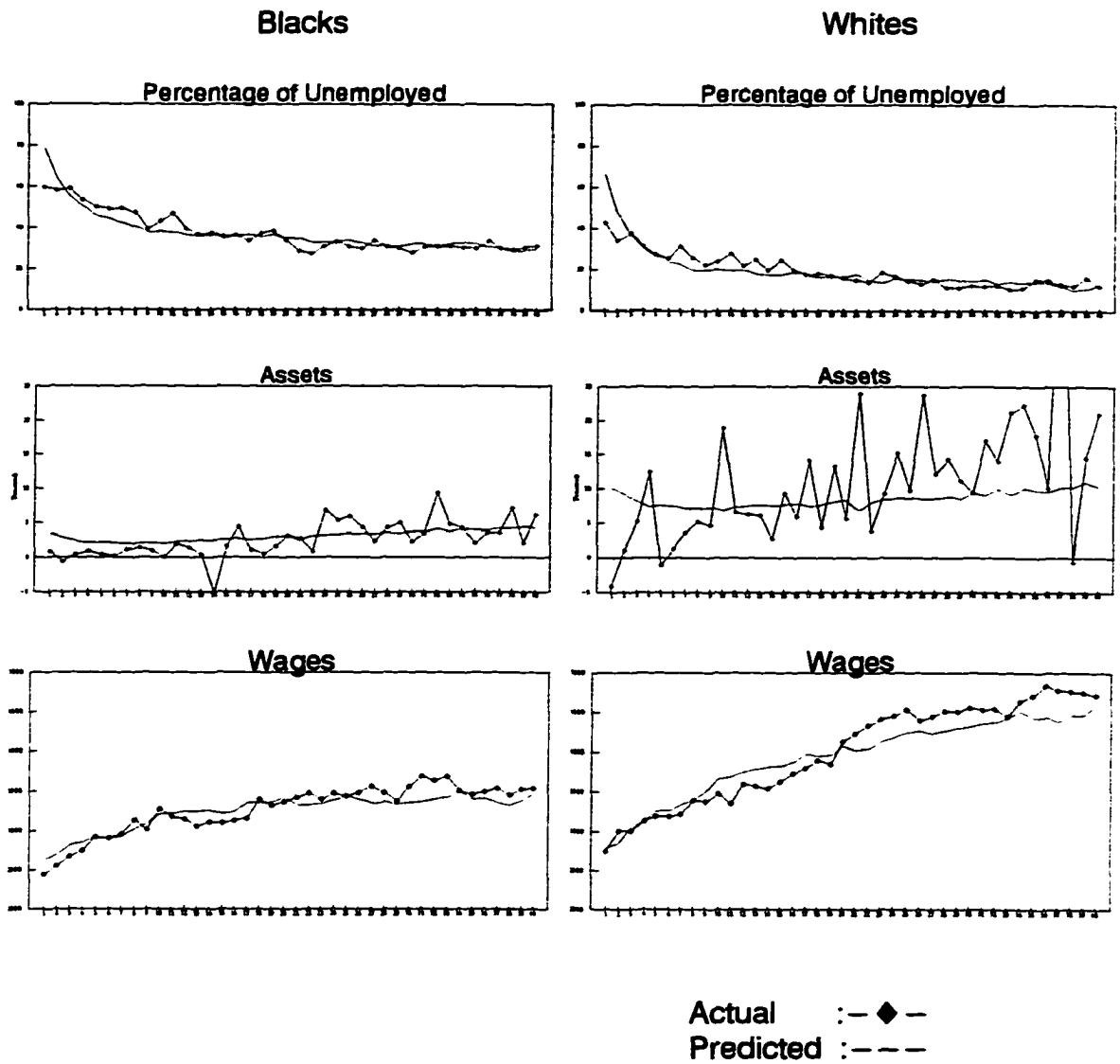


Figure 7.1: Actual and Predicted Variables. Unemployed, Assets, and Wages by Quarter after Graduation. Extended Model

actual ones over time; they also follow them closely from the start of the employment career. The overprediction of the unemployment rate during the first few years after leaving school shows a sizable reduction for both blacks and whites. It is still the case that for both groups the predicted unemployment rate goes down faster than the actual one.

As in the basic estimation, the basic trends in the evolution of assets are replicated. Compared with the first estimation, there are some parameters, like those of the wage equation, which diminish asset accumulation, but there are others, notably the rate of return, the coefficient of risk aversion and the layoff rate, which work in the opposite direction. In the graph, predicted asset holdings for blacks and whites show an increase, which means that the latter effect predominates. Despite this increase, the underprediction of whites' average assets remains in this estimation. Similarly asset fluctuations in the observed data are not reproduced. As with the basic model, without additional sources of randomness, these fluctuations cannot be replicated.

The introduction of on-the-job wage growth and heterogeneity improves the replication of the actual trajectory of average wages over time. Now, actual and predicted average wages show very similar paths. The overprediction of wages at the beginning of the employment career has disappeared for both race groups. The pattern of wage growth is also reproduced closely. For whites, the predicted average

wage shows a higher increase than the actual one before quarter 20 after graduation. After this quarter, the predicted average wage is slightly smaller than the actual one. It is clear that the trajectory of wages is steeper for whites than for blacks, both in the actual and in the predicted wage path.

Figure 7.2 presents employment transitions by quarter after graduation for both race groups. The predicted choices follow the actual ones very closely. The model-predicted rates of transition from unemployment to employment follow the actual rates closely. The predicted rates of transition from employment to unemployment at the beginning of the employment career are still higher than the actual transitions. This overprediction is, however, smaller than in the previous estimation. Similar features are exhibited by the rates of transition of people who change employers, where the underprediction is importantly reduced. As in the estimation of the baseline model, these figures show that predicted employment transitions are clearly more stable than than the actual ones. The erratic percentage of employed blacks who change employer in the actual data is not captured by the model. This extended model decreases the high stability in the current job produced by the basic model. This model is able to mimic the rates of turnover observed in the data, but, as with assets, it cannot account for big fluctuations in switches to new employers.

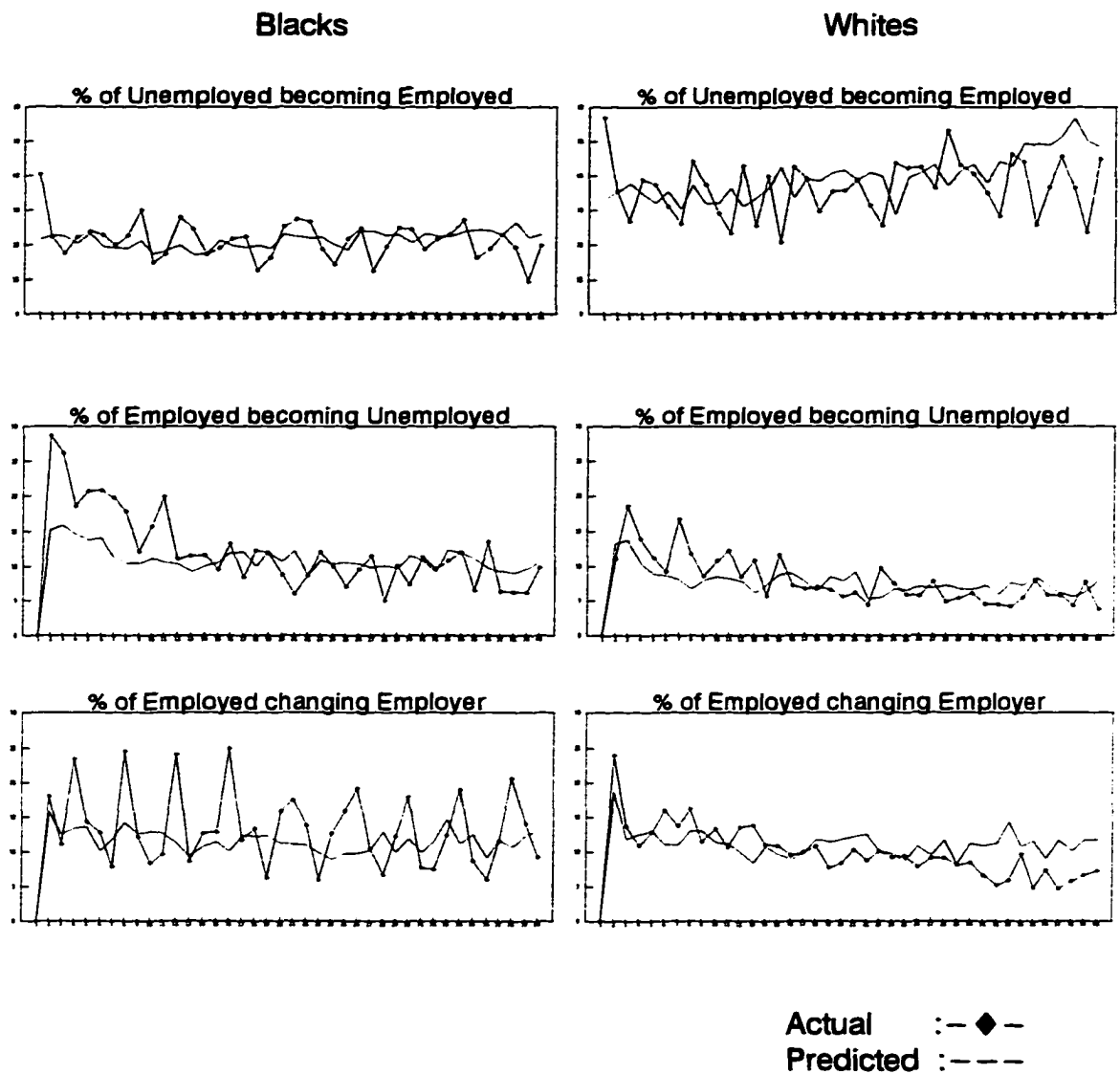


Figure 7.2: Actual and Predicted Variables. Employment Transitions by Quarter after Graduation. Extended Model

7.2.2 Goodness of Fit Tests

I use the test statistics of Equation 6.1 and Equation 6.2 to evaluate the success of the model in fitting the data. The actual and the predicted percentage of unemployment and employment by year after graduation are compared in Table 7.3 and Table 7.4 for blacks and for whites, respectively. In the sixth row these tables report χ^2 tests for employment status at each year after graduation. The last row presents χ^2 tests for each employment state for the whole time period. For the entire populations, the χ^2 statistic is 1.07 for blacks and 2.06 for whites. They are below the critical value, $\chi^2_{(1)}(0.05) = 3.84$, which means that the hypothesis that the observed and predicted probabilities came from the same distribution is not rejected at the 5% significance. This is a clear improvement with respect to same test done with the basic model.

Values of period-by-period statistics are also smaller in general than in the stripped-down estimation. Only in the three first years and in the sixth year after graduation χ^2 statistics fall below the critical value for blacks. For whites, the first years after graduation exhibit a bigger distance between the predicted and actual unemployment rates. The predictions of the model are more accurate in later years after graduation, which do not reject the null hypothesis that the predicted and the actual probability distributions are the same. As in the graphical comparisons and in the basic estimation, the distances between the model and the data for both

Table 7.3: Extended Model. Actual and Predicted Choice Distribution for Employment by Year after Graduation: Blacks

Years after Grad	Unemployed		Employed		χ^2 (row)	Obs
	A	P	A	P		
1	57.67	62.08	42.33	37.92	10.58	1212
2	48.91	43.12	51.09	56.88	16.26	1192
3	42.42	37.67	57.58	62.33	10.85	1174
4	36.55	35.95	63.45	64.05	.30*	1141
5	36.01	36.08	63.99	63.92	.00*	1122
6	30.19	33.58	69.81	66.43	5.97	1103
7	31.42	32.40	68.58	67.60	.48*	1095
8	29.86	31.65	70.14	68.35	1.60*	1085
9	31.36	32.12	68.64	67.88	.29*	1062
10	30.34	29.42	69.66	70.57	.40*	1012
Total	37.88	37.41	62.12	62.59	1.07*	11204
χ^2 (column)	26.75		21.05			

Note: A=actual; P=predicted.

Critical values: $\chi^2_{(1)}(.05) = 3.84$, $\chi^2_{(9)}(.05) = 16.92$.

"*" denotes that actual and predicted rates are statistically equal.

Table 7.4: Extended Model. Actual and Predicted Choice Distribution for Employment by Year after Graduation: Whites

Years after Grad	Unemployed		Employed		χ^2 (row)	Obs
	A	P	A	P		
1	36.53	45.45	63.47	54.55	47.17	1470
2	27.47	23.15	72.53	76.85	15.18	1449
3	23.94	19.65	76.06	80.35	16.67	1433
4	22.14	17.90	77.86	82.10	17.26	1409
5	17.00	16.65	83.00	83.35	.12*	1394
6	15.92	15.38	84.08	84.62	.31*	1382
7	13.38	14.80	86.62	85.20	2.17*	1360
8	11.82	14.20	88.18	85.80	6.16	1328
9	12.70	13.77	87.30	86.22	1.26*	1299
10	13.14	11.30	86.86	88.70	4.28	1263
Total	19.71	19.23	80.29	80.78	2.06*	13787
χ^2 (column)	79.02		33.64			

Note: A=actual; P=predicted.

Critical values: $\chi^2_{(1)}(.05) = 3.84$, $\chi^2_{(9)}(.05) = 16.92$.

"*" denotes that actual and predicted rates are statistically equal.

groups are larger when people start off their employment careers. Unlike the basic estimation, however, the χ^2 statistic falls below the critical value at a 5% level of significance. The χ^2 tests for each employment status over time is not significant at the 5% significance level.

Table 7.5 and Table 7.6 present the distribution of transitions from each employment status for each race group. The transitions for unemployed individuals, staying unemployed and becoming employed, are reported on the left hand side of each table. For both groups the χ^2 statistics for choices over time are significant at the 5% level for all years, except for years 1, 3 and 10 for blacks and for years 1, 9 and 10 for whites. For the entire period, the χ^2 statistic for blacks is 3.32 which falls below the critical value at the 5% significance level. The corresponding value for whites is 0.24, which is also significant.

The panel on the right in the tables shows the transitions of the people who are currently employed: they can become unemployed, stay in the job or switch to another job. Although the χ^2 statistics exhibit in general lower values than in the stripped-down results, they are still not significant for most of the years for both groups. Unlike the basic estimation where none of the test statistics is significant for blacks, the null hypothesis that the predicted and actual distribution of blacks' transitions coincide is not rejected for years 5, 8 and 9. It cannot be rejected for years 6 and 7 for whites.

Table 7.5: Extended Model. Actual and Predicted Choice Distribution by Employment Transitions by Year after Graduation: Blacks

Years after Grad	Unemployed					Employed						
	Un employed		Employed		χ^2 (row)	Un employed		Same employer		New employer		χ^2 (row)
	A	P	A	P		A	P	A	P	A	P	
1	72.33	78.20	27.67	21.80	19.76	24.32	15.15	58.38	71.26	17.30	13.59	38.97
2	77.63	79.72	22.37	20.28	1.42*	19.90	12.30	65.09	75.26	15.01	12.44	43.38
3	77.26	80.87	22.74	19.13	4.22	14.81	10.58	71.91	77.10	13.28	12.33	15.60
4	79.11	81.11	20.89	18.89	.88*	11.19	10.41	73.99	79.18	14.83	10.41	24.63
5	80.39	79.77	19.61	20.23	.21*	10.64	11.15	77.59	76.84	11.76	12.01	.53*
6	78.21	78.46	21.79	21.54	.02*	9.24	10.45	78.52	79.36	12.24	10.19	6.19
7	80.34	77.74	19.66	22.26	1.41*	8.33	10.17	78.49	79.17	13.17	10.66	8.30
8	77.54	77.74	22.46	22.26	.01*	9.61	10.28	79.21	78.89	11.18	10.83	.57*
9	78.82	76.24	21.18	23.76	1.08*	10.66	11.17	77.73	76.95	11.61	11.87	.34*
10	81.65	76.33	18.35	23.67	5.06	7.15	9.63	78.97	78.42	13.88	11.94	7.76
Total	77.57	78.70	22.30	21.30	3.32*	11.78	10.83	75.06	77.69	13.17	11.48	39.63
χ^2 (col)	8.10*		29.31			74.59		27.66		83.64		

Note: A=actual; P=predicted.

Critical values: $\chi^2_{(1)}(.05) = 3.84$, $\chi^2_{(2)}(.05) = 5.99$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

Table 7.6: Extended Model. Actual and Predicted Choice Distribution by Employment Transitions by Year after Graduation: Whites

Years after Grad	Unemployed					Employed						
	Unemployed		Employed		χ^2 (row)	Unemployed		Same employer		New employer		χ^2 (row)
	A	P	A	P		A	P	A	P	A	P	
1	55.25	65.13	44.75	34.87	39.68	14.73	12.23	69.37	74.13	15.91	13.64	9.98
2	64.76	66.38	35.24	33.62	.44*	12.24	8.00	73.08	79.98	14.67	12.02	39.04
3	66.38	67.09	33.62	32.91	.06*	10.01	8.08	77.76	80.53	12.23	11.38	7.30
4	66.98	63.62	33.02	36.38	1.24*	8.92	7.81	79.78	82.76	11.31	9.43	8.29
5	64.94	60.03	35.06	39.97	2.43*	6.47	7.56	84.34	81.28	9.19	11.16	7.98
6	64.35	62.54	35.65	37.46	.30*	6.95	6.69	83.45	82.21	9.61	11.10	3.12*
7	56.35	59.83	43.65	40.17	1.02*	6.10	6.93	85.04	82.88	8.86	10.19	4.17*
8	63.40	58.26	36.60	41.74	2.11*	5.11	6.62	87.83	82.98	7.06	10.40	21.37
9	61.64	52.36	38.36	47.64	6.16	5.88	7.62	87.19	80.99	6.93	11.39	32.51
10	61.49	48.15	38.51	51.85	10.34	5.42	6.52	88.52	82.18	6.06	11.30	38.22
Total	61.73	62.16	38.27	37.84	.24*	7.84	7.53	82.28	81.42	9.88	11.05	19.44
χ^2 (col)	25.22		38.81			48.97		27.59		114.85		

Note: A=actual; P=predicted. $\chi^2_{(1)}(.05) = 3.84$, $\chi^2_{(2)}(.05) = 5.99$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

The χ^2 statistics for columns also show lower values than those of the basic estimation. Yet, they are still too high to reproduce the employment choices over time. In this estimation the model does not generate as much permanence at the current employer as in the first estimation. If anything, the model overstates the transition to unemployment ten years after graduation for both groups. It also overpredicts the rate of switches to work for a new employer at year ten after graduation.

Table 7.7 and Table 7.8 depict the asset distribution for blacks and for whites, respectively. As in the previous chapter, these distributions are presented in the form of asset brackets, which are also used to build the χ^2 statistic. This value is significant only for the first two years and sixth after graduation for blacks and for the first year after graduation for whites. This is similar to the results obtained in the stripped-down estimation. It is clear that the values of the χ^2 statistic decrease, but not enough to be significant.

As mentioned in the graphical comparisons, the model does not produce enough asset accumulation and fluctuations to mimic the actual asset distribution over time. The predicted asset distribution starts off with a higher mean and a greater dispersion than the actual one. Ten years after graduation the predicted asset distribution has a lower mean and is less dispersed than the actual data. During the first few years after graduation the model has a better fit. The initial asset

Table 7.7: Extended Model. Actual and Predicted Choice Distribution for Assets by Year after Graduation: Blacks

Years after Grad	Asset Brackets										χ^2 (row)	Average		Obs
	$A_{it} \leq 0$		$0 < A_{it} \leq 10000$		$10000 < A_{it} \leq 20000$		$20000 < A_{it} \leq 30000$		$A_{it} > 30000$			A	P	
	A	P	A	P	A	P	A	P	A	P				
1	58.33	41.02	41.67	43.75	.00	14.12	.00	1.07	.00	.03	5.43*	476	2667	24
2	42.11	42.35	57.89	47.12	.00	9.53	.00	.95	.00	.05	7.40*	1097	2065	57
3	50.85	41.73	46.61	47.60	.85	9.68	.85	.88	.85	.12	16.81	1521	2177	118
4	41.73	40.58	53.96	47.65	2.16	10.28	.00	1.18	2.16	.33	26.13	1973	2552	139
5	33.94	39.33	61.21	47.95	3.64	10.93	1.21	1.38	.00	.42	16.03	2021	2812	165
6	36.36	38.08	52.24	47.85	6.59	11.70	1.65	1.55	2.20	.82	9.34*	4339	3012	182
7	35.00	36.40	54.00	48.52	4.00	12.15	2.50	2.02	4.50	.90	41.81	4535	3432	200
8	37.69	35.50	49.74	48.83	3.52	12.60	4.02	2.17	6.03	.90	73.68	5233	3754	199
9	40.00	34.50	49.00	48.23	4.50	14.07	3.50	2.25	3.00	.95	24.86	4219	3955	200
10	42.86	33.20	45.81	48.88	6.40	14.57	.99	2.42	3.94	.93	36.25	4497	4257	203
Total	39.81	38.27	51.45	47.64	3.97	11.96	1.88	1.59	2.89	.55	236.67	3602	3068	1487
χ^2 (col)	12.73*		16.06*		163.08		9.12*		293.40					

Note: A_{it} == Assets of individual i at year t .

A=actual; P=predicted.

Critical values: $\chi^2_{(4)}(.05) = 9.49$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

Table 7.8: Extended Model. Actual and Predicted Choice Distribution for Assets by Year after Graduation: Whites

Years after Grad	Asset Brackets										χ^2 (row)	Average		Obs
	$A_{it} \leq 0$		$0 < A_{it} \leq 10000$		$10000 < A_{it} \leq 20000$		$20000 < A_{it} \leq 30000$		$A_{it} > 30000$			A	P	
	A	P	A	P	A	P	A	P	A	P				
1	38.10	29.57	47.62	25.65	4.76	23.68	4.76	14.00	4.76	7.10	9.08*	3071	8665	21
2	38.64	31.85	52.27	26.00	6.82	24.85	.00	11.97	2.27	5.33	24.11	3047	7326	44
3	12.00	31.93	71.00	27.30	9.00	23.70	4.00	12.03	4.00	5.05	97.08	6627	7214	100
4	17.76	31.43	63.82	26.88	8.55	23.15	6.58	13.22	3.29	5.33	106.46	7818	7652	152
5	23.72	30.68	53.95	27.50	10.23	23.55	5.58	12.68	6.51	5.60	83.15	10107	7856	215
6	16.23	31.45	51.32	26.12	16.67	23.60	6.14	12.28	9.65	6.55	87.16	13448	7964	228
7	20.15	29.95	50.95	26.57	15.59	23.73	4.18	12.55	9.13	7.20	90.60	13757	8658	263
8	18.06	27.48	50.66	27.50	11.89	23.60	6.61	13.95	12.78	7.47	82.08	12284	9237	227
9	21.33	26.55	38.67	27.68	16.00	24.05	8.44	13.60	15.56	8.12	37.88	19757	9641	225
10	17.23	25.48	39.92	26.25	15.55	23.68	6.72	15.60	20.59	9.00	77.47	37315	10423	238
Total	19.56	29.64	50.50	26.75	13.25	23.76	5.95	13.19	10.74	6.67	610.01	15774	8464	1713
$\chi^2(\text{col})$	125.93		764.01		165.68		140.33		109.12					

Note: A_{it} = Assets of individual i at year t .

A=actual; P=predicted.

Critical values: $\chi^2_{(4)}(.05) = 9.49$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

distribution, which does not come from the theoretical model accounts for this better fit.

The motivations for people to save in this extended model are more related to the high rate of return, the high layoff rate, the low coefficient of risk aversion. However, all these parameters cannot produce enough asset accumulation to mimic the data, especially for whites. For example, ten years after graduation, 21% of whites have more than \$30,000 of assets, while the model's prediction is 9%. It is not surprising, on the other hand, that the model fails to produce more fluctuations, because arrival rates, wage draws and measurement errors remain the only source of randomness.

For whites, significance test for the choice of assets over time is rejected at a significance level of 5%. The significance test cannot be rejected, however, for certain asset brackets for blacks. It can not be rejected that the predicted distribution of the asset bracket for people with debt or no assets, coincides with the corresponding actual distributions. Since the first asset bracket contains a mass of people which report zero assets, these results should be interpreted carefully. As in the stripped-down model, this estimation understates this proportion and overstates the proportion of people with debt or zero assets. The second asset bracket represents positive asset holdings below \$10,000. The χ^2 value for this bracket over time, presented in the last row is significant. The test for the bracket of assets between

\$20,000 and \$30,000 also cannot be rejected at a 5% level.

Table 7.9 and Table 7.10 show the actual and the predicted accepted wage distributions. As seen in the graphical comparisons, the model replicates average wages very closely. The χ^2 statistic of 2.60 is significant for blacks for the entire sample. None of the corresponding statistics over time for blacks are significant, though. For whites, although the predicted and the actual wage distributions for the entire period look alike, the χ^2 statistics fall below the critical value. The χ^2 statistics for year 1, 2, 4 and 5 are, however, significant.

The introduction of on-the-job wage growth and the increase of the dispersion in the initial wage offer distribution generates a higher percentage of people in the low wage bracket as well as in the high wage bracket, which were underpredicted in the stripped-down estimation.

These results show a closer approximation of the model to the actual data of employment status, assets and wages as compared to the basic model. This is clearly achieved by the introduction of new parameters and, consequently, of new effects in the model. The drawback of this extension, as will be clearer in the next chapter, is the weakening of the link between assets and employment transitions. By introducing two types, one of which has a better labor market environment and higher initial assets than the other, the positive correlation between these two variables is attained automatically, even if for each type this correlation does not

Table 7.9: Extended Model. Actual and Predicted Choice Distribution for Wages by Year after Graduation: Blacks

Years after Grad	Wage Brackets								χ^2 (row)	Average		Obs
	$w_{it} \leq 2000$		$2000 < w_{it} \leq 3000$		$3000 < w_{it} \leq 4000$		$w_{it} > 4000$			A	P	
	A	P	A	P	A	P	A	P				
1	31.91	12.74	59.53	71.36	6.00	14.20	2.57	1.69	166.08	2611	3053	467
2	22.50	10.87	64.32	70.13	10.19	16.49	2.99	2.51	89.68	2982	3174	569
3	20.59	7.99	62.71	69.79	14.04	18.20	2.65	4.01	141.39	3150	3352	641
4	21.57	7.19	58.31	68.43	16.62	20.19	3.50	4.19	207.87	3101	3400	686
5	15.27	6.71	60.21	66.63	19.97	22.06	4.55	4.60	82.81	3311	3491	681
6	14.59	7.15	60.81	66.09	17.57	22.15	7.03	4.60	77.17	3441	3487	740
7	13.70	6.85	59.59	67.79	19.73	20.90	6.99	4.46	68.25	3492	3460	730
8	13.05	6.46	60.44	67.26	17.31	21.92	9.20	4.36	96.19	3564	3480	728
9	12.15	7.15	60.31	65.48	17.80	22.74	9.75	4.63	78.00	3538	3496	708
10	11.42	7.23	61.93	66.77	17.72	21.70	8.93	4.30	57.55	3513	3457	683
Total	17.01	16.56	60.77	60.45	16.18	16.74	6.05	6.25	2.60*	3303	3275	6633
$\chi^2(\text{col})$	26.90		2.96*		18.41		32.42					

Note: w_{it} = wage of individual i at year t .

A=actual; P=predicted.

Critical values: $\chi^2_{(3)}(.05) = 7.82$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

Table 7.10: Extended Model. Actual and Predicted Choice Distribution for Wages by Year after Graduation: Whites

Years after Grad	Wage Brackets								χ^2 (row)	Average		Obs
	$w_{it} \leq 2000$		$2000 < w_{it} \leq 3000$		$3000 < w_{it} \leq 4000$		$w_{it} > 4000$			A	P	
	A	P	A	P	A	P	A	P				
1	22.86	23.19	60.88	59.90	11.98	12.69	4.28	4.22	.51*	2981	2987	818
2	15.59	16.30	62.37	58.78	15.70	18.61	6.34	6.31	6.78*	3249	3317	962
3	15.15	13.01	58.62	55.13	18.74	21.53	7.48	10.33	17.30	3451	3654	1003
4	13.46	11.11	54.23	53.96	23.27	22.96	9.04	11.97	12.67	3616	3824	1040
5	8.89	10.17	53.89	50.57	24.81	25.25	12.41	14.01	6.15*	3912	3990	1080
6	9.88	9.22	46.87	49.34	28.65	25.94	14.60	15.51	5.60*	4353	4089	1103
7	8.36	7.95	43.42	46.13	32.56	29.02	15.66	16.90	7.92	4469	4248	1124
8	8.92	7.34	42.93	46.62	30.12	28.00	18.02	18.04	8.97	4531	4336	1132
9	6.83	7.63	37.55	43.55	36.07	29.02	19.56	19.80	28.46	4651	4452	1084
10	3.24	6.40	37.20	45.04	38.34	28.55	21.22	20.01	66.83	4753	4476	1051
Total	10.94	10.69	49.25	50.41	26.58	24.70	13.22	14.21	25.44	4040	3985	10397
$\chi^2(\text{col})$	33.33		39.30		87.15		26.84					

Note: w_{it} = wage of individual i at year t .

A=actual; P=predicted.

Critical values: $\chi^2_{(3)}(.05) = 7.82$, $\chi^2_{(9)}(.05) = 16.92$.

“*” denotes that actual and predicted rates are statistically equal.

exist at all. These results will be illustrated in the next chapter, which will present comparative statics exercises.

Chapter 8

Policy Experiments

Once the underlying parameters of the model are estimated, some experiments on regime changes can be performed. Four regime changes are explored: (i) the effect of reducing unemployment net transfers on asset holdings; (ii) the effect of improving the initial assets on accepted wages; (iii) the effect of giving blacks (whites) the initial asset distribution of whites (blacks); and (iv) the effect of giving blacks (whites) the arrival rates and wage offer distribution of whites (blacks).

8.1 Change in Transfers while Unemployed

With the parameters of the extended model, I perform a regime change of a 10% decrease in transfers people receive while unemployed. Table 8.1 shows how this parameter affects both job search and asset accumulation during the first un-

Table 8.1: Effect of Regime Change using the Extended Model. 10% Decrease in Transfers while Unemployed

Transfers while Unemployed, <i>b</i> :	Blacks		Whites	
	1660	1494	1592	1433
First Unemployment spell				
Duration	5.59	4.12	2.95	2.57
Savings	-440	-460	-777	-840
First accepted wage	2409	2229	2581	2469
20 Quarters after Graduation				
% Unemployment	35.00	28.00	16.20	13.20
Assets				
Average	2869	2995	7829	7928
Employed	4268	3899	8186	8091
Unemployed	271	671	5981	6856
Wages				
	3152	3032	3650	3592
Welfare				
Average	2718.07	2650.98	4917.91	4855.12
Employed	2782.03	2702.03	4936.48	4862.60
Unemployed	2599.30	2517.42	4832.21	4805.93

employment spell and 20 quarters after graduation. For both groups this regime change decreases unemployment (the duration of the first unemployment spell and the unemployment rate 20 quarters after graduation) and wages (the first accepted wage and average wages 20 quarters after graduation). In particular, the unemployment rate 20 quarter goes down from 35% to 28% for blacks; and from 16% to 13% for whites. Average wages twenty quarters after graduation also go down for both groups: from \$3,152 to \$3,032 for blacks; and from \$3,650 to \$3,592 for whites. It is clear that this change decreases reservation wages and gives people a bigger incentive to become employed. Savings are defined as the difference between assets next quarter and current assets. From savings during the first unemployment spell, it is also clear that it accelerates the decumulation of assets during this period.

The effect on asset twenty quarters after graduation is, however, ambiguous. In the theoretical model people hold assets as a buffer against unemployment. There are two counter-acting effects. On the one hand, reducing transfers while unemployed means reducing the value of being unemployed and calls for increased savings while people are employed. However, these transfers induce agents to accept lower wages, which reduce asset holdings.

For both groups there is an increase in asset holdings 20 quarters after graduation. Blacks' assets increase from \$2,869 to \$2,995; whites' assets increase from \$7,829 to \$7,928. It is interesting to see the composition of this change. In this extended

model, there is a reduction of asset holdings of the employed for both race groups and an increase of asset holdings for the unemployed. Assets of the employed go down from \$4,268 to \$3,899 for blacks, and from \$8,186 to \$8,091 for whites. Counter-intuitively, for the unemployed, assets increase from \$271 to \$671 for blacks, and from \$5,981 to \$6,856 for whites.

In this extended model, with wage growth and unobserved heterogeneity, it is hard to interpret these results. There are two types of agents, which can show opposite trends. There is wage growth, which decreases motives for saving. It is therefore instructive to do this same exercise with the parameters obtained from the baseline model. These results are presented in Table 8.2. This regime change also decreases unemployment and wages for both race groups. As opposed to the previous simulation, average assets go down from \$2,711 to \$2,692 for blacks, and from \$4,408 to \$4,019 for whites. The effect of the decrease in average assets caused by lower wages is predominant in this estimation. For assets of the employed, the result is ambiguous. While assets of the employed go up from \$2,804 to \$2,819 for blacks, for whites they go down from \$4,535 to \$4,209. Unambiguously, this regime change implies a reduction of asset holdings of the unemployed: from \$2,451 to \$2,224 for blacks, and from \$3,771 to \$2,825 for whites.

In other models (Carroll 1992, Skinner 1985, Hubbard et al. 1995) an decrease in unemployment transfers increases savings because unemployment transfers un-

Table 8.2: Effect of Regime Change using the Baseline Model. 10% Decrease in Transfers while Unemployed

Transfers while Unemployed, <i>b</i> :	Blacks 1960	Blacks 1764	Whites 2125	Whites 1912
First Unemployment spell				
Duration	3.97	3.30	3.38	2.93
Savings	-114	-178	-697	-905
First accepted wage	2861	2717	3321	3165
20 Quarters after Graduation				
% Unemployment	26.40	21.40	16.60	13.70
Assets				
Average	2711	2692	4408	4019
Employed	2804	2819	4535	4209
Unemployed	2451	2224	3771	2825
Wages	3384	3270	4048	3974
Welfare				
Average	1688.80	1656.94	1775.03	1756.72
Employed	1690.94	1658.91	1777.69	1759.44
Unemployed	1682.83	1649.69	1761.67	1739.64

determine the need to build a buffer-stock. In the model presented here, decrease in net transfers can decrease savings. These transfers allow an unemployed individual to draw down assets at a slower rate and support the attainment of higher wages and a higher steady state level of assets while employed. Since both effects, i.e. the reduction of the buffer-stock and the wage increase, are present, the net effect crucially depends in the parameters of the model.

In the baseline model, a reduction of 10% in unemployment net transfers of blacks means a decrease of \$110 in quarterly wages twenty quarters after graduation, which in turn leads to a reduction of \$19 in average assets (17 cents per dollar). For whites, twenty quarters after graduation, a reduction of 10% in unemployment transfers implies is a decrease of \$74 in quarterly wages, which produces a reduction of \$389 in assets (183 cents per dollar) twenty quarters after graduation.

8.2 Change in Initial Assets

It is interesting to see to what extent initial assets determine the path of accepted wages and of the rate of unemployment. In the extended model the link between initial assets and wages vanishes. Across individuals the positive correlation between initial assets and wages is obtained by the existence of heterogeneous agents with permanent differences. For both groups, Type 2 starts off richer and also enjoys a better labor market environment than Type 1. In this estimation, however, none

of the types shows a positive relationship between reservation wages and assets. A change in initial assets does not affect accepted wages nor unemployment rates.

A positive effect of initial assets can be seen, however, using the parameters of the baseline model. I simulate the path of the main variables for two different initial asset levels. Table 8.3 presents selected variables when people start off with no assets and when people start off with \$2,000. The variables we are interested in are the duration of the first unemployment spell, the first accepted wage, the percentage of unemployed and average wages twenty quarters after graduation.

When there is an increase in initial assets, both blacks and whites have an increase in the duration of the first unemployment spell and in the first accepted wage. The increase in the duration of this spell is from 3.72 to 4.23 for blacks and from 3.27 to 3.34, for whites. The increase in the first accepted wage is from \$2,800 to \$2,908, for blacks; and from \$3,276 to \$3,301 for whites. For blacks this increase persists. Twenty quarters after graduation, their average wages increase from \$3,357 to \$3,405. This effect dies out twenty quarters after graduation for whites. Wages of whites who started off with \$2,000 worth of assets are the same than for people who started off with zero.

Therefore, it is fairly clear that job search outcomes respond to differences in initial assets. The amount of this response, however, is not sizable. While a zero initial asset level enables blacks to start with a quarterly wage level of \$2,800, initial

Table 8.3: Effect of Regime Change using the Baseline Model. Initial Assets: Before= No Assets; After:\$2000

Initial Assets, A_0 :	Blacks		Whites	
	0	2,000	0	2,000
First Unemployment spell				
Duration	3.72	4.23	3.27	3.34
Savings	0.00	0.00	0.00	-534
First accepted wage	2800	2908	3276	3301
20 Quarters after Graduation				
% Unemployment	25.70	27.50	16.00	16.00
Assets				
Average	2459	3656	2729	3372
Employed	2608	3857	2855	3517
Unemployed	2027	3127	2069	2613
Wages	3357	3405	4029	4029.
Welfare				
Average	1688.41	1690.76	1771.68	1773.39
Employed	1690.60	1693.09	1774.44	1776.10
Unemployed	1682.08	1684.63	1757.22	1759.11

assets of \$2,000 implies a starting wage of \$2,908. For whites, the analogous figures are a starting wage of \$3,276 for zero assets and a \$3,301 starting wage for \$2,000 assets. This implies that for both groups an increase of one hundred dollars in initial assets leads to a five dollar increment in the first accepted quarterly wage. This effect tends to disappear as individuals increase their labor market activity. Twenty quarters after graduation blacks with the higher initial wealth make only \$50 more than blacks with zero initial wealth. For whites, wealth does not make a difference in wages twenty years after graduation

8.3 Change in the Initial Asset Distribution

The effect of initial assets on individual outcomes was shown in the previous section. The experiment, while informative on the effect of initial assets, does not take into account the initial asset distribution of individuals. The experiment is made conditioning on a given level of initial assets, without accounting for the probability of starting off with that level. To make an unconditional comparison of the effect of initial wealth, it is possible to exploit the existence two groups, blacks and whites, where the initial asset distribution of one dominates the one of the other. I simulate the outcomes of each group, giving them the initial asset distribution of the other. Blacks start off with the initial wealth that whites have; whereas whites start off with the initial wealth of blacks.

Table 8.4: Effect of Regime Change. Blacks have the Initial Asset Distribution of Whites. Whites have the Initial Asset Distribution of Blacks

	Blacks		Whites	
	Before	After	Before	After
First Unemployment spell				
Duration	3.97	4.07	3.38	3.31
Savings	-114	-512	-697	-258
First accepted wage	2861	2882	3321	3299
20 Quarters after Graduation				
% Unemployment	26.40	26.70	16.60	16.20
Assets				
Average	2711	4318	4408	2852
Employed	2804	4417	4535	2965
Unemployed	2451	4045	3771	2265
Wages				
	3384	3388	4048	4033
Welfare				
Average	1688.80	1690.97	1775.03	1771.85
Employed	1690.94	1693.02	1777.69	1774.57
Unemployed	1682.83	1685.35	1761.67	1757.75

Table 8.4 reports the selected variables for this experiment using the results of the baseline model.¹ The initial asset distribution of whites dominates that of blacks. Thus, this regime change increases slightly both the duration of the first unemployment spell and the first accepted wage of blacks. For whites, it implies a decrease in both variables. Later, the original and the counter-factual amounts tend to converge. Twenty quarters after graduation the effect of this change in the initial asset distribution is practically disappeared both for blacks and for whites. The direction of the effect is there. A dominant initial asset distribution tends to increase average accepted wages. The effect is, however, not strong.

These results suggest that it is not the initial asset distribution which account for the differences in labor market performance between blacks and whites.

8.4 Change in Arrival Rates and Wage Offer Distribution

Changing initial assets does not seem to produce dramatic changes in labor market outcomes. Having done the estimation for black and white individuals, we can also study the effect of the labor market environment on career paths. I interchange the arrival rates and wage offer distributions for both race groups. Blacks

¹As mentioned in the previous section, the results of the extended model do not show any effect of initial assets on average accepted wages.

are given the labor market parameters of whites, and whites have the corresponding parameters of blacks.

Table 8.5 presents some results of simulating the basic model. Some variables for the first unemployment spell and for the 20th quarter after leaving school are reported. With the arrival rates and wage offers of whites, blacks decrease their unemployment rate and increase their average wages. The first accepted wage of blacks increases from \$2,861 to \$3,165. Twenty quarters after leaving school the increase is from \$3,384 to \$3,974. The opposite is true for whites. Their rate of unemployment increases, while their average wage goes down. While the first average wage decreases from \$3,321 to \$3,013, the average wage twenty quarters after graduation decreases from \$4,048 to \$3,465.

It is noteworthy that both interchanges in arrival rates and wage offer distributions imply a substantial reduction in the wage differential between both race groups. Consequently, these simulations suggest that labor market conditions rather than initial assets are responsible for most of the differences in wages between blacks and whites.

Table 8.5: Effect of Regime Change. Blacks have the Arrival Rates and Wage Offer Distribution of Whites. Whites have the Arrival Rates and Wage Offer Distribution of Blacks

	Blacks		Whites	
	Before	After	Before	After
First Unemployment spell				
Duration	3.97	2.93	3.38	4.84
Savings	-114	-348	-697	-507
First accepted wage	2861	3165	3321	3013
20 Quarters after Graduation				
% Unemployment	26.40	13.70	16.60	29.40
Assets				
Average	2711	3316	4408	3567
Employed	2804	3482	4535	3795
Unemployed	2451	2270	3771	3020
Wages	3384	3974	4048	3465
Welfare				
Average	1688.80	1797.31	1775.03	1678.10
Employed	1690.94	1798.80	1777.69	1682.31
Unemployed	1682.83	1787.88	1761.67	1668.00

Chapter 9

Conclusions

The main purpose of this thesis has been to establish an explicit connection between asset accumulation and employment dynamics under borrowing constraints. I presented empirical evidence for this link and estimated a model which replicates the main observed trends. This approach is able to account for features of the data such as asset decumulation during unemployment and asset accumulation during employment. The need for accumulation while employed comes from the prudence of the agent who builds a buffer-stock against future unemployment.

The model developed in this thesis is also able to account for quits to become voluntarily unemployed. This is an optimal decision motivated by the desire of the individual to stop working at low wages and search for better jobs while unemployed.

It is also shown that tighter borrowing constraints can induce asset accumula-

tion and selectivity in job acceptance decisions. Furthermore, individuals who face borrowing constraints can overtake unconstrained agents in current wages, though obviously not in welfare.

The main quantitative features of the data are captured by the model. The extended version of the model shows a particularly good fit to the data. Through comparative statics experiments, I show that most of the differences in labor market performance between blacks and whites are accounted for by differences in their wage offer distributions and arrival rates. If blacks had the labor market environment of whites, their wage twenty quarters after graduation would be \$3,974 and not \$3,384. This would be still below the \$4,048 of whites.

For black and white individuals, initial wealth does affect job search outcomes by allowing people to be more selective and obtain higher wages. An increase of \$2,000 in initial assets produces an increase of \$50 in quarterly wages twenty quarters after high school graduation. Giving people a better initial asset distribution also increases their average accepted wages, especially at the beginning of their employment careers. This effect diminishes as people accumulate assets and become employed. I made the experiment of giving blacks the initial asset distribution of whites. The increase in wages caused by this change were very small. For the extended model, with heterogeneous agents and wage growth, no relationship between initial assets and labor market variables was found.

Interestingly, a decrease of net transfers while unemployed can produce a reduction in asset holdings for both groups. This result does not coincide with the predictions of the literature on precautionary savings, which does not consider employment dynamics explicitly. Transfers while unemployment do not only undermine the need for a buffer-stock, but also allow people to obtain higher wages and, consequently, increase their asset holdings. A permanent decrease of \$100 in transfers implies to a reduction of \$17 for blacks and \$183 for whites in assets holdings 20 quarters after high school graduation. Since there are counter-acting effects, this result is very sensitive to the introduction of heterogeneity and wage growth in the estimation. Consequently, it has to be interpreted with caution. In any case, this thesis shows a mechanism and empirical evidence that a policy that reduces transfers while unemployed can fail to obtain the desired result of increasing savings and asset holdings. Moreover, if the aim is to increase savings and asset holdings, reducing transfers that unemployed people receive may actually reduce these variables.

Appendix A

Proof of Theorem 1

Let $X_1 = [B, \infty) \subseteq \mathfrak{R}$, $X_2 = [B, \infty) \times [\underline{w}, \bar{w}] \subseteq \mathfrak{R}^2 \times I^2$, and let $C_1(X_1) \subseteq \mathfrak{R}$ and $C_2(X_2) \subseteq \mathfrak{R}$ be sets of bounded continuous functions: $V_u : X_1 \rightarrow \mathfrak{R}$, $V_e : X_2 \rightarrow \mathfrak{R}$ with norm:¹

$$\|V_u\| = \sup_{A \in X_1} \frac{|V_u(A)|}{\max|U(A), 1|} < \infty, V_u \in C_1(X_1),$$

$$\|V_e\| = \sup_{A, w \in X_2} \frac{|V_e(A, w)|}{\max|U(A), 1|} < \infty, V_e \in C_2(X_2),$$

¹Lippman (1975) proposed this norm for dynamic programming problems with unbounded rewards, so that the absence of a uniform bound on the state variables is balanced by some other restriction in their possible rates of growth.

Define the norm:

$$\| (V_u, V_e) \| = \max\{\|V_u\|, \|V_e\|\}, \text{ for } (V_u, V_e) \in X$$

where $X = C_1(X_1) \times C_2(X_2);: X \subseteq \mathfrak{R}^2$.

Let T be a mapping $T : X \rightarrow X$, where (X, d_∞^*) is a Banach space.

$$T(V_u, V_e) = (T_1(V_u, V_e), T_2(V_u, V_e))$$

$$\begin{aligned} T_1(V_u(A), V_e(A, w)) &= \max_{A_u \geq B} \left\{ U \left(A + b - \frac{A_u}{1+r} \right) \right. \\ &\quad \left. + \beta [\lambda_u E \max[V_e(A_u, x), V_u(A_u)] \right. \\ &\quad \left. + (1 - \lambda_u) V_u(A_u)] \right\} \end{aligned}$$

$$\begin{aligned} T_2(V_u(A), V_e(A, w)) &= \max_{A_e \geq B} \left\{ U \left(A + w - \frac{A_e}{1+r} \right) \right. \\ &\quad \left. + \beta [(1 - \theta) (\lambda_e E \max[V_e(A_e, x), V_e(A_e, w), V_u(A_e)] \right. \\ &\quad \left. + (1 - \lambda_e) \max[V_e(A_e, w), V_u(A_e)]) \right. \\ &\quad \left. + \theta [\lambda_e E \max[V_e(A_e, x), V_u(A_e)] \right. \\ &\quad \left. + (1 - \lambda_e) V_u(A_e)] \right\} \end{aligned}$$

Proof of (i).- To prove the reservation wage property it suffices to prove that $V_e(A, w)$ is monotonically increasing in w . Take $V_u^0(A) = U(A + b)$ and $V_e^0(A, w) = U(A + w)$, where V_u is monotonically increasing in A , and V_e is monotonically

increasing in A and in w respectively. The operator T as defined above preserves monotonicity of the arguments. In particular, any $(V_u, V_e)_n = T^n(V_u^0, V_e^0)$ will be monotone increasing in A and in w . So the reservation wage property exists.

Proof of (ii).- First, it needs to be shown that T transforms continuous, bounded functions into other continuous bounded functions. To prove that T preserves continuity, note that U is continuous in wages and assets as is F . Therefore, T preserves continuity.

In order to prove boundedness, note that

$$\begin{aligned} \max\{V_u(A), V_e(A, w)\} &\leq \max\{V_u(A), V_e(A, \bar{w})\} \\ &\leq Y(A), \text{ for all } A \in [B, \infty). \end{aligned}$$

where:

$$Y(A) = \max\left\{U\left(A + \bar{w} - \frac{A'}{1+r}\right) + \beta Y(A')\right\}$$

This is, the expected lifetime utility both of being employed and of being non-employed cannot be higher than the utility of being employed forever at the highest possible wage with no borrowing constraints. For the utility function used here

(CRRA and log) $Y(A)$ admits an analytical solution expressed by:

$$Y(A) = D_1 \times U\left(A + \left(\frac{1+r}{r}\right)\bar{w} - \frac{C_{min}}{r}\right) + D_2,$$

where :

$$D_1 = \frac{\left(1 - \frac{\delta}{1+r}\right)^{1-\gamma}}{1 - \beta\delta^{1-\gamma}},$$

$$D_2 = -\frac{1}{(1-\beta)(1-\gamma)},$$

$$\delta = [\beta(1+r)]^{\frac{1}{\gamma}}; \quad \text{if } \gamma \neq 1,$$

and

$$D_1 = \frac{1}{(1-\beta)},$$

$$D_2 = \frac{\beta \ln[\beta(1+r)]}{(1-\beta)^2} + \frac{\ln(1-\beta)}{1-\beta}; \quad \text{if } \gamma = 1.$$

Because of the concavity of $U(\cdot)$, it is clear that:

$$D_1 U\left(A + \left(\frac{1+r}{r}\right)\bar{w} - \frac{C_{min}}{r}\right) + D_2 \leq D_1 U(A) + D_1 U\left(\left(\frac{1+r}{r}\right)\bar{w} - \frac{C_{min}}{r}\right) + D_2.$$

Therefore:

$$\frac{\max[V_u(A), V_e(A, w)]}{\max[U(A), 1]} \leq D_1 + D_1 U\left(\left(\frac{1+r}{r}\right)\bar{w} - \frac{C_{min}}{r}\right) + D_2 < \infty.$$

This implies that a solution is attained at a bounded level.²

Now, Blackwell's theorem can be applied in the way proposed by Sharma (1987).

Lemma (Blackwell's sufficient conditions for a contraction) Let $T : X \rightarrow X$ be an operator satisfying:

a) (monotonicity) $(V_u, V_e)' \geq (V'_u, V'_e)'$ implies $T(V_u, V_e)' \geq T(V'_u, V'_e)'$, where $(V_u, V_e)', (V'_u, V'_e)' \in X$.

b) (discounting) for any $a_1, a_2 \geq 0$ there exists some $\beta \in (0, 1)$ such that

$$T(V_u + a_1, V_e + a_2) \leq T(V_u, V_e) + \beta \max[a_1, a_2](1, 1)$$

So, T is an operator which defines a contraction mapping with modulus β . This implies that $(V_u, V_e)'$ is a fixed point of the equation $(V_u, V_e)' = T(V_u, V_e)'$.

²Miller (1974) proved that there exists an upper bound for consumption and the value functions corresponding to CRRA and log preferences.

Appendix B

Proofs of Propositions

As discussed by Danforth (1979), because of the max operator, concavity of the utility function does not imply concavity of the value functions. In his analysis, he allowed for a multiplicity of solutions. In my case, I will follow Blundell et al. (1994) and introduce an additional assumption.

Assumption 3 *V_u and V_e are twice differentiable functions with respect to assets and they are increasing and concave.*

This is Assumption 2.2.1 of Blundell et al. (1994). The following analysis will be conditional on this assumption to hold.

Proof of Proposition 1: Define:

$$\Psi_u(A_u) = \lambda_u \int_{w^*(A)}^{\bar{w}} V_e(A_e, x) dF(x) + (1 - \lambda_u (1 - F(w^*(A)))) V_u(A_u) \quad (\text{B.1})$$

$$\Psi_e(A_e, w) = (1 - \theta) \left[\lambda_e \int_{\max(w, w^*(A))}^{\bar{w}} V_e(A, x) dF(x) \right. \quad (\text{B.2})$$

$$\left. + (1 - \lambda_e) \max[V_e(A, w), V_u(A)] \right]$$

$$+ \theta \left[\lambda_e \int_{w^*(A)}^{\bar{w}} V_e(A, x) dF(x) + (1 - \lambda_e (1 - F(w^*(A)))) V_u(A_e) \right]$$

$$\Upsilon_u(A_u) = U \left(A + b - \frac{A_u}{1 + r} \right) \quad (\text{B.3})$$

$$\Upsilon_e(A_e, w) = U \left(A + w - \frac{A_e}{1 + r} \right) \quad (\text{B.4})$$

First part: To prove $w^*(A) > b$, I proceed inductively. It is sufficient to show that a property is preserved by T (Albrecht, Holmlund & Land 1991). This means that $w_n^*(A) > b$ implies $w_{n+1}^*(A) > b$.

Suppose $w_n^*(A) > b$ and $w_{n+1}^*(A) \leq b$, then,

$$\Upsilon_u(A_e) \geq \Upsilon_e(A_e, w^*), \quad \forall A_e$$

$$\Psi_u(A_e) > \Psi_e(A_e, w^*) \quad (\text{implied by Assumption 1})$$

$$\max_{A_u \geq B} \{ \Upsilon_u(A_u) + \beta \Psi_u(A_u) \} > \max_{A_e \geq B} \{ \Upsilon_e(A_e, w^*) + \beta \Psi_e(A_e, w^*) \} \quad \forall (A_u, A_e)$$

This implies that $V_u(A) > V_e(A, w^*), \forall (A, w)$. This cannot occur under $b < \bar{w}$.

So, $w^*(A) > b$.

Second part: w^* is defined as $w^* = \{w \mid V_u(A) = V_e(A, w)\}$,

$$\frac{\partial w^*}{\partial A} = \frac{V'_u(A) - V_{e1}(A, w)}{V_{e2}(A, w)}.$$

Since $V'_u(A) > 0$, $V_{e1}(A, w) > 0$, $V_{e2}(A, w^*) > 0$, the proposition will be true if $V'_u(A) - V_{e1}(A, w^*) > 0$. Because

$$\begin{aligned} V'_u(A) &= U'(C_u) \text{ and} \\ V_{e1}(A, w^*) &= U'(C_e), \end{aligned}$$

the proposition is equivalent to $C_e > C_u$.

Depending on the existence of interior solutions, there are four possible cases.

Case I: $A_u \geq B$ and $A_e > B$.

Suppose that

$$C_u \geq C_e, \tag{B.5}$$

then

$$\begin{aligned} A + b - \frac{A_u}{1+r} &\geq A + w^* - \frac{A_e}{1+r}, \\ \frac{A_e}{1+r} - \frac{A_u}{1+r} &\geq w^* - b > 0, \\ A_e &> A_u. \end{aligned} \tag{B.6}$$

The Euler Equations for this case are:

$$U'(C_u) = \beta(1+r)\Psi'_u(A_u) + \xi^u,$$

$$U'(C_e) = \beta(1+r)\Psi_{e1}(A_e, w^*);$$

where $\xi^u = 0$ if $A^u > B$, and $\xi^u > 0$ if $A^u = B$. By (B.5):

$$U'(C_u) \leq U'(C_e)$$

Therefore,

$$\beta(1+r)\Psi'_u(A_u) + \xi^u \leq \beta(1+r)\Psi_{e1}(A_e, w^*). \quad (\text{B.7})$$

From the first part ($w^* - b > 0$):

$$\beta(1+r)\Psi'_u(A_u) + \xi^u > \beta(1+r)\Psi_{e1}(A_u, w^*) \quad \forall A_u \geq B, \quad (\text{B.8})$$

and using (B.6):

$$\beta(1+r)\Psi'_u(A_u) + \xi^u > \beta(1+r)\Psi_{e1}(A_e, w^*), \quad (\text{B.9})$$

which contradicts (B.7).

Case II: $A_u > B$ and $A_e = B$.

This means that $A_u > A_e$. Suppose $C_u \geq C_e$. As seen above, this implies $A_e > A_u$, which is a contradiction.

Case III: $A_u = B$ and $A_e = B$.

$C_e > C_u$ because

$$A + w^*(A) - \frac{B}{1+r} > A + b - \frac{B}{1+r}.$$

Proof of Proposition 2: If there is an interior solution, i.e. $A_u > B$, the Euler equation for the V_u function can be rewritten as:

$$\begin{aligned} V'_u(A) &= \beta(1+r)\lambda_u \left[\int_{w^*(A_u)}^{\bar{w}} [V'_e(A_u, x) - V'_u(A_u)] dF(x) \right] \\ &\quad + \beta(1+r)V'_u(A_u). \end{aligned} \tag{B.10}$$

From Proposition 1, it is clear that the first term of the right hand side is negative.

This implies that

$$V'_u(A) < \beta(1+r)V'_u(A_u). \tag{B.11}$$

If Assumption (3) holds, then $A > A_u$. If $B > \tilde{B}$, the unemployed will decumulate assets until the constraint B is attained.

Proof of Proposition 3: If $A_e > B$ and $w > w^*(A_e)$,¹ the Euler equation for the V_e function can be rewritten as.

$$\begin{aligned} V_{e1}(A, w) = & \beta(1+r)\lambda_e[(1-\theta) \int_w^{\bar{w}} [V_{e1}(A_e, x) - V_{e1}(A_e, w)]dF(x) \\ & + \theta \int_{w^*(A_e)}^{\bar{w}} [V_{e1}(A_e, x) - V'_u(A_e)]dF(x)] \\ & + \beta(1+r)[(1-\theta)V_{e1}(A_e, w) + \theta V'_u(A_u)]. \end{aligned}$$

The first and the second term from the right hand side of this equation are negative.

If Assumption (3) holds, this implies:

$$V_{e1}(A, w) < \beta(1+r)[(1-\theta)V_{e1}(A_e, w) + \theta V'_u(A_u)]$$

This inequality shows that the only term that can force the individual to save is a high marginal utility of being unemployed. In particular, if $\theta = 0$, then

$$V_{e1}(A, w) < \beta(1+r)V_{e1}(A_e, w),$$

which means that the individual will always decumulate. Thus, it is possible that the individual accumulates only if $\theta > 0$.

¹If $w \leq w^*(A_e)$, the individual will quit. Therefore, the layoff rate does not have any effect on the individual's decision.

Appendix C

Numerical Solution Algorithm

The first requirement to compute the optimal solution is to discretize the continuous variables of the state space.

$A \rightarrow A(k)$ is 50×1 vector.

$w \rightarrow w(j)$ is 51×1 vector.

Now, $V_u(A(k))$ can be also expressed as $V_u(k)$, and $V_e(A(k), w(j))$, as $V_e(k, j)$.

The ranges of these matrices are:

$V_u : 50$,

$V_e : 50 \times 51 = 2,550$.

This discretization is extensive to the wage offer distribution. This means that the integrals of the value function are actually sums which use the discretized densities as weights for the particular values of wages.

The optimal solution is approximated using a procedure which combines a policy iteration algorithm with generalized error bounds (Bertsekas 1976). The program used was Fortran.

The procedure used consists of three steps:

Step 1) (Initialization) Start computation with:

$$V_u^0(k) = U(A(k) + b)$$

$$V_e^0(k, j) = U(A(k) + w(j))$$

Step 2) (Iteration and Computation of Bounds)

Iterate one time using: $(V_u^n, V_e^n)' = T(V_u^{n-1}, V_e^{n-1})'$.

If $\max \{ \sup |V_u^n - V_u^{n-1}|, \sup |V_e^n - V_e^{n-1}| \} \leq \text{tolerance}$, stop; else continue.

Compute (generalized) error bounds:

$$\underline{\eta}^n = \frac{\beta}{1-\beta} \min \left\{ \min (V_u^n - V_u^{n-1}), \min (V_e^n - V_e^{n-1}) \right\},$$

$$\bar{\eta}^n = \frac{\beta}{1-\beta} \max \left\{ \max (V_u^n - V_u^{n-1}), \max (V_e^n - V_e^{n-1}) \right\},$$

$$\eta^n = \frac{\underline{\eta}^n + \bar{\eta}^n}{2}.$$

Step 3) (Jump)

Use a contraction iteration of the form:

$$(V_u^n, V_e^n)' = T(V_u^{n-1} + \eta^{n-1}, V_e^{n-1} + \eta^{n-1})'.$$

Go to step 2 and repeat the process.

The performance of this procedure in terms of accuracy and speed has been compared in favorable terms with the performance of other procedures like: pure policy iteration, successive approximation, simple error bounds, Gauss-Seidel approximations. The simulations were done in a IBM RISC-6000 machine. This procedure required five to seven iteration until convergence was obtained, taking altogether approximately 30-35 CPU seconds.

Bibliography

- Albrecht, J. W., Holmlund, B. & Land, H. (1991), 'Comparative statics in dynamics programming models with an application to job search,' *Journal of Economic Dynamics and Control* **15**, 755–769.
- Andolfatto, D. (1996), 'Business cycles and labor market search,' *American Economic Review* **86**, 112–132.
- Bertsekas, D. P. (1976), *Dynamic Programming. Deterministic and Stochastic Models*, Prentice Hall, New Jersey.
- Blau, F. (1990), 'Black-white differences in wealth and asset composition,' *Quarterly Journal of Economics* **105**(2), 321–339.
- Bloemen, H. G. & Stancanelli, E. G. (1997), Individual wealth, reservation wages and transitions into employment, Center for Economic Research. Discussion Paper No 9702.

- Blundell, R., Magnac, T. & Meghir, C. (1994), Savings, layoff risk and labour market transitions, Mimeo.
- Burdett, K. (1978), 'Employee search and quits,' *American Economic Review* **68**, 212–220.
- Burdett, K. (1979), Search, leisure and individual labor, in S. A. Lippman & J.J.McCall, eds, 'Studies in the Economics of Search,' North-Holland, New York, pp. 157–170.
- Burdett, K. & Mortensen, D. (1977), Labor supply under uncertainty, Northwestern University. Discussion Paper No. 297 (mimeo).
- Burdett, K., Kiefer, N. & Sharma, S. (1985), 'Layoffs and duration of dependence in a model of turnover,' *Journal of Econometrics* **28**, 51–69.
- Campbell, J. Y. & Mankiw, N. G. (1989), Consumption, income and interest rates: Reinterpreting the time series evidence, in O. J. Blanchard & S. Fischer, eds, 'Macroeconomics Annual,' NBER.
- Carroll, C. (1992), 'The buffer-stock theory of saving: Some macroeconomic evidence,' *Brookings Papers on Economic Activity* pp. 61–135.
- Costain, J. S. (1995), Unemployment insurance in a general equilibrium model of job search and precautionary savings, Mimeo, University of Chicago.

- Danforth, J. (1974), Individual Labor Market Behavior under Uncertainty, PhD thesis, Northwestern University, Evanston, Illinois.
- Danforth, J. P. (1979), On the role of consumption and decreasing absolute risk aversion in the theory of job search, in S. A. Lippman & J. McCall, eds, 'Studies in the Economics of Search,' North-Holland, New York, pp. 109–131.
- Deaton, A. (1991), 'Savings and liquidity constraints,' *Econometrica* **59**, 1221–1248.
- Dynarski, M. & Sheffrin, S. M. (1987), 'Consumption and unemployment,' *Quarterly Journal of Economics* **102**, 411–428.
- Eckstein, Z. & Wolpin, K. (1989), 'The specification and estimation of dynamic stochastic discrete choice models,' *Journal of Human Resources* **24**, 562–598.
- Engelhardt, G. V. (1994), 'House prices and the decision to save for down payments,' *Journal of Urban Economics* **36**, 209–237.
- Engen, E. & Gruber, J. (1995), Unemployment insurance and precautionary savings, NBER Working Paper 5252.
- Evans, D. S. & Jovanovic, B. (1989), 'An estimated model of entrepreneurial choice under liquidity constraints,' *Journal of Political Economy* **97**, 808–827.
- Flavin, M. (1981), 'The adjustment of consumption to changing expectations about future income,' *Journal of Political Economy* **89**, 974–1009.

- Flemming, J. (1978), 'Aspects of optimal unemployment insurance. search, leisure, savings and capital market imperfections,' *Journal of Public Economics* **10**, 403–425.
- Flinn, C. & Heckman, J. (1982a), 'Models for the analysis of labor force dynamics,' *Advances in Econometrics 1* pp. 35–95.
- Flinn, C. & Heckman, J. (1982b), 'New methods for analyzing structural models of labor force dynamics,' *Journal of Econometrics* **188**, 115–68.
- Flinn, C. & Heckman, J. (1983), 'Are unemployment and out of the labor force behaviorally distinct labor force states?,' *Journal of Labor Economics* **1**, 28–49.
- Gomes, J., Greenwood, J. & Rebelo, S. (1997), Equilibrium unemployment, NBER Working Paper No 5922.
- Grossman, S., Levhari, D. & Mirman, L. (1979), Consumption under uncertainty, in J. R. Green & J. A. Scheinkman, eds, 'General Equilibrium, Growth and Trade. Essays in Honor of Lionel McKenzie,' C, pp. 105–124.
- Gruber, J. (1994), The consumption smoothing benefits of unemployment insurance, NBER Working Paper No 4750.

- Hakansson, N. (1970), 'Optimal investment and consumption strategies under risk for a class of utility functions,' *Econometrica* **38**(5), 587-607.
- Hall, J. R., Lippman, S. A. & McCall, J. (1979), Expected utility maximizing job search, in S. A. Lippman & J.J. McCall, eds, 'Studies in the Economics of Search,' North-Holland, New York, pp. 133-155.
- Hall, R. E. (1978), 'Stochastic implications of the life cycle-permanent income hypothesis: Theory and evidence,' *Journal of Political Economy* **86**(6), 971-987.
- Hall, R. E. & Mishkin, F. S. (1982), 'The sensitivity of consumption to transitory income: Estimates from panel data on households,' *Econometrica* **50**, 461-81.
- Hamermesh, D. S. (1982), 'Social insurance and consumption: An empirical inquiry,' *American Economic Review* **72**, 101-113.
- Hansen, G. & Imrohoroglu, A. (1992), 'The role of unemployment insurance in an economy with liquidity constraints and moral hazard,' *Journal of Political Economy* **100**(11), 118-142.
- Hayashi, F. (1985), 'The effect of liquidity constraints on consumption: A cross-sectional analysis,' *Quarterly Journal of Economics* **100**, 183-206.
- Heckman, J. & MaCurdy, T. (1980), 'A life cycle model of female labor supply,' *Review of Economic Studies* **47**, 47-74.

- Heckman, J. & Singer, B. (1984), 'A method for minimizing the impact of distributional assumptions in econometric models for duration data,' *Econometrica* **52**, 271–320.
- Heckman, J. & Walker, J. R. (1990), 'The relationship between wages and income and the timing and spacing of births: Evidence from Swedish longitudinal data,' *Econometrica* **58**(6), 1441–74.
- Hubbard, G., Skinner, J. & Zeldes, S. (1995), 'Precautionary saving and social insurance,' *Journal of Political Economy* **103**(2), 360–399.
- Jianakoplos, N. A., Menchik, P. L. & Irvine, F. O. (1989), Using panel data to assess the bias in cross-sectional inferences of life-cycle changes in the level and composition of household wealth, in R. Lipsey & H. S. Tice, eds. 'The Measurement of Saving, Investment and Wealth,' The University of Chicago Press, Chicago, pp. 553–644.
- Jovanovic, B. (1979), 'Job matching and the theory of turnover,' *Journal of Political Economy* **87**(5), 972–989.
- Jovanovic, B. (1987), 'Work, search and rest: A theoretical analysis of the cyclical behavior of unemployment,' *Journal of Labor Economics* **5**, 131–148.

- Kiefer, N. & Neumann, G. (1979), 'An empirical job search model with a test of the constant reservation wage hypothesis,' *Journal of Political Economy* **87**, 69–82.
- Lazear, E. (1979), 'The narrowing of black-white wage differentials is illusory,' *American Economic Review* **69**(4), 553–564.
- Lippman, S. & McCall, J. (1976), 'The economics of job search: A survey,' *Economic Inquiry* **14**, 155–89.
- Lippman, S. A. (1975), 'On dynamic programming with unbounded rewards,' *Management Science* **21**, 1225–1233.
- Lippman, S. A. & Mamer, J. W. (1989), 'A simple search model with procyclical quits,' *jedc* **13**, 247–253.
- MaCurdy, T. (1981), 'An empirical model of labor supply in a life cycle setting,' *Journal of Political Economy* **89**, 1059–85.
- Meyer, B. (1990), 'Unemployment insurance and unemployment spells,' *Econometrica* **58**, 757–82.
- Miller, B. L. (1974), 'Optimal consumption with a stochastic income stream,' *Econometrica* **42**, 253–266.
- Mortensen, D. (1986), Job search and labor market analysis, *in* 'Handbook of Labor Economics,' Vol. 2, C, pp. 849–866.

- Orazem, P. (1987), 'Black-white differences in schooling investment and human capital production in segregated schools'.
- Press, W. H., Teutolsky, S. A., Vetterling, W. T. & Flannery, B. P. (1992), *Numerical Recipes in FORTRAN: The Art of Scientific Computing*, Cambridge University Press, New York.
- Rust, J. (1988), 'Maximum likelihood estimation of discrete control processes,' *SIAM Control and Optimization* **26**(5), 1006–1024.
- Rust, J. (1990), Behavior of male workers at the end of the life cycle: An empirical analysis of states and controls, in D. Wise, ed., 'Issues in the Economics of Aging,' The University of Chicago Press, Chicago, pp. 317–379.
- Schechtman, J. & Escudero, V. L. (1977), 'Some results on 'an income fluctuation problem',' *Journal of Economic Theory* **16**, 151–166.
- Sharma, S. (1987), 'On the existence and uniqueness of value functions in models of labor market dynamics,' *Economic Letters* **24**, 349–352.
- Skinner, J. (1985), 'Risky income, life cycle consumption, and precautionary savings,' *Journal of Monetary Economics* **22**, 237–255.
- Sobol, M. (1979), 'Factors influencing private capital accumulation on the 'eve of retirement',' *Review of Economics and Statistics* **61**, 585–593.

- Whipple, D. (1973), 'A generalized theory of job search,' *Journal of Political Economy* **81**, 1170–88.
- Wolff, E. (1990), 'Methodological issues in the estimation of the size distribution of household wealth,' *Journal of Econometrics* **43**, 179–195.
- Wolpin, K. (1987), 'Estimating a structural search model: The transition from school to work,' *Econometrica* **55**, 801–817.
- Wolpin, K. (1992), 'The determinants of black-white differences in early employment careers: Search, layoffs, quits, and endogenous wage,' *Journal of Political Economy* **100**, 535–560.
- Wolpin, K. (1995), *Empirical Methods for the Study of Labor Force Dynamics*, Harwood Academic Publishers, Luxembourg.
- Zeldes, S. (1989), 'Consumption and liquidity constraints: An empirical investigation,' *Journal of Political Economy* **97**, 305–346.