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Labor market prospects, search intensity and the transition from college to work

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Abstract

In this paper we develop a structural model for job search behavior of students entering the labor market. The model includes endogenous search effort and on the job search. Since students usually do not start a regular job before graduation but start job search earlier, our model is non stationary. The model explains the common finding that a substantial share of individuals starts working immediately upon graduation. We estimate the model using a unique data set of individuals who completed undergraduate education in the Netherlands between 1995 and 2001. Our estimation results show that a 1 percentage point decrease in unemployment rate increases wage offers on average with 3 percent and that there are substantial returns to work experience. Employment rates at graduation could be increased from 40 percent to 65 percent if all students start job search 6 months prior to graduation.

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1 Introduction

Students anticipate the moment of graduation by searching for work already some period before graduating (e.g. Wolpin, 1987). Therefore, a substantial share of students starts working immediately after completing education (e.g. Bowlus, Kiefer and Neumann, 2001, Ferrall, 1997, and Wolpin, 1987). Young workers usually do not stay very long in their first job. Topel and Ward (1992) argue that young workers are searching for good matches, i.e. high paying jobs. Job-to-job transitions are often associated to wage increases and the behavior of young workers is largely consistent with job search theory.[1] The high job turnover and fast wage growth in the beginning of a career can be the result of the existence of frictions within a stationary labor market environment. An alternative explanation is that the returns to work experience are relatively high for new entrants in the labor market. This implies that the labor market conditions faced by young workers change after they start working in their first job.

In this paper we develop a model describing the labor market behavior of individuals around the moment of completing undergraduate education. Our model is a discrete-time job search model (see e.g. Mortensen, 1986, for an extensive discussion on models describing job search behavior). Unlike most empirical studies of labor market behavior, which take job search effort exogenously, we explicitly model the amount of job search effort (see Bloemen, 2004; Fougère, Pradel and Roger, 2002; Stern, 1989; and Yoon, 1981; for structural empirical analyses of job search models with endogenous search effort). Additionally, we model the optimal moment at which individuals start searching for work, which often precedes the date of graduation. The optimal timing of starting job search depends on the returns to job search and the costs of searching. We assume that the costs function of job search effort has two components, fixed costs made at the moment of starting job search, and flexible costs in each period depending on the amount of job search effort. Because students usually do not start working in regular jobs before actually graduating, the decision problem of students is non stationary (even if all structural elements of the model would be constant over time). We show that after the (optimal) moment of starting job search, students increase their job search effort and lower their reservation wage each period until the moment of graduating or accepting a job.

Our model explains the substantial share of individuals who start working immediately after graduation differently from the recent economic literature. Since we have information on the actual moment an individual starts searching for

[1] Christensen, Lentz, Mortensen, Neumann and Werwatz (2005) argue that the effect of tenure on wages in small in the wage growth of individuals.

work, we can identify the job search process prior to graduation. Most closely related is Wolpin (1987), who imposes that all individuals start searching the same fixed period before graduation and that each period all individuals devote the same amount of effort to job search. Other structural empirical analyses do not explicitly model the job search process before graduation. Ferrall (1997) assumes that at the moment of leaving school all individuals have received exactly two job offers, and are employed if the wage associated to the best job offer exceeds the individual's reservation wage. Bowlus, Kiefer and Neumann (2001) ignore job search spells where an individual starts working immediately upon leaving school. Gras and Lindeboom (1994) adopt a similar strategy, but correct for potential selection among those who failed to find a job before graduation.

Because young workers are mobile and wages tend to increase fast, the wage in the first job is not a proper indicator for the present value of life-time earnings (e.g. Eckstein and Wolpin, 1995). Therefore, we do not only model the job search process until accepting the first job, but we also allow for on-the-job search. We do not restrict the structural parameters describing the job search environment to be similar for individuals looking for their first job and for employed workers. This allows us to distinguish between the hypothesis that high job mobility and increasing wages are the result of frictions on the labor market as opposed to the hypothesis that it is the result of accumulating work experience.

A structural model has several advantages when analyzing the labor market behavior of students. Labor marker transitions and wages are jointly determined, and thus the interdependency between these variables can be studied. The model shows how to handle individuals that have not been unemployed between leaving school and starting work. Since we allow for on-the-job search, our model provides estimates of the returns to early work experience. Finally, by explicitly modelling job search behavior, we obtain an estimate for the costs of job search.

In the empirical analyses we use data from an annual survey of young workers who recently finished undergraduate education at Dutch universities. In the Netherlands, it is unusual that after completing undergraduate education, students continue with Ph.D. education. Our data describes cohorts of individuals who graduated in economics, business administration, Dutch law or psychology between 1995 and 2001. Since labor market conditions for these individuals differ, we estimate our model separately for different studies. Our data are unique in a sense that they are extensive on job search behavior, for example the data include the moment at which individuals actually start looking for work and the number of job applications. Furthermore, the data are rich on individual characteristics. It is not our intention to estimate returns to education or to compare returns of the different studies. The latter would require an extended model, which includes

the selection process into these studies.

The Dutch economy experienced a period of relatively fast economic growth at the end of the 1990s. This was characterized by improvements in labor market conditions, i.e. labor force participation rates, worker mobility, number of vacancies, and real wages increased. After 2000 the growth of the Dutch economy slowed down and the economy entered a period of recession. We investigate to what extent labor market prospects of students depend on macroeconomic conditions. We allow the structural parameters to depend on business cycle indicators. The effect of business cycle variation on individual search effort is ambiguous, the direction depends on the values of the parameters (see also Shimer, 2004).

We use the estimation results to compute how labor market prospects vary over the business cycle and to investigate the importance of the returns to early work experience. We show that if there would not be any returns to work experience, individuals change behavior, for example, by setting a higher reservation wage for their first job. Our structural model disentangles the effect of labor market frictions from the effect of early work experience. Because it takes account of changes in individual behavior, the structural model provides ideal counterfactuals. We show that the returns to early work experience are important. Both employment rates and average earnings of young workers would be substantially lower in a world without returns to work experience.

The outline of the paper is as follows. Section 2 provides institutional background on the Dutch educational system and business cycle variation during the observation period. In Section 3 we present the structural model. The data are discussed in Section 4. In Section 5 we show reduced-form analyses to investigate the validity of the structural model. In Section 6 we provide details on the estimation of our structural model. Section 7 presents the estimation results of the structural model and analyses the returns to early work experience. Section 8 concludes.

2 Educational system in the Netherlands

In this section we briefly discuss the university education system in the Netherlands. We restrict attention to elements that are relevant for undergraduate students in economics, business administration, Dutch law or psychology.

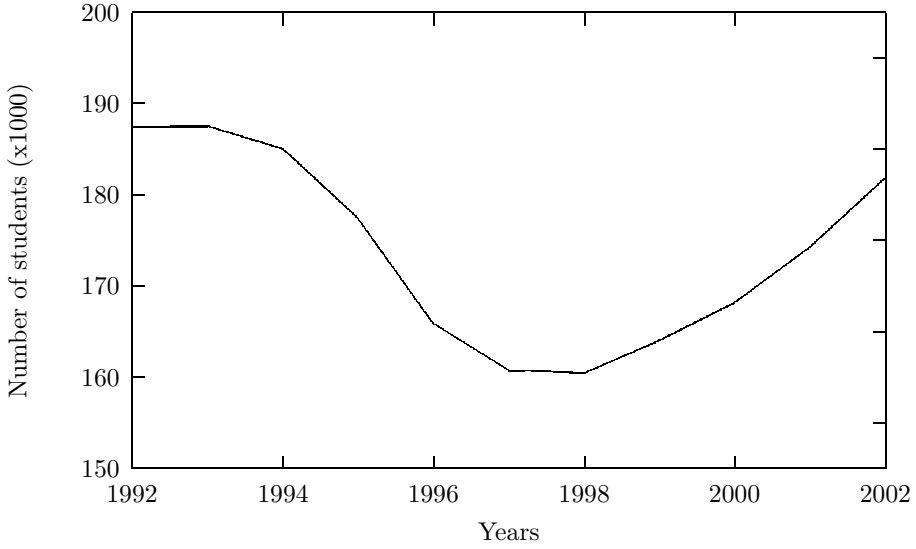
All universities in the Netherlands are public and tuition fees are low. The tuition fee is set by the government and does not vary by field of study or by university attended. Annual tuition fees for full-time students (under age 30) increased from around 800 euros in the early 1990s to around 1250 euros at the

end of the 1990s. Undergraduate students are entitled to a financial aid system. The grant depends on parental income and whether or not students live at their parents' house (see Leuven, Oosterbeek and Van der Klaauw, 2003, for a more extensive discussion). During the 1990s a number of changes occurred. First, a larger share of the grant was made dependent on parental income. In nominal terms the grant for students with low-earning parents remained between 300 euros and 350 euros monthly (dependent on living at the parents' house) during the 1990s, for students with high-earning parents nominal grants decreased more than 50 percent during the 1990s. Second, students with low-earning parents got access to a loan with a maximum of 150 euros in the early 1990s and over 400 euros at the end of the 1990s. Students typically use the grants, but are very reluctant to take up the loan. Third, the duration of entitlement to grants decreased. Students who started university education before 1990 received grants for a maximum of 6 years, from 1991 until 1995 the entitlement period was 5 years and in 1996 it was reduced to a maximum of 4 years. Also grants can become loans if students did not pass a minimum number of courses.

Undergraduate education is accessible to students who graduated from pre-university track in secondary education and for students from higher vocational education. Universities are not permitted to select students, every student satisfying the entry requirements should be admitted. Traditionally most students entered university after the pre-university track in secondary education. However, during the 1990s entry through higher vocational education became more popular. This is particularly true for economics and business administration where in 2002 around 45 percent of the students entered through higher vocational education compared to only 25 percent in 1992. For Dutch law and psychology these percentages are much lower.

Currently only 6 Dutch universities offer undergraduate programs in economics and business administration, 9 offer an undergraduate in law and 10 offer an undergraduate in psychology. At all universities the nominal duration of an undergraduate program is 4 years (although most students do not actually graduate within this period). In the Netherlands a study is a specialization, students take almost 90 percent of their courses within their chosen study. Undergraduate education is often the final stage of an individual's education. In the Netherlands annually only around 200 Ph.D. students graduate in economics, business administration, law and psychology together, which is about 2.5 percent of the total number of individuals completing undergraduate education. Even though undergraduate programs differ between universities, they are considered to be close substitutes. Oosterbeek, Groot and Hartog (1992) compare the labor market outcomes of students from the different economics departments in the

Figure 1: The total number of students ($\times$ 1000) registered at Dutch universities (source: *Statistics Netherlands*).



Netherlands and find that selection corrected wage differentials are modest.

Figure 1 presents total enrollment at Dutch universities during the period 1992 until 2002. From 1992 until 1998 the total number of students decreased from around 187,500 to just above 160,000. After 1998 the number of students increased again to the level at the beginning of the 1990s. In Figure 2 we present first-year enrollment and the number of students finishing undergraduate education. The number of graduates shows a peak in 1995/1996, due to the fact that the 1990/1991 cohort of students received grants for 6 years and the 1991/1992 cohort for 5 years. The pattern in first-year enrollment follows that of total enrollment closely. At the beginning of the 1990s the size of the relevant birth cohort decreased. In 1992 around 14 percent of the individuals between 18 and 23 years old were enrolled in a university. In 1997 this was 15 percent and it increased further to 17 percent in 2002. The latter can be explained from the increased popularity among graduates from higher vocational education to continue with university education.

Trends in graduation, first-year and total enrollment in economics, business administration, Dutch law and psychology follow the general trends closely. The only exception is that for economics the increase in (first-year) enrollment at the end of the 1990s is somewhat larger than the general trend. Again this is caused by the fact that economics is particularly popular among graduates from higher vocational school.

During the end of the 1990s the Dutch economy experienced a period of

Figure 2: The number of students (× 1000) enrolling in the first year and graduating (source: *Statistics Netherlands*).

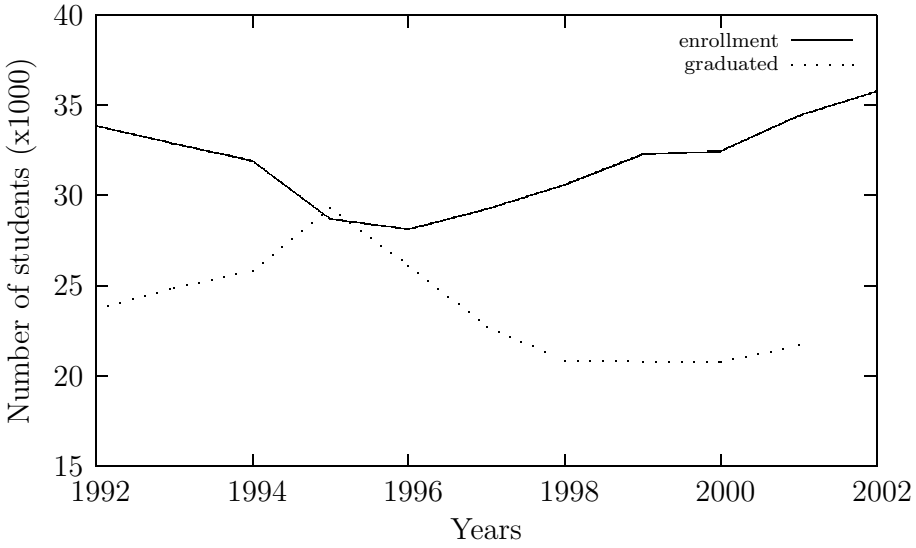


Figure 3: Economic growth measured in percentage increases in GDP (source: *Statistics Netherlands*).

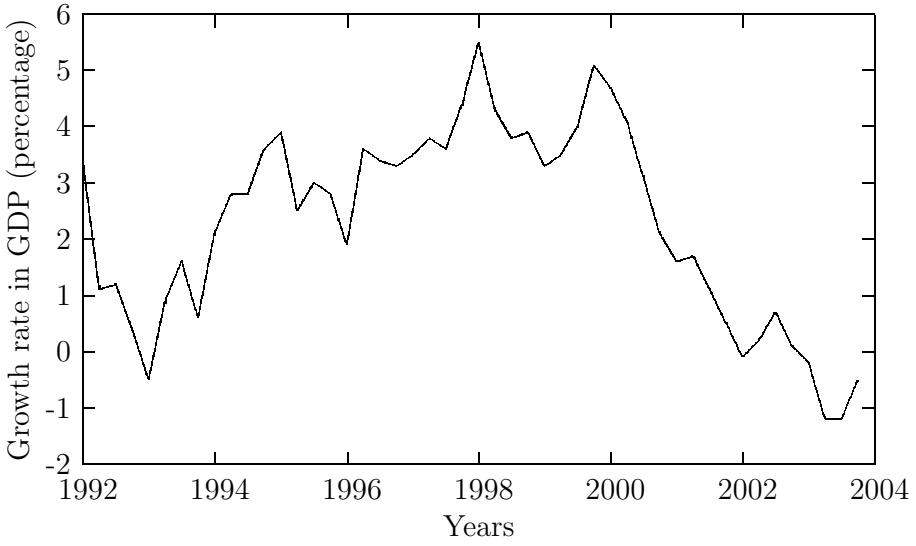
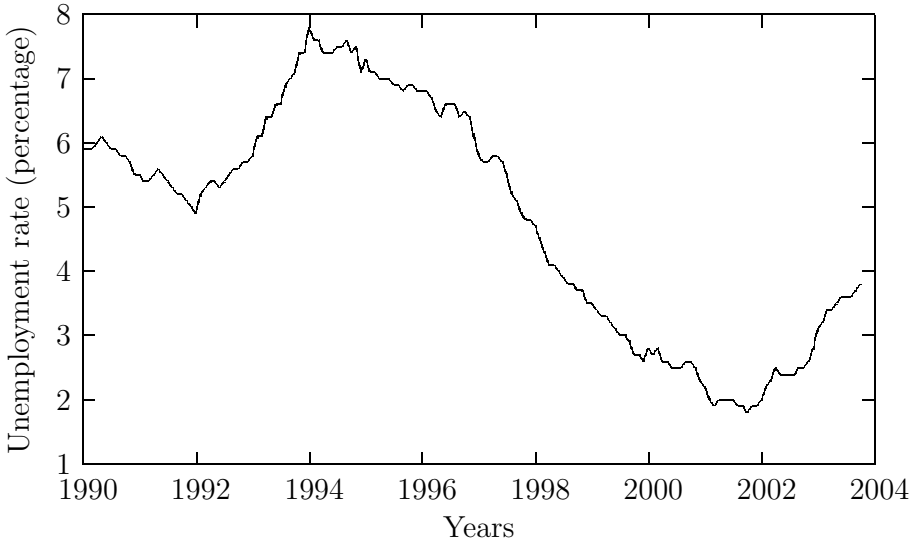


Figure 4: The unemployment rate (in percentage) (source: *Statistics Netherlands*).



relatively large economic growth. Figure 3 provides GDP growth during our observation period and Figure 4 shows the unemployment rate. The year 2000 can be considered as the top of the business cycle. From 1994 until 2000 the growth rate of GDP was increasing and the unemployment rate was decreasing. After 2000 growth in GDP started to decline and at the end of 2001 the unemployment rate started to increase.

3 The model

In this section we present the model that we use to describe the transition from college to work. The model is a discrete-time job search model with endogenous search effort and on-the-job search. Burdett (1978) first derived a job search model that allowed for on-the-job search and Mortensen (1977) explicitly modelled search effort as an individual decision variable. The model imposes that individuals choose their level of job search effort and reservation wage path to optimize their present value of future earnings. Individuals can start searching for work before they graduate, but they (usually) do not start working in a regular job before the actual date of graduation. We assume the moment of graduation to be exogenous and known to the individuals. Usually, students finish their undergraduate study with writing a short thesis (and maybe completing some final courses). Students can graduate each month, but most students graduate in August (slightly over 40 percent in our sample). In the Dutch educational system, students have no incentive to postpone the moment of graduation. High skilled

jobs, at for example international companies, law firms or the government, often require a completed undergraduate education. Furthermore, after graduation individuals are entitled to welfare benefits, which are higher than student grants that only have a limited entitlement period, and while being a students individuals have to pay tuition fees. However, we will allow firms to have some uncertainty about the exact moment of graduation of a student applying for work.

3.1 The search process before graduation

Consider a student τ periods before graduation. The student can be in two possible states, actively searching for work or not searching for work. A student who is searching for work has to decide at the beginning of each period τ how much effort $s_\tau \geq 0$ to devote to job search. There are two types of costs associated to job search effort. First, fixed costs C_0 made only once at the moment the student starts searching for work actively.[2] These fixed costs include for example writing a vitae and a draft of an application letter, registering at public employment offices and private matching agencies, etc. Second, there are some variable costs, denoted by $c_u(s_\tau)$, depending on the amount of job search effort, which involve checking newspapers for job advertisements, sending out applications, etc. A student who is not searching does not have these variable costs, i.e. $c_u(0) = 0$. The costs of devoting job search effort are increasing in the amount of effort, $c'_u(s_\tau) > 0$, and we assume $c''_u(s_\tau) > 0$ (Mortensen, 1986; and Stern, 1989; make similar assumptions to guarantee the existence of a reservation wage).

A student who devotes τ periods before graduation effort s_τ to job search, receives a job offer in this period with probability $0 \leq \lambda_u(s_\tau) \leq 1$. Students who do not devote any effort to job search cannot receive job offers, i.e. $\lambda_u(0) = 0$. Increasing the amount of job search effort increases the probability of receiving a job offer, $\lambda'_u(s_\tau) > 0$, but the returns to job search effort diminish $\lambda''_u(s_\tau) < 0$. A job offer is characterized by its wage w, which is a realization from the (continuous) wage offer distribution function $F_{u,\tau}(w)$ (with finite mean, $\mathrm{E}_{F_{u,\tau}}[w] < \infty$). The wage offer distribution can shift in the period before graduation. This expresses that firms can have some uncertainty about the moment a student will graduate and the skills of the student before all courses are completed. Firms discount this uncertainty in their wage offers, i.e. firms make lower wage offers to a student longer before graduation. For every τ, the wage offer distribution $F_{u,\tau}(\cdot)$ first-order stochastically dominates $F_{u,\tau+1}(\cdot)$, i.e. $F_{u,\tau}(w) \leq F_{u,\tau+1}(w)$ for all $w > 0$. At the moment a job is offered, the student has to decide immediately to accept the job or to reject it and continue searching. We exclude the

[2]Yoon (1981) assumes that a job searcher make some fixed costs in every period.

possibility to reconsider job offers at a later stage. Once the student decides to accept a job offer, he starts working in the new job immediately after graduating. We do not consider the possibility that a student already starts working before graduation. Neither do we allow for the possibility of continuing searching for a better job after a job has been accepted. This assumption simplifies the analysis. Alternatively, we could allow individuals to continue searching after accepting a job. This holds observationally equivalent results, but is in our opinion (only based on anecdotal evidence) a less realistic assumption. An alternative motivation for making this assumption is that a student, who already accepted a job and continues searching for work, might be less credible for other employers.

Individuals have an infinite horizon and they know the values of $\lambda_u(\cdot)$, C_0, $c_u(\cdot)$, and the distribution functions $F_{u,\tau}(\cdot)$. However, they do not know in advance when job offers arrive and what the associated wages are. We assume that students maximize their expected present value of future income. Future income is discounted at the subjective rate $\rho > 0$. For a student who is actually searching for work τ periods before graduation, we define $R_{u,\tau}$ as the present value of search. The Bellman's equation for the student satisfies

$$R_{u,\tau} = \max_{s_t;t=0,\ldots,\tau} \left\{ -\frac{c_u(s_\tau)}{1+\rho} + \frac{\lambda_u(s_\tau)}{1+\rho} \mathrm{E}_{F_{u,\tau}} \left[\max \left\{ \frac{R_e(W)}{(1+\rho)^{\tau-1}}, R_{u,\tau-1} \right\} \right] \right. \\ \left. + \frac{1-\lambda_u(s_\tau)}{1+\rho} R_{u,\tau-1} \right\} \tag{1}$$

where the wage W is a random variable that follows the distribution $F_{u,\tau}(\cdot)$ and $R_e(w)$ is the value of working (after graduation) in a job with wage w. We derive $R_e(w)$ in the next subsection. For convenience we assume that the costs of job search effort $c_u(s_\tau)$ are made at the end of each period. From the Bellman's equation it can be seen that if the student receives a job offer with associated wage w in period τ, he accepts this job offer if the present value of accepting the job $R_e(w)/(1+\rho)^{\tau-1}$ exceeds the value of search $R_{u,\tau-1}$. As will be shown later $R_e(w)$ is an increasing function in w. Therefore, τ periods before graduation there exists a reservation wage ϕ_τ, which is found by solving

$$\frac{R_e(\phi_\tau)}{(1+\rho)^{\tau-1}} = R_{u,\tau-1}$$

Substituting this reservation wage property into the Bellman's equation gives the condition for the optimal reservation wage path

$$R_e(\phi_{\tau+1}) = \max_{s_t;t=0,\ldots,\tau} \left\{ -c_u(s_\tau)(1+\rho)^{\tau-1} + \lambda_u(s_\tau) \mathrm{E}_{F_{u,\tau}} \left[\max \left\{ R_e(W) - R_e(\phi_\tau), 0 \right\} \right] + R_e(\phi_\tau) \right\} \tag{2}$$

Proposition 1 *$\phi_\tau \geq \phi_{\tau-k}$ for all $\tau = 1, \ldots$ and $k = 1, \ldots, \tau$. Before graduation the reservation wage of a student ϕ_τ is non increasing as the moment of graduation approaches.*

Proof in Appendix A.

Given the reservation wage ϕ_τ, the optimal search effort τ periods before graduation maximizes $\phi_{\tau+1}$. The first-order condition for the optimal amount of job search effort s_τ is

$$\frac{c'_u(s_\tau)}{\lambda'_u(s_\tau)} = \frac{1}{(1+\rho)^{\tau-1}} \int_{\phi_\tau}^{\infty} \left[R_e(x) - R_e(\phi_\tau) \right] dF_{u,\tau}(x) \tag{3}$$

The left-hand side is positive and increasing in s_τ (recall that $c''_u(s_\tau) > 0$ and $\lambda''_u(s_\tau) < 0$). A necessary condition for a student to devote a positive amount of effort to job search τ periods before graduation is that

$$\frac{c'_u(0)}{\lambda'_u(0)} < \frac{1}{(1+\rho)^{\tau-1}} \int_{\phi_\tau}^{\infty} \left[R_e(x) - R_e(\phi_\tau) \right] dF_{u,\tau}(x)$$

The right-hand side is positive and decreasing in ϕ_τ, while the left-hand side is constant and positive. Let $\bar{\phi}_\tau$ be the maximum value for which the inequality still holds, which is decreasing in τ. Recall from Proposition 1 that the reservation wage is non decreasing in τ. If in some period τ the reservation wage exceeds $\bar{\phi}_\tau$ the student does not devote any effort to job search in this period, nor has the student devoted any effort to job search in the preceding periods.

Proposition 2 *If $s_\tau > 0$, then $s_\tau < s_{\tau-k}$ for all $\tau = 1, \ldots$ and $k = 1, \ldots, \tau$. Students, who have not accepted a job yet, increase their job search effort as the moment of graduation gets closer.*

Proof in Appendix A.

So far we focused on students who were already actively searching for work. As mentioned above individuals have to make fixed costs C_0 to start searching for work. Consider a student who is not searching for work τ periods before graduation. The present value of this student is defined as

$$V_\tau = \max\left\{\frac{V_{\tau-1}}{1+\rho}, R_{u,\tau} - C_0\right\}$$

This implies that a students decides to start searching for work in this period if

$$R_{u,\tau} - C_0 \geq \max_{t=0,\ldots,\tau-1}\left\{\frac{R_{u,t} - C_0}{(1+\rho)^{\tau-t}}\right\}$$

If we substitute $R_{u,\tau} = R_e(\phi_{\tau+1})/(1+\rho)^\tau$, this condition becomes

$$R_e(\phi_{\tau+1}) - C_0(1+\rho)^\tau \geq \max_{t=0,\ldots,\tau-1}\left\{R_e(\phi_{t+1}) - C_0(1+\rho)^t\right\}$$

Using this inequality we can find the optimal moment τ_0 for a student to start searching for work actively. This moment τ_0 satisfies

$$\tau_0 = \arg\max_{\tau=1,\ldots}\left\{R_e(\phi_\tau) - C_0(1+\rho)^{\tau-1}\right\} \tag{4}$$

The function $C_0(1+\rho)^{\tau-1}$ is the present value at the moment of graduation of the fixed search costs. It is increasing in τ, meaning that the earlier a student starts searching for work, the higher the present value of the fixed search costs. Also $R_e(\phi_\tau)$ is an increasing function in τ, implying that also the payoffs of starting with job search earlier are higher.

Proposition 3 *τ_0 is non decreasing if C_0 decreases, i.e. lower fixed costs of starting job search do not cause a student to start searching for work actively shorter before the moment of graduation.*

Proof in Appendix A.

A student does not start searching at all before graduation if the payoffs of job search do not exceed the present value of the fixed costs, i.e. in each period $\tau = 1, \ldots,$ $R_e(\phi_\tau) < C_0(1+\rho)^{\tau-1}$. Given that a student starts searching for work before graduation, the moment at which the student starts is uniquely determined by equation (4). The function $R_e(\phi_\tau) - C_0(1+\rho)^{\tau-1}$ has a single optimum.

Proposition 4 *The moment τ_0 at which a student starts searching for work is unique or non-existing.*

Proof in Appendix A.

To summarize the behavior of students, prior to period τ_0 the student does not devote any effort to job search and does not obtain any job offers. After that the student starts searching with a relatively low job search effort and increases job search effort each period (until graduation or accepting work). Since the student does not obtain job offers before τ_0, the reservation wage is not specified prior to τ_0. At τ_0 the reservation wage is relatively high. Towards the moment of graduation the reservation wage is at least non increasing, but typically decreasing.

For a student who has not accepted a job until the beginning of period τ, the probability of accepting a job in period τ equals

$$\theta_\tau = \begin{cases} \lambda_u(s_\tau)\left(1 - F_{u,\tau}(\phi_\tau)\right) & \text{if} \quad \tau \leq \tau_0 \\ 0 & \text{if} \quad \tau > \tau_0 \end{cases}$$

Before τ_0 students do not receive job offers and thus the probability of accepting work equals 0. After τ_0, the probability of accepting a job increases as the moment of graduation approaches.

Proposition 5 *$\theta_\tau < \theta_{\tau-k}$ for all $\tau = 1, \ldots, \tau_0$ and $k = 1, \ldots, \tau$.*

Proof in Appendix A.

3.2 The search process after graduation

Upon graduation an individual can either become unemployed or can start working. An individual starts working if he already accepted a job while being student. Individuals can search for a new job when being employed and make a job-to-job transition. We do not allow the possibility that employed workers get fired from a job or that they quit working.[3] Individuals who become unemployed at graduation, either actively searched for work while being student but did not succeed in finding work or did not start searching for work yet.

Consider an individual who did not start working yet. This individual is entitled to collecting a particular type of welfare benefits, denoted by b. Welfare benefits for school leavers are reduced benefits compared to those collected by other welfare recipients, like job losers. The level of benefits depends on the housing

[3]In our data set we hardly observe transitions from being employed to unemployment. Of the individuals who were observed to have had at least 1 job, 99 percent are employed at the end of our observation period.

situation. For most school leavers the level of the monthly gross welfare benefits is about 435 euros. School leavers often qualify for housing subsidies, therefore we set the net monthly benefits level b equal to 450 euros. These welfare benefits are paid for an unlimited period of time. After graduation the structural parameters, $c_u(s)$, $\lambda_u(s)$, and ρ remain the same as before graduation and the wage offer distribution is given by $F_u(w)$. Since the model is stationary (after graduation) unemployed workers choose each period the same amount of job search effort s and the same reservation wage ϕ. Let R_u be the value of search of an unemployed worker. The Bellman's equation for an unemployed individual equals

$$R_u = \max_{s \geq 0} \left\{ \frac{b - c_u(s)}{1+\rho} + \frac{\lambda_u(s)}{1+\rho} \mathrm{E}_{F_u} \left[\max \left\{ R_e(W), R_u \right\} \right] + \frac{1 - \lambda_u(s)}{1+\rho} R_u \right\}$$

From this equation it can be seen that welfare benefits b are paid at the end of each period. The Bellman's equation can be rewritten as

$$\rho R_u = b + \max_{s \geq 0} \left\{ -c_u(s) + \lambda_u(s) \mathrm{E}_{F_u} \left[\max \left\{ R_e(W) - R_u, 0 \right\} \right] \right\}$$

If an unemployed worker receives a job offer with wage w, he accepts the offer if $R_e(w) \geq R_u$. The reservation wage ϕ of the unemployed worker can be found by solving

$$R_e(\phi) = R_u$$

For a given value of ϕ, the optimal amount of job search effort s follows the first-order condition

$$\frac{c_u'(s)}{\lambda_u'(s)} = \int_{\phi}^{\infty} \left(R_e(w) - R_e(\phi) \right) dF_u(w) \tag{5}$$

The left-hand side of the first-order condition is positive, and it is increasing in s. Therefore, a necessary condition for individuals to devote a positive amount of effort to job search is that the reservation wage ϕ should be such that

$$\frac{c_u'(0)}{\lambda_u'(0)} < \int_{\phi}^{\infty} \left(R_e(w) - R_e(\phi) \right) dF_u(w)$$

As the right-hand side is positive and decreasing in ϕ, there exists some reservation wage $\bar{\phi}$ for which an unemployed worker does not devote any effort to job search.

The framework we discussed so far is stationary, which means that as long as an individual is unemployed, the individual has the same reservation wage and

devotes in every period the same amount of effort to job search. It also implies that an individual who does not start searching for work immediately after graduating will never devote any effort to job search and will never start working. This latter contradicts our data as around 20 percent of the individuals have not yet performed any job search activities 1 month after graduation. Almost 10 percent of the individuals have not even started searching for work within 3 months after graduation. These individuals derive for some period an instantaneous utility from not working which is much higher than the welfare benefits level, for example because they planned a long holiday after graduation instead of going to the labor market directly. For individuals who started only some months after graduation, we assume that for a fixed period with length t_0 immediately after graduation their instantaneous utility of being unemployed equals $\bar{b}$. The high value of $\bar{b}$ causes that $\phi > \bar{\phi}$. The individual does not devote any effort to job search for $t_0 - 1$ periods after graduation. For the same reason this individual also does not search for work before graduation. In theory $\bar{b}$ could be infinite, implying that the individual definitely wants to be unemployed for t_0 periods after graduation. We assume that t_0 and $\bar{b}$ are known to the individual already before graduation. Like students, who start searching for work, these individuals have to make fixed search costs C_0 at the moment they first start searching for work ($t_0 - 1$ periods after graduation).

Next, consider an employed individual receiving in each period wage w. While being employed, workers can search for other jobs, but they cannot lose their job. The search process of employed workers is similar to that of students and unemployed workers, but they face different structural parameters. The probability of receiving a job offer equals $\lambda_e(s)$ and wage offers are drawn from the wage offer distribution $F_e(w)$, which have the same properties as $\lambda_u(s)$ and $F_u(w)$ respectively. For employed workers there are only the variable costs $c_e(s)$ of devoting effort to job search, also $c_e(s)$ has the same properties as $c_u(s)$. As mentioned earlier $R_e(w)$ is the value of work with wage w, which comes from the Bellman's equation

$$R_e(w) = \max_{s \geq 0} \left\{ \frac{w - c_e(s)}{1+\rho} + \frac{\lambda_e(s)}{1+\rho} \mathrm{E}_{F_e} \left[\max \left\{ R_e(W), R_e(w) \right\} \right] + \frac{1 - \lambda_e(s)}{1+\rho} R_e(w) \right\} \tag{6}$$

The Bellman's equation implies that wages are received at the end of a period. The equation can be rewritten as

$$\rho R_e(w) = w + \max_{s \geq 0} \left\{ -c_e(s) + \lambda_e(s) \mathrm{E}_{F_e} \left[\max \left\{ R_e(W) - R_e(w), 0 \right\} \right] \right\} \tag{7}$$

From the Bellman's equation follows that $R_e(x) > R_e(y)$ if $x > y$, the value of work increases with the wage received by a worker. Therefore, employed workers accept a job offer if the associated wage exceeds their current wage w. The optimal amount of effort devoted to job search follows from the first-order condition

$$\frac{c_e'(s)}{\lambda_e'(s)} = \int_w^\infty (R_e(x) - R_e(w))\, dF_e(x) \tag{8}$$

Since the right-hand side is a decreasing function in w and the left-hand side is an increasing function in s, the optimal amount of job search effort s is lower if individuals receive higher wages w. Individuals only devote a positive amount of effort to job search if

$$\frac{c_e'(0)}{\lambda_e'(0)} < \int_w^\infty (R_e(x) - R_e(w))\, dF_e(x)$$

Since the left-hand side is positive and the right-hand side is decreasing in w, there is some wage $\bar{w}$ above which employed workers do not search for work anymore.

Proposition 6 *There exists a wage level $\bar{w}$, for which $s = 0$ if $w \geq \bar{w}$. For $w < \bar{w}$, s is positive and decreasing in w. A worker reduces his job search effort if he receives a higher wage. If the wage exceeds a certain level, the worker does not devote any effort to job search (see also Mortensen, 1986).*[4]

Proof in Appendix A.

This proposition implies that above the wage level $\bar{w}$, the value of working $R_e(w)$ equals w/ρ. An individual who reaches a wage level above $\bar{w}$, quits searching for work and stays in this job forever.

3.3 Some remarks on the identification and parameterization

The unknown structural parameters of the model are the wage offer distributions $F_{u,\tau}(w)$, $F_u(w)$ and $F_e(w)$, the job offer arrival probabilities $\lambda_u(s)$ and $\lambda_e(s)$, the variable costs function of job search $c_u(s)$ and $c_e(s)$, the initial costs of starting job search C_0, and the discount rate ρ. Before providing the parameterization of these structural parameters we discuss their identification.

[4]Mortensen (1986) has a continuous-time framework and parameterizes the job offer arrival rate as λs.

Let us for a moment assume that we observe the reservation wage path from the moment an individual starts searching for work. In case we observe the exact moment τ at which the individual accepts a wage offer we can identify the wage offer distribution above the reservation wage $F_{u,\tau}(w|w > \phi_\tau)$. It is well known from Flinn and Heckman (1982) that the tail of the wage offer distribution below the reservation wage cannot be identified without information on wages associated to rejected job offers. Therefore, we cannot identify the wage offer distribution below the lowest possible reservation wage, which is the reservation wage after graduation. A similar identification problem arises for the wage offer distribution of employed workers searching for a new job. An employed worker accepts a new job if the wage offer w exceeds his current wage w_c, so we can identify $F_e(w|w > w_c)$. Again we cannot identify the wage offer distribution below the lowest possible wage at which an individual is working, which is the earlier mentioned lowest possible reservation wage. So we identify $F_e(w)$ on the same support as $F_u(w)$. As will be mentioned below, to establish identification we assume that the shape of the wage offer distribution is known up to a set of unknown parameters.

Before starting the first job, the probability of accepting a job equals $\lambda_u(s_\tau)(1-F_{u,\tau}(\phi_\tau))$. This hazard can be identified from the time individuals have been searching for their first job. Without observing s_τ, we can only identify the job offer arrival rate up to a normalization, as a high job offer arrival rate associated with a wage offer distribution that has some mass below the reservation wage cannot be distinguished from a low job offer arrival rate and a wage offer distribution without any mass under the reservation wage. The identification hinges on the assumption made above that the shape of the wage offer distribution is known up to a finite set of parameters.

The costs function of job search effort is identified from observing job search effort, wages, and reservation wages. Recall that the function for the optimal amount of job search effort is given by equation (3) before graduation and equation (5) after graduation. These equations show that from observing job search effort s we can identify the derivatives of the costs function of job search effort $c'_u(s)$ and $c'_e(s)$. Since $c_u(0) = c_e(0) = 0$, we can actually identify for a given s the costs function $c_u(s)$ as $\int_0^s c'_u(x)dx$ and $c_e(s)$ as $\int_0^s c'_e(x)dx$.

The discount rate ρ is identified from the reservation wage path. In the differential equation (2) describing the optimal reservation wage path all elements except for ρ are identified or observed. So solving the optimal reservation wage path identifies the discount rate ρ. However, estimation of ρ turned out to be problematic even using simulated data. Therefore, we decided not to consider ρ as a parameter to be estimated, but instead to fix its value to 0.20 annually, which gave a better fit than other values we tried.

The initial costs of job search C_0 are identified from the moment a student starts searching for work. Given that we do know all other structural parameters, the value of C_0 is given by equation (4), which ensures that C_0 is identified.

So far, we have supposed that the complete reservation wage path of the unemployed worker is observed. However, the data do not provide reservation wages. Flinn and Heckman (1982) stress that if reservation wages are unobserved, similar identification results can be derived. The identification hinges on the fact that the minimum of the accepted wages equals the reservation wage at graduation.

We allow the structural parameters to be dependent on individual characteristics. Let x denote the vector of individual characteristics (including an intercept). The wage offer distribution can change over time in the period before graduation. To impose some more structure we distinguish the period until three months before graduation and the period from three months before graduation until graduation. Within these periods the wage offer distribution remains the same and follows a lognormal distribution function. Until three months before graduation, the location parameter is given by $\alpha\mu$, afterwards it equals μ. The scale parameter of the wage offer distribution is σ^2. The parameter α reflects the earlier mentioned uncertainty of employers about the graduation date of students. After graduation the wage offer distribution is the same as in the three months before graduation, so lognormal with location parameter μ and scale parameter σ^2. For employed workers the wage offer distribution follows a lognormal distribution function with location parameter $\psi_\mu\mu$ and scale parameters σ^2. The parameter ψ_μ can be interpreted as the returns to early work experience. Furthermore, we let μ depend on individual characteristics by $\mu = x\beta_w$.

The job offer arrival probability of unemployed workers and students follows an exponential distribution with intensity λ

$$\lambda_u(s) = 1 - \exp(-\lambda s) \qquad s \geq 0$$

This functional form ensures that the job offer probability equals 0 if an individual does not devote any effort to job search ($s = 0$) and increases in s. For employed workers we take the job offer probability equal to

$$\lambda_e(s) = 1 - \exp(-\psi_\lambda \lambda s) \qquad s \geq 0$$

The parameter ψ_λ can be considered as a measure for labor market efficiency of employed workers relative to unemployed workers and students. Finally, we allow λ to be dependent on individual characteristics, i.e. $\lambda = \exp(x\beta_\lambda)$.

The costs functions of job search for unemployed workers and students and for employed workers follow

$$c_u(s) = \exp(cs) - 1 \qquad \text{and} \qquad c_e(s) = \exp(\psi_c cs) - 1 \qquad s \geq 0$$

Table 1: Sample size stratified by study.

	Total
Economics	1288
Business (Administration)	741
Dutch Law	875
Psychology	630
Total	3534

These costs functions equal 0 if an individual does not devote any effort to job search and are increasing in s. Like in Fougère, Pradel and Roger (2002) we allow for some unobserved heterogeneity in this costs function. In particular, the parameter c can take the values of some mass points $c_1, \ldots, c_k$ with probabilities $p_1, \ldots, p_k$ (under the restriction $p_1 + \cdots + p_k = 1$).

We do not parameterize the initial costs of job search C_0 as this can easily be estimated nonparametrically. We return to the issue in Subsection 6.1.

4 Data

Our data are from a survey of individuals who completed undergraduate education in the Netherlands.[5] The survey is a written questionnaire which contains questions on education, job search behavior, work history and personal characteristics. Each year in January or February individuals are interviewed who graduated in the academic year two years earlier. For example the sample collected in January 1999 contains individuals who graduated between September 1996 and August 1997. Individuals are interviewed only once and all information is retrospective. The data contain 7 cohorts, interviewed between 1997 and 2003. Yearly around 10,000 questionnaires are sent out and the response rate is between 40 and 45 percent.

Using these cohorts, we take all individuals who graduated in economics, business administration, Dutch law and psychology. Since our model describes individuals who first enter the labor market, we exclude individuals who did part-time education, were over age 30 at the moment of graduation, and who were full-time working before graduation. This results in a data set of 4505 individuals. Furthermore, we exclude 36 individuals, who are unemployed at the moment

[5]For each study a random sample of graduates is selected from the administration of the organization that coordinates enrollment of students at all Dutch universities and that makes the payments of government grants to students.

Table 2: The average real monthly net wage of employed individuals at the moment of the questionnaire (in euros in February 1997).

	Year of interview						
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Economics	1301	1321	1337	1435	1426	1544	1392
Business	1345	1317	1387	1440	1422	1500	1449
Dutch Law	1274	1243	1279	1359	1402	1500	1356
Psychology	1102	1081	1200	1196	1173	1219	1220

of the interview, never searched for work and report not to be interested in working, and 107 individuals whose answers are inconsistent, for example the moment of starting job search is later than the moment they started working or the second job started before the first job. Next we exclude 398 individuals with item nonresponse in the month of graduation or the moment of starting job search. Finally, we exclude 430 individuals who started working freelance, in a family company or their own company, became Ph.D. student or continued with another study. For obvious reasons these individuals do not behave as described by our model, for example they do not have to send application letters to find work. In total the reduced data set includes 3534 individuals. Table 1 provides the sample sizes stratified by study. Individuals within a particular studies can be considered as relatively homogeneous, but there is definitely serious heterogeneity between the groups of students in different studies.

Let us first consider the individual's situation at the moment of the interview. An individual is considered to be employed if he has a job that contains at least 12 contractual working hours. For individuals with a study in economics, business administration or Dutch law employment rates at the moment of the interview are close to 1. For psychology graduates, employment rates at the moment of the interview display an increasing trend over the observation period, from around 0.85 in 1997 to over 0.95 in 2002 and 2003. Conditional on being employed, almost all individuals work full time, the average number of weekly contractual working hours is between 38 and 40 for economics, business administration and Dutch law graduates and about 34 for psychology graduates. For all groups there are no trends over calendar time.

Table 2 provides the real net monthly wages paid at the moment of the survey. These wages are measured in euros in February 1997 (the month of the first wave of the survey). Wages of psychology graduates are typically lower than wages for the other groups. The general picture is that there is an upward trend in real wages (for all groups of graduates) until 2002 and a (small) drop in 2003.

This picture follows the general business cycle closely. Increasing wages can be caused by less frictions in the labor market, i.e. individuals receive more job offers. Therefore, we look at the percentage of individuals who switched jobs at least once before the interview.[6] This job turnover rate is highest among psychology graduates, around 60 percent of the individuals had at least 2 jobs during the observation period and it shows a slightly increasing trend. For all groups about 40 to 45 percent of the individuals held more than 1 job. The data are not only informative on the wage in the job at the moment of the interview, but also on the wage in the first job after graduation. The real wage in this first job follows the same pattern as the current real wage.

The survey asks individuals in which month they graduated and in which month they started searching for work. There does not seem to be any trend in the number of months that students start job search prior to graduation. However, there are some differences between the groups of students. Around 75 percent of the economics and business administration graduates start searching for work before graduation and almost 60 percent started at least 3 months before graduation. For Dutch law and psychology these percentages are lower, around 65 percent start before graduation and slightly less than 50 percent started at least 3 months before graduation.

We see a similar picture for the fraction of students that works immediately upon graduation. There is no clear trend in this fraction within the different groups of graduates, but there are some differences between the groups of graduates. The ranking of the groups by the fraction of working immediately upon graduation largely coincides with the ranking by the fraction that starts job search early. In particular, around 43 percent of the economics and business administration graduates already have work at the moment of graduation, while approximately 33 percent of the Dutch law and psychology graduates start working immediately after graduating. Even though the fraction that works immediately upon graduation is relatively constant over the years, there is in the earlier surveys a downward trend in the fraction of individuals that is still unemployed 6 months after graduation.

The data contain information both about the number of job applications and about the number of job interviews. In the first two surveys individuals were asked about the total number of job applications and job interviews until the moment the first job was accepted. Since 1999 individuals have to report the total number of job applications and job interviews until the moment of the interview. In our empirical analyses we use the number of job applications as a measure for job

[6] In the questionnaire it is explicitly mentioned that individuals should consider job changes within a firm as job-to-job transitions.

Table 3: Number of job applications.

	Year of interview						
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Economics	13.4	12.1	11.6	7.8	5.2	4.7	5.6
Business	9.5	11.8	11.1	8.4	6.0	7.5	9.0
Dutch law	16.8	16.6	15.6	9.8	7.3	5.1	7.0
Psychology	13.3	17.5	14.3	9.9	15.1	13.1	11.0

Explanatory note: In the 1997 and 1998 surveys individuals were asked to report the number of job applications until accepting the first job. Since 1999 individuals have to report the total number of job applications until the moment of the survey.

search intensity. In Table 3 we present the average number of job applications per group of graduates. For all groups, except for psychology graduates, we see a downward trend in the number of job applications. In our empirical analyses we do not use the number of job interviews, but it is interesting to look at job interviews as these provides some insight in the tightness of the labor market. The number of job interviews is relatively constant over time, which implies that in the later years individuals needed less job applications to generate the same number of job interviews. Psychology students need on average the most job applications for obtaining one job interview.

The variables discussed above are the endogenous variables in our structural model. As mentioned in Subsection 3.3 we allow for observed heterogeneity in the job offer arrival rate and the wage offer distribution. Since we will estimate the model separately for each study, the samples are already relatively homogeneous. Due to business cycle variation individuals who graduated in different years faced different labor market conditions. To capture this business cycle variation we use GDP growth and the unemployment rate. We also include a dummy variable for being older than 25 years at the moment of graduation. If an individual is over 25 years old at the moment of graduation, this indicates that either the students entered university via the higher vocational school track or stayed in university for a long time. During our observation period there is a negative trend in the average age at graduation. This negative trend coincides with the shortening of the entitlement period of the government grants (see Section 2). There is no indication that students stayed in university shorter as a consequence of the improved labor market conditions in the later years of the observation period. We include dummy variables for medium grades and for high grades in university. In our sample approximately 53 percent have medium grades and 21 percent high grades. In psychology the percentage of graduates with high grades is slightly

higher than in the other studies, but all percentages are constant over time. We also have information on high school grades, but these are not informative in addition to university grades.

About 53 percent of the individuals in our sample are men. There are large variations between studies. In economics 75 percent of the graduates are men, while in psychology this is only 17 percent. About 50 percent of the individuals have a father with either a degree from higher vocational school or a degree from university. This percentage is the same across studies and over time. And finally we include the region at which an individual lives. We distinguish between living in the west of the Netherlands or the rest of the Netherlands. The west area is the most urbanized area containing the four largest cities in Holland. In this area there are supposed to be more jobs available for university graduates and average wages are also higher. In our sample 65 percent of the individuals live in the west, while 55 percent of the individuals graduated from a university in the west.

5 Reduced-form analyses

In this section we test some predictions of the theoretical model by performing reduced-form analyses.

The theoretical model predicts that conditional on actively searching for the first job, the probability of finding work is per period higher after graduation than before graduation (see Proposition 5). Prior to graduation individuals devote less effort to job search and have higher reservation wages. We use a bivariate hazard rate model to investigate this model prediction. The first hazard describes the transition from not searching to actively searching and the second hazard described the transition from actively searching to finding work. Both hazards are specified in discrete time following logit specifications, containing both observed and unobserved heterogeneity. We allow for interdependency between the hazards

by allowing the unobserved heterogeneity terms to be correlated.[7]

The estimation results are presented in Table 4. For none of the groups we find relevant unobserved heterogeneity in the transition describing the moment students start searching actively for their first job. Conditional on actively searching for work the probability of finding work in a specific month is significantly smaller before graduation than afterwards. This results confirms our theoretical model and holds for all four groups.

It is interesting to pay some attention to the effect of the business cycle indicators on the moment of starting job search. In our framework the effect of the business cycle in the model runs via the job offer arrival rate and the median wage offer. The effect of improved business cycle conditions on the optimal moment at which students start searching for work is ambiguous. Simulation experiments of our theoretical model show that the direction in which business cycle conditions affects the optimal moment of starting job search depends mainly on the variance of the wage offer distribution. If this variance is small, improved business cycle conditions cause students to start searching for work later (in particular if the job offer arrival rate is high).

For psychology students better labor market conditions in the sense of a lower unemployment rate or higher GDP growth cause that students start searching for work later. For all other groups lower unemployment rates have a negative effect while higher GDP growth has a positive effect, making the total effect of a change in the labor market conditions ambiguous. Recall from Figures 3 and 4 that during the observation period the variance in GDP growth and in the unemployment rate are of the same magnitude. Therefore, for business administration students the effect of the unemployment rate dominates, implying that also business administration students start job search on average later in periods of better business cycle conditions. For economics and Dutch law students there is no dominating business cycle effect.

[7]The probability that a students who has not devoted any effort to job search yet starts searching τ periods before graduation equals

$$\frac{\exp\left(\lambda(\tau) + x'\beta_s + v_s\right)}{1 + \exp\left(\lambda(\tau) + x'\beta_s + v_s\right)}$$

where $\lambda(\tau)$ denotes piecewise constant duration dependence. The probability that an individual who is actively searching finds a job in a particular period equals

$$\frac{\exp\left(\delta I(\tau > 0) + x'\beta_w + v_w\right)}{1 + \exp\left(\delta I(\tau > 0) + x'\beta_w + v_w\right)}$$

The parameter δ describes the difference in job finding probabilities before and after graduation. The unobserved heterogeneity follows a bivariate distribution with discrete-mass point.

Table 4: Results of the reduced-form transition model.

	Economics	**Business**	**Dutch law**	**Psychology**
Transition to active job search				
Medium grades	0.061	0.049	−0.122	−0.173
	(0.128)	(0.175)	(0.149)	(0.191)
High grades	0.091	0.144	−0.368	0.036
	(0.164)	(0.222)	(0.189)	(0.211)
Male	0.034	0.146	−0.034	0.172
	(0.126)	(0.145)	(0.138)	(0.190)
Higher education father	0.074	0.090	−0.189	0.135
	(0.115)	(0.141)	(0.130)	(0.138)
Older than 25 years	−0.157	0.024	−0.044	−0.087
	(0.130)	(0.155)	(0.139)	(0.163)
West	−0.029	−0.198	−0.175	0.014
	(0.122)	(0.144)	(0.137)	(0.138)
Unemployment rate	0.079	0.136	0.028	0.146
	(0.039)	(0.046)	(0.041)	(0.042)
GDP growth	0.062	0.047	0.032	−0.045
	(0.029)	(0.037)	(0.032)	(0.038)
Duration dependence				
More than 16 months before graduation	−4.164	−5.224	−5.025	−3.879
	(0.457)	(0.597)	(0.592)	(0.982)
13-15 months before graduation	−3.072	−3.572	−3.850	−2.701
	(0.438)	(0.506)	(0.525)	(0.961)
9-12 months before graduation	−1.699	−2.134	−1.986	−1.545
	(0.402)	(0.453)	(0.413)	(0.936)
7-11 months before graduation	−0.736	−1.110	−0.767	−0.203
	(0.394)	(0.438)	(0.398)	(0.926)
4-6 months before graduation	0.014	−0.301	0.150	0.631
	(0.393)	(0.438)	(0.402)	(0.926)
After 3 months before graduation	0	0	0	0
Transition into first job				
Medium grades	0.086	0.183	−0.314	−0.360
	(0.159)	(0.189)	(0.162)	(0.282)
High grades	−0.010	0.014	0.107	−0.388
	(0.195)	(0.242)	(0.206)	(0.301)
Male	−0.248	−0.253	−0.160	−0.260
	(0.154)	(0.162)	(0.151)	(0.272)
Higher education father	−0.106	0.207	0.042	−0.094
	(0.138)	(0.161)	(0.142)	(0.191)
Older than 25 years	−0.137	−0.051	−0.274	0.312
	(0.156)	(0.173)	(0.152)	(0.222)
West	0.165	−0.243	0.326	0.015
	(0.147)	(0.164)	(0.145)	(0.196)
Unemployment rate	−0.096	0.041	−0.074	−0.070
	(0.049)	(0.053)	(0.043)	(0.057)
GDP growth	0.028	0.053	0.033	−0.052
	(0.036)	(0.042)	(0.034)	(0.050)
Before graduation	−1.481	−1.408	−0.941	−2.246
	(0.248)	(0.267)	(0.239)	(0.856)
After graduation	0	0	0	0

Table 4: (Continued).

	Economics	**Business**	**Dutch law**	**Psychology**
Unobserved heterogeneity				
v_s	−1.481	−1.408	−0.941	−2.246
	(0.248)	(0.267)	(0.239)	(0.856)
v_w^1	∞	−0.475	∞	∞
		(0.319)		
v_w^2	0.025	−0.478	−0.442	−0.356
	(0.387)	(0.531)	(0.339)	(0.471)
$\mathrm{P}(V_s = v_s^1)$	0.201	0.662	0.101	0.439
	(0.061)	(17.407)	(0.055)	(0.050)
$\mathrm{P}(V_s = v_s^2)$	0.799	0.338	0.899	0.561
	(0.243)	(8.901)	(0.494)	(0.064)

According to our theoretical model before graduation the reservation wage is decreasing as the moment of graduation approaches. After graduation the reservation wage is constant. Therefore conditional on having a job at graduation, the wage is positively correlated with the potential search duration (i.e. the duration between the start of active search for work and the moment of graduation). For individuals who start working after graduation, the moment of starting in the first job is not informative on the wage.

Table 5 shows results from two regressions. First, conditional on having work at graduation the first wage is regressed on the potential search duration and individual characteristics. Second, conditional on starting working after graduation, we regress the wage in the first job on the duration between the moment of graduation and the moment of starting the first job and individual characteristics. The potential search duration has a positive (although not for all groups significant) effect on the wage in the first job for individuals who start working immediately upon graduation. This confirms our theoretical model. For individuals who found a job after graduation we do not find evidence that the wage in the first job is correlated to the search duration. For economics and psychology graduates the coefficient is negative and it is positive for the other two groups.

Our theoretical model predicts that the decision to search on the job depends only on the wage. Proposition 6 of the theoretical model shows that only in case the wage in a job exceeds a threshold value an individual does not devote any effort to job search. From our data we can construct which individuals search actively on the job in their first job. First, all individuals who had at least two jobs must have searched on the job in their first job. Second, in the questionnaire it is asked at the moment of the interview the individual actively searches for a new job. Only in case an individual is at the moment of the interview still in his first job and reports not to search actively for work, this individual did not

Table 5: Results of regression on wage in the first job.

	Economics	**Business**	**Dutch law**	**Psychology**
Job found before graduation				
Intercept	7.154	7.216	7.268	7.107
	(0.052)	(0.070)	(0.067)	(0.117)
Period between start job search and graduation	0.010	0.006	0.002	0.012
(in months)	(0.003)	(0.004)	(0.004)	(0.008)
Medium grades	0.065	0.074	−0.032	0.114
	(0.024)	(0.033)	(0.036)	(0.068)
High grades	0.094	0.053	0.028	0.078
	(0.030)	(0.041)	(0.043)	(0.070)
Male	0.067	0.064	0.035	0.028
	(0.022)	(0.027)	(0.030)	(0.069)
Higher education father	0.041	−0.001	0.049	0.031
	(0.021)	(0.027)	(0.029)	(0.048)
Older than 25 years	0.017	−0.002	0.028	0.055
	(0.023)	(0.029)	(0.033)	(0.059)
West	0.015	0.068	0.039	−0.001
	(0.022)	(0.027)	(0.032)	(0.050)
Unemployment rate	−0.026	−0.036	−0.035	−0.032
	(0.006)	(0.009)	(0.009)	(0.014)
GDP growth	−0.003	−0.003	−0.005	0.010
	(0.006)	(0.008)	(0.007)	(0.014)
Job found after graduation				
Intercept	7.204	7.246	7.293	7.102
	(0.050)	(0.068)	(0.067)	(0.118)
Period between graduation and start first job	−0.012	0.002	0.009	−0.023
(in months)	(0.006)	(0.008)	(0.008)	(0.014)
Medium grades	0.068	0.070	−0.030	0.126
	(0.024)	(0.033)	(0.036)	(0.068)
High grades	0.097	0.052	0.029	0.087
	(0.030)	(0.041)	(0.042)	(0.070)
Male	0.067	0.068	0.034	0.015
	(0.023)	(0.027)	(0.030)	(0.070)
Higher education father	0.045	0.000	0.047	0.033
	(0.021)	(0.027)	(0.029)	(0.048)
Older than 25 years	0.006	0.000	0.029	0.054
	(0.024)	(0.029)	(0.033)	(0.059)
West	0.017	0.071	0.035	0.000
	(0.022)	(0.027)	(0.032)	(0.050)
Unemployment rate	−0.027	−0.035	−0.035	−0.027
	(0.006)	(0.009)	(0.009)	(0.014)
GDP growth	−0.004	−0.004	−0.005	0.008
	(0.006)	(0.008)	(0.007)	(0.014)

Table 6: Results of probit model for active job search in first job.

	Economics	**Business**	**Dutch law**	**Psychology**
Intercept	18.243	19.838	21.865	7.484
	(1.522)	(2.036)	(1.931)	(1.708)
Log wage in first job	-2.710	-2.880	-3.119	-0.967
	(0.212)	(0.281)	(0.267)	(0.227)
Employment duration until interview	0.828	0.953	0.696	0.658
(in years)	(0.098)	(0.126)	(0.117)	(0.129)
Medium grades	0.107	0.225	-0.147	0.025
	(0.094)	(0.135)	(0.134)	(0.196)
High grades	0.242	0.068	-0.303	-0.122
	(0.121)	(0.171)	(0.156)	(0.204)
Male	0.090	0.089	-0.373	-0.428
	(0.090)	(0.113)	(0.110)	(0.176)
Higher education father	0.184	-0.066	-0.052	-0.071
	(0.081)	(0.110)	(0.107)	(0.131)
Older than 25 years	0.273	0.302	0.364	0.102
	(0.094)	(0.126)	(0.120)	(0.154)
West	0.190	0.086	0.138	-0.128
	(0.084)	(0.113)	(0.116)	(0.133)
GDP growth	-0.033	-0.073	0.001	-0.060
	(0.026)	(0.035)	(0.032)	(0.039)
Unemployment rate	-0.016	-0.045	0.024	-0.029
	(0.022)	(0.031)	(0.026)	(0.039)

search on the job in his first job.

In Table 6 we provide results from a probit model for actively searching for work in the first job. As regressors we include the wage in the first job, individual characteristics and the employment duration until the moment of the interview. The employment duration is the interval between the moment of starting the first job and the moment of the interview. According to our theoretical model, if it is beneficial for individuals to search on the job, they start immediately upon accepting the job. The estimation results show that indeed for all groups the observed wage in the first job has a significant negative effect on searching on the job. However, also for all groups the impact of the employment duration is significantly larger than 0. This suggests that after accepting a job individuals might wait some period before they start searching for a new job. Alternatively, individuals with short employment duration found their first job late and might have high search costs (recall the unobserved heterogeneity in the search costs function).

The theoretical model predicts that conditional on observing the wage in the first job, the wage in the second job does not depend on the duration in the first job. The wage in the second job is a draw from the distribution function $F_e(w|w > w_1)$, where w_1 denotes the wage in the first job. The wage in the second job is thus positively correlated to the wage in the first job. The wage in

Table 7: Results from regression on the logarithm of the observed wage in the second job.

	Economics	**Business**	**Dutch law**	**Psychology**
Intercept	4.381	3.996	5.668	5.665
	(0.276)	(0.381)	(0.294)	(0.336)
Log wage in first job	0.411	0.460	0.235	0.235
	(0.039)	(0.054)	(0.041)	(0.045)
First job duration (in years)	0.019	0.007	0.017	−0.008
	(0.017)	(0.019)	(0.019)	(0.032)
Medium grades	0.042	0.020	0.007	−0.030
	(0.021)	(0.026)	(0.023)	(0.044)
High grades	0.030	−0.022	0.033	−0.003
	(0.026)	(0.034)	(0.026)	(0.048)
Male	0.011	0.048	0.004	0.037
	(0.020)	(0.021)	(0.019)	(0.043)
Higher education father	0.031	0.021	0.046	0.066
	(0.018)	(0.021)	(0.018)	(0.031)
Older than 25 years	0.033	0.023	−0.006	−0.054
	(0.020)	(0.023)	(0.020)	(0.036)
West	0.012	−0.036	0.030	−0.034
	(0.019)	(0.021)	(0.020)	(0.031)
GDP growth	0.001	−0.001	−0.007	−0.008
	(0.005)	(0.005)	(0.005)	(0.009)
Unemployment rate	−0.018	0.001	−0.028	−0.016
	(0.006)	(0.007)	(0.006)	(0.010)

the second job is only observed if individuals actually found a second job in the observation period.

In Table 7 we show estimation results from regressing the logarithm of the wage in the second job on the logarithm of the wage in the first job, the first job duration, and individual characteristics. Indeed for all groups we find a strong positive correlation between the observed wage in the first job and the observed wage in the second job. And as predicted from the theoretical model for none of the groups the observed duration in the first job has a significant impact on the wage in the second job.

6 Estimation of the structural model

In this section we discuss the estimation of the structural parameters λ, ψ_λ, μ, ψ_μ, σ, c, ψ_c and C_0.

6.1 Preliminary issues

The key problem of estimating the model is that at any point in time the present value of work $R_e(w)$ enters the decision problem of the individual (see Section 3).

Because the model does not provide a closed-form solution for $R_e(w)$, we need to approximate $R_e(w)$.

Proposition 6 shows that there exists a wage level $\bar{w}$ above which employed workers do not search for work ($s_e(w) = 0$ for $w \geq \bar{w}$). This wage level follows from solving

$$\frac{c_e'(0)}{\lambda_e'(0)} = \int_{\bar{w}}^{\infty} (R_e(x) - R_e(\bar{w}))dF_e(x)$$

Because employed workers receiving wages w above $\bar{w}$ stay in their job forever, their present value of work $R_e(w)$ equals w/ρ. Furthermore, we have parameterized $c_e'(0) = \psi_c c$ and $\lambda_e'(0) = \psi_\lambda \lambda$. Therefore, we can determine $\bar{w}$ by solving the condition

$$\frac{\psi_c c}{\psi_\lambda \lambda} = \frac{1}{\rho} \int_{\bar{w}}^{\infty} (x - \bar{w})dF_e(x)$$

Since $F_e(w)$ is specified as a lognormal distribution function, the integral on the right-hand side can be solved analytically.

Given that an employed worker earns a wage w less than $\bar{w}$, the condition for the optimal job search effort is given by equation (8). Solving this condition, given our parameterization provides the optimal amount of job search effort

$$s_e(w) = \frac{1}{\psi_c c + \psi_\lambda \lambda} \left(\log\left(\frac{\psi_\lambda \lambda}{\psi_c c}\right) + \log\left(\int_w^{\infty} (R_e(x) - R_e(w))\, dF_e(x) \right) \right) \quad (9)$$

For employed workers who are actively searching for work, the present value of work $R_e(w)$ does not equal w/ρ, but instead is given by equation (7). If we substitute in this equation the condition for optimal job search effort and the parameterization, we get

$$\rho R_e(w) = w - (\exp(\psi_c c s_e(w)) - 1) + (1 - \exp(-\psi_\lambda \lambda s_e(w))) \frac{\psi_c c \exp(\psi_c c s_e(w))}{\psi_\lambda \lambda \exp(-\psi_\lambda \lambda s_e(w))}$$

Note that $R_e(w)$ depends on $s_e(w)$, which depends on $R_e(x)$ for all $x \geq w$. Therefore, we cannot obtain analytical solutions for $s_e(w)$ and $R_e(w)$. We tried to approximate $R_e(w)$ by different types of polynomials, but we could not find any polynomial that had both an analytic solution for $\int_w^{\bar{w}} (R_e(x) - R_e(w))\, dF_e(x)$ and a sufficiently good fit.[8] Therefore, we use a step-wise approximation for $R_e(w)$.

Note that if $w \geq \bar{w}$, then $s_e(w) = 0$ and $R_e(w) = w/\rho$. Since $F_e(w)$ follows a lognormal distribution function there is an analytic solution for $\int_{\bar{w}}^{\infty} (x - \bar{w}) dF_e(x)$.

[8] Bloemen (2004) approximates $R_e(x) - R_e(w)$ by $(x - w)/(\rho + \sigma)$. Christensen, Lentz, Mortensen, Neumann and Werwatz (2005) use in an equilibrium search model an alternative approximation for $s(w)$ where they let $s(w)$ iterate for different values of w until a fixed point was found. This method yields numerically equivalent results as our approximation.

Next, taking the first-difference with respect to w of both the left-hand side and the right-hand side of equation (7) shows

$$\frac{\partial R_e(w)}{\partial w} = \frac{1}{\rho + \lambda_e(s_e(w))\,(1 - F_e(w))}$$

For a small Δ we can approximate

$$R_e(w - \Delta) \approx R_e(w) - \Delta \frac{\partial R_e(w)}{\partial w}$$

and

$$\begin{aligned}\int_{w-\Delta}^{\infty} (R_e(x) - R_e(w - \Delta))\, dF_e(x) \approx & \int_{w}^{\infty} (R_e(x) - R_e(w))\, dF_e(x) \\ & + (R_e(w) - R_e(w - \Delta)) \left(1 - F_e(w) + \frac{\Delta}{2} f_e(w)\right)\end{aligned}$$

and $s_e(w - \Delta)$ follows from substituting the approximation for this integral in equation (9). So if we start from $R_e(\bar{w}) = \bar{w}/\rho$, $s_e(\bar{w}) = 0$ and the analytic solution for $\int_{\bar{w}}^{\infty} R_e(x) - R_e(\bar{w}) dF_e(x)$, we can approximate $R_e(w)$ and $s_e(w)$ by the recursive formulas above. This approximation provides the behavior of the individual when being employed. Next, we should determine the reservation wage ϕ when being unemployed (after graduation) and the amount of search effort $s_u(\phi)$.

Since we know $R_e(w)$ we can compute for each w

$$s_u(w) = \frac{1}{c + \lambda} \left(\log\left(\frac{\lambda}{c}\right) + \log\left(\int_{w}^{\infty} (R_e(x) - R_e(w))\, dF_u(x)\right)\right)$$

So we can find ϕ by solving

$$\rho R_e(\phi) = b - c(s_u(\phi)) + \lambda_u(s_u(\phi)) \int_{\phi}^{\infty} (R_e(x) - R_e(\phi))\, dF_u(x)$$

The left-hand side is an increasing function in ϕ and the right-hand side is a decreasing function in ϕ. The only numerical complication is that the integral on the right-hand side is taken with respect to $F_u(\cdot)$ instead of $F_e(\cdot)$. Finally, we can use equation (2) and equation (3) to determine the reservation wage path and the amount of job search effort each period before graduation.

We assume that wages are observed with measurement error. Let $\tilde{w}$ denote the observed wage and w is the true wage. These are related according to $\log(\tilde{w}) = \log(w) + \varepsilon$, where ε is normally distributed with mean 0 and variance σ_ε^2.

Job search effort does not have a natural unit. Naturally, one interprets effort as hours spent searching for work, however are data are not informative on this.

Therefore, like Bloemen (2004) we use the number of job applications as a measure for job search. Since making a job application does not always take the same number of hours, we assume that the number of job applications measures job search effort with an error, which has the same properties as the measurement error for observed wages, it is normally distributed with mean 0 and variance σ_s^2.

6.2 Estimation

Our estimation procedure proceeds in two steps. The advantage of a two-step estimation procedure is that we can estimate the initial costs of job search C_0 non parametrically. In the first step of our estimation procedure, we condition on the optimal moment of starting job search. We use the data on job search spells, employment spells, wages and the observed amount of job search effort to estimate the parameters λ, c, ψ_λ, ψ_c, μ, ψ_μ, σ, σ_ε and σ_s. In the second step we use the starting date of job search to estimate the distribution function of C_0. For the ease of presentation we suppress covariates and ignore unobserved heterogeneity in the remainder of this subsection. Because we observe individuals from the start of their career, we do not face initial conditions problems.

Step 1: estimation of λ, ψ_λ, c, ψ_c, μ, ψ_μ, σ, σ_ε and σ_s In the ideal case, we observe for each individual the job search duration before graduation, the period of being unemployed, the number of job applications, the wage in the first job, the length of the first job spell, the wage in the second job, etc.[9] Unfortunately, we do not observe exact job spells, instead we observe the date at which an individual started working in the first job and in the current job, the first wage and current wage, and whether an individual has had one, two, or more jobs before the interview. So for individuals who had more than two jobs, we lack information.[10] To keep the likelihood function trackable, we use only information until accepting the second job. If an individual had more than two jobs, we use the wage in the first job and the duration of the first job spell, i.e. the first job spell ended at least before the current job started.

Individual likelihood contributions depend on the information observed for an individual, for example whether or not the first job was found before or after

[9]Recall from Section 4 that in the 1997 and 1998 surveys individuals were asked about the number of job applications until accepting the first job and in the later surveys individuals had to report all job applications until the moment of the interview. We take account of this in the estimation.

[10]Around 12 percent of the individuals had more than two jobs before the interview. This percentage is highest among psychology graduates with almost 22 percent.

graduation and the number of jobs. We will not show the likelihood contributions for all possible combinations. Instead, we provide insight in the likelihood function by showing some elements.

Let τ_0 denote the period that a student starts searching previous to graduation and let t_0 denote the duration of the search period until finding the first job. If the unemployed worker accepted his first job after graduation ($t_0 > \tau_0$), the likelihood contribution of the first search spell equals

$$\left(\prod_{\tau=1}^{\tau_0}(1-\theta_{u,\tau})\right)(1-\theta_{u,0})^{t_0-\tau_0-1}\theta_{u,0}$$

If the individual started working immediately upon graduation, the likelihood contribution of this search spell is

$$1-\left(\prod_{\tau=1}^{\tau_0}(1-\theta_{u,\tau})\right)$$

For individuals who did not search for work before graduation τ_0 is set to 0.

If an individual had only one job in the observation period, we observe that this individual received a wage $\tilde{w}_1$ and stayed in this job for t_1 periods. If the job was accepted after graduation, the likelihood contribution equals

$$\int_{\phi}^{\infty}\varphi\left(\frac{\log(\tilde{w}_1)-\log(w_1)}{\sigma_\varepsilon}\right)\frac{1}{\sigma_\varepsilon\tilde{w}_1}(1-\theta_e(w_1))^{t_1}\frac{\varphi\left(\frac{\log(w_1)-\mu}{\sigma}\right)\frac{1}{\sigma w_1}}{1-\Phi\left(\frac{\log(\phi)-\mu}{\sigma}\right)}dw_1$$

Because the true wages in the first job is not observed, we integrate over all possible wages in the first job, with the reservation wage ϕ (at the moment of accepting the job) as lower bound. This integral requires numerical integration. The absence of an analytical solution is due to the distribution of the duration of the censored job spell, $(1-\theta_e(w_1))^{t_1}$. If the individual had two jobs, the likelihood contribution becomes slightly more complicated

$$\int_{\phi}^{\bar{w}}\varphi\left(\frac{\log(\tilde{w}_1)-\log(w_1)}{\sigma_\varepsilon}\right)\frac{1}{\sigma_\varepsilon\tilde{w}_1}(1-\theta_e(w_1))^{t_1-1}\theta_e(w_1)$$
$$\times\int_{w_1}^{\infty}\varphi\left(\frac{\log(\tilde{w}_2)-\log(w_2)}{\sigma_\varepsilon}\right)\frac{1}{\sigma_\varepsilon\tilde{w}_2}\frac{\varphi\left(\frac{\log(w_2)-\psi_\mu\mu}{\sigma}\right)\frac{1}{\sigma w_2}}{1-\Phi\left(\frac{\log(w_1)-\psi_\mu\mu}{\sigma}\right)}dw_2\frac{\varphi\left(\frac{\log(w_1)-\mu}{\sigma}\right)\frac{1}{\sigma w_1}}{1-\Phi\left(\frac{\log(\phi)-\mu}{\sigma}\right)}dw_1$$

As the true wages in both the first and second job are not observed, the likelihood contribution contains two integrals. The upper bound in the integral over all possible wages in the first job is now the maximum wage $\bar{w}$ at which the individual

continues on-the-job search. The second integral is over all possible true wages in the second job, the true wage in the second job should exceed the true wage in the first job. The second integral is the convolution of a lognormal distribution and a truncated lognormal distribution function, which has a relatively simple closed-form solution.

Consider that we observe that an individual made $\bar{s}$ job applications until the moment of the interview. For ease of exposition we only discuss the likelihood contribution for an individual who had only one job during the observation period and found this job after graduation

$$\frac{\int_{\phi}^{\infty} \ell(\tilde{s}|t_1, w_1, t_2)\ell(\tilde{w}_1|w_1)\ell(w_1)dw_1}{\int_{\phi}^{\infty} \ell(\tilde{w}_1|w_1)\ell(w_1)dw_1} =$$
$$\frac{1}{\int_{\phi}^{\infty} \varphi\left(\frac{\log(\tilde{w}_1)-\log(w_1)}{\hat{\sigma}_\varepsilon}\right)\frac{1}{\hat{\sigma}_\varepsilon \tilde{w}_1}\varphi\left(\frac{\log(w_1)-\hat{\mu}}{\hat{\sigma}}\right)\frac{1}{\hat{\sigma} w_1}dw_1}$$
$$\times \left(\int_{\phi}^{\infty} \varphi\left(\frac{\log(\tilde{s}) - \log\left(\sum_{\tau=1}^{\tau_0} s_u(\phi_\tau) + (t_0-\tau_0)s_u(\phi) + t_1 s_e(w_1)\right)}{\sigma_s}\right)\frac{1}{\sigma_s \tilde{s}}\right.$$
$$\left.\times\ \varphi\left(\frac{\log(\tilde{w}_1) - \log(w_1)}{\hat{\sigma}_\varepsilon}\right)\frac{1}{\hat{\sigma}_\varepsilon \tilde{w}_1}\varphi\left(\frac{\log(w_1)-\hat{\mu}}{\hat{\sigma}}\right)\frac{1}{\hat{\sigma} w_1}dw_1\right)$$

The search effort before graduation $s_u(\phi_\tau)$, after graduation $s_u(\phi)$ and while being employed $s_e(w_1)$ are computed using the recursive formulas discussed in Subsection 6.1. The integral in the denominator has a closed-form solution, but the integral in the numerator does not have a closed-form solution as it depends on the true amount of search effort. Therefore, this term should be approximated numerically. Similarly, we can derive likelihood contributions for individuals, who never found work and for individuals who had two jobs until the interview.

The only complication in the likelihood contributions above is that some individuals started working immediately upon graduation. In that case, the relevant reservation wage does not equal ϕ, but the reservation wage at the moment of accepting the first job. If the individual started working immediately upon graduation, we summarize over the possible time period in which the individual could have accepted the job.

Step 2: estimation of the distribution function of C_0 In this step we use the observed month of starting job search to estimate the fixed costs of starting job search C_0. Proposition 3 states that the optimal moment of starting job search is a monotone function of C_0. The optimal moment of starting job search is given

by equation (4). Given τ_0 we can bound C_0 by

$$\frac{1}{\rho(1+\rho)^{\tau_0}}\left(R_e(\phi_{\tau_0+2}) - R_e(\phi_{\tau_0+1})\right) \leq C_0 \leq \frac{1}{\rho(1+\rho)^{\tau_0-1}}\left(R_e(\phi_{\tau_0+1}) - R_e(\phi_{\tau_0})\right)$$

For all individuals who started searching for work before graduation, we can compute both bounds for C_0. Recall from Section (3) that individuals who did not start searching for work before graduation receive utility from not working immediately after graduation. This implies that the behavior of these individuals is not informative about C_0. For each study we compute the density function of C_0 and we use kernel smoothing to obtain a relatively smooth density function of C_0.

7 Results

In this section we discuss the estimation results of the structural model. First, we provide the parameter estimates and discuss the fit of the model. Next, we focus on the returns to early work experience.

7.1 Parameter estimates

Students in different studies differ from each other and these differences are most likely not fully captured by the observed individual characteristics. Therefore, we will not focus on the returns to the different studies. Individual characteristics are mainly used as control variables, without giving strong causal interpretations to covariate effects. Table 8 provides the parameter estimates of the structural model.

The χ^2-tests show that individual characteristics are important for economics and business administration students in explaining differences in job offer arrival rates λ. For business graduates, individual characteristics are only jointly significant at a 10%-level. For all groups individual characteristics are jointly significant in the wage offer distribution. Often covariates have opposite effects on the job offer arrival rate and the wage offer distribution, for example, individuals with low grades have at a given search effort higher job offer arrival probabilities (although not significantly) than individuals with high grades who receive on average higher wage offers. In most cases the impact on the wage offer distribution dominates in explaining labor market prospects, i.e. at graduation individuals with high grades have higher reservation wages than individuals with low grades. The opposite impact of covariates on the job offer arrival rate and the wage offer distribution can be explained from individual search behavior. Individuals with

Table 8: Results of the structural model.

	Economics	**Business**	**Dutch law**	**Psychology**
Job offer arrival rate λ				
Intercept	−1.155	−1.133	−1.567	−1.185
	(0.210)	(0.247)	(0.250)	(0.249)
Individual characteristics				
Average level of grades in study				
Medium grades	−0.187	0.008	−0.113	−0.027
	(0.081)	(0.111)	(0.099)	(0.116)
High grades	−0.066	0.018	−0.050	−0.122
	(0.108)	(0.145)	(0.127)	(0.128)
Male	−0.200	−0.239	−0.160	−0.118
	(0.085)	(0.093)	(0.089)	(0.129)
Higher education father	−0.074	−0.083	−0.100	−0.014
	(0.071)	(0.089)	(0.085)	(0.089)
Older than 25 years	−0.025	−0.054	−0.085	−0.097
	(0.078)	(0.100)	(0.094)	(0.099)
West	0.182	−0.096	0.141	0.099
	(0.073)	(0.092)	(0.098)	(0.088)
χ^2-test statistic for joint significance	19.7	11.6	8.6	4.3
Business cycle variation				
GDP growth	0.007	0.014	0.022	−0.008
	(0.018)	(0.023)	(0.021)	(0.025)
Unemployment rate	−0.006	0.004	−0.030	−0.102
	(0.026)	(0.030)	(0.031)	(0.030)
χ^2-test statistic for joint significance	0.4	0.4	3.7	22.5

Explanatory note: The χ^2-test statistic for joint significance is based on a Wald-test.

Table 8: (Continued).

	Economics	**Business**	**Dutch law**	**Psychology**
Mean log earnings level μ				
Intercept	7.231	7.153	7.231	7.289
	(0.029)	(0.037)	(0.034)	(0.051)
Individual characteristics				
Average level of grades in study				
Medium grades	0.060	0.048	0.034	0.014
	(0.012)	(0.016)	(0.017)	(0.032)
High grades	0.088	0.063	0.034	0.049
	(0.015)	(0.021)	(0.022)	(0.034)
Male	0.042	0.065	0.005	0.022
	(0.012)	(0.014)	(0.014)	(0.029)
Higher education father	0.043	0.001	0.060	0.052
	(0.011)	(0.014)	(0.014)	(0.022)
Older than 25 years	0.024	0.006	0.034	−0.023
	(0.012)	(0.015)	(0.014)	(0.025)
West	0.013	0.061	0.049	−0.058
	(0.011)	(0.014)	(0.016)	(0.022)
χ^2-test statistic for joint significance	74.8	51.9	48.1	18.2
Business cycle variation				
GDP growth	0.002	−0.001	−0.004	−0.006
	(0.003)	(0.004)	(0.004)	(0.006)
Unemployment rate	−0.031	−0.025	−0.037	−0.031
	(0.003)	(0.004)	(0.004)	(0.007)
χ^2-test statistic for joint significance	103.4	41.0	75.2	22.6

Explanatory note: The χ^2-test statistic for joint significance is based on a Wald-test.

Table 8: (Continued).

	Economics	**Business**	**Dutch law**	**Psychology**
Additional parameters				
c_1	0.774	1.173	0.746	0.899
	(0.103)	(0.283)	(0.082)	(0.119)
c_2	3.126	3.519	2.923	3.256
	(0.179)	(0.291)	(0.182)	(0.238)
c_3	10.745	14.468	13.943	16.611
	(1.443)	(2.212)	(2.734)	(4.017)
p_1	0.114	0.119	0.202	0.227
	(0.035)	(0.061)	(0.055)	(0.070)
p_2	0.769	0.770	0.740	0.726
	(0.017)	(0.019)	(0.013)	(0.013)
p_3	0.117	0.110	0.058	0.047
	(0.055)	(0.048)	(0.070)	(0.083)
ψ_λ	2.302	2.301	6.972	5.205
	(0.573)	(0.593)	(2.356)	(1.308)
ψ_μ	1.012	1.015	1.007	1.005
	(0.003)	(0.004)	(0.003)	(0.003)
ψ_c	20.365	11.695	22.166	10.752
	(4.513)	(2.433)	(6.802)	(2.236)
α	0.994	0.996	0.986	0.984
	(0.002)	(0.003)	(0.004)	(0.005)
σ	0.078	0.132	0.125	0.131
	(0.011)	(0.015)	(0.015)	(0.017)
σ_ε	0.204	0.171	0.182	0.258
	(0.004)	(0.007)	(0.006)	(0.007)
σ_s	0.763	0.803	0.836	0.774
	(0.024)	(0.032)	(0.030)	(0.036)

favorable characteristics such as high grades might be looking for other types of jobs. Indeed individuals with high grades more often find a first job that requires university education.[11] These jobs pay higher wages, but are more difficult to obtain. Furthermore, males and individuals whose father finished higher education receive better wage offers and have lower job offer arrival rates than their counterparts. For most groups labor market prospects are better in the west of the Netherlands, which is in agreement with the empirical results of Bloemen (2004).

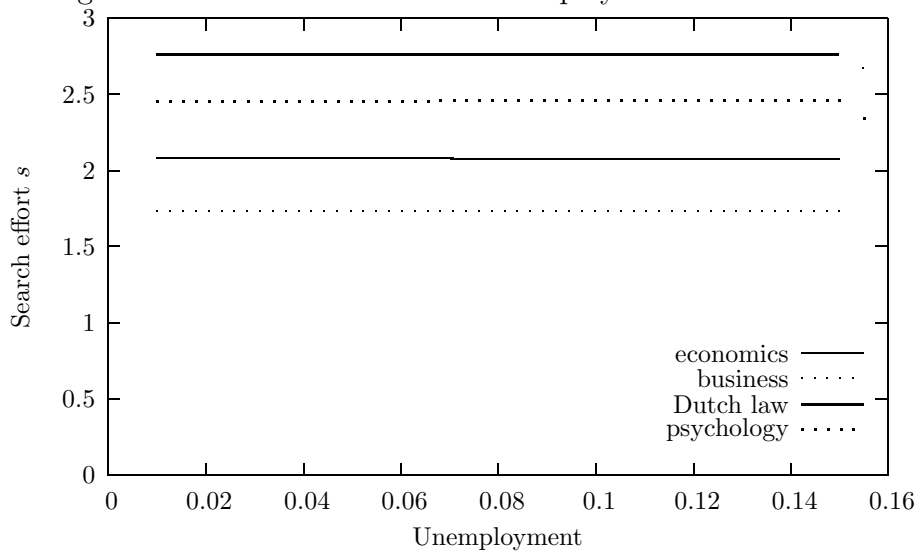
Both the job offer arrival rate and the wage offer distribution depend on the state of the business cycle at the moment of graduation.[12] The indicators for the business cycle are GDP growth and the unemployment rate (see Figures 3 and 4). Because almost all individuals find their job in the time interval from 6 months prior to graduation until 6 months after graduation, we smooth the values for GDP growth and the unemployment rate by taking their average values in this time period. The correlation between the smoothed series of GDP growth and the unemployment rate is -0.40. For all groups the unemployment rate is the more important business cycle indicator than GDP growth. Mean wage offers are significantly lower in periods with high unemployment. The impact of the unemployment rate on the wage offer distribution does not differ much between groups, a 1 percentage point increase in the unemployment rate lowers mean real wage offers with approximately 3 percent. Between the mid-nineties and 2001 the unemployment rate dropped from around 7 percent to 2 percent, implying that real wage offers increased on average 15 percent. Only for psychology graduates the business cycle has a significant impact on the job offer arrival rate. A decrease in the unemployment rate increases the probability of receiving a job offer (at a fixed search effort).

It is interesting to pay some attention to the question why the business cycle only affects the job offer arrival rate of psychology graduates. Recall from Section 4 that labor market outcomes of psychology students are not as good as of the other groups. This suggests that the labor market for psychology graduates is less tight than for the other groups. Finding work has not been the main problem for individuals who graduated in economics, business administration and Dutch law. Therefore, the increased demand for skilled labor associated with the improved

[11] Our data contain some information on job characteristics, such as required level of education and sector.

[12] Ideally, one would like the business cycle to have an ongoing effect on the job offer arrival rate and the wage offer distribution. However, including such business cycle effects in the model requires making assumptions about individuals' predictions of the business cycle and to what extent they are aware of uncertainty concerning economic conditions. In such a model not only the current state of the business cycle is relevant, but also beliefs about future economic conditions directly enter the Bellman's equations described in Section 3.

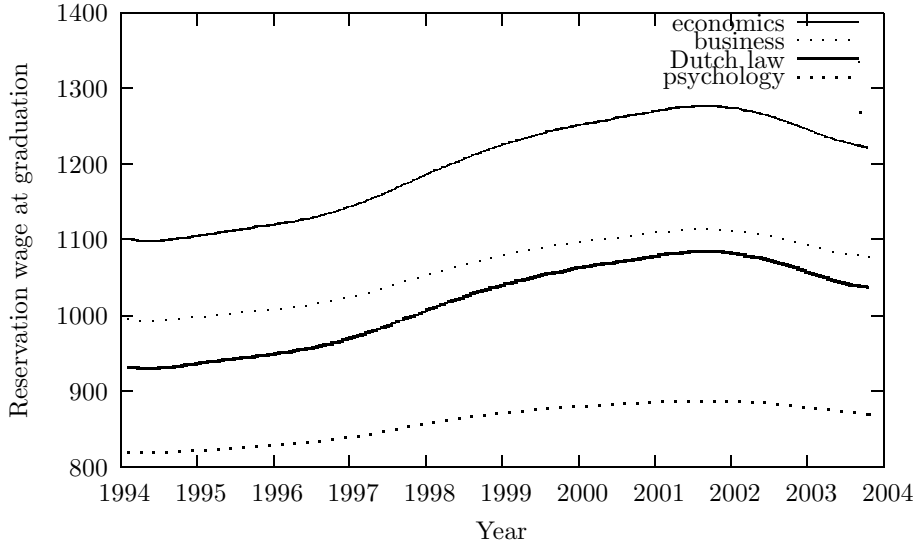
Figure 5: Optimal monthly job search effort (measured in job applications) at the moment of graduation as function of the unemployment rate.



business cycle conditions at the end of the nineties caused employers to raise wages. This is expressed in the increased fraction of individuals who graduates in economics, business administration and Dutch law that finds a first job which requires university education, i.e. this percentage increased from around 60 at the beginning of the observation period until almost 70 in later years. Because psychology graduates had more difficulties finding work, improvements in the business cycle made it more easy for them to find work. However, the percentage of psychology graduates that find a first job which requires university education has been around 50 percent in all years of the observation period. But in the later years they indicate more often that the content of the job connects well to the study.

Shimer (2004) argues that if labor market conditions improve, individuals might lower their job search effort. In our model, the search environment is mainly determined by the unemployment rate. In Figure 5 we show for all groups the average optimal amount of search effort (at the moment of graduation conditional on being unemployed) as a function of the unemployment rate. Dutch law graduates make most job applications per month, on average they write almost 3 application letters per month, while business administration graduates make only around 1.7 job application per month. The optimal amount of job search effort is not sensitive to business cycle variation. This seems to contradict the theoretical predictions of Shimer (2004). However, Shimer (2004) considers a setting where the business cycle only directly affects the job offer arrival rate. If

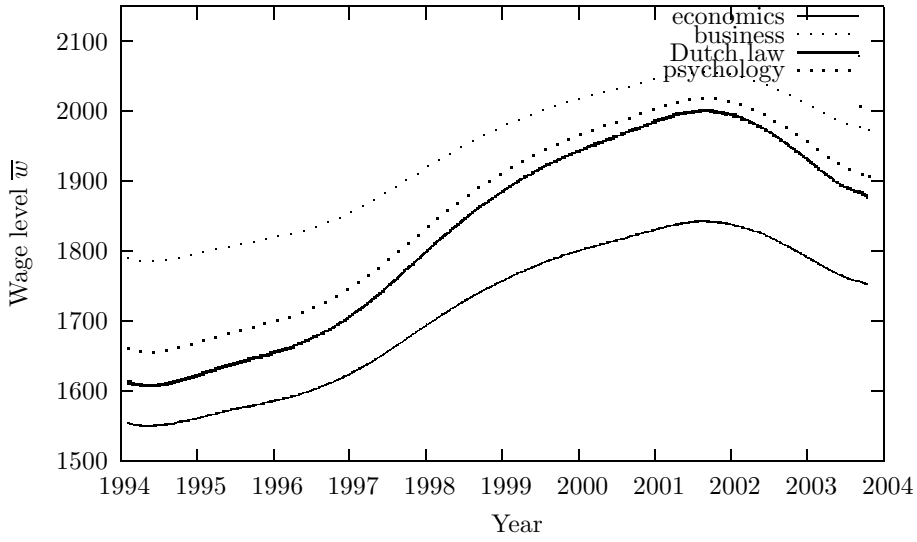
Figure 6: Changes in the reservation wage (ϕ) at the moment of graduation over calendar time.



this would be the case, we would find that higher unemployment increase search effort. Our estimated probabilities of receiving a job offer are much lower than the values Shimer (2004) requires for obtaining his predictions. On average the monthly probabilities of receiving a job offer (at the optimal job search effort at the moment of graduation) do not vary much over calendar time for individuals who graduated in economics, business administration and Dutch law, these probabilities are 0.13, 0.10 and 0.09 respectively. For psychology graduates there is an increasing trend during the observation period in the probability of receiving a job offer. In the beginning of the observation period this probability was 0.09 and it increased to 0.11 at the end of the observation period.

In Figures 6 and 7 we show the estimated reservation wage at the moment of graduation (ϕ) and the estimated lowest wage at which employed workers do not devote any effort to job search ($\bar{w}$). The reservation wage at the moment of graduation is a measure for the labor market prospects of students while the highest wage at which employed workers still search for work reflects the opportunities for employed workers to find better paying jobs. Since unemployed individuals do not change their job search effort over the business cycle, all behavioral responses to business cycle fluctuations are through changes in the reservation wage. Reservation wages are highest for economics graduates and lowest for psychology graduates. Individuals who graduated in business administration continue searching up to a higher wage than the individuals in other groups. This is the result of the relatively high variance in the wage offer distribution σ^2.

Figure 7: Changes in lowest wage at which individuals do not search on the job ($\bar{w}$) over calendar time.



We allowed the variable costs of job search to depend on unobserved heterogeneity. For all groups we found a support of three mass points, where around 75 percent of the probability mass is located to the middle point. For economics and business administration graduates around 11 percent of the individuals have very high search costs, which is around 5 percent for Dutch law and psychology graduates. The average flexible costs of a job application while being unemployed are lowest for economics graduates with 150 euros per application and highest for business administration graduates with 172 euros per application. Job search is much more expensive for employed workers than for unemployed workers, the estimates for ψ_c are for all groups significantly larger than 1. This coincides with the finding of Bloemen (2004) and reflects that the value of leisure is higher for employed workers than for unemployed workers. However, a job application of an employed worker is more likely to generate a job offer than a job application of an unemployed worker, ψ_λ is for all groups significantly larger than 1. It seems that after accepting a first job more jobs become accessible. Bowlus, Kiefer and Neumann (2001) find that the probability of receiving a job offer is lower while being employed than while being unemployed. Our results show this is only because employed workers face higher search costs and therefore make fewer job applications. For all groups we find that on average wage offers are higher while being employed, however this difference is not significant for psychology graduates. Quantitatively the differences are not very large. We return to this issue in the next subsection.

We have allowed for non stationarity in the wage offer distribution of students,

Table 9: Observed and predicted distribution of number of jobs at moment of survey and employment rate at graduation.

	Economics		**Business**		**Dutch law**		**Psychology**	
	pred.	obs.	pred.	obs.	pred.	obs.	pred.	obs.
Number of jobs at survey date								
No jobs	1.6	0.3	2.2	0.1	3.4	0.7	4.2	2.4
1 job	68.7	62.5	68.7	55.3	62.9	53.5	55.8	39.2
2 jobs	23.6	28.4	23.6	34.7	23.6	30.7	25.8	36.5
3 or more jobs	6.0	8.7	6.0	9.9	10.2	15.1	14.3	21.9
Employed rate at graduation	48.9	44.3	45.4	42.6	36.1	32.5	36.4	34.6

until three months prior to graduation the mean wage offers can differ from the period afterwards. This difference is given by the parameter α. For all groups we find that on average wage offers are lower if the remaining time to graduation exceeds three months. Employers are either not willing to commit for longer periods or longer before graduation they are more uncertain about the skills of a student. However, for all groups α is close to 1 and for students in business administration not even significantly different. The uncertainty for employers is not very large.

To get some insight in the performance of the model we report in Table 9 the observed and predicted number of jobs until the survey date and the employment rate at graduation. Our model slightly underpredicts job turnover as measured by the number of jobs individuals have until the moment of the survey. Furthermore, we somewhat overestimate the employment rate at the moment of graduation. The estimated variance of the measurement error can be interpreted as measure for the goodness of fit of the model. The variance in the logarithm of the observed real wages equals 0.0569, 0.0521, 0.0631 and 0.0997 for economics, business administration, Dutch law and psychology graduates respectively. Our model explains 27 percent of the variance in the logarithm of wages for economics graduates, 44 percent for business administration graduates, 48 percent for Dutch law graduates and 33 percent for psychology graduates. Given that our populations are very homogenous the fit of the wages seems reasonably good.

The variance in the observed number of job applications equals 0.8340, 0.9348, 1.0175 and 1.0676 for respectively economics, business administration, Dutch law and psychology graduates. Comparing these variances to the variance in the measurement errors σ_s^2 implies that we can explain 31 percent of the variance in job applications for economic, business administration and Dutch law graduates and 44 percent for psychology graduates. There are three explanations why the fit is not better. First, we seem to underestimate the number of job applications

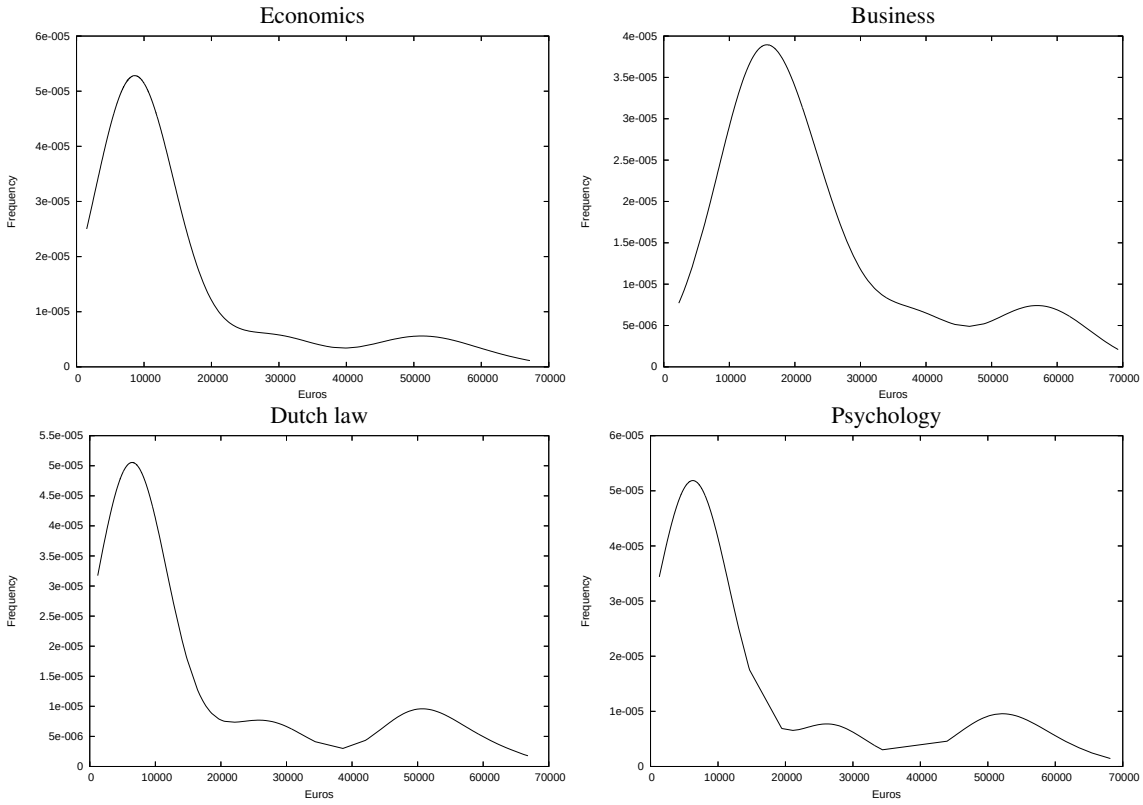
for individuals with short search durations until the first job. Coles and Smith (1998) argue that an individual who starts searching can make job applications to the current stock of vacancies. After the individual is searching for a longer period, the individual can only make job applications to the flow of new vacancies. For a individual who starts job search, finding suitable vacancies is relatively inexpensive and therefore individuals make many job applications in their first search periods.

A second reason why measurement errors are relatively large is that many individuals do not continue searching for work once they start their first job. In the data 47 percent of the economics graduates did not continue searching on the job after accepting the first job, and these percentages are 42, 40 and 21 for business administration, Dutch law and psychology graduates respectively. Using the model we can estimate the fraction of individuals that should search on the job in the first job by $F_u(w \leq \bar{w}|w > \phi)$, where ϕ is the reservation wage at the moment of accepting the first job and $\bar{w}$ is the wage at which individuals quit searching on the job. For all groups at any point in time more than 99 percent of the individuals should search on the job in the first job.

There may be a number of reasons why individuals search less on the job than predicted by our model. After accepting a job individuals may wait some period before they start searching for a next job. Recall from Section 5 that the probability of searching on the job in the first job depends on the job duration. There might be a negative stigma attached to quitting a job soon after starting. Also there may be some fixed costs associated to starting searching on the job. Or it might be the case that firms offer tenure profiles, i.e. individuals know that if they stay in a job their wage will increase gradually over time or that they will get promoted after some period. However, recall that if someone changed job within firms, this should be registered as different jobs. We performed a simple regression of whether individuals continued searching in the first job on the characteristics of the first job. This shows that for all groups the most important reasons not to continue searching are having a permanent contract and the if university education is required for the job. Psychology graduates are also less likely to continue searching for work if the job contains more contractual hours and if they work for the government.

A third possible reason why measurement errors are large is that students might find their first job through an internship. In that case, an individual might not have made any job application. Our data contains some information on the channel through which the first job was found. For roughly 12 percent of the university students the first job follows from an internship. For the studies we consider these percentages are lower, for example 9 percent for economics, with

Figure 8: Non-parametric density estimations of the search start-up costs.



the exception of psychology, where 16 percent of the first job followed after an internship. Most university studies in the Netherlands do not require students to do an internship, which can explain these low percentages.

Figure 8 presents the non-parametric densities of the startup costs for the different studies. In general, the estimated startup costs are large for all groups. These high search startup costs imply that the model has difficulties explaining why individuals start searching for work only shortly before graduation. Given that labor market conditions are very favorable for university graduates, reasonable startup costs between 1000 and 2000 euros imply that students should start searching for work 2 years to 1 year before graduation. Hardly any student starts searching for work this early. Employers might be reluctant to hire a student long before graduation. This would imply that the job offer arrival rate is not constant before graduation, but increasing as the moment of graduation approaches or there is more non stationarity in the wage offer distribution than we allow for. Since our data are not informative on the moment of accepting a job (before graduation), estimating more flexible non-stationary patterns is troublesome.

An alternative explanation is that the time spent on searching for work before graduation might be at the costs of study effort and therefore students postpone searching for work.

Many students start searching for work relatively late and the majority of the students becomes unemployed at graduation. It is interesting to see to what extent the employment rate at graduation can be reduced if students would start searching for work earlier. Let's consider a policy that forces all students to start searching for work actively 6 months before graduation. Such a policy could for example consist of a mandatory course on job search just before the final semester. This policy increases employment rates at graduation substantially to 69 percent for economics graduates, 70 percent for business administration graduates, 61 percent for Dutch law graduates and 64 percent for psychology graduates. These percentages are remarkably close to each other, which suggests that the main reason why employment rates at the moment of graduation for Dutch law and psychology graduates are lower than for economics and business administration graduates, is that they start searching for work later and not that they face more difficulties finding their first job.

7.2 Returns to early work experience

Our model describes individuals who first enter the labor market and who do not have any relevant work experience. In the beginning of a career wages rise faster than at any other point during the life cycle.[13] Topel and Ward (1992) address that wages of young workers may increase with experience even if the true effect of work experience on labor market outcomes is zero. Labor market frictions cause that it takes some time before new entrants in the labor market reach the steady state. Wage increases in the beginning of a career may thus as well be the result of labor market frictions as of accumulated work experience.

In our model work experience is represented by the parameters ψ_λ and ψ_μ. If these parameters equal 1, labor market conditions do not change after an individual accepts his first job and all earnings increases are the consequence of labor market frictions. Recall that for all groups there are significant returns to work experience.

Substantial returns to work experience make the first job a stepping stone towards better jobs. Therefore, individuals will be less selective concerning their first job, i.e. lower reservation wages. Because they also devote more effort to job search, transition rates to work increase and employment rates just after

[13] See Figure 1 in Heckman, Lochner and Todd (2001), which shows that for all levels of education individuals have sharp increases in earnings at the beginning of their career.

Table 10: Results from simulation experiments on the importance on true returns to work experience.

	True returns to work experience	
	Yes	**No**
Average wage in first job (in euros)		
Economics	1330.6	1564.1
Business	1318.3	1555.8
Dutch law	1268.1	1564.7
Psychology	1269.4	1515.0
Fraction changing jobs within year after accepting first job		
Economics	0.36	0.01
Business	0.37	0.01
Dutch law	0.41	0.00
Psychology	0.50	0.02
Average wage increase between first and second job (in euros)		
Economics	207.1	74.4
Business	206.8	73.3
Dutch law	162.5	16.3
Psychology	170.8	77.1

graduation are higher. Returns to work experience have a direct impact on the labor market position after accepting the first job and because individuals have been less selective on choosing their first job, the transition rate out of the first job is higher as well as the expected wage increase between the first and second job. Finally, $\bar{w}$ is higher if there are returns to work experience and thus the expected long-run wage $\mathrm{E}_{F_e}[W|W > \bar{w}]$ will be higher.

We simulate our model twice, first using the estimated parameters and second without returns to work experience $\psi_\lambda = \psi_\mu = 1$. In the latter case all job-to-job transitions and wage increases are the consequence of labor market frictions. In Figures 9 and 10 we show the expected employment rates and the average earnings for the two years following graduation.[14] The difference between both lines in each figure is the result of true returns to early work experience. There are very substantial differences in employment rates with and without true returns to work experience and this difference already exists at the moment of graduation. The existence of true returns to work experience causes individuals to find their first job much faster. The first job is a stepping stone to better jobs and therefore have low reservation wages for the first job. There is also a substantial difference in average earnings with and without true returns to work experience. The difference in earnings in the period just after graduation should be attributed to differences in employment rates, as the average wage in the first job is much lower

[14]In case an individual is unemployed his monthly earnings equal the welfare benefits of 450 euros per month.

Figure 9: Simulated employment rates two years following graduation.

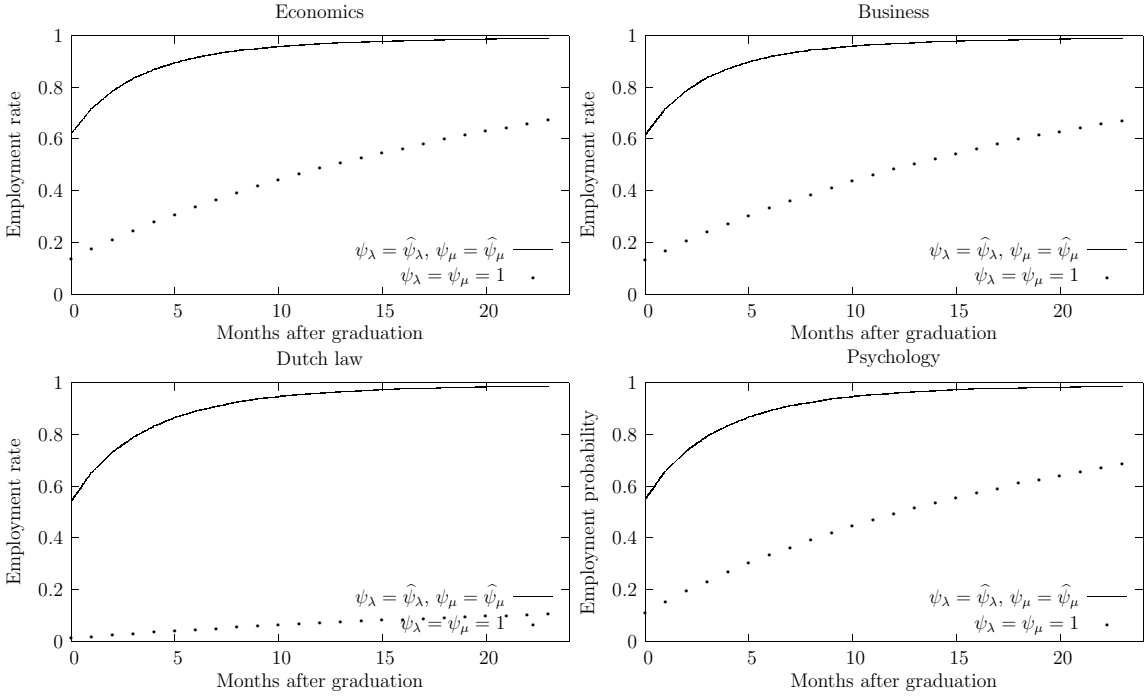
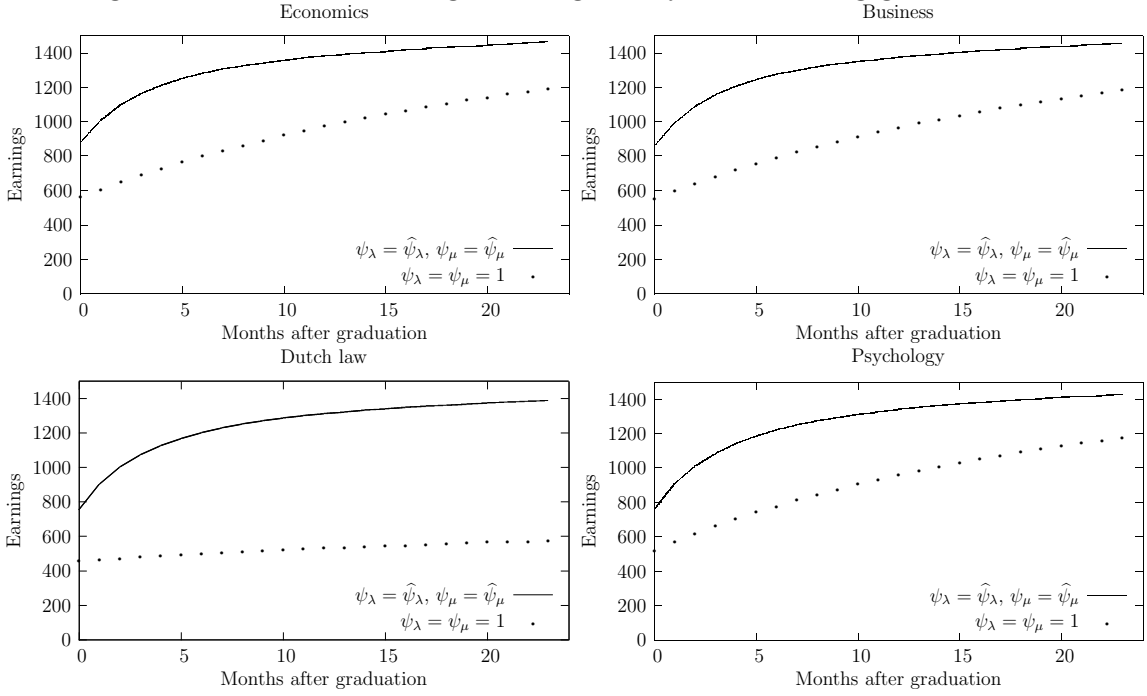


Figure 10: Simulated average earnings two years following graduation



in case there are true returns to work experience (see Table 10). Furthermore, from Table 10 we see if there would be no returns to work experience the fraction of individuals that moves to a new job within a year after accepting the first job is reduced enormously. This reduction in job turnover is the consequence of reduced search effort while being employed due to high costs of on-the-job search. Also the wage increase associated to the move from the first to the second job is much lower if there are no returns to work experience. But this is partly the result of the higher average wages in the first job.

Our simulation experiments indicate that true returns to early work experience have a large impact on labor market outcomes. But in case there are no true returns to work experience, labor market frictions cause that earnings increase over time and individuals switch jobs and experience wage growth. The impact of labor market frictions on average labor market outcomes of a group becomes less if the duration since graduation increases, as individuals reach the steady state of the labor market. Therefore, particularly in the beginning of the life cycle changes in average earnings increases should not all be attributed to accumulated work experience.

8 Conclusion

In this paper we developed a model that describes the labor market behavior of individuals around graduation. We explicitly modelled job search effort and allowed for on-the-job search. Students usually do not start working before graduating, but start searching for work prior to graduation. Therefore, our model is non stationary. In particular, some period before graduation students start searching for work with a low intensity and high reservation wages. As the moment of graduation approaches (and they have not found a job yet), students increase their job search effort and lower their reservation wage. This model explains the common finding that a large share of students starts working immediately after graduating.

Reduced-form analyses show that predictions from our theoretical model are in agreement with our data. In the structural empirical analyses we have used different groups of university graduates in the Netherlands. The data describe a relatively long observation period, which allows to investigate the importance of business cycle variation on labor market prospects. The empirical results indicate that the business cycle is important, in particular the unemployment rate around graduation affects the wage offer distribution. If the unemployment rate decreases with 1 percentage point, wage offers increase on average with 3 percent.

Our model shows that employment rates at graduation could be substantially higher if students would search earlier for work. Currently most students postpone searching for work until only shortly before graduation. Employment rates at graduation could be increased from around 40 percent to 65 percent if all students would start searching for work actively 6 months prior to graduation.

Our results indicate that there are substantial returns to work experience in the beginning of a career. The existence of these returns to work experience have particularly large effects on employment rates just after graduation. This indicates that the first job is often a stepping stone towards better jobs which become only available if an individual has some work experience.

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Appendix A: Proofs of the propositions

Proposition 1 *$\phi_\tau \geq \phi_{\tau-k}$ for all $\tau = 1, \ldots$ and $k = 1, \ldots, \tau$. Before graduation the reservation wage of a student ϕ_τ is non increasing as the moment of graduation approaches.*

Proof of Proposition 1: Rewrite equation (2) as

$$R_e(\phi_{\tau+1}) - R_e(\phi_\tau) = \max_{s_t; t=0,\ldots,\tau} \{-c_u(s_\tau)(1+\rho)^{\tau-1} + \lambda_u(s_\tau) \mathrm{E}_{F_{u,\tau}} [\max \{R_e(W) - R_e(\phi_\tau), 0\}]\}$$

Because $c_u(0) = 0$ and $\lambda_u(0) = 0$, the right-hand side of the equation should be non-negative, which means $R_e(\phi_{\tau+1}) \geq R_e(\phi_\tau)$. $R_e(\cdot)$ is an increasing function in its argument, which implies $\phi_{\tau+1} \geq \phi_\tau$. □

Proposition 2 *If $s_\tau > 0$, then $s_\tau < s_{\tau-k}$ for all $\tau = 1, \ldots$ and $k = 1, \ldots, \tau$. Students, who have not accepted a job yet, increase their job search effort as the moment of graduation gets closer.*

Proof of Proposition 2: Recall that $\phi_\tau \geq \phi_{\tau-1}$. As mentioned above $\int_\phi^\infty [R_e(x) - R_e(\phi)]\, dF(x)$ is decreasing in ϕ, which means

$$\int_{\phi_\tau}^\infty [R_e(x) - R_e(\phi_\tau)]\, dF_{u,\tau}(x) \leq \int_{\phi_{\tau-1}}^\infty [R_e(x) - R_e(\phi_{\tau-1})]\, dF_{u,\tau}(x)$$

Furthermore, because $F_{u,\tau-1}(\cdot)$ first-order stochastically dominates $F_{u,\tau}(\cdot)$,

$$\int_{\phi_{\tau-1}}^\infty [R_e(x) - R_e(\phi_{\tau-1})]\, dF_{u,\tau}(x) \leq \int_{\phi_{\tau-1}}^\infty [R_e(x) - R_e(\phi_{\tau-1})]\, dF_{u,\tau-1}(x)$$

Since $1/(1+\rho)^\tau < 1/(1+\rho)^{\tau-1}$, also

$$\frac{c_u'(s_\tau)}{\lambda_u'(s_\tau)} < \frac{c_u'(s_{\tau-1})}{\lambda_u'(s_{\tau-1})}$$

Because $c_u'(s)/\lambda_u'(s)$ is an increasing function in s, the inequality implies $s_\tau < s_{\tau-1}$. □

Proposition 3 *τ_0 is non decreasing if C_0 decreases, i.e. lower fixed costs of starting job search do not cause a student to start searching for work actively shorter before the moment of graduation.*

Proof of Proposition 3: Consider the case where the fixed costs of starting job search change from C_0 to $C_0' < C_0$. Changing the fixed costs does not affect $R_e(\phi_\tau)$. Therefore, we can rewrite

$$R_e(\phi_\tau) - C_0'(1+\rho)^{\tau-1} = R_e(\phi_\tau) - C_0(1+\rho)^{\tau-1} - (C_0' - C_0)(1+\rho)^{\tau-1}$$

Since for any moment $\tau < \tau_0$

$$R_e(\phi_{\tau_0}) - C_0(1+\rho)^{\tau_0-1} > R_e(\phi_\tau) - C_0(1+\rho)^{\tau-1}$$

we can show that

$$\begin{aligned} R_e(\phi_{\tau_0}) - C_0'(1+\rho)^{\tau_0-1} &= R_e(\phi_{\tau_0}) - C_0(1+\rho)^{\tau_0-1} - (C_0' - C_0)(1+\rho)^{\tau_0-1} \\ &> R_e(\phi_\tau) - C_0(1+\rho)^{\tau-1} - (C_0' - C_0)(1+\rho)^{\tau_0-1} \\ &> R_e(\phi_\tau) - C_0(1+\rho)^{\tau-1} - (C_0' - C_0)(1+\rho)^{\tau-1} \\ &= R_e(\phi_\tau) - C_0'(1+\rho)^{\tau-1} \end{aligned}$$

And thus

$$\arg\max_{\tau=1,\ldots} \left\{ R_e(\phi_\tau) - c_0'(1+\rho)^{\tau-1} \right\} \geq \tau_0$$

□

Proposition 4 *The moment τ_0 at which a student starts searching for work is unique or non-existing.*

Proof of Proposition 4: Note that

$$\begin{aligned} R_e(\phi_{\tau+1}) - R_e(\phi_\tau) = & \max_{s_t; t=1,\ldots,\tau} \left\{ -c_u(s_\tau)(1+\rho)^{\tau-1} \right. \\ & \left. + \lambda_u(s_\tau) \mathrm{E}_{F_{u,\tau}} \left[\max \left\{ R_e(W) - R_e(\phi_\tau), 0 \right\} \right] \right\} \\ = & \ (1+\rho)^{\tau-1} \left\{ \lambda_u(s_\tau) \frac{c_u'(s_\tau)}{\lambda_u'(s_\tau)} - c_u(s_\tau) \right\} \end{aligned}$$

where in the last line s_τ is the optimal amount of job search effort in period τ. The right-hand side is strictly positive. The first term $(1+\rho)^{\tau-1}$ is increasing in τ, but the second term is decreasing in τ, as we know that the term increases in s_τ and $s_{\tau+1} < s_\tau$. Next note that

$$C_0(1+\rho)^{\tau} - C_0(1+\rho)^{\tau-1} = \rho C_0(1+\rho)^{\tau-1}$$

which also increases in τ. Comparing these equations proves that as long as

$$\lambda_u(s_\tau) \frac{c_u'(s_\tau)}{\lambda_u'(s_\tau)} - c(s_\tau) > \rho C_0$$

$R_e(\phi_\tau) - C_0(1+\rho)^{\tau-1}$ increases in τ, otherwise it is decreasing. Since the left-hand side decreases in τ and the right-hand side does not depend on τ, there exists a unique τ_0.

However, if at the optimal moment of starting job search the returns to job search are lower than the present value of the fixed search costs, $R_e(\phi_{\tau_0}) < C_0(1+\rho)^{\tau_0-1}$, the student will not start searching at all before graduation. In this case τ_0 is non-existing. □

Proposition 5 *$\theta_\tau < \theta_{\tau-k}$ for all $\tau = 1, \ldots, \tau_0$ and $k = 1, \ldots, \tau$.*

Proof of Proposition 5: Recall that s_τ is decreasing in τ and ϕ_τ is non decreasing in τ. Since $\lambda_u(s_\tau)$ is an increasing function in s_τ, it is decreasing in τ. Furthermore, because $F_{u,\tau}(\cdot)$ first-order stochastically dominates $F_{u,\tau}(\cdot)$, it holds that $F_{u,\tau}(\phi_\tau) \leq F_{u,\tau+1}(\phi_\tau)$. Since $\phi_{\tau+1} \geq \phi_\tau$, we know $F_{u,\tau+1}(\phi_\tau) \leq F_{u,\tau+1}(\phi_{\tau+1})$. Therefore, $(1 - F_{u,\tau}(\phi_\tau)) \geq (1 - F_{u,\tau+1}(\phi_{\tau+1}))$. As a result θ_τ is decreasing in τ. □

Proposition 6 *There exists a wage level $\bar{w}$, for which $s = 0$ if $w \geq \bar{w}$. For $w < \bar{w}$, s is positive and decreasing in w. A worker reduces his job search effort if he receives a higher wage. If the wage exceeds a certain level, the worker does not devote any effort to job search.*

Proof of Proposition 6: Consider the condition for devoting a positive amount of effort to job search

$$\frac{c_e'(0)}{\lambda_e'(0)} < \int_w^\infty [R_e(x) - R_e(w)]\, dF_e(x)$$

The left-hand side of the equation is positive. The right-hand side is also positive. To show that there exists some $\bar{w}$ above which individuals stop devoting effort to job search, we have to show that the right-hand side is decreasing in w and becomes 0 if w approaches infinity. The derivative of the right-hand side with respect to w equals

$$-\frac{\partial R_e(w)}{\partial w}\,(1 - F_e(w))$$

which is negative, because $R_e(w)$ is an increasing function in w. Next we show that if w approaches infinity the right-hand side of the condition for positive job search effort becomes 0. Note that $R_e(x) - R_e(w) \leq x - w$ for $x \geq w$. This means

$$\int_w^\infty [R_e(x) - R_e(w)]\, dF_e(x) \leq \int_w^\infty (x - w) dF_e(x) = \mathrm{E}_{F_e}[W] - \int_0^w (1 - F_e(x)) dx$$

The wage offer distribution $F_e(\cdot)$ has a finite mean and

$$\lim_{w\to\infty} \int_0^w (1 - F_e(x)) dx = \mathrm{E}_{F_e}[W]$$

Therefore

$$\lim_{w\to\infty}\int_{w}^{\infty}\left[R_e(x)-R_e(w)\right]dF_e(x)=0$$

Next, we already have seen that $\frac{c_e'(s)}{\lambda_e'(s)}$ is an increasing function in s. Since $\int_w^\infty R_e(x)-R_e(w)dF_e(x)$ decreases in w, search effort decreases in w for $w<\bar{w}$. $\square$

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