

Career Progression and Formal versus on the Job Training

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Abstract

This paper evaluates the return to formal education over the life-cycle and compare it to informal, on the job training. More specifically, we assess the apprenticeship system in Germany by comparing the long run value of education choices and subsequent labor market outcomes for apprentices and non-apprentices. We develop a structural model of career progression and educational choice, allowing for unobserved ability, endogenous job to job transition, specific firm-worker matches, specific returns to tenure and to general experience. We estimate this model on a large panel data set which describes the career progression of young Germans. We find that formal education is more important than informal training, even when taking into account for the possible selection into education. We use the estimated model to evaluate the long-run impact of labor market policies on educational choices and career progression. We find that policies such as the Earned Income Tax Credit which subsidize low wage have a detrimental effect on the probability of further education and on job mobility.

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1 Introduction

Public policies that are design to change work incentives can have profound and long term effects on individuals as demonstrated empirically by Cossa et al. (1999). This is not only because current labour market choices may affect future returns to work but also because such programs can affect the returns to education for low skill individuals and as a result change their education choices.

There has been a proliferation of active labour market and welfare to work policies in both the US and Europe. Key examples are the programs in Sweden and the UK (New Deal) as well as the Working Families Tax credit in the UK and the EITC in the US.¹ However the existence of these programs can have a potentially profound effect on the entire life cycle accumulation of Human Capital both in terms of early education choices as well as in terms of labour market careers as pointed out by Cossa et al. (1999).

Welfare to work programs may well encourage on the job training at the expense of formal education. In addition wage floors offered by these kinds of programs may discourage job mobility and change the nature of matching in the labour market.

To address these issues it is necessary to link education choices and labour market careers within a complete life cycle setting and to study the way that incentives at different parts of the life cycle affect education choices. This paper specifies and estimates a life cycle model of education choice and labour market careers for men who complete standard schooling at 16. Individuals face the choice of formal apprenticeship or the standard labour market. Once in the labour market they can search so as to improve the quality of the match. While working they face wage growth by experience and job specific learning. Estimation of such a model requires data on complete work and earnings histories which is available to us. We observe individuals from the moment they enter the labour market, whether as candidate apprentices or as workers. Their complete history is thus available from the age of 16 onwards with all transitions and corresponding wages observed. Moreover the fact that we observe many cohorts allows us to estimate the model over different macroeconomic conditions and hence different opportunity costs

¹Such programs have been evaluated usually ex post and many such examples can be given, such as Heckman et al. (1997) on the US job training Partnership Act (JTPA), Sianesi (2002) for the Swedish programs, Blundell et al. (2003) for the New Deal and Eissa and Liebman (1996) for the EITC are but a few examples.

of education. In fact in descriptive regressions we show that wages in the two sectors (apprentices and non-apprentices) are important determinants of education choice.

The model we estimate combines many features of education choice models (e.g. Taber (2001) and wage growth models (e.g. Topel (1991), Topel and Ward (1992), Dustmann and Meghir (2001), Altonji and Williams (1997) Altonji and Shakotko (1987)) and bears some similarities to the Keane and Wolpin (1997) model. In addition it allows for heterogeneous returns to education, experience and tenure and similarly to the Willis and Rosen (1979) model allows for comparative advantage in education choice. Finally we also model the basic elements of the welfare system to help explain the observed welfare spells.

Estimation of the model provides us with measures of the returns to experience and tenure (and their distribution) as well as the return to apprenticeship training and its distribution. It also provides a way of accounting for the sources of wage growth (learning by doing, search and selection).

Having estimated the model we have a tool that allows us to carry out policy analysis. We thus impose an EITC type program and assess its impact on education choice career progression and wage growth.

Section 2 presents the data set and descriptive statistics. Section 4 presents the model. In Section 5 we display the estimation results. Section 6 we evaluate the effect of in-work benefits.

2 The Data Set

2.1 The Data Set

We use a 1% extract of the German social security records. The data set follows a large number of young individual from 1975 to 1995. For each individual in the sample, we get the exact employment date (starting date, end date) for each job. The data set also reports the daily wage each year if the individual stays an entire year, or for the part of the year the individual works for the firm. We aggregate the data to obtain information on a quarterly basis.

The data set also reports the periods of apprenticeship training. For the purpose of this study, we select our sample to consist only of West-German males, with only post-secondary education and who start either work or an

apprenticeship after school. This is a rather homogenous group of young individuals. We drop all individuals who continue onto higher education, a rather small fraction in Germany.

In total, we follow 27525 individuals through time, quarter after quarter up to 1995. In total, we have 996 872 observations on wages, transitions and education choices. The average age at first observation is 16.7. The oldest individual in our data is 35 years old.

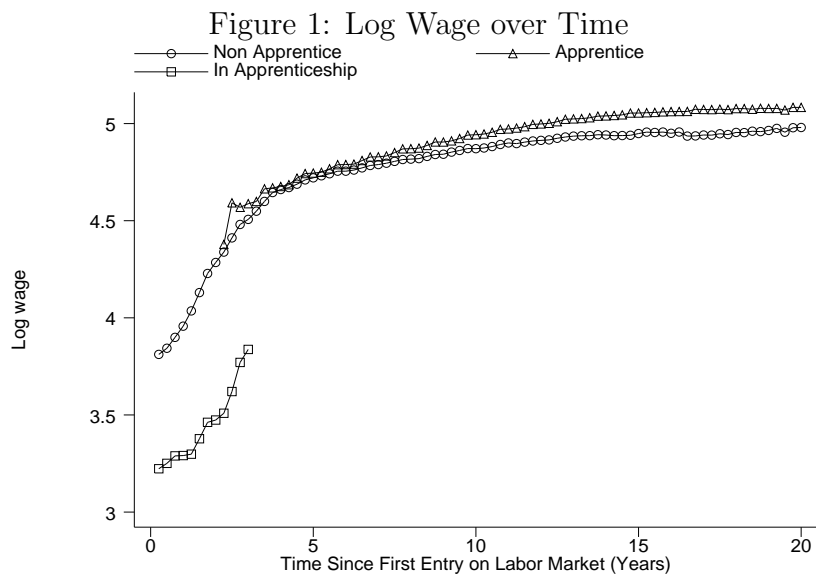
2.2 Descriptive Data

2.2.1 Wage Profile and Labor Market Transitions

Figure 1 displays the log wage profile as a function of years of labor market experience for apprentices and non apprentices. Unskilled workers (non-apprentices) have a rapid increase in their wage during the first five years on the labor market. Over the next fifteen years, the wage growth is only about twenty percent, resulting in a 1.5 percentage growth rate per year (wages have been corrected for inflation). Apprentices in apprenticeship starts at a very low wage, as they are working only part-time. At the end of the apprenticeship training, wages increase up to the level of unskilled wages. From there on, the wages of apprentices increases slightly faster than those of non apprentices at rate of 1.6% per year. After fifteen to twenty years, the difference in wages between skilled and unskilled is about eight to ten percent.

Wages are only one dimension in which education groups may differ. An important dimension is labor market attachment. Table 1 displays the transition probabilities by education groups and time. We distinguish the transition from work to work within and between firms. Unskilled workers have a higher probability of dropping out of the labor force. During the first five years on the labor market, each quarter, about four percent of employed skilled workers exit, while this figure is about eight percent for unskilled. The proportion decreases when we look at more senior workers, but the education difference still persists. The probability of job to job transitions are the same for both education groups, at about two to three percent. This probability decreases with the time since first entry on the labor market.

Unskilled workers have a higher probability of exit from the out-of-labor-force state, about four to five percentage points higher. This only compensates in part, the higher probability of unemployment. In total, unskilled



spend less time working; over 20 years they work a total of 15 years, compared with a total of 16.5 years for skilled workers.

The education differences in exit and entry probabilities implies that non apprentices are more mobile and have more job experiences with more firms than apprentices. Figure 2 displays the number of firms in which an individual has worked in as a function of time since entry on the labor market. The difference comes from the early years, where apprentices (in apprenticeship) are much less mobile.

2.2.2 Decomposing Wage Growth

Next, we try to decompose the wage growth into different components. Figure 4 displays the changes in the log wage for individuals who change jobs. In the first years in the labor market, the wage growth can be substantial, at about 30% for non apprentices and 10% to 20% for apprentices. The gain in wages reduces over time, decreasing towards zero.

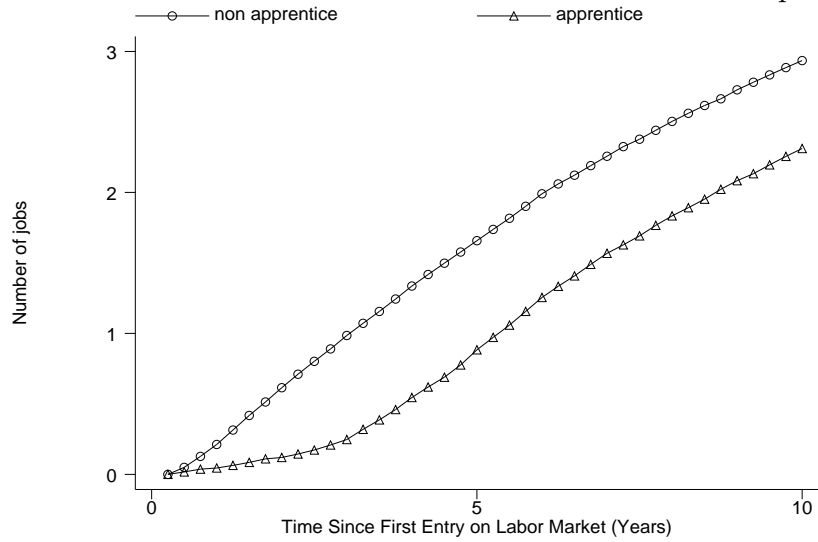
Figure 3 displays the wage growth conditional on staying with the same firm for two consecutive periods. The wage growth is of an order of 1 to 2% and is higher in the first 4 years for non apprentices.

Hence, most of the wage growth is due to job to job transition and very little to gains in experience or tenure. It appears that the rapid wage growth

Table 1: Labor Market Transitions, Quarterly Frequency

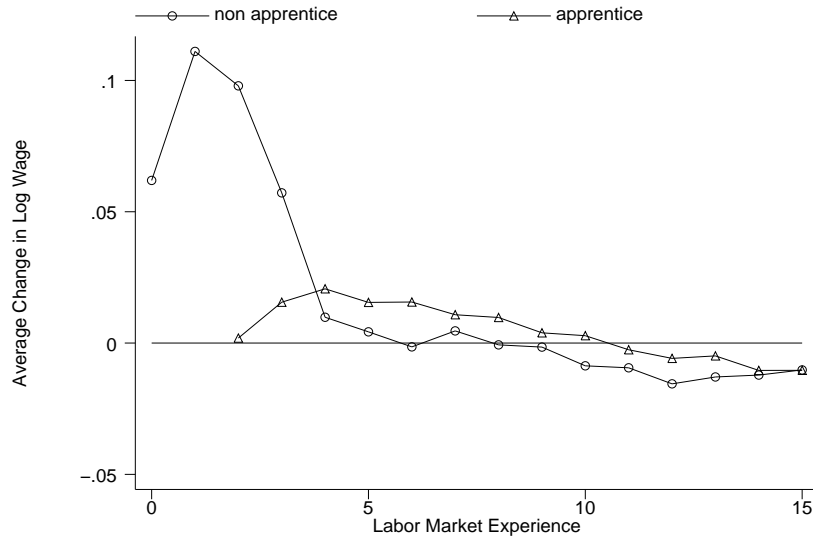
	Work (Same Firm)	Work (New Firm)	Out of Labor Force
Apprentices, First 5 years			
Work	92.8	2.6	4.6
Out of Labor Force	29.6	-	70.4
Non Apprentices, First 5 Years			
Work	88.7	3.0	8.3
Out of Labor Force	25.7	-	74.3
Apprentices, After 5 years			
Work	96.2	1.9	1.9
Out of Labor Force	18.1	-	81.9
Non Apprentices, After 5 Years			
Work	94.4	1.9	3.6
Out of Labor Force	13.1	-	86.8

Figure 2: Cumulative Number of Jobs and Labor Market Experience



of non apprentices is mostly due to better matches and job search in the early years. However, the results in both Figures are potentially biased, because mobility may be endogenous. Our model will be able to disentangle the selection effect from the determinant of wage growth.

Figure 3: Annual Changes in Log Wage (Within) and Labor Market Experience



2.2.3 Education Choices

Table 2 presents the marginal effect of the determinants of going into apprenticeship. In particular, we regress an indicator of apprenticeship on local wages, both skilled and unskilled, *at the time of the decision*. We also include regional indicators as well as time dummies. As apparent, educational choices are influenced by local labor market variables. This provides us with an exogenous variation that shifts the decision of apprenticeship and will help us, in the structural model, to identify both unobserved heterogeneity and the effect of wages on education decisions.

Figure 4: Changes in Log Wage (Between) and Labor Market Experience

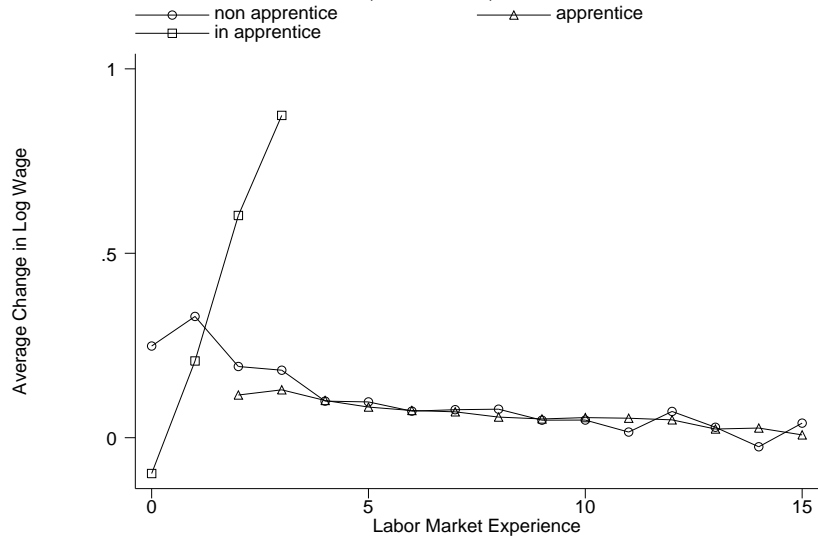


Table 2: Local Wage Effects on Apprenticeship Decision. Marginal Effects

Variable	Marginal Effect	s.e.	t-stat
Local wage Apprentice	.128393	.051	2.49
Local wage Non Apprentice	-.0365127	.025	-1.41
Region 2	.0225809	.023	0.92
Region 3	-.0423446	.029	-1.53
Region 4	.0170435	.021	0.79
Region 5	.0275428	.027	0.94
Region 6	-.0454237	.022	-2.11
Region 7	.0165816	.021	0.76
Region 8	.0243119	.021	1.09
Region 9	-.0119084	.021	-0.55
Region 10	.0569074	.018	2.79
Region 11	-.1495905	.034	-4.97

Note: The regression also controls for time effects.

3 An Overview of the model

The model we describe takes individuals from the first point at which they make a choice and follows them to mid career. This exploits the key advantage of the data that provides information from the first point where there is a choice to be made implying no initial conditions problem and all education and career choices are observed. We focus on the population that drops out of formal academic schooling at 16 years of age and at that point just has the choice of following an apprenticeship or entering the labour market as an unskilled worker. We allow for a production function where unskilled labour and apprentices are not perfectly substitutable. Hence, the relative price of the two types of human capital will be allowed to vary over time. Utility is linear in earnings so in our model liquidity constraints are not an issue since the timing of consumption is irrelevant. We also allow for a utility of leisure by allowing the weight of income to be different when employed from when one is unemployed as well as by an intercept shift in the utility.

At the start individuals choose whether they will take the apprenticeship route, which offers formal on the job and classroom training at a reduced wage, or no formal training. In taking this decision they trade-off current earnings of an unskilled worker with working at a lower wage and possibly obtaining an improved career path through the formal training. The information they possess at that point is the distribution of idiosyncratic match specific shocks as well as the distribution of aggregate shocks that affect the evolution of relative prices in the two skill categories. They also know their type/ability which affects a number of aspects of their career, namely the costs of education, the wage level as well as the returns to experience and tenure, which are heterogeneous in our model. From an econometric point of view it is worth noting that the time variation of unskilled wages relative to skilled ones will help identify the model.

Once the education choice has been made the individual starts up on his career. First we allow for the possibility that during his apprenticeship he may move to a new employer. Once apprenticeship is completed or from the point of initial “entry” in the labour market for the non-apprentices job offers arrive at some rate, which may differ depending on whether the worker is employed or not. Associated with an offer is a draw of a match specific effect which defines the initial wage level given the person’s type and experience. This then evolves as a random walk while the worker remains on the job. In addition the job offer is associated with “fringe benefits” for the job.

The model is set in discrete time. In choosing the time period we needed to address the facts that a) within a firm pay increases are only visible to us at the end of the calendar year; however b) workers may change employer or stop working at any point in time. If they move to a new employer we observe a pay change. To be able to capture the richness of the data without making the model intractable we chose the time period to be a quarter. However, we restrict the arrival of the shocks to the match specific effects to occur only once a year on average.

Apprenticeship lasts more than one period, typically two years in the manufacturing industry, three years in banking services. However both the sectoral choice and the apprenticeship period are both assumed exogenous in this study. Individuals who complete an apprenticeship are hereafter designated as skilled workers ($E = s$), while those who choose the direct labour market route are labelled unskilled workers ($E = u$).

The dynamics in the model are due to the effects of apprenticeship education on future outcomes, the effects of experience and tenure, the different arrival rates of job offers between the employed and the unemployed and the effects of earnings on future unemployment benefits. We now describe the model formally and then discuss estimation.

4 A formal presentation of the model

Time is discrete and individuals live H periods. At $t = 0$ an individual can either leave school and take a regular job or become an apprentice. Apprenticeship lasts τ^A units of time. This training duration is exogenously determined and depends on the particular sector of activity the individual applies to (typically two years in the manufacturing industry, three years in banking services). This sectoral choice may be endogenous but we neglect that possibility. Former apprentices are hereafter designated as skilled workers ($E = \text{“S”}$), school dropouts are unskilled workers ($E = \text{“U”}$). The skill indicator E takes on value “A” while the individual is in apprenticeship.

4.1 Business cycle

We consider a stationary economy subject to exogenous macroeconomic shocks. We assume that the economy fluctuates in a stationary way around a deterministic trend. After detrending, the macro shock is an AR(1) process

$$G' = \rho G + v, \quad v \sim IID, \mathcal{N}(0, \sigma_v^2). \quad (1)$$

In practice, we discretize this AR(1) process into a Markov process of order one. The macro shock is relevant because it potentially affects the relative price of the two skill groups as well as the relative attractiveness of being out of work.

4.2 Instantaneous Rewards

Wages are match specific and there are non-wage benefits to working that vary across firms. Thus, when a worker and a firm meet, they draw a match specific effect comprising a monetary part, κ_0 directly affecting the wage received, and a non monetary part μ affecting the utility of the job. Both of these components are normally distributed ($\kappa_0 \sim \mathcal{N}(0, \sigma_0^2)$ and $\mu \sim \mathcal{N}(0, \sigma_\mu^2)$). We allow the monetary value of the match to follow a random walk:

$$\kappa_t = \kappa_{t-1} + u_t, \quad u_t \sim \mathcal{N}(0, \sigma_u^2)$$

making it time-varying but persistent. A job offer always consists of a new draw from the distribution of κ_0 and μ . These draws are not correlated across job offers, although individual choice will induce a correlation of realized offers.

Wages or earnings, denoted by $w(E, G_t, X_t, T_t, \kappa_t, \varepsilon)$, are skill-specific (E) functions of the macroeconomic environment G_t , experience X_t , tenure T_t , of the current value of the match-specific effect κ_t and of unobserved heterogeneity, denoted by ε .

Workers are assumed risk neutral which also implies that liquidity constraints are not an issue of concern for this model. Thus the instantaneous utility of a worker is defined as his wage plus the non wage value of the match (expressed in monetary terms):

$$R_W = w(E, G_t, X_t, T_t, \kappa_t, \varepsilon) + \mu$$

While unemployed, the individual derives a utility from unemployment benefits calculated as a fraction of the last wage when employed, as in the German UI system. In addition, there is a utility of leisure $\gamma_0^\varepsilon(E, X, \varepsilon)$,

which varies across individuals on the basis of education, experience X , the unobserved heterogeneity component ε and an i.i.d shock η :

$$R_U(E, X, w_{-1}, \varepsilon, \eta) = \gamma_U w_{-1} + \gamma_0^\varepsilon(E, X, \varepsilon) + \eta$$

4.3 Employment transitions

Denote $W^\varepsilon(E, G, X, T, \kappa, \mu)$ the intertemporal utility flow of an individual who is working and by $U^\varepsilon(E, G, X, w_{-1}, \eta)$ the flow of utility for an unemployed person. These allow for optimal actions in the future.

These values are defined recurcively. Thus the value of unemployment is defined by

$$\begin{aligned} U^\varepsilon(E, G, X, w_{-1}, \eta) &= R_U(E, X, w_{-1}, \varepsilon, \eta) \\ &+ \beta \pi_U(E, X) \mathbb{E}_{(G', \eta', \kappa'_0, \mu')} \max \left(\begin{array}{l} U^\varepsilon(E, G', X, w_{-1}, \eta') \\ W^\varepsilon(E, G', X, 0, \tilde{\kappa}'_0, \tilde{\mu}') \end{array} \right) \\ &+ \beta (1 - \pi_U(E, X)) \mathbb{E}_{(G', \eta')} U^\varepsilon(E, G', X, w_{-1}, \eta') \end{aligned}$$

The variable with a prime denotes next period values and β is the discount factor. With a probability $\pi_U(E, X)$, the individual receives a job offer in the next period defined by the match specific characteristics $(\tilde{\kappa}'_0, \tilde{\mu}')$. He then decides whether to accept the offer or to decline it and wait until the next period and resample, possibly obtaining a better offer. The potential difference in the arrival rate of offers creates an option value to waiting. If the offer is accepted however, the worker starts with zero tenure T in the new firm. If the individual does not receive a job offer, then he stays for one more period in unemployment. If he does not receive a job offer, which happens with probability $(1 - \pi_U(E, X))$ he has no choice and receives the expected flow utility of unemployment from the next period on.

We define the value of working by:

$$\begin{aligned} W^\varepsilon(E, G, X, T, \kappa, \mu) &= w(E, G_t, X_t, T_t, \kappa_t, \varepsilon) + \mu \\ &+ \beta \delta(E, X) \mathbb{E}_{(G', \eta')} U^\varepsilon(E, G', X', w(E, G, X', T', \kappa), \eta') \\ &+ \beta (1 - \delta(E, X)) \pi_W(E) \mathbb{E}_{(G', \eta', u', \kappa'_0, \mu')} \max \left(\begin{array}{l} U^\varepsilon(E, G', X', w(E, G, X', T', \kappa), \eta') \\ W^\varepsilon(E, G', X', T', \kappa + u', \mu) \\ W^\varepsilon(E, G', X', 0, \tilde{\kappa}'_0, \tilde{\mu}') \end{array} \right) \\ &+ \beta (1 - \delta(E, X)) (1 - \pi_W(E)) \mathbb{E}_{(G', \eta', u')} \max \left(\begin{array}{l} U^\varepsilon(E, G', X', w(E, G, X', T', \kappa), \eta') \\ W^\varepsilon(E, G', X', T', \kappa + u', \mu) \end{array} \right) \end{aligned}$$

With a probability $\delta(E, X)$, the worker loses his job and has no option but to go next period into unemployment. If the job is not destroyed, the individual gets an outside offer with a probability $\pi_W(E)$, which depends on the education level E . The outside offer is a pair $(\tilde{\kappa}_0, \tilde{\mu})$, to be compared with the value of the current match as it will be in the next period, i.e. $(\kappa + u', \mu)$. The individual then decides whether to stay in the same job, to accept the outside offer or to go into unemployment. If no outside offer is received, the worker only decides on whether to stay on the same job or to quit into unemployment.

A key point is that the effect of the business cycle on wages is allowed to differ by education group. This allows for the relative prices of the two education levels to change with the cycle reflecting the possibility that the two labour factors may not be perfectly substitutable.

Experience X and tenure T grow by one in each period of work. Tenure is set to zero at the start of a new job; we do not allow for depreciation of skills while unemployed.

4.4 Educational choice

After completing high school at 16, an individual can work in a regular job or start as an apprentice, always with experience X being zero at that point.² Apprenticeship lasts τ^A periods. We take the actual length of the apprenticeship as exogenous and we condition on it. The decision of whether to follow formal training will depend on the opportunity cost of doing so and this in turn depends on the current economic environment reflected in the value of the business cycle indicator G . This drives the relative wage of the apprentices and non-apprentices and is observable. It will also depend on expectations about future returns as well as on the unobserved ability ε characterising the individual. It is a key feature of our model that it uses the business cycle fluctuations as identifying information for who decides to move into formal on-the-job training and who decides to obtain a regular job.

The value of apprenticeship W_A^ε is similar to the value of employment W^ε except that the training firm pays the worker only a fraction λ_A of his productivity as an unskilled worker ($w^\varepsilon(0, G, X, T, \kappa)$), the rest presumably

²He can also continue with an academic stream of education. However we condition on stopping full time academic education at 16.

serving as payment for the general training received. In addition, we do not allow individuals to experience unemployment during apprenticeship, although he can decide to change firm if the opportunity arises, which reflects the facts in the data. Thus during the apprenticeship training period ($X < \tau^A$) the value of work is:

$$\begin{aligned} W_A^\varepsilon(G, X, T, \kappa, \mu) &= \lambda_A \cdot w^\varepsilon(0, G, X, T, \kappa) + \mu \\ &+ \beta \pi_A \mathbb{E}_{(G', u', \kappa'_0, \mu')} \max \left(\begin{array}{c} W_A^\varepsilon(G', X', T', \kappa + u', \mu) \\ W_A^\varepsilon(G', X', 0, \tilde{\kappa}'_0, \tilde{\mu}') \end{array} \right) \\ &+ \beta(1 - \pi_A) \mathbb{E}_{(G', u')} W_A^\varepsilon(G', X', T', \kappa + u', \mu) \end{aligned}$$

With a probability π_A , the apprentice gets an outside offer ($\tilde{\kappa}'_0, \tilde{\mu}'$) and choose optimally. If no offer is received, the apprentice stays on for one more period and accumulates experience and tenure within the firm.

At the end of the training period ($X = \tau^A$), he may stay in the same form or not, and he may also choose to stop working. This the value of work now becomes

$$\begin{aligned} W_A^\varepsilon(G, X, T, \kappa, \mu) &= \lambda_A \cdot w^\varepsilon(0, G, \tau^A, T, \kappa) + \mu \\ &+ \beta \pi_A \mathbb{E}_{(G', \eta', u', \kappa'_0, \mu')} \max \left(\begin{array}{c} U^\varepsilon(1, G', X', 0, \eta') \\ W^\varepsilon(1, G', X', 0, \tilde{\kappa}'_0, \tilde{\mu}') \\ W^\varepsilon(1, G', X', T', \kappa + u', \mu) \end{array} \right) \\ &+ \beta(1 - \pi_A) \mathbb{E}_{(G', \eta', u')} \max \left(\begin{array}{c} U^\varepsilon(1, G', X', 0, \eta') \\ W^\varepsilon(1, G', X', T', \kappa + u', \mu) \end{array} \right) \end{aligned}$$

Apprenticeship is the chosen decision at $X = 0$ if the value of apprenticeship at that point is larger than the value of working without vocational training:

$$W_A^\varepsilon(G, 0, 0, \kappa_0, \mu) - \lambda_0^\varepsilon - \omega > W^\varepsilon(E = 0, G, 0, 0, \tilde{\kappa}_0, \tilde{\mu})$$

where λ_0 is a cost of going into apprenticeship. We allow that parameter to differ with unobserved heterogeneity and with region of living, reflecting differences in access into the apprenticeship system. ω is a random cost of going into apprenticeship, normally distributed with mean zero and variance σ_ω^2 .

4.5 Estimation Method

The model is solved numerically using a value function iteration technique. The model is estimated by maximum likelihood. We refer the reader to the

appendix for the likelihood function. The estimation was done at a quarterly frequency, using a random sample of 1635 individuals, totaling about 77137 observations on wages, employment choices and education choices.

We imposed three different “types” of individuals in the likelihood. Each type differ in several ways. First, we allow for different wage levels (fixed effect). Second, we also allow for heterogeneity in the return to experience and tenure, as well as a heterogenous cost of education.

5 Results

5.1 Fit of the Model

We evaluate the fit of the model by simulating the education decisions and the labor market transitions for a cohort of individuals over time. Table 3 displays the labor market transitions by education groups at a quarterly frequency. We distinguish five possible transitions, from and to unemployment, between same job and job to job. Overall, the model match the transition probabilities closely.

Table 3: Goodness of Fit: Labor Market Transitions

	Apprentices		Non Apprentices	
	Obs	Pred	Obs	Pred
U to U	0.82	0.83	0.82	0.84
U to E	0.18	0.17	0.18	0.16
E to U	0.04	0.03	0.08	0.04
E to new E	0.03	0.02	0.03	0.02
E to same E	0.93	0.89	0.89	0.94

Figure 6 plots the average experience and tenure over time for the two education groups. The model does a good job in both dimension and even picks up the non linearity in the evolution of tenure for apprentices.

Figure 5: Goodness of Fit, Wages

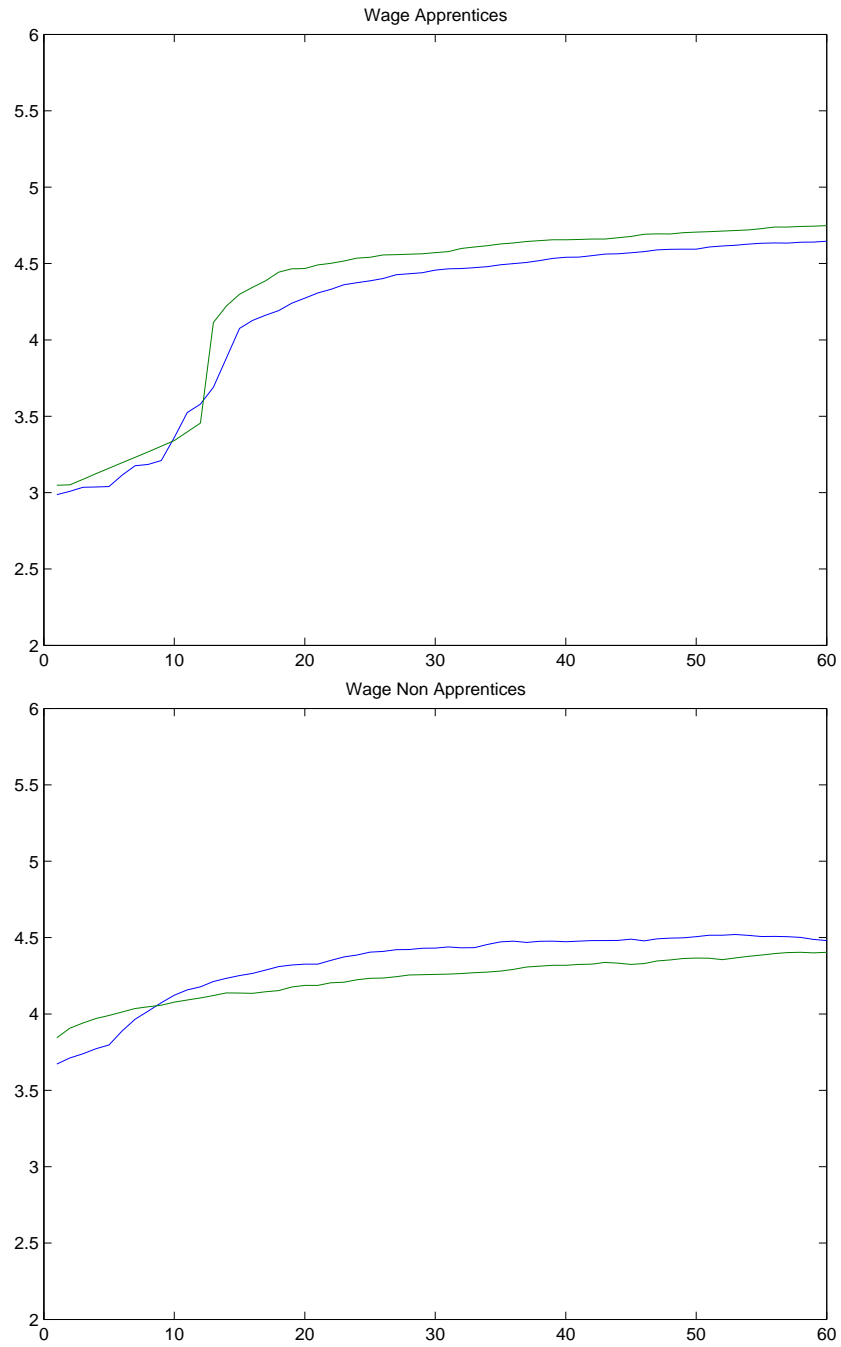
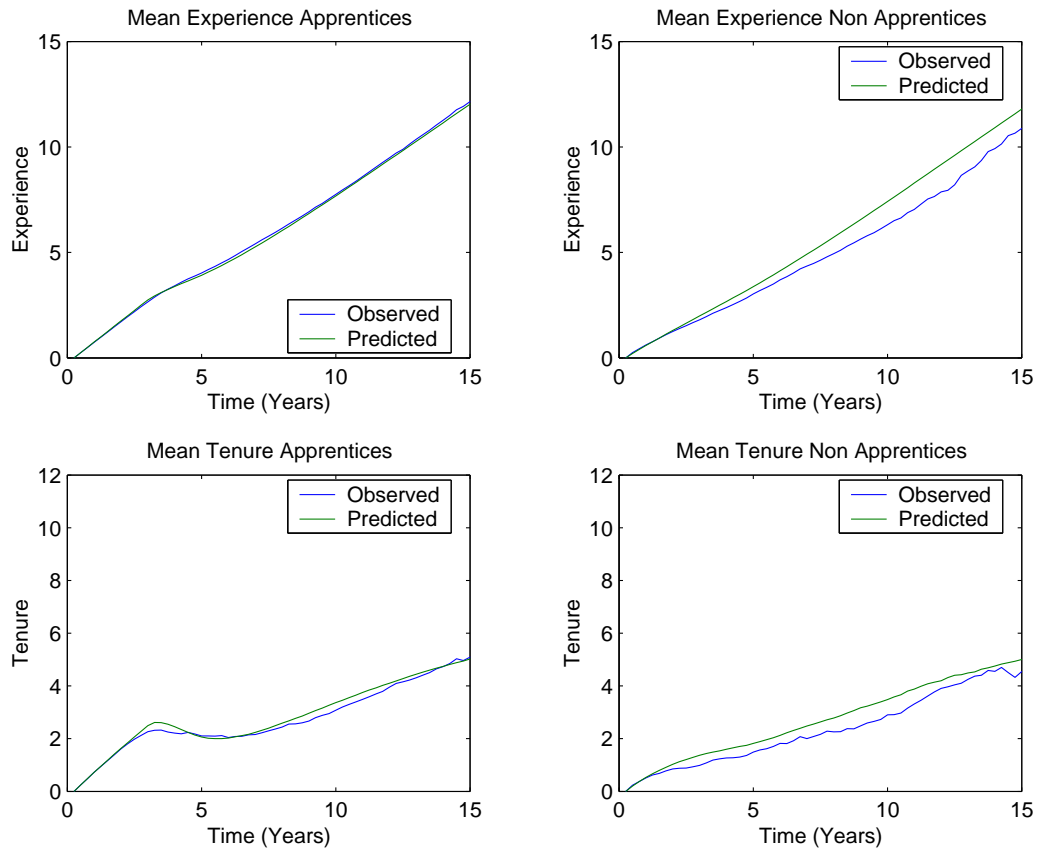


Figure 6: Goodness of Fit, Average Experience and Tenure over Time by Education



5.2 Results

5.2.1 Estimated Parameters

In total we have 60 parameters. The results are presented in Table 6 in appendix B. Given the wealth of data, most of the parameters are estimated with a high precision.

A direct interpretation of some the coefficients in Table 6 is difficult as these parameters are only interesting in combination with others. We also use simulations to illustrate our results below.

We concentrate the discussion around some interesting parameters. First, the price of human capital for both education group is slightly different. When the business cycle goes from bad to good, wages of unskilled increases by 0.5% and by 0.8% for skilled labor. The probability of a job offer while on the job is estimated at 7% per quarter for apprentices (only 4% if they are in apprenticeship) and at 9% for non apprentices. Given that skilled and unskilled have the same probability to move from job to job, it follows that non-apprentices decline job offers more often than apprentices.

In unemployment, skilled individuals have a 21% probability of receiving a job offer. For unskilled, this number is slightly higher at 25%.

5.2.2 Unobserved Heterogeneity

The estimation allows unobserved heterogeneity in the form of three types of individuals. The proportion of these types is respectively 10, 26 and 64%. Table 4 displays summary characteristics for different groups. Type 1 individuals are low ability individuals with the lowest wage at start. They also have the lowest return to experience, at about 2.6% per year if they go into apprenticeship and 0.2% if they are unskilled. They have the highest return to tenure, but the estimated returns to tenure are modest, at about 2% per year over the four first years with a firm. Note that the average seniority is about 4 years for those who have worked for more than ten years. About 84% of type 1 individuals choose to go into apprenticeship, which is the average in the whole population.

Type 2 individuals are high ability individuals, with a first wage about 60% higher than Type 1 individuals. Interestingly, they are under-represented in the skilled group, with only 57% of them choosing apprenticeship. They enjoy also the high returns to experience, 0.3% per year if unskilled, and about 3% if skilled. However, they have no return to tenure. Type 3 is the

most prevalent type, with an intermediate ability. They have the highest return to experience and average returns to tenure (about 1.4% per year if unskilled, 0.2% if skilled). They almost all choose to go into apprenticeship.

Table 4: Unobserved Heterogeneity

Type	Proportion in Sample	Proportion Apprentices	Log Wage Constant	Average Return	
				to Exp. (per year)	to Tenure (per year)
				NA , A	NA, A
1	10%	84%	3.45	0.2%, 2.6%	2.0%, 0.2%
2	26%	57%	4.03	0.3%, 2.9%	0%, 0%
3	64%	98%	3.75	0.3%, 3.1%	1.4%, 0.2%

Note: Average return to experience calculated after a period of 20 years of experience. Average return to tenure calculated after a period of 4 years in the job.

5.2.3 Return to Apprenticeship

The model allows us to compute the value of apprenticeship, $E_{G,\kappa,\mu}W_A^\varepsilon(G, X = 0, T = 0, \kappa, \mu)$ and the value of starting as an unskilled on the labor market, $E_{G,\kappa,\mu}W^\varepsilon(E = u, G, X = 0, T = 0, \kappa, \mu)$. These value functions take into account all possible future outcomes, the wage profile over time as well as the future labor market transitions. Based on these estimated values, we can compute the return to apprenticeship computed as:

$$r^\varepsilon = \sqrt[T]{\frac{E_{G,\kappa,\mu}W_A^\varepsilon(G, X = 0, T = 0, \kappa, \mu)}{E_{G,\kappa,\mu}W^\varepsilon(E = u, G, X = 0, T = 0, \kappa, \mu)}} - 1$$

We condition on the type of the agent and we compute the average return per year, evaluated over forty years. The results are displayed in Table 5. On average, the return to apprenticeship is equal to about 5% a year. However, there is some heterogeneity across types. In particular, the return for Type 2 is close to zero, at 0.8%. This is why this group has the smallest proportion of apprentices. The two other groups have a positive return to education, especially individuals of Type 3. These numbers represent the average effect. As we allow for individual heterogeneity, those who chose to go into apprenticeship face higher returns. The second line of the table displays the average

effect of the treatment on the treated, i.e. the average return for those who opted for a skilled education. These returns are indeed higher and positive for all types.

Table 5: Return to Apprenticeship

	Type 1	Type 2	Type 3	Average
Return to Apprenticeship, per year	4.5%	-0.4%	6.8%	4.7%
Return to Apprenticeship, for apprentices (ATT)	5.3%	3.6%	6.9%	5.5%
Net of utility of education	0.3%	0.8%	0.7%	0.7%
+ Net of opportunity cost of education	0.5%	0.9%	0.8%	0.8%
+ Equal distribution of firm-worker match	0.8%	1.3%	1.2%	1.2%
+ No job to job mobility	0.8%	1.3%	1.2%	1.2%
+ No job destruction	0.4%	0.9%	0.8%	0.8%
+ No return to tenure	0.6%	0.9%	0.9%	0.9%
+ No return to experience	-0.1%	-0.1%	-0.1%	-0.1%

Note: Average returns to apprenticeship calculated over a period of 40 years.

We next decompose the overall return to apprenticeship. We first consider the returns net of the utility of education, noted λ_0^ε in section 4. It turns out that the utility of education is a substantial part of the returns to apprenticeship. Net of this utility, the average return is only 0.7%. This low figure reflects that there is not much financial incentives to go into apprenticeship. There is a large opportunity cost in the first years as individuals in apprenticeship gets about half of the unskilled wage. The wage differential later on in the life cycle, only just compensates for this initial loss. The return to apprenticeship is remarkably similar across types. There is less heterogeneity across types, with Type 2 having the highest return at 0.8%. As argued above, this group is a high ability group, and given the log specification of the wage equation, gains proportionally more from a skilled occupation. Moreover, they also have a sizable return to experience in skilled occupations.

Row 4 in Table 5 sets the opportunity cost of education to zero ($\lambda_W = 1$) in addition to a zero utility of education. This slightly increases the annual return to 0.8%.

Row 5 imposes that the distribution of the firm-worker match specific

effect is the same for apprentices and non apprentices. We set the value of σ_{0NA} to σ_{0A} . As the variance of the distribution of initial matches is higher for non apprentices, unskilled occupation is less attractive, as they are less gains in moving to new firms.

We next impose no job-to-job mobility, by setting $\pi_W(E)$ to zero, i.e. alternative job offer never arrives. Note that mobility still takes place through work to non work and back to work. This has little consequences on the return to apprenticeship.

Imposing in addition the rate of job destruction to be zero decreases the return to apprenticeship, because job destruction occurs more frequently in unskilled occupation. Note that unemployment still occurs through voluntary unemployment.

Rows 8 and 9 impose further that the return to tenure and experience are zero. The estimated return to tenure is small, so the effect of imposing it to be zero is negligible. However, with similar return to experience across skill groups, the return to apprenticeship is almost zero. At this point, the careers of apprentices and non apprentices are almost identical, given that we have removed most of the heterogeneity we allowed for in the model.³

5.2.4 Decomposing Wage Growth

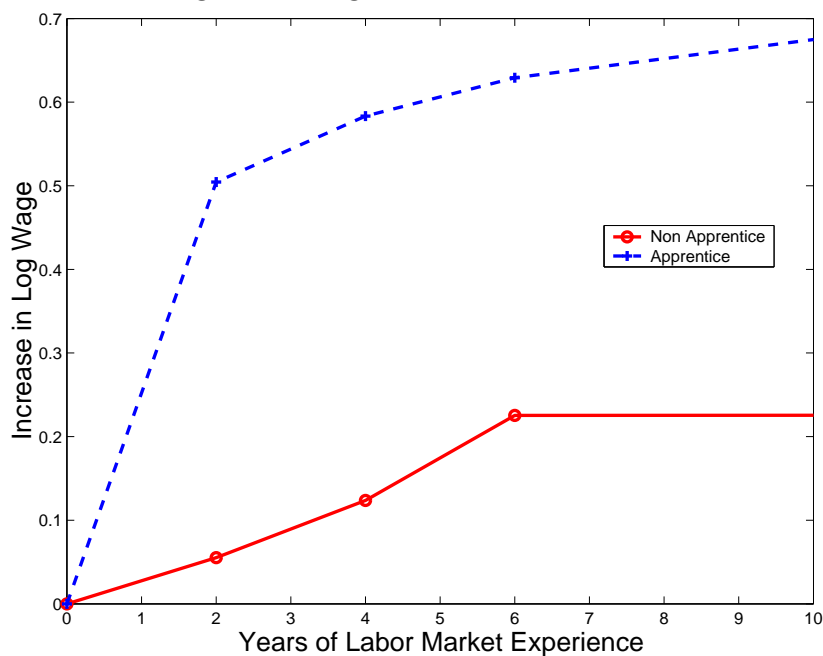
Both apprentices and non apprentices see a sizable wage growth within the firm, at about 8% per year for apprentices and 7% per year for non apprentices. Note that most of the wage growth occurs within 4 years after finishing basic schooling. There is very little wage growth after that period. However, even after many years, there is still a gap between education groups suggesting that the value of training is positive.

We now decompose the return to experience and to tenure. Figure ?? displays the return to experience, conditional on ability and on staying forever in the same firm (with a zero match specific effect), for apprentices and non apprentices. In both cases, the return to experience is steep in the first 3-4 years and then flat. The return to experience is larger for apprentices than non apprentices (respectively about 6% and 4% per year).

Figure ?? displays the return to tenure for apprentices and non apprentices. These are lower than the return to experience, at about 3% per year

³The only remaining source of heterogeneity is the value of leisure and the effect of the business cycle.

Figure 7: Wage Growth Within Firm



for non apprentices and 2% for apprentices. Note also that the return to tenure is almost zero in the first two years.

6 Policy Evaluations

In this section, we evaluate the effect of labor market policies on career progression and education choices. In particular, we evaluate the effect of in-work benefits on human capital accumulation and acquisition of skills. These policies offer subsidies to employed individuals with a low wage. Examples of such policies are the Earn Income Tax Credit (EITC) in the US and the Working Family Tax Credit (WFTC) in the UK. These policies are in place to encourage labor market participation.

We simulate a reform similar to the EITC, where low wage individuals get a subsidy. This subsidy starts at 0 for a zero wage, increases with the wage up to a first limit, stays constant over a range of income and finally declines to zero. Hence, two categories of individuals do not receive a subsidy: individuals not working and individuals with a high enough wage.

In general, these in-work benefit policies have an effect on labor market participation. However, these policies could also have detrimental long-term effects on education choices and skill acquisition. As lower wages are subsidized, individuals are less likely to obtain higher education levels as the wage gap between education groups might decrease. Second, due to the non linearity of the benefits, the policy might discourage job-to-job mobility. This would reduce the mobility of workers across jobs and slow down or prevent the best matches between firms and workers to form, decreasing over-all productivity.

Figures 8 to 10 show the results of the policies simulated from the estimated model. The policy has a positive impact on labor participation. It raises participation by about 3 to 4%. However, the policy has a negative impact on the match between firm and workers. The match is about 2% lower. Finally, the in-work benefit decreases the incentive to undertake further education. The proportion of individuals going into apprenticeship decreases by about 4%.

The policy has a negative effect on overall productivity.

Figure 8: Effect of In-Work Benefits on Labor Market Participation

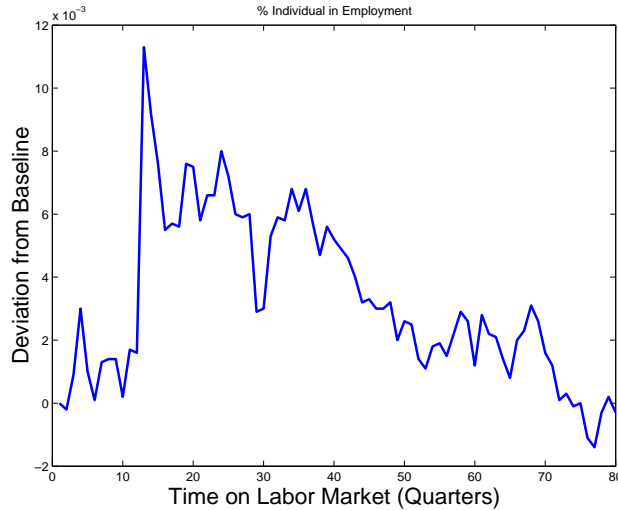


Figure 9: Effect of In-Work Benefits on Firm-Worker Match

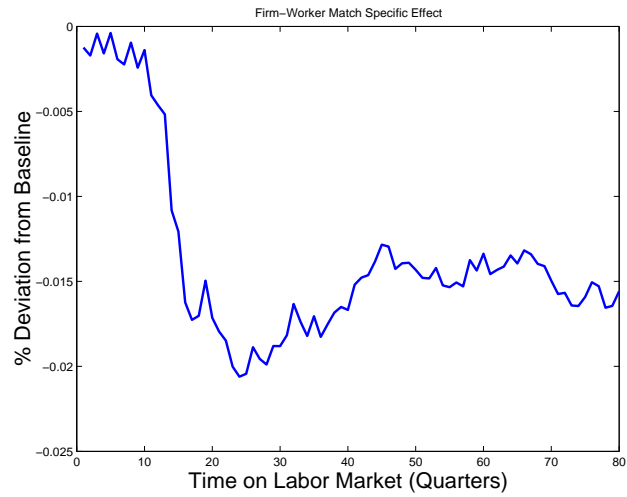
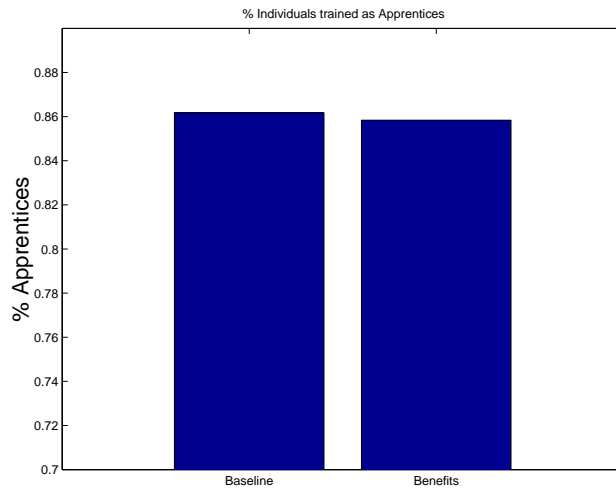


Figure 10: Effect of In-Work Benefits on Education Choices



7 Conclusion

This paper evaluates the return to formal education over the life-cycle and compare it to informal, on the job training. More specifically, we assess the apprenticeship system in Germany by comparing the long run value of education choices and subsequent labor market outcomes for apprentices and non-apprentices. We develop a structural model of career progression and educational choice, allowing for unobserved ability, endogenous job to job transition, specific firm-worker matches, specific returns to tenure and to general experience. We estimate this model on a large panel data set which describes the career progression of young Germans. We find that the return to apprenticeship is positive, but the financial incentives are minimal. A large part of the return to apprenticeship comes from non financial returns as the utility of education.

We use the estimated model to evaluate the long-run impact of labor market policies on educational choices and career progression. We find that policies such as the Earned Income Tax Credit which subsidize low wage have a detrimental effect on the probability of further education and on job mobility.

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Appendix

A Likelihood

$$U^\varepsilon(E, G, X, w_{-1}, \eta) = \gamma_w w_{-1}^\varepsilon + \gamma_0 + \eta + \widehat{U}^\varepsilon(E, G, X, w_{-1}) \quad (\text{say}),$$

$$W^\varepsilon(E, G, X, T, \kappa, \mu) = w^\varepsilon(E, G, X, T, \kappa) + \mu + \widehat{W}^\varepsilon(E, G, X, T, \kappa, \mu).$$

$$W^A(G, X, T, \kappa, \mu) = \lambda_w \cdot w(0, G, X, T, \kappa) + \mu + \widehat{W}^{A\varepsilon}(G, X, T, \kappa, \mu)$$

$$W^A(G, \tau, T, \kappa, \mu) = \lambda_w \cdot w^\varepsilon(0, G, \tau, T, \kappa) + \mu - \lambda_0 - \omega + \widehat{W}_t^A(G, T, \kappa, \mu).$$

$$\begin{aligned} W_A^\varepsilon(G, 0, 0, \kappa_0, \mu) - \lambda_0^\varepsilon - \omega &> W^\varepsilon(E = 0, G, 0, 0, \tilde{\kappa}_0, \tilde{\mu}) \\ &\Leftrightarrow \omega < \lambda_w \cdot w^\varepsilon(0, G, 0, T, \kappa_0) - w^\varepsilon(0, G, 0, T, \kappa'_0) - \lambda_0 \\ &+ \widehat{W}_t^{A,\varepsilon}(G, 0, \kappa_0) - \widehat{W}_t^\varepsilon(0, G, 0, 0, \kappa'_0), \end{aligned}$$

An individual occupational trajectory is denoted as $y = (\dots, w_t, d_t, \dots)$ for $t \geq 0$ or τ depending on education. The variable d_t^A indicates whether an individual in the course of apprenticeship is employed in a new job with tenure zero ($d_t = 1$) or employed in the same job as in period $t - 1$ with positive tenure ($d_t = 2$). The variable d_t indicates whether an individual who has left school or apprenticeship is unemployed in period t ($d_t = 0$), employed in a new job with tenure zero ($d_t = 1$) or employed in the same job as in period $t - 1$ with positive tenure ($d_t = 2$). We let $w_t = 0$ if $d_t = 0$. Employment trajectories are conditioned by the initial educational choice: $E = 1$ for apprentices and $E = 0$ for non apprentices. Knowledge of y suffices to construct the experience and tenure variables X_t and T_t . Also, one must keep track of the last paid wage for currently unemployed workers (call it $w_{-1,t}$).

Conditional on observed and unobserved heterogeneity, the likelihood of one individual observation (E, y) is constructed as follows.

Educational choice: The apprenticeship probability, conditionally on a business cycle G and an accepted wage as an apprentice w^A is:

$$\begin{aligned} \Pr \{E = 1|G, w^A\} &= \Pr \left\{ \begin{aligned} &\omega < w^A - w(0, G, 0, 0, \tilde{\kappa}_0) - \lambda_0^\varepsilon + \mu - \tilde{\mu} \\ &+ \widehat{W}_A^\varepsilon(G, 0, 0, \kappa, \mu) - \widehat{W}^\varepsilon(0, G, 0, 0, \tilde{\kappa}_0, \tilde{\mu}) | G, w^A \end{aligned} \right\} \\ &= \iiint \Phi \left(\frac{w^A - w(0, G, 0, 0, \tilde{\kappa}_0) - \lambda_0^\varepsilon + \mu - \tilde{\mu}}{\widehat{W}_A^\varepsilon(G, 0, 0, \kappa, \mu) - \widehat{W}^\varepsilon(0, G, 0, 0, \tilde{\kappa}_0, \tilde{\mu})} \right) dF(\tilde{\kappa}_0) dF(\mu) dF(\tilde{\mu}) \end{aligned}$$

and the likelihood of observing wage w^A is:

$$\ell(w^A|G) = \frac{1}{w^A} \frac{1}{\sigma_{\kappa_0}} \varphi \left(\frac{\kappa}{\sigma_{\kappa_0}} \right).$$

where $\kappa = w^A - w(0)$

Apprentices changing employers in the course of apprenticeship:

The probability of accepting a new apprentice job paid w_t^A for in-apprenticeship workers in period $t - 1$ is such that :

$$\begin{aligned} &\Pr \{d_t^A = 1|G_t, T_t, w_t^A, w_{t-1}^A\} \\ &= \Pr \left\{ W_t^A \left(G_t, 0, \underbrace{\kappa \left(0, G_t, t, 0, \frac{w_t^A}{\lambda_w} \right)}_{\kappa_t} \right) > W_t^A \left(G_t, T_t, \underbrace{\kappa \left(0, G_t, t-1, T_t-1, \frac{w_{t-1}^A}{\lambda_w} \right)}_{\kappa_{t-1}} \right) + \tilde{u} \right\} \\ &= \int_0^1 \mathbf{1} \left\{ \begin{aligned} &W_t^A \left(G_t, 0, \kappa \left(0, G_t, t, 0, \frac{w_t^A}{\lambda_w} \right) \right) \\ &> W_t^A \left(G_t, T_t, \kappa \left(0, G_t, t-1, T_t-1, \frac{w_{t-1}^A}{\lambda_w} \right) \right) + \sigma_u \Phi^{-1}(u) \end{aligned} \right\} du \\ &\approx \frac{1}{n} \sum_{i=1}^n \mathbf{1} \left\{ \begin{aligned} &W_t^A \left(G_t, 0, \kappa \left(0, G_t, t, 0, \frac{w_t^A}{\lambda_w} \right) \right) \\ &> W_t^A \left(G_t, T_t, \kappa \left(0, G_t, t-1, T_t-1, \frac{w_{t-1}^A}{\lambda_w} \right) \right) + \sigma_u \Phi^{-1}(u) \end{aligned} \right\} \end{aligned}$$

and

$$\ell(w_t^A|G_t) = \frac{1}{w_t^A} \frac{1}{\sigma_{\kappa_0}} \varphi \left(\frac{\kappa \left(0, G_t, t, 0, \frac{w_t^A}{\lambda_w} \right)}{\sigma_{\kappa_0}} \right) \quad (2)$$

Apprentices keeping the same employer in the course of apprenticeship: The probability of keeping the same job given a new wage w_t^A is:

$$\begin{aligned}
& \Pr \{d_t^A = 2 | G_t, T_t, w_t^A, w_{t-1}^A\} \\
&= \Pr \left\{ W_t^A(G_t, 0, \kappa_0) > W_t^A \left(G_t, T_t, \kappa \left(0, G_t, t, T_t, \frac{w_t^A}{\lambda_w} \right) \right) \right\} \\
&= \int_0^1 \mathbf{1} \left\{ W_t^A \left(G_t, T_t, \kappa \left(0, G_t, t, T_t, \frac{w_t^A}{\lambda_w} \right) \right) > W_t^A(G_t, 0, \sigma_{\kappa_0} \Phi^{-1}(u)) \right\} du \\
&\approx \frac{1}{n} \sum_{i=1}^n \mathbf{1} \left\{ W_t^A \left(G_t, T_t, \kappa \left(0, G_t, t, T_t, \frac{w_t^A}{\lambda_w} \right) \right) > W_t^A(G_t, 0, \sigma_{\kappa_0} \Phi^{-1}(u)) \right\}
\end{aligned}$$

and the density of that new wage is:

$$\ell(w_t^A | G_t, T_t, w_{t-1}^A) = \frac{1}{w_t^A} \frac{1}{\sigma_u} \varphi \left(\frac{\kappa \left(0, G_t, t, T_t, \frac{w_t^A}{\lambda_w} \right) - \kappa \left(0, G_t, t-1, T_t-1, \frac{w_{t-1}^A}{\lambda_w} \right)}{\sigma_u} \right) \quad (3)$$

Transition from unemployment to employment: The probability of accepting a job paid w_t for unemployed workers in period $t-1$ is such that :

$$\begin{aligned}
& \Pr \{d_t = 1 | E, G_t, X_t, w_{-1,t}, w_t, d_{t-1} = 0\} \\
&= \Pr \{U_t(E, G_t, X_t, w_{-1,t}, \tilde{\eta}) \leq W_t(E, G_t, X_t, 0, \kappa(E, G_t, X_t, 0, w_t))\} \\
&= \Phi \left(\frac{W_t(E, G_t, X_t, 0, \kappa(E, G_t, X_t, 0, w_t)) - \gamma_w w_{-1,t} - \gamma_0 - \widehat{U}_t(E, G_t, X_t, w_{-1,t})}{\sigma_\eta} \right).
\end{aligned}$$

If $X_t = 0$ then $w_{-1,t} = 0$.

The density of the accepted wage is:

$$\ell(w_t | E, G_t, X_t, T_t, w_{t-1}, d_{t-1} = 0) = \frac{1}{w_t} \frac{1}{\sigma_{\kappa_0}} \varphi \left(\frac{\kappa(E, G_t, X_t, 0, w_t)}{\sigma_{\kappa_0}} \right). \quad (4)$$

Long term unemployed: The probability of remaining unemployed in period t given unemployment in period $t - 1$ is:

$$\begin{aligned}
& \Pr \{d_t = 0 | E, G_t, X_t, w_{-1,t}, d_{t-1} = 0\} \\
&= \Pr \{U_t(E, G_t, X_t, w_{-1,t}, \tilde{\eta}) > W_t(E, G_t, X_t, 0, \tilde{\kappa}_0)\} \\
&= \int_0^1 \bar{\Phi} \left(\frac{W_t(E, G_t, X_t, 0, \sigma_{\kappa_0} \Phi^{-1}(u)) - \gamma_w w_{-1,t} - \gamma_0 - \hat{U}_t(E, G_t, X_t, w_{-1,t})}{\sigma_\eta} \right) du \\
&\approx \frac{1}{n} \sum_{i=1}^n \bar{\Phi} \left(\frac{W_t(E, G_t, X_t, 0, \sigma_{\kappa_0} \Phi^{-1}(\frac{i}{n})) - \gamma_w w_{-1,t} - \gamma_0 - \hat{U}_t(E, G_t, X_t, w_{-1,t})}{\sigma_\eta} \right).
\end{aligned}$$

Transition from employment to unemployment: The probability of losing one's job in period t is:

$$\begin{aligned}
& \Pr \{d_t = 0 | E, G_t, X_t, T_t, w_{t-1}, d_{t-1} > 0\} \\
&= \Pr \left\{ U_t(E, G_t, X_t, w_{t-1}, \tilde{\eta}) > \underbrace{\max \left(\begin{array}{c} W_t(E, G_t, X_t, 0, \tilde{\kappa}_0) \\ W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t - 1, T_t - 1, w_{t-1}) + \tilde{u}) \end{array} \right)}_{\text{call that } \Lambda(\tilde{\kappa}_0, \tilde{u})} \right\} \\
&= \int_0^1 \int_0^1 \bar{\Phi} \left(\frac{\Lambda(\sigma_{\kappa_0} \Phi^{-1}(u), \sigma_u \Phi^{-1}(v)) - \gamma_w w_{t-1} - \gamma_0 - \hat{U}_t(E, G_t, X_t, w_{t-1})}{\sigma_\eta} \right) dudv \\
&\approx \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n \bar{\Phi} \left(\frac{\Lambda(\sigma_{\kappa_0} \Phi^{-1}(\frac{i}{n}), \sigma_u \Phi^{-1}(\frac{j}{n})) - \gamma_w w_{t-1} - \gamma_0 - \hat{U}_t(E, G_t, X_t, w_{t-1})}{\sigma_\eta} \right).
\end{aligned}$$

Job movers: The probability of accepting a new job paid w_t for employed workers in period $t - 1$ is such that :

$$\begin{aligned}
& \Pr \{d_t = 1 | E, G_t, X_t, T_t, w_{t-1}, d_{t-1} > 0, w_t\} \\
&= \Pr \{W_t(E, G_t, X_t, 0, \kappa(E, G_t, X_t, 0, w_t)) > \max(U_t(E, G_t, X_t, w_{t-1}, \tilde{\eta}), \\
&\quad W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t - 1, T_t - 1, w_{t-1}) + \tilde{u}))\} \\
&= \Phi \left(\frac{W_t(E, G_t, X_t, 0, \kappa(E, G_t, X_t, 0, w_t)) - \gamma_w w_{t-1} - \gamma_0 - \widehat{U}_t(E, G_t, X_t, w_{t-1})}{\sigma_\eta} \right) \\
&\quad \times \int_0^1 \mathbf{1} \left\{ \begin{array}{c} W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t - 1, T_t - 1, w_{t-1}) + \sigma_u \Phi^{-1}(u)) \\ < W_t(E, G_t, X_t, 0, \kappa(E, G_t, X_t, 0, w_t)) \end{array} \right\} du \\
&\approx \Phi \left(\frac{W_t(E, G_t, X_t, 0, \kappa(E, G_t, X_t, 0, w_t)) - \gamma_w w_{t-1} - \gamma_0 - \widehat{U}_t(E, G_t, X_t, w_{t-1})}{\sigma_\eta} \right) \\
&\quad \times \frac{1}{n} \sum_{i=1}^n \mathbf{1} \left\{ \begin{array}{c} W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t - 1, T_t - 1, w_{t-1}) + \sigma_u \Phi^{-1}\left(\frac{i}{n}\right)) \\ < W_t(E, G_t, X_t, 0, \kappa(E, G_t, X_t, 0, w_t)) \end{array} \right\}
\end{aligned}$$

and

$$\ell(w_t | E, G_t, X_t, T_t, w_{t-1}, d_{t-1} > 0) = \frac{1}{w_t} \frac{1}{\sigma_{\kappa_0}} \varphi \left(\frac{\kappa(E, G_t, X_t, 0, w_t)}{\sigma_{\kappa_0}} \right) \quad (5)$$

Job stayers: The probability of keeping the same job given a new wage w_t is:

$$\begin{aligned}
& \Pr \{d_t = 2 | E, G_t, X_t, T_t, w_{t-1}, d_{t-1} > 0, w_t\} \\
&= \Pr \left\{ W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t, T_t, w_t)) > \max \left(\begin{array}{c} U_t(E, G_t, X_t, w_{t-1}, \tilde{\eta}) \\ W_t(E, G_t, X_t, 0, \tilde{\kappa}_0) \end{array} \right) \right\} \\
&= \Phi \left(\frac{W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t, T_t, w_t)) - \gamma_w w_{t-1} - \gamma_0 - \widehat{U}_t(E, G_t, X_t, w_{t-1})}{\sigma_\eta} \right) \\
&\quad \times \int_0^1 \mathbf{1} \{W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t, T_t, w_t)) \geq W_t(E, G_t, X_t, 0, \sigma_{\kappa_0} \Phi^{-1}(u))\} du \\
&\approx \Phi \left(\frac{W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t, T_t, w_t)) - \gamma_w w_{t-1} - \gamma_0 - \widehat{U}_t(E, G_t, X_t, w_{t-1})}{\sigma_\eta} \right) \\
&\quad \times \left(\frac{1}{n} \sum_{i=1}^n \mathbf{1} \left\{ W_t(E, G_t, X_t, T_t, \kappa(E, G_t, X_t, T_t, w_t)) \geq W_t \left(E, G_t, X_t, 0, \sigma_{\kappa_0} \Phi^{-1} \left(\frac{i}{n} \right) \right) \right\} \right)
\end{aligned}$$

and the density of that new wage is:

$$\ell(w_t|E, G_t, X_t, T_t, w_{t-1}, d_{t-1} > 0) = \frac{1}{w_t} \frac{1}{\sigma_u} \varphi\left(\frac{\kappa(E, G_t, X_t, T_t, w_t) - \kappa(E, G_t, X_t - 1, T_t - 1, w_{t-1})}{\sigma_u}\right) \quad (6)$$

B Results

Table 6: Estimation Results

Parameter	Coeff	s.e.
σ_U	0.032533	6.1276e-05
σ_η	133.78	9.9207
σ_ω	18433	0.011576
σ_{0A}	0.2287	0.0021257
σ_{0AA}	0.38813	0.0091234
σ_{0NA}	0.47903	0.014058
σ_{UA}	0.23442	0.0007753
α_0	3.41	0.047466
α_G , non apprentice	0.0066755	0.001576
α_G , apprentice	0.0073086	0.00086977
π_A	0.069007	0.0024827
π_{NA}	0.093103	0.0072749
π_{AA}	0.038315	0.0027868
π_{AU}	0.21573	0.004892
π_{NAU}	0.24655	0.0092794
π_{AUs}	-0.0042197	0.00069235
π_{ANUs}	-0.0039509	0.0018031
λ_W	0.5	0.20
$\alpha_X, X = 2$, non apprentice	0.053	0.008
$\alpha_X, X = 4$, non apprentice	0.079	0.014
$\alpha_X, X = 6$, non apprentice	0.083	0.017
$\alpha_X, X = 30$, non apprentice	0.085	0.11
$\alpha_X, X = 2$, apprentice	0.49	0.04
$\alpha_X, X = 4$, apprentice	0.56	0.046
$\alpha_X, X = 6$, apprentice	0.61	0.05
$\alpha_X, X = 30$, apprentice	0.90	0.08
$\alpha_T, T = 2$, non apprentice	0	0.03
$\alpha_T, T = 4$, non apprentice	0.05	0.08
$\alpha_T, T = 6$, non apprentice	0.21	0.12
$\alpha_T, T = 30$, non apprentice	0.21	1.11
$\alpha_T, T = 2$, apprentice	0	0.01
$\alpha_T, T = 4$, apprentice	0.014	0.02
$\alpha_T, T = 6$, apprentice	0.015	0.03
$\alpha_T, T = 30$, apprentice	0.016	0.20
$\alpha_{X,\varepsilon}$, Type 2	1.00	0.090
$\alpha_{X,\varepsilon}$, Type 3	1.03	0.095
$\alpha_{T,\varepsilon}$, Type 2	0.02	0.10
$\alpha_{T,\varepsilon}$, Type 3	0.04	0.46
γ_{0A}	-178.54	7.7394
γ_{0NA}	-173.91	14.162
α_ε , Type 2	0.61164	0.050223
α_ε , Type 3	0.35872	0.053055
Probability Type 1	0.16	
Probability Type 2	0.27	
Probability Type 3	0.56	
δ_{A1}	0.14575	0.00737