Higher Education Subsidies and Human Capital Mobility

Preliminary and Incomplete

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Abstract

In the U.S. there are large differences across States in the extent to which college education is subsidized, and there are also large differences across States in the proportion of college graduates in the labor force. State subsidies are apparently motivated in part by the perceived benefits of having a more educated workforce. The paper uses the migration model of Kennan and Walker (2011) to analyze how geographical variation in college education subsidies affects the migration decisions of college graduates. The model is estimated using NLSY data, and used to quantify the sensitivity of migration decisions to differences in expected net lifetime income.

1 Introduction

There are substantial differences in subsidies for higher education across States. Are these differences related to the proportion of college graduates in each State? If so, why? Do the subsidies change decisions about whether or where to go to college? If State subsidies induce more people to get college degrees, to what extent does this additional human capital tend to remain in the State that provided the subsidy?

There is a considerable amount of previous work on these issues, summarized in Section 3 below. What is distinctive in this paper is that migration is explicitly modeled. Recent work on migration has emphasized that migration involves a sequence of reversible decisions that respond to migration incentives in the face of potentially large migration costs.[1] The results of Kennan and Walker (2011) indicate that labor supply responds quite strongly to geographical wage differentials and location match effects, in a life-cycle model of expected income maximization. The model is related to earlier work by Keane and Wolpin (1997), who used a dynamic programming model to analyze schooling and early career decisions in a national labor market. Keane and Wolpin (1997) estimated that a

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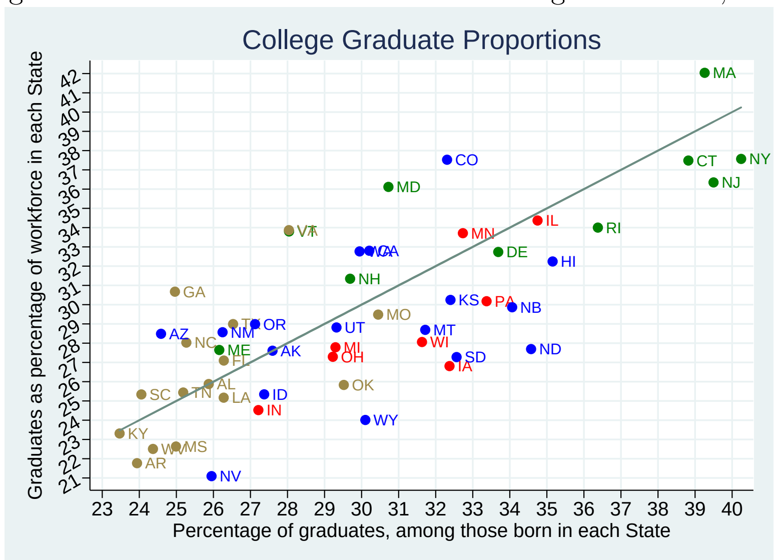
[1]See Kennan and Walker (2011),Gemici (2011) and Bishop (2008).

Figure 1: Birth and Work Locations of College Graduates, 2000



$2000 tuition subsidy would increase college graduation rates by 8.4%. This suggests that variation in tuition rates across States should have big effects on schooling decisions.

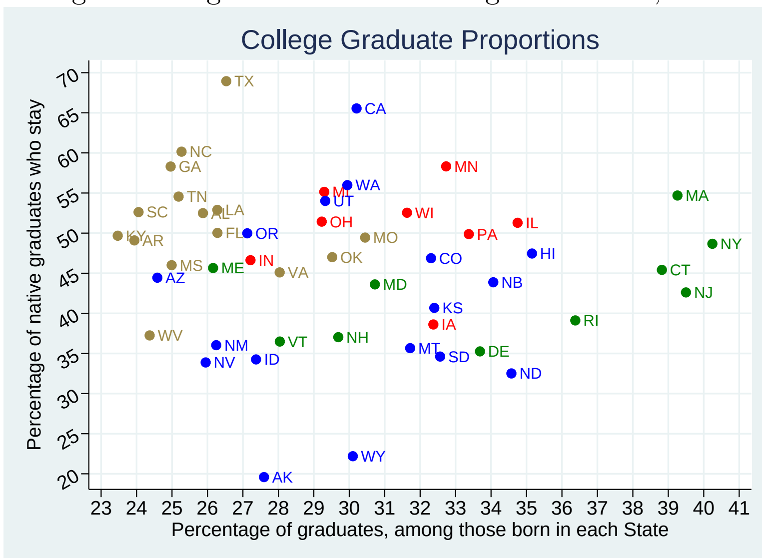
This paper considers these effects in a dynamic programming model that allows for migration both before and after acquiring a college degree. In the absence of moving costs, the optimal policy for someone who decides to go to college is to move to the location that provides the cheapest education, and subsequently move to the labor market that pays the highest wage. At the other extreme, if moving costs are very high, the economic incentive to go to college depends only on the local wage premium for college graduates, and estimates based on the idea of a national labor market are likely to be quite misleading. Thus it is natural to consider college choices and migration jointly in a model that allows for geographical variation in both the costs and benefits of a college degree.

2 Geographical Distribution of College Graduates

There are surprisingly big differences across States in the proportion of college graduates who are born in each State, and in the proportion of college graduates among those working in the State. Figure 1 shows the distribution of college graduates aged 25-50 in the 2000 Census, as a proportion of the number of people in this age group working in each State, and as a proportion of the number of workers in this age group who were born in each State. For example, someone who was born in New York is almost twice as likely to be a college graduate as someone born in Kentucky, and someone working in Massachusetts is twice as likely to be a college graduate as someone working in Nevada. Generally, the proportion of college graduates is high in the Northeast, and low in the South.

There are also big differences in the proportion of college graduates who stay in the State where they were born. Figure 2 shows the proportion of college graduates who work in their birth State. On average, about 45% of all college graduates aged 25-50 work in the State where they were born,

Figure 2: Migration Rates of College Graduates, 2000



but this figure is above 65% for Texas and California, and it is below 25% for Alaksa and Wyoming.

States spend substantial amounts of money on higher education, and there are large and persistent differences in these expenditures across States. Figure 3 shows the variation in (nominal) per capita expenditures across States in 1991 and 2004, using data from the Census of Governments.

The magnitude of these expenditures suggests that a more highly educated workforce is a major goal of State economic policies, perhaps because of human capital externalities. Thus it is natural to ask whether differences in higher education expenditures help explain the differences in labor force outcomes shown in Figures 1 and 2. Figure 4 plots expenditure per student of college age against the proportion of college graduates among those born in each State. There are big variations across States in each of these variables, but these variations are essentially unrelated.

Figure 3: Higher Education Expenditures

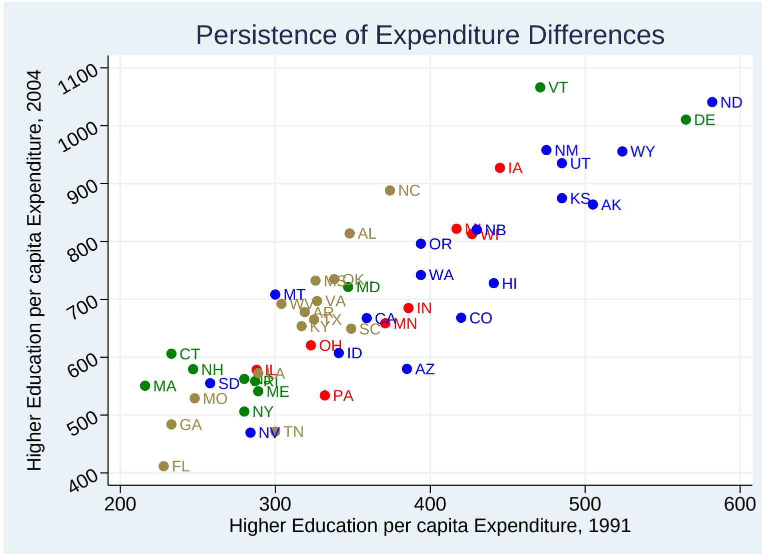
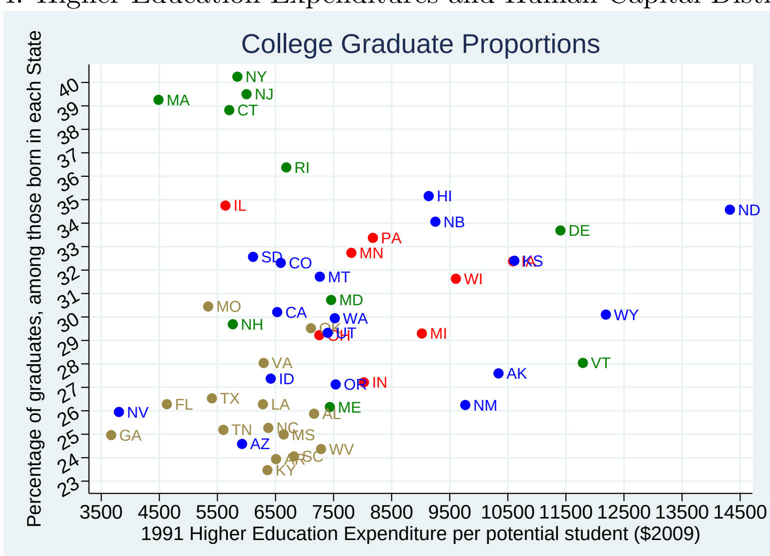


Figure 4: Higher Education Expenditures and Human Capital Distribution



2.1 Tuition Differences

State expenditure on higher education provides a very broad measure of the variation in subsidies, and it might be argued that a more direct measure of college costs might be more relevant. Resident and nonresident tuition rates in 2008-09 by State are shown in Figure 5, and the relationship between (resident) tuition and the proportion of college graduates is shown in Figure 6.[2] Again, there are big differences in tuition rates across States, but no indication that these differences affect college completion rates.

[2]See http://www.hecb.wa.gov/research/issues/documents/TAB6.TuitionandFees2008-09Report-FINAL.pdf

Figure 5: Higher Education Expenditures

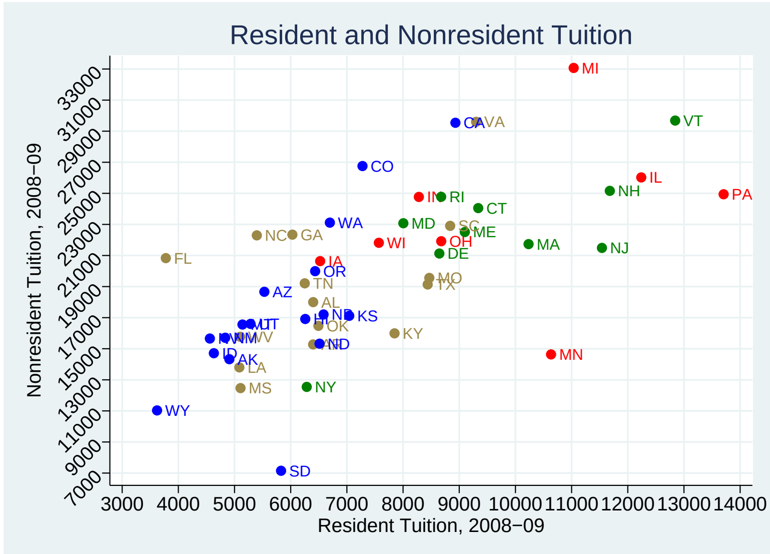
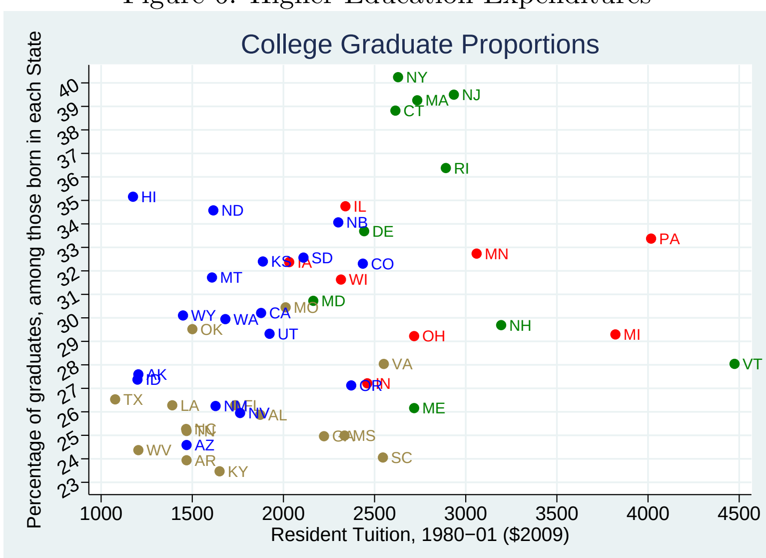


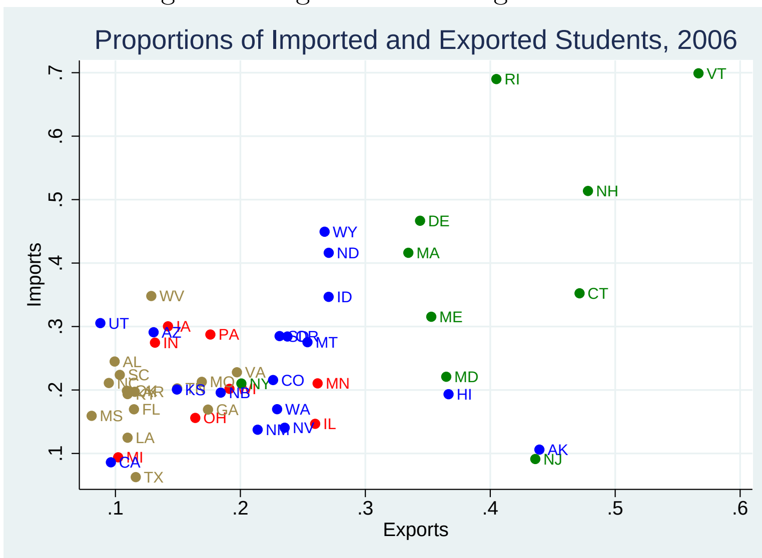
Figure 6: Higher Education Expenditures



A common assumption in the literature on the relationship between college enrollment and cost is that the relevant measure of tuition is the in-state tuition level, given that most students attend college in their home State. This is a crude approximation. On average, 23% of college freshmen in 2006 enrolled in an out of State college (U. S. Department of Education (2008)). Moreover, this proportion varies greatly across States, as shown in Figure 7. At one extreme, the proportion of both imported and exported students was around 10% for California and Texas, which between them accounted for about 18% of all freshmen in the country.[3] At the other extreme, most of the

[3]Here the proportion of imported students is the number of nonresident students as a fraction of total enrollments

Figure 7: Migration of College Students



freshmen in Vermont were not from Vermont, while most students from Vermont were not studying in Vermont.

2.2 Intergenerational Relationships

One possible explanation for the differences in the proportion of college graduates across States is that there are similar differences across States in the proportion of college graduates in the parents' generation, and there is a strong relationship between the education levels of parents and children. Of course this "explanation" merely shifts the question to the previous generation, but it is still of interest to know whether parental education is enough to account for the observed differences in college choices.

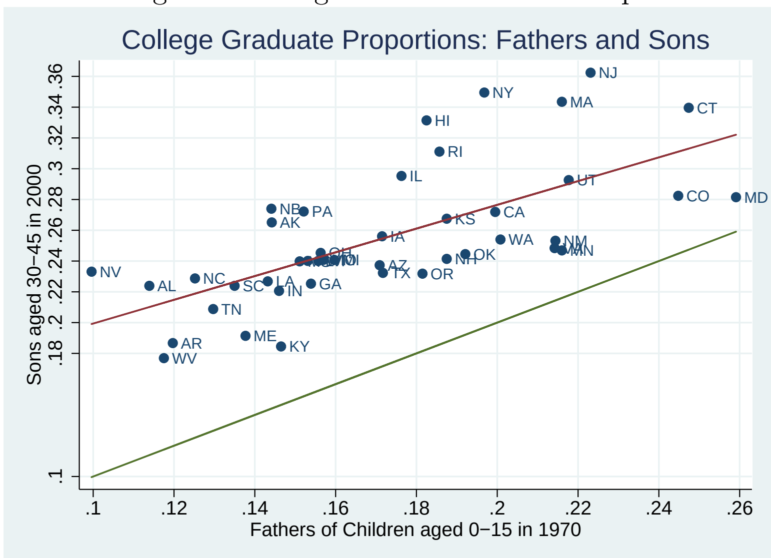
Figure 8 plots the proportion of college graduates by State of birth for men aged 30-45 in the 2000 Census against the proportion of college graduates among the fathers of these men, by State of residence in the 1970 Census. As one might expect, these proportions are quite strongly related: the regression coefficient is about .78, and the R^2 is about .45.[4] The figure includes a 45°line, showing a substantial increase in the proportion of graduates from one generation to the next, and a regression line, showing that there is still plenty of inter-State variation in college graduation rates, even after controlling for the proportion of fathers who are college graduates.[5]

in the State, while the proportion of exported students is the number of students from this State attending college out of state, as a proportion of all students from this State.

[4]The inclusion of mothers' education levels or of the proportion of fathers who attended college adds almost nothing to this regression.

[5]The interstate differences in the proportions of college graduates in the 1970 Census are determined to a substantial extent by differences in the proportions of high school graduates. For example, 71% of white parents living in Kansas had graduated high school, while in Kentucky only 42% of white parents had graduated high school. In the country as a whole, 23% of the white parents had some college (including college graduates); the figures for Kansas and Kentucky were 26% and 17% . Thus the proportion of high school graduates going to college was actually slightly higher in

Figure 8: Intergenerational Relationships



3 Related Literature

The literature on the effects of State differences in college tuition levels is summarized by Kane (2006, 2007). The "consensus" view is that these effects are substantial – that a $1,000 reduction in tuition increases college enrollment by something like 5%. Of course a major concern is that the variation in tuition levels across States is not randomly assigned, and there may well be important omitted variables that are correlated with tuition levels.[6] There is no fully satisfactory way to deal with this problem. One approach is to use large changes in the net cost of going to college induced by interventions such as the introduction of the Georgia Hope Scholarship, as in Dynarski (2000), or the elimination of college subsidies for children of disabled or deceased parents, as in Dynarski (2003), or the introduction of the D.C. Tuition Assistance Grant program, as in Kane (2007). Broadly speaking, the results of these studies are not too different from the results of studies that use the cross-section variation of tuition levels over States, suggesting that the endogeneity of tuition levels might not be a major problem. A detailed analysis of this issue would involve an analysis of the political economy of higher education subsidies in general, and of tuition levels in particular. For example, a change in the party controlling the State legislature or the governorship might be associated with a change in higher education policies, and the variation induced by such changes might be viewed as plausibly exogenous with respect to college choices, although of course this begs the question of why the political environment changed.

Card and Lemieux (2001) analyzed changes in college enrollment over the period 1968-1996, using a model of college participation that included tuition levels as one of the explanatory variables. The model includes State fixed effects, and also year fixed effects, so the effect of tuition is identified by differential changes in tuition over time within States – i.e. some States increased their tuition

Kentucky than in Kansas (40.5% vs. 36.9%, the national proportion being 37.5%).

[6] Kane (2006) gives the example of California spending a lot on community colleges while also having low tuition.

levels more or less quickly than others. The estimated effect of tuition is significant, but considerably smaller than the results in the previous literature (which used cross-section data, so that the effect is identified from differences in tuition levels across States at a point in time).

Card and Krueger (1992) analyzed the effect of school quality using the earnings of men in the 1980 Census, classified according to when they were born, where they were born, and where they worked. An essential feature of this analysis is that the effect of school quality is identified by the presence in the data of people who were born in one State and who worked in another State (within regions, since the model allows for regional effects on the returns to education). This ignores the question of why some people moved and others did not.

Bound et al. (2004) and Groen (2004) sidestep the issue of what causes changes in the number of college graduates in a State, and focus instead on the relationship between the flow of new graduates in a State and the stock of graduates working in that State some time later. They conclude that this relationship is weak, indicating that the scope for State policies designed to affect the educational composition of the labor force is limited.

Keane and Wolpin (2001) estimated a dynamic programming model of college choices, emphasizing the relationship between parental resources, borrowing constraints, and college enrollment (but with no consideration of spatial differences). A major result is that borrowing contraints are binding, and yet they have little influence on college choice. Instead, borrowing constraints affect consumption and work decisions while in college: if borrowing constraints were relaxed, the same people would choose to go to college, but they would work less and consume more while in school.

Aghion et al. (2009) used a set of political instruments to distinguish between arguably exogenous variation in State expenditures on higher education and variation due to differences in wealth or growth rates across States. The model allows for migration, and it considers both innovation and imitation. Higher education investments affect growth in different ways depending on how close a State is to the "technology frontier". Each State is assigned an index measuring distance to the frontier, based on patent data. In States close to the frontier, the estimated effect of spending on research universities is positive, but the estimated effect is negative for States that are far from the frontier. The model that explains this in terms of a tradeoff between using labor to innovate or to imitate.

4 A Life-Cycle Model of Expected Income Maximization

The empirical results in Kennan and Walker (2011) indicate that high school graduates migrate across States in response to differences in expected income. This section analyzes the college choice and migration decisions of high-school graduates, using the dynamic programming model developed in Kennan and Walker (2011), applied to panel data from the 1979 cohort of the National Longitudinal Survey of Youth. The aim is to quantify the relationship between college choice and migration decisions, on the one hand, and geographical differences in college costs and expected incomes on the other. The model can be used to analyze the extent to which the distribution of human capital across States is influenced by State subsidies for higher education. The basic idea is that people tend to buy their human capital where it is cheap, and move it to where wages are high, but this tendency is substantially affected by moving costs.

Suppose there are J locations, and individual i's income y_{ij} in location j is a random variable with a known distribution. Migration and college enrollment decisions are made so as to maximize the present value of expected lifetime income.

Let x be the state vector (which includes the stock of human capital, ability, wage and preference information, current location and age, as discussed below), and let a be the action vector (the location and college enrollment choices). The utility flow is $u(x, a) + \zeta_a$, where ζ_a is a random variable that is assumed to be iid across actions and across periods and independent of the state vector. It is assumed that ζ_a is drawn from the Type I extreme value distribution. Let $p(x'|x, a)$ be the transition probability from state x to state x', if action a is chosen. The decision problem can be written in recursive form as

$$V\left(x, \zeta\right) = \max_j \left(v(x, a) + \zeta_a\right)$$

where

$$v(x, a) = u(x, a) + \beta \sum_{x'} p(x'|x, a)\bar{v}(x')$$

and

$$\bar{v}(x) = E_\zeta V\left(x, \zeta\right)$$

and where β is the discount factor, and E_ζ denotes the expectation with respect to the distribution of the vector ζ with components ζ_a. Then, using arguments due to McFadden (1973) and Rust (1994), we have

$$\exp\left(\bar{v}(x)\right) = \exp\left(\bar{\gamma}\right) \sum_{k=1}^{N_a} \exp\left(v(x, k)\right)$$

where N_a is the number of available actions, and $\bar{\gamma}$ is the Euler constant. Let $\rho\left(x, a\right)$ be the probability of choosing a, when the state is x. Then

$$\rho\left(x, a\right) = \exp\left(v\left(x, a\right) - \bar{v}\left(x\right)\right)$$

The function v is computed by value function iteration, assuming a finite horizon, T. Age is included as a state variable, with $v \equiv 0$ at age $T + 1$, so that successive iterations yield the value functions for a person who is getting younger and younger.

4.1 College Choices

In each period, there is a choice of whether to enroll in college. There are three types of college: community colleges, other public colleges and universities, and private colleges. There are also three levels of schooling: high school (12 or 13 years of schooling completed), some college (14 or 15 years) and college graduate (16 years or more). The college types differ with respect to tuition levels, State subsidies, graduation probabilities, and psychic costs and benefits.

4.2 Wages

The wage of individual i in location j at age g in year t is specified as

$$w_{ij} = \mu_j(e_i) + \upsilon_{ij}(e_i) + G(e_i, X_i, g_i) + \varepsilon_{ij}(e) + \eta_i$$

where e is schooling level, μ_j is the mean wage in location j (for each level of schooling), υ is a permanent location match effect, $G(e, X, g)$ represents the effects of observed individual characteristics, η is an individual effect that affects wages in the same way in all locations, and ε is a transient effect. The random variables η, υ and ε are assumed to be independently and identically distributed across individuals and locations, with mean zero. It is also assumed that the realizations of υ and η are seen by the individual (although $\upsilon_{ij}(e_i)$ is seen by individual i only after moving to location j with education level e_i).

The function G is specified as a piecewise-quadratic function of age, with an interaction between ability and education:

$$G(e, b, g) = \begin{cases} \theta_e b + y_e^* - c_e (g - g_e^*)^2 & g \le g_e^* \\ \theta_e b + y_e^* & g \ge g_e^* \end{cases}$$

where b is measured ability, y_e^* is the peak wage for education level e, and g_e^* is age at the peak. Thus both the shape of the age-earnings profile and the ability premium are specified separately for each level of education, with four parameters to be estimated ($\theta_e, y_e^*, c_e,$ and g_e^*).

The relationship between wages and actions is governed by the difference between the quality of the match in the current location, measured by $G(e, b, g) + \mu_j(e) + \upsilon_{ij}(e)$, and the prospect of obtaining a better match in another location or at a higher level of schooling. The other components of wages have no bearing on migration or college choice decisions, since they are added to the wage in the same way no matter what decisions are made.

4.2.1 Stochastic Wage Components

Since the realized value of the location match component υ is a state variable, it is convenient to specify this component as a random variable with a discrete distribution, and compute continuation values at the support points of this distribution. For given support points, the best discrete approximation $\hat{F}$ for any distribution F assigns probabilities so as to equate $\hat{F}$ with the average value of F over each interval where $\hat{F}$ is constant. If the support points are variable, they are chosen so that $\hat{F}$ assigns equal probability to each point.[7] Thus if the distribution of the location match component υ were known, the wage prospects associated with a move to State k could be represented by an n-point distribution with equally weighted support points $\hat{\mu}_k + \hat{\upsilon}(q_r), 1 \le r \le n$, where $\hat{\upsilon}(q_r)$ is the

[7] See Kennan (2006)

q_r quantile of the distribution of υ, with

$$q_r = \frac{2r-1}{2n}$$

for $1 \leq r \leq n$. The distribution of υ is in fact not known, but it is assumed to be symmetric around zero. Thus for example with $n = 3$, the distribution of $\mu_j + \upsilon_{ij}$ in each State for each education level is approximated by a distribution that puts mass $\frac{1}{3}$ on μ_j (the median of the distribution of $\mu_j + \upsilon_{ij}$), with mass $\frac{1}{3}$ on $\mu_j \pm \tau_\upsilon$, where τ_υ is a parameter to be estimated.

Measured earnings in the NLSY are highly variable, even after controlling for education and ability. Moreover, while some people have earnings histories that are well approximated by a concave age-earnings profile, others have earnings histories that are quite irregular. In other words, the variability of earnings over time is itself quite variable across individuals. It is important to use a wage components model that is flexible enough to fit these data, in order to obtain reasonable inferences about the relationship between measured earnings and the realized values of the location match component. The fixed effect η is assumed to be uniformly and symmetrically distributed around zero, with three points of support, so that there is one parameter to be estimated. The transient component ε should be drawn from a continuous distribution that is flexible enough to account for the observed variability of earnings. It is assumed that ε is drawn from a zero mean normal distribution with zero mean for each person, with a variance that differs across people. Specifically, person i initially draws $\sigma_\varepsilon(i)$ from a uniform discrete distribution with two support points (which are parameters to be estimated), and subsequently draws ε_{it} from a normal distribution with mean zero and standard deviation $\sigma_\varepsilon(i)$, with ε_{it} drawn independently in each period.

4.3 State Variables and Flow Payoffs

Let $\ell = (\ell^0, \ell^1)$ denote the current and previous location, and let ω be a vector recording wage and utility information at these locations. Let ξ denote current enrollment status. The state vector x consists of ℓ, ω, education level achieved so far, ability, parental education, home location and age. The flow payoff may be written as

$$\tilde{u}_h(x, a) = u_h(x, a) + \zeta_a$$

where h is the home location, and $u_h(x, a)$ represents the payoffs associated with observed states and choices, and ζ_a represents the unobserved component of payoffs.

The systematic part of the flow payoff is specified as

$$u_h(x, j) = \alpha_0 w\left(g, e, b, \ell^0, \omega, \xi\right) + \sum_{k=1}^{K} \alpha_k Y_k\left(\ell^0\right) + \alpha^H \chi\left(\ell^0 = h\right) - C_h\left(\ell^0, \xi\right) - \Delta_\tau(x, j)$$

Here the first term refers to wage income in the current location (which depends on age, schooling and ability, as discussed above). This is augmented by the nonpecuniary variables $Y_k\left(\ell^0\right)$, representing amenity values. The parameter α^H is a premium that allows each individual to have a preference for their home location (χ_A denotes an indicator meaning that A is true). The cost of attending a college of type ξ in location ℓ for a person whose home location is h is denoted by $C_h(\ell, \xi)$. The cost of moving from ℓ^0 to ℓ^j for a person of type τ is represented by $\Delta_\tau(x, j)$.

4.3.1 College Costs

For someone who is in college, the systematic part of the flow payoff is specified as

$$u_h(x, j) = \sum_{k=1}^{K} \alpha_k Y_k\left(\ell^0\right) + \alpha^H \chi\left(\ell^0 = h\right) - \Delta_\tau(x, j) - C_h\left(\ell^0, \xi\right)$$

where $C_h(\ell, \xi)$ is the cost of a college of type ξ in location ℓ, for a student whose home location is h. The college cost depends on ability, b, resident and nonresident tuition rates, $\tau_r(\ell, \xi)$ and $\tau_n(\ell, \xi)$, subsidies for higher education, $S(\ell, \xi)$, financial aid $F(\ell, \xi)$, and also on parents' education. Let d_m and d_f be indicators of whether the mother and the father are college graduates. The cost of attending a college of type ξ is specified as

$$C(\ell, \xi) = \delta_0(\xi) + \delta_1 \tau(\ell, \xi) - \delta_2 F(\ell, \xi) - \delta_3 S(\ell, \xi) - \delta_4 d_m - \delta_5 d_f - \delta_6 b$$

$$\tau(\ell, \xi) \quad = \quad \chi(\ell = h)\, \tau_r(\ell, \xi) + \chi(\ell \neq h)\, \tau_n(\ell, \xi)$$

where δ_0 measures the disutility of the effort required to obtain a college degree (offset by the utility of life as a student).[8] If tuition and financial aid could be measured exactly, the parameters δ_1 and δ_2 would be unity; in practice, however, the tuition and financial aid measures are just broad averages across different universities within a State. Thus it is assumed that the actual net tuition is a linear function of the State average tuition and financial aid measures, and δ_1 and δ_2 represent the slope of this function. Similarly, the parameter δ_3 measures the extent to which State higher education expenditures reduce the cost of college, without specifying any particular channel through which this effect operates.

4.4 Moving Costs

Let $D\left(\ell^0, j\right)$ be the distance from the current location to location j, and let $\mathbb{A}(\ell^0)$ be the set of locations adjacent to ℓ^0 (where States are adjacent if they share a border). The moving cost is

[8] In this specification, the disutility of effort is the same for each year spent in college. A plausible alternative is that the disutility of effort rises as courses become more difficult, so that for example the effort required to obtain a college degree is more than double the effort required to complete two years of college. Estimates of this alternative specification yielded virtually no improvement in the likelihood. Similarly, allowing the effect of ability on the college cost to depend on college level had a negligble effect on the empirical results.

specified as

$$\Delta_\tau(x,j) = \left(\gamma_{0\tau}(e) + \gamma_1 D\left(\ell^0, j\right) - \gamma_2 \chi\left(j \in \mathbb{A}\left(\ell^0\right)\right) - \gamma_3 \chi\left(j = \ell^1\right) + \gamma_4 g - \gamma_5 n_j\right) \chi\left(j \neq \ell^0\right)$$

Thus the moving cost varies with education. The observed migration rate is much higher for college graduates than for high school graduates, and the model can account for this either through differences in potential income gains or differences in the cost of moving. The specification allows for unobserved heterogeneity in the cost of moving: there are several types, indexed by τ, with differing values of the intercept γ_0. In particular, there may be a "stayer" type, who regards the cost of moving as prohibitive, in all states. The moving cost is an affine function of distance (which is measured as the great circle distance between population centroids). Moves to an adjacent location may be less costly (because it is possible to change States while remaining in the same general area). A move to a previous location may also be less costly, relative to moving to a new location. In addition, the cost of moving is allowed to depend on age, g. Finally, it may be cheaper to move to a large location, as measured by population size n_j.

4.5 Transition Probabilities

The state vector can be written as $x = (\tilde{x}, g)$, where $\tilde{x} = \left(e, \ell^0, \ell^1, x_v^0\right)$ and where x_v^0 indexes the realization of the location match component of wages in the current location. Let $q(e,\xi)$ denote the probability of advancing from education level e to $e+1$, for someone who is enrolled in a college of type ξ, with $q(e,0) = 0$ for someone who is not enrolled, and let $a = (j,\xi)$. The transition probabilities are as follows

$$p\left(x' \mid x\right) = \begin{cases} q(e,\xi) & \text{if} \quad j = \ell^0, \quad \tilde{x}' = \left(e+1, \ell^0, \ell^1, x_v^0\right), \quad g' = g+1 \\ 1 - q(e,\xi) & \text{if} \quad j = \ell^0, \quad \tilde{x}' = \left(e, \ell^0, \ell^1, x_v^0\right), \quad g' = g+1 \\ q(e,\xi) & \text{if} \quad j = \ell^1, \quad \tilde{x}' = \left(e+1, \ell^1, \ell^0, s_v\right), \quad g' = g+1, \quad 1 \leq s_v \leq n_v \\ 1 - q(e,\xi) & \text{if} \quad j = \ell^1, \quad \tilde{x}' = \left(e, \ell^1, \ell^0, s_v\right), \quad g' = g+1, \quad 1 \leq s_v \leq n_v \\ \frac{q(e,\xi)}{n} & \text{if} \quad j \notin \left\{\ell^0, \ell^1\right\}, \quad \tilde{x}' = (e+1, j, \ell^0, s_v), \quad g' = g+1, \quad 1 \leq s_v \leq n_v \\ \frac{1-q(e,\xi)}{n} & \text{if} \quad j \notin \left\{\ell^0, \ell^1\right\}, \quad \tilde{x}' = (e, j, \ell^0, s_v), \quad g' = g+1, \quad 1 \leq s_v \leq n_v \\ 0 & \text{otherwise} \end{cases}$$

4.6 Data

The primary data source is the National Longitudinal Survey of Youth 1979 Cohort (NLSY79); data from the 1990 Census of Population are used to estimate State mean wages. The NLSY79 conducted annual interviews from 1979 through 1994, and changed to a biennial schedule in 1994; only the information from 1979 through 1994 is used here. The location of each respondent is recorded at the date of each interview, and migration is measured by the change in location from one interview to the next.

In order to obtain a relatively homogeneous sample, only white non-Hispanic male high school graduates (or GED recipients) are included, using only the years after schooling is completed; the analysis begins at age 19. The (unbalanced) sample includes 12,895 annual observations on 1,281 men. Wages are measured as total wage and salary income, plus farm and business income, adjusted for cost of living differences across States (using the ACCRA Cost of Living Index).

The State effects $\{\mu_j(e)\}$ are estimated using data from the Public Use Micro Sample of the 1990 Census, since the NLSY does not have enough observations for this purpose. The State effects are estimated using median regressions with age and State dummies, applied to white males who have recently entered the labor force (so as to avoid selection effects due to migration).

4.6.1 Tuition

Tuition measures for public institutions were obtained from annual surveys conducted by the State of Washington Higher Education Board.[9] Tuition in community colleges in each State is the average in 1985-86 over all community colleges within the State; similarly tuition in higher level public colleges is measured as the average undergraduate tuition in Colleges and State Universities within each State, excluding "flagship" universities, except for a few States where only flagship tuition levels are available (Delaware, Hawaii, Alaska and Wyoming). Students attending college in their home State are assumed to pay tuition at the resident rate, while others pay the non-resident rate (allowing for a few reciprocity agreements across States). The home State is defined as the State in which the individual last went to high school. Private school tuition is obtained from the Digest of Educational Statistics.[10]

4.6.2 College Subsidies

State subsidies to higher education might affect either the cost or the quality of education. For example, given the level of tuition, the cost of attending college is lower if there is a college within commuting distance, and the cost of finishing college is higher if graduation is delayed due to bottlenecks in required courses. From the point of view of an individual student, an increase in tuition paid by other students has much the same effect as an increase in subsidies, in the sense that it increases the resources available for instruction and student support services. But because tuition also acts as a price, it seems more informative to model the effect of direct subsidies, holding tuition constant. This means that the effect of tuition should not be interpreted as a movement along a demand curve, since a college that charges high tuition, holding subsidies constant, can use the additional tuition revenue to improve the quality of the product, or to reduce other components of college costs.

The subsidies measure was constructed by adding federal, State and local appropriations and grants over all public colleges in the 1984 IPEDS file, by State, and by college level, the lower level

[9] A recent example of these surveys can be found at http://www.hecb.wa.gov/research/issues/documents/TuitionandFees2009-10Report-Final.pdf.

[10] Within-State averages for 1994-95 were adjusted by the ratio of the ratio of the national averages in 1994-95 and 1985-86 (which is $\frac{3672}{6121} = .600$). See http://nces.ed.gov/programs/digest/d95/dtab307.asp and http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=91660, Table 281.

being defined as community colleges, and the upper level as all other public colleges.[11] The total subsidies figure was then divided by the number of potential students, measured as the number of high school graduates in the State aged 22-36 in the 1990 Census.

5 Empirical Results

As a point of reference, the model of Kennan and Walker (2011) is first estimated separately for (white male) high school and college graduates. The model is estimated by maximum likelihood, assuming a 40-year horizon with a discount factor $\beta = .95$.

The estimates in Table 1 show that expected income is an important determinant of migration decisions. The results for high school graduates are taken from Kennan and Walker (2011); a slightly enhanced version of the model is estimated for college graduates. The overall migration rate is much higher for college graduates (an annual rate of 8.6%, compared with a rate of 2.9% for high school graduates), but the parameter estimates are quite similar for the two samples, aside from a substantially lower estimated migration cost for college graduates.

5.1 Why do College Graduates Move so Much?

It is well known that the migration rate for skilled workers is much higher than the rate for unskilled workers; in particular the migration rate for college graduates is much higher than the rate for high school graduates (see, for example, Topel (1986),Greenwood (1997),Bound and Holzer (2000), and Wozniak (2010)). Malamud and Wozniak (2009), using draft risk as an instrument for education, find that an increase in education causes an increase in migration rates (the alternative being that people who go to college have lower moving costs, so that they would have higher migration rates even if they did not go to college).[12] The model described in Table 1 can be used to simulate the extent to which the differences in migration rates for college graduates can be explained by differences in expected incomes, as opposed to differences in moving costs. This distinction affects the interpretation of measured rates of return on investments in college education. For example, if college graduates move more because the college labor market has higher geographical wage differentials, then a substantial part of the measured return to college is spurious, because it is achieved only by paying large moving costs.

Table 2 shows the observed annual migration rates for the high school and college graduate samples along with the migration rates predicted by the estimated model, where these rates are computed by using the model to simulate the migration decisions of 100 replicas of each person in the data. The extent to which the large observed difference in migration rates can be attributed to

[11]These data can be found at http://nces.ed.gov/ipeds/datacenter/Default.aspx

[12]Notowidigdo (2010) interprets the difference in migration rates between skilled and unskilled workers in terms of differential responses to local demand shocks. When there is an adverse local shock, house prices decline. Low-wage workers spend a large fraction of their income on housing, so the decline in the price of housing substantially reduces the incentive to migrate, while this effect is less important for high-wage workers. At the same time, public assistance programs respond to local shocks, and these programs benefit low-wage workers (although the relevance of this in explaining the differential migration rates for high-school and college graduates is doubtful, especially for men).

Table 1: **Interstate Migration, White Male High School and College Graduates**

	High School		College			
	$\hat{\theta}$	$\hat{\sigma}_\theta$	$\hat{\theta}$	$\hat{\sigma}_\theta$	$\hat{\theta}$	$\hat{\sigma}_\theta$
Utility and Cost						
Disutility of Moving (γ_0)	4.794	0.565	3.583	0.686	3.570	0.687
Distance (γ_1) (1000 miles)	0.267	0.181	0.483	0.131	0.482	0.131
Adjacent Location (γ_2)	0.807	0.214	0.852	0.130	0.852	0.131
Home Premium (α^H)	0.331	0.041	0.168	0.019	0.167	0.019
Previous Location (γ_3)	2.757	0.357	2.374	0.178	2.382	0.179
Age (γ_4)	0.055	0.020	0.084	0.024	0.085	0.024
Population (γ_5) (millions)	0.654	0.179	0.679	0.116	0.678	0.118
Stayer Probability	0.510	0.078	0.221	0.058	0.227	0.057
Cooling (α_1) (1000 degree-days)	0.055	0.019	0.001	0.011	0.001	0.011
Income (α_0)	0.314	0.100	0.172	0.031	0.172	0.030
Wages						
Wage intercept	-5.133	0.245	-6.019	0.496	-6.054	0.505
Time trend	-0.034	0.008	0.065	0.008	0.065	0.008
Age effect (linear)	7.841	0.356	7.585	0.649	7.936	0.667
Age effect (quadratic)	-2.362	0.129	-2.545	0.216	-2.739	0.220
Ability (AFQT)	0.011	0.065	-0.045	0.158	-0.254	0.167
Interaction(Age,AFQT)	0.144	0.040	0.382	0.111	0.522	0.114
Transient s.d. 1	0.217	0.007	0.212	0.007	0.188	0.687
Transient s.d. 2	0.375	0.015	0.395	0.017	0.331	0.131
Transient s.d. 3	0.546	0.017	0.828	0.026	0.460	0.131
Transient s.d. 4	1.306	0.028	3.031	0.037	0.921	0.019
Transient s.d. 5	—	—	—	—	3.153	0.179
Fixed Effect 1	0.113	0.036	0.214	0.024	0.205	0.022
Fixed Effect 2	0.296	0.035	0.660	0.024	0.722	0.023
Fixed Effect 3	0.933	0.016	1.020	0.024	1.081	0.025
Location match (τ_υ)	0.384	0.017	0.627	0.016	0.634	0.016
Loglikelihood	-4214.160		-4902.453		-4876.957	
	4274 observations		3114 observations			
	432 men,124 moves		440 men, 267 moves			

Table 2: **Interstate Migration, White Male High School and College Graduates**

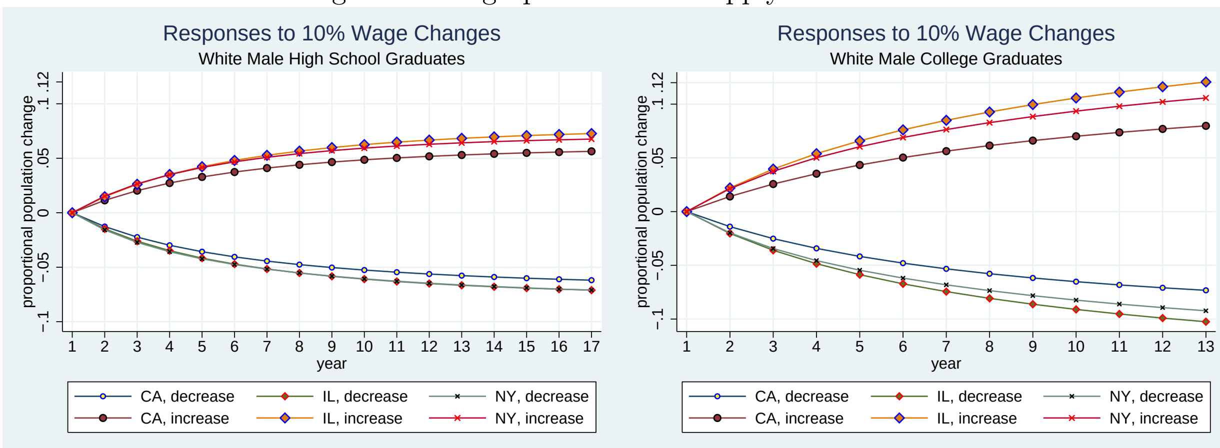
	High School	College Wages	College	HS Wages
	$\hat{\theta}$		$\hat{\theta}$	
Utility and Cost				
Disutility of Moving (γ_0)	4.794		3.570	
Distance (γ_1) (1000 miles)	0.267		0.482	
Adjacent Location (γ_2)	0.807		0.852	
Home Premium (α^H)	0.331		0.167	
Previous Location (γ_3)	2.757		2.382	
Age (γ_4)	0.055		0.085	
Population (γ_5) (millions)	0.654		0.678	
Stayer Probability	0.510		0.227	
Cooling (α_1) (1000 degree-days)	0.055		0.001	
Income (α_0)	0.314		0.172	
Wages				
Location match (τ_υ)	0.384		0.634	
NLSY Data				
Observations	4,274		3,114	
Migration Rate	2.90%		8.57%	
Simulated Observations	427,429	427,421	311,571	311,428
Migration Rate	3.16%	3.96%	8.60%	8.23%

differences in geographical wage dispersion can be measured by simulating the migration decisions that would be made by one group if they faced the same wage dispersion as the other group. Thus, according to the model, the migration rate of high school graduates would increase considerably if they faced the higher wage dispersion seen by college graduates, but the migration rate in this simulation is still only about 4% per year, compared with 8.6% for the college sample. The reverse experiment gives a similar result: the migration rate for college graduates facing the high school wage process would still be more than twice the observed rate for high school graduates. Thus although geographical wage dispersion can explain a nontrivial part of the difference in the explained migration rates, the model attributes the bulk of this difference to other factors, such as differences in moving costs.

5.2 Spatial Labor Supply Elasticities

According to the estimates in Table 1, college graduates are less sensitive to income differences than high school graduates (in the sense that the income coefficient in the payoff function is smaller) but they face bigger geographical income differences (in the sense that there is more dispersion in the location match component of wages, and also more dispersion in mean wages across locations). One interpretation of the results in Table 2 is that moving costs are much lower for college graduates. But an equally valid interpretation is that the nonpecuniary incentives to move are much greater for college graduates. It is thus of interest to know whether the greater mobility of college graduates

Figure 9: Geographical Labor Supply Elasticities



generates a more elastic response to geographic wage differences.

Following Kennan and Walker (2011), the estimated model can be used to analyze labor supply responses to changes in mean wages, for selected States. Since the model assumes that the wage components relevant to migration decisions are permanent, it cannot be used to predict responses to wage innovations in an environment in which wages are generated by a stochastic process. Instead, it is used to answer comparative dynamics questions: the estimated parameters are used to predict responses in a different environment.

The first step is to take a set of young white males who are distributed over States as in the 1990 Census data, and allow the population distribution to evolve, by iterating the estimated transition probability matrix (given the observed wages). The transition matrix is then recomputed to reflect wage increases and decreases representing a 10% change in the mean wage of an average 30-year-old, for selected States, and the population changes in this scenario are compared with the baseline simulation. Supply elasticities are measured relative to the supply of labor in the baseline calculation. For example, the elasticity of the response to a wage increase in California after 5 years is computed as $\frac{\Delta L}{\Delta w}\frac{w}{L}$, where L is the number of people in California after 5 years in the baseline calculation, and ΔL is the difference between this and the number of people in California after 5 years in the counterfactual calculation.

Figure 9 shows the results for three large States that are near the middle of the one-period utility flow distribution. The high school results are reproduced from Kennan and Walker (2011), showing substantial responses to spatial wage differences, occurring gradually over a period of about 10 years. The wage responses for college graduates are larger (with a supply elasticity around unity), and the length of the adjustment period is longer. This is consistent with the hypothesis that college graduates face substantially lower moving costs than high school graduates.

Table 3: **Ability, Parents' Education and Schooling**

Neither Parent went to College				
	High School	Some College	College	Total
Years	12-13	14-15	16+	
Low Ability	375 **84.8%**	33 7.5%	34 7.7%	442 62.3%
High Ability	128 47.8%	56 20.9%	84 31.3%	268 37.7%
Total	503 70.8%	89 12.5%	118 16.6%	710
Both Parents went to College				
Low Ability	41 51.9%	19 24.1%	19 24.1%	79 29.7%
High Ability	24 12.8%	44 23.5%	119 **63.6%**	187 70.3%
Total	65 24.4%	63 23.7%	138 51.9%	266

5.3 Migration and College Choices

The results in Table 1 deal only with migration decisions, conditional on education level. In the model described in Section 4, on the other hand, the level of education is also a choice variable. Moreover, since there is an interaction between ability and eduction in the wage function, the choice of whether to go to college depends on ability. The simplest specification uses just two ability levels. This binary ability measure is specified as an indicator of whether the AFQT percentile score is above or below the median in the full sample (which is 63). The model allows college students to choose their college location in the same way as the work location. Thus, for example, if the college labor market in an alternative location is more attractive, it might be preferable to go to college there, rather than going to college in the home location and moving after college. Moreover, it might be expected that States which provide large education subsidies would attract college students from other States.

As is well known, there is a very strong relationship between college choices and parental education levels. For the sample used here, this relationship is summarized in Table 3. For example, if both parents went to college, there is a 52% chance that their sons will graduate from college, and this rises to 64% if the son is in the top half of the distribution of AFQT scores. There is also a strong relationship between AFQT scores and college choices, but note that sons whose parents went to college are much more likely to have high AFQT scores.

Table 4 gives results for the full model, including both migration and college choices. The estimates of the parameters governing migration decisions are quite similar to the estimates in Table 1 above. The estimated income coefficient in the full model reflects both migration and college choice decisions; as in the migration model, the effect is highly significant. Ability and parental education levels have very strong effects on college costs (as would be expected, given the data in Table 3). The

Table 4: **College Location Choice and Migration, White Males**

Utility and Cost Parameters		
	$\hat{\theta}$	$\hat{\sigma}_\theta$
Moving Cost: HS	3.643	0.244
Moving Cost: SC	2.946	0.262
Moving Cost: CG	2.079	0.272
Distance	0.280	0.058
Adjacent Location	0.875	0.075
Home Premium	0.183	0.009
Previous Location	2.144	0.108
Age	0.137	0.010
Population	0.875	0.063
Climate	0.016	0.005
Income	0.316	0.010
Disutility of college: Pub lo	4.864	0.078
Disutility of college: Pub hi	5.539	0.081
Disutility of college: Pvt lo	8.220	0.074
Disutility of college: Pvt hi	6.403	0.058
Region (Pvt hi, NE)	1.017	0.077
Mother's education	0.572	0.055
Father's education	0.933	0.044
Ability effect on cost	0.779	0.039
College Subsidy: Pub lo	32.830	2.559
College Subsidy: Pub hi	8.781	0.920
Tuition: 2-year Pub College	4.095	0.520
Tuition: 4-year Pub College	3.035	0.264
Loglikelihood	-22719.5	

	Wage Parameters					
	High School		Some College		College	
	$\hat{\theta}$	$\hat{\sigma}_\theta$	$\hat{\theta}$	$\hat{\sigma}_\theta$	$\hat{\theta}$	$\hat{\sigma}_\theta$
Peak Wage	1.337	0.016	1.625	0.044	1.423	0.034
Age at Peak	31.670	0.313	31.475	0.500	31.668	0.294
Curvature	2.437	0.113	4.578	0.418	6.037	0.390
AFQT	0.063	0.023	-0.051	0.043	0.025	0.033
Location match	0.298	0.008	0.567	0.018	0.571	0.012
Transient s.d. 1	0.365	0.003	0.371	0.009	0.353	0.005
Transient s.d. 2	1.033	0.006	1.438	0.016	1.626	0.016
Individual Effect		0.822			0.009	

estimated moving costs are decreasing in the level of education, reflecting the positive relationship between education and migration rates in the data. There is a large disutility of attending college. This is especially true for someone of low ability whose parents did not go to college, but even if ability is high and both parents went to college, the model cannot explain why even more people don't choose to go to college without imputing a large "psychic" cost of attending college. In the model it is assumed that the payoff shocks representing unobserved influences on college choices are drawn from the same distribution for each person, regardless of ability or parental education. For someone at the mean of this distribution, the estimated model indicates that going to college would increase the net present value of lifetime earnings. Dispersion in the distribution of college payoff shocks explains heterogeneous choices made by people who look similar in the data, while differences in the disutility of attending college explain why the proportion of people choosing college increases with ability and parental education.

For public colleges, higher tuition has a strong negative effect on enrollment, and the effect is stronger for community colleges that for other public colleges. There is considerable variation in tuition levels for private colleges, but since this variation is not determined at the State level, the effect of differences in private college tuition cannot be inferred from locational choices, as is done here for public colleges. Instead, it is assumed that private college tuition is determined in a national market, so that the tuition level for each private college type is held constant across locations. This means that the effects of private college tuition are subsumed in the estimates of the private college "disutility" parameters.

One way to interpret the magnitude of the tuition coefficients is to ask how they compare with other coefficients in the cost function. In particular, the estimated model says that ability and parents' education have strong effects on college choices (and these effects are apparent in the raw data). So, for example, one can ask how much tuition would have to change to match the effect of replacing a father who did not attend college with one who did. The answer, for higher-level public colleges, is \$3,074. The tuition data are for 1985-86, in nominal dollars. The (unweighted) average for in-state tuition is \$1,202 (and it is \$3,010 for non-residents).

The results in Table 4 indicate that subsidies have a very significant effect on college enrollments. The effect is much stronger for community colleges than for other public colleges. As was mentioned above, the channels through which this effect operates are not clear. One possibility is that subsidies are used to provide financial aid to students; this could be analyzed by introducing data on financial aid provided by each college. Another possibility is that subsidies allow a richer menu of course offerings, making college enrollment a more attractive alternative, particularly in the case of community colleges.

6 Conclusion

The data indicate that there are strong economic incentives to migrate from low-wage to high-wage locations. Using a dynamic programming model of expected income maximization to quantify these incentives, it is found that they do in fact generate sizable supply responses in NLSY data. There are also big differences across States in the extent to which higher education is subsidized, and these State subsidies are apparently motivated to a large extent by a perceived interest in having a highly educated labor force. Given the finding that workers respond to migration incentives, it might be expected that State subsidies would have the intended effect, in the sense that States that provide more generous subsidies induce more people to go to college. It is then reasonable to conclude that even if some of these people subsequently move elsewhere, the costs of migration are such that most people will choose to stay, so that subsidies increase the level of human capital in the local labor force. The preliminary evidence presented here suggests that more generous subsidies actually do have significant effects on college enrollments. The strongest effects are found for community colleges, which are financed to a large extent by subsidies at the local level in many States. Much work remains before reasonable conclusions can be drawn about the policy implications of these results.

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