The Effects of High School Career and Technical Education on Employment, Wages, and Educational Attainment

Michael LaForest
Pennsylvania State University

Forthcoming, *Journal of Human Capital*
August 23, 2022

Abstract

I investigate the effects of high school career and technical education (CTE) on later life outcomes, by constructing a dynamic structural model which instruments for curricula choice using variation in CTE opportunities and local labor market controls. Estimates derived from national longitudinal data suggest that trade CTE, relative to general education and business CTE, improves wages and employment opportunities while increasing high school graduation but decreasing university graduation propensities. Policy simulations suggest that incorporating vocational certification into CTE would improve labor market outcomes. Simulations also suggest that strict high school tracking would increase the drop-out rate, but improve outcomes for graduates at the expense of their high school utility.

JEL classification: I2, J2, C3
Keywords: Returns to Education, Human Capital, Occupation Choice, Dynamic Discrete Choice Models
Acknowledgments: I am grateful to Steven Stern and John Pepper for their extensive guidance. I would like to thank Leora Friedberg, Benjamin Castleman, William Johnson, James Wycoff, Jens Ludwig, several anonymous referees, and participants at various seminars for helpful advice and comments. I would like to thank the Institute for Education Sciences for restricted-use data access, and the Bankard Fund for Political Economy, the Radulovacki Summer Research Fund, and the UVA Quantitative Collaborate for financial support. All errors are my own.

1. Introduction

In 2018, 31% of U.S. high school seniors did not attend any post-secondary institutions following graduation (Bureau of Labor Statistics, 2019). For many non-college bound students, taking career and technical education (CTE) courses in high school, which prepare them for trade and business careers, may be preferable to concentrating solely in general education courses.[1] An important question is which type of high school education is most advantageous for these students. Learning particular labor market skills while attending high school may improve their ability to find well-paying jobs after graduation. Alternatively, these students may be better served by learning a wide range of non-honors English, math, and science courses in high school and waiting to learn job-specific skills in the labor market.

There is disagreement among researchers and policy makers about the merits of high school career and technical education.[2] Some see high school CTE as an alternative to college which helps students find well-paying careers, while others see it as a system that limits students' future post-secondary education (PSE) and labor market opportunities. Still others see it as a system that can prepare students to pursue PSE as well as prepare them for the labor market. Partially due to this lack of consensus, high school education policy has favored an expansion of academic and general education curricula alongside a reduction in CTE curricula over the last 30 years, which has caused the number of high school students in the United States concentrating in a vocational field to fall from one-third to one-fifth since 1982 (U.S. Department of Education, 2013). However, little empirical research has been conducted on the benefits and drawbacks of high school CTE, and there remains general disagreement among researchers about its effects.

[1] The terms "Career and Technical Education" and "Vocational Education" are used synonymously by different sets of policy makers and researchers throughout the field.

[2] For a discussion of these disagreements, see Silverburg et al. (2004), Bozick and Dalton (2013), Levesque et al. (2008), U.S. Department of Education (2013), and Independent Advisory Panel of the NACTE (2014).

In addition, the percentage of students who drop out of high school in the U.S. is sizable as is the percentage of students who begin but never complete a post-secondary education degree. Specifically, 10% of the potential high school class of 2012 did not receive a high school diploma or General Educational Development (GED) certificate by age 21 (Flood et al., 2015). As well, only 29% of students who began PSE certificate / associate degree programs in 2009 completed them in three years or less, and only 59% of students who began PSE bachelor's degree programs in 2006 completed them in six years or less (National Center for Education Statistics, 2015). These sizable attrition rates motivate three additional questions. First, how does the availability of high school CTE affect students' propensity to drop out of high school? Second, how does taking high school CTE affect students' propensity to complete PSE degrees? Finally, how does taking high school CTE affect the labor market outcomes of both high school dropouts and high school graduates who begin but never complete PSE degrees?

This work contributes to the literature by first providing a thorough and interconnected empirical analysis of the education and labor market effects of different types of high school education. To evaluate these effects, I construct and estimate a dynamic structural model of high school education, post-secondary education, and labor market decisions, accounting for high school curriculum self-selection with high school CTE opportunity instruments and local labor market controls. The model, described in Section 3, separates education and labor market decisions into 15 distinct yearly choices - attending high school in one of five fields (trade CTE, business CTE, general education, academic, and other), completing the general education development (GED) exam, working in one of five types of occupations (professional, skilled manual labor, skilled non-manual labor, skilled other, and unskilled), attending one of three types of post-secondary education institutions (trade school, community college, and four-year university), or “neither working nor attending school.” An individual’s present choices affect her future wage offers, and she chooses between these education and labor market options each year to maximize her expected lifetime utility.

I estimate the model using data from the restricted-use version of the Educational Longitudinal Study of 2002 (ELS:2002), as discussed in Section 4. The data set follows a random sample of 16,200 students, from one of 750 different high schools across the United States. It follows these students for twelve years – from the start of high school, in 2000, until eight years after high school graduation, in 2012. In addition to student surveys in 2002, 2004, 2006, and 2012, the study includes a variety of detailed education and labor market information about each student including her high school transcript, PSE attainment, yearly occupation information, and wages.

Section 5 describes the maximum simulated likelihood estimation strategy and exogeneity assumptions. Section 6 presents and discusses the parameter estimates of the structural model and compares them to parameter estimates of linear models of later-life wages and employment estimated using two-stage least squares (2SLS) regression analysis. The parameter estimates from the 2SLS regressions suggest that, relative to general education courses, trade vocational courses improve a student’s later labor market wages and chance of being employed in a skilled occupation while business vocational courses decrease a student’s wages but have little effect on employment. The structural model estimates confirm these findings but provide additional context. First, they suggest that the lower average wages associated with completing business vocational courses are driven by occupation selection. Specifically, a business vocational curriculum improves wages in low-wage occupations that are associated with high levels of non-pecuniary utility (i.e., skilled non-manual labor occupations), incentivizing business vocational concentrators to choose those occupations. The structural parameters also suggest that the positive wage returns to trade vocational education are generally confined to skilled manual labor occupations, incentivizing trade vocational concentrators to choose those occupations.

Next, structural estimates suggest that concentrating in a trade or business vocational field slightly decreases the propensity to pursue a four-year PSE degree after high school relative to concentrating in a general education field. In addition, the estimates show that an increased availability of vocational course offerings and vocational opportunities decreases a student's propensity to drop out of high school. Finally, the estimates suggest that individuals in the population can be split between two types of individuals: those who will always graduate from high school (two-thirds of the population) and those who are at high risk of dropping out of high school (one-third of the population). The third of the population at high risk of dropping out of high school are also less likely to attend PSE institutions, less likely to be employed, and (conditional on employment) less likely to be employed in skilled occupations. These estimates suggests that interventions to decrease the high school dropout rate should be tailored to appeal to this subgroup of students.

Finally, this work further contributes to the literature by simulating the effects of several possible changes to high school CTE and course selection policy. These simulations leverage the estimated model to provide theoretical predictions about how each policy would affect students' education and employment decisions throughout their lifetimes, and are presented in Section 7. The first simulates a federal policy that makes CTE available at every high school nationwide. The results suggest that this expansion would lead to positive but relatively minor long-term effects on individuals' education and labor market outcomes. The second simulates the effect of incorporating vocational certification directly into high school vocational curricula.[3] This policy would lead to an additional students taking vocational courses (2.9 percentage points), notable positive increases in employment (0.3 percentage points), as well as an increase in average wages (9.1%) and average welfare (2.2%) in the population among individuals who change their behavior.

Third, I simulate the effect of a strict high school tracking system, loosely following the system used in Germany, that pushes students into specific curricula at the time they enter secondary school based on standardized test scores. This simulation leads to more students being pushed into, and completing, academic and vocational curricula instead of general education curricula. However, it also predicts a large increase in the number of students who drop out of high school and instead pursue GEDs, due to the inability to select their own high school curricula. Among individuals who graduate from high school, the increase in academic and vocational concentrations lead to increased PSE attainment, average wages, and likelihood of being employed, though these gains come at the expense of non-pecuniary utility in high school. Students who drop out of high school experience worse PSE and labor market outcomes, leading to an overall decrease in average welfare (-1.3%) in the population among individuals who change their behavior.[4] Section 8 concludes.

2. Literature Review

To date, little evidence exists about the effects of high school career and technical education on education and labor market outcomes. First, many previous studies on the effects of

---

[3] Vocational certification is historically pursued after high school graduation and is needed to work in various vocational occupations. The number of high school vocational programs that confer vocational certification has dramatically increased since 2006 (two years after the students in the ELS:2002 sample graduated high school), largely due to the Carl D. Perkins Career and Technical Education Act of 2006 (U.S. Department of Education, 2013).

[4] An additional exploratory policy simulation, which investigates the effects of making community college free for all high school graduates, is discussed in Appendix D.

high school education do not control for high school curricula self-selection. This set of studies does not separately identify the effects of high school curricula from the effects of unobserved factors (such as motivation and ability in a particular high school field) that cause students to take different classes in the first place. These studies have used data from the same three data sets (The National Longitudinal Study of the High School Class of 1972 (NLS-72), High School and Beyond (HS&B), and The National Education Longitudinal Study of 1988 (NELS:88)) and have reached differing conclusions regarding the effects of high school CTE due to differences in empirical specifications. For example, Meyer and Wise (1982), Stromback (2010), and Davis and Obenauf (2011) each found no significant effect of high school CTE on early labor market experiences, while Arum and Shavit (1995), Mane (1999), and Bishop and Mane (2004) each found statistically significant positive effects of high school CTE on wages and employment chances.

Several prior studies have controlled for self-selection while investigating adjacent research questions about high school and PSE curricula. Kirkeboen et al. (2016) investigated the effects of PSE field choice in Norway, using discontinuities in admission cutoffs into different institutions and fields of study. They found that PSE field has a larger impact on labor market outcomes than PSE institution, but that returns are largely driven by students selecting fields in which they have a comparative advantage. Altonji et al. (2012) and Altonji et al. (2016) created theoretical models of both high school curriculum and college major choice, discussed the general lack of causal evidence about the effects of specific high school courses, and provided suggestions for future research.

Several studies looked at the effects of high school courses more generally. Altonji (1995) used data from NLS-72, instrumenting curricula choice with aggregate course enrollment at each school, and found the return to wages from different types of courses to be small. Dahl et al. (2021)

investigated the effects of high school major by leveraging a discontinuity in admission cutoffs into different majors in Sweden, and found little returns from completing an academic program relative to other types of courses.

Finally, several recent studies focus directly on the effects of CTE. Meer (2007) used data from NELS:88 and dealt with the problem of high school curriculum self-selection using the Heckman (1979) correction in addition to including a set of high school vocational opportunity instruments. He estimated a static model with one observation of high school education in 1992 and one observation of income in 2000 for each individual. He found minor positive effects of high school CTE on later-life earnings for a subset of the population but concluded that a majority of individuals in that subset were already concentrating in high school vocational curricula.

Kreisman and Stange (2020) investigated the returns to high school vocational education using data from NLSY97 and focused on the marginal effect of each additional vocational course taken. They split up vocational courses between basic and advanced courses and estimated the effects of high school course choice on post-secondary education attendance and wages. To control for high school curricula self-selection, they included a small set of student ability and high school characteristic controls. Their findings suggest that each additional vocational course marginally decreases four-year college attendance and has no effect on high school graduation, but that each additional advanced vocational course improves later life wages. Finally, recent work by Daugherty (2018) found positive effects of CTE on on-time graduation using a regression discontinuity design around admissions into a CTE program in Connecticut.

While my research reaches several similar conclusions to this prior work, it goes beyond these studies in several dimensions. Specifically, it includes a fuller set of high school curricula choice instruments and local labor market controls, uses students' choice paths over time to infer additional information about unobserved heterogeneity, and uses education and employment data from every year in the panel data set to improve the precision of the estimates. In addition, it jointly estimates the interrelated effects of CTE education on an individual's high school dropout propensity, PSE attainment, employment outcomes, and wages, and separately identifies the present and future benefits that drive current education and labor market choices. Finally, it allows for policy-relevant simulations.

My estimation methodology follows the previous literature on dynamic structural models of individual behavior such as Berkovec and Stern (1991), Keane and Wolpin (1997), Eckstein and Wolpin (1999), Diermeier et al. (2005), and Chan (2013). Differences include that my model is the first to look at high school curriculum choice and that it makes fewer assumptions by modeling a broader range of lifetime choices than previous models.[5]

3. Model

I model an individual's schooling and work decisions using a dynamic discrete choice model. Every year, an individual chooses among mutually exclusive education and labor market options in order to maximize her lifetime utility, knowing that current education and labor market decisions affect future wages and educational opportunities. An individual's decision each year depends on the utility she receives from her decision in the current year as well as her knowledge about how that decision will affect her in the future.

3.1 Choices

[5] This research models 15 education and labor market choices across an individual's lifetime. As comparison, Eckstein and Wolpin (1999) model six high school education and part-time / full-time work options, and Chan (2013) models eight labor supply and welfare participation options.

As illustrated in Figure 1, the model is structured as follows: an individual begins making choices in her first year of high school when she is 14 years old. In each period, which is one year long, she chooses among:

(A) Attending high school in one of five fields: *Academic, General Education, Business Vocational, Trade Vocational, or Other (agriculture, health, art, physical education, etc.);*

(B) Working in one of five types of occupations: *Professional, Skilled Non-Manual Labor, Skilled Manual Labor, Skilled Other, or Unskilled;*

(C) Neither working nor attending school: *Not Employed.*

Once the individual has completed four years of high school, she graduates. As soon as the individual graduates, she receives a high school diploma that reflects her aggregate curriculum across her four years of high school.[6] Denote the number of years individual *i* has completed in high school field *k* prior to the start of period *t* as F_{it}^{k}. After completing her fourth year of high school ($\sum_j F_{it}^{j} = 4$), individual *i*'s aggregate curriculum vector, H_{it}, is updated to indicate the field that she chose for a plurality of the four years she completed:

$$H_{it}^{k} = 1 \quad \text{iff} \quad k = \underset{j}{\operatorname{argmax}}\left[F_{it}^{j}\right] \quad . \tag{1}$$

If the individual devoted the same number of years to multiple fields, the most recently taken field is assigned as her aggregate high school curriculum.[7] The student is aware of how aggregate

[6] Yearly high school field choices are modeled to capture an individual's propensity to drop out of high school over time and to change her high school field over time. A single high school curriculum type is assigned at graduation to decrease the size of the state space over which the likelihood function must be evaluated when estimating the model.
[7] In practice, the aggregate curriculum construction rule is slightly more complicated for the general education and "other" fields: students receive an overall general education curriculum or "other" curriculum only if they concentrated in that field for twice as many years as they concentrated in any academic or vocational field and if they chose that field during their senior year. The reason for this complexity is that students who are considered academic and vocational concentrators in the U.S. high school education system generally still take some general education and alternative (art, health, physical education, etc.) courses in high school in addition to their academic and vocational courses, particularly during their first two years of high school. This specification follows specifications used in the previous literature, such as Meer (2007).

curriculum will be assigned when she makes her high school field choice each year. Her decision is driven by the enjoyment she receives from taking classes in a particular field during the current year, her knowledge of how the choice will affect her overall high school curriculum, and her knowledge of how her overall high school curriculum will affect her future wage offers and PSE choices (as discussed below).

The individual cannot drop out of high school prior to age 16 due to compulsory school attendance laws, or choose to attend high school after age 21 due to high school attendance age requirements.[8] If the individual is any age over 18 and has not yet graduated from high school, in addition to her other choices, she can choose to:

(D) Complete the General Educational Development exam: *GED*.

After completing the GED exam, individual i's aggregate curriculum vector (H_{it}) is updated to indicate that she earned a GED:

$$H_{it}^{GED} = 1 \quad \text{iff} \quad F_{it}^{GED} = 1 \quad . \tag{2}$$

After graduating from high school or receiving a GED, the individual can no longer choose any of the five high school education options or the GED option. Instead, in addition to working and non-employment, she can choose to:

(E) Attend one of three types of post-secondary education institutions: *Trade School, Community College, or Four-Year University.*[9]

The individual can pursue any of these PSE degrees each year, in any order. Once an individual

[8] All states set their compulsory school attendance age at either 16, 17, or 18, though many states provide some exceptions which allow students to drop out prior to reaching this age (Education Commission of the States, 2015). A majority of states set the high school attendance age cutoff at 21 (29 states). A minority of states set the age cutoff at 19 (1 states), 20 (9 states), 22 (1 state), 26 (1 state), or provide no age cutoff at the state level (9 states) (Education Commission of the States, 2013).

[9] Throughout this paper "trade school" refers to any vocational certificate granting PSE institution, "community college" refers to any associate degree granting PSE institution, and "four-year university" refers to any bachelor's degree granting PSE institution.

has attended and passed one year at a trade school, two years at a community college, or four years at a four-year university, she receives a degree from that institution and can no longer attend that type of institution. Let N_{it}^{k} denote the number of years individual i has completed at PSE institution type k prior to the start of period t. Her PSE graduation vector, P_{it}, is constructed as

$$\begin{aligned} P_{it}^{4yr} &= 1 \quad \text{iff} \quad N_{it}^{4yr} = 4 \quad , \\ P_{it}^{CC} &= 1 \quad \text{iff} \quad N_{it}^{CC} = 2 \quad , \\ P_{it}^{cert} &= 1 \quad \text{iff} \quad N_{it}^{cert} = 1 \quad . \end{aligned} \tag{3}$$

After the individual graduates from a four-year university, she can choose among only work options and the "not employed" option.[10] The student is aware of these PSE institution graduation rules when making her choice each year.[11] Overall, there are 15 total options available to a person over her lifetime: five high school education fields, one GED exam, five occupations, three types of PSE institutions, and the not employed option.[12]

Every year an individual works in an occupation, she has a chance to gain occupation-specific human capital in that occupation (O_{it}^{k}). Specifically, the law of motion of occupation-specific human capital in each occupation is

---

[10] That is, an individual who receives her bachelor's degree cannot choose to attend a community college at a future date to pursue an associate degree. This assumption is made to simplify the choice set available to bachelor's degree completers. Only 0.2% of individuals in the data set attended a two-year community college or a one-year trade school after attaining a bachelor's degree.

[11] Approximately 20% of individuals who enroll in a two-year community college eventually transfer to a four-year university (Hossler et al., 2012). The amount of community college credit that is transferable varies widely across institutions from 0% to 100%, with an average of around 70% among transferees, which takes into account that many transfer credits do not give specific course credit towards graduation (Monaghan and Attewell, 2014). I currently code community college transfers who attain bachelor's degrees as having attended four-year universities for four years. Potential future work involves expanding the model to allow community college credit to transfer to four-year universities with a certain probability, realized after community college courses are taken.

[12] Marriage and child birth choices are left out of the model to avoid another level of model complexity and to preserve estimation tractability. Omitting child birth may add additional self-selection bias to the model if individuals who plan to have children choose specific high school concentrations and choose not to participate in the labor market. Similar to other high school curriculum self-selection bias in the model, this bias is dealt with by including instruments for high school curriculum choice and by estimating the distribution of unobserved heterogeneity in the population, as discussed in Section 5.2.

$$O_{it+1}^{k} = O_{it}^{k} + \psi_{it} \quad \text{iff} \quad k_{it} = k \quad \& \quad \underset{j}{sum}(O_{it}^{j}) < 2, \qquad (4)$$

$$O_{it+1}^{k} = O_{it}^{k} \qquad \text{otherwise,}$$

where ψ_{it} is a random variable distributed iid $Bernoulli(\theta_e)$ and realized at the end of period t.[13] An individual's level of occupation-specific human capital is allowed to vary between low ($O_{it}^{k} = 0$), medium ($O_{it}^{k} = 1$), and high ($O_{it}^{k} = 2$) in each occupation to reflect the discrete raises an individual receives, after controlling for inflation, in her occupation throughout her lifetime. The assumptions that occupation-specific human capital accrues probabilistically and is constrained to a small number of possible states follow Sullivan (2010) and are made to decrease the size of the state space. Note that an individual can accumulate only up to two levels of occupation-specific human capital across all occupations ($sum_j(O_{it}^{j}) \leq 2$) over her lifetime, which follows the results of previous studies that show that individuals rarely accrue high levels of occupation-specific human capital in multiple occupations (e.g., Topel and Ward, 1992, and Pavan, 2010).

The individual can choose among education and labor market options until she turns 35, after which she remains in her most recently chosen occupation for the rest of her career. This assumption conforms with labor market evidence that most career switches occur very early in an individual's career (e.g., Neal, 1999) and follows the treatment of future utility used in prior studies (e.g., Berkovec and Stern, 1991, and Francesconi, 2002). Once the individual turns 65, she retires. Following retirement, all individuals receive the same amount of utility which is independent of previous choices.

[13] The probability an individual gains occupation-specific human capital, θ_e, varies based on the individual's highest level of educational attainment (i.e., no high school diploma or equivalent (θ_{noHS}), high school diploma or equivalent (θ_{HS}), PSE trade certificate (θ_{cert}), associate degree (θ_{CC}), or bachelor's degree (θ_{4yr})). Depreciation of occupation-specific human capital over time is omitted from the model to avoid another level of model complexity.

3.2 Utility Function

The individual receives utility each period from both her current wage, if working, and the non-pecuniary utility of her current choice. Each period, the individual receives a wage offer in each of the five occupations.[14] Specifically, the wage offer for person i in occupation k in period t is

$$w_{it}^{k} = X_i\tilde{\beta}_X^k + H_{it}\tilde{\beta}_H^k + P_{it}\tilde{\beta}_P^k + P_{it}^{cert}H_{it}\tilde{\beta}_{PH}^k + O_{it}\tilde{\beta}_O^k + \tilde{u}_i^k + \tilde{\varepsilon}_{it}^k \ . \qquad (5)$$

The symbol "~" denotes wage parameters and wage error terms. The vector X_i is comprised of time-invariant characteristics of the individual, such as personal characteristics about the individual, characteristics about the individual's high school, and characteristics about the local labor market where the individual's high school was located. Vectors H_{it} and P_{it} are comprised of dummy variables for high school graduation curriculum and PSE institution graduation as defined above.[15] Vector $P_{it}^{cert}H_{it}$ is comprised of dummy variables for whether the individual completed a particular high school track followed by a PSE trade school certification.[16] Vector O_{it} is comprised of the occupation-specific human capital the individual has gained in each of the five occupations. Error terms $\tilde{u}_i^k$ and $\tilde{\varepsilon}_{it}^k$ are discussed below.

Next, the individual receives non-pecuniary utility each period from her current choice. The total utility she receives in a period is a linear function of her wage, if working, and the non-pecuniary utility she receives from her choice. Specifically, individual i's total utility flow from choice k at time t is

[14] I assume the individual receives a wage offer in every occupation every period with 100% certainty, an assumption used in a variety of other structural models (e.g., Eckstein and Wolpin, 1999). An individual who, in reality, did not receive a wage offer in an occupation in a period is represented in the model as having received an extremely low wage offer in that occupation that period.

[15] The model is agnostic about whether the effects of high school graduation curriculum and PSE institution graduation on wages ($H_{it}\tilde{\beta}_H^k$ and $P_{it}\tilde{\beta}_P^k$) are driven by skill accumulation or signaling value.

[16] These interaction terms are included to investigate whether there is an additional benefit to wages from both concentrating in a particular vocational curriculum in high school and receiving a PSE trade school certification.

$$
\begin{aligned}
U_{it}^k &= X_i\beta_X^k + u_i^k + \varepsilon_{it}^k && \forall k \in \textit{HS Fields} \quad ,\\
U_{it}^k &= X_i\beta_X^k + u_i^k + \varepsilon_{it}^k + H_{it}\beta_H^k && \forall k \in \textit{PSE Institution Types} \ , \qquad (6)\\
U_{it}^k &= X_i\beta_X^k + u_i^k + \varepsilon_{it}^k + \varphi w_{it}^k && \forall k \in \textit{Occupations} \quad .
\end{aligned}
$$

The coefficient φ represents the utility value of wages relative to non-pecuniary utility.[17] For PSE options, β_H^k captures how the utility an individual gains from attending each type of post-secondary institution is affected by her previous high school education choice (H_{it}). This is because her previous education choice affects whether she is accepted into colleges, receives scholarships that impact her net tuition, and whether she knows other material that may help her succeed in college, giving her more incentive to attend. All of these effects cumulatively make up β_H^k.[18]

The stochastic error terms $\tilde{\varepsilon}_{it}^k$ and ε_{it}^k (associated with wage offers and non-pecuniary utility, respectively) vary across individuals, across choices, and across time. Each $\tilde{\varepsilon}_{it}^k$ is distributed $iid\ N(0, \sigma_{\tilde{\varepsilon}}^2)$, and each ε_{it}^k is distributed $iid\ EV(0,1)$.[19] The error terms $\tilde{u}_i^k$ and u_i^k vary across individuals and choices but are constant over time, and reflect individual unobserved heterogeneity. For example, $\tilde{u}_i^k$ and u_i^k include the effects of an individual's unobserved motivation and ability in each education field and labor market occupation. Each individual's unobserved heterogeneity terms are restricted to one of two possible sets in the population, u_1

---

[17] The characteristics that comprise X_i (personal characteristics, high school characteristics, and labor market characteristics) vary across choices. Personal characteristics affect wages and utility for each of the 15 choices in the model. Local labor market characteristics affect the wages of each occupation choice. Characteristics about the individual's high school related to curriculum availability and curriculum selection affect the utility of each high school field and GED choice. Finally, characteristics about the individual's high school related to PSE attendance and PSE opportunities affect the utility of each PSE institution choice.

[18] P_{it} and H_{it} do not affect occupation non-pecuniary utility as I assume that the labor market returns to education are exclusively wage-related. That is, I assume that taking particular classes in high school will increase wages in each occupation but will not directly increase the non-pecuniary enjoyment of working in each occupation.

[19] Error terms $\tilde{\varepsilon}_{it}^k$ and ε_{it}^k are each assumed to be independent across individuals, choices, and time. The error term associated with the wage in each occupation each year, $\tilde{\varepsilon}_{it}^k$, can be thought of as a yearly wage bonus in each occupation that changes from year to year. The error term associated with the non-pecuniary utility of each choice each year, ε_{it}^k, can be thought of as stochastic randomness in an individual's life that changes her enjoyment of that choice from year to year.

(type one) and u_2 (type two), where

$$u_\tau = (\tilde{u}_\tau^{k_1}, \tilde{u}_\tau^{k_2}, \dots, \tilde{u}_\tau^{k_5}, u_\tau^{k_1}, u_\tau^{k_2}, \dots, u_\tau^{k_{15}}) \quad , \quad \tau = 1, 2 \quad . \tag{7}$$

Define ζ as the proportion of individuals in the population with type-one unobserved heterogeneity values.[20]

An individual chooses between her education and employment options in each period t to maximize the value of her expected lifetime utility between the current period and retirement at age 65.[21] The construction of the value function is similar to the derivation used in other dynamic discrete choice models such as Keane and Wolpin (1997) and Chan (2013). For more details see Appendix E.

4. Data

I estimate the model using data from the restricted-use version of the Educational Longitudinal Study of 2002 (ELS:2002). The study, conducted by the U.S. Department of Education, followed a nationally representative random sample of 16,200 students from 750 different high schools across the United States.[22] The study collected data from August 2000, when the respondents began high school, until May 2012, eight years after the majority of the

---

[20] Restricting the distribution of unobserved heterogeneity to two types in the population follows the treatment of unobserved heterogeneity in the previous literature (e.g., Duflo et al., 2011, and Chan, 2013). Fox et al. (2011) simulate models with up to 40 types of unobserved heterogeneity and find that models restricting individuals to only two types in the population capture unobserved heterogeneity extremely well and find little improvement from adding additional types.

[21] Budget constraints and switching costs are subsumed in the model. For example, the model depicts a budget constraint for a choice as a large negative non-pecuniary utility parameter for individuals of low socio-economic status for that choice. The model depicts switching costs as both the loss in wages from moving from an occupation with previously accrued human capital to one without it as well as the forgone opportunity to gain additional human capital in the prior occupation this period.

[22] As shown in Appendix A, the ELS:2002 study sample is nationally representative of U.S. high school sophomores in 2002 with two exceptions – it oversampled individuals attending private schools and undersampled eventual high school dropouts. Note that I do not use ELS:2002 sample weights as I include the entire sample of 16,200 individuals in the structural analysis. Using ELS:2002 sample weights does not have an appreciable effect on 2SLS estimation results.

respondents had graduated from high school. The initial survey was conducted in 2002 and was succeeded by three follow-up surveys in 2004, 2006, and 2012. In addition to student surveys, it collected supplementary information from each student's parents, teachers, high school administrators, high school librarians, and high school counselors. It also collected high school transcripts and post-secondary education transcripts for nearly all students.

4.1 Choice Construction

I construct each student's yearly high school field choice based on high school transcript data.[23] First, each course a student took is coded into one of five field types (academic, general education, trade vocational, business vocational, or other) based on the Classification of Secondary School Courses (CSSC) code for that class.[24] Academic courses include all honors, Advanced Placement (AP), and International Baccalaureate (IB) courses, while general education courses include all non-honors math, science, English, and foreign language courses. Trade vocational courses include all CTE courses that prepare students for a specific manual trade, such as construction, mechanics, industrial arts, and personal services (e.g., barber / beautician training). Business vocational courses include all CTE courses that teach students general business skills which can be applied across a variety of careers, such as office management, marketing, communications, and computer sciences. "Other" courses include all courses that do not fit into

[23] When constructing individual-year choices, I treat an individual who worked part-time while attending high school or college full-time as having attended school and not as having worked. This simplification is made to greatly reduce the number of choices in the model and is used in previous dynamic structural models such as Keane and Wolpin (1997). I only code an individual as attending high school or a post-secondary institution in a given year if she took and passed at least half the average course load of credit hours at her school that year. This assumption is implied in previous structural models such as Eckstein and Wolpin (1999) and is analogous to the assumption in labor market literature that treats individuals who are fired from their job the same as individuals who quit their job. Similarly, an individual who took five years of attendance in high school to graduate is coded as having failed her coursework during the year in which she passed the least number of credits.

[24] CSSC codes are six digit codes associated with each secondary school course taught in the United States. Codes are assigned based on the content of each course (National Center for Education Statistics, 2000).

any of these categories, such as agriculture, home economics, art, music, health, and physical education.[25]

Next, a single overall field concentration is constructed for each year of high school, defined as the field in which the student took a plurality of courses that year.[26] The tiebreaking rule favors labeling a yearly concentration as vocational as opposed to non-vocational, though very few ties occur. Finally, overall high school curriculum is determined based on the yearly field the individual selected for a plurality of years as defined in Section 3.1.[27]

Next, I construct occupation type by reassigning the 17 occupation codes provided in ELS:2002 to one of the five occupation types (professional, skilled manual labor, skilled non-manual labor, skilled other, and unskilled). Professional occupations include professional and managerial occupations and skilled manual labor occupations include craftspersons, operatives, protective service occupations, and skilled laborers. Skilled non-manual labor occupations include clerical, sales, and skilled service occupations, and skilled other occupations include farmers, military occupations, and teachers. Unskilled occupations include low-skill and minimum wage jobs such as fast food workers, bartenders, waiters, janitors, cleaners, attendants (service stations, ticket takers, etc.) and cashiers.[28]

---

[25] The complete mapping of CSSC codes to curriculum types is provided in Appendix F.

[26] In practice the yearly curriculum construction rule is slightly more complicated than this with regard to the "other" and general education fields: students are considered "other" and general education yearly concentrators only if they took twice as many courses in the "other" or general education fields as courses in any academic or vocational field. The reason for this complexity is that students who are considered academic and vocational concentrators in the U.S. high school education system generally still take a few general education and alternative (art, health, physical education, etc.) courses each year in addition to their academic and vocational courses. This specification is similar to that of Meer (2007).

[27] Curricula outcomes are very similar under my chosen construction rule relative to alternative specifications, as shown in Appendix F. Also note that approximately 480 individuals in the sample attended a PSE masters, professional, or doctoral program. As I do not include this choice in the model, these individuals are currently treated as "missing information" during years when they attended these programs. Additionally, note that I do not observe high school transcripts after 2003: all high school attendance between 2004 and 2007 is coded as "HS Unknown Type."

[28] These occupation categories are similar to the categories used in the previous literature (e.g., Aram and Shavit, 1995), which in general follows the occupation schema created by Erikson, Goldthorpe, and Portocarero (1979). Additional occupation mapping details can be found in Appendix F.

4.2 Summary Statistics

Summary statistics about the personal characteristics of the students are displayed in Table 1, Panel A. Among surveyed students, 50% were male, 56% were white, 13% were black, and 15% were Hispanic. A larger percent of the sample was from areas that identified as suburban than from areas that identified as urban or rural, and approximately 80% of students attended public high schools.

Table 1, Panels C and D display school-level summary statistics, including the high school vocational and academic opportunities at each student's school, the selection methods for school enrollment at each student's school, and the selection methods for high school course selection at each student's school. Approximately three-fourths of students in the sample attended high schools that offered some type of vocational curriculum either on-site or at an area vocational school.[29] Approximately 10% of students attended schools that conferred GED degrees on-site, and three-fourths of students attended schools that admitted students principally based on the geographic location of their parents' homes. Next, the influence students had on their own course selection, as reported by high school counselors, varied widely throughout the sample, though on average students had a large influence on their course selection. Finally, the average student attended a high school where, in regards to the previous year's graduating class, a large percent had enrolled in a four-year college (60%), a relatively small percent had enrolled in a two-year college (25%), and a relatively small percent had entered the labor market (15%).

Finally, Table 1 Panel C provides summary statistics about the local labor market

[29] An area vocational school is an off-grounds location where high school vocational courses are taught. Students who enroll in courses at an area vocational school bus between the area vocational school and their primary high school multiple times each week.

characteristics, in 2002, in the county in which each student's high school was located.[30] The average unemployment rate was 4.2% with a fairly large variance across counties. The percent of employees working in each type of industry varied widely across counties, however, more employees worked in manual (23%) and non-manual labor (24%) industries, on average, than in professional industries (7%).

Summary statistics on educational attainment, employment, and wage outcomes are presented in Appendix A. In the sample, 33% of students completed a general education curriculum, 21% completed an academic curriculum, and 5%, 5%, and 13% completed a business vocational curriculum, trade vocational curriculum, and other curriculum, respectively. Just under 7% of students in the sample did not graduate from high school by age 19.[31]

By 2012, eight years after the majority of students in the sample had graduated from high school, 40% of students had graduated from a four-year university, while 9% and 8% of students had graduated from (at most) trade school or community college, respectively. At age 26, 27% of individuals in the sample were working in professional occupations, 20% were working in skilled manual labor occupations, 25% were working in skilled non-manual labor occupations, 6% were working in unskilled labor occupations, and 11% were neither working nor attending school.

Regarding wages, individuals in professional occupations received the highest average log hourly wages (2.6, which corresponds to an hourly wage of $13.5), followed by individuals in the

---

[30] Data on county unemployment rates comes from the Bureau of Labor Statistics' (BLS) Local Area Unemployment Statistics. Data on average wages and industry employment percentages by county comes from the Bureau of Economic Analysis's (BEA) regional data on Local Area Personal Income & Employment. Employment percentages across industries are used because employment percentages across occupations are not available at the county level. Industry employment percentages closely match occupation employment percentages at the national level and at the MSA level, as shown in Appendix F, and as such are likely a good approximation for occupation employment percentages at the county level.

[31] Note that this 7% number is around half the national average for high school dropouts by age 19 in 2005 (National Center for Education Statistics, 2015), implying that ELS:2002 under-sampled students who were at risk of dropping out of high school.

skilled other (2.5), skilled manual labor (2.4), skilled non-manual labor (2.3), and unskilled occupations (2.1), respectively.

5. Estimation Methodology

5.1 Maximum Simulated Likelihood Estimation

I estimate the parameters in the model using maximum simulated likelihood estimation. Specifically, I estimate the model by selecting parameters that maximize the sample likelihood function, which is defined as the product of each sample member's individual likelihood function, using simulation methods. See Appendix E for a detailed discussion of the sample likelihood function, simulation methods, and the identification of each parameter in the model.

5.2 Endogenous Course Selection

I deal with endogenous high school curriculum selection in two ways. First, I explicitly estimate unobserved heterogeneity. Differences in individuals' choice paths and wages, given observable personal characteristics, provide additional information about the unobserved heterogeneity within the population that drives selection, such as motivation and ability. Second, I use the CTE programs and opportunities available at a student's high school as instruments for her high school curriculum choices. CTE opportunities are correlated with a student's high school curriculum choice, as they influence the courses the student chooses to take but are uncorrelated with the student's unobserved heterogeneity (such as ability and passion) that can influence later labor market outcomes.

These instruments include whether each individual's high school offers CTE curricula, whether it is offered within the school or at an area vocational school, the number of CTE–related opportunities in the individual's high school and community, and the number of CTE teachers per student in the individual's school (see Table 1 Panel C).[32] Observing otherwise identical individuals make different choices when they have access to expanded curriculum offerings and curriculum-related opportunities identifies the effects of those curriculum offerings separately from the unobserved heterogeneity that may be influencing both curricula choice and labor market outcomes. In addition, I include the PSE-related programs and opportunities available at a student's high school as instruments for her PSE choices. These instruments include whether each student's high school offers college application programs, whether each student's high school offers academic counseling, and the percent of the previous year's class that attend two-year and four-year PSE institutions (see Table 1 Panel D).[33]

CTE programs and opportunities at each student's school are determined by a combination of state requirements and local school board choices. To deal with the concern that local school board choices about vocational offerings may be correlated with local labor market conditions (e.g., local school boards in areas with more CTE job opportunities may choose to offer more CTE programs in their high schools), I include the local labor market characteristics in the county where each school is located in the model (specifically, local labor market conditions impact wages in each occupation as part of vector X_i in equation 5). After controlling for the local labor market characteristics around each school, the remaining difference in CTE opportunities across schools is fully accounted for by state requirement differences and local randomness that is uncorrelated with local labor market conditions, such as historic curriculum offerings at the school, CTE teacher

[32] ELS:2002 includes a substantial number of variables about each high school's vocational offerings, academic offerings, and selection methods. I selected the variables in Table 1 to be indicative of the full set of high school-related variables available in ELS:2002. Changing this subset of variables does not affect the 2SLS estimation results.
[33] A potential extension to this work involves constructing PSE instruments for the distance from an individual's high school to the nearest post-secondary trade school, community college, and four-year university following Card (1995).

interest and availability, and school board superintendent preferences.

Another concern is if parents choose where to live based on the location of the school they want their child to attend. However, for lower income families whose children are more likely to take general education and vocational education classes, housing choice is substantially more likely to be driven by parental job opportunities and housing costs than by the vocational programs available in the area school system, as discussed in Lareau (2011). A final concern is that, conditional on housing location, parents sometimes have an endogenous choice between multiple nearby high schools for their child to attend. I deal with this concern by including indicators for the type of each student's high school (public, non-Catholic private, Catholic) in the model as well as an indicator for whether the high school admits students primarily based on geographic area, which is the case for 74% of the students in the sample.[34]

6. Estimation Results

6.1 Two-Stage Least Squares Estimates

The 2SLS regressions, whose estimates are included as a comparison to estimates from the structural model, use data on each student's HS curriculum, PSE attainment, wages, and occupation at the time the final survey wave was conducted in 2012.[35] Results are presented in Appendix B.[36]

[34] Further, conditional on housing location, a student in a rural area is less likely to have a choice between multiple high schools than a student in an urban area. As such, estimates for rural students in particular are not subject to this potential school selection bias. 2SLS parameter estimates are robust to restricting the sample to rural students.

[35] For a discussion of the differences between structural and non-structural estimates see Appendix E. For examples of the general model fit and out-of-sample fit benefits provided by structural models, see Todd & Wolpin (2006), Duflo et al. (2011), and Kaboski & Townsend (2011).

[36] The first-stage regressions, used to construct high school curriculum predicted probabilities, are multinomial logit regressions of high school curriculum and PSE attainment on personal characteristics (Table 1 Panel A), local labor market characteristics (Table 1 Panel B), and high school vocational and PSE instruments (Table 1, Panels C and D). Results are appreciably similar when estimated using a control function approach.

First, without accounting for selection, individuals who concentrate in vocational education courses receive higher later-life wages than individual who concentrate in general education courses. Specifically, as the probability of graduating with a trade or business vocational curriculum goes from zero to one (relative to graduating with a general education curriculum), average wages increase by 0.06 log dollars an hour. However, the 2SLS results, which use high school CTE opportunity instruments and local labor market controls, show that selection is driving this result. After instrumenting for high school curriculum selection, the results suggest that trade vocational education increases later-life wages (by .34 log dollars an hour) while business vocational education decreases later-life wages (by -.45 log dollars an hour) relative to general education. 2SLS results also show that the returns to an academic high school curriculum disappear after accounting for curricula self-selection and post-secondary education attainment, and that the returns from graduating from a four-year university are quite high (.32 log dollars an hour).

Next, I estimate the results from second-stage logit regressions on employment, and skilled employment conditional on employment, at age 26. Results suggest that concentrating in a business or trade vocational curriculum causes a positive but statistically insignificant increase in the chance of being employed at age 26, relative to concentrating in a general education curriculum. The results also suggest that taking trade vocational courses increase the chances of being employed in a skilled occupation conditional on being employed, relative to taking general education courses, while the effects for business vocational courses are positive but insignificant. Next, results suggest that an academic high school curriculum has little effect on employment or skilled employment relative to a general education high school curriculum, but that graduating from a four-year university greatly increases the chances of being employed at age 26. Finally, the results suggest that individuals who graduate from community college are less likely to be employed in skilled occupations, conditional on employment, than other individuals.

6.2 Structural Estimates

Selected structural estimates are presented in Tables 2-5.[37] Selected wage and utility parameters related to occupation choices are presented in Table 2. Looking vertically at each column in Table 2 provides a comparison of how each type of high school curriculum and PSE degree affects log wages in a specific occupation. First, graduation from high school in any field improves wages in the skilled manual labor, skilled non-manual labor, and unskilled labor occupations relative to dropping out. Next, a business vocational curriculum has the greatest effect of any high school curriculum on log hourly wages in the skilled non-manual labor occupation (an increase of .29 log dollars an hour) relative to not graduating from high school, while a trade vocational curriculum has the greatest effect of any high school curriculum on log hourly wages in the skilled manual labor occupation (an increase of .11 log dollars an hour).[38] Finally, note that the large log hourly wage parameters associated with the "skilled other" occupation (ranging from 2.15 to 2.39), combined with the small log hourly wage constant for that occupation (-.59), imply that high school dropouts receive very low wages in the "skilled other" occupation relative to individuals who graduate from high school.

Recall that the 2SLS results suggest that a business vocational curriculum has a negative effect on wages relative to a general education curriculum. The structural results suggest a more

[37] The full set of structural parameter estimates are presented in Appendix C.

[38] The negative log hourly wage parameters for high school graduation associated with the professional occupation (ranging from -.26 to -.14) imply that individuals who drop out of high school receive higher wages than individuals with only a high school degree in the professional occupation. This result is driven by the fact that few individuals in the data set work in professional occupations without having earned a bachelor's degree and that, of those individuals, high school dropouts had higher wages than individuals with only a high school degree.

nuanced effect. First, the structural estimates separate the effects on wages across occupations. These occupation-specific results suggest that a business vocational curriculum improves log hourly wages in the professional, skilled non-manual labor, and skilled manual labor occupations. However, as a large number of individuals who graduate in the business vocational field choose to work in the skilled non-manual labor occupation, which has low wages relative to other occupations, business vocational completers appear to receive lower average wages.

Second, the structural estimates identify the mechanism behind why business vocational completers choose skilled non-manual labor occupations (which provide lower average wages) more than other individuals. The choice is driven by the higher total utility (wage plus non-pecuniary utility) business vocational completers receive from the skilled non-manual labor occupation. Though wages are lower on average in the skilled non-manual labor occupation, relative to other occupations, non-pecuniary utility is higher on average in that occupation (as seen by comparing the non-pecuniary utility constants in Table 2). As an individual with a general education curriculum is more or less indifferent between occupations after taking into account both the wage and non-pecuniary utility of each occupation, an individual with a business vocational curriculum is more likely to choose a skilled non-manual labor occupation due to the wage premium she receives in that occupation. Thus, a business vocational concentrator chooses the skilled non-manual labor occupation because of the high amount of non-pecuniary utility the occupation naturally provides in addition to the wage premium she receives in the occupation, despite the fact that the job provides lower total wages than other occupations available to her. Similar incentives cause individuals who take trade vocational high school curricula to work in skilled manual labor occupations, and individuals who take "other" types of high school curricula to work in "skilled other" occupations.

Next, recall that an individual's choice of whether to work in the model is driven by three factors: the wage offer she receives in each occupation in the current period, the non-pecuniary utility of each occupation in the current period, and the increase in future wages she will receive if she gains occupation-specific human capital. As the model estimates suggest that a trade vocational curriculum provides higher wage returns across all skilled occupations, relative to a general education curriculum, they imply that a trade vocational curriculum increases an individual's likelihood to be employed in a skilled occupation relative to a general education curriculum, confirming the 2SLS results. As the estimates suggest that a business vocational curriculum provides higher wage returns in the professional, skilled manual labor, and skilled non-manual labor occupations, but lower wage returns in the "skilled other" occupation, relative to a general education curriculum, the model provides additional context behind the 2SLS results that a business vocational curriculum has no effect on the likelihood of employment in a skilled occupation. Finally, as a general education curriculum increases the wage returns in the unskilled occupation, relative to a trade or business vocational curriculum, the structural results provide additional context about why we do not observe an effect of high school CTE on the overall likelihood of being employed in the 2SLS results.

Graduating from a four-year university provides high log hourly wage returns to all occupations, but particularly high returns to the professional occupation (an increase of .46 log dollars an hour relative to graduating from high school and not attending a PSE institution). Community colleges and one-year trade schools provide much smaller returns overall, with community college graduation providing slight negative returns in the skilled manual labor, skilled non-manual labor, and unskilled occupations. Occupation-specific human capital in each occupation accrues infrequently over an individual's lifetime (9%-14% chance each year based on educational attainment) but adds a large premium to log hourly wages (ranging from .71 to .83 log dollars an hour).

Selected PSE choice estimates are presented in Table 3. The estimates show that concentrating in an academic curriculum in high school, relative to a general education curriculum, greatly increases the utility of attending a four-year university (recall that the model is agnostic about whether this is caused by an increase in the enjoyment of attending a four-year university, a decrease in the monetary cost of attending a four-year university, or an increase in the number and quality of four-year universities that accept the student). This result explains the lack of direct relationship between academic high school curriculum and labor market outcomes we observed in the 2SLS results: individuals choose an academic high school curriculum to directly increase their chances of attending a four-year university, which is what improves wages in all occupations. Concentrating in either trade or business vocational courses in high school has a slight negative effect on four-year university enrollment, but each has a slight positive effect on two-year community college enrollment, relative to concentrating in general education courses. Obtaining a GED has a negative effect on attending a two-year community college or a four-year university relative to receiving a high school diploma.

Selected high school choice estimates are presented in Table 4. Increased vocational offerings and opportunities (such as offering marketing courses on site, precisions courses on site, and the percent of students in the previous year's class who took vocational courses) increase the utility of taking a vocational curriculum in high school. These estimates imply that as vocational opportunities in high school increase the high school drop-out rate decreases, as each opportunity increases the utility of concentrating in a vocational curriculum relative to dropping out of high school to pursue the labor market or "not employed" options.

Lastly, Table 5 presents unobserved heterogeneity parameter estimates for the second type of individual in the population (relative to the parameters for the first type of individual which are standardized to zero). First, note that the constants for high school curricula in the bottom row of Table 4 are quite large (23.2 to 27.1 utils) relative to other parameters. These large high school curriculum constants indicate that type-one individuals never drop out of high school. For type-two individuals, estimated to be 34.3% of the population, high school unobserved heterogeneity parameter estimates are negative and of similar magnitude (-33.71 to -32.0 utils) to these constants. These results suggest that type-two individuals are at high risk of dropping out of high school as their total non-pecuniary utility from attending high school (calculated by combining the constant and unobserved heterogeneity parameter) is slightly negative before accounting for observed personal and school characteristics. Individuals with the second type of unobserved heterogeneity also receive lower non-pecuniary utility from working and from attending PSE institutions and are substantially more likely to choose to be "neither working nor attending school" than individuals with the first type of unobserved heterogeneity. These result suggests that interventions to decrease the high school dropout rate should be tailored to this third of students, who are at high risk of dropping out and extended unemployment.

6.3 Model Fit

Table 6 Columns 1 and 2 compares ELS:2002 student outcomes with simulated student outcomes, given the initial conditions of each student in the data set at age 16 and the parameter estimates discussed in Section 6.2. The aggregate simulated student education, employment, and wage outcomes closely match the aggregate student outcomes observed in the data. However, the model over-predicts the percent of individuals who graduate from a four-year university by age 26

(48% instead of 41%) and the number of individuals attending PSE institutions at age 26 (11% instead of 5%). This over-prediction is driven by the assumption in the model that the non-pecuniary utility from attending a PSE institution does not change with age. In reality, the non-pecuniary utility from attending a PSE institution likely decreases with age as an individual become older than their potential peers at each PSE institution. Since this relationship is not included in the model the simulation over-predicts the number of individuals that choose to attend college in their twenties.

7 Policy Analysis

I use the model and structural estimates to conduct several theoretical policy simulations. The simulated percentage point change in population outcomes for each policy are presented in Table 6 Panels A-C, Columns 3-5, relative to simulated outcomes under current policy settings in Column 2.[39] Table 6 Panels D-F presents simulated differences in average log hourly wages and total utility for each policy simulation, relative to current policy settings, as well as the percent of the population the model predicts would be directly affected by each policy.[40]

The first policy simulation simulates the effects of a federal mandate requiring business and trade CTE to be taught on-site in every high school nationwide. Overall, the simulation leads to positive but relatively minor long-term effects on individuals' education and labor market outcomes. The second simulation investigates the effects of incorporating vocational certifications into high school vocational curricula. Historically, vocational high school education in the United

[39] Note that general equilibrium effects are not taken into account in these simulations. The model assumes that the wages and utility for each occupation remain constant as students in the population change their labor supply decisions. This assumption should be taken into account when drawing conclusions from these theoretical simulations.
[40] Simulated wage differences are averaged across all individuals who choose to work at age 26 in both the baseline simulation and policy simulation and whose simulated wages differ. The simulated early-life utility (ages 16-26) and later-life utility (ages 27+) differences are averaged across all individuals whose simulated early-life and later-life utility differ between the baseline simulation and the policy simulation.

States has not included industry certification exams or certificate conferral – students have had to take relevant certification exams after graduating from high school, by attending one-year PSE trade schools or taking exams independently, to become certified (Castellano et al., 2005). In the past decade, however, and after students in the ELS:2002 sample had graduated from high school, there has been a notable increase in the number of high school vocational programs that confer vocational certifications due to the re-authorization of the Carl D. Perkins Career and Technical Education Act of 2006 (U.S. Department of Education, 2013). Overall, the simulation predicts that incorporating vocational certifications into high school vocational curricula would have substantial positive effects on student labor market outcomes.[41]

7.1 High School Tracking

Next, I simulate the effects of instituting a strict high school tracking system, loosely following the system used in Germany. In Germany, students are split into three tracks when they enter secondary school: a vocational track (Hauptschule) which prepares students for career and technical occupations, a general education track (Realschule) which teaches students general education math, science, and English content, and an academic track (Gymnasium) which teaches students rigorous academic content and prepares them for a university education. Tracks are chosen for each student based on their abilities and grades throughout primary school, and to a lesser extent based on student and parent preferences. By comparison, relatively little tracking occurs in the United States – most students retain substantial control over the high school courses they take. This simulation investigates the effects of requiring students to take specific high school

[41] See Appendix D for further details and discussion of these simulations, as well as an additional exploratory policy simulation which investigates the effects of making community college free for all high school graduates.

courses based on their test scores and prior grades, and how it would impact students' educational attainment and labor market outcomes.

To conduct this simulation, I separate students into three tracks at the beginning of ninth grade – an academic track, a general education track, and a vocational track – based on the test score they received when the ELS:2002 survey was first administered in 2002. I assign students with the lowest third of test scores to the vocational track, students with middle third of test scores to the general education track, and students with the highest third of test scores to the academic track, to loosely match the percentage of students in each type of school in Germany. Students on the academic track can only take academic courses, students on the general education track can only take general education courses, and students on the vocational track can only take business or trade vocational courses. Students may still drop out of high school starting in 11^{th} grade. Due to the rigorous nature of the vocational track in Germany, I also update the model so that students on the vocational track receive a vocational certificate at the time of high school graduation.[42]

The results of this simulation are presented in Column 5 of Table 6. The policy pushes many students to take academic or vocational courses in high school who otherwise would have chosen general education courses, leading to a substantial increase in the percentage of students who graduate with academic (from 22.8% to 31.0% of the population) and vocational concentrations (from 8.4% to 20.3% of the population). However, due to restricted high school options, the model predicts a substantial increase in the number of students who decide not to

[42] Note that a simulation that institutes tracking without incorporating vocational certification into HS curricula reaches the same conclusions about the benefits and drawbacks of tracking as this simulation, just with somewhat lower later labor market returns for vocational curricula. Additionally, in the simulation, I allow students on any of the three tracks to attend all types of PSE institution following high school graduation. In the German system, it is difficult for students who graduate from Realschule and Hauptschule to attend four-year universities (though not impossible) relative to students who graduate from Gymnasium. A question of future work involves incorporating this difficulty into the policy simulation by calibrating the β_H^k variables to reflect the ease / difficulty of attending college after graduating from each type of high school.

finish high school and instead complete GEDs (3.5% → 13.0%). Each additional academic high school concentrator is more likely to graduate from four-year universities while each additional GED completer is less likely to graduate from four-year universities, leading to a slight overall decrease in the percent of individuals who attain bachelor's degrees (48.2% → 47.8%). Each additional vocational concentrator receives a vocational certificate at high school graduation, leading to a decrease in the number of individuals in the population without any PSE credentials and an increase in the number of individuals employed in the skilled manual labor (17.7% → 18.1%) and skilled non-manual labor occupations (21.3% → 22.4%) at age 26.

Overall, individuals who are forced onto academic and vocational tracks, who otherwise would have concentrated in the general education field, realize better labor market outcomes conditional on completing high school. For these students, improved labor market outcomes come at the expense of non-pecuniary utility in high school as they would have preferred to take general education courses had they been available. Students who do not complete high school degrees and instead complete GEDs realize lower non-pecuniary utility in high school, worse PSE outcomes, and worse labor market outcomes then they would have received if they had been able to choose their own curriculum. Overall, the simulation predicts that the policy would lead to slightly higher average labor market log wages (2.4%) and later life utility (2.2%) among individuals who change their behavior, with benefits concentrated among non-GED high school graduates pushed onto the academic and vocational tracks, gains that would be more than offset by the sharp decrease in average early life utility (-2.8%) among individuals who change their behavior.

Finally, a note about how this policy would affect inequality. As tracking is determined based on prior grades and test scores, this policy would improve later life outcomes for students at the top (tracked into academic courses) and bottom (tracked into vocational courses) ends of the grade distribution relative to students in the middle of the grade distribution. However, the simulation predicts that a sizable percentage of tracked students would choose to drop out of high school rather than complete their required track. These students (who the model estimate are among the third of students with the second type of unobserved heterogeneity, estimated in Section 6, who are at high risk of dropping out of high school and extended unemployment) would incur substantially worse outcomes than individuals who complete high school. As such this policy would exacerbate inequality between these types of students unless additional policies were put into place alongside the tracking system to keep students engaged in school.

8. Conclusion

This work suggests that a high school trade vocational curriculum is beneficial for a student's later labor market wages and chances of being employed in a skilled occupation relative to a general education curriculum. Comparatively, the benefits of a high school business vocational curriculum, relative to a general education curriculum, are concentrated in skilled non-manual labor occupations which provide higher non-pecuniary utility and lower wages relative to other occupations. In addition, this work suggests that concentrating in a vocational high school curricula modestly decreases a student's propensity to attend four-year PSE institutions, but that additional high school vocational and academic opportunities increase a student's high school graduation propensity, particularly for the one-third of students at high risk of dropping out.

Policy simulations predict that improving the quality of high school vocational education (by incorporating vocational certifications into vocational curricula) would provide greater labor market benefits for students than increasing the availability of high school vocational education options. They also predict that a high school tracking system that pushes more individuals to take academic and vocational courses would improve the labor market outcomes of high school graduates at the expense of their non-pecuniary utility, while increasing the percent of students who drop-out of high school.

Building upon this work, one pertinent area of future research involves investigating which particular aspects of different types of occupations cause them to provide different amounts of non-pecuniary utility. For example, further research is needed to better understand what specific aspects of skilled non-manual labor occupations lead them to provide higher non-pecuniary utility and lower wages than skilled manual labor and professional occupations. Another pertinent area of future research involves exploring the extent to which students know their own ability, match quality, and potential future returns from different high school curricula, post-secondary education institutions, and occupations at the time they enter high school. The current model assumes that individuals begin high school with a reasonable sense of their short- and long-term education and employment options, and select high school courses based only on the current period utility they derive as well as general expectations of how the decision will impact their future choice set and wages. In reality, students may begin high school with a much weaker understanding of their current and future opportunities, and match quality across these opportunities, than assumed in the model. If so, student decisions to change curricula from year to year, or drop out of high school, may provide an additional benefit to students by helping them learn more about their match quality with different educational fields and occupations, and how their educational choices and occupational outcomes are connected.

References

Agodini, Roberto and John Deke. 2004. *The Relationship Between High School Vocational Education and Dropping Out.* Princeton, NJ: Mathematica Policy Research.

Altonji, Joseph G. 1995. "The Effects of High School Curriculum on Education and Labor Market Outcomes," *Journal of Human Resources* 30(3): 410-438.

Altonji, Joseph G., Erica Blom, and Costas Meghir. 2012. "Heterogeneity in Human Capital Investments: High School Curriculum, College Major, and Careers." *Annual Reviews of Economics* 4: 185-223.

Altonji, Joseph G., Peter Arcidiacono, and Arnaud Maurel. 2016. "The Analysis of Field Choice in College and Graduate School: Determinants and Wage Effects." In R. Hanushek, S. Machin, and L. Worrseman (eds) *The Handbook of the Economics of Education*, Volume V., Ch. 7.

Arum, Richard and Yossi Shavit. 1995. "Secondary Vocational Education and the Transition from School to Work." *Sociology of Education* 68: 187-204.

Berkovec, James and Steven Stern. 1991. "Job Exit Behavior of Older Men." *Econometrica* 59(1): 189-210.

Bishop, John H. and Ferran Mane. 2004. "The Impacts of Career-Technical Education on High School Labor Market Success." *Economics of Education Review* 23: 381-402.

Bozick, Robert and Benjamin Dalton. 2013. "Career and Technical Education and Academic Progress at the End of High School: Evidence from the Education Longitudinal Study of 2002." Research Triangle Park, NC: RTI International.

Bureau of Labor Statistics. 2019. "College Enrollment and Work Activity of Recent High School and College Graduates – 2018." Bureau of Labor Statistics Economic News Release, April 25, 2019.

Card, David. 1995. "Using Geographic Variation in College Proximity to Estimate the Return to Schooling." *Aspects of Labor Market Behaviour: Essays in Honour of John Vanderkamp*. Toronto: University of Toronto Press.

Castellano, Marisa, James R. Stone III, and Sam Stringfield. 2005. "Earning Industry Recognized Credentials in High School: Exploring Research and Policy Issues." *Journal of Career and Technical Education* 21(2): 7-34.

Chan, Marc K. 2013. "A Dynamic Model of Welfare Reform." *Econometrica* 81: 941-1001.

Council of Economic Advisors. 2010. "2010 Economic Report of the President." Washington, D.C.

Current Population Survey, U.S. Census Bureau. 2012. "2012 Annual Social and Economic Supplement." Washington, D.C.

Curtin, Thomas R., Steven J. Ingels, Shiying Wu, Ruth Heuer, and Jeffrey Owings. 2002. *Base-year to fourth follow-up data file user's manual*. Washington, DC: National Center for Education Statistics.

Dahl, Gordon B., Dan-Olof Rooth, and Anders Stenberg. 2021. "High School Majors, Comparative (Dis)Advantage, and Future Earnings." NBER Working Paper,

https://www.nbe r.org/papers/w27524, retrieved February 22, 2022.
Dougherty, Shaun M. 2018. "The Effect of Career and Technical Education on Human Capital Accumulation: Causal Evidence from Massachusetts." *Education Finance and Policy* 13(2): 119-148.
Davis, Tracy and Kaitlin Obenauf. 2011. "Participation in Vocational Education and Its Effects on Labor Market Earnings." Presented at the 2011 Conference for the Association for Education Finance and Policy.
Diermeier, Daniel, Michael Keane, and Antonio Merlo. 2005. "A Political Economy Model of Congressional Careers." *American Economic Review* 95, 347–373.
Duflo, Esther, Rema Hanna, and Stephen Ryan. 2011. "Incentives Work: Getting Teachers to Come to School," *American Economic Review* 102(4): 1241-1278.
Eckstein, Zvi and Kenneth I. Wolpin. 1999. "Why Youths Drop Out of High School: The Impact of Preferences, Opportunities, and Abilities." *Econometrica* 67(6): 1295-1339.
Education Commission of the States. 2013. "School Attendance Age Limits." *http://www.ecs.org /clearinghouse/01/07/04/10704.pdf*, retrieved October 13, 2016.
Education Commission of the States. 2015. "Free and Compulsory School Age Requirements in the United States" *http://www.ecs.org/clearinghouse/01/18/68/11868.pdf*, retrieved October 14, 2016.
Erikson, Robert, John Goldthorpe, and Lucianne Portocarero. 1979. "Intergenerational Class Mobility in Three Western European Societies: England, France, and Sweden." *British Journal of Sociology* 30: 415-430.
Flood, Sarah, Miriam King, Steven Ruggles, and J. Robert Warren. 2015. Integrated Public Use Microdata Series, Current Population Survey: Version 4.0. [Machine-readable database]. Minneapolis: University of Minnesota.
Fox, Jeremy T., Kyoo il Kim, Stephen P. Ryan, and Patrick Bajari. 2011. "A Simple Estimator for the Distribution of Random Coefficients." *Quantitative Economics* 2: 381-418.
Francesconi, Marco. 2002. "A joint dynamic model of fertility and work of married women." *Journal of Labor Economics* 20, 336–380.
Heckman, James J. 1979. "Sample Selection Bias as a Specification Error." *Econometrica* 47(1): 153–162.
Hossler, Don, Doug Shapiro, Afet Dundar, Mary Ziskin, Jin Chen, Desiree Zerquera, and Vasti Torres. 2012. "Transfer & Mobility: A National View of Predegree Student Movement in Postsecondary Institutions." National Student Clearinghouse Research Center and Project on Academic Success, Indiana University.
Hotchkiss, Lawrence and Linda Dorsten. 1987. "Curriculum Effects on Early Post-High School Outcomes." *Research in the Sociology of Education and Socialization* 7: 191-219.
Independent Advisory Panel of the National Assessment of Career and Technical Education. 2014. "Putting "Career" in "College and Career Ready": The Report of the Independent Advisory Panel of the National Assessment of Career and Technical Education." Washington, DC.

Kaboski, Joseph and Robert M. Townsend. 2011. "A Structural Evaluation of a Large-Scale Quasi-Experimental Microfinance Initiative." *Econometrica* 79(5): 1357-1406.

Keane, Michael P. and Kenneth I. Wolpin. 1997. "The Career Decisions of Young Men." *The Journal of Political Economy* 105(3): 473-522.

Kirkeboen, Lars J., Edwin Leuven, and Magne Mogstad. 2016. "Field of Study, Earnings, and Self-Selection." *The Quarterly Journal of Economics* 131(3): 1057–1111.

Kreisman, Daniel and Kevin Stange. 2020. "Vocational and Career Tech Education in American High Schools: The Value of Depth Over Breadth." *Education Finance and Policy* 15(1): 11-44.

Lareau, Annette. 2011. "*Unequal Childhoods: Class, Race, and Family Life*." Berkeley, CA: University of California Press.

Levesque, Karen, Jennifer Laird, Elisabeth Hensley, Susan P. Choy, Emily F. Cataldi, and Lisa Hudson. 2008. "Career and Technical Education in the United States: 1990–2005." (NCES 2008-035). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Mane, Ferran. 1999. "Trends in the Payoff to Academic and Occupation-Specific Skills: the Short and Medium-Run Returns to Academic and Vocational High School Courses for Non-College Bound Students." *Economics of Education Review* 18: 417–437.

Meer, Jonathan. 2007. "Evidence on the Returns to Secondary Vocational Education." *Economics of Education Review* 26: 559-573.

Meyer, Robert and David Wise. 1982. "High School Preparation and Early Labor Force Experience." Pg. 277-339 in *The Youth Labor Market Problem: Its Nature, Causes, and Consequences*, edited by Richard Freeman and David Wise. Chicago: University of Chicago Press.

Monaghan, David B. and Paul Attewell. 2014. "The Community College Route to the Bachelor's Degree." *Educational Evaluation and Policy Analysis*, published online March 18, 2014; doi: 10.3102/ 0162373714521865

National Center for Education Statistics, U.S. Department of Education. 2002. "Private School Universe Survey." *https://nces.ed.gov/surveys/pss/tables.asp*, retrieved November 4, 2016.

National Center for Education Statistics, U.S. Department of Education. 2015. "The Condition of Education 2015." NCES 2011-144, released May 2015.

National Center for Education Statistics, U.S. Department of Education. 2016. "High School Transcript Studies - CSSC Courses/Course Codes." *https://nces.ed.gov/surveys/hst/courses.asp*, retrieved March 4, 2016.

Neal, Derek. 1999. "The Complexity of Job Mobility among Young Men." *Journal of Labor Economics* 17(2): 237-261.

Pavan, Ronni. 2010. "The Role of Career Choice in Understanding Job Mobility" *Review of Labour Economics and Industrial Relations* 24(2): 107-127.

Silverberg, Marsha, Elizabeth Warner, Michael Fong, and David Goodwin. 2004. "National

Assessment of Vocational Education (NAVE)." Washington, DC: Policy and Program Studies Service, Office of Under Secretary, U.S. Department of Education.

Stromback, Thorsten. 2010. "Earnings, Schooling and Vocational Education and Training." *Australian Journal of Labour Economics* 13(3): 241-263.

Sullivan, Paul. 2010. "A Dynamic Analysis of Educational Attainment, Occupational Choices, and Job Search." *International Economic Review* 51: 289–317.

Todd, Petra and Kenneth I. Wolpin. 2006. "Assessing the Impact of a School Subsidy Program in Mexico: Using a Social Experiment to Validate a Behavioral Model of Child Schooling and Fertility." *American Economic Review* 96(5): 1384-1417.

Todd, Petra and Kenneth I. Wolpin. 2010. "Structural Estimation and Policy Evaluation in Developing Countries," *Annual Review of Economics* 2: 21-50.

Topel, Robert, and Michael Ward. 1992. ''Job Mobility and the Careers of Young Men.'' *Quarterly Journal of Economics* 107(2): 439–479.

Train, Kenneth E. 2003. "*Discrete Choice Methods with Simulation*," New York, NY: Cambridge University Press.

U.S. Census Bureau. 2000. "Census of Population and Housing, 2000." Washington, D.C.

U.S. Department of Education, Office of Planning, Evaluation and Policy Development, Policy and Program Studies Service. 2013. "National Assessment of Career and Technical Education: Interim Report." Washington, D.C.

Table 1: ELS-2002 Summary Statistics

Variable	Mean	Std Dev	# Obs	Variable	Mean	Std Dev	# Obs
A. Personal Characteristics				*C. High School Vocational Instruments*			
Male	0.500	0.500	16,200	Voc Taught in High School	0.349	0.477	15,450
Black	0.134	0.341	16,200	Voc Taught in Area School	0.068	0.252	15,450
Hispanic	0.150	0.357	16,200	Voc Taught in Both HS & Area Sch	0.312	0.463	15,450
Other Race	0.158	0.365	16,200	Marketing Courses Taught on Site	0.580	0.494	10,310
Socio-Economic Status	0.038	0.746	16,200	Marketing Courses Taught at Area Sch	0.116	0.320	10,310
Test Score	0.066	0.988	15,890	Precisions Courses Taught on Site	0.614	0.487	10,150
Midwest	0.249	0.432	16,200	Precisions Courses Taught at Area Sch	0.221	0.415	10,150
South	0.363	0.481	16,200	(ln) Students per Vocational Teacher	3.264	2.670	12,330
West	0.205	0.404	16,200	Career Pathways Prog Available	0.740	0.439	11,010
Suburban	0.479	0.500	16,200	% Students Free/Reduced Price Lunch	0.240	0.250	15,690
Rural	0.182	0.386	16,200	Admission Based on Geography	0.737	0.440	11,790
Catholic School	0.122	0.327	16,200	(0-3) Student Infl on Course Selection	2.517	0.709	11,090
Private School	0.090	0.286	16,200	% Students Take Academic Courses	0.645	0.313	10,260
				% Students Take Vocational Courses	0.174	0.186	7,460
B. Labor Market Characteristics				(0-5) % Prev Students Enter Labor Market	1.542	0.917	11,360
Unemployment Rate	0.042	0.017	16,200				
(ln) Average Hr Wage	2.928	0.245	16,200	*D. High School PSE Enrollment Instruments*			
% Professional Employment	0.067	0.032	16,200	Academic Counseling Available	0.958	0.200	13,680
% Manual Labor Employment	0.131	0.042	16,200	% Students Attend College Fairs	0.148	0.142	10,940
% Non-Manual Labor Employment	0.323	0.057	16,200	(0-5) % Students in College App Prog	3.572	1.580	11,030
				(0-5) % Prev students Attend 4yr College	3.590	1.157	11,490
				(0-5) % Prev Students Attend 2yr College	2.326	0.982	11,400

Notes:
A subset of percentage variables (e.g. Prev Students Enter Labor Market) were recorded in discrete bins with ranges of 0-3 and 0-5. Baseline options are as follows: Race - White; Region - Northeast; Urbanicity - Urban; School - Public; Industry - Other; Vocational Courses - Not Taught. "Student Infl on Course Selection" is a discrete variable that takes the values of none (0), a little (1), moderate (2), and a lot (3). "% Prev Students Enter Labor Market", "% Prev Students Attend 4yr College", and "% Prev Students Attend 2yr College", are discrete variables that take the values of none (0), 1-10% (1), 11-24% (2), 25-49% (3), 50-74% (4), and 75-100% (5). Sample sizes are rounded to the nearest ten to comply with secure data disclosure requirements.

Table 2: Selected Structural Occupation Parameters

Variable	Professional Estimate		Professional SE	Skilled Manual Labor Estimate		Skilled Manual Labor SE	Skilled Non-Manual Labor Estimate		Skilled Non-Manual Labor SE	Skilled Other Estimate		Skilled Other SE	Unskilled Estimate		Unskilled SE
A. Previous Education (Log-Wage Utility)															
Academic	-0.26	***	*(.027)*	0.04	**	*(.015)*	0.17	***	*(.016)*	2.16	***	*(.068)*	0.16	***	*(.024)*
General Education	-0.21	***	*(.026)*	0.04	***	*(.012)*	0.20	***	*(.014)*	2.25	***	*(.068)*	0.23	***	*(.016)*
Business Vocational	-0.14	***	*(.028)*	0.09	***	*(.015)*	0.29	***	*(.017)*	2.15	***	*(.071)*	0.19	***	*(.026)*
Trade Vocational	-0.16	***	*(.029)*	0.11	***	*(.013)*	0.22	***	*(.018)*	2.39	***	*(.074)*	0.13	***	*(.025)*
Other Curriculum	-0.16	***	*(.027)*	0.08	***	*(.013)*	0.24	***	*(.015)*	2.38	***	*(.068)*	0.27	***	*(.017)*
GED	-0.23	***	*(.028)*	-0.02		*(.015)*	0.27	***	*(.017)*	2.27	***	*(.065)*	0.13	***	*(.024)*
1-yr Trade School	0.22	***	*(.014)*	0.15	***	*(.011)*	0.15	***	*(.010)*	-0.08		*(.049)*	-0.11	***	*(.023)*
2-yr Community College	0.02	***	*(.006)*	-0.05	***	*(.006)*	-0.02	***	*(.005)*	-0.01		*(.021)*	-0.10	***	*(.022)*
4-yr University	0.46	***	*(.008)*	0.25	***	*(.009)*	0.25	***	*(.008)*	0.46	***	*(.018)*	0.12	***	*(.022)*
B. Occupation-Specific Human Capital (Log-Wage Utility)															
Occ-Specific Human Capital	0.83	***	*(.012)*	0.71	***	*(.011)*	0.71	***	*(.011)*	0.78	***	*(.022)*	-		-
C. Constants															
Log-Wage Utility	1.89	***	*(.080)*	1.62	***	*(.056)*	1.30	***	*(.065)*	-0.59	***	*(.156)*	1.62	***	*(.102)*
Non-Pecuniary Utility	-1.05	***	*(.040)*	-2.21	***	*(.039)*	-0.93	***	*(.038)*	-1.31	***	*(.066)*	-2.62	***	*(.060)*

Notes:
The parameter on log hourly wages (relating wage utility to non-pecuniary utility) is 1.37, with SE of (.002). The variance of the normal wage error terms is estimated to be 0.16, with a SE of (.001). The estimates for work experience accumulation probabilities with educational attainment HS Degree, 1-yr Trade, 2-yr CC, and 4-yr University are 9%, 14%, 14%, and 11% respectively, with SEs of (.000), (.001), (.001), and (.000) respectively. Total # Observations is 16,200, and *,**,*** denote 90%, 95%, and 99% statistical significance respectively. Standard errors (SE) are calculated using the covariance of the parameter estimate scores, following Train (2003).

Table 3: Selected PSE Structural Parameters

	2-yr CC			4-yr University		
Variable	Estimate		*SE*	Estimate		*SE*
Academic	-0.66	***	*(.042)*	0.43	***	*(.034)*
Business Vocational	0.14	**	*(.058)*	-0.09	*	*(.042)*
Trade Vocational	0.14	*	*(.068)*	-0.09	*	*(.048)*
Other Curriculum	0.03		*(.043)*	0.06	*	*(.030)*
GED	-0.20	**	*(.089)*	-0.58	***	*(.064)*
Constant	2.00	***	*(.105)*	4.64	***	*(.107)*

Notes:
Estimates are relative to graduating high school in the general education field. Total # Observations is 16,200, and *,**,*** denote 90%, 95%, and 99% statistical significance respectively. Standard errors (SE) are calculated using the covariance of the parameter estimate scores, following Train (2003).

Table 4: Selected HS Education Structural Parameters

	Academic			General Ed			Business Voc			Trade Voc			Other		
Variable	Estimate		*SE*	Estimate		*SE*	Estimate		*SE*	Estimate		*SE*	Estimate		*SE*
Marketing HS	-		-	-		-	0.50	***	*(.067)*	-		-	-		-
Marketing Area	-		-	-		-	0.16		*(.114)*	-		-	-		-
Precisions HS	-		-	-		-	-		-	0.29	***	*(.075)*	-		-
Precisions Area	-		-	-		-	-		-	0.43	***	*(.089)*	-		-
Voc Taught HS	-		-	-		-	0.22	*	*(.113)*	0.18		*(.126)*	0.00		*(.071)*
Voc Taught Area	-		-	-		-	0.16		*(.111)*	-0.12		*(.132)*	-0.12		*(.074)*
Voc Taught Both	-		-	-		-	0.28	***	*(.115)*	0.01		*(.129)*	-0.01		*(.073)*
Career Pathways	-		-	-		-	0.27	***	*(.082)*	0.34	***	*(.086)*	-0.17	***	*(.054)*
Percent Vocational	-		-	-		-	1.20	***	*(.162)*	2.02	***	*(.138)*	1.29	***	*(.120)*
Percent Academic	0.82	***	*(.078)*	0.42	***	*(.062)*	-		-	-		-	-		-
Constant	26.2	***	*(.589)*	27.1	***	*(.582)*	23.3	***	*(.621)*	23.2	***	*(.626)*	25.1	***	*(.595)*

Notes:
Total # Observations is 16,200, and *,**,*** denote 90%, 95%, and 99% statistical significance respectively. Standard errors (SE) are calculated using the covariance of the parameter estimate scores, following Train (2003).

Table 5: Unobserved Heterogeneity Parameters

	Non-Pecuniary Utility			Wages		
Variable	Estimate		*SE*	Estimate		*SE*
A. Employment						
Professional	-4.38	***	*(0.04)*	-0.12	***	*(0.03)*
Skilled Manual Labor	-2.27	***	*(0.03)*	0.03		*(0.01)*
Skilled Non-Manual Labor	-2.56	***	*(0.03)*	0.03	*	*(0.01)*
Skilled Other	-5.57	***	*(0.13)*	0.34	***	*(0.07)*
Unskilled	-1.65	***	*(0.04)*	-0.03		*(0.02)*
B. High School Education						
Academic	-33.71	***	*(0.56)*	-		-
General Education	-32.69	***	*(0.56)*	-		-
Business Vocational	-32.51	***	*(0.57)*	-		-
Trade Vocational	-32.00	***	*(0.56)*	-		-
Other Curriculum	-32.04	***	*(0.56)*	-		-
GED	-32.73	***	*(0.61)*	-		-
C. Post-Secondary Education						
1-yr Trade School	-0.67	***	*(0.16)*	-		-
2-yr Community College	-2.93	***	*(0.06)*	-		-
4-yr University	-8.71	***	*(0.07)*	-		-

Notes:
The estimate for the percentage of the population with type-two unobserved heterogeneity is 34.3%. *,**,*** denote 90%, 95%, and 99% confidence respectively. Total # Observations is 16,200. Standard errors (SE) are calculated using the covariance of the parameter estimate scores, following Train (2003).

Table 6: Model Fit & Policy Simulations

Variable	*Model Fit* ELS:2002 Data	Simulation No Policies	*Policy Simulations* Voc In Every School	HS Voc Certification	HS Tracking
A. HS Graduation Curriculum					
Academic	23.5%	22.8%	-0.9%	-0.9%	8.2%
Gen Ed	40.1%	44.9%	-2.2%	-1.1%	-14.6%
Bus Voc	6.0%	4.1%	3.9%	-0.2%	2.9%
Trade Voc	5.2%	4.3%	0.9%	3.1%	9.0%
Other	16.1%	15.4%	-1.6%	-0.7%	-15.4%
GED	5.7%	3.5%	-0.2%	-0.2%	9.5%
Never Graduate	3.4%	4.9%	0.0%	0.0%	0.3%
B. PSE Degrees					
HS Grad Or Less	40.7%	38.2%	0.1%	-0.9%	-9.6%
1-yr Trade	10.5%	6.8%	-0.3%	8.6%	18.3%
2-yr Community College	13.7%	11.7%	0.3%	-2.6%	-2.7%
4-yr University	40.9%	48.2%	-0.2%	-1.1%	-0.4%
C. Employment Age 26					
Professional	27.4%	28.5%	0.0%	0.3%	-0.1%
Skilled Manual Labor	20.4%	17.7%	0.0%	0.5%	0.4%
Skilled Non-Manual Labor	25.4%	21.3%	0.0%	0.4%	1.1%
Skilled Other	4.1%	3.0%	0.0%	-0.4%	-0.2%
Unskilled	6.3%	4.2%	-0.1%	-0.3%	-0.5%
Unemployed	11.0%	13.9%	0.0%	-0.3%	0.0%
Attending PSE	5.4%	11.3%	0.1%	-0.3%	-0.7%
D. Wages Age 26					
Average (ln) Hourly Wage	2.47	2.42	1.8%	9.1%	2.4%
E. Utility					
Lifetime Utility		150.0	0.2%	1.9%	-1.4%
Realized Utility Ages 16-26		104.7	0.1%	-0.4%	-2.8%
Expected Utility Ages 27+		45.3	2.0%	8.4%	2.2%
F. % Changed Observations					
% Changed Average (ln) Hourly Wage			4%	16%	40%
% Changed Realized Utility Ages 16-26			27%	28%	73%
% Changed Expected Utility Ages 27+			5%	24%	56%

Notes:

Column (1) displays ELS:2002 population percentages. Column (2) displays simulated outcomes, given the model, structural parameters, and initial conditions in the ELS:2002 data set. Columns (3-5) panels A-C display the percentage point difference between the baseline simulation in Column (2) and the simulated outcomes for the policy simulations discussed in Sections 7.1 and 7.2. Columns (3-5) panels D-E display the percent difference between the baseline simulation in column (2) and the average simulated outcomes for the policy simulations discussed in Sections 7.1 and 7.2, among individuals whose outcome value changed between the baseline outcome and simulated outcome, and in the case of wages conditional on an occupation being chosen in 2012 in both simulations. Panel F, "% Changed Observations", denotes the percent of individuals who meet these conditions. PSE degrees are cummulative: An individal in the sample can have multiple types of PSE credentials. Hence the total number of PSE degrees in each column can be higher than the number of individuals in the sample. Total # Observations is 16,200.