Family Structure, Human Capital Investment, and Aggregate College Attainment*

Adam Blandin†
Virginia Commonwealth University

Christopher Herrington‡
Virginia Commonwealth University

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Abstract

We provide new facts about the increase in US college attainment from 1995-2015. College *attendance* grew more among children from low resource families than among those from high resource families (7pp vs 1pp). However, college *completion* grew less among low resource children than high resource children (4pp vs 13pp). We propose a theory to explain the increase in aggregate college completion since 1995 that is consistent with these trends. The theory has two key components: (i) High resource families increased pre-college investment relative to low-resource families in response to a growing college wage premium. (ii) Pre-college investment is an important determinant of college completion conditional on attendance. Consistent with this theory, we provide empirical evidence of growing gaps in pre-college investment and college preparedness between children from high and low resource families. Finally, we construct a model of intergenerational human capital investment and college attainment to quantitatively test our theory.

JEL Classification: J12, J24, E24, E6

Keywords: College attainment, Human capital, Family structure, Single parents

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†Contact Info: Department of Economics, Virginia Commonwealth University, P.O. Box 844000, Richmond VA 23284-4000. *Email*: ajblandin@vcu.edu

‡Contact Info: Department of Economics, Virginia Commonwealth University, P.O. Box 844000, Richmond VA 23284-4000. *Email*: herringtoncm@vcu.edu

1 Introduction

From 1975-1995, the share of 28 year olds in the US who had attended college grew 13 percentage points (pp), while the share who had completed a four year degree grew only 3pp. Since then, from 1995-2015, aggregate attendance grew 10pp, while completion grew 9pp. Why did aggregate completion grow so rapidly—both in raw terms and relative to attendance—after 1995? We find this question interesting because rising college completion rates (both raw and conditional on attending college) have the potential to ameliorate recent concerns over income inequality and student debt levels.[1,2]

This paper attempts to understand the increase in aggregate college completion since 1995. A key feature of our analysis is to show that attainment trends differed by *family structure*. Specifically, we use the Panel Study of Income Dynamics (PSID) 1968-2015 to follow children from birth to age 28. We classify a household with children as "low resource" if only one parent is present and they lack a four year college degree; we classify a household as "high resource" if there are two parents and at least one has a four year degree. Trends for these two family types are important in the aggregate because they currently account for the majority of households with children (see Figure 2). [3] We also show that family structure is an important predictor of college attainment even after controlling for race, sex, siblings, geographic region, and parent earnings.

We begin with two contrasting findings. First, college attendance grew more for children from low resource families than for those from high resource families (7pp vs 1pp). Second, college completion grew less for low resource children than high resource children (4pp vs 13pp). As a result, the attendance gap between low and high resource children *shrank* by 6pp over the sample period, while the completion gap *grew* by 9pp.

[1] These qualitative patterns are robust to moving the cutoffs several years forwards or backwards. We compute aggregate attendance and completion rates using the March Current Population Survey (CPS) for individuals who turned 28 from 1975-2015.

[2] Bound, Lovenheim and Turner (2010) document the 1975-1995 trends, and argue that completion rates conditional on attendance declined because the influx of students included many who were poorly prepared and attended low quality colleges. A complementary paper by Castro and Coen-Pirani (2016) argues specifically that completion rates for white men fell over this period primarily because of an increase in college tuition and a decrease in ability of successive birth cohorts.

[3] We also analyze children from other family types: those with a single college-educated parent, and those with two parents but no 4-year college degrees. For simplicity the introduction focuses on the highest and lowest resource types. For details see Section 2.1.

We then propose a theory to explain the increase in aggregate completion that is consistent with both of the above findings. Our premise is that, conditional on attending college, an individual's chances of completing depend on how prepared the individual is for college. [4] Our hypothesis is that a rising college wage premium since the 1980's induced a large increase in pre-college investment among high resource families, but only a minor increase among low resource families. This led to a large increase in college completion among high resource children, even though attendance barely increased. Meanwhile, this led to a minimal increase in college completion among low resource children, despite a large increase in attendance. [5]

We provide three types of evidence in support of our hypothesis. First, we document large and growing gaps in measures of pre-college investment between high and low resource families. We use the Consumer Expenditure Survey (CEX) to show that the gap in expenditures per child between high and low resource families increased from 1967-2015 (individuals who turned 28 between 1995-2015 were born between 1967-1987). We also use the American Heritage Time Use Surveys and the American Time Use Surveys to show large and growing gaps in parent-child time during this period.

Next, we document large and growing gaps in measures of college preparedness between children from high and low resource families. Because the PSID only began collecting test score data fairly recently, we use data from the 1979 and 1997 National Longitudinal Surveys of Youth (NLSY). Fortunately, the cohorts in these studies align fairly closely with the beginning and end of our sample period.[6] We measure college preparedness using SAT scores, and arrive at three findings. First, SAT scores strongly predict college completion. Next, in the NLSY79 there already existed fairly large gaps in SAT scores between children from high and low resource families. Last, these SAT score gaps grew substantially between the NLSY79 and NLSY97.

Finally, we ask whether a rise in the college wage premium could have plausibly

[4] A large literature supports this view. See, for example, Bowen, Chingos and McPherson (2009), Bound, Lovenheim and Turner (2010), Hendricks and Schoellman (2014), Hendricks and Leukhina (2014), Athreya and Eberly (2016).

[5] One reason attendance increased more for low resource children is that attendance rates started far below attendance rates for high resource children: 40% vs. 84% in 1996.

[6] NLSY79 respondents turned 28 from from 1985-1992, and the NLSY97 respondents turned 28 from 2008-2012.

induced the empirical trends in pre-college investment and college attendance that we observe. To do so we construct a structural life-cycle model of intergenerational human capital investment with household heterogeneity along two dimensions: number and education of parents. In our model single parents have a smaller time endowment than dual parents, and less-educated parents have less productive time. Therefore, variation across households in the number and education of parents leads to variation in child investments.

When model children turn 18 they leave their parents' household and make a college attendance decision. College has two key features. First, it is *risky*. All individuals who attend college face both tuition and opportunity costs, but only those who complete college earn the college wage premium, and completion is stochastic.[7] Second, completing college requires *preparation*. The probability of completing college, conditional on attending, is increasing in the individual's human capital. This human capital is accumulated throughout childhood (before college) via parental investments.

We calibrate our model to be consistent with several key moments in the data in 1986 (the year that our first PSID cohort, who were born in 1968 and turned 28 in 1996, turned 18). We then ask whether our model is able to quantitatively account for college attainment trends among low- and high resource children who turn 28 between 1995-2015. Our main counterfactual exogenously changes college tuition and the college wage premium from their 1986 values to 2005 levels, the year in which our final PSID cohort turned 18. Consistent with the data, we find that children from low resource households experience a large increase in college attendance, but a minimal increase in college completion. Also consistent with the data, we find that children from high resource households experience a smaller increase in college attendance compared to their increase in college completion.

The paper most closely related to ours is Athreya and Eberly (2016). Their central argument is that further increases in the college wage premium are unlikely to increase college completion, because any new college attendees will tend to be poorly prepared for college, and therefore unlikely to complete. The key assumption behind their prediction

[7] Hendricks and Leukhina (2014) find that college dropouts earn about $70,000 more over their lifetime than high school graduates. By contrast, college graduates earn about $400,000 more over their lifetime than high school graduates in 2000 dollars.

is that the distribution over college preparedness is fixed. Their prediction is qualitatively consistent with empirical trends since 1995 for children from low resource families, but is at odds with aggregate trends since 1995, and especially with trends for children from high resource households. Therefore, one of our main contributions is to show that endogenizing the distribution over college preparedness is important to understand the link between changes in the college wage premium and changes in aggregate college completion.

Ramey and Ramey (2010) argue that, especially for college-educated parents, parental time investments in children increased beginning in the 1990's in response to growing competition for college admission. Like that paper, we argue that inequality in pre-college investments has increased since the 1980's. However, in our theory the exogenous driver is the college premium, rather than capacity constraints college admission. We also emphasize that attainment trends differ by number of parents as well as parental education. Finally, we martial several additional pieces of evidence in support of our theory: trends in expenditures on children, trends in test scores, and a quantitative structural model.

We contribute to a large literature on inequality and intergenerational human capital investments in dynamic general equilibrium models. De La Croix and Doepke (2003), Moav (2005), and Bar et al. (2015) examine channels through which inequality can affect human capital investments in children and subsequently impact aggregate growth. Fernandez and Rogerson (2001) and Fernández (2003) quantify how changes in assortative mating over time can affect inequality through differential human capital investments. Restuccia and Urrutia (2004), Erosa and Koreshkova (2007), and Herrington (2015) study the transmission of inequality over time via parental investments in child human capital. We especially complement two recent papers linking family structure to human capital investment. Greenwood et al. (2016) study the driving forces behind the changing family structure in the US since 1960 via a model with marriage, divorce, endogenous fertility, and intergenerational human capital investments. Gayle, Golan and Soytas (2015) study how between-race differences in marriage, divorce, and wages contribute to a black-white achievement gap through endogenous differences in intergenerational human capital investment.

The rest of the paper proceeds as follows. Section 2 documents the empirical trends in educational attainment by family structure. Section 3 introduces a highly stylized model that we use to interpret the empirical college trends. Section 4 provides evidence on growing gaps between family types in pre-college investment and college preparedness. Section 5 introduces the quantitative structural model. Section 6 assigns values to model parameters. Section 7 discusses the quantitative analysis and results. Section 8 concludes.

2 College attainment in the data

This section documents college attainment rates from 1986-2005 by family background. Section 2.1 provides details on our data sources and measurement. Section 2.2 describes the educational attainment trends by family background that are the focus of this paper. Section 2.3 provides evidence that family background (number and education of parents) is an important determinant of college attainment even after controlling for other individual and family characteristics. Finally, Section 2.4 documents that the lowest- and highest-resource family types (single parents with no college degree and dual parents with a college degree) represent a large and growing share of US households with children.

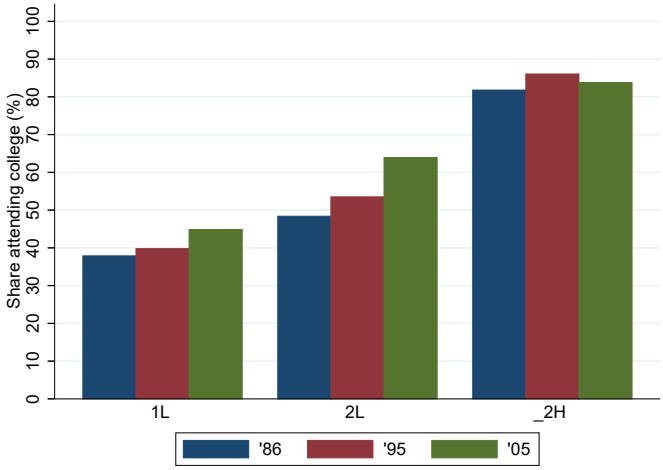
2.1 Details on data sources and measurement

Table 1: Summary statistics.

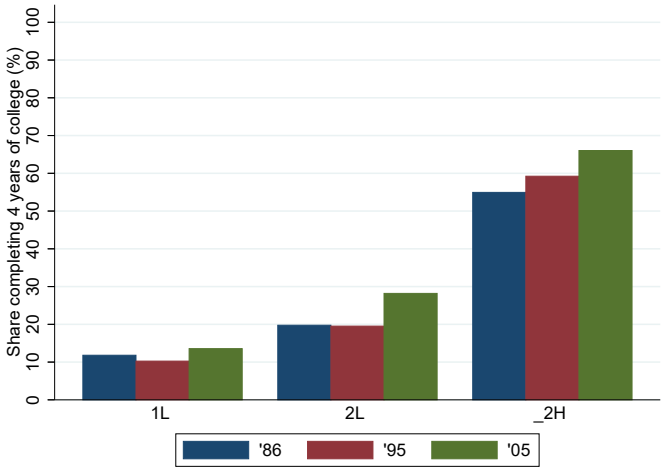
Population characteristics	
Male share of heads (%)	80.9
Female share of spouses (%)	99.9
White share of heads (%)	85.3
Black share of heads (%)	8.7
Mean age of head	39.0
Mean number of children	1.9
Share 1L (%)	21.0
Share 1H (%)	3.2
Share 2L (%)	47.2
Share 2H (%)	28.5
Observations	54,918

Note: Data source is the PSID 1968-2015. Sample is households with children and valid measures of parent cohabitation status and parent years of education. See text for details.

Figure 1: US college attendance and completion rates by age 28



(a) College attendance



(b) College completion

Note: Data source is the PSID. Bars plot college attainment shares by age 28 (5-year moving average centered around year $t \in \{1986, 1995, 2005\}$. The year corresponds to the year individuals turned 18. College attendance corresponds to at least 13 years of education. College completion corresponds to at least 16 years of education. Number of parents is measured using cohabitation. Individuals assigned to the "minimum resource family type" they experienced from age 0-16. Attainment rates for 1H children are not included due to small sample size. See text for details.

Our primary data source for documenting these trends is the 1968-2015 waves of the Panel Study of Income Dynamics (PSID). The PSID is well suited for our investigation because it allows us to follow children from birth through into adulthood, it allows us to do so for several cohorts, and it allows us to link children to parents.

In order to study college attainment by family background, we partition households with children under 18 along two dimensions. The first dimension is the number of parents

in the household. Our primary method of classifying households as having either single or dual parents is by cohabitation: we classify a household as dual parent if there both a household "head" and a "spouse" are present, even if the two are unmarried, and we classify a household as single parent if there is no "spouse" present.[8]

The second dimension along which we partition families is by parent education. Specifically, we measure whether or not at least one parent in the household has completed 4 years of college.[9] Partitioning households by number and education of parents yields four family types: 1L, 1H, 2L, 2H, where the number corresponds to the number of parents in the household, and the letter corresponds to whether or not at least one parent has completed college (H) or not (L).

When measuring college attainment by family type, we need to assign each child to a single family type. This is not always trivial, because some children experience multiple family types during childhood (for example, in the case of divorce). We assign children to a single family type using two procedures. The first assigns individuals to their "lowest resource" type experienced during childhood (from age 1-17). [10] The second assigns individuals to their mode family type: the family type they experienced most often during childhood. The results are very similar across both methods. We present the "lowest resource" results because they seem to present the least noisy estimates.

Finally, we briefly comment on how we measure college attainment. We compute the individual's maximum reported years of education by age 28. We say that an individual attended college if they report at least 13 years of school. We say that an individual completed college if they report at least 16 years of school.

[8] Alternatively, we have repeated our analysis using marriage in place of cohabitation. With this measure, we only classify a household as dual parent if there both a household "head" and a "spouse" are present and the two are married. The results are robust to using this classification method. We prefer the cohabitation measure for two reasons. First, we cannot tell whether a cohabiting couple is married before 1977. Second, due to changing social norms about unmarried cohabitation, we think cohabitation is a more consistent definition of "dual parents" over our sample period.

[9] In the case of dual parent households, we do not distinguish between cases where only one parent completed college or both parents completed college. We do this mainly in an attempt to reduce the number of family types. This simplifies the analysis, and helps keep the sample sizes of each family type as large as possible.

[10] Using this procedure, if a child ever lived in a 1L household from age 1-17, they are assigned to 1L. If they never spent time in a 1L household, but did spend time in a 1H household, they are assigned to 1H. If they never spent time in either a 1L or 1H household, but did spend time in a 2L household, they are assigned to 2L. Only children who spent every year from age 1-17 in a 2H household are assigned to 2H. Our assumption that a 1H family type is ranked lower than a 2L family type is arbitrary. This decision turns out to be unimportant for our results because 1H households are extremely rare in the data.

2.2 College attainment rates by family type

Figure 1 displays 3-year moving averages of college attendance and completion rates by family background from 1986-2005. Individuals are assigned to the year they turned 18. So, for example, the aggregate attendance rate of 53% in 1986 corresponds to individuals who turned 18 from 1986-87 (and who turn 28 from 1994-98).

Figure 1a displays college completion rates. Aggregate attendance increased 12pp, from 53% to 65%. Attendance grew most among children from 1L and 2L families: by 7pp and 13pp, respectively. Attendance grew least, only 1pp, among children from 2H families. As a result, the gap in attendance rates between 2H-2L and 2H-1L children *decreased* by about 6pp over the sample period.

Figure 1b displays college completion rates. Like aggregate attendance, aggregate completion also increased 12pp, from 23% to 35%. Again, completion trends differed by family background. However, in this case completion grew most, 13pp, among children from 2H families. Completion grew slightly less, 9pp, among 2L families. Completion grew much less, 4pp, among 1L families. As a result, the gap in completion rates between 2L-1L and 2H-1L children *increased* by around 9pp over the sample period.

Together Figures 1a-1b show that while aggregate attendance and completion grew by similar amounts from 1986-2005, attendance and completion did not grow proportionately across children from different family backgrounds. Attendance increased more than completion among children from lower resource families, while completion increased more than attendance among children from higher resource families.

Of course, variation in college attainment by number and education of parents might be driven by third variables correlated with family structure, as opposed to being driven by family structure per se. The next section documents that family structure is an important predictor of college attainment even after controlling for parent earnings, race, sex, number of siblings, and the geographic region where the child grew up.

2.3 Regression analysis: Predictors of college completion

Table 2: Linear probability model for college completion.

	Impact on predicted probablity of completing college			
Constant	0.184^{***} (0.005)	0.125^{***} (0.006)	0.121^{***} (0.009)	0.088^{***} (0.010)
1L	-0.103^{***} (0.008)	-0.054^{***} (0.009)	-0.057^{***} (0.009)	-0.056^{***} (0.009)
1H	0.133^{***} (0.021)	0.117^{***} (0.021)	0.112^{***} (0.021)	0.117^{***} (0.021)
2H	0.304^{***} (0.010)	0.253^{***} (0.010)	0.251^{***} (0.010)	0.253^{***} (0.010)
log of mean parent earnings	–	0.088^{***} (0.005)	0.088^{***} (0.005)	0.088^{***} (0.005)
Female	–	–	0.048^{***} (0.007)	0.067^{***} (0.007)
Number siblings	–	–	-0.011^{***} (0.003)	-0.012^{***} (0.003)
Black	–	–	0.014 (0.017)	-0.011 (0.017)
Region effects	–	–	–	*X*
Year effects	*X*	*X*	*X*	*X*
Obs.	13850	13211	13073	13073
R^2	0.11	0.13	0.14	0.15

Note: $p < .05^{*}, .01^{**}, .001^{***}$. Data source is the PSID. College completion corresponds to at least 16 years of education. Reference group is a child from a 2L family. Number of parents is measured using cohabitation. Individuals assigned to the "minimum resource family type" they experienced from age 1-16. Parent earnings are the sum of earnings for the household head and spouse. Mean parent earnings are computed over ages 1-16. Number of siblings is mean siblings from age 1 -16. See text for details.

This section investigates which individual and family characteristics predict college completion. Specifically, we run a linear probability model of college completion on dummies for family type with all cohorts 1986-2005 pooled together. We control for the log of mean parent earnings during childhood (parent earnings are the the sum of earnings by the household head and spouse), the child's sex, the mean number of additional children living in the household during childhood, whether the child is black, and geographic region and year fixed effects. The reference family type is dual parents with no college degree (2L).

Table 2 displays the results. The left-most column corresponds to the regression which controls for family type and year effects, but no other variables. Moving from a 2L to a 1L family lowers the predicted probability of completing college by 10.1pp, moving to a 1H family increases predicted probability by 13.6pp, and moving to a 2H family raises the predicted probability by 30.2pp.

Controlling for other variables only slightly reduces the size of the coefficients on family structure. The right-most column corresponds to the regression with all controls included. In that case moving from a 2L to 1L family lowers the predicted completion probability by 5.5pp. Moving from a 2L to 1H family increases the predicted completion probability by 12.0pp. Finally, moving to a 2H family increases the predicted completion by 25.2pp. These coefficients are large relative to the coefficient on the log of mean parent earnings, which implies that doubling parent earnings increases the predicted probability of completing college by about 9pp.

The upshot is that living with two parents and having college-educated parents are strong predictors of whether an individual completes college, even after controlling for family earnings, number of children, race, sex, and the geographic region in which you grew up. This is consistent with the idea that family background is an important driver of the different trends in college attendance and completion discussed in the previous section.

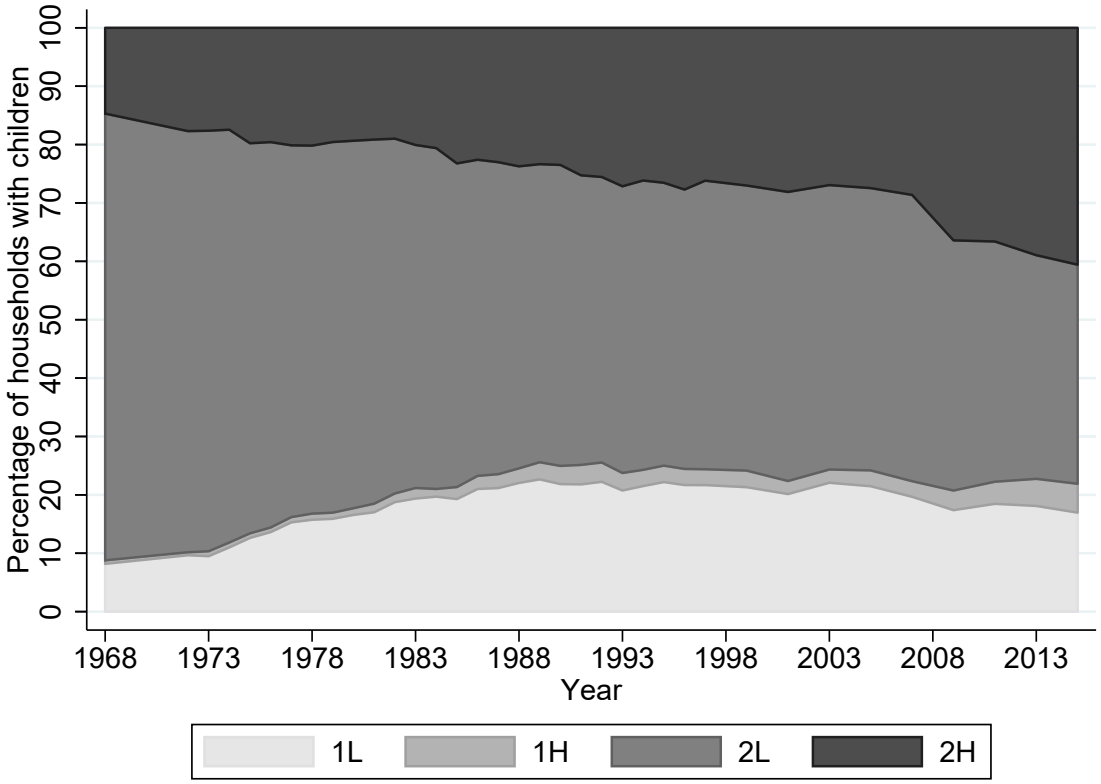
Our results reaffirm the consistent finding in the literature that family structure is a strong predictor of educational attainment. For example, Cameron and Heckman (1998) and Sacerdote (2007) both find that differences in family structure are more important in explaining educational attainment than family earnings. Also, our finding that being female substantially increases the predicted probability of completing college is consistent with previous work by Bound, Lovenheim and Turner (2010).

2.4 Population shares of family types

This paper argues that heterogeneity in family structure is crucial for understanding recent trends in aggregate college attainment. Here we briefly document that family structures have become more polarized in the US over our sample period. Because more children are being raised in the polar family types, 1L and 2H, college attainment trends within these family types are becoming increasingly important determinants of aggregate college attainment.

Figure 2 displays the share of households with children accounted for by each of the

Figure 2: Population shares of family types, 1968-2015



Note: Data source is the PSID. Family type is composed of number of parents (1 or 2) and education of parents (no college graduate, L, or at least one college graduate, H). Number of parents is measured using cohabitation. Parents are labeled college gradautes if they report completing at least 16 years of education. We exclude years 1969-71 because the education of the "spouse" was not reported for those years. See text for details.

four family types from 1968-2015. In 1968, the year our 1986 cohort was born, 76% of households with children fell into the 2L category (dual parents, no college degrees). 14% of households were headed by dual parents with at least one college degree between them. Only 8% of households were headed by single parents. Of these, the vast majority had noh college degree.

By 2005, the year our final cohort turned 18, only 48% of households with children were in the 2L category. The 1L share had nearly tripled to 22%, and the 2H share had doubled to 28%. Interestingly, the 1L share has remained constant or even slightly declined since 1990. By contrast, the 2H share has steadily increased throughout the sample period, reaching 41% of households with children by 2015.

3 Simple model of college attendance and completion

This section uses a highly stylized model of college attainment to interpret the empirical college trends documented in Section 2. Specifically we ask how an increase in the return to graduating college impacts both college attendance and completion. Section 3.1 analyzes a version of the model where an individual's preparedness for college is exogenously given. Section 3.2 shows how the predictions of this model change when we endogenize college preparedness. Finally, Section 3.3 discusses the empirical college trends in the context of these model results. The proofs for all results can be found in Appendix B.

3.1 Exogenous human capital version

The model is static. There is a unit interval of individuals $j \in [0,1]$. Individuals have heterogeneous human capital endowments $H^j > 0$. We impose that the resulting distribution over human capital $z(H)$ is continuous and has connected support.

Individuals make a single decision: whether to go to college ($s = g$) or not ($s = ng$). An individual with human capital H who goes to college pays tuition cost τ and graduates with probability $\gamma(H)$, where $\gamma \in (0,1)$ and $\gamma' > 0$. Individuals who do not graduate simply earn their human capital H. College graduates earn their human capital augmented by a college wage premium $H(1+\omega)$. There is no premium for college dropouts. An individual with human capital H maximizes expected earnings net of tuition cost:

$$\max_{s \in \{ng,g\}} \quad \left\{ H + \mathbb{1}_{(s=g)} \left[\gamma(H)\omega H - \tau \right] \right\} , \tag{1}$$

where $\mathbb{1}_{(s=g)}$ is an indicator function that equals 1 when $s = g$ and zero otherwise.

3.1.1 Equilibrium

Equilibrium in this model is simply a collection of optimal attendance decisions $s^j \; \forall j$. Equilibrium is characterized by a cutoff value of human capital $\underline{H}$. All individuals with $H^j \geq \underline{H}$ choose to go to college, and all individuals with $H^j < \underline{H}$ choose to not go. $\underline{H}$ is the

unique human capital value where the expected benefits of attending equal the tuition cost:

$$\gamma(\underline{H})\omega\underline{H} = \tau \ . \tag{2}$$

We write the aggregate college attendance $\overline{g}$ and completion $\overline{G}$ rates as

$$\overline{g} = \int_{\underline{H}}^{\infty} z(dH) \ , \tag{3}$$

$$\overline{G} = \int_{\underline{H}}^{\infty} \gamma(H) z(dH) \ . \tag{4}$$

The intuition for the equilibrium cutoff is that the cost of attendance, τ, is the same for all individuals, but the benefit is increasing in H. The benefit is increasing in H for two reasons. First, because the increase in earnings for college graduates is proportional to their human capital H. Second, because individuals only earn college premium if they graduate college, and the probability of graduating is increasing in H.

3.1.2 Impact of the college premium ω

Result 1. *(Exogenous human capital version). Consider an increase in the college premium from ω_1 to ω_2. Denote equilibrium elements corresponding to ω_j with a subscript j. Then $\underline{H}_2 < \underline{H}_1$. Further, both attendance and completion rates increase, but attendance increases more: $0 < \overline{G}_2 - \overline{G}_1 < \overline{g}_2 - \overline{g}_1$.*

Proof. See Appendix B. □

An increase in the college premium lowers the equilibrium cutoff value $\underline{H}$ because the cost of attending has not changed, but the benefit of attending is strictly increasing in ω (see Equation (2)). Therefore, an individual with $H \in (\underline{H}_2, \underline{H}_1)$ will go to college given ω_2 but not given ω_1.

As a result, an increase in the college premium will increase both aggregate attendance

and completion.[11] However, completion will increase by strictly less than attendance:

$$0 < \overline{G}_2 - \overline{G}_1 = \int_{\underline{H}_2}^{\underline{H}_1} \gamma(H) z(dH) < \int_{\underline{H}_2}^{\underline{H}_1} z(dH) = \overline{g}_2 - \overline{g}_1, \tag{5}$$

where $\overline{G}_2 - \overline{G}_1$ is the increase in aggregate completion and $\overline{g}_2 - \overline{g}_1$ is the increase in aggregate attendance. Completion must increase by less than attendance because each new college attendee, with $H \in (\underline{H}_2, \underline{H}_1)$, only completes college with probability $\gamma(H) < 1$.

Our analysis so far borrows heavily from existing work by Athreya and Eberly (2016). They use a more detailed version of this model to argue that further increases in the college wage premium may not lead to quantitatively large increases in college completion in the US because any new marginal attendees are likely to be less prepared for college and therefore have low conditional completion probabilities. The predictions of their model are qualitatively consistent with the empirical trends from Section 2 for children from single parent, non-college (1L) families, whose attendance increased more than completion.

However, these predictions are inconsistent with aggregate empirical trends, and especially with empirical trends for children from dual parent, college-educated (2H) families, where completion increased by more than attendance. To interpret these trends, we introduce one additional feature to the simple human capital model.

3.2 Endogenous human capital

We now introduce an endogenous human capital version of this model. In this version individuals are endowed with an initial human capital level h with distribution $y(h)$, and individuals can choose a final human capital H by paying an investment cost $c(H-h)$. We assume that c is strictly positive, strictly increasing, strictly convex, and differentiable.

The individual's maximization problem is similar to the exogenous case, but now they have an additional choice (final human capital H) and consider investment costs:

$$\max_{H \geq h, s \in \{ng, g\}} \quad \left\{ H - c(H-h) + \mathbf{I}_{(s=g)} \left[\gamma(H) \omega H - \tau \right] \right\} . \tag{6}$$

[11] This assumes that the aggregate attendance rate was strictly less than 1 given ω_1.

3.2.1 Equilibrium

We can solve this problem given initial human capital h in two steps. We first find the optimal final human capital given each possible attendance decision, H_{ng} and H_g:

$$c'(H_{ng} - h) = 1 \tag{7}$$

$$c'(H_g - h) = 1 + \omega\left(\gamma'(H_g)H + \gamma(H)\right) . \tag{8}$$

Next, we choose the attendance decision $s \in \{ng, g\}$, and corresponding human capital choice, which maximizes the objective.

Equilibrium is now a collection of optimal human capital and attendance choices H^j, s^j. Equilibrium is characterized by two objects: a distribution over final human capital types $z(H)$ and a cutoff value of human capital $\underline{H}$ which continues to satisfy Equation (2).

3.2.2 Impact of college premium ω

Result 2. *(Endogenous human capital version). Consider an increase in the college premium from ω_1 to ω_2 in the endogenous version of the model. Denote equilibrium elements corresponding to ω_j with a subscript j. Then the resulting final human capital distribution z_2 first order stochastically dominates z_1. Further, $\underline{H}_2 < \underline{H}_1$. Finally, both attendance and completion rates increase, but completion may increase more than attendance.*

Proof. See Appendix B. □

Just as in the exogenous human capital model, an increase in the college premium lowers the cutoff value $\underline{H}$ to decline. In the endogenous version, however, there is also a change in the distribution over final human capital from $z_1(H)$ to $z_2(H)$.

The intuition for why z_2 dominates z_1 is twofold. First, individuals who do not attend given ω_2 do not change their investment choice $H - h$ because the marginal benefits of investing do not change (see Equation 7). Second, individuals who do attend given ω_2 strictly increase their investment choice $H - h$ because the marginal cost hasn't changed, but the marginal benefit of investing has strictly increased (see Equation 8).

Because z is an endogenous object, it is no longer guaranteed that attendance will increase by more than completion. In particular, Equation (5) no longer describes the equilibrium increase in completion and attendance because the distribution z changes in response to a change in ω.

3.3 Model application: attendance and completion trends by family type

The key college trends from Section 2 were that (i) attendance increased much more than completion for children from 1L families, while (ii) completion increased much more than attendance for children from 2H families.

For the endogenous human capital model to generate (i) in response to an increase in the premium ω, it must be that the attendance cutoff $\underline{H}$ increased substantially, but investment, and therefore the distribution $z(H)$, changed little. This could be the case if the marginal cost of investment c' was a very steep function, so that increasing investment was very costly (see Equation (8)). In this case, large changes in ω would only lead to small changes in $z(H)$. The extreme case of this is the exogenous human capital model, where $z(H)$ does not respond at all to a change in ω.

For the model to generate (ii) in response an increase in the premium ω, it must be that investment, and therefore z, increased substantially. This could be the case if the marginal cost of investment c' was a very shallow function, so that increasing investment was not very costly. In this case, a modest increase in ω could lead to a large increase in investment, a large rightward shift in $z(H)$, and a large increase in aggregate completion.

Our hypothesis is that an increase in the college wage premium generated a larger increase in pre-college investment among 2H and 2L families than 1L families, which in turn generated the college trends (i) and (ii) above. (We put off answering *why* investment increased more among 2H families until Section 5). If this is correct, it suggests that we should observe diverging patterns of pre-college investment between 2H families and 1L families in the data. It also suggests that we should observe diverging measures of pre-college preparedness. The next section provides evidence consistent with these predictions.

4 Empirical evidence of diverging pre-college investment and college preparedness by family type

In this section we provide evidence of diverging pre-college investments and college preparedness by family type. To do so we supplement our main data source, the PSID, with additional sources. First, we rely on evidence from the PSID and Consumer Expenditure Survey (CEX) to discuss parent earnings and monetary investments in children. Next, we utilize the American Time Use Survey (ATUS) and American Heritage Time Use Study (AHTUS) to document parental time investments in children. We argue that growing gaps in money and time investments during childhood are plausibly linked to growing gaps in college preparedness. To establish this final piece of evidence we utilize test score data from the 1979 and 1997 National Longitudinal Surveys of Youth (NLSY79 and NLSY97).

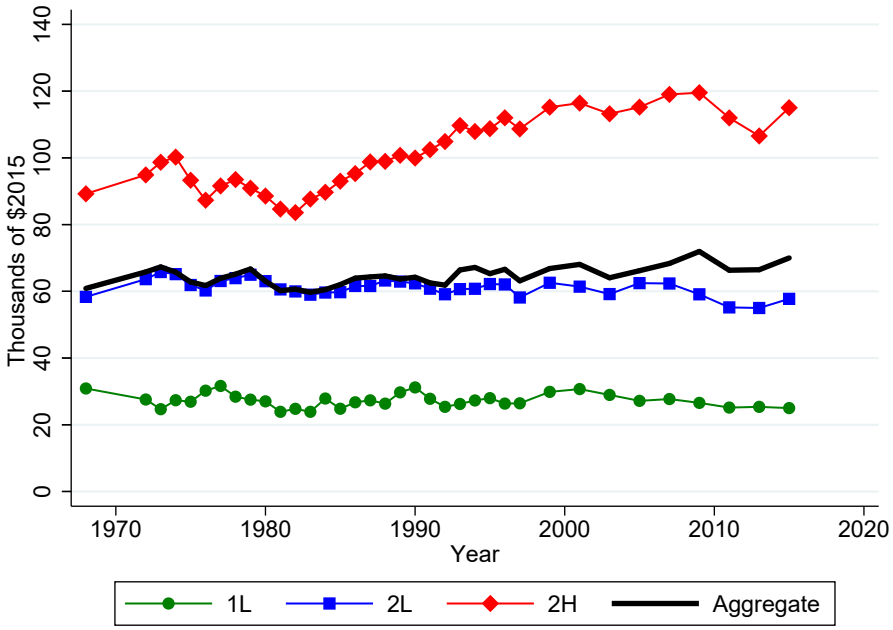
4.1 Diverging investments

4.1.1 Gaps in parental earnings and expenditures on children

We begin by documenting trends in family earnings by family type, which has clear implications for the family's capacity to invest money in children's human capital accumulation. Figure 3 plots median parent earnings by family type using PSID data from 1968-2015. Parent earnings are the sum of labor earnings by the household head and spouse, if present.

From 1968, the year our 1986 cohort was born, until 2005, the year our final cohort turned 18, aggregate median parent earnings increased roughly 10%, from $60,900 to $66,200 (in 2015 dollars). This increase did not occur proportionately across family types. Median earnings fell by 12% for 1L parents, grew by 7% for 2L parents, and grew by 29% for 2H families. These widening resource gaps are suggestive that monetary investments may have also diverged, and we turn to this evidence next.

Figure 3: Median parent earnings by family type



Note: Data source is the PSID. Parental earnings are the sum of labor earnings by the household "head" and "spouse" if the "spouse" is present. Number of parents is measured using cohabitation. Earnings for 1H households are not included due to small sample size. We exclude years 1969-71 because the education of the "spouse" was not reported for those years. See text for details.

Unfortunately the PSID has limited data on expenditures for children, so we report estimates from the CEX instead.[12] Kornrich and Furstenberg (2013) has a thorough analysis of these data from the early 1970s through the late 2000s, which covers almost the entire period of time we are interested in, except the late 1960s. We review several of their findings that are pertinent to our story.

Kornrich and Furstenberg (2013) consider expenditures on children that fall in three main categories: child care (day care and babysitting), education (tuition, fees, room and board, books, private lessons), and other miscellaneous (clothes, toys, games, musical instruments,and recreational/sports equipment). After converting all nominal amount into 2008 dollars, they find that inequality in expenditures per child increased substantially from the 1970s through 2000s. For example, in 1972-73 they find a gap of roughly $1,200 in annual spending per child between the 2nd and 9th deciles of the income distribution, and this gap increased to $2,800 by 2006-07. We exclude the first and last deciles to minimize

[12]The PSID Child Development Supplements, which began in 1997, do have data on child expenditures; however, we are interested in longer run trends, and this source lacks sufficient historical data.

effects at the tails of the income distribution, but those gaps and their growth over time were even larger.

In a multivariate regression analysis, they also document the effects of parent's education and family structure. Comparing college educated to high school educated households, they find a gap of roughly $700 in 1972-73, and this more than doubled to over $1,500 in 2006-07. With respect to family structure, they find that single mothers in 1972-73 actually spent about $500 more per child compared to dual-parent households, and by 2006-07 this difference had essentially disappeared. We presume the initial gap was largely due to higher child care expenses in single parent households, and this difference waned as more married women entered the labor force, resulting in higher child care expenses for dual-parent households.

In summary, these data indicate that parental earnings by family type diverged substantially over the last several decades, and expenditures on children followed suit. Higher income and more highly educated families spent significantly more money investing in children. Furthermore, while single parents formerly spent a few hundred dollars more per child compared to dual-parent households, this gap has been erased over time. Next, we turn to examining a second key investment channel: parent time.

4.1.2 Gaps in parental time with children

Parent time is widely credited as being a crucial input in the production of a child's human capital (see, e.g., the seminal contributions Leibowitz (1974) and Leibowitz (1977), the review by Haveman and Wolfe (1995), and more recent confirmation in Del Boca, Flinn and Wiswall (2014). In addition, recent work by Aguiar and Hurst (2007) and Ramey and Ramey (2010) has found that parent time with children has increased in recent decades. As with expenditures, the PSID Child Development Supplements contain information on time use, but no historical historical time use data exists in the PSID. Hence, we utilize data from the ATUS and AHTUS and focus attention particularly on how time use trends relate to the number and education of parents.

Table 3: Average weekly childcare hours

	Family type			
Sample period	1L	1H	2L	2H
1965–1985	6.0	5.3	10.4	12.9
2003–2016	10.9	11.0	19.2	26.0
Change	+4.9	+5.7	+8.8	+13.1

Note: Sample includes parents aged 25-54 with at least one child under age 18. 1L and 1H includes mothers only due to small sample of single fathers. 2L and 2H includes time of mother and father, and assumes both have the same education level.

Table 3 shows the average childcare time for single versus dual parents, and college versus non-college educated parents.[13] We document the "modern" era corresponding to the end of our PSID sample using ATUS data for 2003-20016 and the "historical" era corresponding to the beginning of our PSID sample using AHTUS data for 1965-1985. Because time use is reported at the individual rather than household level, we construct hypothetical average dual-parent couples by adding the average time of married mothers and married fathers.

Several key points should be taken from Table 3. First, parent time has increased among all family types, but college-educated parents have increased their childcare time by more than non-college parents. This point has been previously emphasized by others including Ramey and Ramey (2010). Second, conditional on education the gaps in childcare time between single- and dual-parent families are larger than the gaps by education, and have grown more over time. Finally, comparing low resource (1L) and high resource (2H) families, we find that the gaps between 1L and 2H were large to begin with (6.9 hours during 1965-1985) and have grown substantially (to 15.1 hours during 2003-2016). Furthermore, the 2H-1L ratio of childcare time has increased from 2.2 to 2.4 indicating that the gap has widened even after accounting for the initial level differences. Notably, some concerns have been raised about the quality of the historical AHTUS data and its com-

[13] We follow Ramey and Ramey (2010) in selecting the activity codes which qualify as "childcare time".

parability with modern ATUS data (see, e.g., the discussion related to Ramey and Ramey (2010)). While we recognize these concerns, we emphasize that for our purposes the most important point is that differences across household types are large and growing, even relative to the overall trends in childcare time.

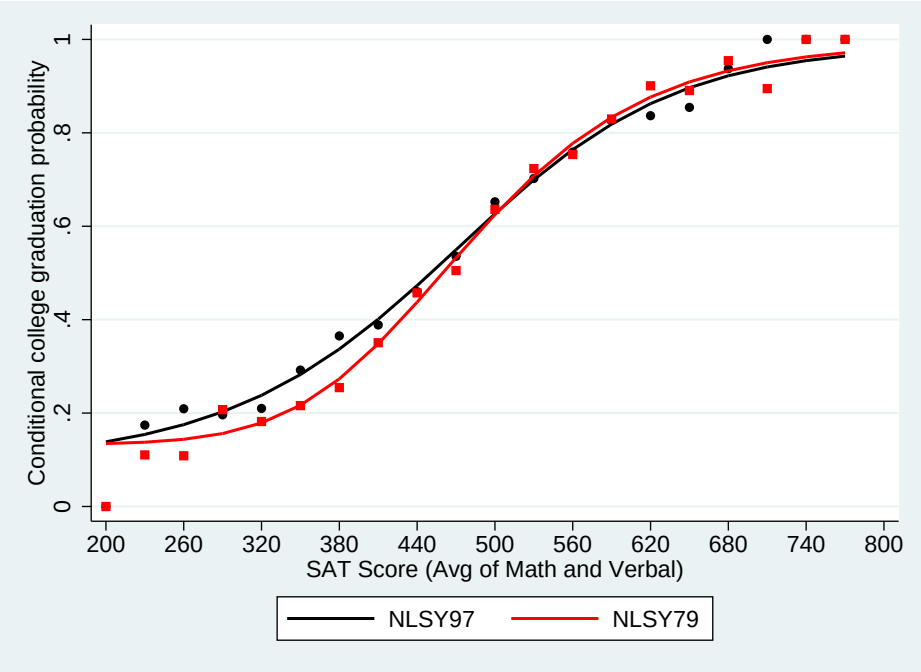
4.2 Diverging preparedness

The evidence above showed that investment gaps between high and low resource families were significant to begin with and have grown wider over time. We claim that these growing investment gaps are plausibly linked to widening gaps in college preparedness, as well. To show this we proceed in three steps. First, we provide evidence that SAT test scores are strong predictors of college completion rates conditional on attendance. Second, we document large gaps in the distribution of SAT scores between 2H children and 1L children who turned 18 around 1980. Finally, we show that the gap in test scores between 1L children and 2H children, as well as the gap between 1L children and 2L children, increased substantially between cohorts who turned 18 around 1980 and cohorts who turned 18 around 2000.

4.2.1 Test scores strongly predict conditional completion rates

Because the PSID only has test score data beginning in 2005, we rely on data from the NLSY79 and NLSY97 for this section. The age of NLSY respondents roughly line up with the ages of our first and last cohorts in the PSID. The NLSY79 cohorts turned 28 from 1976-1982, just prior to our first PSID cohort who turned 18 in 1986. The NLSY97 cohorts turned 18 from 1998-2002. Section C provides details on the construction of our NLSY samples. It also verifies that the family type shares and educational attainment rates by family type in the NLSY align closely with those in the PSID.

Figure 4: College completion rate, conditional on attendance, by SAT



Note: Figure displays the fraction of individuals who, by age28, complete college conditional on attending college as a function of their average Math and Verbal SAT score. For details see Appendix C.

A long literature has already shown that SAT scores strongly predict various measures of success in college (see, e.g., Wilson (1983) and Burton and Ramist (2001)). Figure 4 confirms this finding using both NLSY79 and NLSY97 data. For individuals in the NLSY79 we compute the average of their SAT math and verbal scores.[14] We then group scores into 30-point bins and within each bin calculate the share of students who complete college by age 28, conditional on attending. Finally, we fit a nonlinear logistic function to the SAT score bins. We then repeat this procedure for the NLSY97.

SAT scores are normalized each year so that the national mean is 500 and the standard deviation is 100. Figure 4 shows that, conditional on attending college, roughly 60% of NLSY79 individuals with an SAT equal to the national mean completed college. Those one standard deviation above the mean (score = 600) complete with roughly 80% probability, and those one standard deviation below the mean (score = 400) complete with roughly 30% probability. Figure 4 also shows that the probability of graduation based on SAT changed little from the NLSY79 to the NLSY97 (one difference is that in the NLSY97

[14]For those without SAT scores, we impute a score from their ASVAB math and verbal z-scores.

the conditional graduation probability was about 5-10pp higher for individuals with SAT scores between 250-450).

4.2.2 Gaps in test scores and conditional completion rates

This section documents large and growing gaps in college preparedness by family type. Specifically, Table 4 displays SAT scores, conditional on attending college, by family type in the NLSY79 and NLSY97.

Around 1980 there already existed small test score gaps between 2L and 1L children, and large test score gaps between 2H and 1L children. In the NLSY79 the 25th percentile of SAT scores among 2L children was 400, which was 11 points higher than the corresponding score among 1L children. The scores at the 50th and 75th percentiles of 2L children were 7 points higher than the corresponding scores among 1L children. The test score gap between 2H and 1L children was over five times as large: between 60-67 points.

By 2000, test score gaps by family type had increased substantially. Test score gaps between 2L and 1L children were now 22 points at the 25th percentile and 35 points at the 75th percentile. The gaps between 2H and 1L children grew even more. The 2H-1L gap at the 25th percentile increased 12 points, to 79, and the gap at the 75th percentile increased 39 points, to 99. That is, by the year 2000 the 2H-1L SAT gap at the 75th percentile was a full (national) standard deviation.

4.2.3 Discussion

In this section we have provided evidence to support three key points. First, over the last several decades there have been large and growing gaps between high (2H) and low (1L) resource families in parent earnings, expenditures on children, and time spent with children. Second, these growing gaps in pre-college investment are plausibly linked to growing gaps in college preparedness, as measured by SAT scores. Third, because SAT scores strongly predict college completion, growing gaps in SAT scores are plausibly linked to growing gaps in college completion by family type.

The evidence we have provided supports the mechanism shown in the simple model

Table 4: SAT by family type in the NLSY

NLSY79					
Percentile	1L	2L	2H	2L-1L	2H-1L
25	389	400	457	11	67
50	448	455	512	7	64
75	505	512	565	7	60

NLSY97					
Percentile	1L	2L	2H	2L-1L	2H-1L
25	391	413	470	22	79
50	447	473	532	25	84
75	498	533	597	35	99

of Section 3. Further, it provides justification for a theory in which parents invest time and money to build their child's human capital prior to college. But the evidence so far does not provide a sufficient answer for *why* parental investments in children increased more among 2H families than 1L families.

Our explanation for "why" is in two parts: (i) High resource (2H) parents responded to the rising college wage premium by investing more time and money in their children; and (ii) Low resource (1L) parents faced tight time and budget constraints, and responded less to the rising college wage premium. For high resource families, who were already attending college at very high rates, this led to significantly higher completion rates despite little change in attendance. For low resource families, our mechanism is the same as that of Athreya and Eberly (2016): the larger college wage premium induced more children to attend college, but because many of these children were poorly prepared, few of them graduated.

While this is an intuitively appealing story, it is not obvious that the forces we discuss are large enough to induce the investment and attendance patterns we document. In the next sections we build a structural model of intergenerational human capital investment and college with heterogeneous family types to show that a plausible change in the college premium in our model actually can generate these patterns.

5 The quantitative model

In this section we construct a one-shot life cycle model of intergenerational human capital investment that incorporates several dimensions of household heterogeneity. The key ingredients of the model are as follows.

The model is populated by a unit mass of households. Households consist of parents and children. Time is discrete, and runs from period 1 to period J. Children are born in period 1 and die in period J; parents are middle-aged in period 1 and die before period J. In period 1 households are heterogeneous in parental human capital, parental education, number of parents, and initial human capital of children. Parents are altruistic and also value their own consumption. Each period parents split their time endowment between market work and time investments in their children, and split their income between consumption, saving, and market investments on their children.

For children there are three stages of life: early childhood, late childhood, and adulthood. During early childhood children accumulate human capital passively via investment by their parents. When children transition to late childhood they leave their parents' household and decide once and for all whether or not to enroll in college. Children who enroll in college pay a tuition cost, a psychic utility cost, and an opportunity (time) cost. Students graduate with a probability that is increasing in the human capital they acquired in early childhood. When a child's education is complete (either because the individual did not enroll in college, dropped out of college, or graduated from college), they enter the labor force. Children who graduate college receive a college wage rate, while all other receive a non-college wage rate. Children in the labor force rent their human capital inelastically to the market, and make consumption and savings decisions each period.

The subsections below provide the details of this model.

5.1 Early Childhood/ Early Parenthood ($j = 1, ..., J_{lc} - 1$)

Children are born into a household with their parents and remain in that household until the end of early childhood. The state of an early child is the state of their household: a vector (H, K, S, P, h), where H is the aggregate human capital of the child's parents; K is the net level of riskless assets owned by parents; $S \in \{G, NG\}$ indicates whether the parents are college graduates (G) or not graduates (NG); $P \in \{1, 2\}$ is the number of parents the child has; and h is the child's human capital. A child's initial human capital endowment at birth is stochastic and given by $h \in \{h_1, h_2\}$. We use upper case letters to denote state variables for parents, and lower case letters for children.

For a given household, the state variables (H, S, P) remain constant throughout early childhood,[15] while K and h evolve dynamically. Children are completely passive until the end of early childhood; the change in h throughout early childhood is determined by the investment decisions of the child's parents. Specifically, an early child's human capital h evolves via:

$$h' = F(m, i, H, h) \tag{9}$$

where F is an increasing function of market investments m, time investment i, parent human capital H, and the child's existing human capital h.

During periods $j < J_{lc} - 1$, parents in state $x = (H, K, S, P, h)$ choose household consumption c, net assets next period K', market investment m, and time investment i to maxi-

[15] Note that this assumes away divorce and parental human capital accumulation. See Greenwood, Guner and Knowles (2003) and Gayle, Golan and Soytas (2015) for papers which explicitly study the role of divorce for intergenerational human capital transmission.

mize the value of remaining lifetime utility:

$$V_j^p(x) = \max_{c,K',m,i} \quad \{u(c) + \beta V_{j+1}^p(x')\} \tag{10}$$

$$s.t. \quad c + m + K' = K(1+r) + \omega_S H(P-i)\ ; \tag{11}$$

$$h' = F\left(m, i, H, h\right)\ ; \tag{12}$$

$$x' = (H, K', S, P, h')\ ; \tag{13}$$

$$i \leq P. \tag{14}$$

Line (11) is the household budget constraint. It says that the sum of consumption, market investments, and savings in period j cannot exceed income in period j. Income comes from financial assets, $K(1+r)$, where r is the net real interest rate, and market earnings, $\omega_S H(P-i)$. Market earnings are the product of the household's wage rate ω_S (which depends on the parents' education S), the parents' human capital H, and the amount of time spent on market work, $P-i$.

Line (11) reveals the central distinction between single ($P=1$) and dual ($P=2$) parent households: dual parent households have twice the time endowment of single parent households. All else equal, dual parents can spend more time investing, purchase larger quantities of market investments, consume more, or some combination of all three.

The budget constraint also reveals the distinction between college ($S=G$) and non-college ($S=NG$) parents. In the calibrated model $\omega_G > \omega_{NG}$, so each unit of time spent on market work for a college parent yields more earnings than for a non-college parent. All else equal, similar to dual parent households, college-educated parents are able to choose larger quantities of time investments, market investments, or consumption. However, parental education also has a substitution effect: the opportunity costs of time investments are larger for more educated parents. For this reason, it will be important to pin down the elasticity of substitution between market investments and time investments in the human capital production functions F.

The parents' maximization problem looks identical in the final period of early child-

hood, $j = J_{lc} - 1$, except for two changes. First, the parents' next state does not include their child's human capital stock, since children leave the household at the end of early childhood. Second, now the objective function explicitly includes the continuation value of the child:

$$V^p_{J_{lc}-1}(x) = \max_{c,K',,m,i} \quad \{u(c) + \beta V^p_{J_{lc}}(x') + \alpha \tilde{V}^c_{J_{lc}}(\tilde{x})\} \tag{15}$$

$$s.t. \qquad c + m + K' = \omega_S H(P - i) + K(1 + r) \; ; \tag{16}$$

$$\tilde{h} = F\left(m, i, H, h\right) \; ; \tag{17}$$

$$\tilde{x} = (\tilde{h}) \; ; \tag{18}$$

$$x' = (H, K', S, P) \; ; \tag{19}$$

$$i \leq P \; . \tag{20}$$

The child's state variable in the first period of late childhood is $\tilde{x} = \tilde{h}$, the stock of human capital that was accumulated during early childhood. The function $\tilde{V}^c_{J_{lc}}(\tilde{x})$ is the continuation value of a child who beings period J_{lc} in state $\tilde{x} = \tilde{h}$. The parameter α determines the weight parents place on the utility of their child.

5.2 Late Childhood ($j = J_{lc}$)

Late childhood only lasts one period. At the start of the period children are characterized by the state variable $\tilde{h}$, the child's human capital acquired during early childhood. Children first decide once and for all whether to enroll in college. Formally, their decision problem is

$$\tilde{V}^c_{J_{lc}}(\tilde{h}) = \max\left\{V^c_{J_{lc}}(\tilde{h}, g) + \zeta \; , \; V^c_{J_{lc}}(\tilde{h}, ng)\right\} \tag{21}$$

where $s \in \{g, ng\}$ denotes whether the child chooses to go (g) or not go (ng) to college. ζ is an idiosyncratic preference shock representing the psychic costs or benefits of attending

college.

After one period, all college students exit college, but only a fraction of students graduate. Specifically, a child who goes to college graduates ($s' = g$) with probability $\gamma(h)$, and fails to graduate ($s' = ng$) with probability $1 - \gamma(h)$. The function $\gamma(h)$ is increasing in h. Children not enrolled in college inelastically supply a unit of time each period to market work. The wages that workers receive, $\omega_s h$, depends on whether they have graduated college (g) or not (ng), and on the worker's human capital h.

Children who are enrolled in college solve the following problem:

$$V^c_{J_{lc}}(h,g) = \max_{c,k'} \quad \{u(c) + \beta\left[\gamma(h)V_{J_{lc}+1}(h,k',g) + (1-\gamma(h))V^c_{J_{lc}+1}(h,k',ng)\right]\} \tag{22}$$

$$s.t. \quad c + \tau_m + k' = \omega_{ng} h(1-\tau_i) \tag{23}$$

Students take their graduation probability as given. They also take as given the tuition cost of college τ_m and their labor earnings $\omega_{ng} h(1-\tau_i)$. Labor earnings during college are the product of the non-graduate wage rate ω_{ng}, the student's human capital h, and the student's time endowment net of the time cost of college τ_i. Students only decision, therefore, is how much to consume and save.

Children who do not go to college solve the following problem:

$$V^c_{J_{lc}}(h,ng) = \max_{c,k'} \quad \{u(c) + \beta V^c_{j+1}(h,k',ng)\} \tag{24}$$

$$s.t. \quad c + k' = \omega_{ng} h \tag{25}$$

5.3 Adulthood ($j = J_{lc}+1, \ldots, J$)

Even during adulthood, we continue to refer to the younger generation as "children" to distinguish them from their parents. In adulthood, all children have completed their schooling.

The state vector of a child in adulthood is $x = (h, k, s)$. The decision problem is given by:

$$V^c_{J_j}(x) = \max_{c,k'} \quad \{u(c) + \beta V^c_{j+1}(x')\} \tag{26}$$

$$s.t. \quad c + k' = k(1+r) + \omega_s h \tag{27}$$

$$x' = (h, k', s)\ . \tag{28}$$

(27) is the child's budget constraint. Note that labor earnings depend both on the child's human capital and on their education-specific wage rate ω_s. We normalize $V^c_{J+1}(x) = 0\ \forall x$. In the final period, $j = J$, we impose an additional constraint $K_{J+1} = 0$, so all parents die with zero net assets.

5.4 Late Parenthood ($j = J_{lc}, ..., J_p$)

Parents transition to late parenthood at the same time that children transition into late childhood. At this point, all ties between parents and children are severed. Therefore, the optimization problem of late adults becomes simpler: parents do not invest ($i = m = 0$), and simply make a consumption/saving decision each period:

$$V^p_j(x) = \max_{c,K'} \quad \{u(c) + \beta V^p_{j+1}(x')\} \tag{29}$$

$$s.t. \quad c + K' = K(1+r) + \omega_S H \tag{30}$$

$$x' = (H, K', S) \tag{31}$$

where $V_{J+1}(x) = 0\ \forall x$. In the final period of the parents' life, $j = J_p$, we impose an additional constraint $K_{J+1} = 0$, so all parents die with zero net assets.

5.5 Equilibrium

Equilibrium is a collection of parent and child decisions which maximize expected utility given their state. For a formal definition of equilibrium, see Appendix A.

6 Parameterization

We now explain how we assign values to model parameters. Section 6.1 discusses parameters set independently from one another; Section 6.2 discusses parameters jointly targeted to empirical moments.

6.1 Parameters set independently

The life-cycle A model period corresponds to 4 years, and we begin the model at age 2. Childhood lasts 4 periods, corresponding to ages 2-5, 6-9, 10-13, and 14-17 respectively. Late childhood, which corresponds to ages 18-21, is set to $J_{lc} = 5$. The first period of adulthood, which corresponds to ages 22-25, is therefore $J_{lc} + 1 = 6$. We assume parents start period 1 at age 30 and live to age 70-73, so $J_p = 10$. The final period of the child's life, which corresponds to age 70-73, is $J = 17$.

Prices and preferences The non-college wage rate for both children and parents is normalized to $\omega_{ng} = \omega_{NG} = 1$. The net risk free interest rate is set to $r = 0.17$, which corresponds to an annual net interest rate of 4%. The period discount rate is set to $\beta = 1/(1+r)$. Utility over consumption is log: $u(c) = \log(c)$.

College The time cost of college is set to $\tau_i = 0.75$, which leaves college students 25 hours per week to work for wages. In 1986 mean out of pocket tuition spending per college student was \$5,086, while median earnings among households with children was \$63,950 (all dollar figurs are in 2015 dollars). This implies that four years of college tuition amounted to roughly 32% of annual median earnings in 1986. We therefore set the tuition cost of college in the model so that it equals 32% of median parent earnings in equilibrium.

The graduation probability function has the following form:

$$\gamma(\hat{h}) = \gamma_0 + \gamma_1 \hat{h}(h) \,, \tag{32}$$

$$\hat{h}(h) = \max\left\{\min\left\{\frac{h-200}{800-200}, 1\right\}, 0\right\} \,. \tag{33}$$

Table 5: Parameters and prices set independently for baseline economy

	Parameter/Price	Description	Value
Life-cycle	J_{lc}	Late childhood	5
	J_p	Final period of parents' life	10
	J	Final period of life	17
Prices	ω_{NG}	Non-college wage rate	1
	r	Risk free net interest rate	0.32
Preferences	β	Period discount factor	0.85
College	τ_I	Period time cost of college	0.75
	τ_M	Period tuition cost of college	.17
	γ_0	Graduation intercept parameter	.1
	γ_1	Graduation slope parameter	.8
Population shares	(1,L)	Share of (1,L) households	0.21
	(1,H)	Share of (1,H) households	0.03
	(2,L)	Share of (2,L) households	0.50
	(2,H)	Share of (2,H) households	0.26

Note: This table displays the parameter values for the baseline economy. Intertemporal parameters are expressed in period values (a period corresponds to 4 years). The tuition cost of college is expressed as a fraction of the equilibrium value of mean period earnings by adult children. The initial human capital stock h_0 is normalized to one. See text for details.

$\hat{h}$ is the student's human capital normalized to reflect the average SAT math/verbal score scale from 200-800. A student with human capital $h \leq 200$ graduates with probability γ_0; as h increases from 200-800 the chances of graduating increase linearly at rate γ_1; once h exceeds 800, the chances of graduating remain fixed at $\gamma_0 + \gamma_1$. We set $\gamma_0 = 0.1$ and $\gamma_1 = 0.8$ as a linear approximation to the nonlinear function estimated in Figure 4.

Population shares We impose population shares corresponding to 2005: 1L make up 21% of households, 1H make up 3% of households, 2L make up 50% of households, and 2H make up 26% of households.

Parent human capital and assets For simplicity we assume all parents have the same human capital level, H. We also assume that all parents start with zero initial assets. Future versions of the model will relax these assumptions.

6.2 Parameters set jointly

Table 6: Parameters set jointly for baseline economy

	Parameter	Description	Value
Parent preferences	α	Parent altruism	1.35
Child preferences	σ	SD of college psychic shock	0.81
College premium	ω_G/ω_{NG}	College wage premium	1.43
Child human capital	A	Parent ability (TFP)	5.44
	ρ_i	Weight, time investments	0.26
	ρ_m	Weight, market investments	0.07
	ρ_h	Weight, existing human capital	0.09

Note: This table displays the baseline economy's values for parameters set jointly. The empirical moments targeted during calibration, and the corresponding moments in the baseline economy, are produced in Table 7. See text for details.

In our baseline calibration, seven parameters remain to be set. Four are part of the human capital production function, which we assume to be Cobb-Douglas in market investments m, effective parent time investments iH, and the child's existing human capital h:

$$h_{j+1} = F(m,i,H,h) = A(iH)^{\rho_i} m^{\rho_m} h^{\rho_h} \ . \tag{34}$$

The parameters ρ_i, ρ_m, and ρ_h are the Cobb-Douglas weights on time investments, market investments, and existing human capital, respectively. A is a TFP term for parent investments, which is homogeneous across the population.

We also need to parametrize the strength of parental altruism α and the college wage premium ω_G. Finally, the seventh parameter governs the distribution of psychic preferences for college. We impose that the college preference shock is Normally distributed with mean zero and standard deviation σ: $\zeta \sim N(0,\sigma)$.

We jointly target these moments to seven empirical moments for the year 1986: mean parent time spent with children, the ratio of mean parent time spent with children to mean expenditures on market investments, the earnings ratio of college workers versus non-college workers, the aggregate college attendance rate, the aggregate college completion

rate, the gap in college attendance rates between 2H children and 1L children, and the gap in college completion rates between 2H children and 1L children.

While almost all parameters impact almost all targeted moments to some extent, several of these parameters have tight, intuitive links to specific moments. All else equal, more altruistic parents spend more time investing in their children; larger values for the college premium increase the earnings ratio between college graduates and non-college graduates; the higher is parent TFP the more students attend college; a larger ratio of ρ_i/ρ_m increases the ratio of mean parent time spent with children to mean expenditures on market investments.

The link between σ and empirical moments is less tight. However, we have generally found it to be the case that greater variance in psychic shocks reduces the gap in college attendance between 2H and 1L children. The intuition is that large idiosyncratic psychic costs can weaken the link between college attendance and college preparedness (and therefore family resources). We have also found that the link between ρ_h and empirical moments is somewhat ambiguous.

7 Results (Preliminary and Incomplete)

7.1 Properties of baseline economy

Table 7 displays the 1986 empirical momments targeted during calibration alongside the corresponding moments produced in the baseline economy. Overall the model is able to fit the targeted moments fairly well, although not perfectly.

In the model, households differ in their parent time endowments: single parents are endowed with one unit of time, dual parents are endowed with two. Mean parent time investment per child in the model is simply the mean units of time endowment spent on time investments i across all model households during early childhood. Empirically, mean parent time investment is measured as the ratio of mean childcare time per child (see Table 4.1.2) to mean non-leisure time per parent. In both the model and data mean time investments per

Table 7: Model fit: Targeted moments for 1986

Moment	Data	Model
Mean parent time investment per child	.57	.57
Ratio of time investment share to market investment share	4.00	4.00
College/non-college earnings ratio, parents	1.55	1.53
Aggregate attendance rate	.69	.71
Aggregate conditional completion rate	.71	.72
Attendance gap in pp, 2H-1L	.47	.30
Conditional completion gap in pp, 2H-1L	.29	.32

Note: This table displays empirical moments targeted during calibration, and the corresponding moments in the baseline economy. Mean parent time per child is expressed as a fraction of non-leisure time. See text for details.

child are .57, which has the interpretation that, in a given period, the average child receives 57% of the average parent's non-leisure time as a time investment.

The ratio of time investment share to market investment share is composed of a numerator and a denominator. The numerator is the previously-discussed moments, the mean parent time investment per child. The denominator is the mean spending on market investments per child expressed as a fraction of mean parental labor earnings per child. Therefore, the ratio of time investment share to market investment share compares the share of parents' "time budget" spent on child investments relative to the share of parents' "earnings budget" spent on child investments. The ratio of 4.00 implies that parents spend a larger fraction of their time budget on investing than their earnings budget.

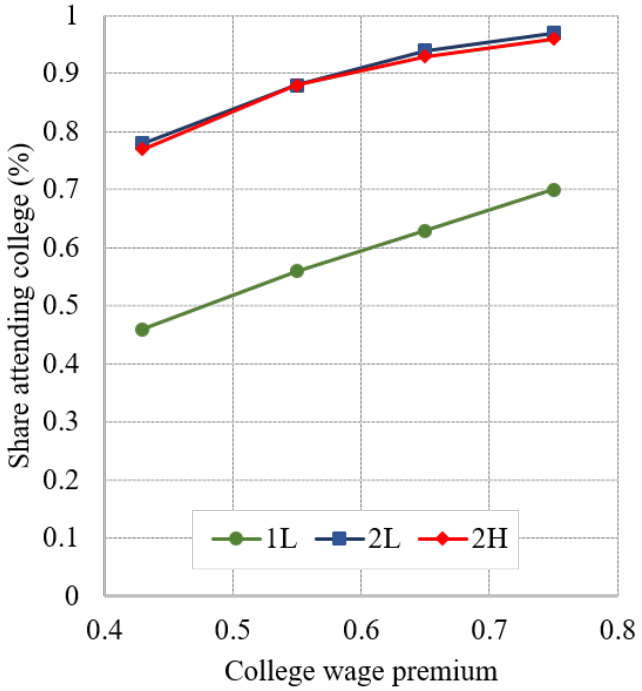
The model produces an aggregate college attendance rate, an aggregate completion rate conditional on attending college, and a gap in conditional completion rates between 2H and 1L children that are closely in line with the data. However, the model produces a gap in attendance rates between 2H and 1L children that is too small.

7.2 Impact of an increase in the college premium

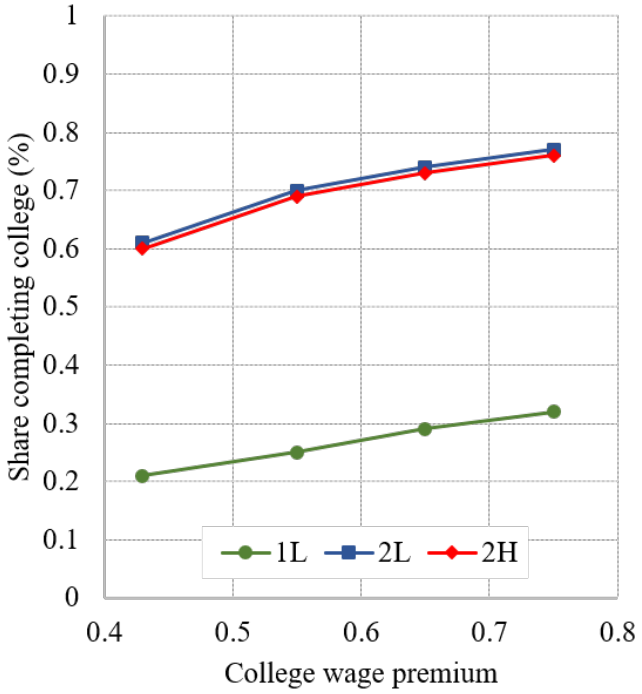
Figure 5 shows how an exogenous increase in the college wage premium ω_G impacts college attendance and completion by family type. In the baseline economy $\omega_G = 1.43$, which

Figure 5: Impact of a college premium increase in the model

(a) College attendance



(b) College completion



Note: Figure displays college attendance and completion rates by family type in the model. The base. The year corresponds to the year individuals turned 18. College attendance corresponds to strictly more than 12 years of education. College completion corresponds to at least 16 years of education. Number of parents is measured using cohabitation. Individuals assigned to the "minimum resource family type" they experienced from age 0-16. Attainment rates for 1H children are not included due to small sample size. See text for details.

implies that college graduates receive a wage premium of 43%. This value generated a ratio of earnings by college graduate parents to earnings by non-college graduate parents of 1.53 in the model, which closely approximated the college/non-college earnings ratio for prime aged workers in 1986 (see Table 7).[16] Our key counterfactual is to exogenously increase the college wage premium from 1.43 to 1.75. A college premium of 1.75 generates a college/non-college earnings ratio for model parents of 1.95, which was the empirical ratio of prime aged workers in 2005.

The increase in the college wage premium increases attendance and completion among children from all family types. However, attendance and completion do not increase proportionately across all family types. Attendance increases most, 24pp, for children from 1L households, while it increases least, 19pp, for children from 2H household. Completion increases least, 11pp, for children from 1L households, while it increases most, 16pp, for children from 2H households.

As a result the attendance gap between 2H and 1L children *decreases* by 5pp from the baseline (1986) case to the 2005 case, while the completion gap between 2H and 1L children *increases* by 5pp. Qualitatively, these patterns are in line with our empirical findings in Section 2. Quantitatively, the model is able to account for almost the entire 6pp decrease in the 2H-1L attendance gap observed in the data, and about half of the 9pp increase in the observed 2H-1L completion gap.

8 Conclusion

We provide new facts about the increase in US college attainment for children born 18 between 1986-2005. We classify a household with children as "low resource" if it has only one parent present and that parent lacks a 4-year college degree; we classify a household as "high resource" if it has two parents and at least one parent holds a 4-year college degree. We find that college *attendance* grew more among children from low resource families than

[16]The college/non-college earnings ratio for parents in the model differs from the college wage premium because college-educated parents also tend to spend more time working than non-college parents.

among those from high resource families (7pp vs 1pp). However, college *completion* grew less among low resource children than high resource children (4pp vs 13pp).

We propose a theory to explain these trends with two key components: (i) High resource families increased pre-college investment relative to low-resource families in response to a growing college wage premium. (ii) Pre-college investment is an important determinant of college completion conditional on attendance. Consistent with this theory, we provide empirical evidence of growing gaps in pre-college investment and college preparedness between high and low resource families. Finally, we construct a model of intergenerational human capital investment and college attainment with heterogeneous households to ask whether such a model is able to quantitatively account for these trends.

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APPENDIX

A DEFINITION OF EQUILIBRIUM FOR QUANTITATIVE MODEL

Definition 1. *State variables for parents are a 5-tuple during early parenthood, $x = (H, K, S, P, h)$; and a triple during late parenthood, $x = (H, K, S)$. State variables for children are a 5-tuple during early childhood, $x = (H, K, S, P, h)$; are a single at the start of late childhood, $x = h$; and are a triple during adulthood, $x = (h, k, s)$. An equilibrium for the model economy is a collection of parental decisions $\{c_j(x), K'_j(x), m_j(x), i_j(x)\}$ during early parenthood; parental consumption and savings decisions $\{c_j(x), K'_j(x)\}$ during late parenthood; child college attendance decisions $s(x)$ at the start of late childhood; child consumption and savings decisions $\{c_j(x), k'_j(x)\}$ during late childhood; and child consumption and savings decisions $\{c_j(x), k'_j(x)\}$ during adulthood such that:*

1. *In early parenthood parents solve the decision problems defined in Section 5.1.*
2. *In late parenthood parents solve the decision problem defined in Section 5.4.*
3. *In late childhood children solve the decision problems defined in Section 5.2.*
4. *In adulthood children solve the decision problems defined in Section 5.3.*

B PROOFS FOR SIMPLE MODEL

Lemma 1. *In the Exogenous human capital version, fix ω, and individuals $j'' \neq j'$.*

a) If $H'' \geq H'$, then $s' = g \implies s'' = g$.

b) If $s'' = g$ and $s' = ng$, then $H'' > H'$.

Proof. For part (a): Consider the function

$$F(s,H) = H + \mathbb{1}_{(s=g)}[\omega\gamma(H)H - \tau] \ .$$

F satisfies the Strict Single Crossing Property (SSCP), and so by the Monotone Comparative Statics Theorem (MCST) $s' = g$ implies $s'' = g$.
For part (b): If $s'' = g$ and $s' = ng$, then by revealed preference

$$\omega\gamma(H'')H'' - \tau \geq 0 > \omega\gamma(H')H' - \tau \ .$$

Therefore, $H'' > H'$. □

Lemma 2. *In the Endogenous human capital version, fix ω, and individuals $j'' > j'$ with $h'' > h'$.*

a) $H'' > H'$.

b) $s' = g \implies s'' = g$.

Proof. For part (a): Lemma 1 implies $\exists$ a cutoff $\underline{H}$ above which individuals enroll and below which they do not. Consider the function

$$F(H,h) = H - c(H-h) + \mathbb{1}_{\{H \geq \underline{H}\}}[\omega\gamma(H)H - \tau] \ .$$

F satisfies the SSCP, and so by the MCST $H'' \geq H'$. Suppose towards contradiction that $H'' = H'$. This would imply that the marginal benefit of increasing H in each case would

be equal, but that the marginal cost of increasing H would not:

$$\begin{aligned} MB(H'') = MB(H') &= 1 + \mathbf{I}_{(H' \geq \underline{H})} \omega [\gamma'(H')H' + \gamma(H')] \\ &= MC(H') = c(H' - h') > c(H'' - h'') = MC(H'') \ , \end{aligned}$$

which implies H'' not optimal $(\rightarrow\leftarrow)$. Therefore, $H'' > H'$.

For part (b): The result is immediate from Lemma 1 and Lemma 2(a). □

Lemma 3. *In the Endogenous human capital version, fix $\omega_2 \neq \omega_1$, and individual j.*

a) If $H_2 \geq H_1$, then $s_1 = g \implies s_2 = g$.

b) If $s_2 = g$ and $s_1 = ng$, then $H_2 > H_1$.

Proof. For part (a): Given $H_2 \geq H_1$ and $s_1 = g$. Suppose towards contradiction $s_2 = ng$. Then

$$\begin{aligned} MB(H_2) = 1 < 1 + \mathbb{1}_{\{H_1 \geq \underline{H}\}} \omega_1 [\gamma'(H_1)H_1 + \gamma(H_1)] &= MB(H_1) \\ &= MC(H_1) = c(H_1 - h) \leq c(H_2 - h) \\ &= MC(H_2) \ , \end{aligned}$$

which implies H_2 is not optimal, $(\rightarrow\leftarrow)$. Therefore, $H_2 \geq H_1$.

For part (b):

$$\begin{aligned} MB(H_2) = 1 + \mathbb{1}_{\{H_1 \geq \underline{H}\}} \omega_2 [\gamma'(H_1)H_1 + \gamma(H_1)] > 1 &= MB(H_1) \\ &= MC(H_1) = c(H_1 - h) \ . \end{aligned}$$

Therefore, since c is strictly increasing in H holding h fixed, $H_2 > H_1$. □

Lemma 4. *In the Endogenous human capital version, fix $\omega_2 > \omega_1$.*

a) Fix an individual j. $H_2 \geq H_1$, and strictly so if $s_2 = g$.

b) $\underline{H}_2 < \underline{H}_1$

Proof. Case (a): There are four cases to consider. First, $s_2 = ng,\ s_1 = g$; this case is not possible by Lemma 3(a). Second, $s_2 = g,\ s_1 = ng$; this case is immediate by Lemma 3(b). Third, $s_2 = ng,\ s_1 = ng$; this case is trivial since ω does not enter into the objective. Fourth, $s_2 = g,\ s_1 = g$; consider the function

$$F(H,\omega) = H + -c(H-h) + \omega\gamma(H)H - \tau\ .$$

F satisfies the SSCP, and so by the MCST $H_2 \geq H_1$. By an analogous argument to that of Lemma 2(a), $H_2 > H_1$.

Case (b): By construction of $\underline{H}_1$, $\tau = \omega_1\gamma(\underline{H}_1)\underline{H}_1 < \omega_2\gamma(\underline{H}_1)\underline{H}_1$. So $\underline{H}_2 < \underline{H}_1$.

□

Result 1. *(Exogenous human capital version). Consider an increase in the college premium from ω_1 to ω_2. Denote equilibrium elements corresponding to ω_j with a subscript j. Then $\underline{H}_2 < \underline{H}_1$. Further, both attendance and completion rates increase, but attendance increases more: $0 < \overline{G}_2 - \overline{G}_1 < \overline{g}_2 - \overline{g}_1$.*

Proof. The fact that $\underline{H}_2 < \underline{H}_1$ follows immediately from Lemma 4(b). Attendance increases more than completion because each new college attendee only completes college with a probability strictly less than one:

$$0 < \overline{G}_2 - \overline{G}_1 = \int_{\underline{H}_2}^{\underline{H}_1} \gamma(H)z(dH) < \int_{\underline{H}_2}^{\underline{H}_1} z(dH) = \overline{g}_2 - \overline{g}_1.$$

□

Result 2. *(Endogenous human capital version). Consider an increase in the college premium from ω_1 to ω_2 in the endogenous version of the model. Denote equilibrium elements corresponding to ω_j with a subscript j. Then the resulting final human capital distribution z_2 first order stochastically dominates z_1. Further, $\underline{H}_2 < \underline{H}_1$. Finally, both attendance and completion rates increase, but completion may increase more than attendance.*

Proof. The fact that $\underline{H}_2 < \underline{H}_1$ follows immediately from Lemma 4(b). The fact that the distribution z_2 FOSD dominates z_1 follows immediately from Lemma 4(a). Finally, note that it is now possible for completion to increase more than attendance in response to an increase in the college premium. For example, consider the case where $\overline{g}_1$ is arbitrarily close to 1 and $\overline{G}_1$ is much lower than 1. □

C DETAILS FOR NLSY79 AND NLSY97

This section provides details on our empirical work with the NLSY79 and NLSY97 presented in Section 4.2.

C.1 Sample construction

In both the NLSY79 and NLSY97, our sample consists of individuals who met two criteria. The first was that individuals remained in the survey until at least age 27 or 28, so that we could measure educational attainment by age 28. Consistent with our PSID methodology, we say that an individual attended college if they report completing at least 13 years of school by age 28. We say that an individual completed college if they report completing at least 16 years of school by age 28.

The second sample criteria is that we are able to assign the individual to a single family type. While the PSID allowed us to observe the family structure during each year of an individual's childhood, the NLSY does not begin interviewing children until age 11 or later. Instead, family structure information is primarily communicated through retrospective questions. We do our best to replicate our PSID methodology using information available in the NLSY. Specifically, in the NLSY79, we say that an individual had two parents if they report that they resided with two biological parents until at least 16 years of age. The NLSY97 does not contain this exact question, but it does ask about family structure at three ages of childhood: 2, 6, and 12. For this sample we say that an individual had two parents if they report residing with two parents in all three of these questions.

Table 1 displays the share of individuals assigned to each family type in the NLSY79 and NLSY97. Individuals in these surveys turned 18 between 1976-1983 and 1998-2002. For comparison, Table 1 also lists the analagous information for the PSID cohorts who turn 18 in 1986 and 2000. Note that our first PSID cohort turns 18 in 1986, so the NLSY79 cohort turned 18 earlier than the PSID 1986 cohort. The NLSY and PSID shares are fairly consistent with each other.

Note that the shares of individuals assigned to a given family type are different from family type shares in the cross section (see Figure 2). The reason is that individuals are assigned to the "lowest resource" type they experience during their childhood. Therefore, share of children assigned to 1L will be larger than the cross sectional 1L share for any given year, and the share of children assigned to 2H will be smaller than the cross sectional 2H share for any given year.

Table 1 displays the share of individuals who attended and completed college by age 28, by family type, in the NLSY79 and NLSY97. Again, for comparison, Table 1 also lists the analagous information for the PSID cohorts who turn 18 in 1986 and 2000. Again, the NLSY and PSID attainment rates are fairly consistent with each other. One significant difference is that attendance rates are lower in the NLSY79 sample than the PSID 1986 sample. For example, aggregate attendance is 45% in the NLSY, but 53% in the PSID. This is unsurprising: the NLSY79 cohort on average turned 18 in 1979, and aggregate attendance increased by several percentage points between this cohort and the cohort that turned 18 in 1986.

Table 1: Share of children assigned to each family type in the PSID and NLSY

Family type	1979 NLSY	1986 PSID	1997 NLSY	2000 PSID	Δ NLSY	Δ PSID
1L	0.262	0.237	0.358	0.330	0.096	0.092
1H	0.020	0.025	0.088	0.047	0.068	0.022
2L	0.545	0.596	0.337	0.410	−0.208	−0.187
2H	0.173	0.141	0.217	0.213	0.044	0.072

Table 2: Attendance and completion rates by family type in the PSID and NLSY

ATTENDANCE RATE						
Family type	1979 NLSY	1986 PSID	1997 NLSY	2000 PSID	Δ NLSY	Δ PSID
Agg	0.451	0.526	0.616	0.657	0.164	0.132
1L	0.321	0.394	0.433	0.541	0.112	0.147
2L	0.383	0.500	0.601	0.620	0.218	0.120
2H	0.831	0.857	0.895	0.889	0.064	0.032
COMPLETION RATE						
Family type	1979 NLSY	1986 PSID	1997 NLSY	2000 PSID	Δ NLSY	Δ PSID
Agg	0.226	0.226	0.334	0.319	0.108	0.094
1L	0.107	0.100	0.147	0.126	0.041	0.026
2L	0.163	0.194	0.290	0.265	0.127	0.071
2H	0.579	0.553	0.682	0.709	0.103	0.156