College Choice, Credit Constraints and Educational Attainment

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Introduction

US Higher Education

- Rising tuition and need-based grants, Stagnant limits on subsidized borrowing.
- Private schools up to 3 times as expensive (also ability-to-pay pricing)
- Strengthening correlation between family income & degree attainment.

Tuition, Fees, Room and Board

Year	Harvard†	Public 4 Yr.‡
2010	48,868	15,919
2005	39,880	12,108
2000	32,164	8,653
1995	26,230	7,014

†: https://oir.harvard.edu/fact-book/undergraduate_package
‡: https://nces.ed.gov/fastfacts

This Paper

- Develops a lifecycle model of college quality choice, student borrowing, work and loan repayment
- Estimates the model using the NLYS97, augmented with parallel CPS data
- Distentangles selection, quality, 'tastes', and in determining choices and labor market returns
- Evaluates response to policy changes (TBD).

Details

- Endogenize choice among 4 college quality types
- Model 'youth' attendance, work, credit accumulation, student borrowing, parental transfers and govt grants
- Endogenous transition to 'adulthood': loan repayment & default, saving, job search, work

Related Literature

Models of Schooling & Credit Constraints:

Surveyed by Lochner & Naranjo (2011); Keane & Wolpin (2001), Johnson (2013)

College Quality:

Fu (2014)

Equilibrium with credit constraints:

Abbott (2019), Caucutt & Lochner (2020)

Shameless Plug

Calculations conducted in

`ferrall.github.io/niqlow`

design, solve and estimate dynamic programs

For Context See:

Object Oriented (Dynamic) Programming: Closing the "Structural" Estimation Coding Gap

`ferrall.github.io/OODP`

Model

Non-stationary Infinite Horizon Problem

α: action vector

θ: state vector

γ: group vector

$$V(\alpha;\theta,\gamma) = \int_{\zeta} \left[\max_{\alpha \in A(\theta)} U(\alpha;\epsilon,\theta,\gamma) + \zeta_{\alpha} + \delta_k E_{\alpha,\theta,\gamma} V(\theta';\gamma) \right] f(\zeta) d\zeta.$$

FLOW

Heterogeneity

$$\gamma = \begin{pmatrix} \underline{Symbol} & \underline{Choice} & \underline{Number} \\ k & \text{Ability} & 3 \\ AFQT & \text{Test Score} & 2 \\ PI & \text{Parent Income} & 2 \end{pmatrix}$$

Distn of k depends on `AFQT` and `PI`.

`AFQT` and `PI`: indicators for above 75% percentile of the distribution.

Action Vector

$$\alpha = \begin{pmatrix} q & \text{College Quality} & 5 \\ a & \text{Attend} & 2 \\ b & \text{Borrow} & 3 \\ w & \text{Work} & 3 \\ m & \text{Miss Payment} & 2 \\ s & \text{Save} & 3 \end{pmatrix}$$

Feasible set $A(\theta)$ depends on lifecyle phase and other state variables

State Vector

$$\theta = \begin{pmatrix} t & \text{Time/Age} & 25 \\ Q & \text{Quality Feasible Set} & 3 \\ \breve{q} & \text{Alma Mater} & 5 \\ H & \text{Yrs since enrolled } (a = 1) & 3 \\ L & \text{Total Loans} & 3 \\ C & \text{Credits} & 5 \\ D & \text{Degree Earned} & 2 \\ K & \text{Skill} & 10 \\ \breve{m} & \text{Missed Payment} & 2 \\ \breve{s} & \text{Savings} & 3 \end{pmatrix}$$

$\breve{}$: *value determined by a past choice with corresponding letter.*

Lifecyle Phases

Choices and preferences change over time

- $p(H) \in$ {Y,A,M} = (Young, Adult, Mature).
- Y $\rightarrow$ A

  when $H = 2$ (consec. years not attending)

  OR at $t = 13$
- Y: attend, borrow for school, receive transfers
- A: save build skill (K) through LBD
- At $t = 24$ A $\rightarrow$ M: stationary work & saving phase.

  $\breve{m}$, $\breve{q}$, D and K are remembered but fixed.

FLOW

Quality Choice Q

- q is a once-and-for-all choice at Age 18 ($t = 0$)
- Choose q from $Q(k)$

$$
\begin{aligned}
Q_0(k) &= \{\text{None}, \text{Public}\} \\
Q_1(k) &= Q_0(k) \cup \{\text{ElitePublic}, \text{Private}\} \\
Q_2(k) &= Q_1(k) \cup \{\text{ElitePrivate}\}
\end{aligned}
$$

Choice of q by γ

QC Tables : qByDemo

		College Quality (q)				
AFQT	PInc	None	Public	Private	E.Public	E. Pr
0	0	0.29	0.57	0.11	0.03	0.0
1	0	0.07	0.63	0.11	0.16	0.0

Credits, Degrees and Skills

- Credits (years) accumulate based on ability, school quality and work
- Degree Earned after 4 earned years: $D = I\{C = 4\}$
- Initial Adult skill, K, depends on credits.
- K accumulates through LBD on adult jobs

Loan Repayment

- Subsidized borrowing up to $\bar{L}$ at repayment factor h_0
- Market borrowing $L - \bar{L}$ at factor $h_1 \ > \ h_0$
- *Scheduled* payments over T_l years:
  $M(\breve{m}) = (1 + .1\breve{m}) \left[h_0 \min \left\{ L \, , \, \bar{L} \right\} + h_1 \max \left\{ L - \bar{L} \, , \, 0 \right\} \right]$
- Payment is missed if it exceeds 90% of GI.
- From then payment includes penalty and garnished wages:
  $$\begin{aligned} \text{Payment} = (1 - \breve{m}) & \min \left\{ M(0) \, , \, 0.9 \times \text{GI} \right\} \\ & + \breve{m} \min \left\{ M(1) \, , \, 0.5 \times Earn \right\} \end{aligned}$$

CONSUMPTION

$$\text{Earn} = wW$$

$$w \in \{\text{NW},\text{PT},\text{FT}\} \equiv \{0,0.5,1\}$$

When Young:

$$\text{Consumption} = \text{Earn} + a\left[\text{Grant} - \text{Tuition} + B\right] + \text{Trans.}$$

When Adult:

$$\text{GI} = \text{Earn} + (1 + r_{1+\breve{m}})\breve{s}$$

$$\text{Consumption} = \text{GI} - \text{Payment} - s.$$

Utility

- While Young U is linear:

$$U_Y = u_0 \quad + u_1 \text{Consumption} \\ + \gamma_{\breve{q}} a \; + \gamma_w - a I_{w=FT} \gamma_x$$

- When Adult U is concave:

$$U_A = \frac{max\{ \text{Consumption} , 0 \}^\rho}{\rho} + \gamma_w .$$

SEAM

Size of the Model

```
      SPACE                    POINTS         NOTES
       EV()Iterating            230400        max. contemporary transitions
    ChoiceProb.track           2995200        potential points for single type (group)
      TotalReachable            237058        actual size of state space after pruning

Total Groups(Gamma)                12

 FEASIBLE ACTION SETS

  i    [sawsbm]   A[0]     A[1]     A[2]     A[3]     A[4]     A[5]     A[6]     A[7]     A[8]
  ------------------------------------------------------------------------------------------
     #States        0    34880   199680      659      456     1380        1        1        1
  ------------------------------------------------------------------------------------------
```

SPECIFICATION

Summary

Vector	Definition	Specification
$\mathcal{V}$	Select Choice Set Q_j	Ordered Probit
Γ	Non-pecuniary utility	Coefficients on choices
Θ	Uni. Credit Accumulation	Logit for adding a credit
Φ	Initial Skill & Accumulation	Beta, Logit
Ω	FTE Wages	Log-linear, discrete offers
$\mathcal{T}$	Grants and transfers	Exponential eqns
$\mathcal{M}$	Mean ability	Linear eqn
Δ	Discount Factor & ability	Logit in (0.9,0.99)

Choice Set ($\mathcal{V}$)

$$\nu = (-\infty, \nu_1, \nu_2, +\infty)$$
$$Prob(Q_j|k) = \Phi(\nu_{j+1} - k) - \Phi(\nu_j - k)$$

Credits (Θ)

$$Prob\left(C' = C + 1\right) = aLogit\left(\theta_0 + \theta_{\breve{q}} k + \theta_p w\right).$$

Skills (Φ)

Initial K

$$P_i = Beta(i/5, \phi_{\underset{q}{\sim}}^{y} C, 1), \text{ for } i = 0, 1, \ldots, 5.$$

$$Prob(K' = i) = P_{i+1} - P_i \text{ for } i = 0, 1, \ldots, 4.$$

LBD

$$Prob\left(K' = K + 1\right) = I_{w>0} Logit\left(\phi_0^o + \phi_a^o a + \phi_w^o w\right).$$

Distn

Wages (Ω)

Offers

$$\epsilon \overset{\text{iid}}{\sim} dN(0,1), \quad 5 \text{ values}$$

FTE Wages

$$W = \exp\Big(\omega_p + \omega_k k + \omega_{\breve{q}} D + I_{p=A} \left[\omega_K K + \omega_{K2} K^2 \right] + \sigma_p \epsilon \Big)$$

Grants and Parental Transfers ($\mathcal{T}$)

$$\text{Grant} = a \exp\left(\tau_0^G + \tau_i^G PI\right)$$
$$\text{Trans} = \exp\left(\tau_0^T + \tau_k^T k - \tau_t t + \tau_a^T a + \tau_i^T PI\right)$$

Ability ($\mathcal{M}$) and Patience (Δ)

Conditional Mean Ability

$$\mu = \mu_A AFQT + \mu_P PI.$$

Discount Factor

$$\delta = 0.9 + 0.09 Logit(\delta_0 + \delta_k k)$$

Data & Estimation

GMM

- Only way to use Geocode data outside the U.S.
- Calculated, not SMM
- Current weights: importance weights multiplied by in-sample inverse standard deviation

NLSY Moments

By γ and age (t)

- Male high school graduates through 2011 (maximum $t = 13$)
- $q = 0$ category associated with those who never attend (ex-post labeling of a hidden ex-ante decision).
- Choosing $q > 0$ incurs a 'cost' γ_0: estimate will match fraction that never attend.
- Enrollment, credits, loans, work, degree, earnings, interacted with $\breve{q}$

Aggregate Moments

Averaged Over γ using sample weights

- Three observations of assets and age ($\breve{s}$) from Johnson (2013)
- Aggregate lifetime loan default ($\breve{m}$) rate of 10%
- Work time, degree status and earnings from parallel CPS sample ($t = 14, \ldots, 22$)

QC Tables : Moments

Interactions					School				Other		Work					
t	q	q	qXAtt		Borr.	Cred	Grant	Trns	Sav.	InDef	PT	FT	Earn	Earn2	Deg	ExDeg
0	0			X												
	1			X												
	2			X												
	3			X												
	4			X												
1,3,8									**A**							
13										**A**						
1-13		0						X			X	X	X	X	X	X
		1			X			X			X	X	X	X	X	X
		2			X			X			X	X	X	X	X	X
		3			X			X			X	X	X	X	X	X
		4			X			X			X	X	X	X	X	X
			1	X		X	X				X	X				
			2	X		X	X				X	X				
			3	X		X	X				X	X				
			4	X		X	X				X	X				
14-22											A	A	A	A	A	A

X: interacted moment is matched and is crossed with fixed Test Score and Parent Income combinations.
A: aggregate moment across fixed groups is matched to periods shown
Total Moments Matched = 4(5 + 64*11) + 4 + 9*6 = 4(708) +76= 2908

Moments

Current Estimates

QC Tables : Parameters

Vector	Description	Category	Variable	Estimate	
V	Admissions	Cutoffs	Elite Public	1.6576	
			Elite Private	2.6537	
Γ	Non-pecuniary	Application	Intercept	1.4333	
	Utility	Attend	Public	0.0164	
			Private	0.0216	
			Elite Public	-0.0195	
			Elite Private	0.0152	
		Work	None	0.0000	*
			Partime	-0.1639	
			Fulltime	2.3221	
			Attend X FullTime	2.0070	
Θ	Credits		None	0.0000	*
			Partime	0.1584	
			Fulltime	-0.0896	
			Ability	0.7077	
Φ	Skill Accum.	Young	Intercept	1.9305	
		Adult	Intercept	6.5001	
			Ability	0.4904	
			Work (fraction)	0.0171	
Ω	Wages	Intercepts		-0.0294	
				1.3195	
		Ability		0.0062	
		Degree	Public	0.5747	
			Private	0.6662	
			Elite Public	0.7832	
			Elite Private	0.7148	
		Skill	Linear	1.0727	
			Quadratic	0.0018	

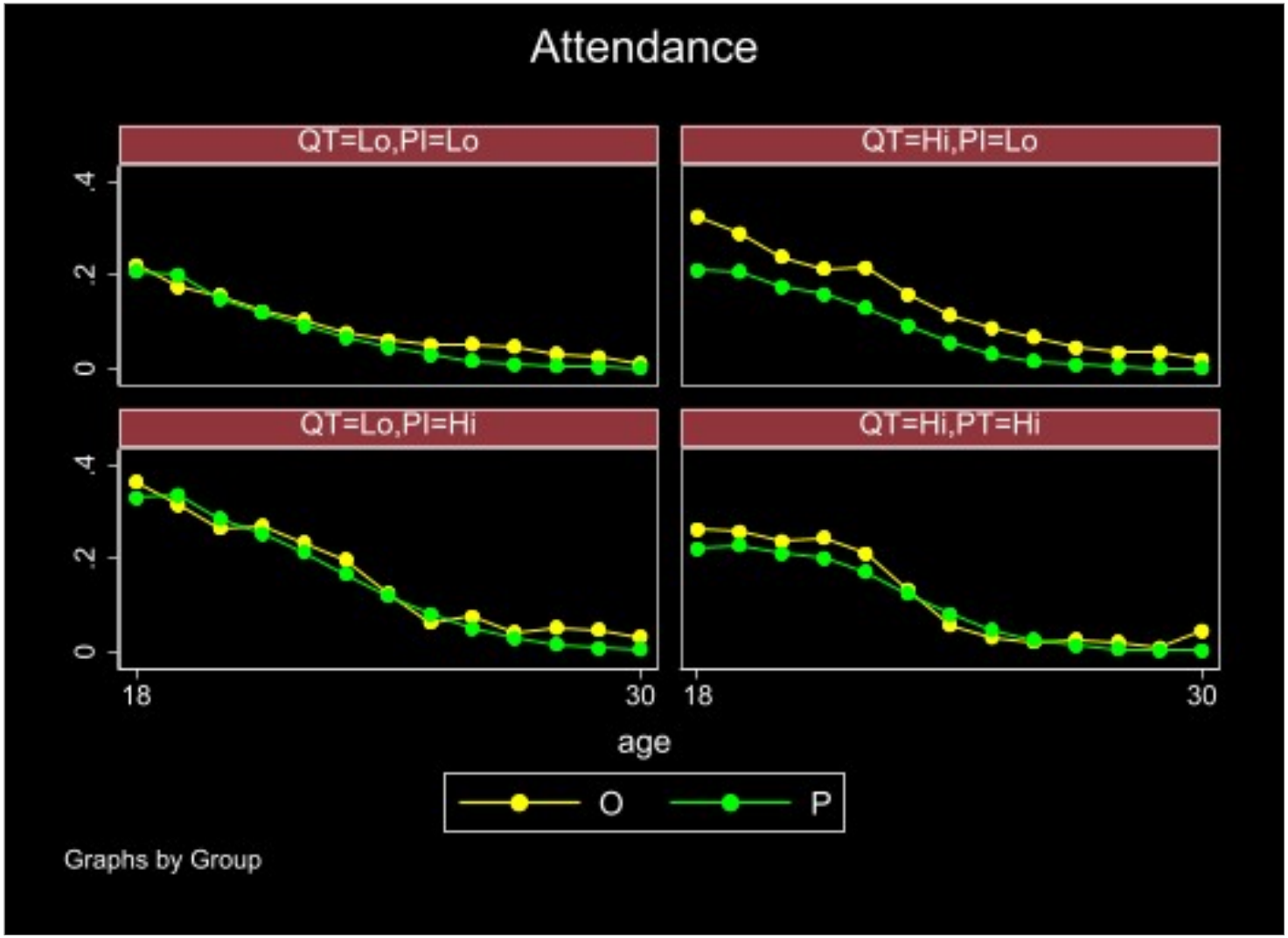
Parameters

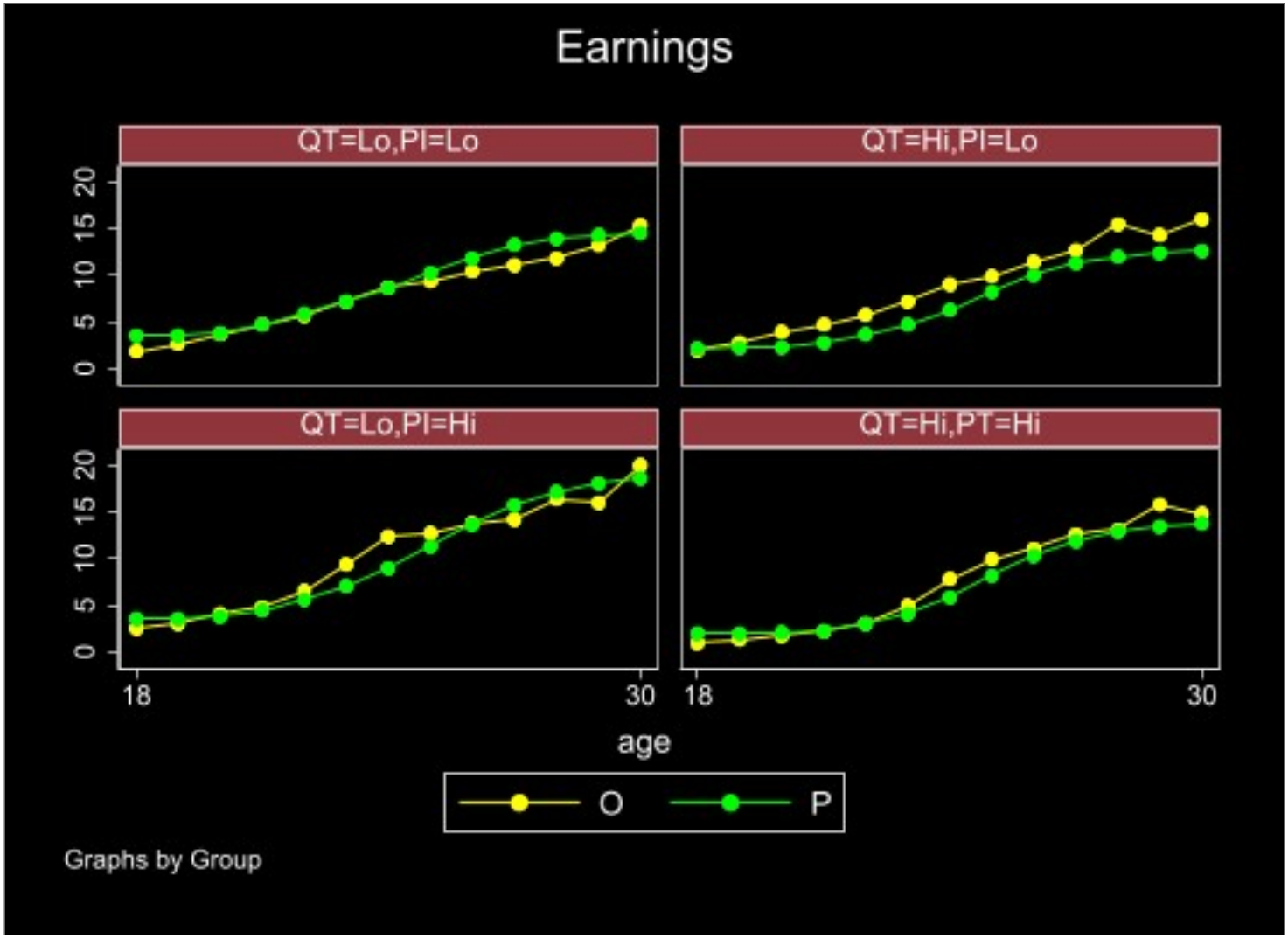
Fit & Experiments

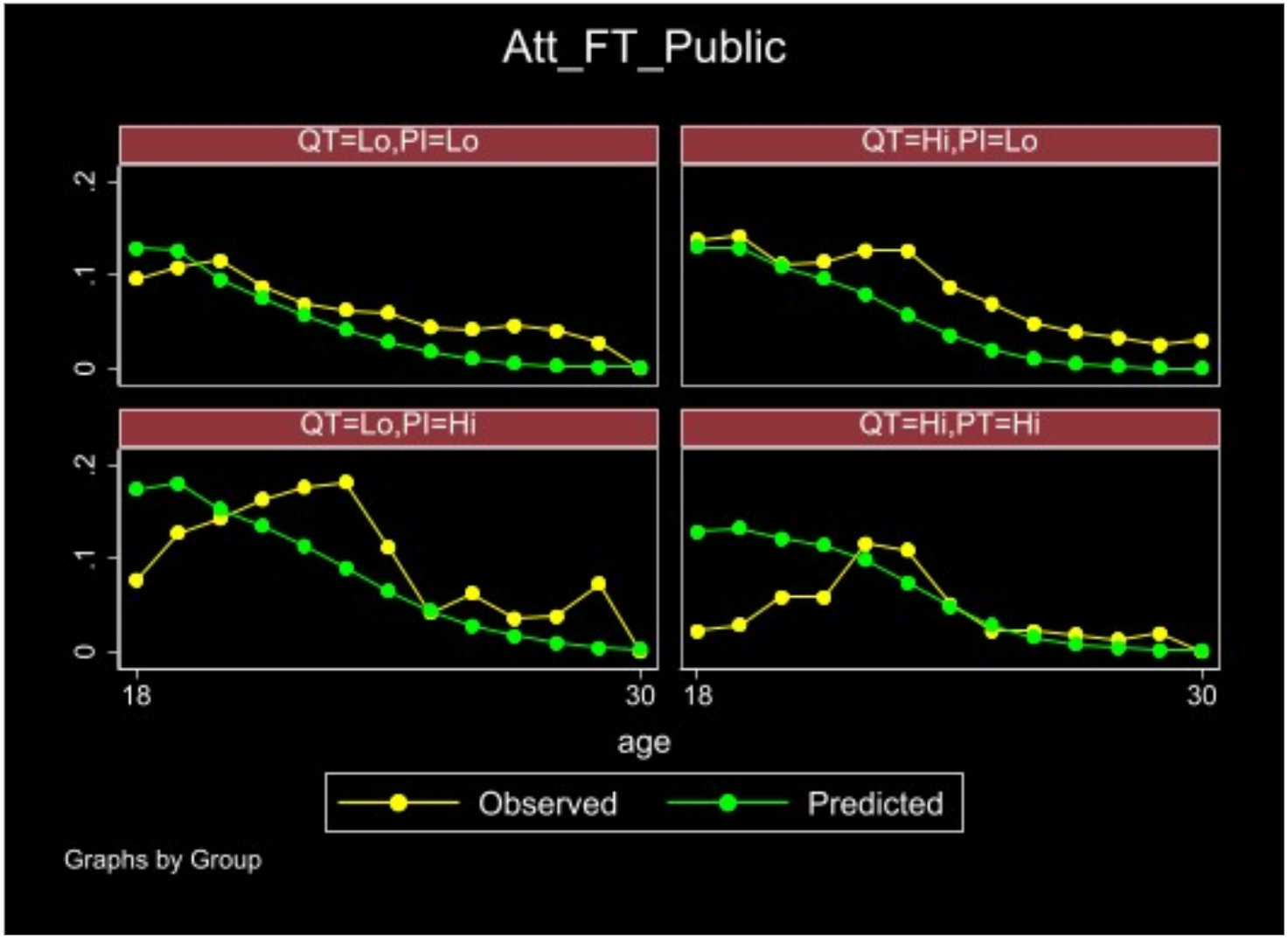
QC Tables : S_0x

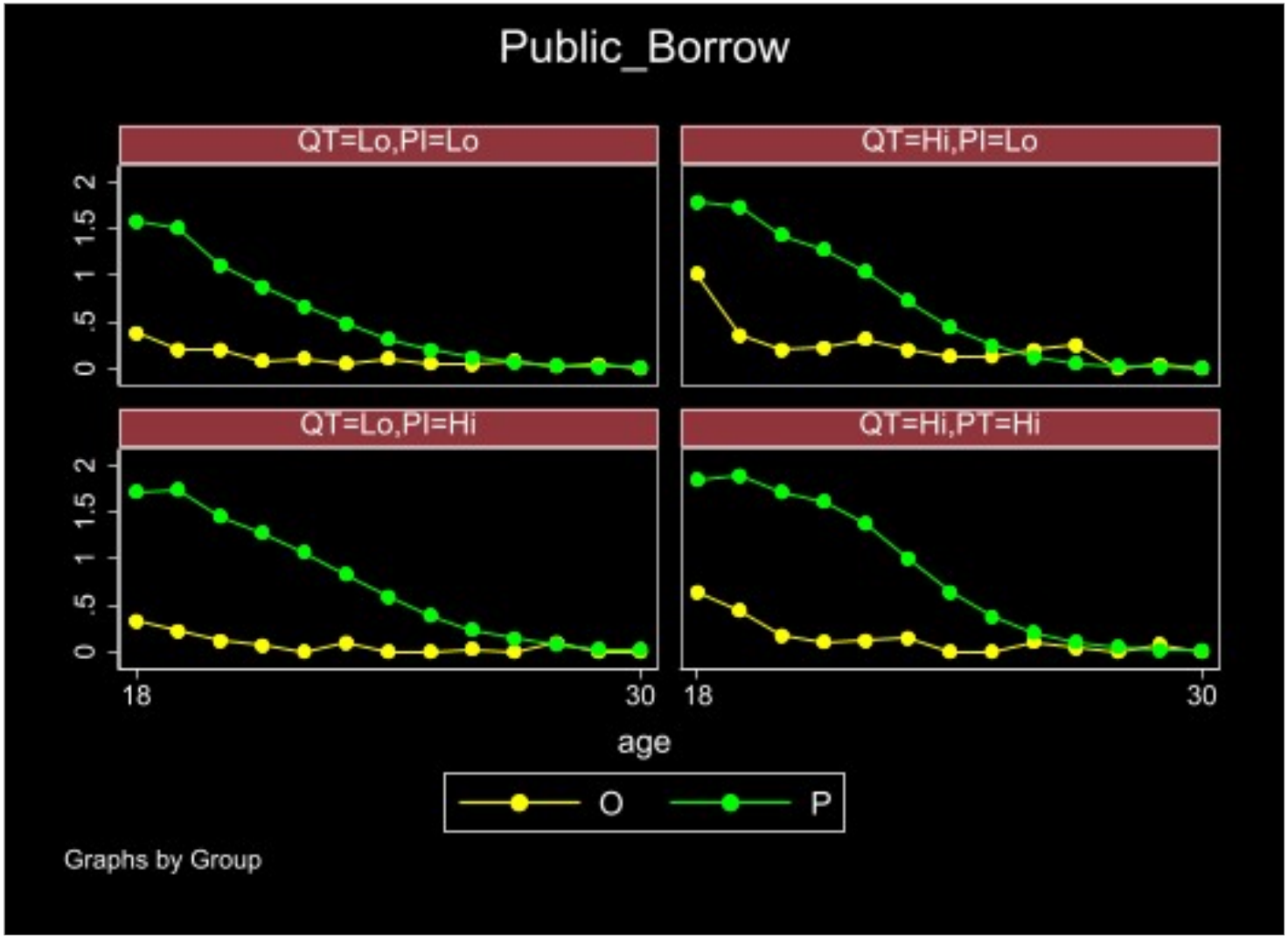
				Ordinary		
AFQT	Par. Inc	Type	None	Public	Private	Pub
0	0	Predicted	0.358	0.607	0.016	0.0
		Observed	0.290	0.568	0.108	0.0
		%Δ	*28%*	*7%*	*-80%*	*-20*
1	0	Predicted	0.138	0.452	0.213	0.1
		Observed	0.066	0.625	0.112	0.1
		%Δ	*36%*	*-37%*	*77%*	*7%*
0	1	Predicted	0.263	0.481	0.049	0.0
		Observed	0.154	0.646	0.139	0.0
		%Δ	*71%*	*-36%*	*-67%*	*-33*
1	1	Predicted	0.045	0.447	0.217	0.1
		Observed	0.043	0.446	0.174	0.2

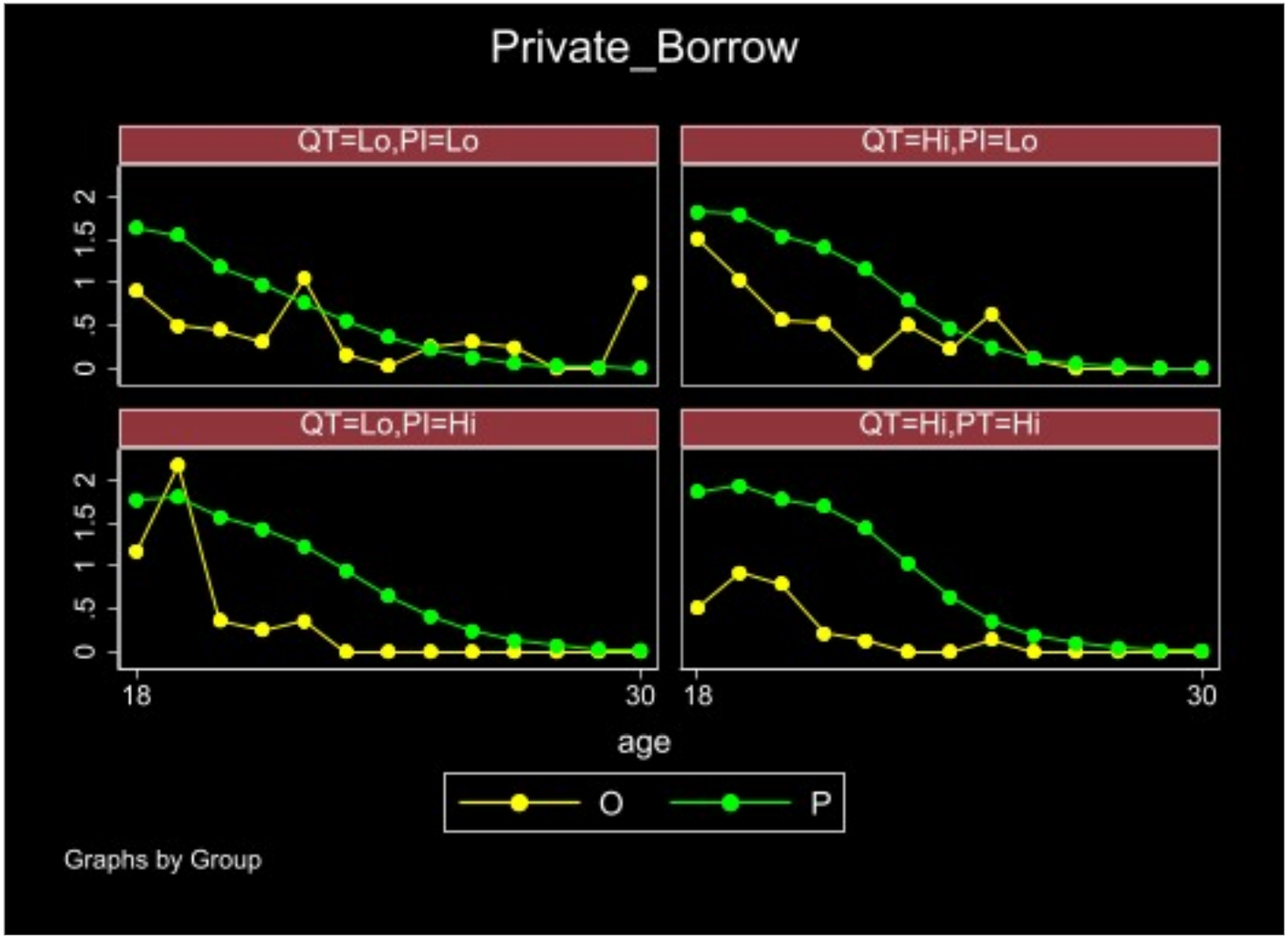
S_0x

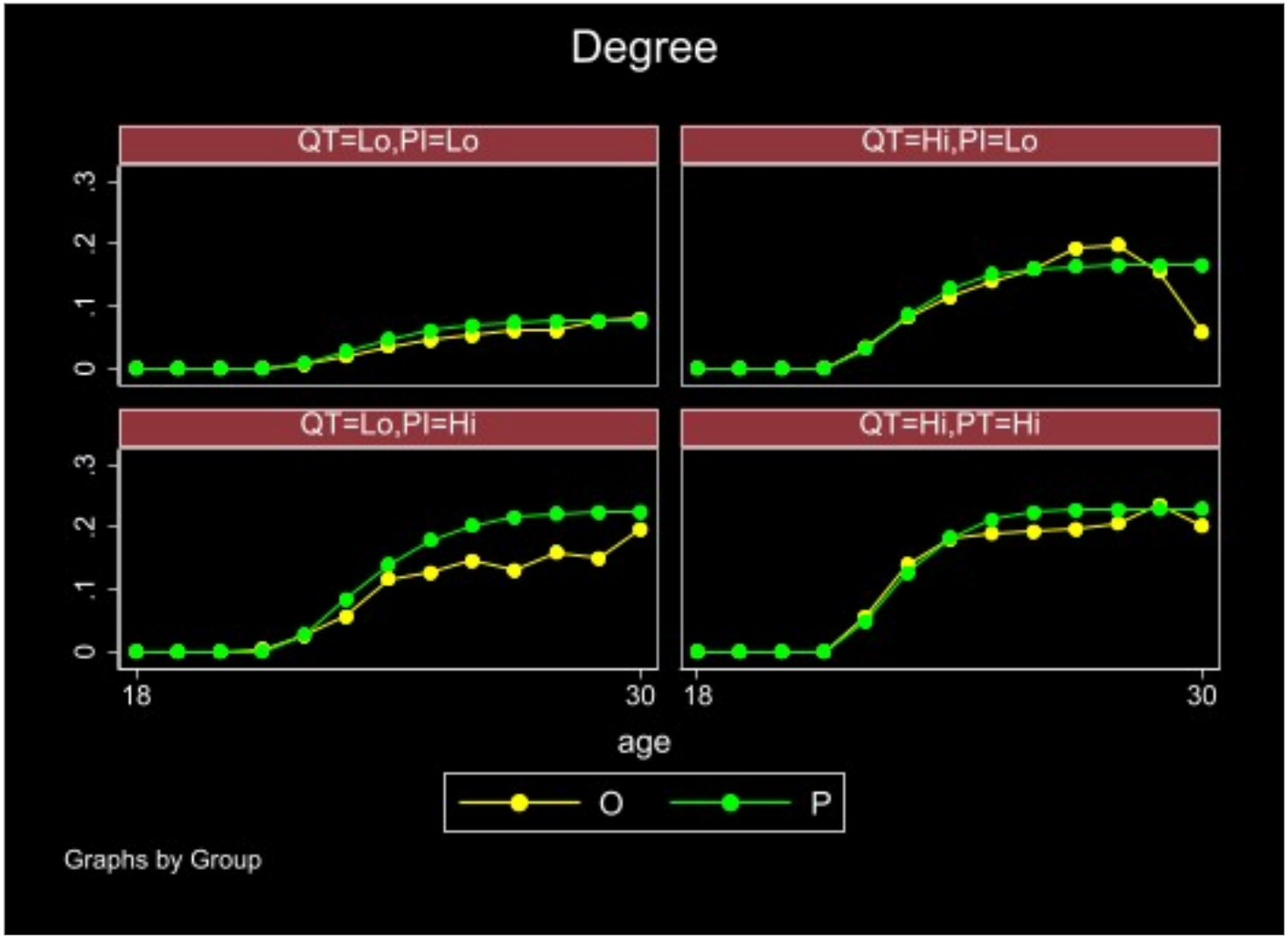

Attendance
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0
.2
.4
18
30
age
O
P
Graphs by Group

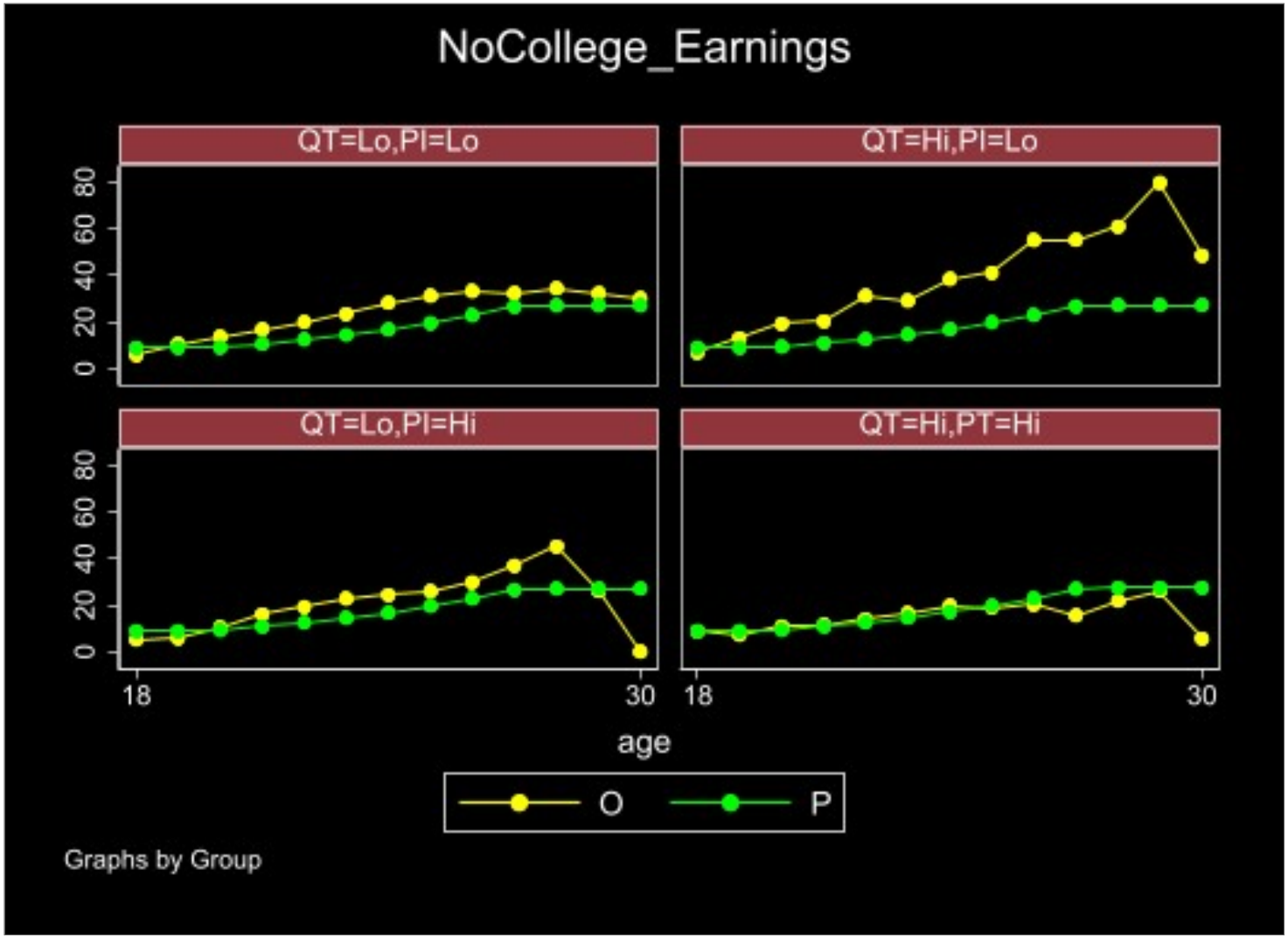

Earnings
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0 5 10 15 20
18
30
age
O
P
Graphs by Group

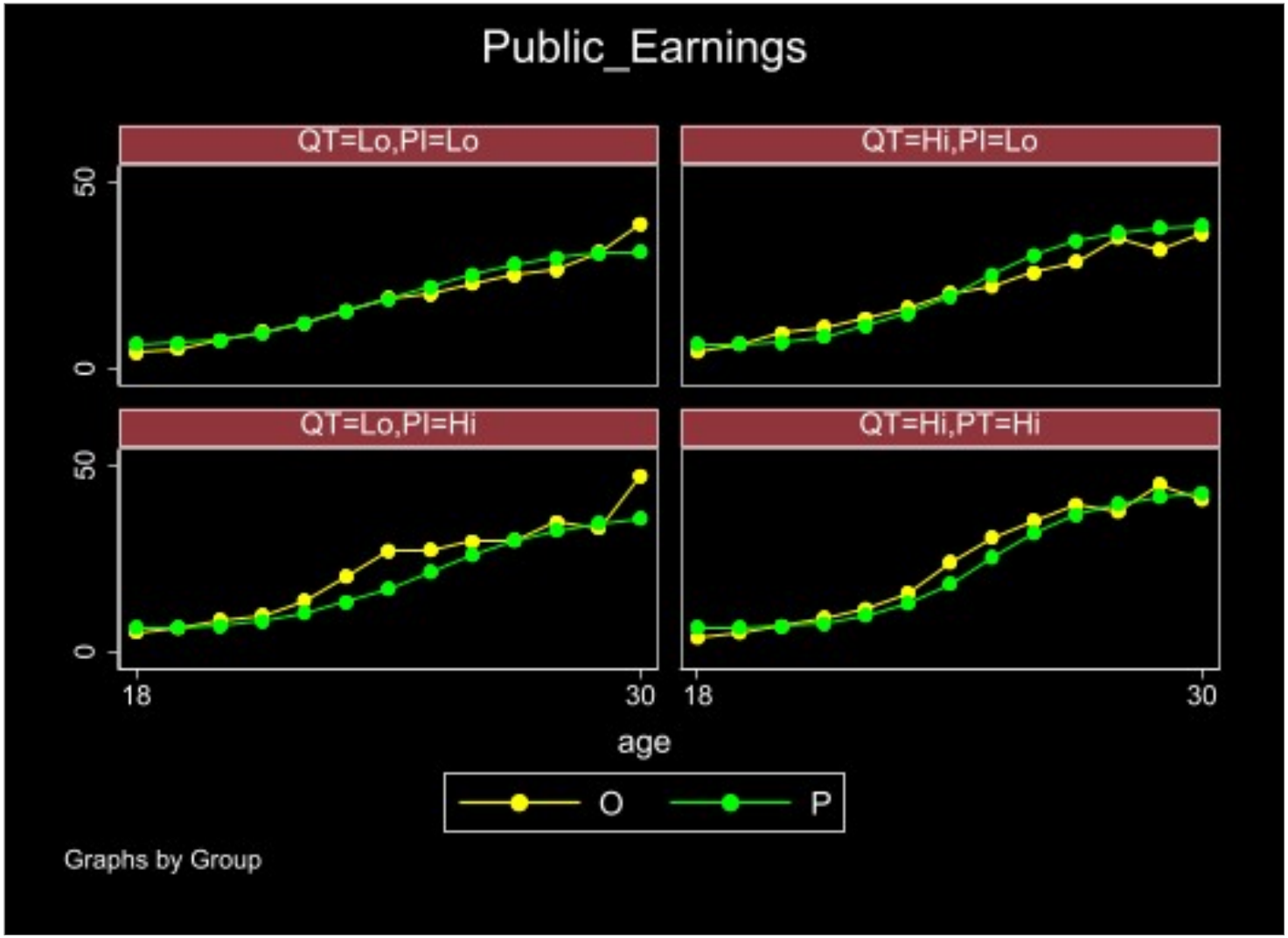

Att_FT_Public
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0
.1
.2
18
30
age
Observed
Predicted
Graphs by Group

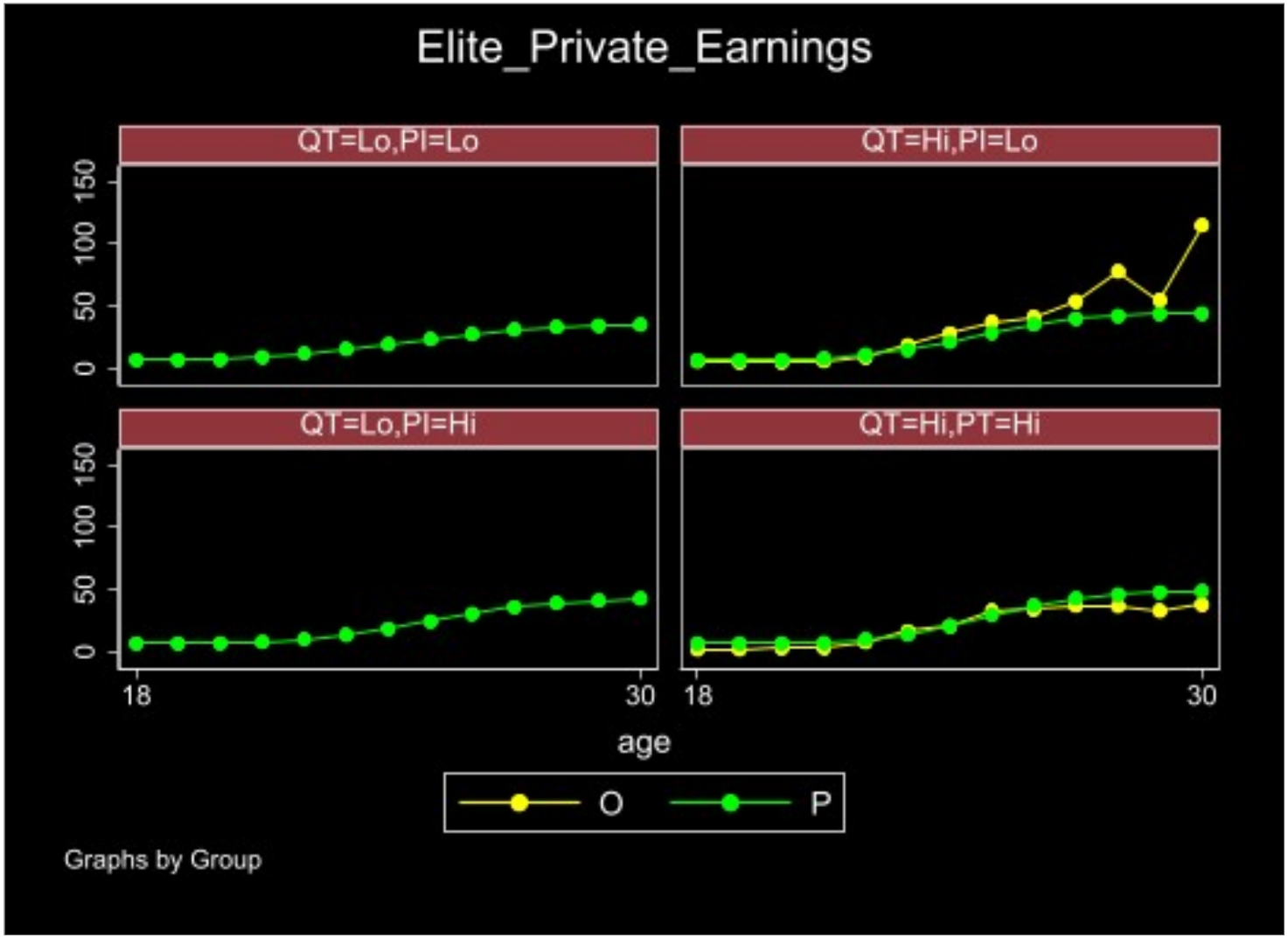

Public_Borrow
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0 .5 1 1.5 2
18
30
age
O
P
Graphs by Group


Private_Borrow
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0 .5 1 1.5 2
18
30
age
O
P
Graphs by Group


Degree
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0
.1
.2
.3
18
30
age
O
P
Graphs by Group


NoCollege_Earnings
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0 20 40 60 80
18
30
age
O
P
Graphs by Group


Public_Earnings
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0
50
0
50
18
30
18
30
age
O
P
Graphs by Group


Elite_Private_Earnings
QT=Lo,PI=Lo
QT=Hi,PI=Lo
QT=Lo,PI=Hi
QT=Hi,PT=Hi
0
50
100
150
18
30
age
O
P
Graphs by Group


AggEarnings
10
20
30
40
50
18
39
age
Observed
Predicted

Last Words