Timing of Human Capital Investment and Career Outcomes: Evidence from an Oil Boom and Bust

Erik Katovich
UW-Madison

Dominic Parker
UW-Madison

Steven Poelhekke
University of Auckland
CEPR

UW-Madison
Environment Seminar

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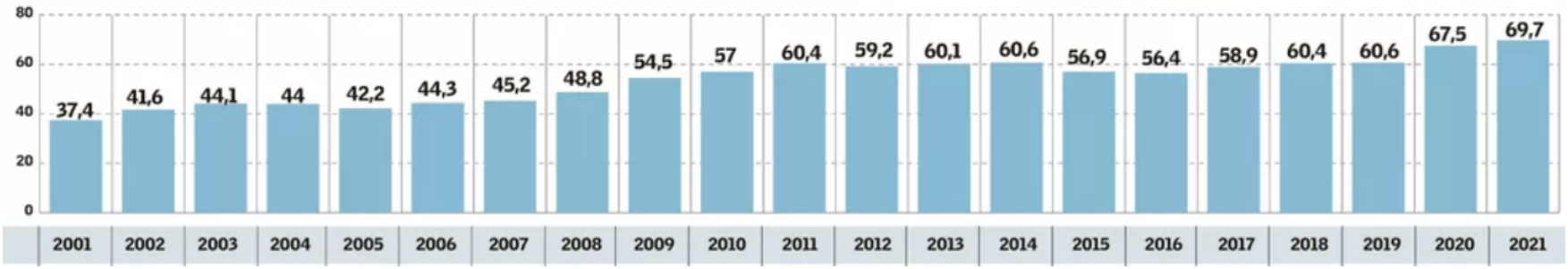
Uncertainty and volatility are exacerbated in **commodity sectors**, which dominate the economies of many low and middle-income countries



Brazil: Commodities as Percentage of Total Export Value (*Valor Econômico*, 2021)

Research Questions and Preview of Results

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3. **Human Capital Investment:** Do prospective workers respond to a booming oil sector by investing in oil-relevant skills?

   Yes. The oil boom was accompanied by a boom in oil-linked higher education, driven by growth in private-sector technical training programs

Conceptual Framework: Corden and Neary's (1982) Model of a Booming Sector

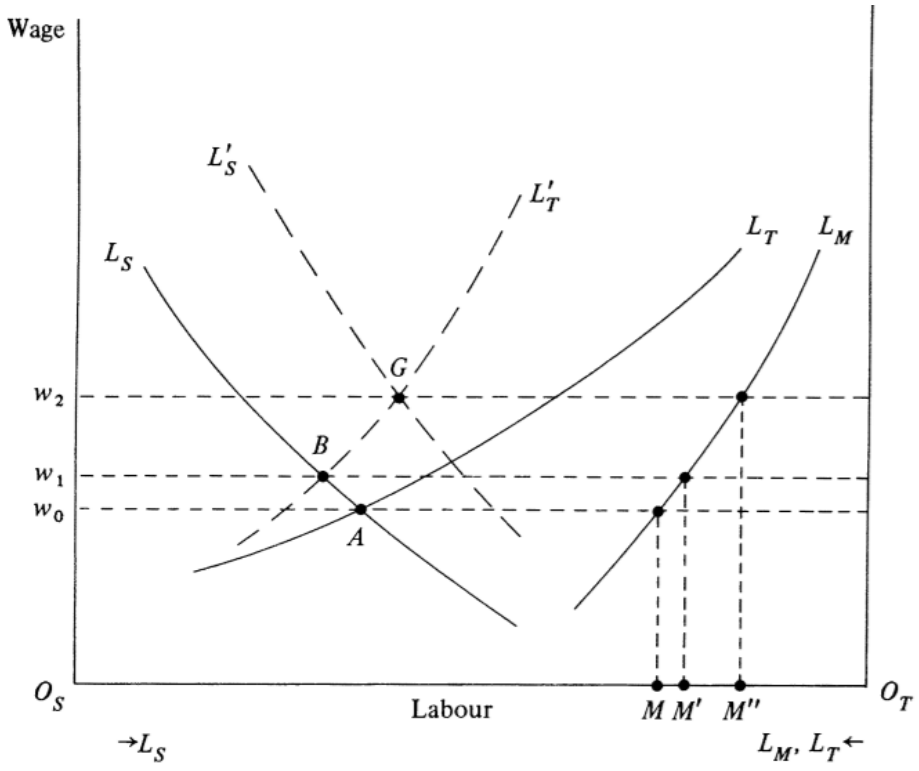

Fig. 1. Effect of the boom on the labour market.

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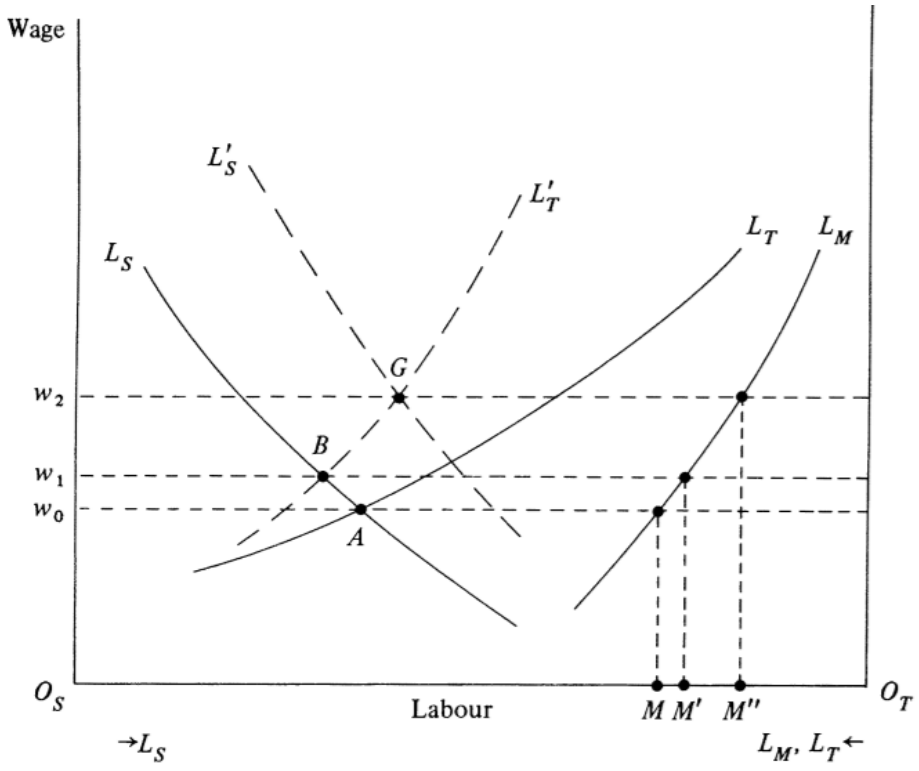


Fig. 1. Effect of the boom on the labour market.

- Fixed, inelastic labor supply (no unemployment or new entrants)
- No worker heterogeneity
- No labor market frictions (e.g., regulations)

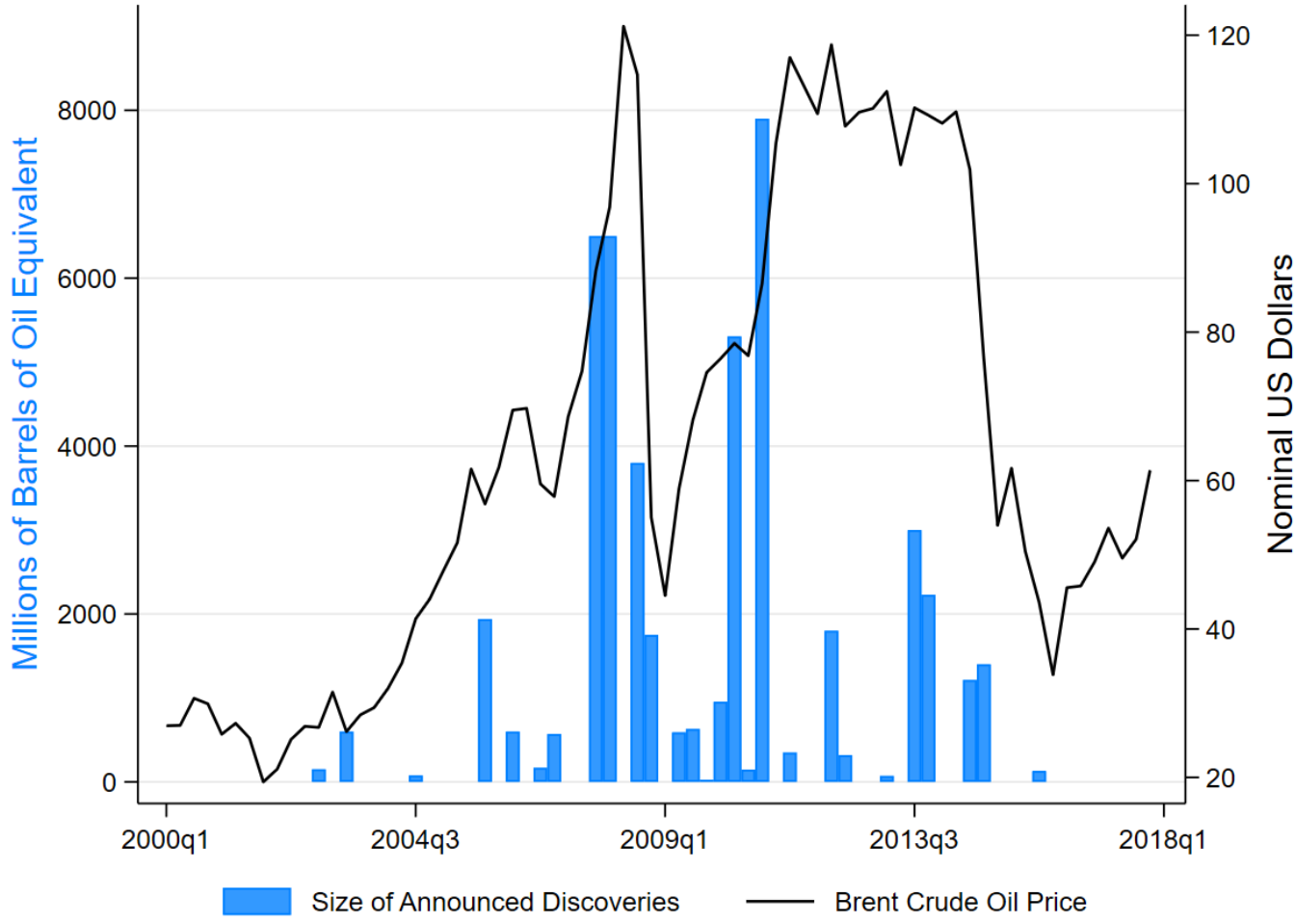
Extending the Corden and Neary Model

We use rich worker-level panel data (**Brazil's RAIS matched employer-employee administrative records**) to explore empirical extensions to the standard booming sector model:

- Large pool of unemployed and informal workers
- Heterogeneity in worker education levels
- Endogenous human capital investment in response to skill-biased boom
- Labor market regulations that disproportionately benefit senior workers

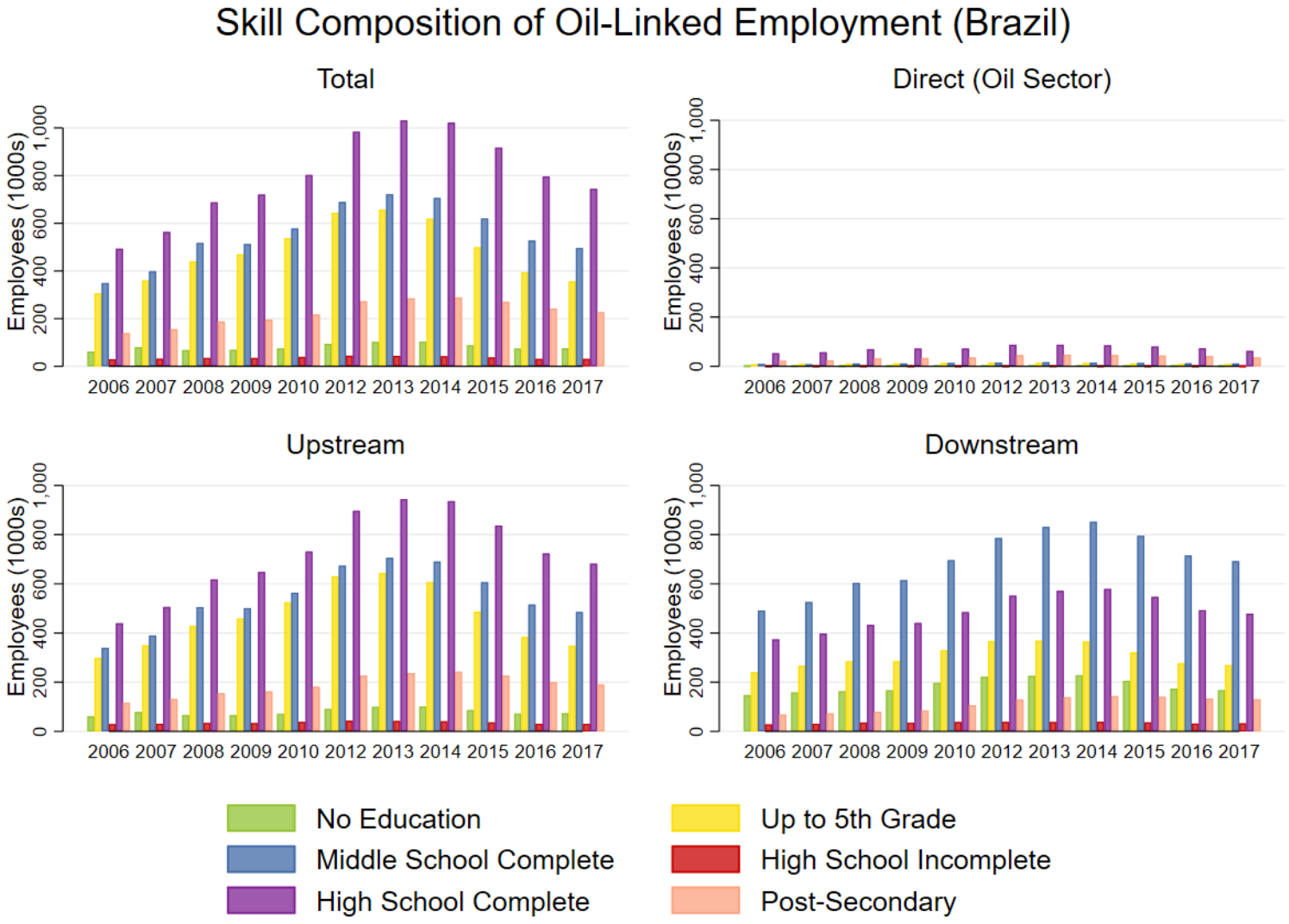
Boom and Bust in Brazil's Oil Sector

Global Oil Prices and Offshore Oil & Gas Discoveries in Brazil

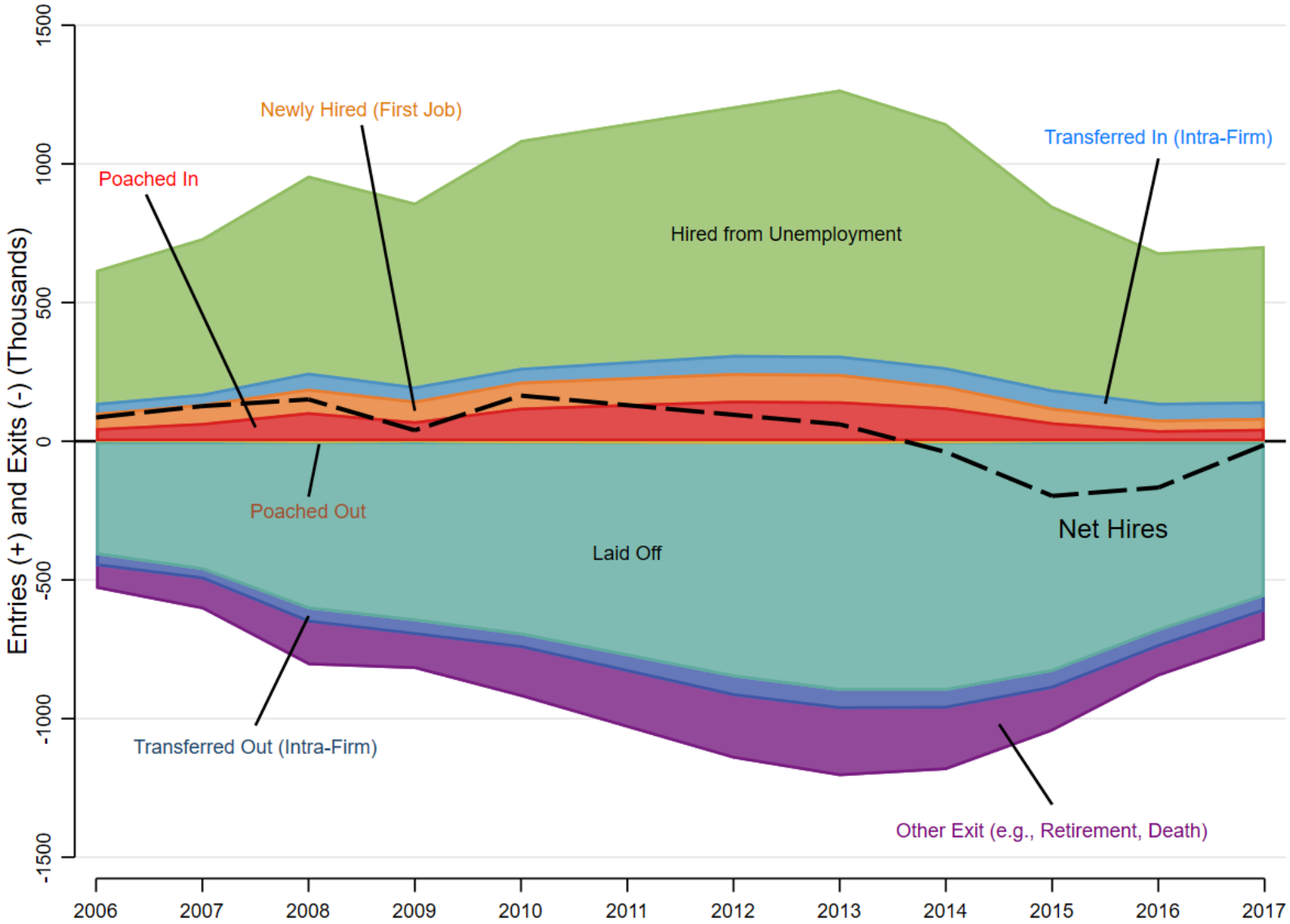


▸ Petrobras Investment

Employment by Skill-Requirement: Oil and Linked Sectors



Employment Inflows and Outflows from Oil-Linked Sectors



Using Input-Output Matrix (67 × 127) to Identify "Oil-Linked" Sectors

Oil Sector	**Leontief Coefficient**
Oil Extraction and Support Activities	1.068
Top Upstream Sectors	
Legal, Accounting, and Consulting Services	0.055
Land Transportation of Cargo	0.039
Petroleum Refining and Coke Plants	0.032
Fabrication of Machines and Mechanical Equipment	0.027
Production of Pig Iron, Alloys, Steel, and Steel Pipes	0.023
Storage and Logistics	0.021
Construction	0.021
Maintenance, Repair, and Installation of Machines and Equipment	0.020
Architecture, Engineering, and R&D	0.018
Aquatic Transportation	0.017
Top Downstream Sectors	
Petroleum Refining and Coke Plants	0.411
Land Transportation of Cargo	0.088
Production of Organic and Inorganic Polymers and Resins	0.053
Electrical Energy and Utilities	0.047
Extraction of Non-Ferruginous Metals	0.045
Fabrication of Non-Metalic Mineral Products	0.029
Production and Refining of Sugar	0.029
Air Transportation	0.028
Production of Biofuels	0.027
Fabrication of Cellulose and Paper Products	0.026

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⇓ (SCN/CNAE 2.0 Conversion Table)

2-Digit CNAE 2.0 Activity Code Roots

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14 Directly-Linked, 109 Upstream, 31 Downstream Subclasses

Constructing Worker-Level Panels from RAIS Data

RAIS (*Relação Anual de Informações Sociais*): linked registry of universe of formal employers-employees in Brazil, supports social security/unemployment insurance

- We have identified data for 2003-2017
- Worker-level data is at job-year level (can have multiple jobs per worker-year)

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We focus on two types of entrants into oil-linked sectors:

- **Poaches** (i.e., all workers in Corden & Neary Model): workers who voluntarily leave a job (*Recisão sem justa causa por iniciativa do empregado*) and are rehired by a new firm within 4 months
- **New Hires**: workers who are hired into their first formal job (*Primeiro emprego*)

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For all poaches and new hires in year t, match IDs with $t \pm 1...n$ periods.

Assumption: Impute formal earnings of zero when worker does not appear (i.e., unemployed, informally employed, or self-employed)

Empirical Strategy I: Pre-Matching

Goal: Estimate causal effects of being poached or newly hired into an oil-linked sector on subsequent wages, employment, and earnings, and other outcomes

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Strategy: Match workers poached/newly hired into an oil-linked establishment in year t with counterfactual workers poached/newly hired into other sectors in same year using Coarsened Exact Matching:

- **Poaches**: Exact match on Schooling, Sex, Race, **Previous Establishment $(t-1, t-2)$**, Previous Occupation Category $(t-1, t-2)$, Destination Municipality; Binned match on Previous Wage $(t-1, t-2)$, Age
- **New Hires**: Exact match on Schooling, Sex, Race, Destination Municipality, Macro-Sector; Binned match on First Hired Wage, First Hired Firm Size, Age

Empirical Strategy II: Event Studies Around Poach or New Hire into Oil-Linked Sector

- Let E_{ic} be period when worker i in cohort c is treated by poach or new hire into oil. Let $K_{ict} = t - E_{ic}$ be number of years before or after this event
- Let Y_{ict} be outcome for i in cohort c in year t
- Include worker and year fixed effects; cluster standard errors at worker level

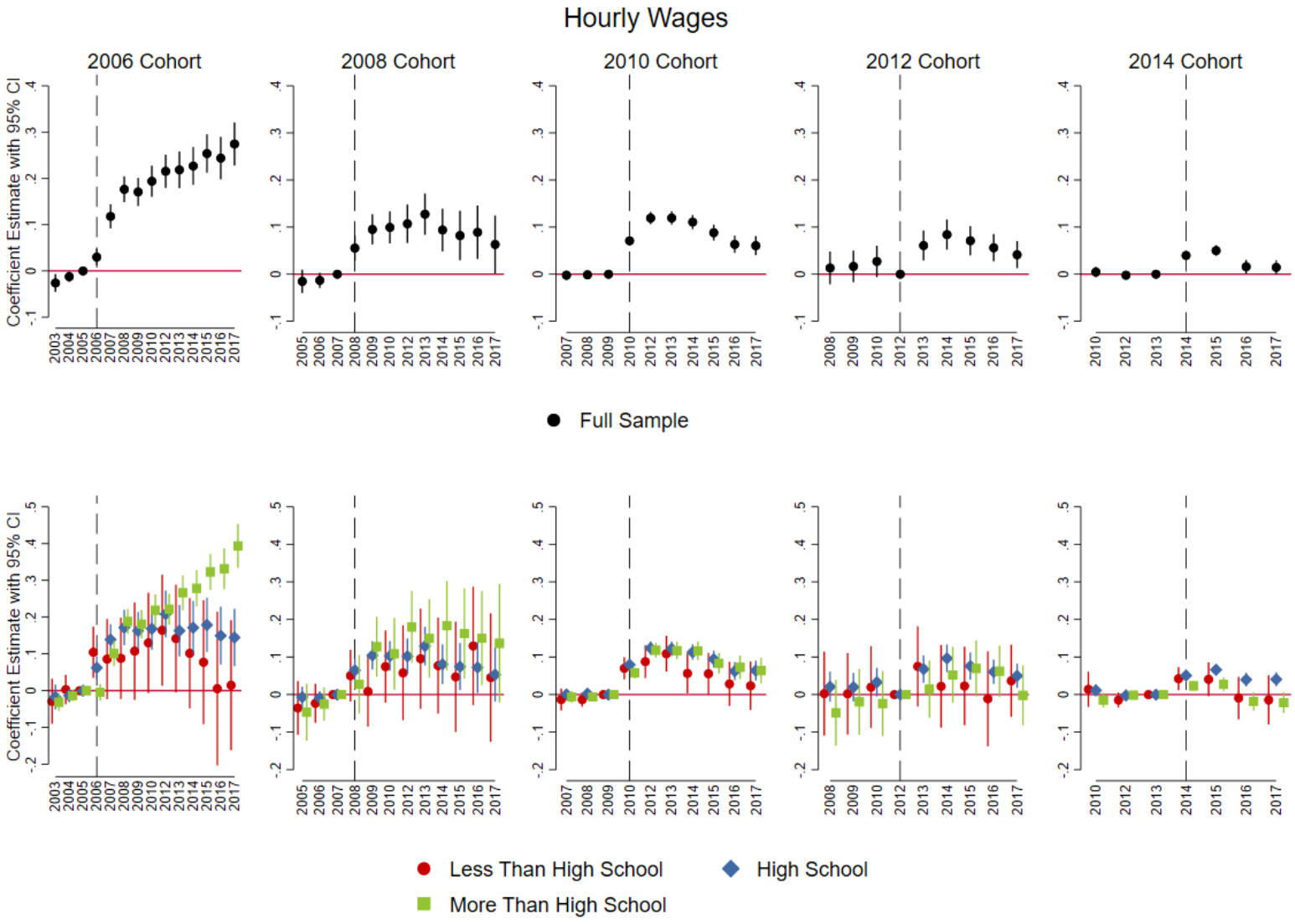
$$Y_{ict} = \delta_i + \lambda_t + \sum_{k \neq -1} [\mathbb{1}(K_{ict} = k)]\beta_k + \epsilon_{it}$$

- Estimate separately for each cohort c relative to **matched controls**
- To explore heterogeneity by education, re-estimate separately for low, medium, and high education workers
- Transform continuous outcomes with IHS transformation, deflate monetary values to constant 2018 $BRL

Identification

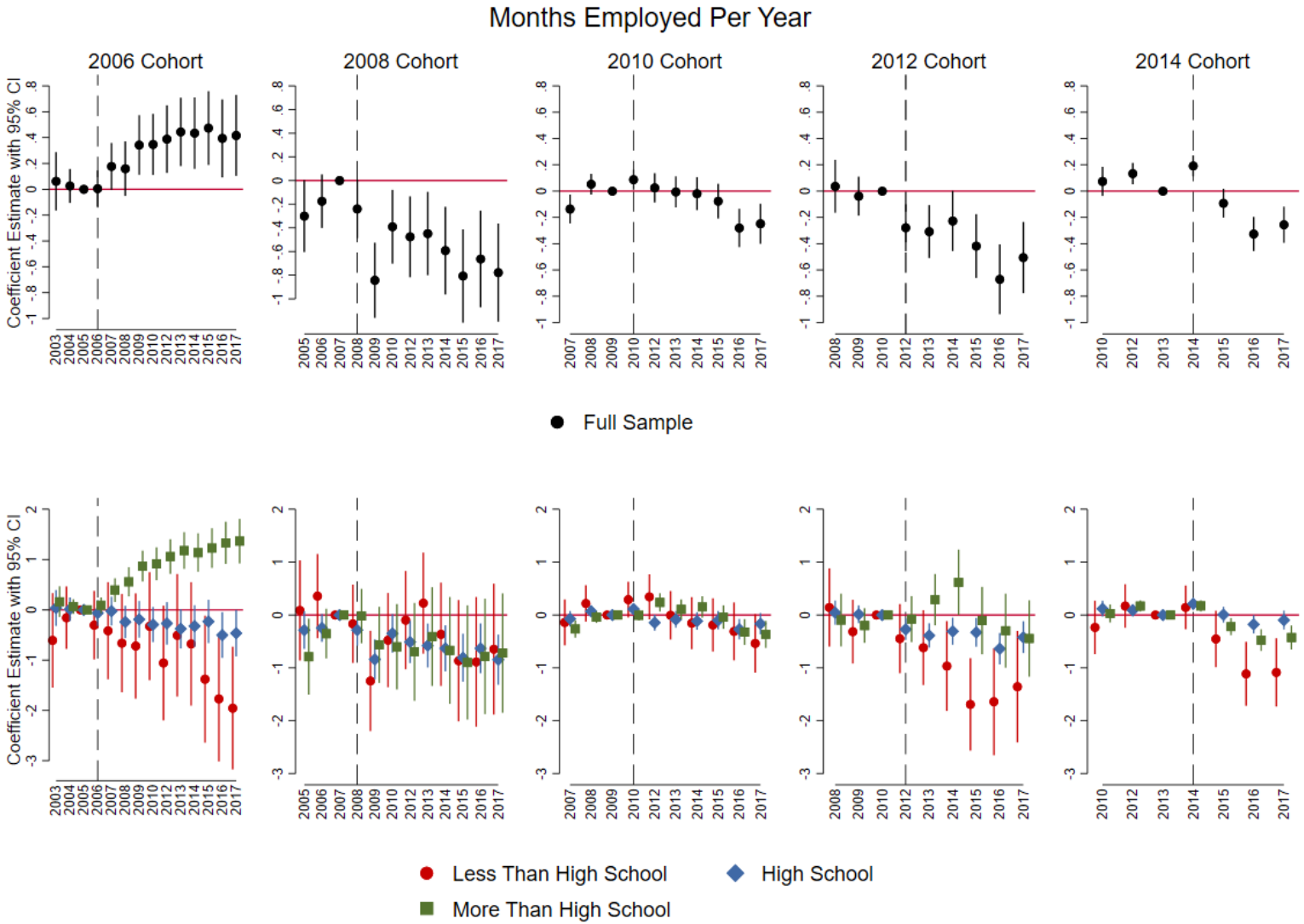
- Estimates of β_k identify ATE at length of exposure k from poach/new hire into oil-linked establishment, given **parallel pre-trends** ($\beta_k = 0$ for $t < -1$)
- **Minimizing bias from selection into treatment**: we match on nearly all variables available to employers hiring new workers: age, sex, race, education, previous employer/employment characteristics
- **Worker fixed effects** control for time-invariant worker characteristics, including unobservables (i.e., ability, risk aversion)
- Compared to (extremely) closely-matched workers hired into other sectors, **oil-linked workers are exposed to exogenous sectoral shocks** driven by global prices and offshore discoveries

Results: Hourly Wages After **Poach** into Oil-Linked Sector



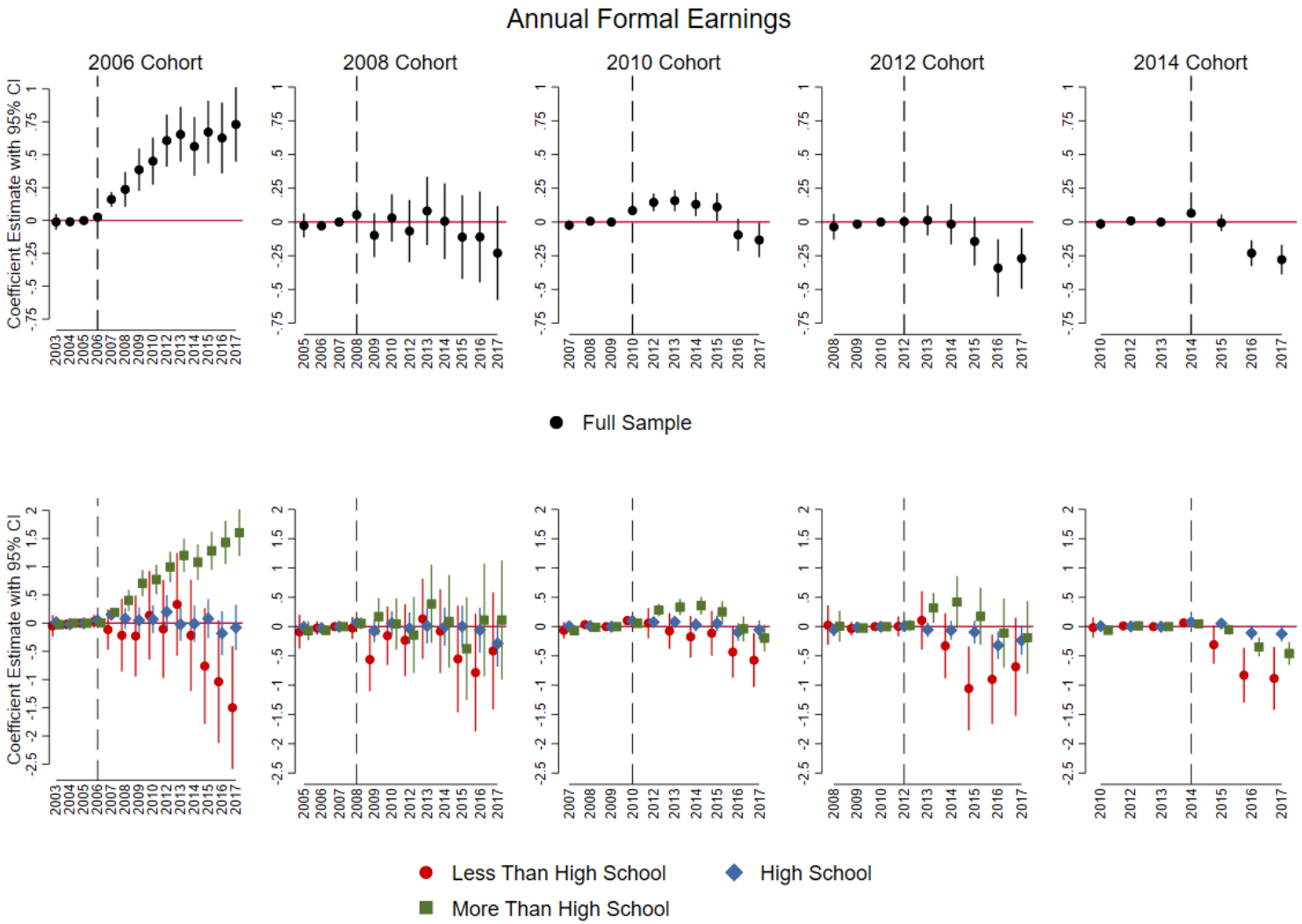
Note: Wages deflated to 2018 BRL and transformed using IHS. Standard errors clustered at individual level. This specification keeps only employed individuals to focus on intensive margin.

Results: Months Employed Per Year After **Poach** into Oil-Linked Sector



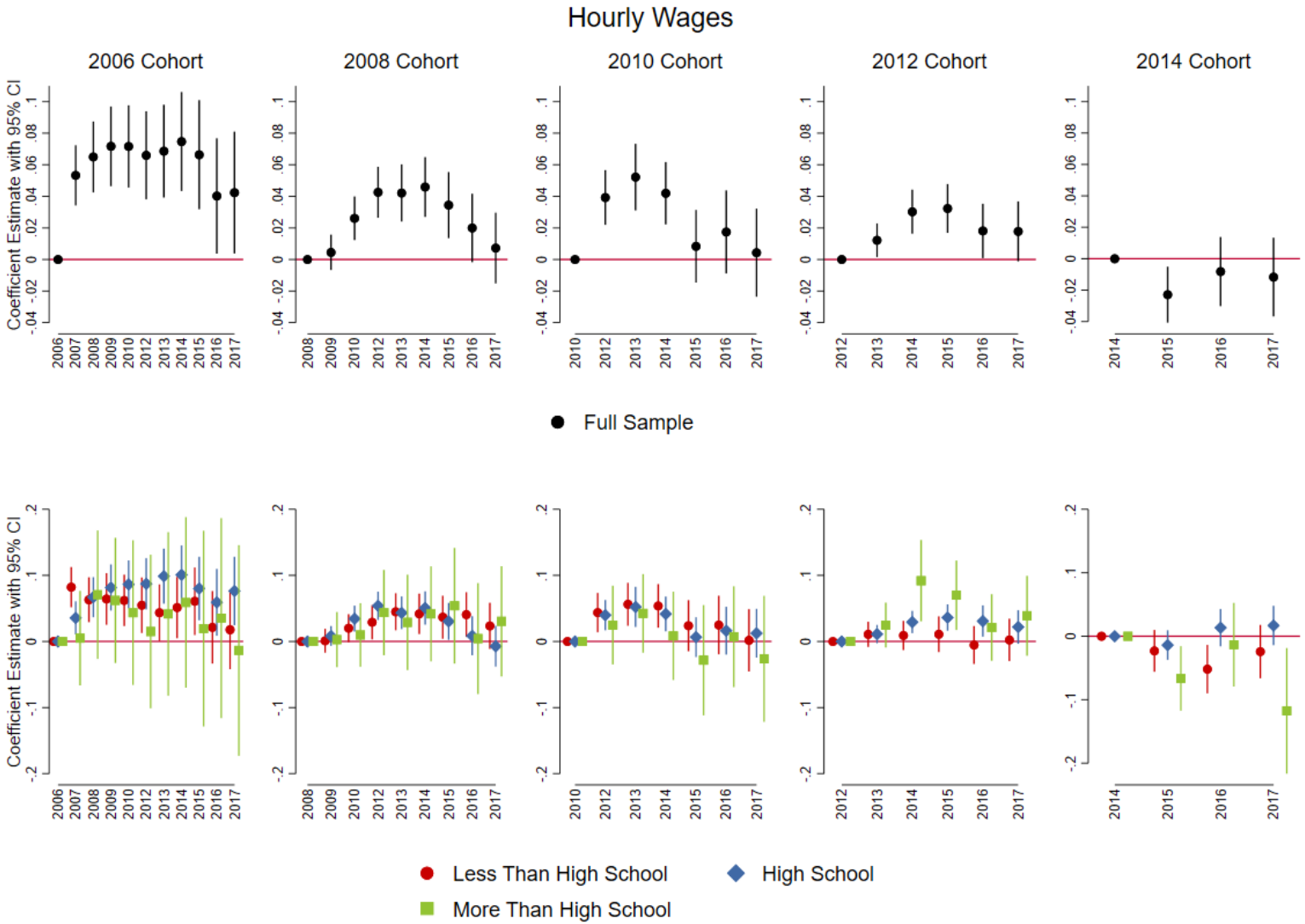
Note: Months employed ranges from zero if worker never appeared in RAIS registry during a year, to 12 if individual was employed each month. To analyse effects at the extensive margin, this specification keeps all treated individuals and matched controls (whether formally employed or not) in strongly balanced panel.

Results: Annual Earnings After **Poach** into Oil-Linked Sector



Note: Annual earnings refers to total earnings across all formal jobs. Earnings are transformed using the IHS and deflated to 2018 BRL. To analyse effects at the extensive margin, this specification keeps all treated individuals and matched controls, whether formally employed or not. In periods where individuals do not appear in panel, they are ascribed a value of zero formal earnings for this period.

Results: Hourly Wages After **New Hire** into Oil-Linked Sector

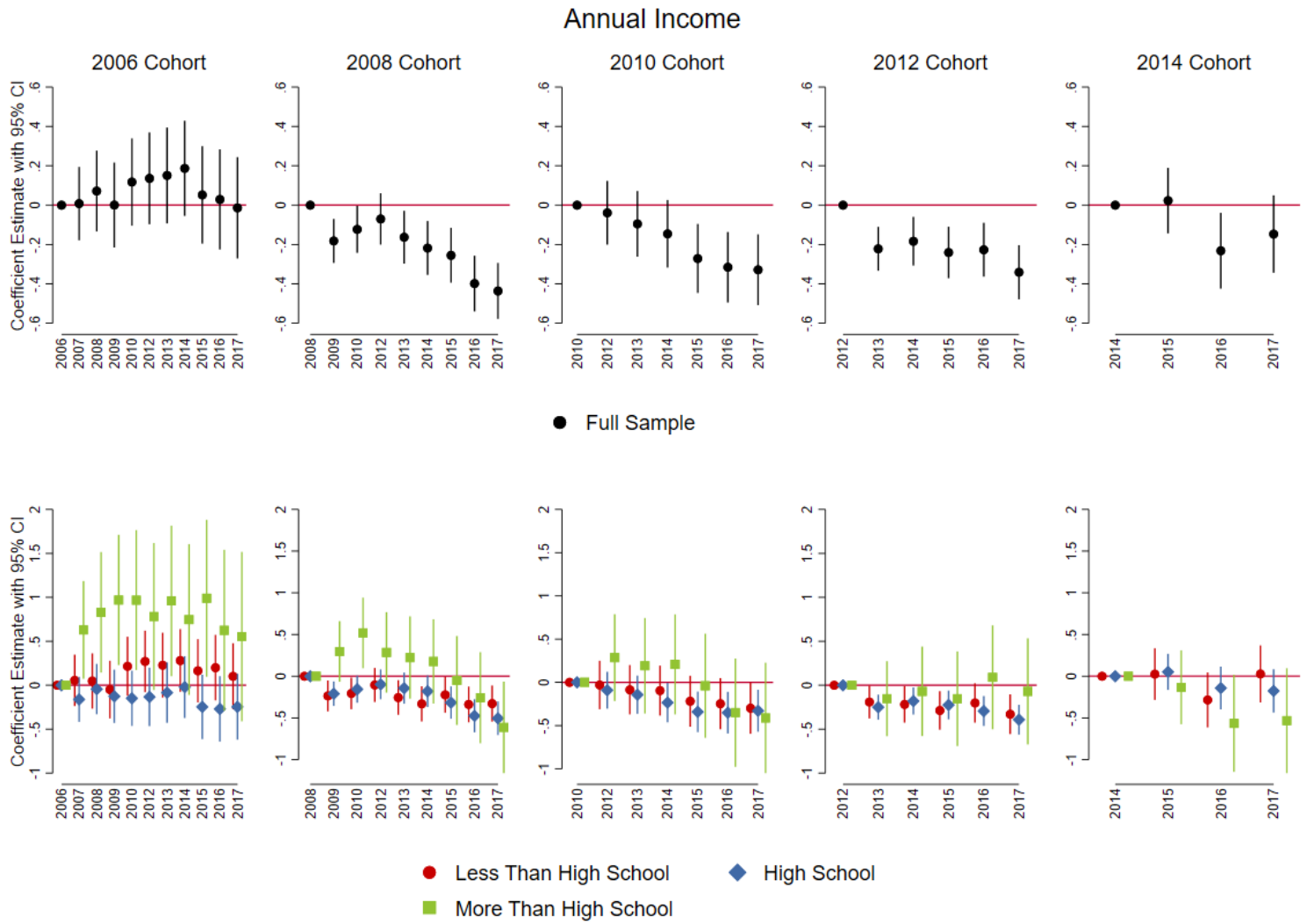


Note: Wages deflated to 2018 BRL and transformed using IHS. Standard errors clustered at individual level. To analyse effects at the intensive margin, this specification keeps only employed individuals.

Results: Months Employed/Year After **New Hire** into Oil-Linked Sector

Note: Months employed ranges from zero if individual never appeared in RAIS registry during a year, to 12 if individual was employed each month. To analyse effects at extensive margin, this specification keeps all treated individuals and matched controls, whether formally employed or not, in a strongly balanced panel.

Results: Annual Earnings After **New Hire** into Oil-Linked Sector



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Results may be sensitive to definition of “oil-linked” sectors or matching specifications

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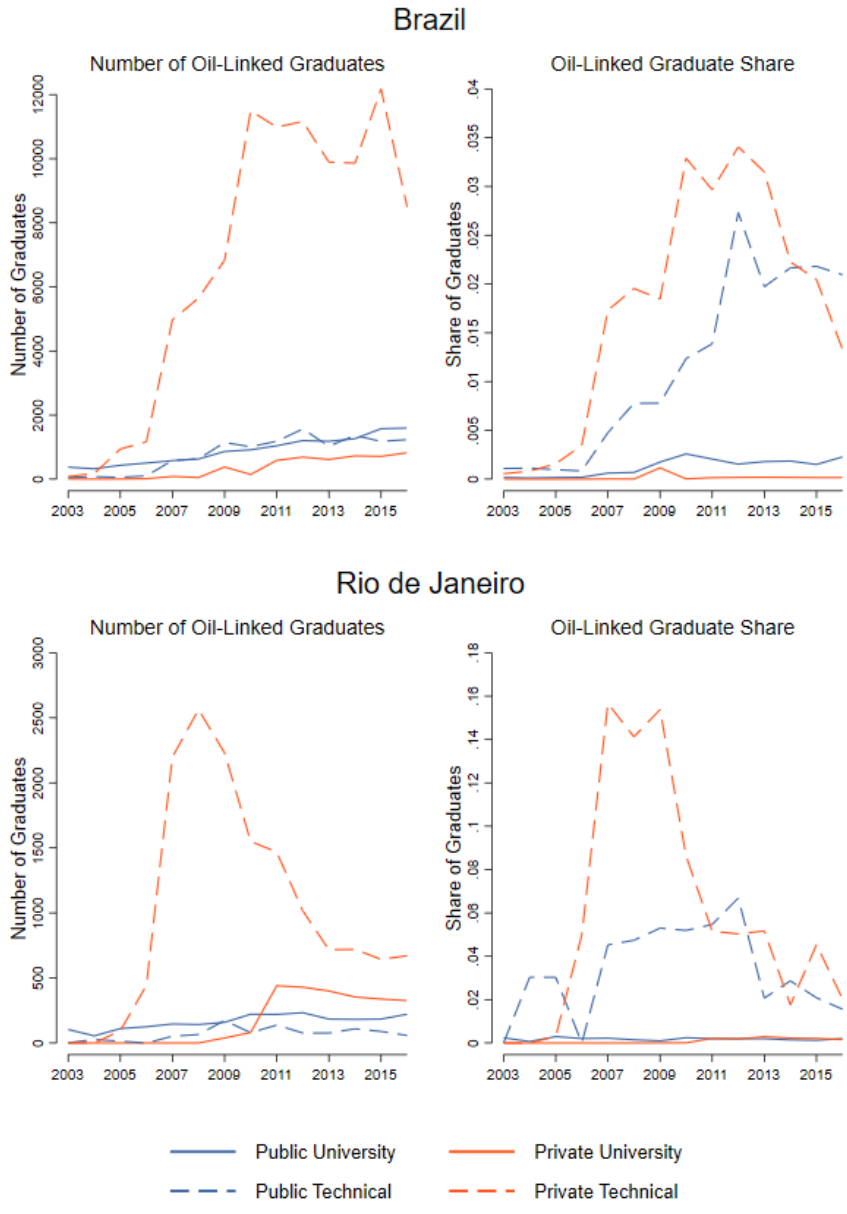
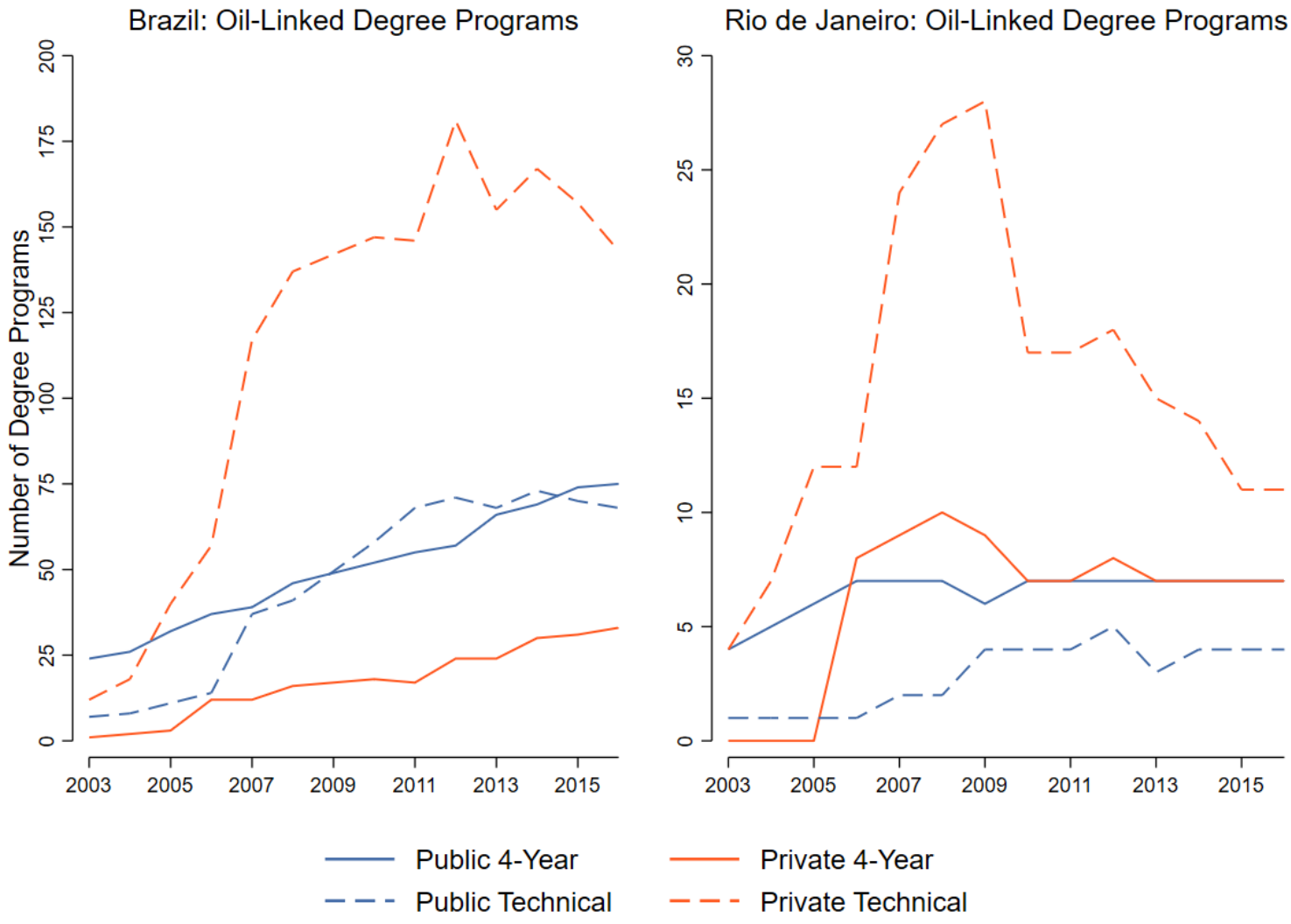
3. Re-estimate event studies using **loose match** and restricting sample in post-2006 cohorts to **workers in later cohorts who share common support with workers in 2006 cohort** (In Progress)

Mechanism: Oil-Specific Human Capital Investment

▸ Oil-Linked Degree Programs



Oil-Specific Degree Programs Over Boom and Bust Period



	Number of Graduates from Oil-Linked Majors				
Variables	**Total**	**Public 4-Year**	**Private 4-Year**	**Public Tech.**	**Private Tech.**
<50km from Shipyard	0.382***	0.257***	0.095*	0.073	0.278***
	(0.099)	(0.063)	(0.052)	(0.048)	(0.081)
Boom Year (2006-2013)	0.197***	-0.001	0.001	0.032***	0.184***
	(0.018)	(0.008)	(0.004)	(0.009)	(0.016)
Near × Boom	0.415***	0.032	0.019	0.048	0.522***
	(0.158)	(0.095)	(0.075)	(0.072)	(0.144)
State FEs	YES	YES	YES	YES	YES
Observations	16,600	16,600	16,600	16,600	16,600
R-squared	0.074	0.076	0.037	0.014	0.067

	Share of STEM Graduates in Oil-Linked Majors				
Variables	**Total**	**Public 4-Year**	**Private 4-Year**	**Public Tech.**	**Private Tech.**
<50km from Shipyard	-0.007	0.002**	0.000	-0.001	0.009
	(0.004)	(0.001)	(0.000)	(0.006)	(0.009)
Boom Year (2006-2013)	0.014***	0.001**	0.000	0.004***	0.027***
	(0.002)	(0.001)	(0.000)	(0.001)	(0.002)
Near × Boom	0.010	-0.001	0.000	0.008	0.065***
	(0.007)	(0.001)	(0.001)	(0.009)	(0.017)
State FEs	YES	YES	YES	YES	YES
Observations	16,600	16,600	16,600	16,600	16,600
R-squared	0.011	0.015	0.007	0.017	0.042

Note: Number of graduates uses inverse hyperbolic sine transformation. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

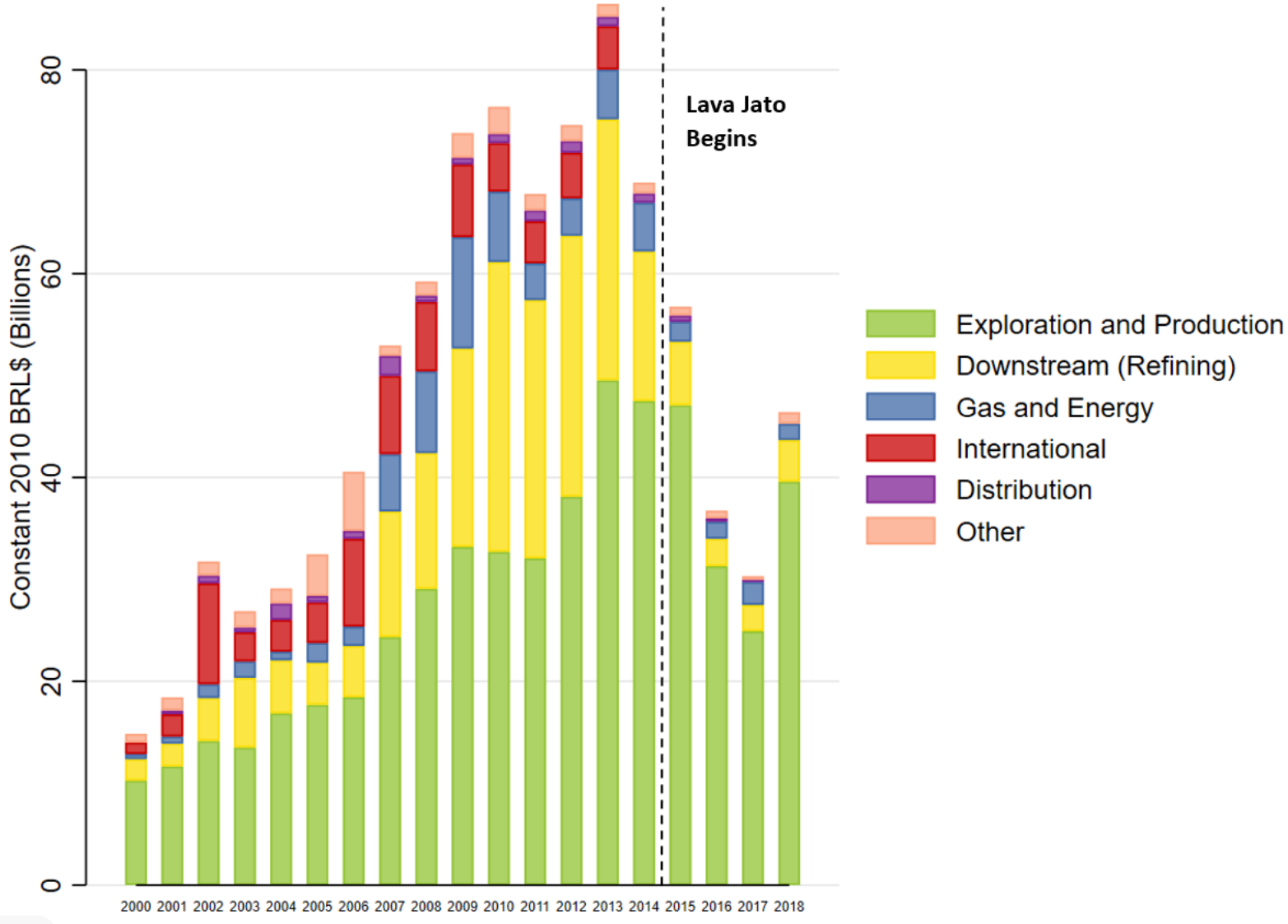
Conclusions

- **Timing of entry into oil sector has significant and lasting impacts on workers**: those hired by oil-linked establishment at beginning of boom earn significantly more than closely matched workers hired into other sectors at same time; workers hired into oil prior to or during bust suffer significant earnings and employment penalties

- **Oil generates income and employment inequality**: highly educated workers earn more during boom and are retained by firms during bust; low-education workers never enjoy earnings premiums during boom and loose their jobs during bust

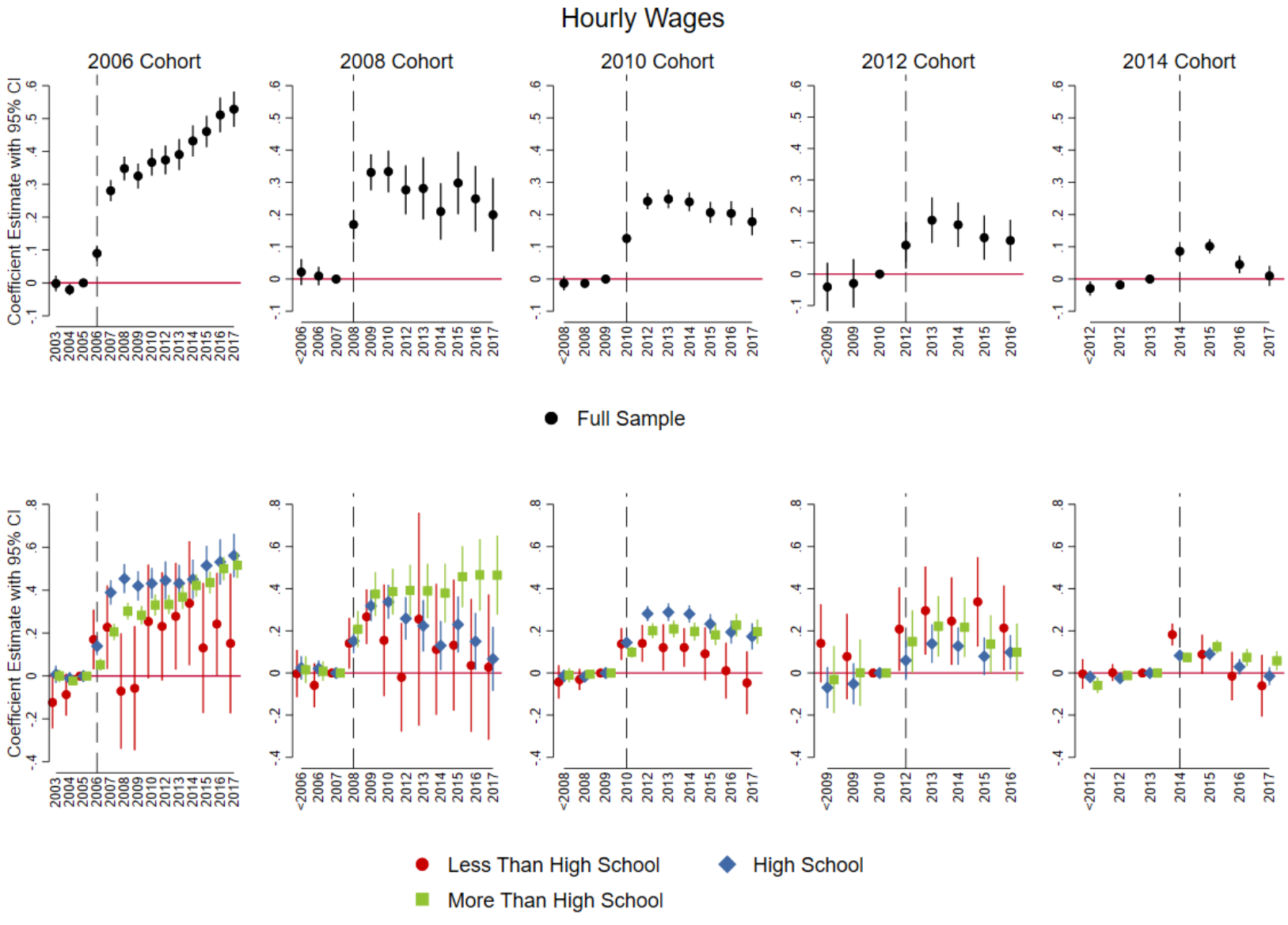
- **Oil boom provoked growth in sector-specific higher education**: driven by private-sector technical training programs

Petrobras Investment (Billions of 2010 $BRL), by Area

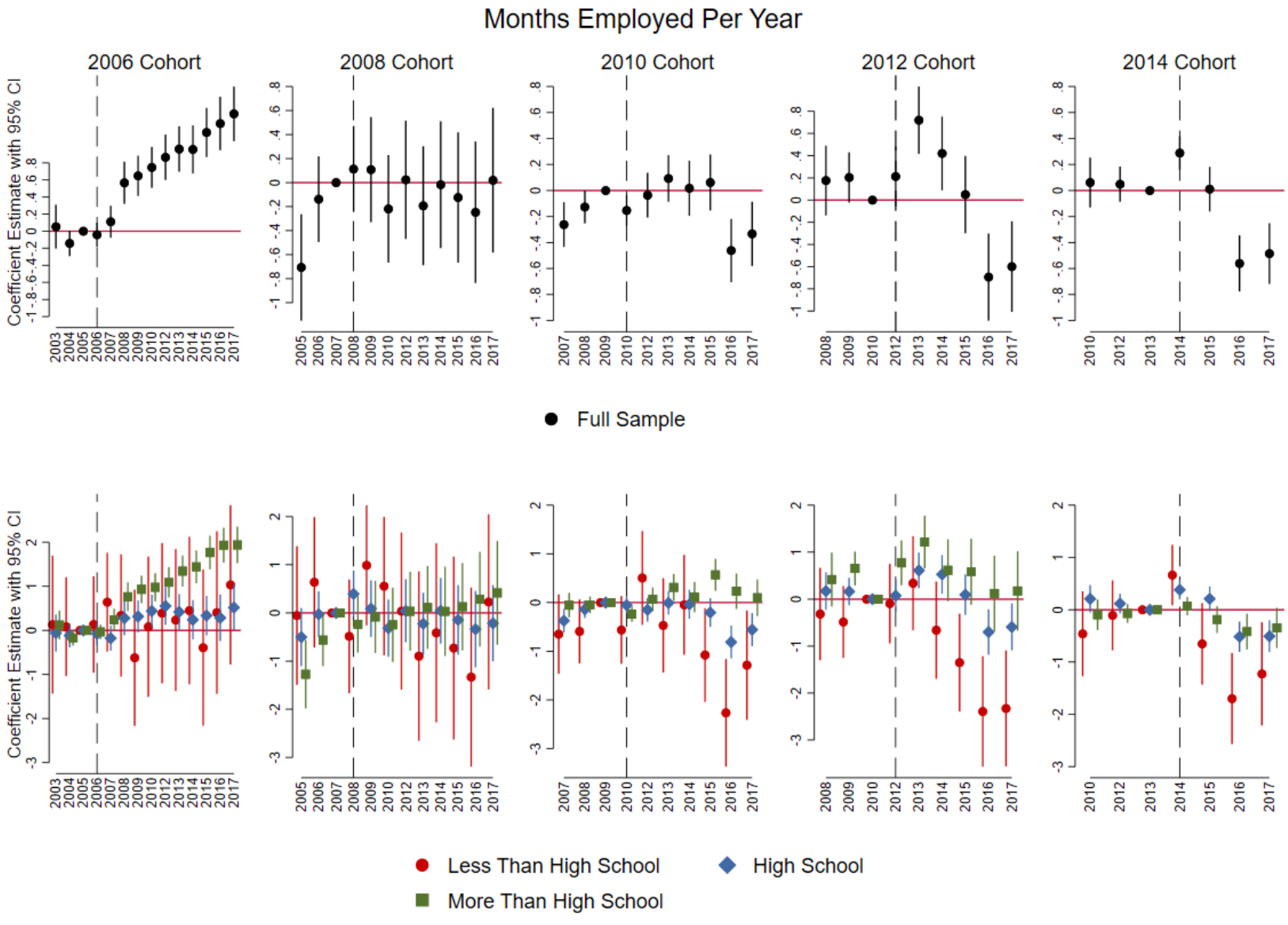


Return

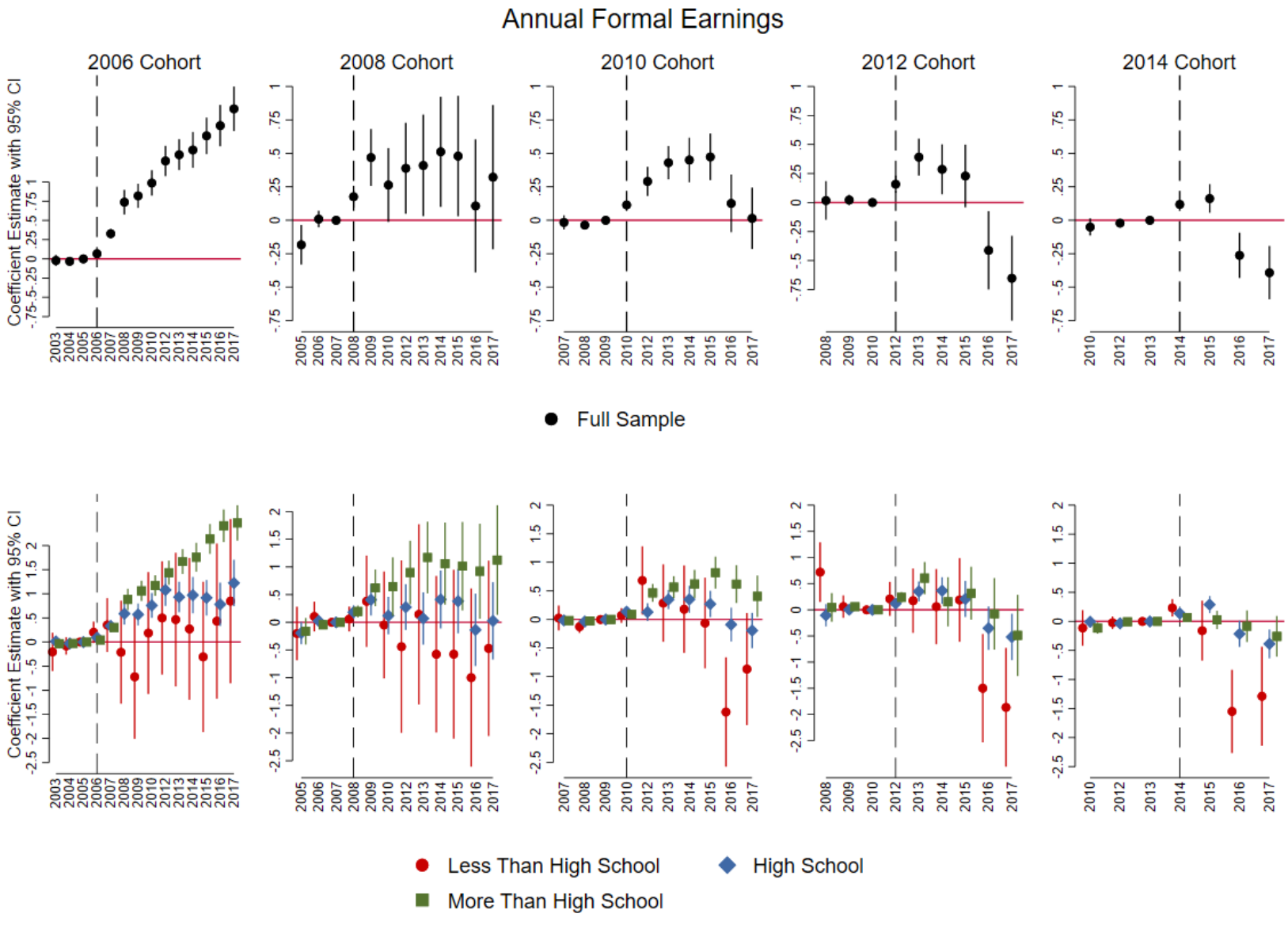
Direct-Loose Poached: Wages



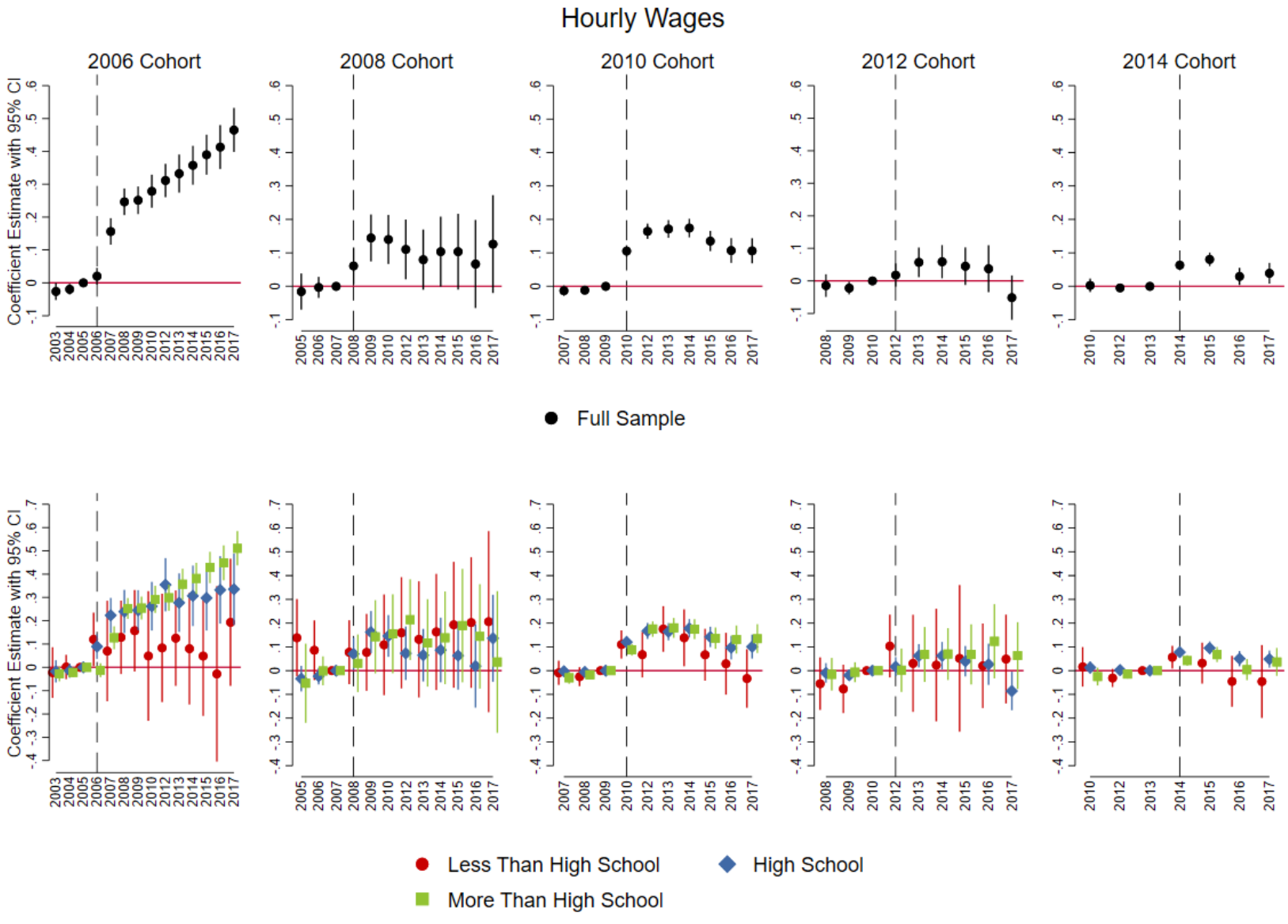
Direct-Loose Poached: Months Employed



Direct-Loose Poached: Annual Earnings



Close to Shipyards Poached: Wages



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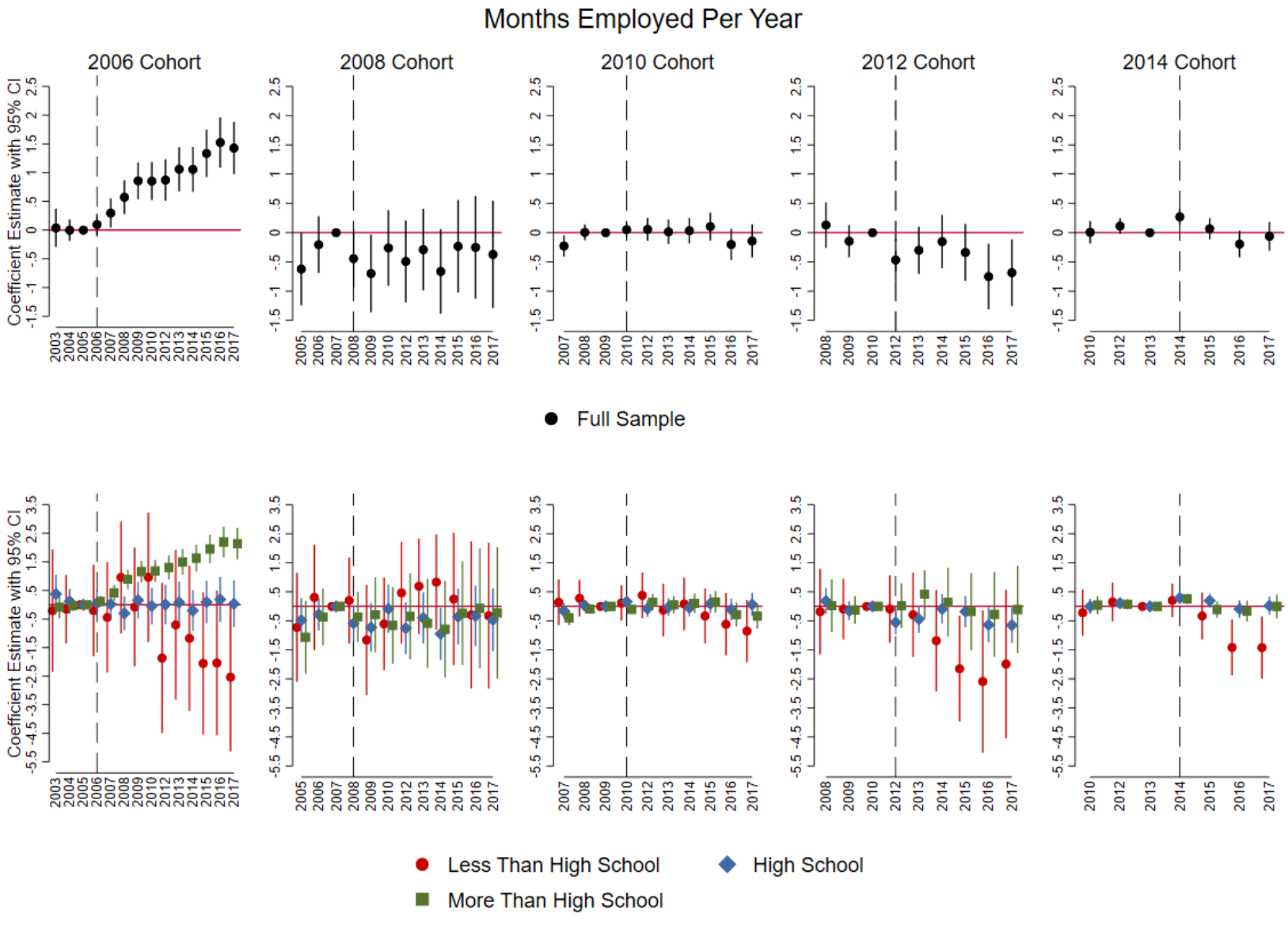

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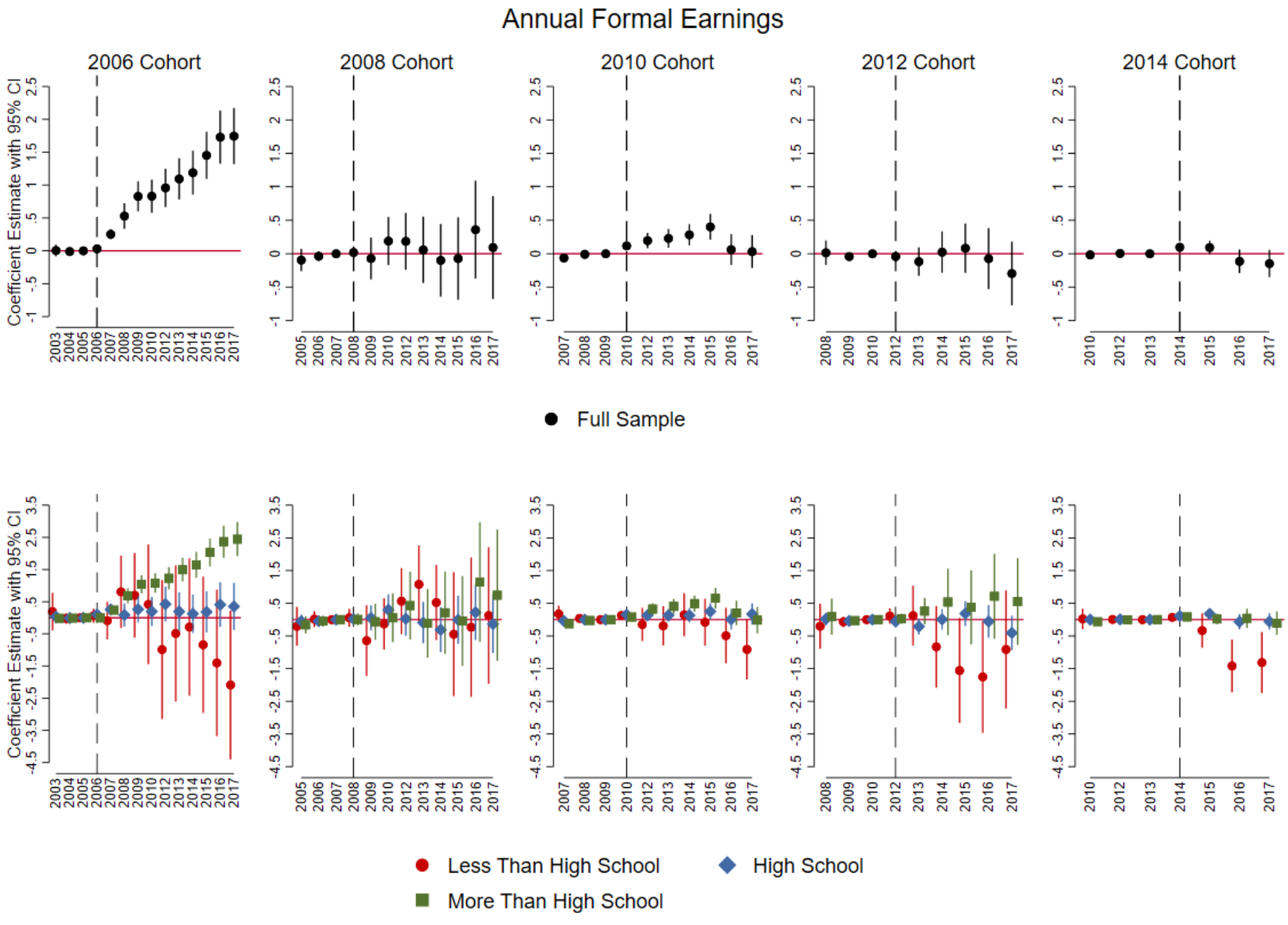
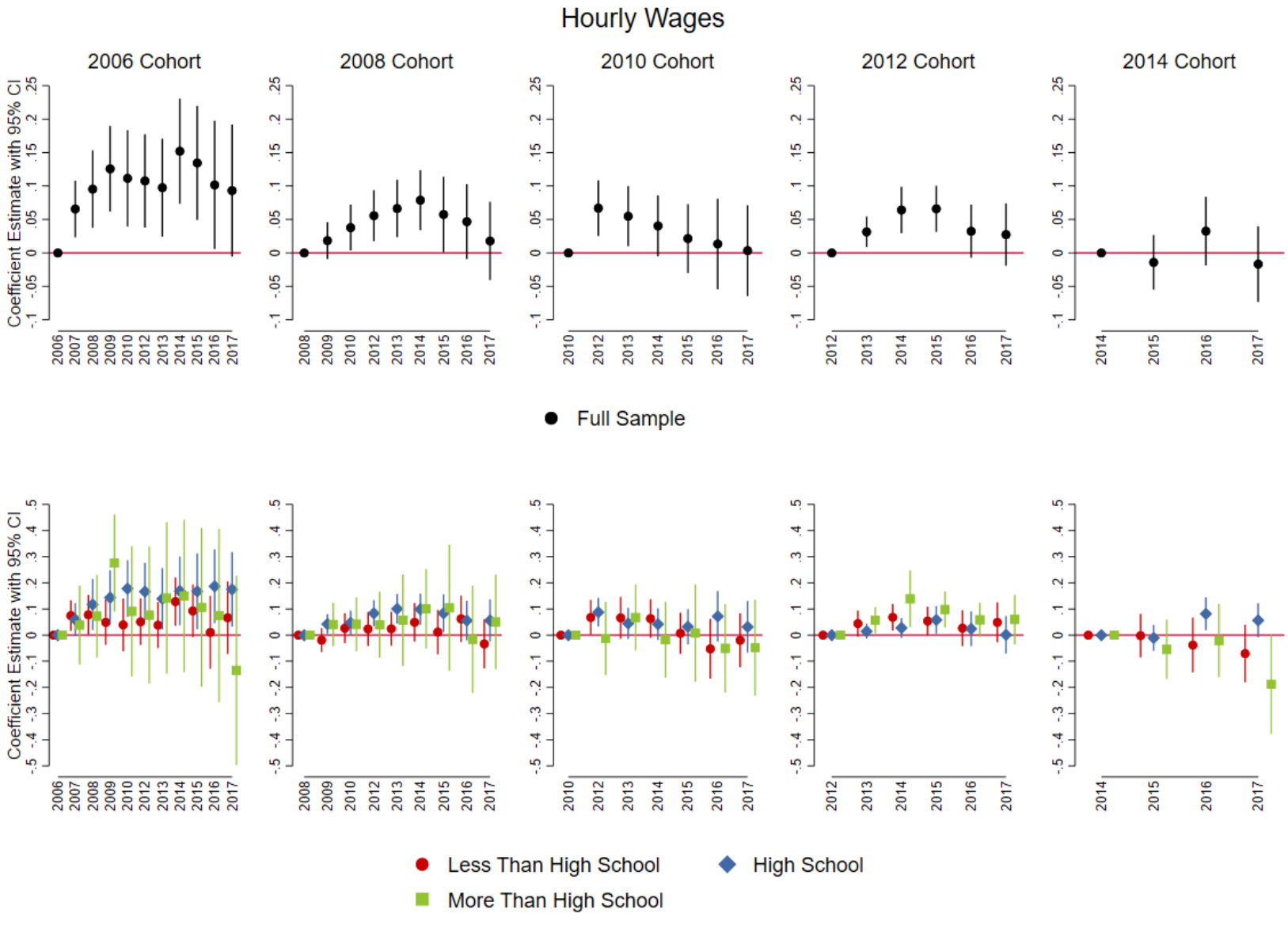


Close to Shipyards New Hires: Wages



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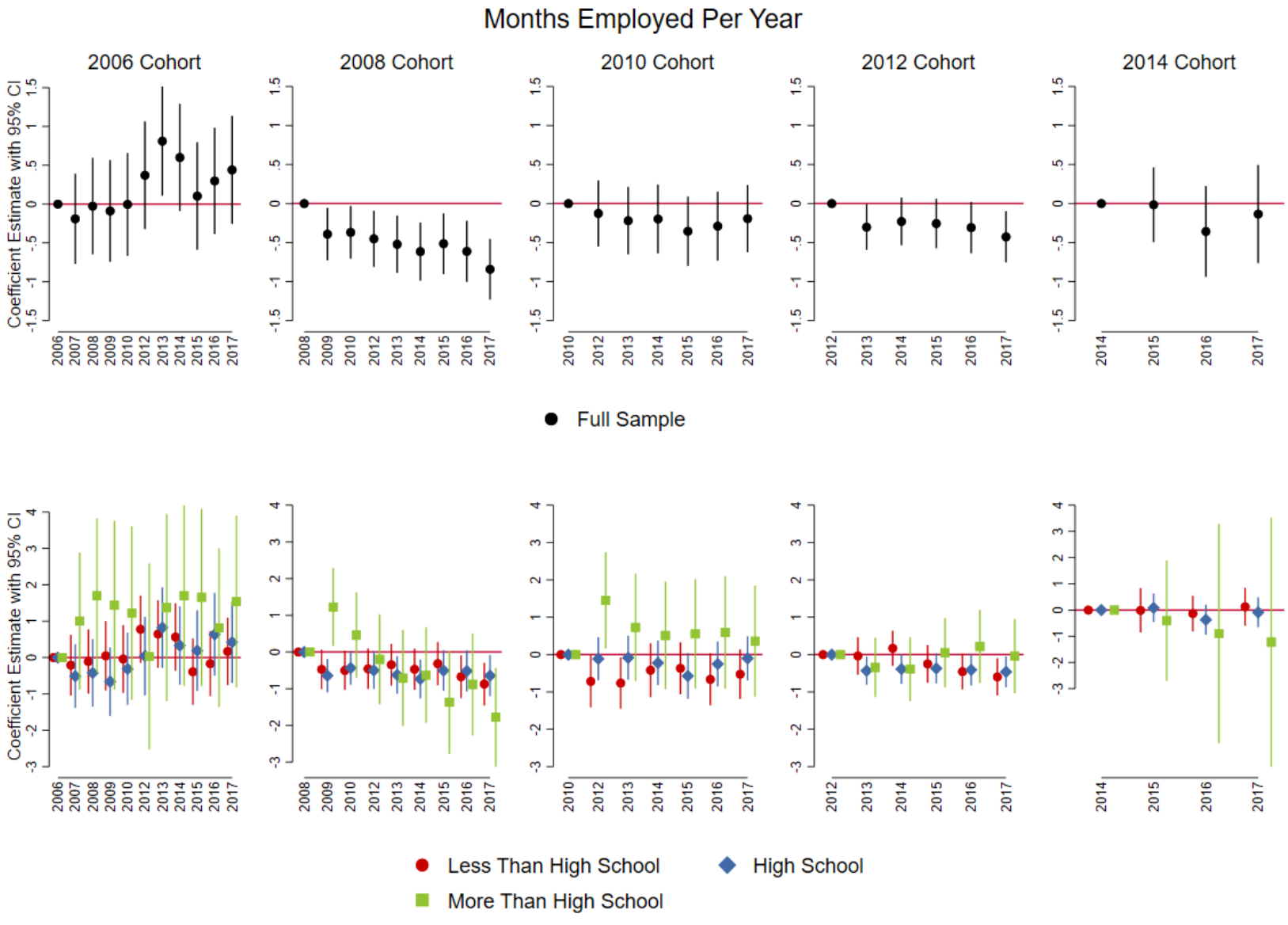

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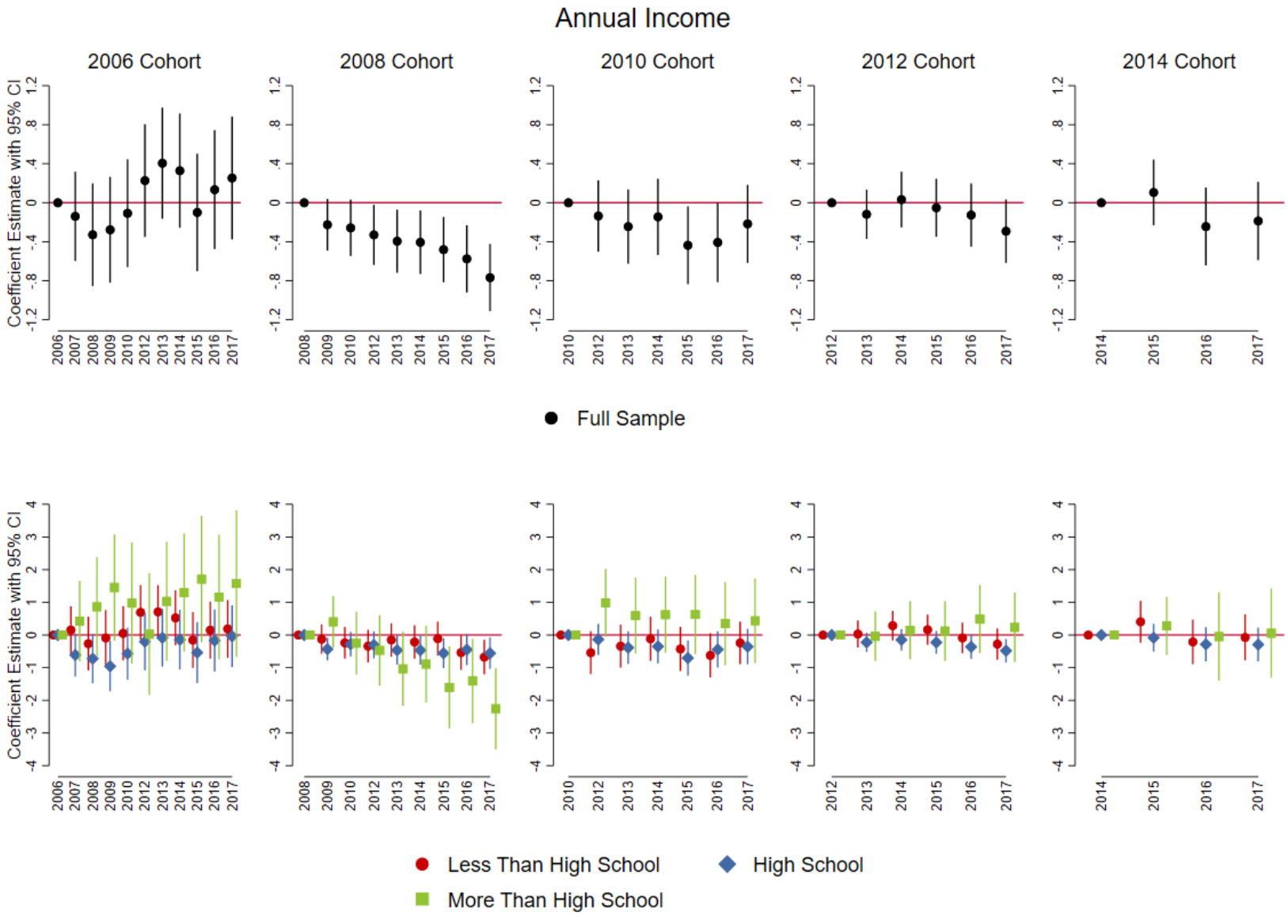
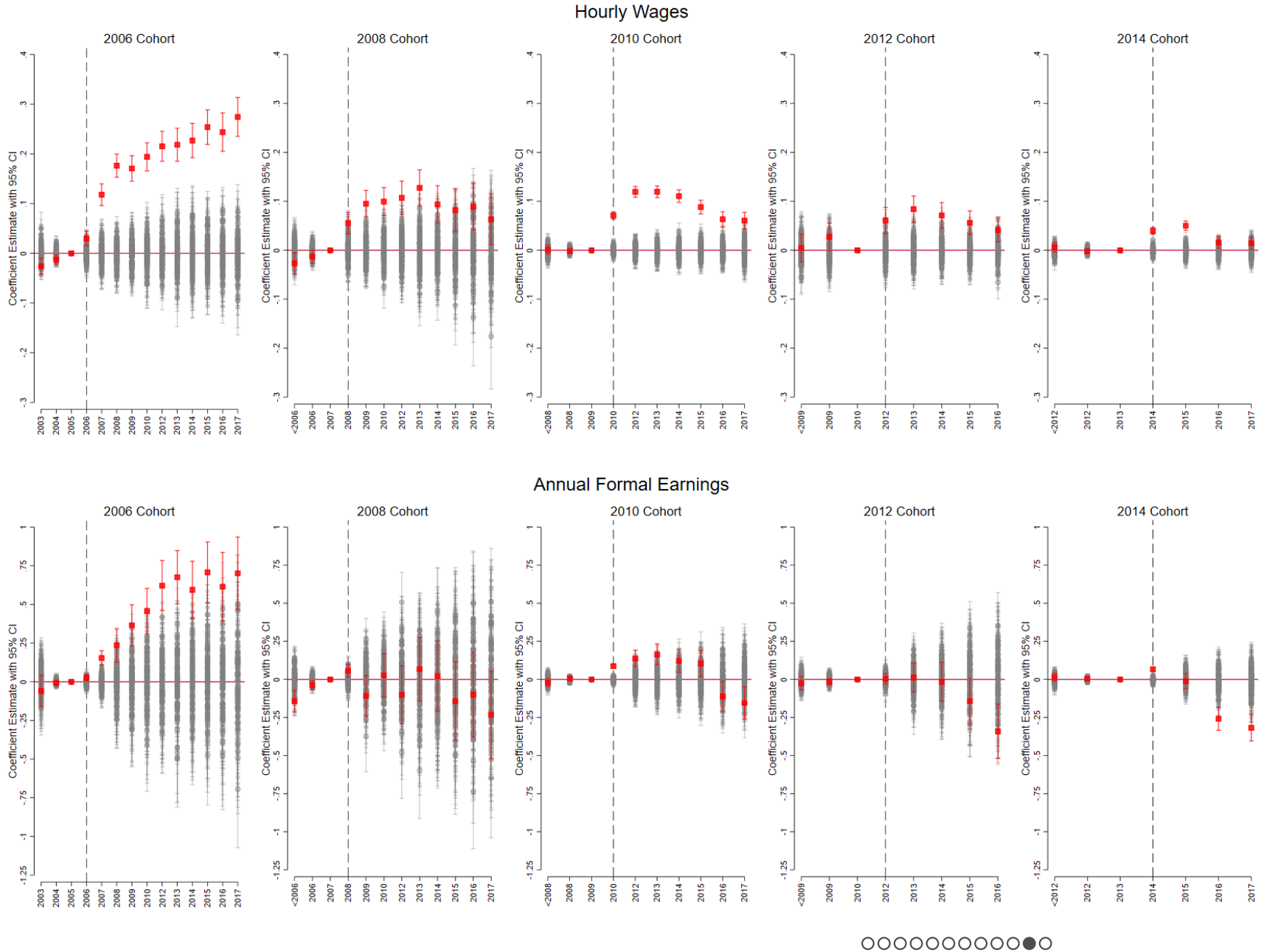


Placebo Tests (Real Estimates vs. 100 Random Treatment Assignments)



Defining Oil-Linked College Majors

Oil-Linked Majors (Narrow Definition)	
Petroleum Engineering	Environmental Management
Geological Engineering	Naval maintenance
Naval Engineering	Petrochemical Maintenance
Shipbuilding	Mining & Extraction
Shipbuilding (non-motorized)	Marine Navigation
Naval Construction	Operation of Ships
Environmental Control	Paleontology
Water Pollution Control	Petrology
Extraction of Petroleum & Gas	Processing of Petroleum & Petrochemicals
Geoscience	Petroleum Refining
Geophysics	Environmental Cleanup
Geology	Environmental Protection Technology

Disaggregate degree programs into:

- 4-Year and Technical
- Public and Private
- STEM and Other

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