The Welfare Cost of Inflation with Skill Loss during Unemployment

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Introduction

- Inflation in the U.S. is at its highest level in 40 years
- The relationship between monetary policy and labor market performance is a classic question
- One reason to worry about inflation is illustrated in Berensten et al. (2011)
- Empirical evidence: workers lose skills during unemployment; lowering productivity (Ortego-Marti, 2017b)
- What is the welfare cost of inflation when workers lose skills during unemployment?

What we do

1. **Theory**: micro-founded model of money with a frictional labor market
   - Our innovation: skill loss during unemployment
2. **Quantitative analysis**: the welfare costs of inflation with skill loss

Key findings

- Estimate welfare cost
  - With skill loss
  - Without skill loss
- At Hosios Condition, the welfare cost of inflation is higher with skill loss.
- Transitioning from the Friedman rule to 10% annual inflation lowers welfare by approximately 5%
- The gap in the welfare cost can be higher when Hosios condition does not hold

(Brief) related literature

- Inflation and unemployment
  - Berentsen et al. (2011); Dong and Xiao (2019); Gu et al. (2019); Gomis-Porqueras et al. (2020); Ait Lahcen et al. (2020); Rocheteau et al. (2021)
- Unemployment, skill loss, and TFP
  - Pissarides (1992); Doppelt (2019); Ortego-Marti (2017a, 2017b)
- Welfare cost of inflation
  - Lucas (2000), Craig and Rocheteau (2008), Bajaj and Mangin (2022)

Environment

Agents, time, and goods

- A large measure of firms
- Measure 1 of households
- Time: $t = 0, 1, \ldots, \infty$
- Each period is divided into three stages
  - **Stage 1**: A decentralized labor market
  - **Stage 2**: Specialized goods are produced and traded in a retail market
  - **Stage 3**: Fiat money and a general good traded in a frictionless market
    - General good taken as the numéraire
- Goods are non-storable across time periods

Timeline

Labor Market (LM)	**Retail Market (RM)**	**Centralized Market (CM)**
– Entry of firms – Matching of workers and firms – Bargaining over wages – Skill loss shocks	– Consumption and sale of specialized goods	– Sale of unsold inventories – Payment of wages – Portfolio choice

Preferences

- Household's lifetime discounted utility:

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t[\epsilon_t v(q_t)+x_t]$$

  - $\beta=(1+\rho)^{-1}\in(0,1)$
  - $\{\epsilon_t\}_{t=0}^{\infty}$ is i.i.d. across agents and time
    - $\Pr[\epsilon_t=1]=\alpha$; $\Pr[\epsilon_t=0]=1-\alpha$
  - $q_t\in\mathbb{R}_+$ is consumption of specialized goods
    - $v(0)=0$, $v'(0)=\infty$, $v'(\infty)=0$
  - $x_t\in\mathbb{R}_+$ is general good consumption

Skills and technology

- Skills indexed by $\varepsilon \in \{L, H\}$: low (L) and high (H)
- Stage 1 production (measured in the general good)
  - High skill: y
  - Low skill: δy
    - $\delta \in (0, 1)$

Skill loss

- High skill workers are susceptible to skill loss
- High skill workers who enter stage 1 unemployed and do not find a job become low-skilled with probability σ
- Skill loss is permanent

Stage 1

- The labor market is unsegmented
- Meeting technology: $\mathcal{N}(u_t, v_t)$
  - Satisfies standard properties
- Worker's skill level is observable to firm upon meeting
- Matches are destroyed at the beginning of stage 1 with probability λ
  - Can not be matched again until period $t + 1$

Stage 2

- Retail market
  - Anonymity and lack of commitment $\rightarrow$ means of payment is essential
  - Fiat money is always recognizable; can not be counterfeited
  - Counterfeit claims to real assets cannot be recognized
- Matched firms can sell q units of their inventory at cost $c(q)$
  - $c'(q) > 0$, $c''(q) \geq 0$

Stage 3

- Households
  - Pay lump-sum taxes T
  - Receive dividends
  - Employed receive their wage
  - Unemployed receive an unemployment benefit $b < \delta y$
- Vacant firms pay k units of the numéraire to enter the labor market
- Agents have the opportunity to accumulate real balances

Distribution of skills

- In-between periods t and $t+1$
  - Fraction $\mu \in (0,1)$ of workers leave the labor force
  - Measure μ of workers enter the labor force as unemployed and high skilled
  - Real balances among those who exit are equally redistributed among new entrants

Government policy

$$G_t + bu_t = T + \phi_t \pi M_t$$

- Government consumption: G_t
- Fiat money supply: M_t
  - $M_{t+1} = (1 + \pi) M_t$
- Price of money in terms of the numéraire: ϕ_t

Equilibrium

Working backwards: stage 3

- Restrict to stationary equilibria
  - Real gross rate of return of money: $1 + r = 1/(1 + \pi)$
- Value of a type $\Omega \in \{L, H\} \times \{0, 1\}$ household

$$W_\Omega(z) = \underbrace{I_\Omega}_{\text{Net income}} + z + \max_{z'} \left\{ -\frac{z'}{1+r} + \underbrace{\bar{\beta}}_{\equiv\beta(1-\mu)} \overbrace{U_\Omega(z')}^{\text{LM continuation value}} \right\}$$

  - Linear in z (as long as b is large enough)
  - We show z' is independent of Ω
    - Degenerate distribution of real balances

Stage 2

- Competitive retail market with price taking behavior

- Household's problem

$$\max_{q^D} \; \upsilon(q^D) - pq^D$$
$$\text{s.t.} \quad pq^D \leq z$$

- Problem of a firm matched with a type ε worker

$$\max_{q_\varepsilon^S} \; pq_\varepsilon^S - c(q_\varepsilon^S)$$
$$\text{s.t.} \quad c(q_\varepsilon^S) \leq y_\varepsilon$$

Revenue

- Prices are equated with marginal cost
- RM profits: $c'\left(q^S\right)q^S - c\left(q^S\right) > 0$ if $c'' > 0$
- Revenue of a vacancy matched with type ε worker

$$R_\varepsilon = y_\varepsilon + c'\left(q^S\right)q^S - c\left(q^S\right)$$

  - Revenue tied to value of money through q^S
  - Real balance channel (BMW, 2011)

Stage 1: Value of unemployment

- Low skill

$$U_{L,0}(z) = \xi_h V_{L,1}(z) + (1 - \xi_h) V_{L,0}(z)$$

- High Skill

$$U_{H,0}(z) = \xi_h V_{H,1}(z) + (1 - \xi_h)\{\underbrace{\sigma V_{L,0}(z) + (1 - \sigma) V_{H,0}(z)}_{\text{Risk of skill loss}}\}$$

Wages and entry of firms

- Wages determined through Nash bargaining:

$$w_\varepsilon = \arg\max \left[V_{\varepsilon,1}(z) - V_{\varepsilon,0}(z)\right]^\gamma \left[K_\varepsilon\right]^{1-\gamma}$$

- Free entry of firms $\rightarrow$ job creation condition

$$\frac{k}{\xi_f} = \bar{\beta}(1-\gamma)\left[\varphi S_L + (1-\varphi)S_H\right]$$

  - φ: (endogenous) fraction of the unemployed who are less-skilled
  - S_ε: total surplus of a match with type ε worker

Equilibrium

Definition: A stationary equilibrium is a vector $\{q, \theta, u, \varphi\}$ such that:

- Optimizing behavior and market clearing in the retail market
- Households make their optimal portfolio choice
- Firms post vacancies until expected profits $= 0$
- Unemployment rate and skill distribution satisfy laws of motion

Characterization

Proposition 1: Assume that

$$k < \frac{(1-\gamma)(\delta y - b)}{(\mu + \rho(1+\mu) + \lambda)}$$

- There exists at least two (non-monetary and monetary) steady-states with $\theta > 0$

- Non-monetary and monetary equilibrium may not be unique

  - Job creation improves the skill distribution among the unemployed (Pissarides, 1992)

Quantitative Analysis

Calibration Choices

- Two version
  - Hosios Condition: $\gamma = \eta$ s.t. congestion exteranlities and thick market externalities cancels out
  - Flinn (2005):Hosios Condition does not hold

Parameter		Hosios Condition	Flinn (2005)
Labor Bargainging Power	γ	0.5	0.4
Match Elasticity	η	0.5	0.196

Model and Data Comparison

Moment	Data	Hosios		Flinn(2005)	
		With Skill Loss	Without Skill Loss	With Skill Loss	Without Skill Loss
Unemployment rate	0.0590	0.0590	0.0590	0.0590	0.0590
$\partial \log(w)/\partial$[unemp. duration](-)	0.012	0.011	-	0.0121	-
Average Money demand	0.1740	0.1767	0.1741	0.1739	0.174
Elasticity of money demand (-)	0.3830	0.3839	0.383	0.3830	0.3826

Welfare Cost of Inflation

$$\mathcal{W}(q,\theta) = \overbrace{-k\theta u(\theta)}^{\text{Vacancy Cost}} + \overbrace{(1-u(\theta))[\varphi\delta y + (1-\varphi(\theta))y]}^{\text{LM output}}$$
$$+ \underbrace{u(\theta)b}_{\text{Unemp. Consump.}} + \underbrace{\alpha\upsilon(q)}_{\text{RM consump.}} - \underbrace{(1-u(\theta))c\left(\frac{\alpha q}{1-u(\theta)}\right)}_{\text{Prod. cost in RM}}$$

$$\mathcal{W}(q,\theta,\Delta_\pi) = \overbrace{-k\theta u(\theta)}^{\text{Vacancy Cost}} + \overbrace{\Delta_\pi(1-u(\theta))[\varphi\delta y + (1-\varphi(\theta))y]}^{\text{LM output}}$$
$$+ \underbrace{\Delta_\pi u(\theta)b}_{\text{Unemp. Consump.}} + \underbrace{\alpha\upsilon(q\Delta_\pi)}_{\text{RM consump.}} - \underbrace{(1-u(\theta))c\left(\frac{\alpha q}{1-u(\theta)}\right)}_{\text{Prod. cost in RM}}$$

Welfare Cost of Inflation

- Define function

$$\mathcal{W}(\Delta_\pi) \equiv \mathcal{W}(q_{i0}, \theta_{i0}, \Delta_\pi)$$

- Solve for Δ_π such that

$$\mathcal{W}(\Delta_\pi) = \mathcal{W}(q, \theta) \text{ at interest rate } i_\pi$$

  where $i_\pi \equiv \frac{\pi+1}{1+r} - 1$

- Welfare cost $(1 - \Delta_\pi)$: the fraction of consumption an individual is willing to give up to transition from π% to 0% inflation

Welfare Cost of Inflation

$$\mathcal{W}(q,\theta) = \overbrace{-k\theta u(\theta)}^{\text{Vacancy Cost}} + \overbrace{(1-u(\theta))[\varphi\delta y + (1-\varphi(\theta))y]}^{\text{LM output}}$$
$$+ \underbrace{u(\theta)b}_{\text{Unemp. Consump.}} + \underbrace{\alpha\upsilon(q)}_{\text{RM consump.}} - \underbrace{(1-u(\theta))c\left(\frac{\alpha q}{1-u(\theta)}\right)}_{\text{Prod. cost in RM}}$$

- Real balance channel (BMW)
  - Real balances are more costly to hold $\rightarrow$ q decreases
  - Firms post less vacancies $\rightarrow$ u increases
  - Net impact on an individual firm's RM output is ambiguous

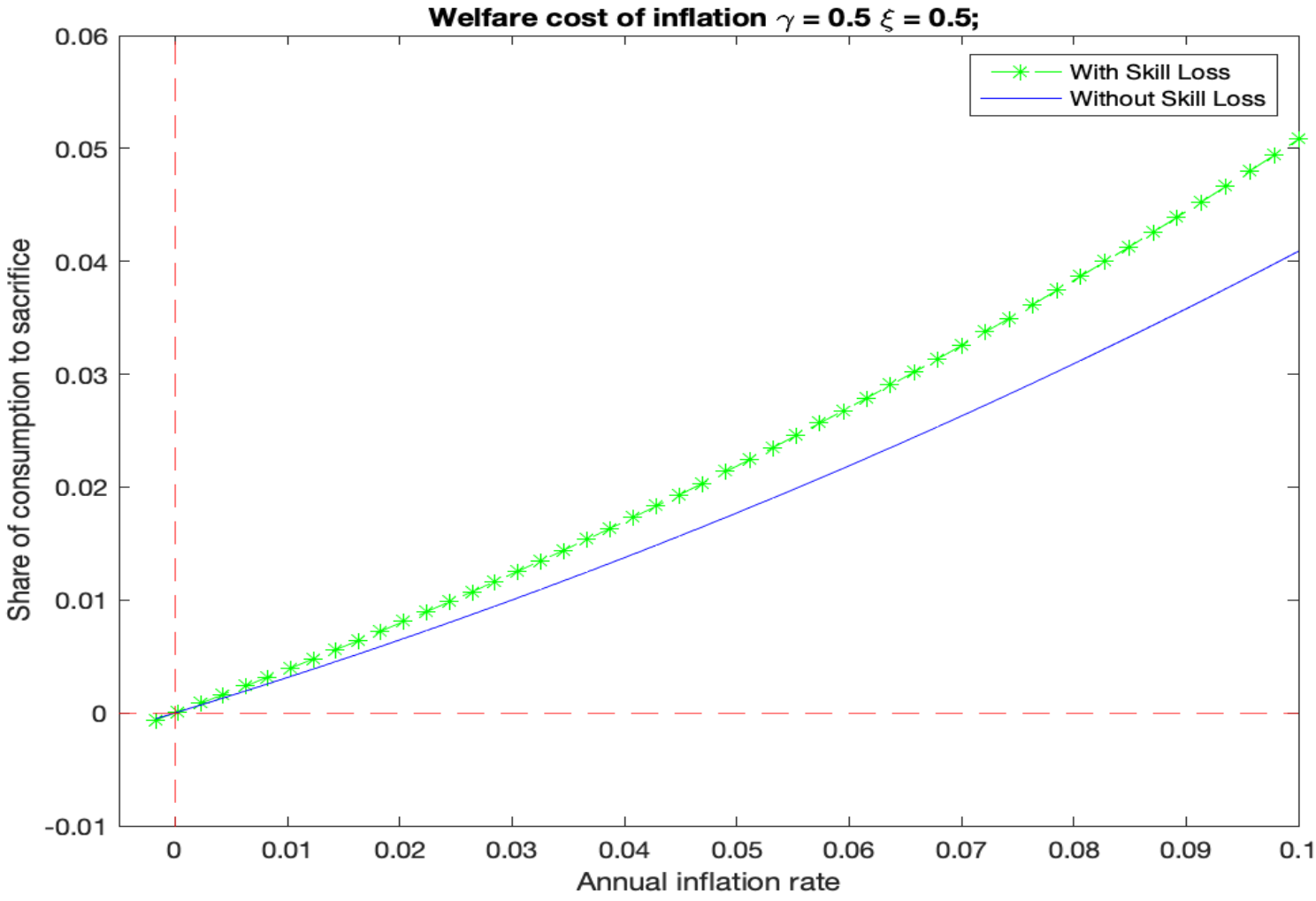
Welfare Cost of Inflation

$$\mathcal{W}(q,\theta) = \overbrace{-k\theta u(\theta)}^{\text{Vacancy Cost}} + \overbrace{(1-u(\theta))[\varphi\delta y + (1-\varphi(\theta))y]}^{\text{LM output}}$$
$$+ \underbrace{u(\theta)b}_{\text{Unemp. Consump.}} + \underbrace{\alpha v(q)}_{\text{RM consump.}} - \underbrace{(1-u(\theta))c\left(\frac{\alpha q}{1-u(\theta)}\right)}_{\text{Prod. cost in RM}}$$

- Skill loss channel
  - Skill distribution deteriorates $\rightarrow \varphi$ increases
  - Average LM production decreases

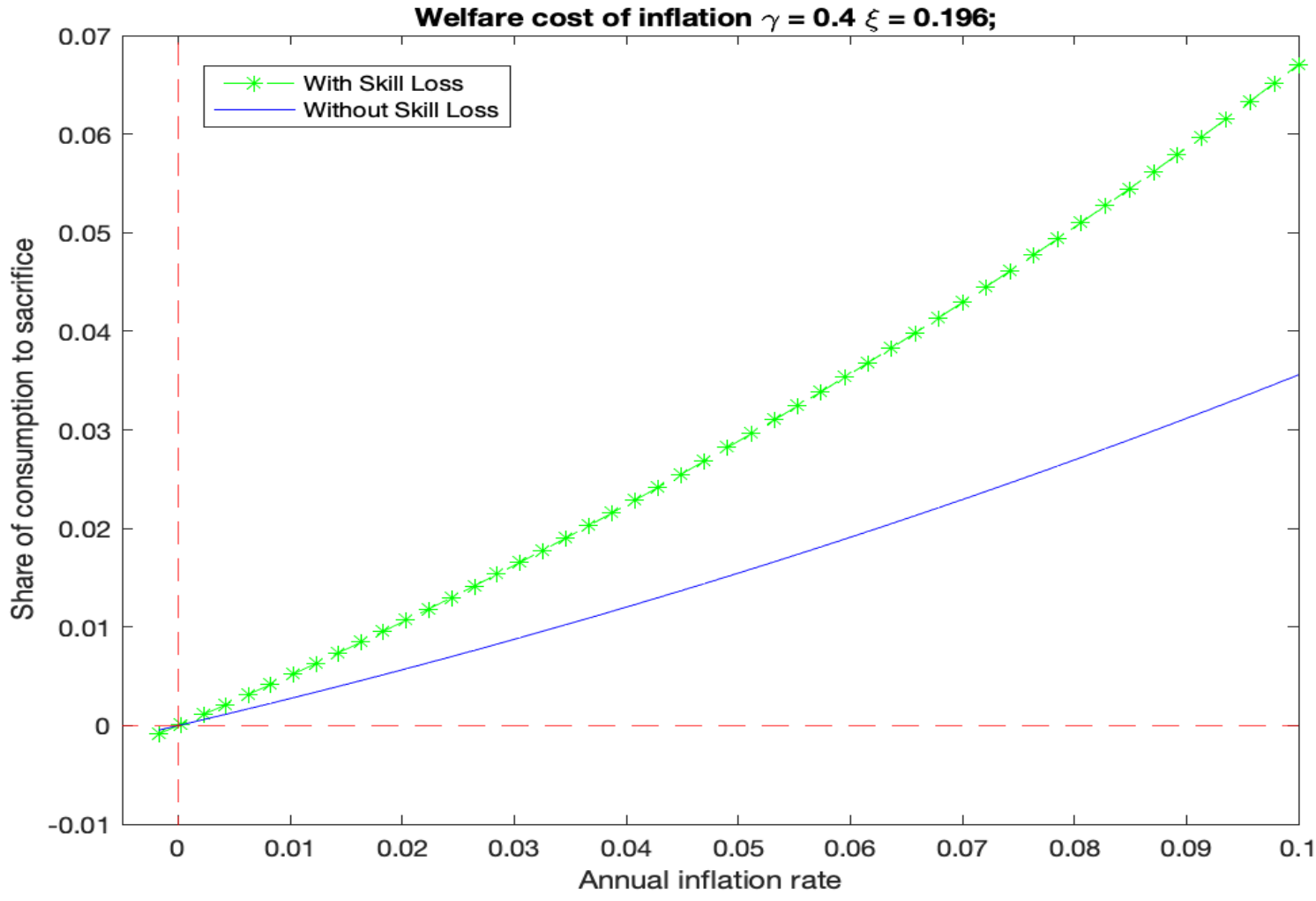
Welfare Cost of Inflation

Hosios Condition



Welfare Cost of Inflation

Flinn (2005)



Friedman rule to 10% inflation

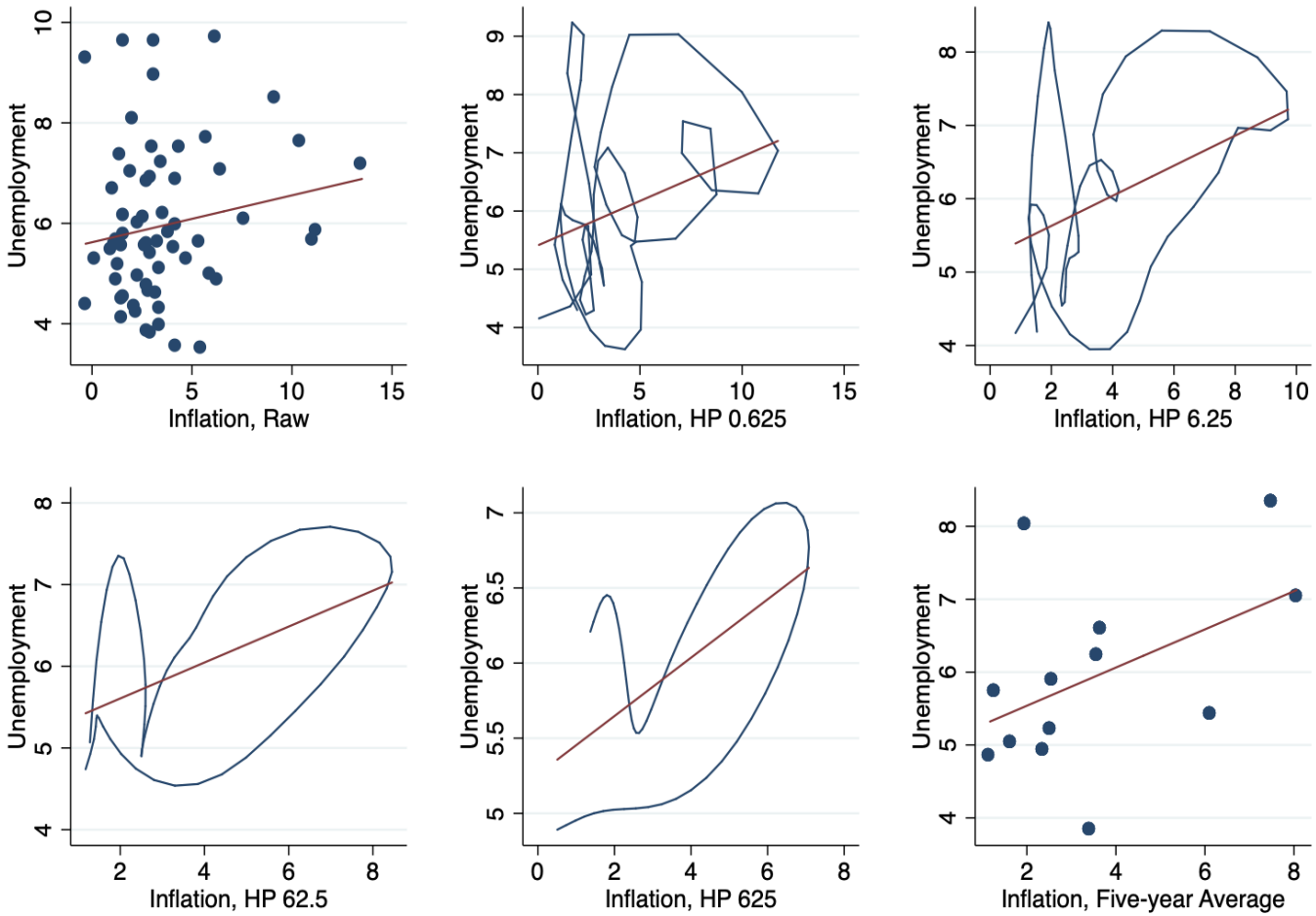
Welfare Cost		Friedman rule	10% annual inflation
With Skill Loss			
	Hosios Condition	$-6.2066e-04$	0.0508
	Flinn (2005)	$-8.1967e-04$	0.067
Without Skill Loss			
	Hosios Condition	$-5.0606e-04$	0.0409
	Flinn (2005)	$-4.4363e-04$	0.0356

Conclusion

Conclusions

- Monetary search model with skill loss during unemployment
- Under Hosios condition, transitioning from the Friedman rule to 10% annual inflation lowers welfare by approximately 5%
- Under Hosios Condition, the welfare cost of inflation is higher with skill loss
- Next steps...
  - Examine mechanism of the welfare gap due to skill loss.
  - Understand externalities associated with skill loss

Inflation and unemployment



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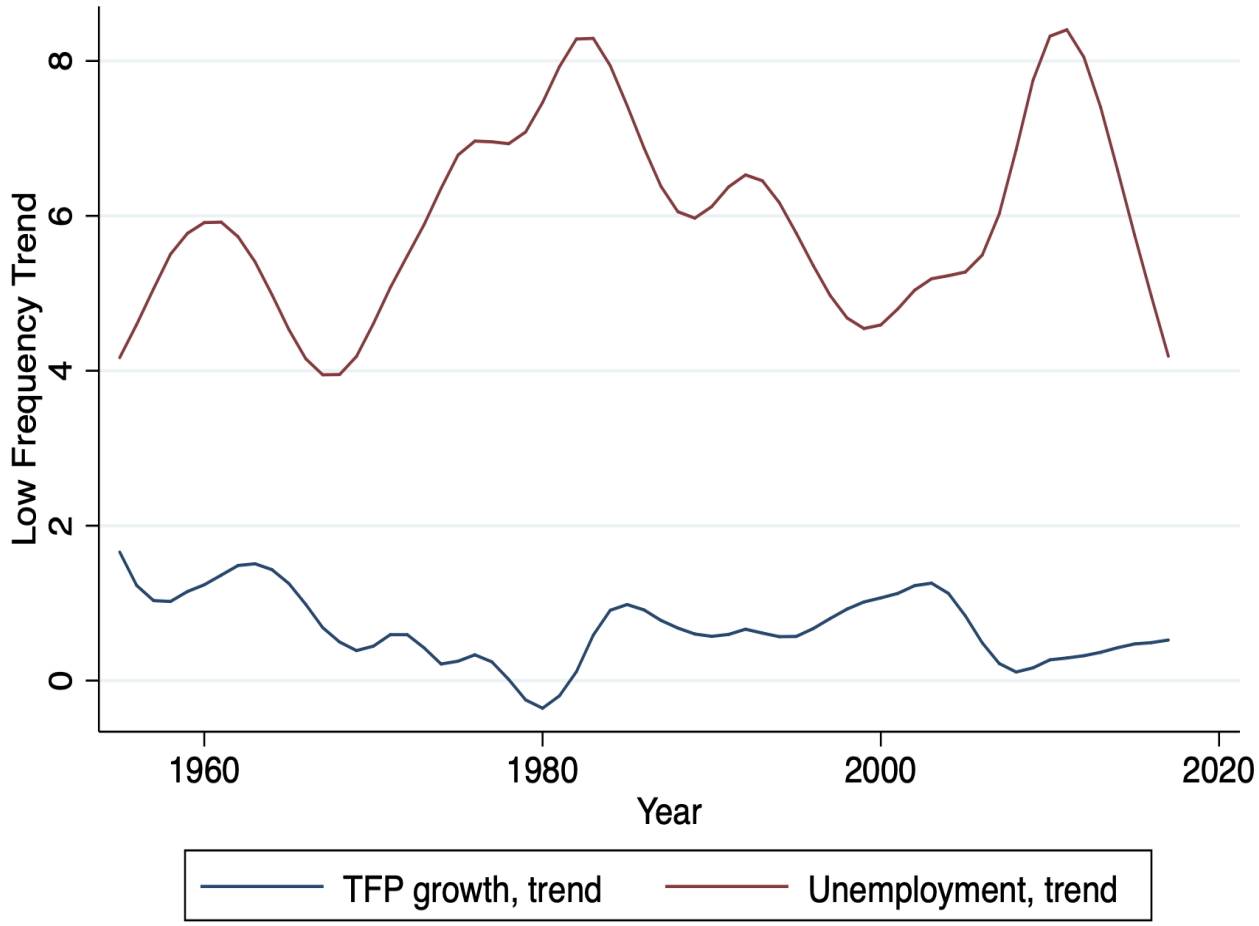
Unemployment and TFP growth



Correlation $= -0.5481$

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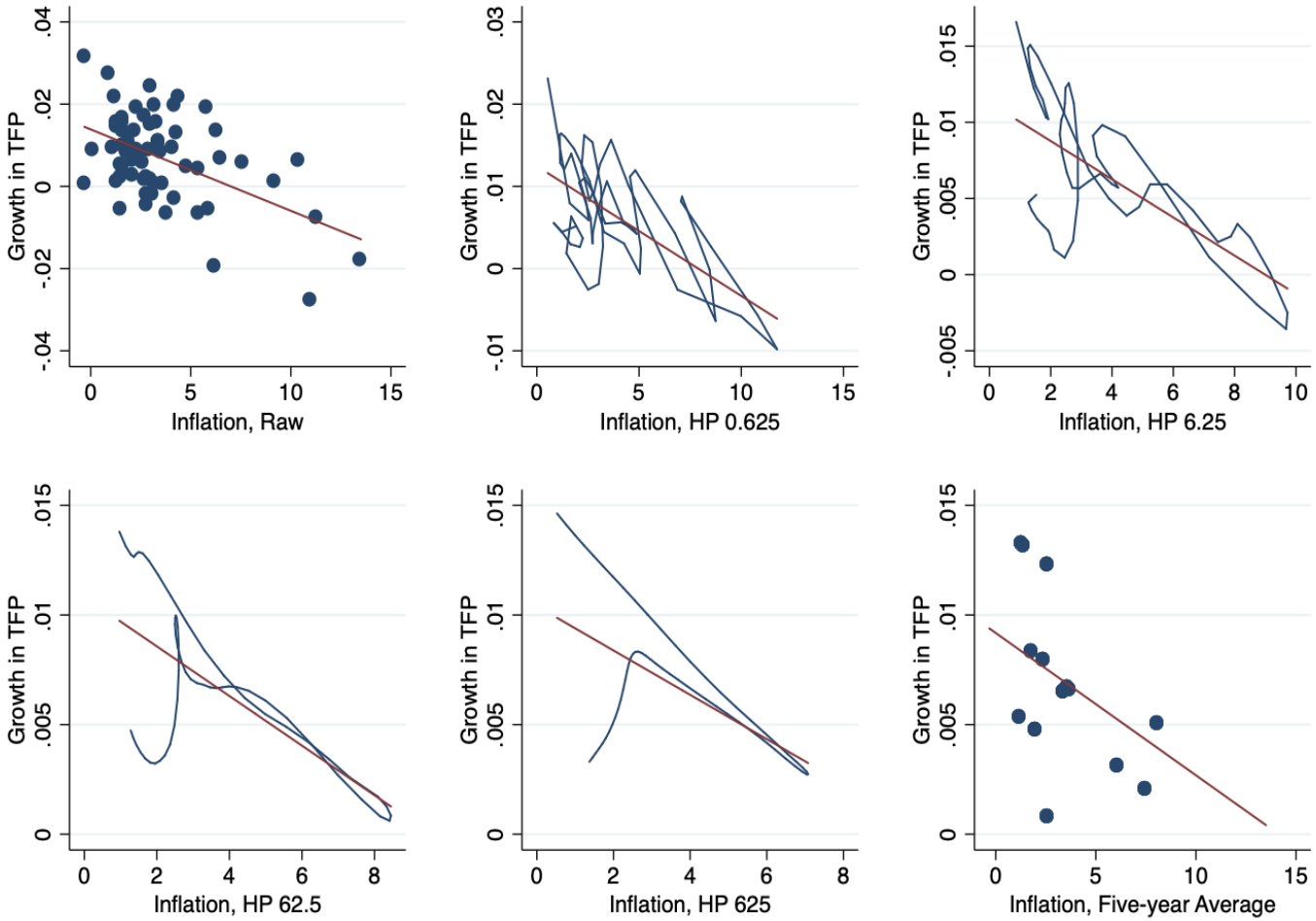
Inflation and TFP growth



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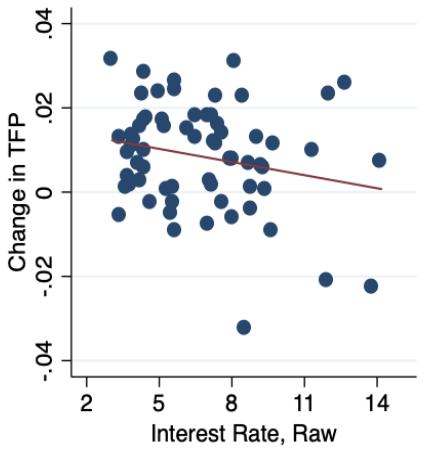
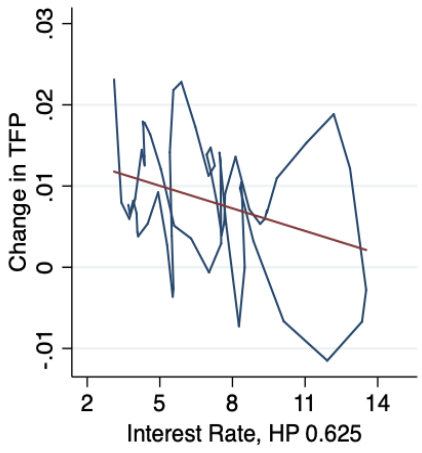
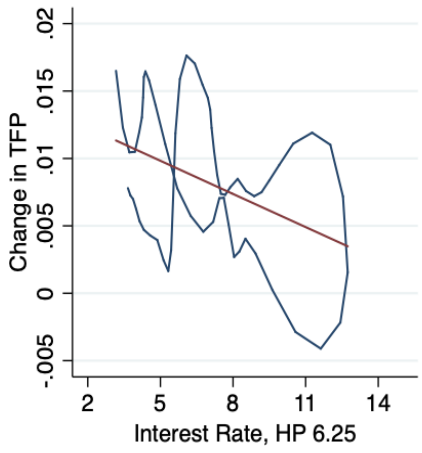
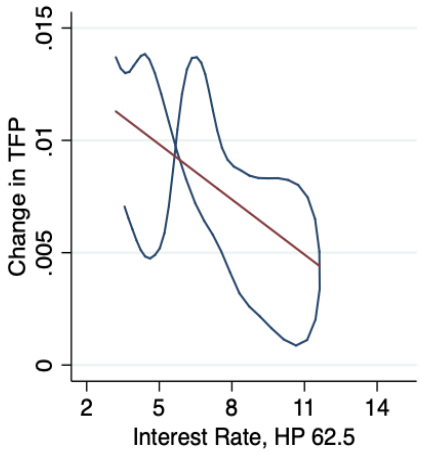
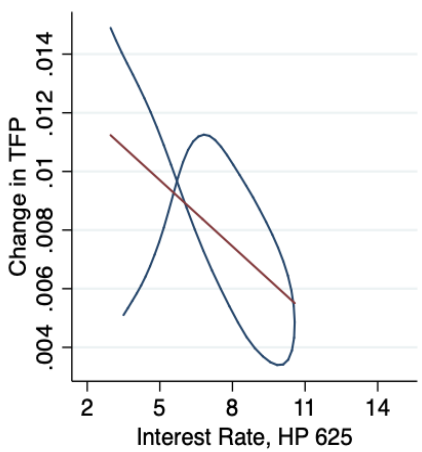
Interest rates and TFP differences

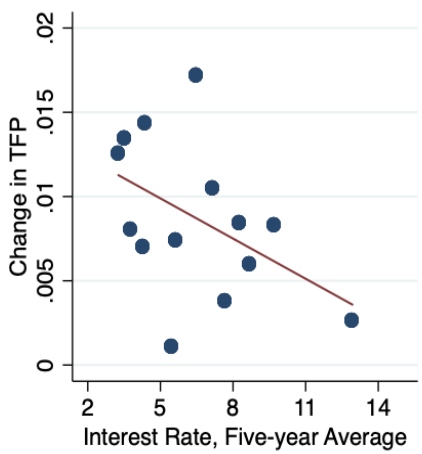












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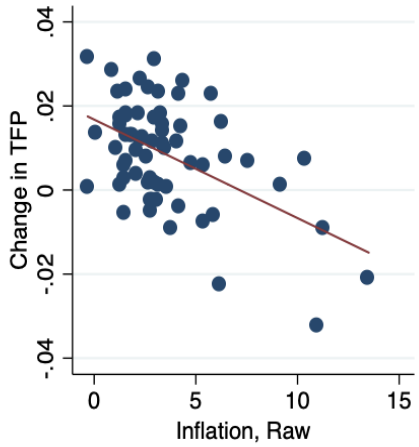
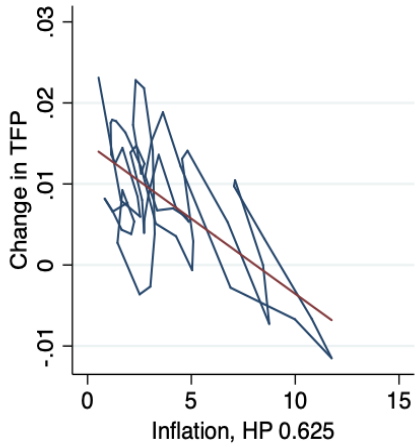
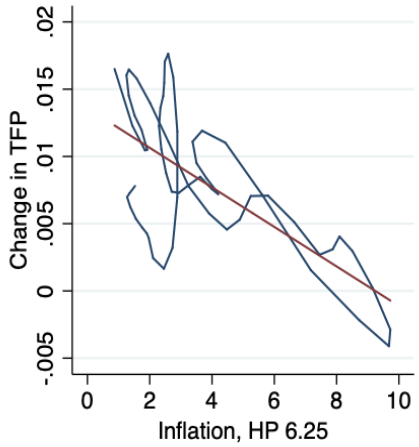
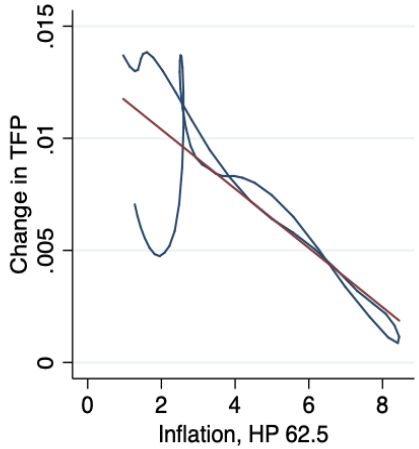
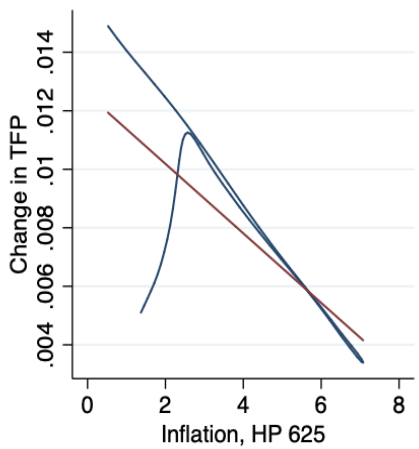
Inflation and TFP differences

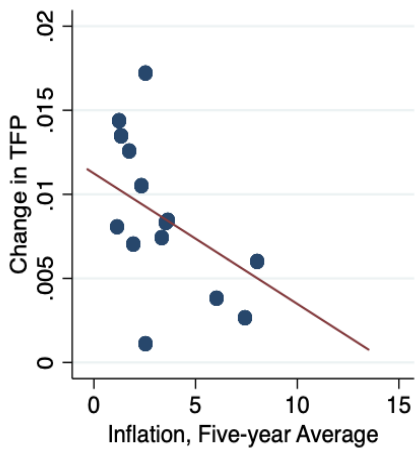












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Characterization

Proposition: Assume that

$$k_\chi < \frac{(1-\gamma)\sigma(1-\mu)(\delta_\chi y_\chi - b)}{(\mu+\rho(1+\mu)+\lambda)(\mu+(1-\mu)\sigma)} \quad \text{for } \chi \in \{s, c\}$$

- There exists at least two (non-monetary and monetary) steady-states with $\theta > 0$ and $\zeta \in (0, 1)$
- Non-monetary and monetary equilibrium may not be unique

Back

Match formation

Proposition: Define $\overline{q} \equiv \arg\max\{c'(q)q - c(q)\}$. All matches generate a positive surplus if

$$\frac{\delta_\chi y_\chi + [c'(\overline{q})\overline{q} - c(\overline{q})] - b}{\delta_{\chi'} y_{\chi'} - b} < \frac{\mu + \rho(1+\mu) + \lambda + \gamma}{\gamma} \quad \text{for } \chi \in \{s, c\}$$

Back

Measuring job complexity

- Job complexity measured by comparing abstract and manual tasks
- Abstract and manual task inputs from US Department of Labor's Dictionary of Occupation Titles (Autor and Dorn, 2013)

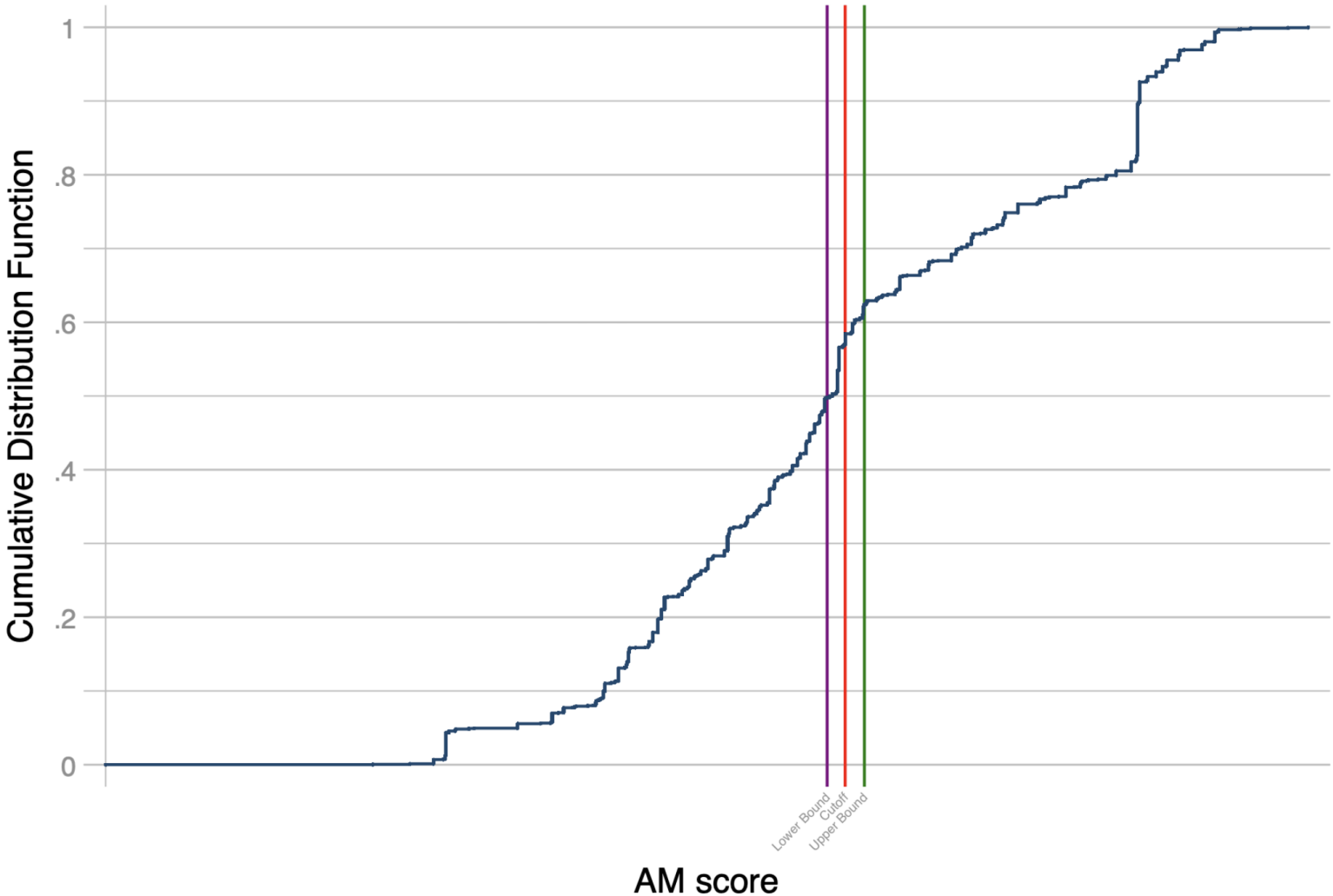
Measuring job complexity

- Normalized measure of job complexity for occupation k:

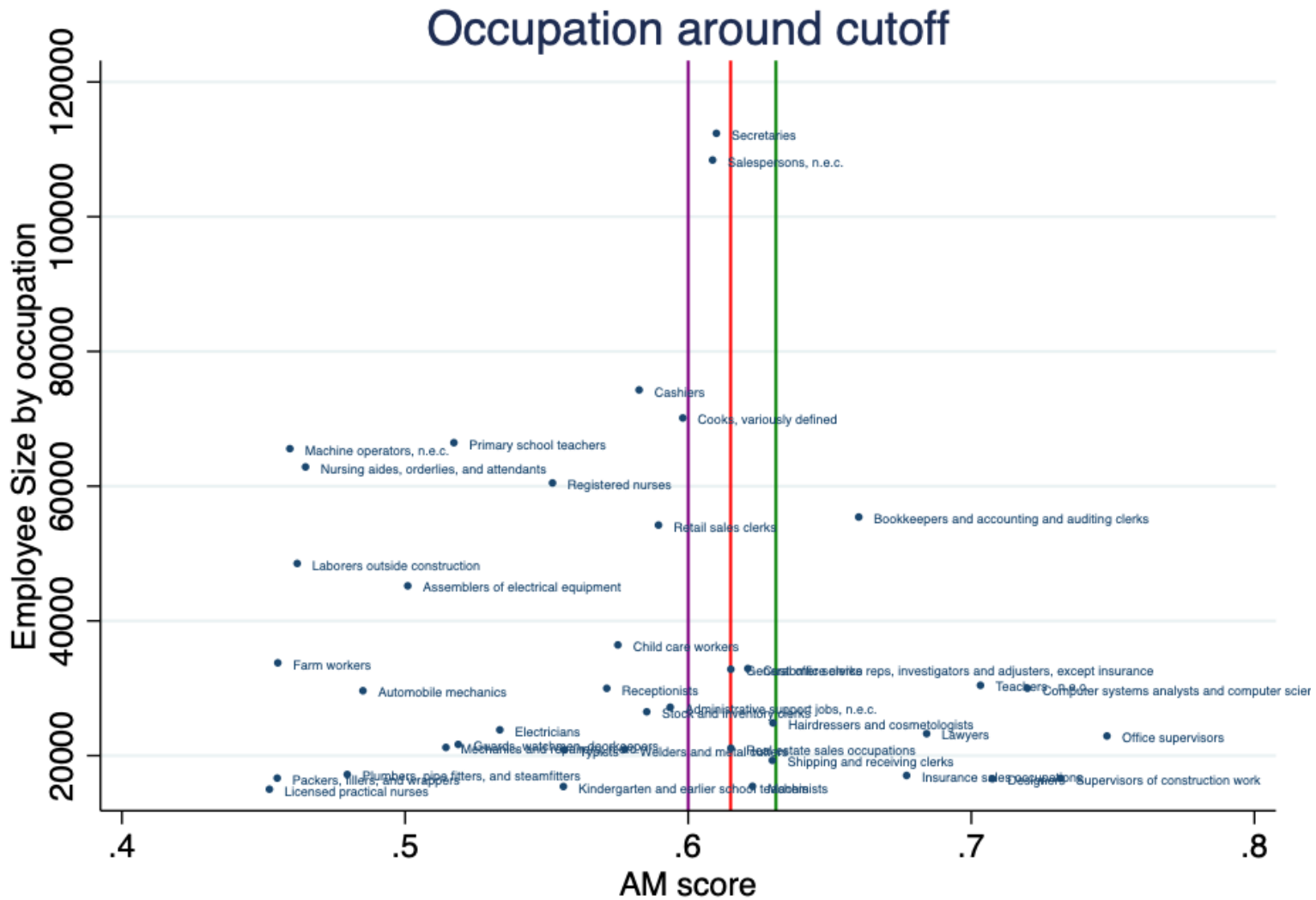
$$AM_k = \frac{\left(T^A_{k,1980} - T^M_{k,1980}\right) - \underline{AM}}{\overline{AM} - \underline{AM}}$$

  - $T^A_{k,1980}$: abstract task input
  - $T^M_{k,1980}$: manual task input
  - $\underline{AM} \equiv \min\left\{T^A_{1,1980} - T^M_{1,1980}, \ldots, T^A_{K,1980} - T^M_{K,1980}\right\}$
  - $\overline{AM} \equiv \max\left\{T^A_{1,1980} - T^M_{1,1980}, \ldots, T^A_{K,1980} - T^M_{K,1980}\right\}$

Complex Job Cutoff



Occupations Around Cutoff



Calibration strategy Complex job cutoff

Detail on task scores

- Task scores are created by Autor and Dorn (2013) using the US Department of Labor's *Dictionary of Occupational Titles* (DOT)
  - $T^{M}_{k,1980}$: DOT variable for occupation's demand for "eye-hand-foot coordination"
  - $T^{A}_{k,1980}$: average of
    1. DOT variable for "direction control and planning" which measures managerial and interactive task
    2. "GED Math", measuring mathematical and formal reasoning requirement

Back Calibration strategy

Highest and lowest AM scores

Table 4: Occupation with the highest and lowest AM

Highest 20	AM	Lowest 20	AM
Physical Scientist	1	Dancers	0
Chemical Engineers	0.983	Parking Lot Attendant	0.222
Chemists	0.952	Paving, surfacing, and tamping equipment operators	0.253
Actuaries	0.944	Operating Engineers of construction equipment	0.273
Dietitians and Nutritionists	0.942	Fire Fighting	0.273
Metallurgical and Materials Engineers	0.926	Excavating and Loading Machine Operators	0.281
Mechanical Engineers	0.926	Bus Driver	0.283
Funeral Directors	0.924	Truck, Delivery, and Tractor Drivers	0.283
Accountants and Auditors	0.922	Taxi Cab Driver	0.285
Petroleum, Mining and Geological Engineers	0.921	Roofer and Slaters	0.291
Managers of Medicine	0.914	Crane, derrick, winch, and hoist operators	0.291
Financial Managers	0.911	Structural Metal Workers	0.302
Aerospace Engineer	0.897	Plasterers	0.306
Atmospheric and Space Scientists	0.895	Textile and Sewing Machine Operator	0.343
Other Financial Specialist	0.893	Garbage and Recyclable Material Collector	0.343
Subject Instructor (HS/College)	0.892	Driller of Earth	0.361
Managers and Specialists in Marketing, Advertising, and Public relations	0.883	Railroad brake, coupler, and switch operators	0.362
Biological Scientists	0.882	Millwrights	0.370
Computer Software Developer	0.879	Carpenter	0.371

Back Calibration strategy

Effect of unemployment duration on wages (Ortego-Marti, 2017a)

Occupation	
Professional, technical	-0.0177
Managers, officials	-0.0208
Clerical, sales	-0.0164
Craftsmen, foremen	-0.0078
Operatives	-0.0039

Simple occupations are highlighted in **green**