From Biology to Wages: Lifecycle Comparative Advantage in Task Space

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Motivation

- Older and younger workers are imperfect substitutes.
- The relative supply of older workers has increased substantially.
- Yet relative wages of older workers have **risen**, not fallen.
- Standard models: increased supply $\Rightarrow$ lower relative wage.
- What explains this?

This Paper

1. **Framework:** Task-based model where workers have three skill dimensions—physical, fluid cognitive, crystallized cognitive—that evolve differently with age. Explicit focus on biologically-determined endowments.

2. **Mechanism:** Productivity depends on *distance* between worker skills and task requirements. Aging shifts comparative advantage across task space.

3. **Application:** Study general equilibrium effects of introduction of "age-friendly" technology. Result: counterintuitive distributional consequences.

Workers are endowed with three skill types that follow **distinct biological trajectories**:

Physical (s_P)

- VO2 max, grip strength
- Peaks $\sim$25
- Declines steadily

Fluid (s_F)

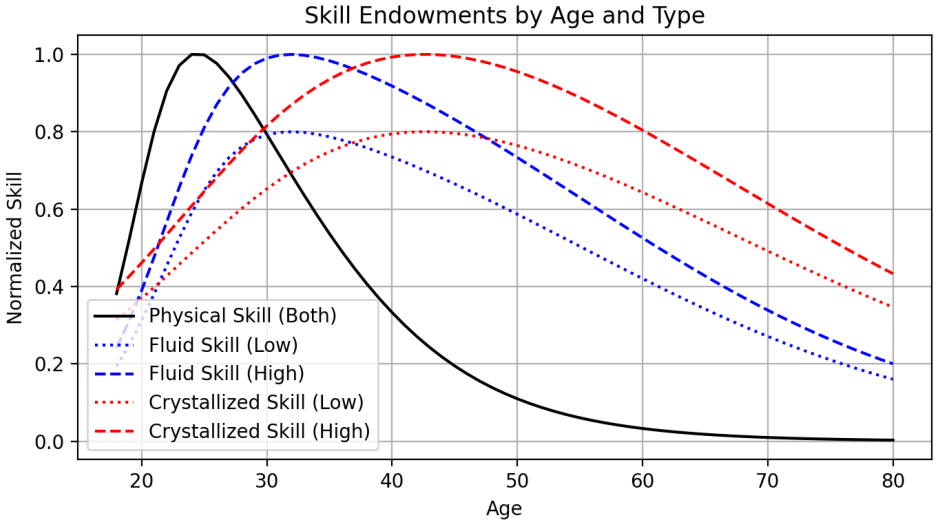
- Processing speed, novel problem-solving
- Peaks $\sim$30–35
- Gradual decline

Crystallized (s_C)

- Accumulated knowledge, expert judgment
- Peaks $\sim$50–60
- Slower decline

These are **immutable biological endowments**, not job-specific human capital.

Skill Endowments by Age



Tasks: Each task j is defined by a requirement vector $T_j = (\tau_P, \tau_F, \tau_C)$.

Final Good: CES aggregator over tasks with demand shifters D_j:

$$Y = \left(\sum_{j \in \mathcal{T}} (D_j y_j)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

Task Demand:

$$y_j = Y \cdot p_j^{-\sigma} \cdot D_j^{\sigma-1}$$

Productivity in task j depends on match quality:

$$\Gamma(i,j) = \underbrace{G(i)}_{\text{Absolute productivity}} - \underbrace{M(i,j)}_{\text{Mismatch cost}}$$

where the mismatch cost is:

$$M(i,j) = \sum_{k \in \{P,F,C\}} \frac{\theta_k}{2} \left(s_k(i) - \tau_k(j)\right)^2$$

Key insight: Older workers are not "less productive"—they are *mismatched* for physical/fluid tasks but well-matched for crystallized tasks.

Occupational Sorting

Workers choose tasks to maximize expected income:

$$w(i,j) = p_j \cdot \Gamma(i,j)$$

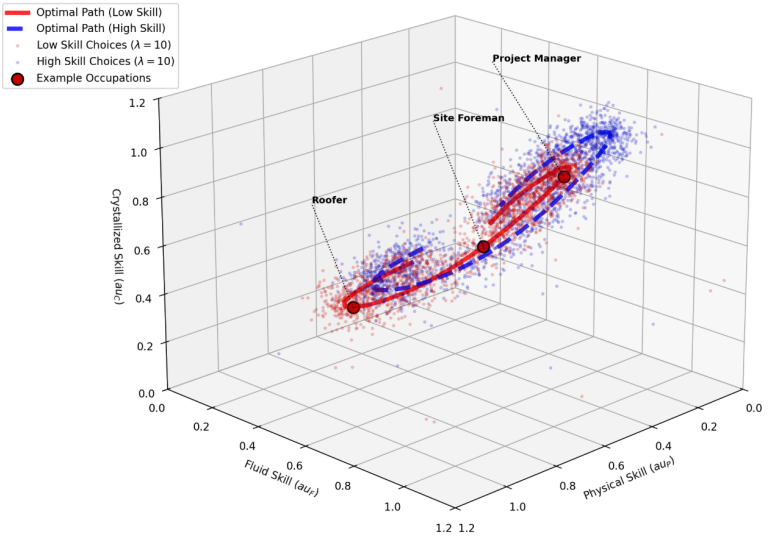
Probabilistic sorting (logit):

$$\pi(i,j) = \frac{\exp(\lambda \cdot w(i,j))}{\sum_{j'} \exp(\lambda \cdot w(i,j'))}$$

Optimal task choice: Balance skill premium against mismatch cost.

$$\tau_k^* = s_k(i) + \underbrace{\frac{1}{\theta_k} \cdot \frac{\Gamma(i,T^*)}{p(T^*)} \cdot \frac{\partial p}{\partial \tau_k}}_{\text{Deviation toward high-price tasks}}$$

Lifecycle Paths Through Task Space



Policy Experiment: Age-Friendly Technology

Setting: Warehouse worker moving boxes.

Before

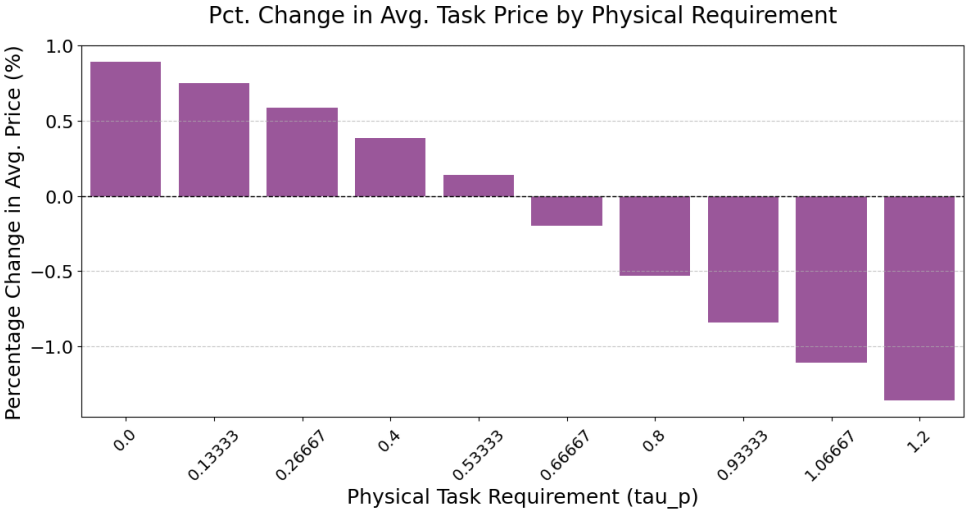
- Task: manually lift boxes
- High physical requirement τ_P
- Older workers face large mismatch cost

After

- Firm adopts lift-assist or exoskeleton
- Task: operate tool to move boxes
- Physical requirement τ_P falls

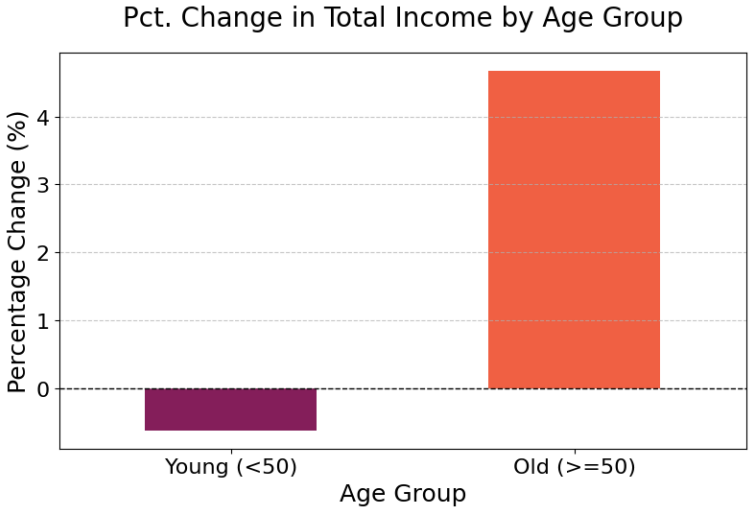
Question: What are the general equilibrium effects on wages and sorting?

Result: Task Prices Adjust



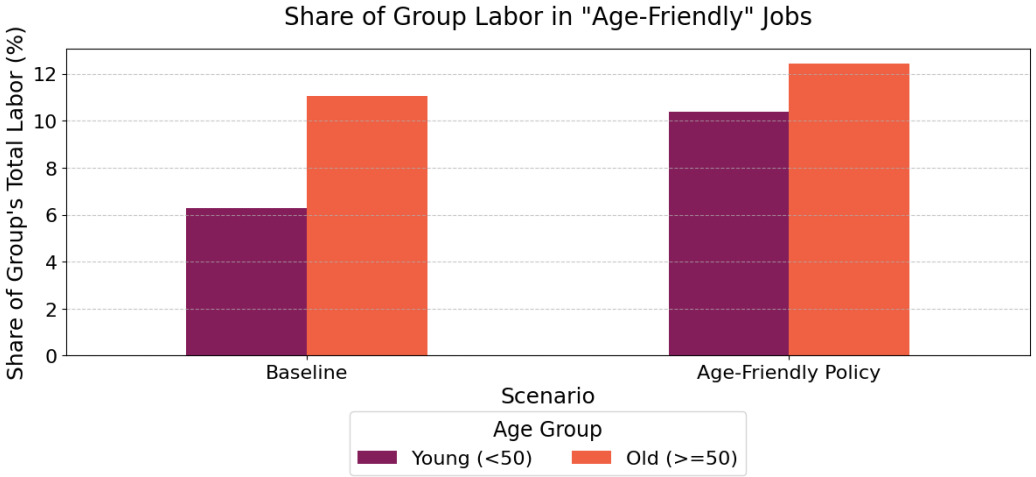
Low-physical tasks command higher prices; high-physical tasks fall.

Result: Older Workers Gain Income Share



Older workers (≥ 50) gain $\sim$5%; younger workers lose $\sim$0.5%.

Result: "Age-Friendly" Jobs Accrue to the Young



Young workers increase share in low-physical jobs more than old workers.

Mechanism: Price changes shift comparative advantage; re-sorting follows.

Takeaways

1. Modeling distinct, biologically-determined, skill trajectories explains why older and younger workers are imperfect substitutes, and why relative wages need not fall with supply.

2. Productivity is *distance-dependent*: workers are not "better" or "worse," but differently matched to tasks.

3. General equilibrium effects of age-friendly technology are complex: intended beneficiaries may not be the primary recipients.