Growth Accounting with Non-Wage Amenities

Gerard Maideu-Morera

Toulouse School of Economics

August 2025

Non-wage amenities are typically excluded in macro measurements

- Improvements in non-wage amenities (e.g., safety) can raise living standards
- Amenities are goods: enter the utility function and are part of the production process

Non-wage amenities are typically excluded in macro measurements

- Improvements in non-wage amenities (e.g., safety) can raise living standards
- Amenities are goods: enter the utility function and are part of the production process

Q1: Is it a problem to exclude amenities?

- Welfare assessments incomplete
- Productivity mismeasured as long as amenities are costly to provide; and wages $\neq$ MPLs

Non-wage amenities are typically excluded in macro measurements

- Improvements in non-wage amenities (e.g., safety) can raise living standards
- Amenities are goods: enter the utility function and are part of the production process

Q1: Is it a problem to exclude amenities?

- Welfare assessments incomplete
- Productivity mismeasured as long as amenities are costly to provide; and wages $\neq$ MPLs

Q2: How should macro measurements/growth accounting be adjusted?

- My approach: aggregate the shadow value of amenities into output and redo the traditional growth accounting

Non-wage amenities are typically excluded in macro measurements

- Improvements in non-wage amenities (e.g., safety) can raise living standards
- Amenities are goods: enter the utility function and are part of the production process

Q1: Is it a problem to exclude amenities?

- Welfare assessments incomplete
- Productivity mismeasured as long as amenities are costly to provide; and wages $\neq$ MPLs

Q2: How should macro measurements/growth accounting be adjusted?

- My approach: aggregate the shadow value of amenities into output and redo the traditional growth accounting

Q3: Quantitative relevance?

- Depends on size of compensating differentials (i.e. shadow prices)

Results

Model: GE generalized Roy model with costly amenity provision by producers

Mismeasurement under the conventional TFP:

- Changes in labor supply, reallocations of workers across producers, and changes in expenditures on amenities affect measured TFP growth

Results

Model: GE generalized Roy model with costly amenity provision by producers

Mismeasurement under the conventional TFP:

- Changes in labor supply, reallocations of workers across producers, and changes in expenditures on amenities affect measured TFP growth

Augmented measurements that include the value of amenities:

- Show a Hulten's thm (macro envelope condition) for augmented TFP growth

Results

Model: GE generalized Roy model with costly amenity provision by producers

Mismeasurement under the conventional TFP:

- Changes in labor supply, reallocations of workers across producers, and changes in expenditures on amenities affect measured TFP growth

Augmented measurements that include the value of amenities:

- Show a Hulten's thm (macro envelope condition) for augmented TFP growth

Results

Model: GE generalized Roy model with costly amenity provision by producers

Mismeasurement under the conventional TFP:

- Changes in labor supply, reallocations of workers across producers, and changes in expenditures on amenities affect measured TFP growth

Augmented measurements that include the value of amenities:

- Show a Hulten's thm (macro envelope condition) for augmented TFP growth

Quantitative evaluation:

- Occupational reallocation US since 1980; hedonic pricing with occ. level amenity data
- The conventional TFP measure underestimated productivity improvements by 25%, but find larger growth slowdown since mid-2000s

Related Literature

1. **Growth accounting:** Hulten (1978), Basu and Fernald (2002), Petrin and Levinsohn (2012), Baqaee and Farhi (2020), Dávila and Schaab (2023) ⇒ Growth accounting theory with amenities; productivity improvements mismeasured; Hulten's thm iff include value of amenities
   - **Productivity growth slowdown:** Fernald (2015), Syverson (2017), Byrne et al. (2016), Gordon (2018), Rachel (2024), De Ridder and Lukasz (2025) ⇒ estimate larger slowdown
2. **Welfare measures beyond GDP:** Nordhaus and Tobin (1972), Becker et al. (2005), Jones and Klenow (2016)... ⇒ focus on job amenities; aggregate amenities into output through shadow prices and then follow the same approach of the traditional growth accounting literature
3. **Changes in non-wage job characteristics over time:** Hamermesh (1999), Hamermesh (2001), Boar and Lashkari (2021), Kaplan and Schulhofer-Wohl (2018) ⇒ Estimate value amenities with hedonic pricing and quantify aggregate effects

Outline

1. Model
2. Examples
3. Augmented measurements
4. Conventional vs augmented TFP growth
5. Quantitative application

Environment

- Generalized Roy model with costly amenity provision by firms
- **Workers** with heterogeneous skills and preferences for consumption goods and amenities
- **Producer types** differ in their production functions and costs of providing amenity bundles
  - Cost stems from purchases of an intermediate input, but consider several alternatives

Workers

- Continuum of workers indexed by $i \in [0,1]$, skill type $\theta_i \in \mathbb{R}^L_+$, mass $f(\theta)$
- **Preferences:**

$$U_i(\underbrace{\{c_n\}}_{\text{Consumption goods}}, \underbrace{\{a_m\}}_{\text{Amenities}}, \underbrace{1-l}_{\text{Leisure}})$$

  - Increasing in all arguments but no restrictions on preference heterogeneity otherwise

- Given wage w_i, **budget constraint:**

$$\sum_n p_n c_{i,n} = w_i l_i + Q k_i$$

- **Choose:** producer type, wage-amenity bundle from the menu offered by the producer, labor supply, and quantity of each consumption good

Producers

- Finite set of **intermediate producer types** indexed by $j \in \mathcal{J}$

Producers

- Finite set of **intermediate producer types** indexed by $j \in \mathcal{J}$
- **Production functions:**

$$y_j = z_j m_j(\{h^j(\theta)\}_\theta)$$

  - $h^j(\theta)$ labor input of type θ in j; z_j producer-specific technology shifter

Producers

- Finite set of **intermediate producer types** indexed by $j \in \mathcal{J}$
- **Production functions:**

$$y_j = z_j m_j(\{h^j(\theta)\}_\theta)$$

  - $h^j(\theta)$ labor input of type θ in j; z_j producer-specific technology shifter

- **Costs of amenity provision:** expenditures on intermediate y_A

$$p_A \times g_j(\{a_m\}; q_j) \times l$$

  - p_A price of the input used to provide the amenities
  - q_j (Hicks-neutral) shifter to the cost of providing amenities

Producers

- Finite set of **intermediate producer types** indexed by $j \in \mathcal{J}$
- **Production functions:**

$$y_j = z_j m_j(\{h^j(\theta)\}_\theta)$$

  - $h^j(\theta)$ labor input of type θ in j; z_j producer-specific technology shifter

- **Costs of amenity provision:** expenditures on intermediate y_A

$$p_A \times g_j(\{a_m\}; q_j) \times l$$

  - p_A price of the input used to provide the amenities
  - q_j (Hicks-neutral) shifter to the cost of providing amenities

- **Final goods:** $Y_n = F_n(\{y_{n,j}\}_j, K_n)$
- **Input used to provide amenities:** $Y_A = F_A(\{y_{A,j}\}_j, K_A)$

Wage-amenity determination

- **Total cost of compensation** per unit of labor: $\widetilde{w}_{j,i} = w_i + p_A g_j(\{a_{m,i}\}_m; q_j)$

Wage-amenity determination

- **Total cost of compensation** per unit of labor: $\widetilde{w}_{j,i} = w_i + p_A g_j(\{a_{m,i}\}_m; q_j)$
- In equilibrium, this cost must be the same for every (j, θ):

$$\widetilde{w}_j(\theta) = p_j z_j \frac{\partial m_j(\{h^j(\theta)\}_\theta)}{\partial h^j(\theta)} \equiv MPL_j(\theta)$$

- So, intermediate producers offer **wage functions:**

$$w_j(\{a_m\}; \theta) = \widetilde{w}_j(\theta) - p_A g_j(\{a_m\}; q_j)$$

- (Firm-specific) local amenity price: $\delta_{j,m}(\{a_m\}; \theta) \equiv -\frac{\partial w_j(\{a_m\}; \theta_i)}{\partial a_m} = p_A \frac{\partial g_j}{\partial a_m}$

Wage-amenity determination

- **Total cost of compensation** per unit of labor: $\widetilde{w}_{j,i} = w_i + p_A g_j(\{a_{m,i}\}_m; q_j)$
- In equilibrium, this cost must be the same for every (j, θ):

$$\widetilde{w}_j(\theta) = p_j z_j \frac{\partial m_j(\{h^j(\theta)\}_\theta)}{\partial h^j(\theta)} \equiv MPL_j(\theta)$$

- So, intermediate producers offer **wage functions:**

$$w_j(\{a_m\}; \theta) = \widetilde{w}_j(\theta) - p_A g_j(\{a_m\}; q_j)$$

- (Firm-specific) local amenity price: $\delta_{j,m}(\{a_m\}; \theta) \equiv -\frac{\partial w_j(\{a_m\}; \theta_i)}{\partial a_m} = p_A \frac{\partial g_j}{\partial a_m}$

Proposition

The equilibrium is a Pareto efficient allocation.

Conventional macro measurements and classical results without amenities

- Nominal GDP: $E \equiv \sum_n p_n C_n$
- Real output growth:

$$d \log Y = \sum_n \frac{p_n C_n}{E} d \log C_n$$

  - Aggregation through prices welfare-relevant because $p_n = \lambda_i^{-1} \frac{\partial U_i}{\partial c_{i,n}}$

- TFP growth (Solow residual):

$$d \log Y = d \log TFP + \underbrace{\int \frac{w(\theta) L(\theta)}{E} d \log L(\theta) d\theta}_{\text{Quality-adjusted labor input growth}} + \frac{QK}{E} d \log K$$

- Hulten (1978): $d \log TFP = \sum_j \frac{p_j y_j}{E} d \log z_j$

Two simple examples on the measurement problems and solutions with amenities

Example 1: representative producer with costly amenity provision

- One cons. good and amenity; no capital; no skill heterogeneity; one producer type $y_j = z$

Example 1: representative producer with costly amenity provision

- One cons. good and amenity; no capital; no skill heterogeneity; one producer type $y_j = z$
- Combining market-clearing conditions: $y_j = C_n + \int g(a_i)di$; but GDP is:

$$
\begin{aligned}
E &= C_n && \text{(expenditure)} \\
&= \int w_i di && \text{(income)} \\
&= Y_n - \int g(a_i)di && \text{(value added)}
\end{aligned}
$$

Example 1: representative producer with costly amenity provision

- One cons. good and amenity; no capital; no skill heterogeneity; one producer type $y_j = z$
- Combining market-clearing conditions: $y_j = C_n + \int g(a_i)di$; but GDP is:

$$\begin{aligned} E &= C_n && \text{(expenditure)} \\ &= \int w_i di && \text{(income)} \\ &= Y_n - \int g(a_i)di && \text{(value added)} \end{aligned}$$

- TFP (and real output) growth:

$$d\log TFP = d\log z - \int \frac{g'(a_i)a_i}{E} d\log a_i di = d\log W$$

  - Aggregate increases in the cost of amenity provision imply $d\log TFP < d\log z$

Example 1: representative producer with costly amenity provision

- But recall marginal cost of amenity equals its price ($\delta(a) = g'(a)$), so:

$$d\log z = \underbrace{d\log W + \int \frac{\delta(a_i)a_i}{E} d\log a_i di}_{\text{Total compensation growth}}$$

- Measure technical improvements and more welfare-relevant measure as $\delta(a_i) = \lambda_i^{-1} \frac{\partial U_i}{\partial a_i}$

Example 1: representative producer with costly amenity provision

- But recall marginal cost of amenity equals its price ($\delta(a) = g'(a)$), so:

$$d\log z = \underbrace{d\log W + \int \frac{\delta(a_i)a_i}{E} d\log a_i di}_{\text{Total compensation growth}}$$

- Measure technical improvements and more welfare-relevant measure as $\delta(a_i) = \lambda_i^{-1}\frac{\partial U_i}{\partial a_i}$
- More generally, we can define **augmented output** as:

$$E^A \equiv C_n + \int \Delta(a_i) di$$

  - where $\Delta(a_i) = \int_0^{a_i} \delta(\widetilde{a}) d\widetilde{a} = -(w(a_i) - w(0))$
  - And then define real output growth $d\log Y^A$, TFP growth $d\log ATFP$... as usual

Example 2: occupational choice with fixed amenities

- Two occupations $\mathcal{J} = \{S, R\}$; occupation S is safer: $a_S > a_R$
- In equilibrium, must have: $w_R = MPL_R > w_S = MPL_S$
  - Amenity value: $\Delta_S = -(w_S - w_R)$

Example 2: occupational choice with fixed amenities

- Two occupations $\mathcal{J} = \{S, R\}$; occupation S is safer: $a_S > a_R$
- In equilibrium, must have: $w_R = MPL_R > w_S = MPL_S$
  - Amenity value: $\Delta_S = -(w_S - w_R)$
- TFP growth:

$$d \log TFP = d \log z - \underbrace{(MPL_R - MPL_S)}_{\text{"Measured misallocation"}} \frac{h^S}{E} d \log h^S = d \log W$$

  - A reallocation to the **safe occupation decreases** measured TFP, output, and income

Example 2: occupational choice with fixed amenities

- Two occupations $\mathcal{J} = \{S, R\}$; occupation S is safer: $a_S > a_R$
- In equilibrium, must have: $w_R = MPL_R > w_S = MPL_S$
  - Amenity value: $\Delta_S = -(w_S - w_R)$
- TFP growth:

$$d \log TFP = d \log z - \underbrace{(MPL_R - MPL_S)}_{\text{"Measured misallocation"}} \frac{h^S}{E} d \log h^S = d \log W$$

  - A reallocation to the **safe occupation decreases** measured TFP, output, and income
- Again, if we measure instead total compensation get:

$$d \log z = \underbrace{\frac{W}{E} d \log W + \frac{\Delta_S h^S}{E} d \log h^S}_{\text{Total compensation growth}}.$$

Augmented measurements

Augmented measurements

- **Nominal augmented output**

$$E^A = \sum_n p_n C_n + \int \Delta(\mathbf{a}_i; \theta_i) l_i di$$

  - Where the **amenity value** is defined as: Details

$$\Delta(\mathbf{a}; \theta) \equiv -(\underbrace{w_{j(\mathbf{a};\theta)}(\mathbf{a}; \theta)}_{\text{Highest wage at bundle } \mathbf{a}} - \underbrace{\overline{w}(\theta))}_{\text{Highest wage available}} > 0$$

  - Cost of bundle **a** is $\Delta(\mathbf{a}; \theta)$, not $p_A g_{j(\mathbf{a};\theta)}(\mathbf{a}; q_j)$

- **Real augmented output growth**

$$d \log Y^A = \sum_n \frac{p_n C_n}{E^A} d \log C_n + \int \frac{\Delta(\mathbf{a}; \theta) l}{E^A} \widehat{\gamma}(\mathbf{a}, l|\theta) f(\theta) d(\mathbf{a}, l, \theta)$$

  - Conditional choice distribution: $\gamma(\mathbf{a}, l|\theta)$

Conventional vs augmented TFP growth

Conventional TFP growth

$$d\log TFP = d\log Y - \underbrace{\int \frac{w^{avg}(\theta)L(\theta)}{E} d\log L(\theta) d\theta}_{\text{Quality-adjusted labor input growth}} - \frac{QK}{E} d\log K$$

Conventional TFP growth

$$d\log TFP = d\log Y - \underbrace{\int \frac{w^{avg}(\theta)L(\theta)}{E} d\log L(\theta) d\theta}_{\text{Quality-adjusted labor input growth}} - \frac{QK}{E} d\log K$$

Proposition

$$d\log TFP = \sum_j \frac{p_j y_j}{E} d\log z_j + \int \underbrace{\frac{[\widetilde{w}^{avg}(\theta) - w^{avg}(\theta)]L(\theta)}{E}}_{\text{Difference avg. MPLs and avg. wages}} d\log L(\theta) d\theta$$

$$+ \int \underbrace{cov_j\left(MPL_j(\theta), \frac{h^j(\theta)}{f^j(\theta)} d\log h^j(\theta) | \theta\right)}_{\text{"Measured" misallocation}} f(\theta) d\theta - \underbrace{\frac{p_A Y_A}{E} d\log Y_A}_{\text{Amenity input expenditure}} .$$

Augmented TFP growth and Hulten's theorem

- Augmented TFP growth:

$$d\log ATFP = d\log Y^A - \int \frac{\overline{w}(\theta)L(\theta)}{E^A} d\log L(\theta) d\theta - \frac{QK}{E^A} d\log K$$

Proposition

$$d\log ATFP = \sum_j \left[\frac{p_j y_j}{E^A} d\log z_j + \frac{\widetilde{W}_j - W_j}{E^A} d\log q_j \right]$$

where $\widetilde{W}_j = \int \widetilde{w}_j(\theta) h^j(\theta) d\theta$ *and* $W_j = \int w_j(\mathbf{a};\theta) l \gamma_j(\mathbf{a}, l, \theta) d(\mathbf{a}, l, \theta)$

Quantitative application

Occupational reallocation in the US since 1980s

- Reallocation from blue-collar and clerical occs. to services and white-collar/abstract occs.
- Substantial differences in measures of job amenities across these occupation groups

Occupational reallocation in the US since 1980s

- Reallocation from blue-collar and clerical occs. to services and white-collar/abstract occs.
- Substantial differences in measures of job amenities across these occupation groups

Data sources: Data detail

- Occ.-level amenity measures from O*NET and ATUS (Kaplan and Schulhofer-Wohl, 2018)
- Worker level data from NLSY79 and Census/ACS; aggregate to 330 occs.

Occupational choice model:

- Identify producer types j with occupations
- And assume that amenities are fixed characteristics of occupations: $\{a_{m,j}\}_m$

Hedonic pricing with skill proxy method (Bell, 2024)

1. **Main assumption:** wage functions can be represented as: $w^g(\mathbf{a}; \phi)$ with $\frac{\partial w^g}{\partial \phi} > 0$
   - where g indexes an observable worker type (age, gender...)
   - and ϕ is an unobservable scalar index
   - Implicit restriction: if $i \in g$ earns more at bundle **a** than $i' \in g$, she must also earn more at any other (**undominated**) bundle $\mathbf{a}'$

Hedonic pricing with skill proxy method (Bell, 2024)

1. **Main assumption:** wage functions can be represented as: $w^g(\mathbf{a}; \phi)$ with $\frac{\partial w^g}{\partial \phi} > 0$
   - where g indexes an observable worker type (age, gender...)
   - and ϕ is an unobservable scalar index
   - Implicit restriction: if $i \in g$ earns more at bundle **a** than $i' \in g$, she must also earn more at any other (**undominated**) bundle $\mathbf{a}'$

2. **Hedonic pricing with skill proxy:** Parametrize $w^g(\mathbf{a}; \phi)$ and use skill proxy (e.g. AFQT score) that is independent of preferences as a shifter of (ϕ) to recover amenity prices

Estimation | Non cross ass. | Proxy method

Hedonic pricing with skill proxy method (Bell, 2024)

1. **Main assumption:** wage functions can be represented as: $w^g(\mathbf{a}; \phi)$ with $\frac{\partial w^g}{\partial \phi} > 0$
   - where g indexes an observable worker type (age, gender...)
   - and ϕ is an unobservable scalar index
   - Implicit restriction: if $i \in g$ earns more at bundle **a** than $i' \in g$, she must also earn more at any other (**undominated**) bundle $\mathbf{a}'$

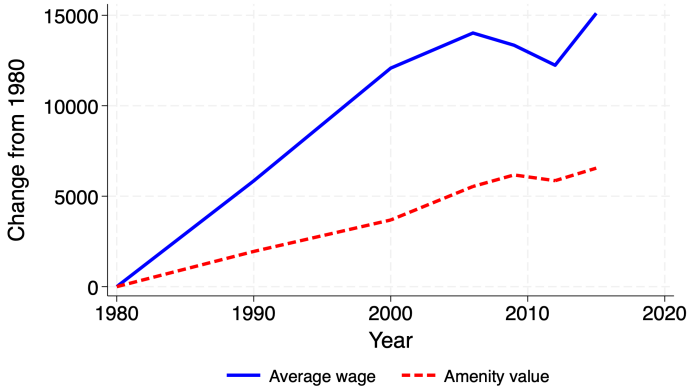
2. **Hedonic pricing with skill proxy:** Parametrize $w^g(\mathbf{a}; \phi)$ and use skill proxy (e.g. AFQT score) that is independent of preferences as a shifter of (ϕ) to recover amenity prices

   Estimation | Non cross ass. | Proxy method

3. **Map hedonic prices to growth accounting formulas:** In the census data, use estimates to compute ϕ_i; discretize by quantiles ϕ_q^g; compute prices and employment shares at every bin (g, q, j, t)

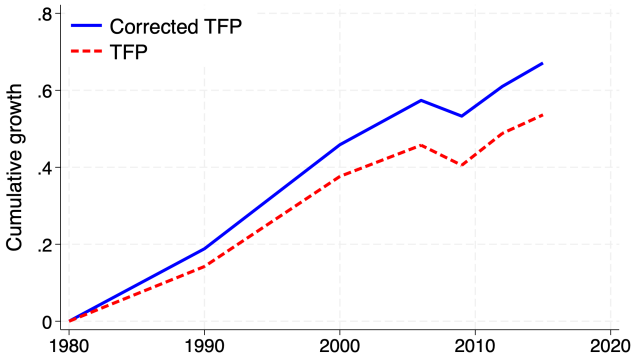
Growth in total compensation (1980-2015)

(per-worker and 2012 prices)



- Increase in total compensation is 40% larger than increase in avg. wages By education By gender

Corrected TFP growth



⇒ Increase in productivity is 25% larger than suggested by the conventional TFP measure

- But larger slowdown post-2006

Augmented

Conclusions

Is abstracting from amenities a problem for macro measurements?

- Yes, welfare and productivity improvements mismeasured

Growth accounting with non-wage amenities:

- Aggregate shadow value of amenities into output and redo the traditional growth accounting
- Quantification suggests substantially larger growth in total compensation than wages and productivity improvements

Still a lot to do on the quantification:

- Refine estimation, ECEC data, corrections to popular TFP measures, labor share...

Amenity value and local amenity prices

Frontier: All $(w, \{a_m\})$ combinations available that are undominated by other options given θ

- Wage associated with bundle $\mathbf{a} = \{a_m\}$ in frontier: $w_{j(\mathbf{a};\theta)}(\mathbf{a};\theta)$
- Highest wage in frontier: $\overline{w}(\theta)$

Amenity value and local amenity prices

Frontier: All $(w, \{a_m\})$ combinations available that are undominated by other options given θ

- Wage associated with bundle $\mathbf{a} = \{a_m\}$ in frontier: $w_{j(\mathbf{a};\theta)}(\mathbf{a};\theta)$
- Highest wage in frontier: $\overline{w}(\theta)$

Amenity value of bundle **a** for a worker with skill θ:

$$\Delta(\mathbf{a};\theta) \equiv -(w_{j(\mathbf{a};\theta)}(\mathbf{a};\theta) - \overline{w}(\theta)) > 0$$

- Cost of bundle **a** is $\Delta(\mathbf{a};\theta)$, not $p_A g_{j(\mathbf{a};\theta)}(\mathbf{a};q_j)$
- Need to take into account the cost of not choosing the highest MPL producer

Amenity value and local amenity prices

Frontier: All $(w, \{a_m\})$ combinations available that are undominated by other options given θ

- Wage associated with bundle $\mathbf{a} = \{a_m\}$ in frontier: $w_{j(\mathbf{a};\theta)}(\mathbf{a};\theta)$
- Highest wage in frontier: $\overline{w}(\theta)$

Amenity value of bundle **a** for a worker with skill θ:

$$\Delta(\mathbf{a};\theta) \equiv -(w_{j(\mathbf{a};\theta)}(\mathbf{a};\theta) - \overline{w}(\theta)) > 0$$

- Cost of bundle **a** is $\Delta(\mathbf{a};\theta)$, not $p_A g_{j(\mathbf{a};\theta)}(\mathbf{a};q_j)$
- Need to take into account the cost of not choosing the highest MPL producer

Local amenity price: $\delta_m(\mathbf{a};\theta) \equiv \frac{\partial \Delta(\mathbf{a};\theta)}{\partial a_m}$ Back

Data sources

Datasets and variables for amenity estimation:

- Amenities (27 in total):
  1. O*NET context file (Bell (2022)): extreme temperature, contaminants, time sitting...
  2. O*NET interests: Realistic, Investigative, Artistic, Social, Enterprising, Conventional
  3. ATUS (Kaplan Schulhofer-Wohl (2018)): meaning, pain... asked during work hours
- Income, occupation, and ability proxy (Armed Forces Qualification Test (AFQT)):
  - National Longitudinal Survey of Youth (NLSY 79): born between 1957 and 1964
- To account for age effects:
  - Estimate amenities and skills at different years and aggregate with age distribution of 1980

Aggregate employment and wages by occupation:

- Census and ACS (1970-2015). Aggregate to 330 occupations

Back

Estimation

$$x_i = \eta^g + \gamma_1^g \frac{w_i^{\gamma_2^g}}{\gamma_2^g} + \sum_m \pi_m^g a_{j(i),m} + \epsilon_i \quad (i \text{ worker, } j(i) \text{ occupation of worker } i, \ n \text{ amenity})$$

- $x_i =$ AFQT score in main specification, but run robustness with other non-cognitive proxies
- Also robustness with other specifications
- Local amenity price:

$$\hat{\delta}_m^g(w) = \frac{\frac{\partial \hat{x}^g}{\partial a_m}}{\frac{\partial \hat{x}^g}{\partial w}} = \frac{\hat{\pi}_m^g}{\hat{\gamma}_1^g} w^{1-\hat{\gamma}_2^g}$$

Back

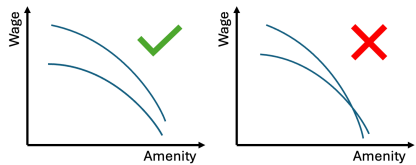
Non-crossing frontiers assumption

- Assume that $\phi(w, \{a_m\}; \theta) = \phi(w, \{a_m\})$ for all θ, so

$$\overline{\Phi}(\theta) = \{(w, \{a_m\}) : \phi(w, \{a_m\}) = \overline{\phi}(\theta)\}$$

  - Frontiers only differ in the total compensation level: $\overline{\phi}$

- Restriction is that frontiers do not cross: ex and counterex.



  - Once observe $(w, \{a_m\})$, know all the menu of options available to the worker

back

Skill proxy method (Bell, 2024)

- Skill proxy x that satisfies
  - x independent of $(w, \{a_m\})$ conditional on total compensation level $\overline{\phi}$
  - $\mathbb{E}[x|\overline{\phi}]$ is strictly monotone in $\overline{\phi}$
- Bell (2024) shows that the amenity prices are identified and can be consistently estimated as

$$\hat{\delta}_m(\overline{w}, \{\overline{a}_m\}) = \frac{\frac{\partial \hat{x}(\overline{w}, \{\overline{a}_m\})}{\partial a_m}}{\frac{\partial \hat{x}(\overline{w}, \{\overline{a}_m\})}{\partial w}}$$

  - where

$$\hat{x}(\overline{w}, \{\overline{a}_m\}) = \mathbb{E}[x|w = \overline{w}, \{a_m = \overline{a}_m\}]$$

Back

Augmented TFP growth (2006-2015)

- For the last periods, can measure changes in amenities within occupations in the O*NET

	Absolute value (Thousand of 2012 Dollars)	Relative to Y^a
Augmented output (Y^a) in 2006	131.02	1
Output (Y) in 2006	102.32	78%
Change in productivity ($d\log z$ and $\{d\log q_j\}_j$)	10.32	7.9%
Change in amenity value within occupation ($\{d\log A_j\}_j$ terms)	0.84	0.6%
Change in augmented TFP (ATFP)	$dATFP = 11.16$	$d\log ATFP = 8.5\%$

- Augmented output (Y^a) is 1.28x larger than the measured output (Y)
- During that period $d\log TFP = 7.9\%$ and $d\log CTFP = 9.7\%$
- Higher growth if define amenities as "bads": $Y^a/Y = 0.83$ and $d\log ATFP = 13.1\%$

Back