Generalized Compensation Principle

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Introduction

• Economic disruption affects wage distribution \( \leadsto \) winners and losers
  • e.g., technological change, immigration inflow, trade liberalization

• Welfare compensation problem: can we design a reform of the tax system that offsets the losses by redistributing the winners' gains?
  • \ldots and if so, is it budget-feasible?

• Traditional PF [Kaldor 1939, Hicks 1939/40]: compensating variation
  • amount that agent \( i \) is willing to pay to be as well off as before the shocks
  • limitation 1: only distortionary income taxes are available policy tools
  • limitation 2: many disruptions of interest require general equilib. setting
Introduction

• E.g., consider an immigration inflow $\sim$ no welfare impact in PE
  • in GE, higher supply of labor affects wage distribution via two channels:
    • (i) decreasing marginal product, (ii) skill complementarities in production
  • Combining distortionary taxes and GE makes the compensation difficult
    • lowering taxes raises labor supply – just like the immigration inflow . . .
    • further welfare effects that need to be compensated using the tax code
      $\sim$ complex fixed point problem

• Goal: design tax reform to bring each agent’s utility back to initial level
  • consider (marginal) disruption of wage distribution in arbitrary direction
  • result: compensating reform and fiscal surplus in closed-form
  • application: compensating the impact of automation (robots) in the US
Introduction

• **First step:** partial equilibrium environment with distortionary taxes
  • **key:** to a first order, indirect utility moves one-for-one with total tax bill
  • because envelope theorem $\rightsquigarrow$ marginal tax rate does not affect welfare
  • adjust average tax rate to cancel out the exogenous wage disruption

• **GE:** simultaneously solve for average and marginal tax rates (IDE)
  • **key:** marginal tax rate directly affects welfare, even conditional on ATR
  • because changes in labor supply (MTR) impact wages, and hence utility
  • progressive reform at rate $=\frac{\text{ratio of labor demand vs. supply elasticities}}{}$

• Application: compensating the impact of robots [data: Acemoglu Restrepo 17]
  • other possible applications: immigration, international trade, etc
  • alternative strand in the literature: optimal taxation of robots
    Guerreiro Rebelo Teles 17, Thuemmel 18, Costinot Werning 18
Outline

1. The Welfare Compensation Problem

2. Designing the Compensating Tax Reform

3. Application: Compensating the Impact of Robots
Initial equilibrium

- **Individuals** $i \in [0, 1]$: wage $w_i$, labor supply $l_i$, income tax $T(w_i l_i)$

  welfare: \[ U_i = \max_{l_i > 0} u_i (w_i l_i - T(w_i l_i), l_i) \]

- **Endogenous labor supply**: first-order condition

  labor supply: \[ l_i \text{ satisfies } - \frac{u'_{i,l} (c_i, l_i)}{u'_{i,c} (c_i, l_i)} = [1 - T'(w_i l_i)] w_i \]

- **Endogenous wage**: marginal product of aggregate labor input

  wage: \[ w_i = \mathcal{F}'_i \left( \{ L_j \}_{j \in [0,1]} \right) \]

- **Government** tax revenue $R$ given the tax schedule $T$

- **In the paper**: endogenous participation, unequal capital ownership
Wage disruptions and tax reforms

- **Disruption** of wage distribution in arbitrary direction \( \{ \hat{w}_i^E \} \in [0,1] \)
  - e.g., due to exogenous change \( \hat{F} \) in the production function (tech change)
  - size of the disruption \( \mu > 0 \) \( \rightsquigarrow \) on impact: perturbed wage \( w_i (1 + \mu \hat{w}_i^E) \)
  - government implements **tax reform** \( \hat{T} \) \( \rightsquigarrow \) perturbed tax schedule \( T + \mu \hat{T} \)

- **Equilibrium**: agents adjust labor supply which further impacts wages etc
  - \( \{ \hat{w}_i, \hat{l}_i \} \in [0,1] \): total endogenous % changes in wages and labor supplies
  - \( \{ \hat{U}_i \} \in [0,1] \): welfare gains or losses after disruption and tax reform

- **Welfare compensation problem**: find \( \hat{T} \) s.t. \( \hat{U}_i = 0 \ \forall i \) in new equilibrium
  - focus on marginal disruptions in the direction \( \hat{w}^E \): size \( \mu \rightarrow 0 \)
  - once we solve for \( \hat{T} \), deriving the fiscal surplus is straightforward
Compensation in Partial Equilibrium

- **Partial equilibrium**: no further endogenous wage adjustments: $\hat{w}_i = 0 \ \forall i$

  - marginal disruption $\rightsquigarrow$ change in the indirect utility $\hat{U}_i = 0$ of agent $i$ is

    $0 = \left[ (1 - T'(w_il_i)) w_il_i \right] \hat{w}_i^E - \hat{T}(w_il_i)$

    1. exogenous wage change $\hat{w}_i^E$ weighted by the retention rate $1 - T'(w_il_i)$
    2. absolute tax change $\hat{T}(w_il_i)$, which makes him poorer iff it is positive

- **Envelope thm**: in PE, the marginal tax rate change $\hat{T}'(w_il_i)$ does not matter for welfare, conditional on the average tax rate change $\hat{T}(w_il_i)$

  - key: to a first order, indirect utility moves one-for-one with total tax bill
  - immediately get compensating tax reform $\hat{T}$ following any disruption $\hat{w}_i^E$
  - adjust ATR by income change due to disruption $\frac{\hat{T}(y_i)}{y_i} = (1 - T'(y_i)) \hat{w}_i^E$
Compensation in General Equilibrium

- **GE:** linearizing the zero-compensating-variation condition $\hat{U}_i = 0$ yields

$$0 = \left[ (1 - T'(w_i l_i)) l_i \right] (\hat{w}_i^E + \hat{w}_i) - \hat{T} (w_i l_i)$$

- wage change $\hat{w}_i$ determined by labor supply adjustments $\{\hat{l}_j\}_{j \in [0, 1]}$  
  [decreasing MPL and skill complementarities in production]

- in turn each $\hat{l}_i$ determined by MT and AT changes $\{\hat{T}'(y_j), \hat{T}(y_j)\}_{j \in [0, 1]}$  
  [standard disincentive effects of distortionary taxes + cross-wage effects]

- **Key:** In GE, changes in labor supply, and hence in MTR, have 1st-order welfare effects despite the envelope theorem because they impact wages

  - higher marginal tax rate raises utility: hours ↓ & wage ↑ [cf. Stiglitz 82]
Compensation in General Equilibrium

- Compensating reform $\hat{T}$ solution to functional (integro-differential) eqn
  - **main result:** solve for reform $\hat{T}$ (and fiscal surplus) in closed-form

- Key elasticities entering the welfare compensation formula:
  based on the analysis of Sachs Tsyvinski Werquin 2017
  - labor supply elasticities of $l_i$ wrt retention rate, wage: $\varepsilon_{i,r}^{S}, \varepsilon_{i,w}^{S}$ [Hicks]
  - labor supply elasticity of $l_i$ wrt non-labor income: $\varepsilon_{i,n}^{S}$ [income effect]
  - cross-wage elasticity of $w_j$ wrt $L_i$: $\gamma_{ji}$ [skill complementarities in prod.]
    $\gamma_{ji}$ discontinuous at $j \approx i$
  - own-wage elasticity of $w_i$ wrt $L_i$: $\frac{1}{\varepsilon_{i}^{D}}$ [decreasing mg product of labor]
    inverse elasticity of labor demand
Compensation in General Equilibrium

- **Proposition:** The compensating tax reform is given in closed-form by

\[
\frac{\hat{T}(y_i)}{y_i} = (1 - T'(y_i)) \left[ \int_1^1 E_{ij} \hat{\Omega}_j^E \, dj + \Lambda_i \right]
\]

where: \( \hat{\Omega}_j^E \) is the modified wage disruption variable
accounts for incidence of the initial shock \( \hat{w}_i^E \) (labor demand spillovers)

where: \( \Lambda_i \) is the compensation-of-compensation variable
series \( \Lambda_i = \sum_n \Lambda_i^{(n)} \) of compensations. \( \Lambda \) constant with CES: uniform shift in MTR

where: \( E_{ij} \) is the progressivity variable
implies a progressive compensating reform: \( E_{ij} \propto y_i^{\varepsilon^D/\varepsilon^S, r - p} \) if CES/CRP
Progressivity of the compensating tax reform

- $\mathcal{E}_{ij}$: assume decreasing MPL, infinite substitutability between skills

- in PE, the compensating tax reform is $\frac{\hat{T}(y_i)}{y_i} = (1 - T'(y_i)) \hat{w}_i^E$

- in GE, ATR must compensate both the wage disruption and the welfare effects generated endogenously by the marginal tax rate changes

$$\frac{\hat{T}(y_i)}{y_i} = (1 - T'(y_i)) \hat{\Omega}_i^E + [1 + \frac{\varepsilon_D}{\varepsilon_{S,r}} - p]^{-1} \hat{T}'(y_i)$$

- Progressive reform b/c any AT hike must be compensated by MT hike

  - rate of progressivity $= \frac{\text{labor demand elasticity}}{\text{labor supply elasticity}}$ - rate of progressivity of the initial tax schedule

  - key: this ratio determines how much ↑ mg tax rate ↑ wage and utility
Graphical representation

- **Calibration:** QL / CELS utility, CES production, CRP tax code
  - $100 gross income loss at levels $20,000 and $60,000
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2. Designing the Compensating Tax Reform

3. Application: Compensating the Impact of Robots

- Quantitative application based on Acemoglu and Restrepo (2017)

1990-2007: one additional robot per 1000 workers

Wage disruption (% effect on wages 1990-2007)

Income losses and partial-equilibrium compensation
Compensation of automation

- **Compensation:** tax bill changes by $-112\%$ of income loss at 10th centile, $+124\%$ of income gain at 90th centile, fiscal surplus $\approx 0$
Conclusion

- **Classic PF question**: economic shock generally creates winners and losers
  
  Kaldor 39, Hicks 39/40, Kaplow 04/12, Hendren 14

  - design a compensating tax reform and evaluate its fiscal surplus
  - closed-form in general equilibrium with only distortionary taxes

- **Applications**: automation, job polarization, immigration, int’l trade
  
  Acemoglu Restrepo 17, Goos et al 14, Dustmann Frattini Preston 13, Antras Gortari Itshkoki 17

  - need GE framework: relative wages determined by relative supply of skills

- **Advantages of compensation principle over optimal taxation**
  
  Stiglitz 82, Rothschild Scheuer 13/16, Ales Kurnaz Sleet 15

  - no need to choose a particular social welfare function
  - tractability (closed form) in more general environments
  - policy-relevance: work with actual tax system and observable variables