Generalized Compensation Principle

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Introduction

• An economic disruption typically creates winners and losers
  • e.g., technological change, immigration inflow, trade liberalization
  • more generally, any shock that affects the wage distribution

• Welfare compensation problem:
  • can we design a reform of the tax-and-transfer system . . .
  • that offsets these losses by redistributing the gains of the winners . . .
  • 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
  • simple implementation if lump-sum taxes are available policy instruments
Introduction

• **First limitation** of the Kaldor-Hicks criterion:
  
  • in practice, tax instruments are distortionary [Mirrlees 1971]
  
  • asymmetric information: only an income tax is available

• **Second limitation**: for many disruptions we need general equilibrium
  
  • e.g., consider an immigration inflow: no welfare impact in PE
  
  • in GE, a higher supply of labor affects the wage distribution through:
    
    (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 an immigration inflow . . .
  
  • this generates further welfare gains and losses that need to be themselves compensated using the tax code \(\Rightarrow\) complex fixed point problem
Introduction

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

• **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 \( \rightarrow \) 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 \( = \) ratio of labor demand vs. supply elasticities
Outline

1. The Welfare Compensation Problem

2. Design of 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 [FOC]

  labor supply: $l_i$ 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 [MPL]

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

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

- **in the paper**: endogenous participation decisions, capital ownership
Wage disruptions and tax reforms

• Arbitrary disruption \( \hat{w}^E = \{\hat{w}_i\}_{i \in [0,1]} \) of the wage distribution \( w \)
  
  • e.g., due to exogenous change \( \hat{F} \) in the production function (tech change)
  
  • before agent \( i \) adjusts behavior \( \leadsto \) perturbed wage is \( w_i (1 + \mu \hat{w}_i) \)
  
  • government implements tax reform \( \hat{T} \leadsto \) perturbed tax schedule \( T + \mu \hat{T} \)

• New equil. \( (\{w_i(1 + \mu \hat{w}_i^E + \mu \hat{w}_i)\}, \{l_i(1 + \mu \hat{l}_i)\}, \{U_i + \mu \hat{U}_i\}, T + \mu \hat{T}) \)
  
  • individuals adjust labor supply, which further impacts their wage, etc
  
  • \( \{\hat{w}_i\}_{i \in [0,1]} \): total endogenous (percentage) changes in wages

• Welfare compensation problem: find \( \hat{T} \) s.t. \( \hat{U}_i = 0 \ \forall i \) in new equil.
  
  • focus on marginal disruptions in the direction \( \hat{w}^E \): size \( \mu \to 0 \)
  
  • once we solve for \( \hat{T} \), deriving the fiscal surplus \( \hat{R} \) is straightforward
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Welfare compensation in PE

- **Partial equilibrium** (exogenous wages): \( \mathcal{F}(\{L_i\}_{i \in [0,1]}) = \int_0^1 \theta_i L_i di \)
  - exogenous disruption \( \hat{w}^E \) induces no further adjustment: \( \hat{w}_i = 0 \forall i \)

- **Marginal wage disruption:** linearize the condition \( \hat{U}_i = 0 \) as \( \mu \to 0 \)

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

- in PE, the change in the indirect utility \( \hat{U}_i \) of agent \( i \) is due to:
  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 \( \hat{T}(w_il_i) \)
  - immediately get compensating tax reform \( \hat{T} \) following any disruption \( \hat{w}^E \)
Elasticities

• **Conclusion:** compensating tax reform with distortionary taxes in PE
  
  • adjust average tax rate by the net income gain or loss due to disruption

  \[
  \frac{\hat{T}(y_i)}{y_i} = (1 - T'(y_i)) \hat{w}_i^E
  \]

• **GE:** tax formulas in terms of standard (observable) elasticities

  • labor supply elasticities of \( l_i \) wrt retention rate, wage: \( \varepsilon_{i,S,r} \), \( \varepsilon_{i,S,w} \) [Hicks]

  • labor supply elasticity of \( l_i \) wrt non-labor income: \( \varepsilon_{i,S,n} \) [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
Welfare compensation problem in GE

- **GE**: Linearizing the zero compensating variation condition \( \hat{U}_i = 0 \)

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

- **MPL**: endogenous wage adjustment

\[
\hat{w}_i = -\frac{1}{\varepsilon_i} \hat{l}_i + \int_0^1 \gamma_{ij} \hat{l}_j dj
\]

- **FOC**: total labor supply adjustment

\[
\hat{l}_i = \hat{l}_{pe} + \varepsilon_{i,w}^S \int_0^1 \Gamma_{ij} \hat{l}_{pe} dj
\]

elasticity \( \Gamma_{ij} \) accounts for infinite series of cross-wage effects [Sachs Tsyvinski Werquin 17]

- where PE incidence:

\[
\hat{l}_{pe} = \varepsilon_{i,w}^S \hat{w}_i^E - \varepsilon_{i,r}^S \frac{T'(y_i)}{1-T'(y_i)} + \varepsilon_{i,n}^S \frac{\hat{T}(y_i)}{(1-T'(y_i))y_i}
\]

- **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]
Welfare compensation in GE: Solution

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

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

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

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 in closed-form)

where: $\mathcal{E}_{ij}$ is the progressivity variable
  implies a progressive compensating reform. CES-CRP: $\mathcal{E}_{ij} \propto y_i^{\varepsilon D / \varepsilon S, r - p}$

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 tax rates)
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

$$\frac{\hat{T}(y_i)}{y_i} = (1 - T'(y_i)) \hat{\Omega}_i^E + \left[1 - p + (\varepsilon^D/\varepsilon^{S,r})\right]^{-1} \hat{T}'(y_i)$$

- suppose agents $i < i^*$ are undisrupted $\Rightarrow$ progressive tax reform, because in GE, an average tax hike must be compensated by a marginal tax hike

- Consequence [ODE]: ATR evolve below $y_{i^*}$ at constant rate $\frac{\varepsilon^D}{\varepsilon^{S,r}} - p > 0$

$$\frac{\hat{T}(y_i)}{y_i} \propto y_i^{\varepsilon^D/\varepsilon^{S,r}-p} I\{y_i \leq y_{i^*}\}$$

- rate of progressivity: labor demand elasticity $\div$ labor supply elasticity

- key: this ratio determines how much $\uparrow$ mg tax rate $\uparrow$ wage / utility
Graphical representation

- **Calibration**: constant elasticities $(\varepsilon, \sigma, p) = (0.33, 0.6, 0.156)$
  compensation of a $100$ gross income loss at $y_i^* = \$20K, \$60K$
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- Quantitative application based on Acemoglu and Restrepo (2017)

1990-2007: one additional robot per 1000 workers

![Graph showing wage disruption and income changes](image-url)
Compensation in GE

- **Compensating tax changes:** $-113$ at 10\textsuperscript{th} centile (112\% income loss), $+260$ at 90\textsuperscript{th} percentile (124\% income gain) $\leadsto$ fiscal surplus $16$

![General-equilibrium compensation (U.S.)](image1)

![Compensation (U.S.): Average tax rates](image2)
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 tax reform in general equilibrium with only distortionary taxes
  - more generally: compensate so that welfare of agent $i$ changes by $h_i \in \mathbb{R}$

• **Applications:** automation, job polarization, immigration, intl 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, Sachs Tsyvinski Werquin 16
  - policy-relevance: work with actual tax system and observable variables
  - tractability (closed form) in much more general environments
  - no need to choose a particular social welfare function