Equalization of opportunity: Definitions, implementable conditions and application to early-childhood policy evaluation

Francesco Andreoli[◇] Tarjei Havnes[♠] Arnaud Lefranc[♣]

[◇]CEPS/INSTEAD, Luxembourg and University of Verona

[♠]ESOP, University of Oslo and Statistics Norway

[♣]Thema, University of Cergy-Pontoise

SITE Workshop - Stockholm School of Economics - 1.-2. Sep 2014

Introduction

An important goal for public policy is to promote equality of opportunity

- to let individual success be determined by merit not social background.

Introduction

An important goal for public policy is to promote equality of opportunity

- to let individual success be determined by merit not social background.

While we celebrate equality of opportunity, we live in a society in which birth is becoming fate.

James Heckman (on US society) – Boston Review 2012

[We need to] make sure none of our children start the race of life already behind. [...] Lack of access to preschool education can shadow [poor kids] for the rest of their lives. [...] I propose working with states to make high-quality pre-school available to every child in America.

US President Barack Obama, State of the Union 2013

Introduction

Important questions include

- Is inequality of opportunity changing over time in a given country?
- Does country A exhibit more inequality of opportunity than some other country B?
- Did a particular policy intervention succeed at equalizing opportunities? Or did it have the opposite effect?

Introduction

Important questions include

- Is inequality of opportunity changing over time in a given country?
- Does country A exhibit more inequality of opportunity than some other country B?
- Did a particular policy intervention succeed at equalizing opportunities? Or did it have the opposite effect?

But how do we evaluate this in practice?

Introduction

A natural and appealing starting point is the principle of *Equality of Opportunity*.

- Individuals who exert similar effort
- should face similar opportunities
- irrespective of their circumstances

Roemer (1998), Fleurbaey (2008), Lefranc, Pistolesi and Trannoy (2009)

Introduction

A natural and appealing starting point is the principle of *Equality of Opportunity*.

- Individuals who exert similar effort
- should face similar opportunities
- irrespective of their circumstances

Roemer (1998), Fleurbaey (2008), Lefranc, Pistolesi and Trannoy (2009)

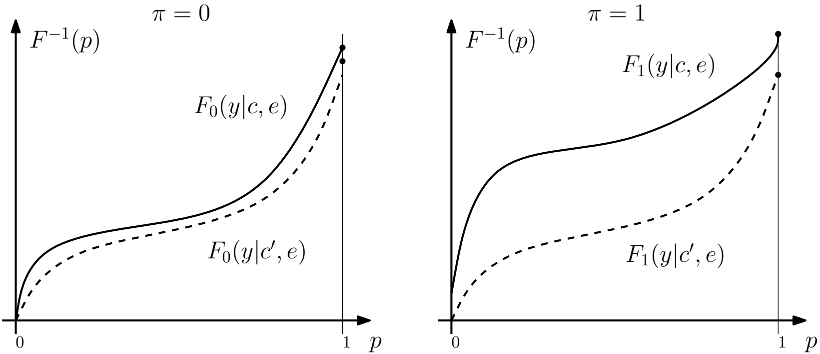
But existing literature either

1. is too demanding to provide a satisfying answer
2. relies on particular indicators of advantage or on parametric social welfare functions
    - conclusions rest on functional form and parameter choices
    - ranking can be non-monotonic in inequality aversion

Checchi and Peragine (2010), Ramos and Van de gaer (2012), Bourguignon, Ferreira and Menendez (2007), Lefranc, Pistolesi and Trannoy (2008), Aaberge, Mogstad and Peragine (2011).

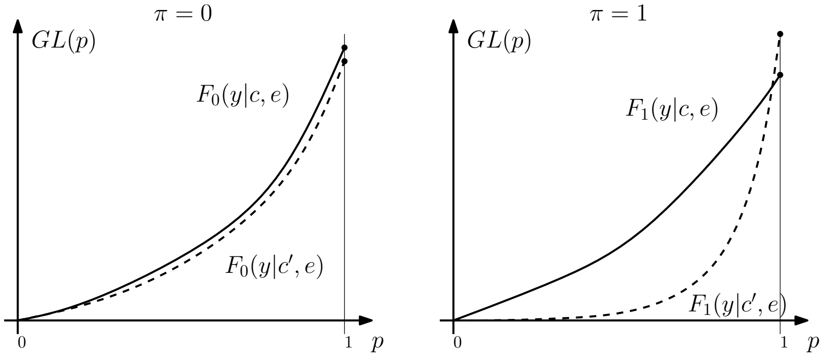
Introduction

The basic EOp framework may not distinguish even when states are severely and obviously different.



Introduction

Even second-order dominance tools may fail to conclude in cases that seem intuitively obvious.



This paper

We make three contributions:

1. provide a framework for robust ranking of states according to EOp
    - robust wrt to the class of rank-dependent preferences
    - allows ranking by using (inverse) stochastic dominance tools
2. We develop a statistical framework for implementing this ranking.
3. We apply our framework to evaluate how the introduction of universally available child care in Norway affected inequality of opportunity.

Outline

Notation and setup

Notation and setup

The opportunity set of an individual in social state π is given by the conditional distribution $F(y|c, e, \pi)$

- The EOp condition can then be formulated as

$$F(y|c, e, \pi) = F(y|c', e, \pi), \quad \forall e \text{ and } \forall (c, c').$$

where e = effort; y = outcome; c = circumstances

Notation and setup

The opportunity set of an individual in social state π is given by the conditional distribution $F(y|c, e, \pi)$

- The EOp condition can then be formulated as

$$F(y|c, e, \pi) \;=\; F(y|c', e, \pi), \quad \forall e \text{ and } \forall (c, c').$$

where e = effort; y = outcome; c = circumstances

Note that $F(y|c, e, \pi)$ could be degenerate if circumstances and effort completely partition the determinants of y. Alternatively,

- individuals are offered lotteries
- imperfect observation of the determinants of outcome from the viewpoint of the social planner
- some determinants of outcome are not seen as belonging to either effort or circumstances: luck

Equalization of Opportunity: Simple setting

We begin by considering

- two types with the same effort: (c, e) and (c', e).
- two social states: $\pi = 0$ and $\pi = 1$
- generates four cdf's: F_0, F_0', F_1, F_1'
  where F_π (resp.F_π') denotes $F(.|c, e, \pi)$ (resp. $F(.|c', e, \pi)$).
- individuals are endowed with preferences W
  - F yields utility $W(F)$.
- preferences are heterogenous within the class of preferences $\mathcal{C}$.

Equalization of Opportunity: Simple setting

We begin by considering

- two types with the same effort: (c, e) and (c', e).
- two social states: $\pi = 0$ and $\pi = 1$
- generates four cdf's: F_0, F'_0, F_1, F'_1
  where F_π (resp.F'_π) denotes $F(.|c, e, \pi)$ (resp. $F(.|c', e, \pi)$).
- individuals are endowed with preferences W
  - F yields utility $W(F)$.
- preferences are heterogenous within the class of preferences $\mathcal{C}$.

Definition (Equalization of opportunity: EzOP)

Moving from $\pi = 0$ to $\pi = 1$, equalizes opportunity iff $\forall W \in \mathcal{C}$:

$$|W(F_0) - W(F'_0)| \geq \; |W(F_1) - W(F(y'_1)|$$

EzOP: Rank-dependent preferences

The key question we face is how to assess whether EzOP is satisfied when distributions of opportunity are observed but preferences are not.

- To proceed, we restrict to preferences within the rank-dependent class, denoted $\mathcal{R}$
- In this case, $W(F) = \int_0^1 w(p)F^{-1}(p)dp$ with the weighting function $w(p) > 0$ some quantile weighting function that sums to 1.

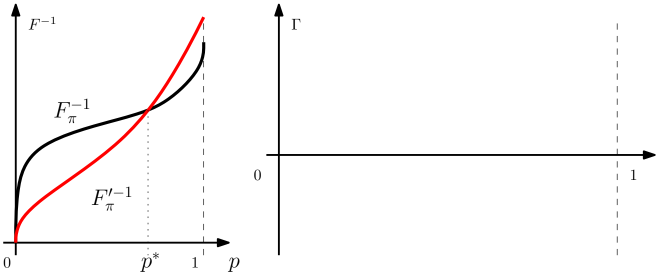
The rank-dependent approach

- resolves important paradoxes in choice under uncertainty (Allais, 1953; MacCrimmon, 1968; Kahneman et al., 1979; Quiggin, 1981),
- is a work horse for measurement of inequality and social welfare (see e.g. Sen, 1974; Sen, 1976).

EzOP: The Gap curve

We define the **gap curve** as follows

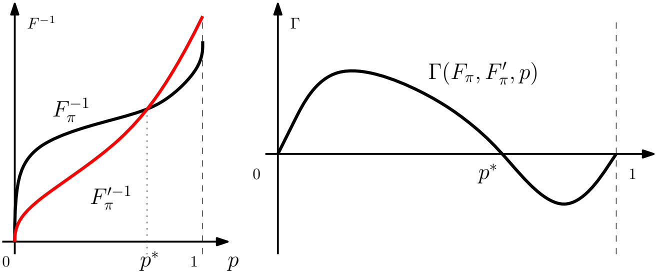
$$\Gamma(F, F', p) = F^{-1}(p) - F'^{-1}(p)$$



EzOP: The Gap curve

We define the **gap curve** as follows

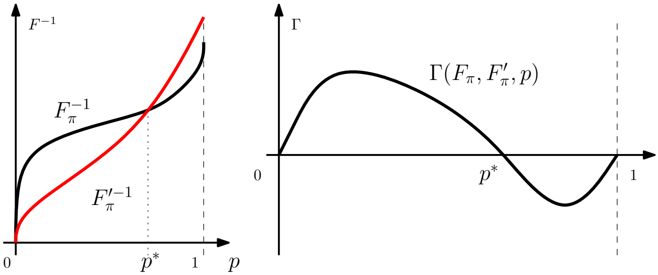
$$\Gamma(F, F', p) = F^{-1}(p) - F'^{-1}(p)$$



EzOP: The Gap curve

We define the **gap curve** as follows

$$\Gamma(F, F', p) = F^{-1}(p) - F'^{-1}(p)$$



- The size of the **unfair advantage according to preference** W is

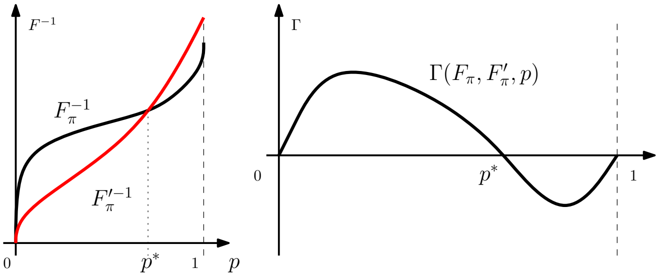
$$|W(F_\pi) - W(F'_\pi)| \;=\; |\int_0^1 w(p)\Gamma(F_\pi, F'_\pi, p)dp|$$

EzOP: A necessary condition

Proposition (necessary condition for EzOP)

If EzOP is satisfied on the set of preferences $\mathcal{R}$ then

$$|\Gamma(F_1, F_1', p)| \leq |\Gamma(F_0, F_0', p)|, \quad \forall p \in [0, 1].$$

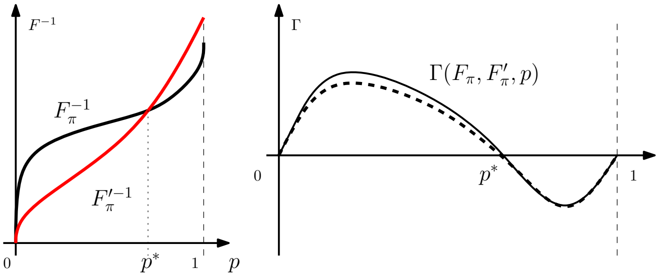


EzOP: A necessary condition

Proposition (necessary condition for EzOP)

If EzOP is satisfied on the set of preferences $\mathcal{R}$ then

$$|\Gamma(F_1, F_1', p)| \leq |\Gamma(F_0, F_0', p)|, \quad \forall p \in [0, 1].$$



EzOP: A necessary condition

Note: This provides a **necessary but not sufficient** condition for EZOP

- Evaluation of which type is advantaged may differ across individuals
- If so, then a narrowing of the gap may be regarded as an increase or a decrease in inequality of opportunity,
    - depending on which group is regarded as advantaged

EzOP: A necessary condition

Note: This provides a **necessary but not sufficient** condition for EZOP

- Evaluation of which type is advantaged may differ across individuals
- If so, then a narrowing of the gap may be regarded as an increase or a decrease in inequality of opportunity,
  - depending on which group is regarded as advantaged

To get a **necessary and sufficient** condition, we need

- agreement on the advantaged type
- in all social states

EzOP: A necessary and sufficient condition

Proposition (necessary and sufficient condition for EzOP)

If c and c' can be unanimously ordered under each π, then EzOP is satisfied on the set of preferences $\mathcal{R}$ if and only if

$$\left|\Gamma(F_0, F_0', p)\right| \geq \left|\Gamma(F_1, F_1', p)\right|, \quad \forall p \in [0,1]$$

.

- If c and c' can be unanimously ordered but absolute gap curves cross, then we cannot conclude on EzOP;
- What if c and c' cannot be unanimously ordered?
  - We can identify a subclass of preferences over which circumstances can be unanimously ordered,
  - then check equalization within that class.

EzOP: Partial agreement on advantage

The class of preferences $\mathcal{R}$ can be partitioned into subclasses $\mathcal{R}^k \subset \mathcal{R}^{k-1} \subset ... \subset \mathcal{R}$ with more homogenous attitudes towards risk by restricting the higher order derivatives of the weighting functions (Aaberge 2009):

$$\mathcal{R}^k = \left\{ W \in \mathcal{R} \mid (-1)^{i-1} \cdot \frac{d^i \widetilde{w}(p)}{dp^i} \geq 0, \ \frac{d^i \widetilde{w}(1)}{dp^i} = 0 \ \forall p \in [0,1] \ \forall i \in [1,k] \right\}$$

- For any (F, F'), we can always find the largest subclass $\mathcal{R}^{k_0}$ in which F and F' can be unanimously ranked.
- This is equivalent to **inverse stochastic dominance** at order k_0: $F \succeq_{ISD_{k_0}} F'$ (or the reverse)
  - Aaberge, Havnes and Mogstad, 2014

EzOP: Partial agreement on advantage

Weights on rank u can be represented by the derivative of $P(u)$

- Increasing k shifts weight from higher to lower rank
- In the limit, maxi-min

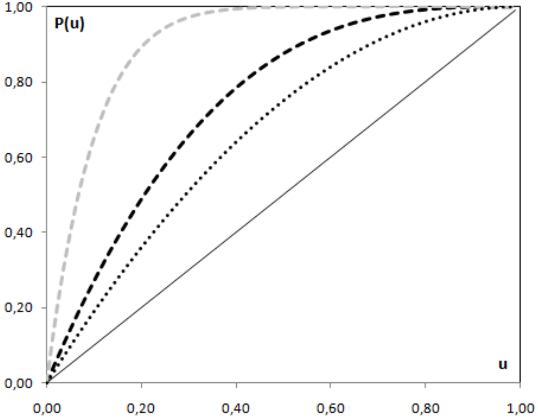


Figure : From Aaberge, Havnes, and Mogstad 2014.

EzOP: Partial agreement on advantage

Some notation:

- Let κ denote the minimal order at which F and F' can be ranked in both social states.
- Define the **cumulative opportunity gap curve** as

$$\Gamma^k(F_\pi, F'_\pi, p) = \Lambda^k_\pi(p) - \Lambda'^k_\pi(p),$$

  where $\Lambda^k_\pi(p)$ is the integral of order $k-1$ of the quantile function.
- Let c be advantaged compared to c' (wolg)

EzOP: Partial agreement on advantage

Some notation:

- Let κ denote the minimal order at which F and F' can be ranked in both social states.
- Define the **cumulative opportunity gap curve** as

$$\Gamma^k(F_\pi, F'_\pi, p) = \Lambda^k_\pi(p) - \Lambda'^k_\pi(p),$$

  where $\Lambda^k_\pi(p)$ is the integral of order $k-1$ of the quantile function.
- Let c be advantaged compared to c' (wolg)

Proposition (Necessary and sufficient condition for EzOP)

Let $F_\pi \succ_{ISD\kappa} F'_\pi \; \forall \pi$. Then EzOP over the set of preferences $\mathcal{R}^\kappa$ if and only if

$$\Gamma^\kappa(F_0, F'_0, p) \geq \Gamma^\kappa(F_1, F'_1, p), \quad \forall p \in [0,1].$$

EzOP: Partial agreement on advantage

Some notation:

- Let κ denote the minimal order at which F and F' can be ranked in both social states.
- Define the **cumulative opportunity gap curve** as

$$\Gamma^k(F_\pi, F'_\pi, p) = \Lambda^k_\pi(p) - \Lambda'^k_\pi(p),$$

  where $\Lambda^k_\pi(p)$ is the integral of order $k-1$ of the quantile function.
- Let c be advantaged compared to c' (wolg)

Proposition (Necessary and sufficient condition for EzOP)

Let $F_\pi \succ_{ISD\kappa} F'_\pi$ $\forall \pi$. Then EzOP over the set of preferences $\mathcal{R}^\kappa$ if and only if

$$\Gamma^\kappa(F_0, F'_0, p) \geq \Gamma^\kappa(F_1, F'_1, p), \quad \forall p \in [0,1].$$

Remarks

- necessary and sufficient condition over $\mathcal{R}^\kappa$ but only necessary over $\mathcal{R}$
- when κ is high this is a very partial condition
- however a high κ indicates that there is little agreement on which type is advantaged, which may indicate that inequality of opportunity is quite weak.

Equalization of Opportunity: General case

Till now, we have used 2 circumstances, 1 level of effort.

- How do we generalize to multiple types and effort levels?
- With multiple types: need to take into account the possibility of type re-ranking - the anonymity issue: the identity of the disadvantaged type might not be relevant.
  - fix the circumstance label (**non-anonymous**)
  - fix the advantage of circumstances (**anonymous**)
  - prioritize some circumstances
  - aggregate evaluations
- With multiple effort:
  - require equalization across groups with similar effort
  - comparison across different effort levels are not relevant

Child care in Norway

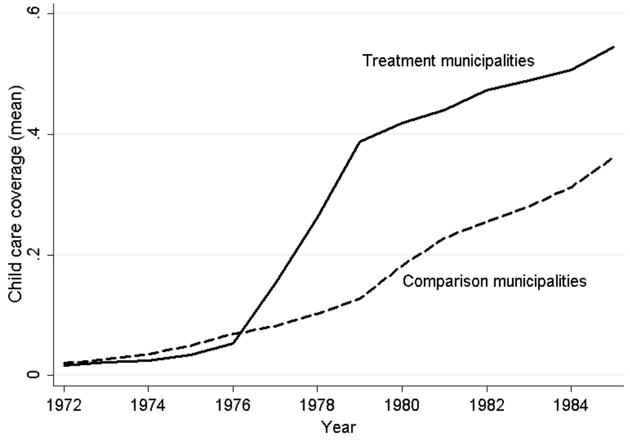
A major reform in 1975 essentially introduced universally available child care in Norway

- led to a large positive shock to supply of formal child care
- From 1976 to 1979 coverage rates for 3 to 6 year olds grew by 18 percentage points on average, from 10% to 28%
- Largest supply shocks in municipalities where subsidized child care was most rationed before the reform
    - received higher federal subsidies

Havnes and Mogstad (2011a, AEJ: Policy; 2011b, JPubEc) use the staged expansion of subsidized child care induced by the reform:

- to estimate its mean impacts on (a) child outcomes and (b) maternal labor supply
- controlling for unobserved differences between children born in different years and children born in different municipalities
- Havnes and Mogstad (2014, JPubEc) study the distributional effects

Treatment and comparison municipalities: Expansion



Data and empirical implementation

Data: Norwegian register data

- *Outcome:* average yearly earnings over the period 2006–2009
- *Circumstances:* average family income when aged 3–6, in 10 deciles

Data and empirical implementation

Data: Norwegian register data

- *Outcome:* average yearly earnings over the period 2006–2009
- *Circumstances:* average family income when aged 3–6, in 10 deciles

Estimation:

- Diff-in-diff following Havnes and Mogstad (2011):
  - two cohorts: individuals born 1967–1969 (pre-reform cohorts) and born 1973-1976 (post-reform cohorts).
  - two groups: municipalities with high childcare expansion (treatment group) and low childcare expansion (control group)
- QTE estimation using RIF-DID as in Havnes and Mogstad (2014)
  - Compare the cdf at various income levels using DiD
  - transform into income changes at each quantile following Firpo et al. (2009, Ecta).
- Allow for treatment heterogeneity by family income background

Data and empirical implementation

$$\mathbb{1}\left\{y_{it} \geq y\right\} = \gamma_t^y + [\beta_0^y + \beta_1^y P_t + \beta_2^y T_i + \beta_3^y T_i \cdot P_t] \cdot g(y_{it}^p) + \epsilon_{it}^y$$

- y_{it}: earnings in 2006–2009
- y: threshold value of income
- T_i: treatment dummy
- P_t: post-reform dummy
- γ_t: birth cohort fixed effect
- $g\left(y_{it}^p\right)$: polynomial in family income.

Estimated **QTE** at percentile p for circumstance c:

$$QTE(p|c) = \frac{\mathrm{E}\left[\beta_3(Q_1(p|c)) \cdot g\left(x_{it}\right)|C_{it} = c\right]}{f\left(Q_1(p|c)|C_{it} = c\right)} \qquad (1)$$

Estimated counterfactual distribution:

$$Q_0(p|c) = Q_1(p|c) - QTE(p|c)$$

Data and empirical implementation

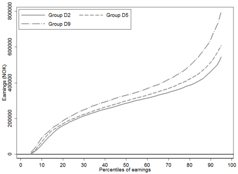
- **Gap curve dominance and QTE:**
  let type c be advantaged compared to c', then the difference in gap curves $\Delta(p)$ becomes:

$$\begin{aligned}
\Delta(p) &= \Gamma\big(F_0, F_0', p\big) - \Gamma\big(F_1, F_1', p\big) \\
&= \Big[Q_0(p|c) - Q_0(p|c')\Big] - \Big[Q_1(p|c) - Q_1(p|c')\Big] \\
&= Q_1(p|c') - Q_0(p|c') - \Big[Q_1(p|c) - Q_0(p|c)\Big] \\
&= QTE(p|c') - QTE(p|c)
\end{aligned}$$

  Opportunities are equalized if the distribution of gains (QTE) from the policy and the degree of advantage of types are negatively associated.

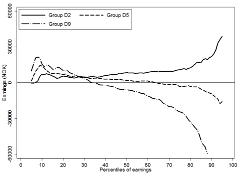
A - Income distributions and conditional QTEs

cdf $\pi = 0$



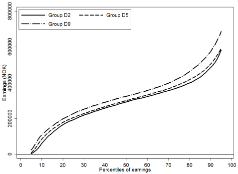
Big

QTE



Big

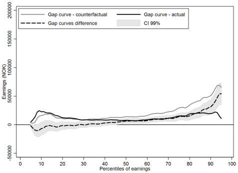
cdf $\pi = 1$



Big

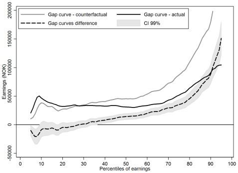
B - Gap curves

D2 vs D5



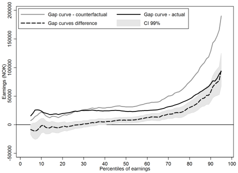
Big

D2 vs D9



Big

D5 vs D9



Big

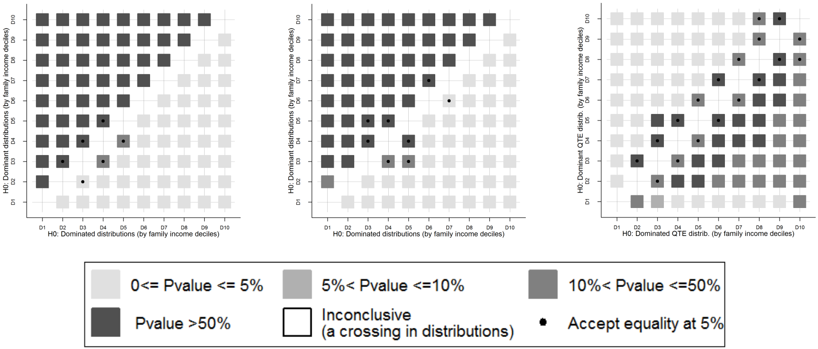
Stochastic dominance tests – Three deciles

	Pairwise groups comparisons:					
	D2 vs. D5		D2 vs. D9		D5 vs. D9	
A - Cdfs, counterfactual setting ($\pi = 0$)						
$H_0 : \sim$	72.9	[0.000]	659.4	[0.000]	384.2	[0.000]
$H_0 : \succcurlyeq$	72.9	[0.000]	659.4	[0.000]	384.2	[0.000]
$H_0 : \preccurlyeq$	0.0	[0.944]	0.0	[0.949]	0.0	[0.947]
B - Cdfs, actual setting ($\pi = 1$)						
$H_0 : \sim$	40.1	[0.003]	423.7	[0.000]	266.3	[0.000]
$H_0 : \succcurlyeq$	40.1	[0.000]	423.7	[0.000]	266.3	[0.000]
$H_0 : \preccurlyeq$	0.0	[0.949]	0.0	[0.952]	0.0	[0.948]
C - Gap curves ($\pi = 0$ vs $\pi = 1$)						
H_0 : Neutrality	84.2	[0.000]	266.4	[0.000]	125.0	[0.000]
H_0 : Equalization	4.8	[0.672]	11.2	[0.381]	9.1	[0.468]
H_0 : Disequalization	76.0	[0.000]	248.4	[0.000]	112.0	[0.000]

Stochastic dominance tests – All deciles

Equality and stochastic dominance tests

cdf $\pi = 0$ | cdf $\pi = 1$ | gap curves



Stochastic dominance tests – All deciles

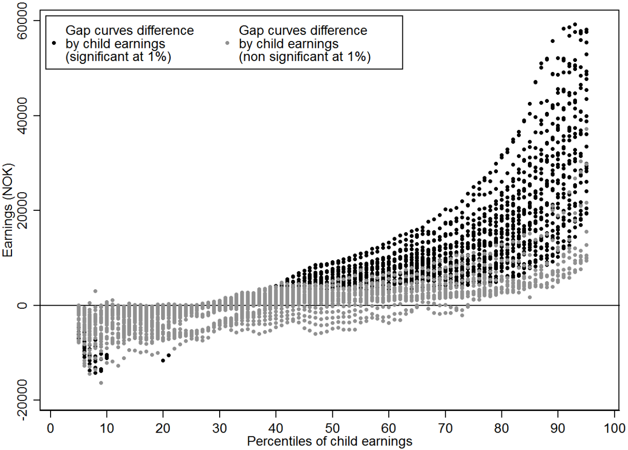


Figure : Difference between gap curves with and without the child care reform, for advantaged compared to disadvantaged groups, all family income deciles.

Gap curve differences – Four deciles

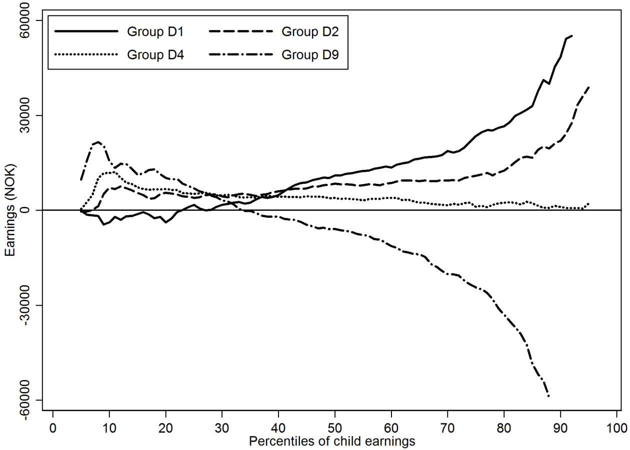


Figure : Difference between gap curves with and without the child care reform, for advantaged compared to disadvantaged groups, four family income deciles.

Concluding remarks

Theoretical contribution

- We offer a new criterion for unanimous ranking of social states.
- We provide both necessary conditions and necessary and sufficient conditions for comparing two social states according to this criterion
- Our framework provides a general condition for ranking based on inequality of opportunity indices

Concluding remarks

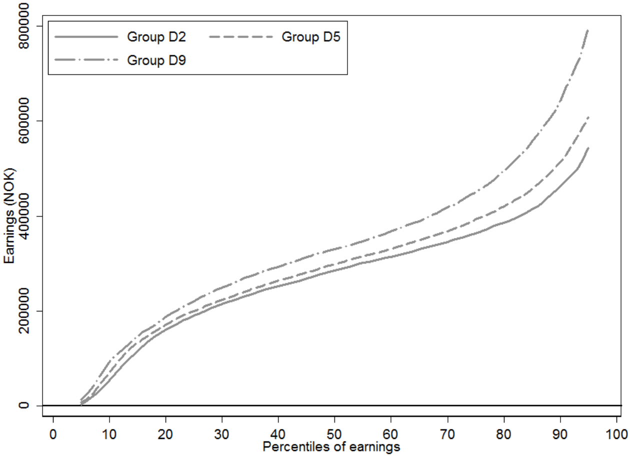
Theoretical contribution

- We offer a new criterion for unanimous ranking of social states.
- We provide both necessary conditions and necessary and sufficient conditions for comparing two social states according to this criterion
- Our framework provides a general condition for ranking based on inequality of opportunity indices

Empirical contribution

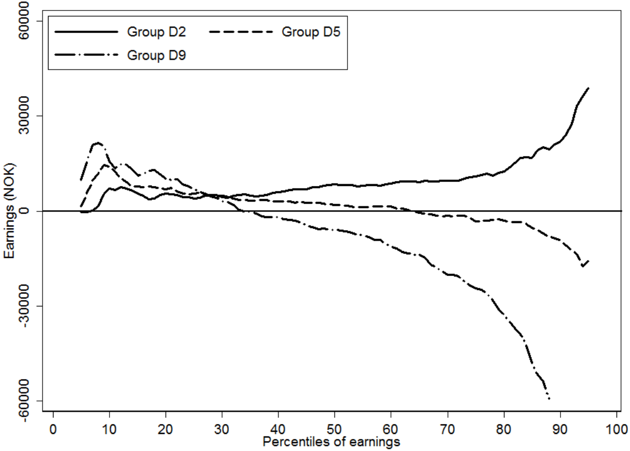
- We illustrate how the framework can be used for policy evaluation
- Expand on Havnes and Mogstad (2014) by
  1. looking closer at heterogeneity by family income deciles
  2. evaluating the impact on EOp
- Overall, estimates suggest a positive effect of child care on EOp
  - 8% drop in inequality of opportunity (Gini evaluation function)
- Two caveats:
  1. Driven in part by negative effects on the top for children from advantaged backgrounds
  2. No benefits for the low achievers in the most disadvantaged group

Estimated CDF, $\pi = 0$



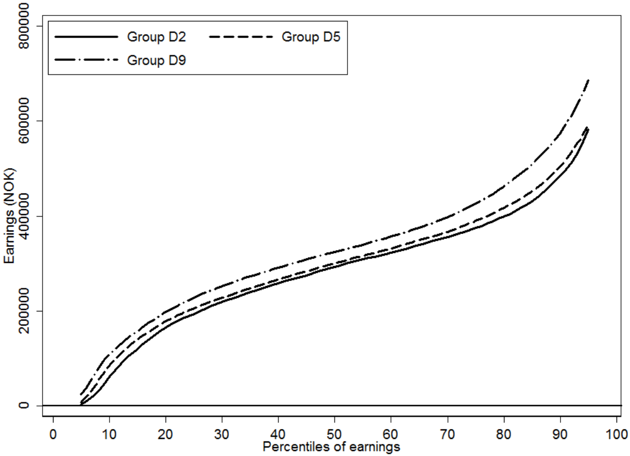
back

Estimated $QTE(p|c)$



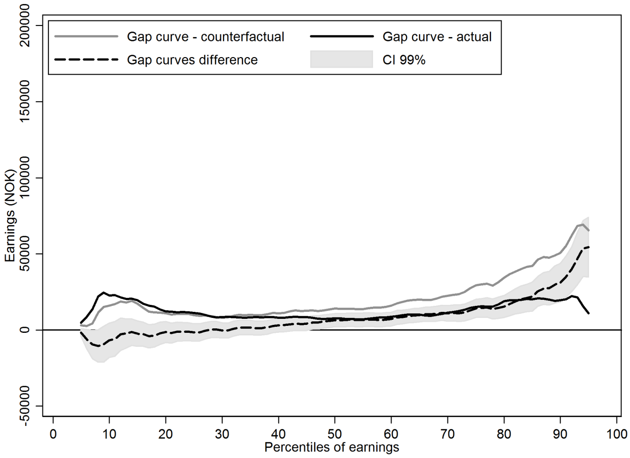
back

Actual CDF, $\pi = 1$



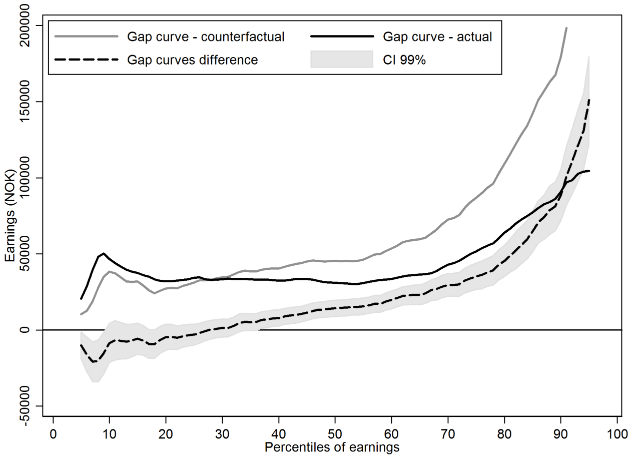
back

Gap curves – D2 vs D5



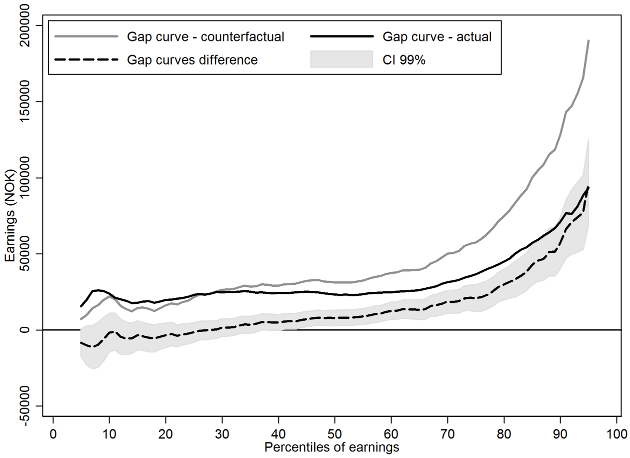
▸ back

Gap curves – D2 vs D9



back

Gap curves – D5 vs D9



back