Mergers and Cost Efficiency: Evidence from the Electricity Distribution Industry

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Introduction

- **Motivation:** In an effort to lower costs of provision, governments have *encouraged* consolidation of providers for a number of services
  - Examples include: school boards, hospitals, local electricity distribution companies (LDCs), municipalities
- **Our focus:** Ontario's electricity distribution market
  - The government wants to incentivize significant reorganization (from 76 LDCs to 10) by subsidizing consolidation
- **Questions:**
  - What sort of consolidation will occur under the proposed subsidy scheme?
  - Is the proposed reorganization optimal?

Introduction

- How to answer these questions?
- **Retrospective analysis:**
  - Make predictions about outcomes based on past observations
- But past experience doesn't inform as to the impact of unconsummated amalgamations or predict whether and which mergers will occur (Einav & Levin, 2010)
- **Our approach:**
  - Develop an empirical framework for forecasting which mergers will take place and for evaluating the consequences of consolidation

Introduction

- Merger forecasting framework:
  - Serious methodological challenges:
    - Any firm can merge with any other
    - Merger decisions are interdependent:
      A's acquisition of C prevents B from acquiring C
  - Our approach overcomes these challenges by borrowing from the theory literature on endogenous mergers (Gowrisankaran, 1999)
    - Specify a sequential acquisition process
  - Our setting provides some advantages:
    - Each LDC is a monopoly: no competition among LDCs
    - Prices are capped and so we do not need to consider post-restructuring competition

Approach: specifics

1. Specify a sequential merger algorithm
   - Buyers make offers that can be accepted or rejected
   - Merging combines customer bases and efficiency levels
     - **Scale**: Tradeoff when increasing customer base (higher revenue vs higher cost if in diseconomies of scale region)
     - **Relative-influence**: merging firms' pre-merger efficiency levels influence efficiency levels of merged-entity
2. Estimate stochastic frontier for costs
   - AC of merged entity determined using the *relative-influence* function that shifts the AC of the new firm relative to the industry's cost frontier for that firm size
3. Calibrate parameters using a minimum distance approach
   - Compare consolidation patterns predicted by the model to those observed in the data
4. Analyze effects of a tax incentive in current configuration using calibrated parameters

Summary of findings:

- Buyers have a stronger influence (75%) on the newly merged firm's cost efficiency than sellers
- Buyers are on average much larger and less efficient than acquired firms before the merger
- Mergers do not achieve the desired average cost reductions, and, in fact, can even lead to cost increases
- Even a substantial subsidy reduces the number of LDCs by only 13%, nowhere near the stated objective.

Electricity distribution market

- Electricity markets consist of three segments:
    - Generation
    - Transmission
    - Distribution
- Depending on the jurisdiction, there may be vertical integration of some or all of these segments
- The distribution segment buys electricity from high voltage lines and sells electricity at a lower voltage to final consumers.

Consolidation in the electricity distribution market

- Prior to the Electricity Act of 1998:
  - About 300 municipal electric utilities (MEUs) operated as departments within municipalities
  - Regulated by Ontario Hydro (rates and terms of service)
- Electricity Act
  - Grants new powers to Ontario Energy Board (OEB) to regulate distribution
  - OEB moves towards incentive regulation (from cost of service) in year 2000
- LDCs have been the object of policies to incentivize consolidation

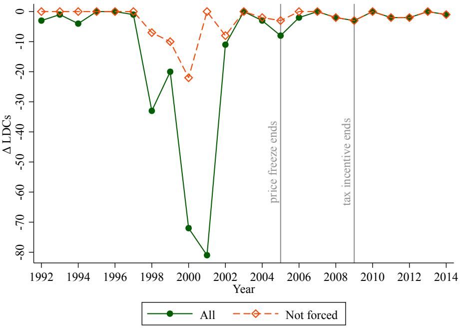
— U.S. 1990s through Energy Policy Act: up to 23 LDC mergers per year

— Ontario: late 1990s, decreasing # of LDCs from 305 to 76

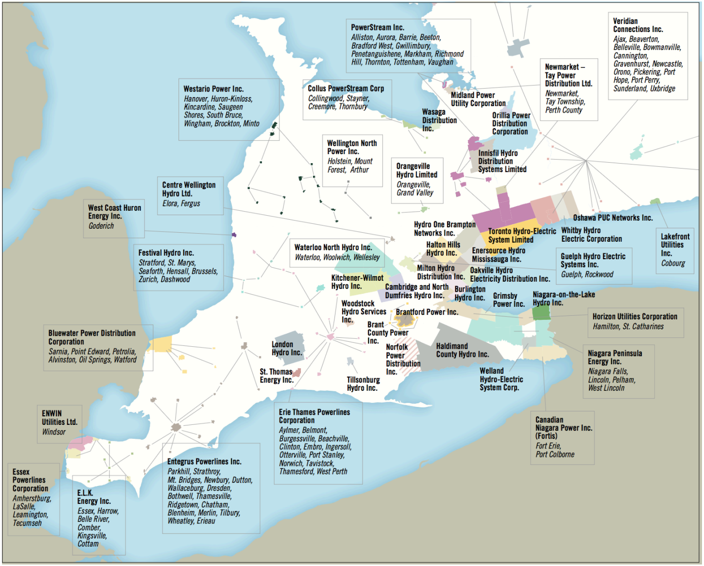
  - Forced acquisitions by Hydro One, amalgamation of cities (1990s and early 2000s)
  - 33% tax incentive on the transaction amount

Consolidation in Ontario's distribution market

Figure : Annual change of number of LDCs in Ontario



LDC Map 2014


PowerStream Inc.
Alliston, Aurora, Barrie, Beeton, Bradford West, Gwillimbury, Penetanguishene, Markham, Richmond Hill, Thornton, Tottenham, Vaughan
Veridian Connections Inc.
Ajax, Beaverton, Belleville, Bowmanville, Cannington, Gravenhurst, Newcastle, Orono, Pickering, Port Hope, Port Perry, Sunderland, Uxbridge
Newmarket – Tay Power Distribution Ltd.
Newmarket, Tay Township, Perth County
Westario Power Inc.
Hanover, Huron-Kinloss, Kincardine, Saugeen Shores, South Bruce, Wingham, Brockton, Minto
Collus PowerStream Corp
Collingwood, Stayner, Creemore, Thornbury
Midland Power Utility Corporation
Wasaga Distribution Inc.
Orillia Power Distribution Corporation
Wellington North Power Inc.
Holstein, Mount Forest, Arthur
Innisfil Hydro Distribution Systems Limited
Orangeville Hydro Limited
Orangeville, Grand Valley
Centre Wellington Hydro Ltd.
Elora, Fergus
West Coast Huron Energy Inc.
Goderich
Hydro One Brampton Networks Inc.
Toronto Hydro-Electric System Limited
Oshawa PUC Networks Inc.
Whitby Hydro Electric Corporation
Lakefront Utilities Inc.
Cobourg
Festival Hydro Inc.
Stratford, St. Marys, Seaforth, Hensall, Brussels, Zurich, Dashwood
Waterloo North Hydro Inc.
Waterloo, Woolwich, Wellesley
Halton Hills Hydro Inc.
Enersource Hydro Mississauga Inc.
Milton Hydro Distribution Inc.
Oakville Hydro Electricity Distribution Inc.
Guelph Hydro Electric Systems Inc.
Guelph, Rockwood
Kitchener-Wilmot Hydro Inc.
Cambridge and North Dumfries Hydro Inc.
Burlington Hydro Inc.
Grimsby Power Inc.
Niagara-on-the-Lake Hydro Inc.
Woodstock Hydro Services Inc.
Brantford Power Inc.
Horizon Utilities Corporation
Hamilton, St. Catharines
Brant County Power Inc.
Bluewater Power Distribution Corporation
Sarnia, Point Edward, Petrolia, Alvinston, Oil Springs, Watford
London Hydro Inc.
Norfolk Power Distribution Inc.
Haldimand County Hydro Inc.
Niagara Peninsula Energy Inc.
Niagara Falls, Lincoln, Pelham, West Lincoln
St. Thomas Energy Inc.
Tillsonburg Hydro Inc.
Welland Hydro-Electric System Corp.
ENWIN Utilities Ltd.
Windsor
Erie Thames Powerlines Corporation
Aylmer, Belmont, Burgessville, Beachville, Clinton, Embro, Ingersoll, Otterville, Port Stanley, Norwich, Tavistock, Thamesford, West Perth
Canadian Niagara Power Inc. (Fortis)
Fort Erie, Port Colborne
Entegrus Powerlines Inc.
Parkhill, Strathroy, Mt. Bridges, Newbury, Dutton, Wallaceburg, Dresden, Bothwell, Thamesville, Ridgetown, Chatham, Blenheim, Merlin, Tilbury, Wheatley, Erieau
Essex Powerlines Corporation
Amherstburg, LaSalle, Leamington, Tecumseh
E.L.K. Energy Inc.
Essex, Harrow, Belle River, Comber, Kingsville, Cottam

Ontario's new push for further consolidation

- Consolidation trend slows down: stable starting in about 2008 (between 0-2 mergers per year)

- 2012: Govt recommends that the 76 LDCs should consolidate into 8-12 to reduce costs and incentivize investment

  > *"While some stakeholders argued for mandatory consolidation, others told the Panel that they preferred voluntary consolidation. The Panel's preference is for voluntary consolidation, but action must be swift. The Panel recommends that licence applications of all new regional distributors be submitted to the OEB within two years of the government adopting the recommendations of this report."*

Ontario Distribution Sector Review Panel.

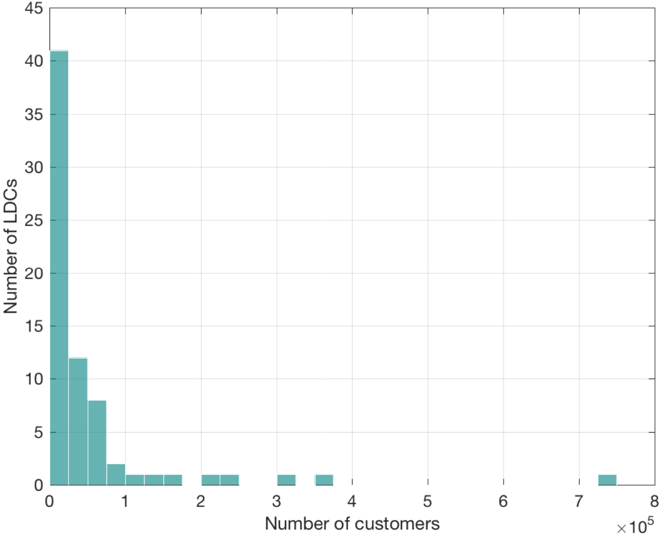
Data

- We obtain accounting books for each LDC from the Ontario Energy Board (OEB) for 2005-2014
- LDC location data: used to determine potential merger sets
- Some data on acquisition prices

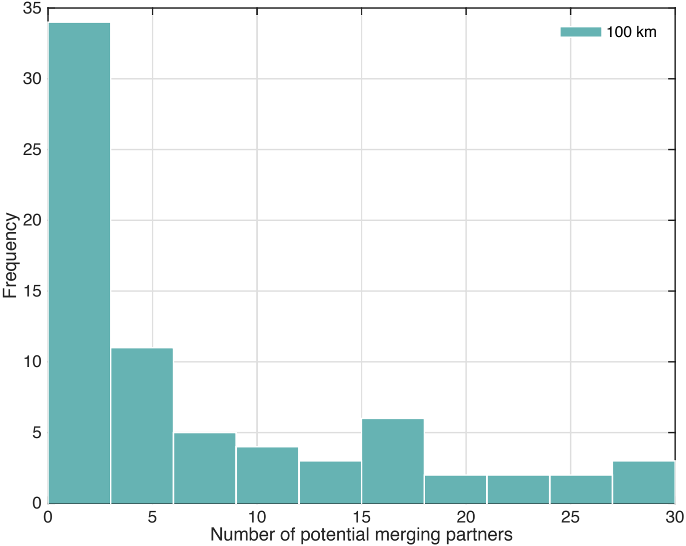
Table : Summary statistics: 2014

Variable	Mean	Std. Dev.	Min	Median	Max
Avg. cost ($/customer)	455.2	167.7	212.8	420.4	1,482.5
Density line (cust./km)	46.3	17.9	6.3	46.3	80.9
Fraction urban serv. area	.65	.38	0	.83	1
Price of capital ($/km)	132,777	62,500.9	29,850.8	130,000	414,873.8
Electricity sold (kWh/customer)	22,521.2	5,279.2	9,623.9	21,843	39,662.9
Fraction of losses	.04	.02	.02	.04	.09
Number full time employees	139.9	420.9	0	39	3,214
Density area (cust./km^2)	310.1	242.4	.82	284.6	1,181.4
Total customers	69,289.7	173,737	1,221	20,842.5	1,219,292
CAIDI (including line losses)	1.4	.87	.04	1.08	3.9
SAIDI (including line losses)	1.5	1.8	.01	1.03	10.1
SAIDI	2.3	2.5	.01	1.45	12.3
Rural service area (km^2)	9,374.3	76,580.3	0	7.5	650,000
Fraction overhead lines	.68	.19	.24	.71	1
Avg. # potential merging partners	6.7	8.3	0	3	30
N	72				

Size distribution



Potential merging partners



Endogenous Merger Model

- Profits for firm *i* serving q_i customers:

$$\pi_i = q_i \times (\bar{p}_i - AC(q_i))$$

  $\bar{p}$ is the price cap in the industry, *AC* is avg cost function

- **Want to forecast which firms merge and with whom**

- Specify a sequential algorithm which allows buyers to make acquisition offers to potential sellers
  - Sort LDCs according to observed net income (we also try alternative sortings)
  - Most profitable LDC moves first, makes take-it-or-leave-it (TIOLI) offer to the best available target in its *feasible set*
  - Move down the list sequentially until no more offers occur

- LDCs compare profits from merger to profits from staying alone

- **Empirical challenge**: determine firm *i*'s *AC*
  - For existing firms: use actual *AC* observed in the data
  - What about merging firms? Harder

Endogenous Merger Model

If firms i and j merge, profits for the merged entity:

$$\pi_{ij} = (q_i + q_j) \times \left(\bar{p}_{ij} - \widehat{AC}(q_i + q_j) \times \Psi(d_i, d_j)\right) - Z_{ij}$$

- $\widehat{AC}(q_i + q_j)$ is the estimated average cost for a firm serving $q_i + q_j$ customers
- $\Psi(d_i, d_j) = \alpha d_i + (1 - \alpha) d_j$
- $d_{\cdot}$ is firm's *relative inefficiency* from a stochastic frontier for costs
  - α represents the relative influence of the buyer's efficiency on the merged entity
  - $\Psi(d_i, d_j)$ is the relative inefficiency of the merged entity
- Interconnection costs Z_{ij}: quadratic function of the number of firms in the conglomerate, I_{ij}, at the moment when i acquires j (and including j). Specifically $Z_{ij} = \lambda I_{ij}^2$ and we calibrate λ from the data.

Endogenous Mergers

- Net gains for a buyer:

$$NG_{buyer} = \max\{0, \pi_{ij} - b_{ij} - \pi_i + s_{ij}\}$$

- Net gains for seller:

$$NG_{seller} = (1 - \tau)b_{ij} - \pi_j + s_{ij}$$

- s_{ij} is a cost/synergy random shock (Gowrisankaran (1999), Jeziorski (2013))
- b_{ij} is the TIOLI offer
- τ is the acquisition tax

Endogenous Mergers

- The buyer solves

$$\max_{b_{ij}} E[NG_{buyer}(b_{ij})|NG_{buyer}(b_{ij}) > 0] \qquad \text{s.t. } \Pr[NG_{seller}(b_{ij}) > 0] = 1$$

- Assume synergy random shock $s_{ij} \sim U[-s^{\max}, s^{\max}]$
- Then,

$$b_{ij}^{*} = \frac{\pi_j + s^{\max}}{1 - \tau}$$

Acquisitions

- Suppose firms are sorted as: $A > B > C > D > E$
- We start with A. Suppose that only B and D are within the feasible geographic set for A
- A determines $b^*_{AB}, b^*_{AD}, NG_{buyer}(b^*_{AB})$ and $NG_{buyer}(b^*_{AD})$
- Suppose $NG_{buyer}(b^*_{AD}) > NG_{buyer}(b^*_{AB}) > 0$, then a new firm is created with number of customers $q_A + q_D$ and avg. costs $\widehat{AC}(q_A + q_D)$
- Now firm $\{AD\}$ makes an offer to firm B. If joint surplus of $\{ADB\}$ is positive, we continue the process
- If joint surplus of $\{ADB\}$ is negative, we now let firm C make offers

Estimation and calibration

- Steps:

  1. Stochastic frontier estimation
  2. Calculate synergies using info on bids from consummated mergers
  3. Find buyer influence and interconnection costs parameters using merger algorithm
  4. Use these parameters to simulate mergers under counterfactual conditions

Stochastic Frontier Estimation

- We estimate an AC curve in two dimensions: electricity output q_i and $density_i$ (# customers per km of line)

- First we estimate a stochastic frontier for costs (see Knittel (2002) for an application to the U.S. electricity industry)

$$C(q_{it}, density_{it}) = f(q_{it}, density_{it}, \mathbf{W}_{it}; \theta)\xi_{it}\exp(\epsilon_{it})$$

  $\mathbf{W}_i$ is a vector of observables, θ is a parameter to be estimated, ϵ_i is the unobservable error term

- $\xi_i \geq 1$ is the firm's level of inefficiency: if $\xi = 1$ the firm is at the cost frontier
  Deviations from this cost frontier are associated to values of $\xi > 1$

Stochastic Frontier Estimation

- Using the rest of the estimates and the predicted values for $\hat{C}$ we compute average costs:

$$\widehat{AC}(q_{it}, density_{it}) = \hat{C}(q_{it}, density_{it})/q_{it}$$

- Consider the set of scattered data points of $\widehat{AC}(q_i, density_i)$ and find a surface that best interpolates those scattered data points

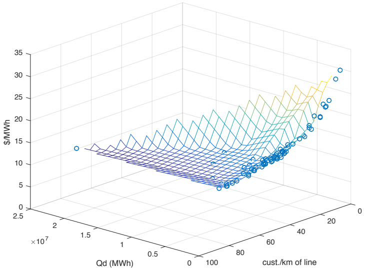


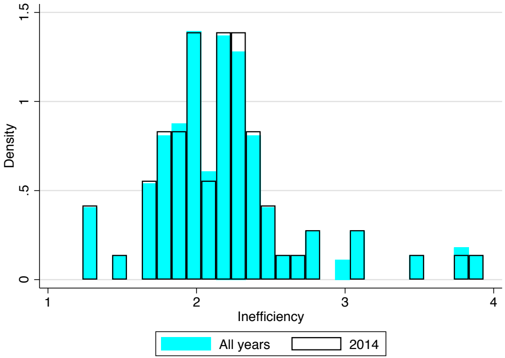
Figure : Average cost curve as a function of q_i and line density

Table : Stochastic frontier analysis. 2009-2014.

Variable	(1)	(2)	(3)
log q	0.931***	0.905***	0.923***
	(0.0210)	(0.0210)	(0.0267)
log density	−0.394***	−0.580***	−0.581***
	(0.0573)	(0.0711)	(0.0929)
log price capital		0.258***	0.267***
		(0.0637)	(0.0647)
log frac. urban area			0.0119
			(0.0395)
log frac. overhead lines			0.153
			(0.131)
constant	4.493***	2.636***	2.351***
	(0.497)	(0.634)	(0.708)
log σ_ν^2	−2.097***	−2.170***	−2.188***
	(0.108)	(0.107)	(0.105)
inv. logit γ	0.136	0.0446	0.00248
	(0.219)	(0.225)	(0.225)
μ	0.831*	0.758*	0.766*
	(0.389)	(0.330)	(0.369)
N	380	380	380

Notes: Dependent variable: log cost. We use the results from specification (1) for our merger simulations. Standard errors in parentheses * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Figure : Inefficiency scores for the pooled sample and only for year 2014.



Fixed parameters for grid search

Table : Fixed parameters for grid search

Parameter	Description	Value
s^{max}	Upper bound of the random synergy shocks	11.61 million $
$\bar{p}_i$	Price cap for LDC i (ij)	i's average revenue
$\bar{D}$	Bound on distance between merging firms	100 km

Calibration of the relative-influence parameter

- We solve the following problem:

$$\min_{\alpha,\lambda>0}\left\{F(\alpha,\lambda)=\sum_{C_i\in\mathcal{J}_1}(NG_i(\alpha,\lambda))^2+\sum_{C_i\in\mathcal{J}_2}(NG_i(\alpha,\lambda)-NG_i'(\alpha,\lambda))^2\right\},$$

  where C_i is the conglomerate created when it is buyer *i*'s turn to offer

- $\mathcal{J}_1$ contains conglomerates predicted by the merger algorithm, but where the buyer *is not* part of any observed mergers. Two cases:
  (i) All feasible mergers result in $NG_i < 0$
  (ii) No more feasible additions exist to the conglomerate

- $\mathcal{J}_2$ consists of the conglomerates for which $NG_i < 0$ for any potential merger with a feasible firm *j* in the last *i*'s attempt to make an acquisition, but in this case the conglomerate so far constructed contains an observed merger

Results: Efficiency parameters

Table : Value of α and cost of distance from grid search

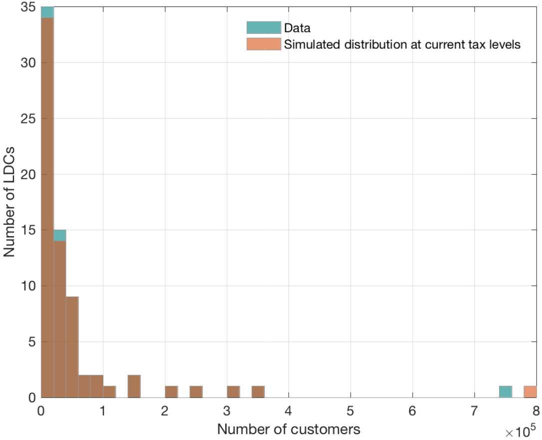
$\bar{D}$ (km)	α	λ
80	0.6483	4.0241×10^6
100	0.7517	4.0552×10^6
120	0.7517	4.2748×10^6

Notes: We use the values from the 100 km specification in all of our merger simulations.

- Buyer's influence is larger than the seller's.

Results: Goodness-of-fit

Figure : Data vs. BAU distribution



Mergers under different policy environments

Table : Mergers under different policy environments

	Data	BAU	Counterfactuals: Proposed tax	Subsidy 10%	Subsidy 60%	Subsidy 150%	Subsidy 400%
Nbr LDCs	71	69	69	68	67	65	62
Survival ratio	-	0.97	0.97	0.96	0.94	0.92	0.87
Nbr of conglomerates	-	1	1	2	3	5	7
Nbr merged firms (rel. to bench.)	-	-	0	1	2	4	7
Nbr conglom. (rel. to bench.)	-	-	0	1	2	4	6
Avg. Nbr LDCs/conglom.	-	2	2	1.5	1.33	1.2	1.29
Avg. size buyer (thous. cust.)	-	763.6	763.6	576.2	550	450.6	325.8
Avg. size seller (thous. cust.)	-	22.9	22.9	95.3	72.8	86	87.5
Avg. AC ($/MWh)	20.07	20.21	20.21	20.23	20.4	20.47	20.71
S.D. AC ($/MWh)	8.92	9	9	9.07	9.02	9.15	9.3
Avg. inefficiency *d*	2.12	2.119	2.119	2.117	2.126	2.131	2.143
S.D. inefficiency *d*	0.57	0.567	0.567	0.569	0.563	0.571	0.577
Avg. ineff. buyer	-	2.667	2.667	2.342	2.42	2.264	2.003
Avg. ineff. seller	-	1.825	1.825	2.015	1.814	1.859	1.907
Mean bid (mill. $)	-	14.93	14.93	25.68	15.12	10.04	4.86
S.D. bid (mill. $)	-	3.58	3.58	21.09	12.89	6.27	2.62
# of tested combinations		2,986					
1 - mistakes / testedComb.		0.99					

Notes: Averages are non-weighted. Proposed tax is 22% or 0% depending on whether nbr of customers is greater than 30,000 or not. Subsidy X% is a negative transfer tax of X% (X=10, 60, 150, 400).

More results

- Many of our counterfactual subsidy experiments predict mergers involving some combination of Enersource, PowerStream, and Horizon Utilities
- A conglomerate composed of these three LDCs formed following the end of our period of analysis
- Our results are robust to random orderings for offers

Table : Average survival ratio and nbr of conglomerates with random orderings for offers

	BAU	Subsidy 10%	Subsidy 60%	Subsidy 400%
Survival ratio	0.96	0.94	0.92	0.83
Nbr of conglomerates	2.02	3.43	4.57	10.79

Summary of findings:

- Buyers have a stronger influence (75%) on the newly merged firm's cost efficiency than sellers
- Buyers are on average much larger and less efficient than acquired firms before the merger
- Mergers do not achieve the desired average cost reductions, and, in fact, can even lead to cost increases
- Even a substantial subsidy reduces the number of LDCs by only 13%, nowhere near the stated objective.

Conclusion

- We propose a method that endogenizes the merger process in the electricity distribution industry with take-it-or-leave-it offers
- Method is easily computable even if number of firms is large
- Can be used to evaluate current recommendation as well as tax incentives and changes in price regulation
- Findings: tax reduction provides insufficient incentive to achieve policy objective