Local Impacts of Resource Shocks

Three quantitative case studies from Indonesia

Ryan B. Edwards

Contributed presentation at the 60th AARES Annual Conference,
Canberra, ACT, 2-5 February 2016
LOCAL IMPACTS OF RESOURCE SHOCKS

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Ryan B. Edwards

AARES Annual Conference, 4 February 2016

Center on Food Security and the Environment
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Australian National University
How does rapid resource sector expansion affect a local district economy and its residents’ welfare?
Indonesia: world’s largest coal and palm oil exporter.
Why You Care

- Indonesia: world’s largest coal and palm oil exporter.
- Development implications of sustained resource-driven growth in Indonesia are still not well understood.
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- Indonesia: world’s largest coal and palm oil exporter.
- Development implications of sustained resource-driven growth in Indonesia are still not well understood.
- Quantitative studies can often lack context and disregard heterogeneity.
- Qualitative case studies cannot quantify impacts.
What I Do

- Case study approach, at the district level.
What I Do

∙ Case study approach, at the district level.
∙ One district for each of Indonesia’s three largest exports: coal, natural gas, and palm oil.
Case Study Districts

Indragiri Hilir, Riau

Tapin, South Kalimantan

Manokwari, West Papua
What I Do

I use a relatively new empirical method—**synthetic control modeling**—to construct a “synthetic” comparison district for each resource boom district, allowing me to compare the booming districts’ observed outcomes with reasonable counterfactuals.
Synthetic Control Method

Outcome (Y)

-3 -2 -1 t t+1 t+2

Effect

Synthetic control (Y, X1, X2, X3)

Treatment N = 1?
1. Set up a balanced panel
1. Set up a balanced panel
2. Identify outcomes of interest
1. Set up a balanced panel
2. Identify outcomes of interest
3. Identify appropriate case studies
1. Set up a balanced panel
2. Identify outcomes of interest
3. Identify appropriate case studies
4. Identify relevant predictor variables
1. Set up a balanced panel
2. Identify outcomes of interest
3. Identify appropriate case studies
4. Identify relevant predictor variables
5. Restrict pool of potential comparison units
Case Study Districts—Treatments

- Indragiri Hilir palm oil (LHS)
- Tapin mining (RHS)
- Manokwari oil & gas /10 (RHS)
RESULTS—OIL PALM IN INDRAGIRI HILIR
Oil Palm and Industry

![Graph showing per capita industry RGDP (million IDR) from 2001 to 2011 for Indragiri Hilir and synthetic control.](image-url)
<table>
<thead>
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<th>Year</th>
<th>Indragiri Hilir</th>
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**Per capita services RGDP (million IDR)**

- **Oil Palm and Services**
Results—Coal Mining in Tapin
Coal Mining and Aggregate Output

Per capita RGDP (million IDR)

Year

2001 2003 2005 2007 2009

Tapin synthetic control
Coal Mining and Agriculture

![Graph showing the trend of per capita agriculture RGDP (in million IDR) from 2001 to 2009 for Tapin and a synthetic control. The graph indicates an increasing trend over the years.]
COAL MINING AND POVERTY

![Poverty rate over years graph]

- **Poverty rate (%)**: 5, 6, 7, 8, 9, 10
- **Lines**:
  - Red: Tapin
  - Dashed: Synthetic control
GAS EXTRACTION AND AGGREGATE OUTPUT

Per capita RGDP (million IDR)

Year

2001 2003 2005 2007 2009 2011

Manokwari --- synthetic control
GAS EXTRACTION AND AGRICULTURE

![Graph showing per capita agriculture RGDP (million IDR) over years from 2001 to 2011 for Manokwari and synthetic control.]
GAS EXTRACTION AND POVERTY

![Graph showing poverty rate over years with a comparison between Manokwari and synthetic control.](image-url)
Key Findings

- Three booms boosted GDP relative to counterfactuals.
- Oil palm in Indragiri Hilir reduced poverty and generated small but positive spillovers.
- Coal mining in Tapin reduced poverty and economic output in non-resource sectors.
- The Tangguh LNG project reduced agricultural output and had no discernible impact on residents’ welfare.

Synthetic control modeling is a useful impact evaluation tool for policy changes and events affecting single units.
Three Contributions

New causal evidence on local economic and welfare impacts of resource sector expansion for each of Indonesia’s three primary exports.

Unique application of method: 2nd to sub-national developing country data; 1st to non-dichotomous treatments; 1st for resource sector within-country.

Demonstrate approach is a flexible way to look at the impacts of district policies and shocks in Indonesia.
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Follow me on Twitter: @ryanbedwards

See me on campus until May 2016: Arndt-Corden Department of Economics, HC Coombs Building, Fellows Road, Australian National University
APPENDIX
Synthetic Control Method

A systematic way to choose case study comparison units, allowing causal quantitative inference in small samples, often a single treated unit.
d = 1 is the “treated” boom district in sample of D + 1.
d = 2 to d = D + 1 are potential comparison districts.

$Y_{d,t}$ is the outcome of interest for district d at time t.

A synthetic control for $d = 1$ is constructed as a weighted average of comparison pool districts with weights:

$$W = (w_2, ..., w_{d+1})'$$  \hspace{1cm} (1)

with $0 \leq w_d \leq 1$ for $d = 2, ..., D + 1$ and $w_2 + ... + w_{d+1} = 1$. 
Use a data-driven algorithm to minimize pre-treatment differences in outcomes of interest to get a single comparison district that best resembles the treated district’s outcome levels, behaviour, and observables.

Find $W^*$ that minimizes:

$$\begin{align*}
    (X_1 - X_0 W)'V(X_1 - X_0 W)
\end{align*}$$

$X_1$: pre-treatment variables for the treated district.

$X_0$: same variables for D potential comparison districts.

$V$: a diagonal matrix reflecting their relative importance.
If a good pre-treatment fit is achieved, differences in post-treatment outcomes likely due to treatment. Treatment effect for $d = 1$ in post-boom period $t$ is

$$Y_{1,t} - \sum_{d=2}^{D+1} w_d^* Y_{d,t}$$

where $w_d^*$ are the optimal weights.

Assumption: treatment is the only major change.
1. Set up a Balanced Panel

Synthetic controls require:

- Balanced panel for outcomes (Ys) for all units.
- Each predictor (Xs) available for all units for at least one pre-treatment period.

District level panel data (2001–) taken from Indonesia Database for Economic and Policy Research.

- 2001 boundaries; sample is as large as data permit.
2. Identify Outcomes of Interest

Regional gross domestic product (RGDP)
- Million IDR; per capita terms
- Total and components (agriculture, industry, services)

District average monthly household expenditures
- SUSENAS; IDR; per capita terms

District poverty rate (%)
- Percentage of the population with expenditure below a universal consumption requirement (mostly caloric)
- Derived from SUSENAS
3. Identify Appropriate Case Studies

One district resource boom for each of Indonesia’s three key export commodities, where each “treatment” event must be significant relative to idiosyncratic shocks.

1. Sort district-year observations by 2-year changes in mining & quarrying; oil & gas; palm oil production
3. Identify Appropriate Case Studies

One district resource boom for each of Indonesia’s three key export commodities, where each “treatment” event must be significant relative to idiosyncratic shocks.

1. Sort district-year observations by 2-year changes in mining & quarrying; oil & gas; palm oil production
2. Restrict sample to 2005 and after
3. Identify Appropriate Case Studies

One district resource boom for each of Indonesia’s three key export commodities, where each “treatment” event must be significant relative to idiosyncratic shocks.

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3. Select highest ranked, with a dichotomous treatment
One district resource boom for each of Indonesia’s three key export commodities, where each “treatment” event must be significant relative to idiosyncratic shocks.

1. Sort district-year observations by 2-year changes in mining & quarrying; oil & gas; palm oil production

2. Restrict sample to 2005 and after

3. Select highest ranked, with a dichotomous treatment
   - consistently low/zero production in early years, a rapid scale-up of production that remains high, and no other resource booms or major shocks
CASES—TREATMENTS

Figure: Resource boom “treatments”

- Indragiri Hilir palm oil
- Tapin mining
- Manokwari mining
4. Identify Relevant Predictors

W* depends on V. Select predictors in $X_0$ & $X_1$ carefully to

1. Describe each case’s pre-treatment profile; and
2. Predict each case’s post-treatment trajectory

I use output per capita, literacy rate, population density, agricultural and industry employment shares, average household expenditures, the poverty rate, the poverty gap index, the agricultural and manufacturing output shares, and lagged outcome variables (not all lags), subject to data availability.
5. Restrict the Pool of Comparison Districts

Selecting untreated units sufficiently similar to the treated units is vital to conduct valid comparisons.

I restrict the pool of potential comparison districts to:

1. Untreated districts

- Avg. annual mining output <10 billion IDR and palm oil production <1000 tons for whole period; no big shocks
- Not affected by treatment in the treated district: Different province, to minimize spatial spillovers
- Sufficiently similar to the treated districts: $0.5$ to $1.5 \times$ outcome and, where feasible, same island
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3. Sufficiently similar to the treated districts
   - 0.5 to 1.5 × outcome and, where feasible, same island
Robustness

- **Dose-response design**: track treatment to economy.
- **Falsification tests**: placebo tests across time, across space, and even on synthetics.
- **Leave-out-out analysis**: check sensitivity of estimates to the inclusion of particular control districts.
- **Alternative specifications**: Predictors; donor pools.
- **Replication cases**: oil palm in Kalimantan and Sumatra, oil and gas in East Java, mining in Sulawesi.
<table>
<thead>
<tr>
<th>District</th>
<th>Indragiri Hilir</th>
<th>Tapin</th>
<th>Manokwari</th>
<th>Nat. avg.</th>
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<td>Treatment yr</td>
<td>2008</td>
<td>2005</td>
<td>2008</td>
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<td>Coal</td>
<td>Gas</td>
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<td>8</td>
<td>51</td>
<td>18</td>
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<td>1,215,282</td>
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<td>49</td>
<td>52</td>
<td>32</td>
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<td>85</td>
<td>95</td>
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<td>95</td>
<td>87</td>
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<td>RGDP per capita (2008)</td>
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<td>Industry employment share</td>
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<tr>
<td>0.5</td>
<td>Dairi</td>
<td>North Sumatra</td>
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<td>0.31</td>
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<td>0.01</td>
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### Results—Oil Palm in Sumatra

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## Results—Coal Mining in Kalimantan

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## Results—Gas Extraction in West Papua

### Treatment minus synthetic control

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<td>Services</td>
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<td>0.12</td>
<td>0.04</td>
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Oil Palm in Indragiri Hilir, Riau

Figure: Agriculture
Figure: Industry
Figure: Services
Oil Palm in Indragiri Hilir, Riau

Figure: Poverty
Three potential explanations:

1. Data issues?
2. Is oil palm particularly pro-poor and redistributive?
3. Steep cumulative distribution function and bunching at the poverty line?
Coal mining in Tapin, South Kalimantan

Figure: Agriculture
Coal mining in Tapin, South Kalimantan

**Figure:** Industry
Coal mining in Tapin, South Kalimantan

Figure: Services
Coal mining in Tapin, South Kalimantan

Figure: Household Expenditure
Figure: Agriculture
Figure: Industry
Figure: Services
Figure: Household expenditure