Casualties of border changes: Evidence from nighttime lights and plant exit

Kristian Behrens
UQÀM, and CEPR

Maria Kuznetsova
Higher School of Economics
Introduction

- International borders change over time.
- Besides geopolitical consequences, changes in borders—and in the ease with which they can be crossed—have substantial economic consequences.

- **Market access** affects the location and size of economic activity:
  - German division and reunification after WWII and population growth in border cities (Redding and Sturm, 2008);
  - Fall of the Iron Curtain and wage and employment growth in Austrian border municipalities and cities (Brülhart et al., 2012, 2018);
  - Division and reunification of Berlin after WWII; reorientation of land price and employment gradients (Ahlfeldt et al., 2015);
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• More granular data—nighttime lights (NTL) and firm-level data—to assess effects of market access on regional outcomes. For example, NTL to investigate:
  • the effects of sanctions in North Korea (Lee, 2018);
  • changes in border cities’ GDP following African regional trade agreements (Eberhard-Ruiz and Moradi, 2019);
  • the ‘dimming’ effect of international borders on nighttime lights (Brülhart et al., 2022);
  • firm-level data to look at the eastern EU expansion effects on firms’ sales and exports close to new external EU borders (Vermeulen, 2022).

• New findings emerging from finer spatial data:
  • market access effects in border regions are highly localized, usually less than 50 km;
  • effects differ substantially across locations, depending on initial exposure to other regions’ economic activity (e.g., Yang et al., 2022);
  • localized effects driven by economic activity that is very sensitive to distance frictions.
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- localized effects driven by *economic activity that is very sensitive to distance frictions*. 
Setting and main findings

- Annexation of Crimea in 2014 and the ensuing conflict (up to 2018) as a source of exogenous variation in market access for Russian border regions;

- Assessing the direct effect of the annexation is complicated: Western sanctions after 2014 affect growth and firm performance.

- We exploit differential exposure to changes in market access along the border (north vs south) to identify the economic effects.

- We also exploit the closure of local border crossings as a source of exogenous variation in cross-border labor movements.
Setting and main findings

- We quantify the effects of border changes using NTL and georeferenced plant data.
- Regions with relatively deteriorating market access or more exposed to Ukraine pre-2014
  - *saw less growth in lights* (preferred: 3.4%-4% less growth in GDP; average across specifications: 5.2%);
  - *saw more plant exit*, about 1.5 pp increase.
- In northern regions, local cross-border labor movements may drive localized effects.
Geopolitical context and timeline

- August 1991: Ukraine declares independence from USSR; border regions were historically highly integrated and remained so
- February 1995: agreement on state border checkpoints and simplified border procedures for cross-border commuting
- April 2004: ratification of formal border treaty
- Early 2012: initiation of the EU Association agreement
- November 2013: ‘Euromaidan’ following the decision to not sign the Association Agreement in favor of the Eurasian Economic Union.
- March 2014: annexation of Crimea by Russia
- April 2014: armed conflict erupts in the Donbass following the proclamation of two independent republics
- March 2015: Ukraine tightens border controls
- We cover the period 2006–2018
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Data

**NTL and plant-level data**

Harmonized nighttime lights, 2005–2018, digital number $\in [0, 63]$ (Li et al., 2020). Based on DMSP and VIIRS.

Ruslana and Interfax SPARK manufacturing plant-level databases: entry and exit date, status updates, industry code, de facto address. Geocoded using Yandex API.

**Key dependent variables**

Cell-level (1 $\times$ 1 km), raw NTL or lights-weighted regional GDP.

Plant-level exit status in year $t \in [2006, 2018]$, regular updates from the Unified State Register of Legal Entities.
Main exposure measures

- **Dummies** for plants/cells less than 50, 100, or 150 kilometers from the border;
- **Market potential measures**, access to NTL or GDP in Ukraine, inversely weighted by distance;
  - Relative crow-fly distance (distance from the positive border segment in the south to distance from the negative border segment in the north);
  - Relative network distance on the main road system;
  - Mean-centered latitude (continuous), or discretized latitude bands: South, Donbass, North.
Exposure to activity in Ukraine and to border changes

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Exposure to Ukrainian market potential, 2010–2013: NTL cells
Empirical analysis

Empirical strategy:

- Estimate the effects of border changes using a ‘DiD’ framework: we compare less exposed cells or plants pre 2014 with more exposed cells/plants;
- Some cells/plants are more exposed to negative border ‘changes’ (Donbass, north) while others are more exposed to positive border changes (south) post 2014;
- We expect (and do find) worse outcomes for more exposed cells/plants after 2014.

Robustness and mechanisms:

- Many robustness checks and additional analyses to rule out potential confounders;
- Explore economic mechanisms behind the results
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Our baseline specifications:

\[ y_{i,t} = \beta_0 + \gamma_1 (\text{post}_{2014} \times \ln \text{minD}_i) + \gamma_2 (\text{post}_{2014} \times \exp_i) + \alpha_i + \delta_t + \varepsilon_{i,t}, \]

\[ y_{p,t} = \beta_0 + \gamma_1 (\text{post}_{2014} \times \ln \text{minD}_p) + \gamma_2 (\text{post}_{2014} \times \exp_p) + \mathbf{X}_{p,t} \gamma_3 + \alpha_p + \delta_t + \varepsilon_{p,t} \]

where

- \( y_{i,t} \) is one plus log NTL-GDP (or NTL) of cell \( i \) in year \( t \);
- \( y_{p,t} \) is a dummy that takes value 1 if plant \( p \) exits in year \( t \);
- \( \ln \text{minD}_i \) is the minimum distance of cell \( i \) from the border;
- \( \exp_i \) is the log one of our exposure measures;
- \( \text{post}_{2014} \) is a dummy variable taking value 1 starting in 2014.

Our coefficient of interest is \( \gamma_2 \).
## Changes in cell-level GDP

<table>
<thead>
<tr>
<th></th>
<th>(1) distance band</th>
<th>(2) distance band</th>
<th>(3) LMP Ukr</th>
<th>(4) GMP Ukr</th>
<th>(5) GC</th>
<th>(6) LAT</th>
<th>(7) LAT bands</th>
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<tbody>
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<td>0.952&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>1.764&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>post2014 × band (negative)</td>
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<td>-0.345&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>8,133,230</td>
<td>8,133,230</td>
<td>8,133,230</td>
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<td>(1) distance band</td>
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<td>post2014</td>
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<td>0.294&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>0.160&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>0.003&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>post2014 × Lat (Donbass)</td>
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<td>Plant controls</td>
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<tr>
<td>Observations (plant-year)</td>
<td>528,147</td>
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<td>528,147</td>
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<tr>
<td>R-squared</td>
<td>0.222</td>
<td>0.222</td>
<td>0.222</td>
<td>0.222</td>
<td>0.222</td>
<td>0.222</td>
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</table>
Changes in outcomes by exposure decile

(a) Cell-level NTL

NTL increased 20–25% less for most exposed cells, about 3.4%-5.2% difference in GDP growth.

(b) Plant exit

About 30–35% more exit (1.5 pp of 7.2% baseline) for most exposed plants.
Robustness checks

Our results are robust to a large number of robustness checks:

- Separate minimum distance measures to northern and southern borders.
- Raw nighttime lights, 2013 GDP-NTL weighted lights as dependent variables;
- Trimming of cells that have zero light;
- Years 2012–2013 as alternative treatment date (initiation of EU accession talks, Euromaidan) yield qualitatively similar effects, but smaller magnitudes;
- Quarterly nighttime lights (VIIRS from 2012–2018) and plant-level data;
- Estimates with industry-year fixed effects for plant exit.
- Exclude plants that exit because of accession and mergers.
Possible confounding factors we try to rule out (see the paper for details):

- Unequal regional effects of the 2014 sanctions which could hit more strongly the north if specialized in sanctioned industries;
- Potential regional effects of the 2014 Winter Olympic Games in Sochi;
- Public investments or politically motivated subsidies to private firms that target more the south;
- More negative expectations about future conflict in the north;
- Disruptions in cross-border electricity trade that affects lights and could also affect more strongly firms that are energy intensive.
More evidence on market access: the local effects of closed border crossings

Zoom on the northern regions (Bryansk, Belgorod, Voronezh, and Kursk):

- We assembled a novel dataset on local border crossings (from the agreement between Russia and Ukraine to facilitate cross-border movements);
- *No trade through these points* (residents of border regions can only move goods not intended for production or other commercial activities across the border);
- Historically an economically highly integrated region (Zhukov, 2016); substantial local cross-border movement of labor (Kolosov et al., 2016; Zayats et al., 2017);
- In March 2015, *shutdown of local border crossings* (the international crossings, serving mainly big cities, remained open); provides variation in the distance to nearest border crossing.
Closing of local border crossings and changes in distance travelled

- Estimate effects of an increase in distance to nearest open border X-ing;
- Use more granular data (quarterly NTL and plant exit series, treatment starting March 2015; VIIRS NTL 500 × 500 meters cells);
- We find negative effects on NTL, especially in treated areas of big cities;
- Eberhard-Ruiz and Moradi (2019) find localized effects of small-scale cross-border trade. Our findings suggest that local cross-border labor movements matter too.
- No statistically significant effect on plant exit
Changes in NTL and distance to border crossings, 50km

<table>
<thead>
<tr>
<th></th>
<th>(1) Equipped X-ings</th>
<th>(2) All X-ings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GC</td>
<td>GCW</td>
</tr>
<tr>
<td>post2015-Q1</td>
<td>0.080(^a)</td>
<td>0.077(^a)</td>
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<tr>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>post2015-Q1 × ΔcrossingDistance</td>
<td>-0.020(^a)</td>
<td>-0.080(^a)</td>
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<td>(0.000)</td>
<td>(0.002)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>post2015-Q1 × bigCity</td>
<td>0.364(^a)</td>
<td>0.356(^a)</td>
</tr>
<tr>
<td>(0.014)</td>
<td>(0.013)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>post2015-Q1 × ΔcrossingDistance × bigCity</td>
<td>-2.978(^a)</td>
<td>—</td>
</tr>
<tr>
<td>(0.606)</td>
<td>—</td>
<td>(0.580)</td>
</tr>
</tbody>
</table>

Cell fixed effects ✓ ✓ ✓ ✓
Year-quarter fixed effects ✓ ✓ ✓ ✓
Observations 8,216,500 8,216,500 8,216,500 8,216,500
R-squared 0.875 0.875 0.875 0.875
Conclusion

- We leverage spatially and economically disaggregated data (nighttime lights and georeferenced plants) to contribute to a recent literature on the regional effects of economic integration and conflict.

- We confirm the robustness of new key insights from that literature:
  - spatial effects of changes in market access are highly localized, effects vary substantially across places and firms;
  - highly localized effects may be partly driven by economic activity that is very sensitive to distance frictions;

- Less growth in lights and more exit in relatively more exposed regions: 3.4%-5.2% difference in GDP growth, about 30%-35% (1.5 pp) difference in plant exit.

- Direct economic costs of the annexation sizeable in some regions, redistributive effects; but DiD and sanctions do not allow for aggregate assessment.