Semaine Data SHS: Valoriser la dimension spatiale des données

Living from the Canopy: Mining in Sub-Saharan Africa (SSA)

Mboundor Diouf* –Ahmed Tritah– Raja Chakir¬

Chaire EIEA (CERNA, Mines ParisTech & UM6P)
University of Poitiers

December 06, 2022

Outline

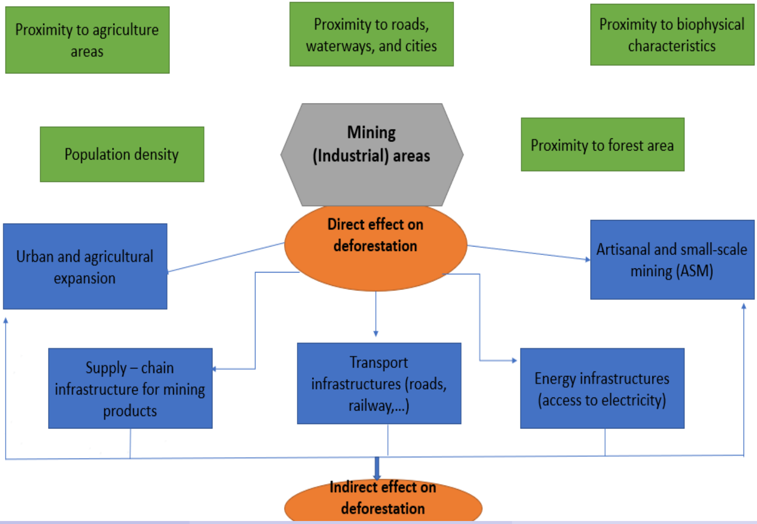
Outline

Motivations: Pressure on the forest cover (1/2)

- Role of forest:
  - Important for mitigating climate variability (Agrawal et al., 2014).
  - Forests capture about 30% of the CO_2 emissions from fossil fuel combustion each year.
- Domestic demand: exceptional demographic context in Africa –> urbanization, industrialization, and the "green" revolution.
- International demand: a global rush on minerals
  Chinese and global demand for minerals during 2000s –> prospecting and discovery of new mines.
  ==> intense pressure on land and forest resources.

Motivations: Pressure on the forest cover (2/2)

Figure: Direct and indirect effect with channel transmissions



Research question

- In this paper, we assess the causal effect of mining on deforestation:
  - How do the dynamic and heterogeneity effects of mining-induced deforestation diffuse across space and time?
  - To quantify, evaluate and identify the direct and indirect effects
  - How has mining impacted the interaction between local economic development and deforestation in Sub-Saharan Africa?

Existing literature I: costs and benefits of mines

- Mining benefits:
  - Positive effect on: living standards (Mamo et al., 2019), standard income (Von der Goltz and Barnwal, 2019), local economic development (Mamo et al., 2019; Cavalcanti et al., 2019).
  - Negative effect on: conflicts (Bhattacharyya and Mamo, 2021), and poverty (Zabsonré et al., 2018; Marlet, 2020)
- Negative consequences of mining:
  - Positive effect on: the incidence of conflict (Berman et al., 2017), inequality (Addison et al., 2017), metal toxicity and pollution, (Hausermann et al., 2018; Von der Goltz and Barnwal, 2019) and forest loss (Sonter et al., 2017; Azomahou and Ouédraogo, 2021; Kinda and Thiombiano, 2021; Girard et al., 2022).
  - Different effect on different dimensions of welfare (Von der Goltz and Barnwal, 2019; Cust and Mensah, 2020)

Existing literature II: mining and deforestation

- Direct effects:
  Within the immediate boundaries of mining companies (Durán et al., 2013) and up to tens of kilometers (Edwards et al., 2014). Sonter et al. (2017): mining increases deforestation inside (direct) and outside (indirect) mine concession boundaries.
- Indirect effects:
  Three (3) main channels:
  - (i) Pollution.
  - (ii) Transport infrastructure and energy needs (Zhang and Wilkes, 2010; Busch and Ferretti-Gallon, 2020; Nelson and Hellerstein, 1997; Geist and Lambin, 2001)
  - (iii) Economic and agricultural development, spatial population dispersion, and urbanization.

- We identify direct and indirect effects that show how a mining area affects the diffusion of deforestation over space and time.
- We mobilize a research design that is suitable to assess the dynamic and heterogeneity effects of mines (across space and time)
  - Why are dynamic and heterogeneous effects important in the context of mines? Why should we care about spatial diffusion (the SUTVA assumption in our context is challenging)
  - We use a credible and robust identification strategy that relies on recent advances in the dynamic spatial treatment effect.

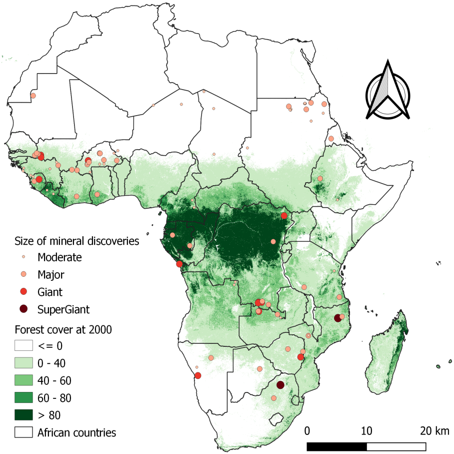
- Main results:
  - Industrial mining leads to deforestation at the district level.
  - significant and positive spillover effects 50 miles away from the mining cell.
  - The indirect impact of mining on annual forest loss is more significant and robust than the direct effects.
  - Indirect effects decrease with the distance from the mining site.
  - Exogenous variations in mineral world prices confirm the detrimental impact of mining on deforestation.
  - Transmission channels: local economic development.
  - Heterogeneous effect on deforestation: mines' sizes, the type of minerals, mines' properties, and the number of mines discovered in the district.

Outline

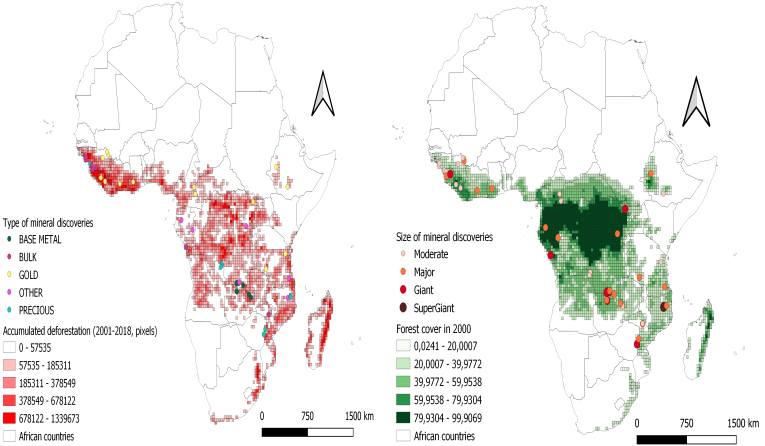
Data description (1/1)

- Deforestation and forest cover:
  deforestation data annually (2001-2018) and the forest cover (>20% of trees, 2000) data of Hansen et al. (2013). The spatial resolution is 30 m.
- Mining industry:
  from Minex Consulting. Contain information on mines' geographical positions and characteristics worldwide since 1950.
- Other data:
  - NDVI: variable as a proxy to measure agricultural production.
  - Population density (number of people per km^2): from Gridded Population density(2000, 2005, 2010 and 2015).
  - Nighttime lighting: To approximate economic activity at the sub-national level between 2000 and 2018. From National Oceanic and Atmospheric Administration (2013).

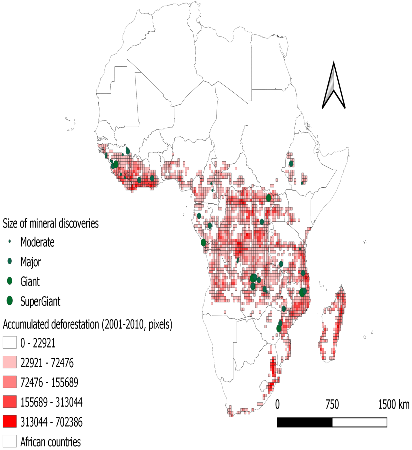
Spatial correlation between the localization of mineral discoveries and forest cover (2000) in SSA

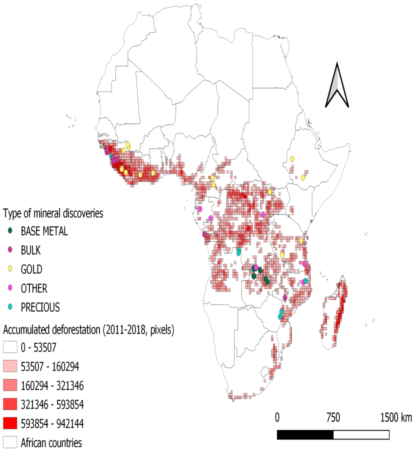


Localization of forest cover in 2000 and the accumulated deforestation (2001-2018) with the size of mineral discoveries (2001-2018) at grid cell 55x55 km level



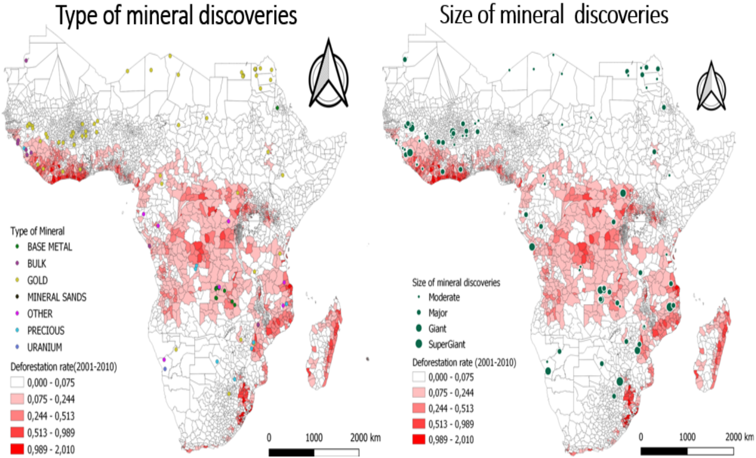
Deforestation correlates with the size of mineral discoveries but also with the type of minerals in SSA at grid cell 55x55 km level



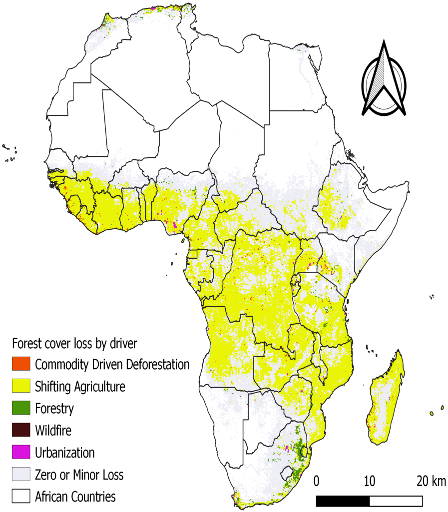


Source: Authors' calculations

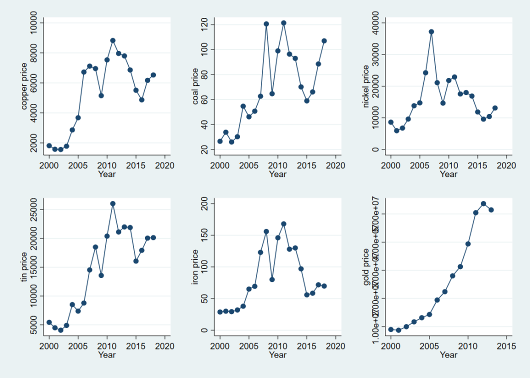
Deforestation rate (2001-2010) and type and size of mineral discoveries in production between 2001 and 2018 in SSA at district level

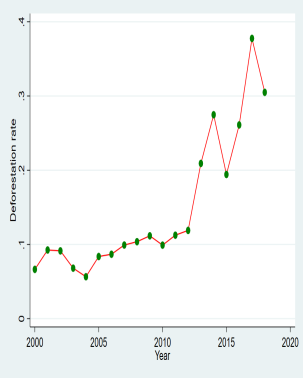


Tree Cover Loss by Dominant Driver in Africa



Stylized facts: deforestation responded to price surge but with lag





Outline

Research Design: dynamic treatment effect (TWFE-DD)

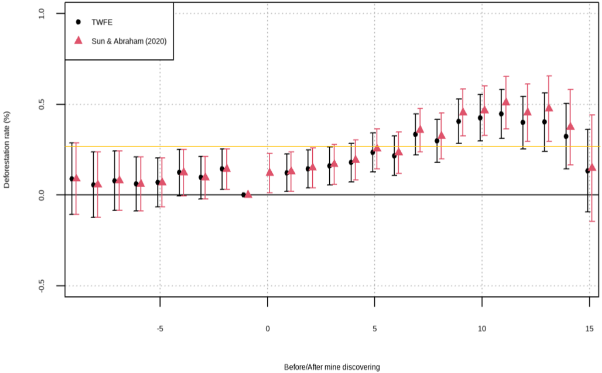
We estimate the following equation:

$$Y_{it} = \alpha_i + \lambda_t + \sum_{k=-9}^{-2} \pi_y D_{it}^k + \sum_{k=0}^{15} \tau_y D_{it}^k + \varepsilon_{it} \quad (1)$$

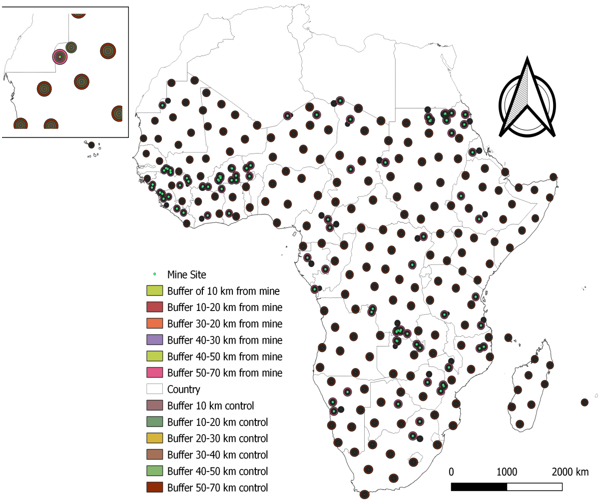
- $Y_{i,t}$: deforestation rate for unit i at time t.
- D_{it}^k: the treatment of having at least one mine in production in an area i (district, cell, and buffer zone) at time t.
  D_{it}^k = 1 if a unit i has been treated by time t for k years and $D_{i,t}$=0 otherwise.
- π_y: test of parallel pre-trends;
  τ_y: the treatment effect of mining y years after mineral discoveries.
- α_i and λ_t are, respectively, the units (district, grid cell, or buffer zone) fixed effects and time-fixed effects.

Outline

Event Study Results in District level

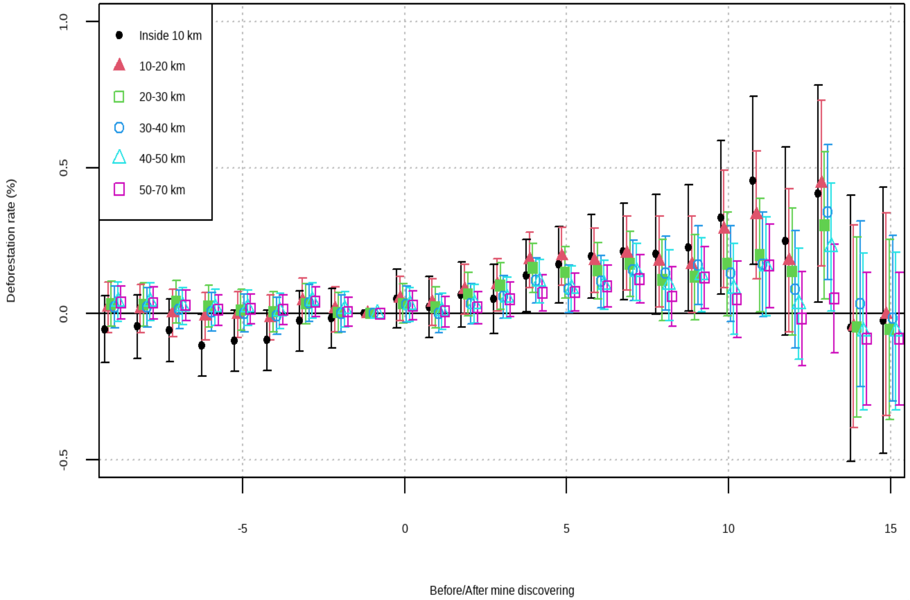


Treated and controlled buffers zones created



Source: Authors' calculations.

Indirect effect results



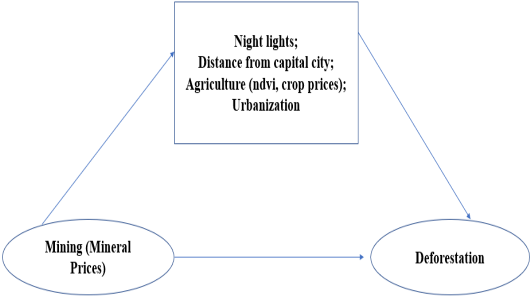
Deforestation in sq of km at district level

Cohort treated	Year treated	ATT (%)	Deforestation total in sq of km	Deforestation induced mining in sq of km	Deforestation induced other sources in sq of km
cohort	2001	0,02	12441,83	2,35	12439,48
cohort	2002	0,04	13247,82	5,90	13241,92
cohort	2003	0,14	9469,68	12,93	9456,75
cohort	2004	0,37	10131,99	37,33	10094,66
cohort	2005	0,16	13593,35	21,50	13571,84
cohort	2006	0,42	13955,18	58,97	13896,20
cohort	2007	0,26	16213,37	41,81	16171,56
cohort	2008	0,39	15857,12	61,92	15795,20
cohort	2009	0,26	19607,78	51,51	19556,27
cohort	2010	0,09	19692,09	17,76	19674,32
cohort	2011	0,54	17132,76	92,93	17039,83
cohort	2012	0,05	19556,34	9,09	19547,25
cohort	2013	0,51	30119,47	153,49	29965,98

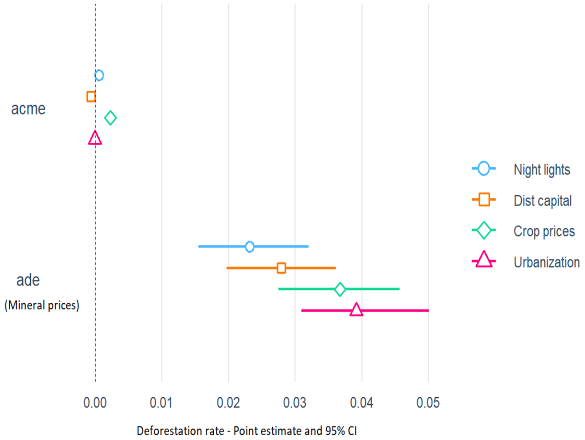
Notes: We do not include 2014, 2015 and 2016 cohorts because they are not statistically significant.

Outline

Conceptual framework of Causal Mediation Analysis



Mineral prices on deforestation and mechanism effects



Outline

Alternative research design: Direct and Indirect (or spillover) effects

$$Y_{it} = \mu_i + \mu_t + \sum_{k=-9}^{-2} \tau D_{it}^k + \sum_{k=0}^{15} \tau D_{it}^k + \sum_{k=-9}^{-2} \tau_{\text{spill,control}} \text{ Within } 50\text{mi}_{it} * S_{it}^k (1 - D_{it}) + \sum_{k=0}^{15} \tau_{\text{spill,control}} \text{ Within } 50\text{mi}_{it} * S_{it}^k (1 - D_{it}) +$$

$$\Sigma_{k=-9}^{-2} \tau_{\text{spill,treat}} \text{ Within } 50\text{mi}_{it} * (1 - S_{it})^k D_{it} + \Sigma_{k=0}^{15} \tau_{\text{spill,treat}} \text{ Within } 50\text{mi}_{it} * (1 - S_{it})^k D_{it} + \varepsilon_{it} (2)$$

S_{it}^k =1 if cell i is within 50 miles distance from the nearest treated cell at period t.

$\textit{Within 50mi}_{it}$: the nearest treated unit being within 50 miles.

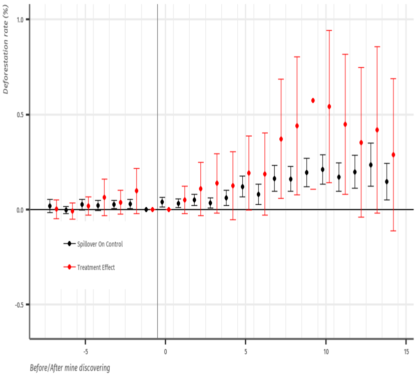
D_{it}: the treatment of having at least one mine in production in an area i (district, cell, and buffer zone) at time t.

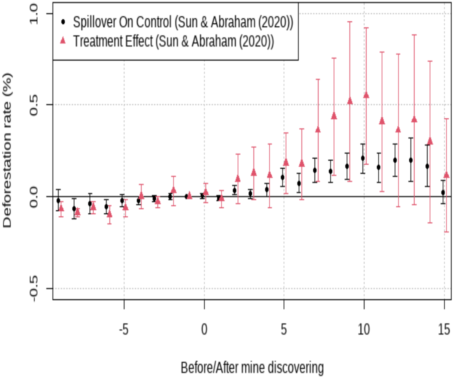
τ: total effect;

$\tau_{spill,control}$: spillover effect on control;

$\tau_{spill,treat}$: spillover effect on treated.

Direct and spillover results at Grid cell level

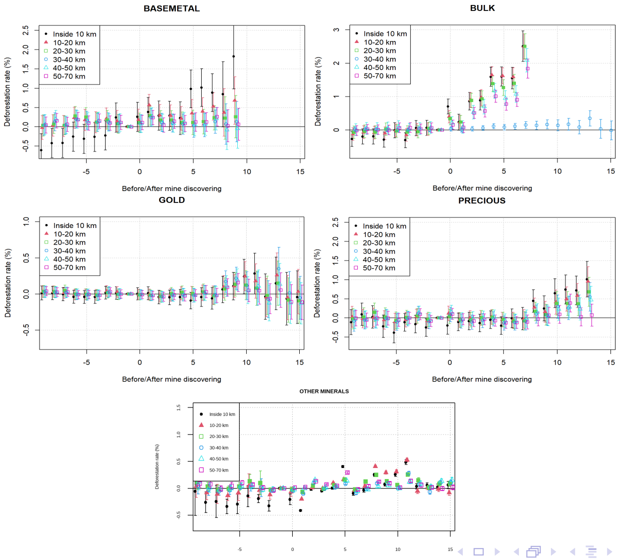




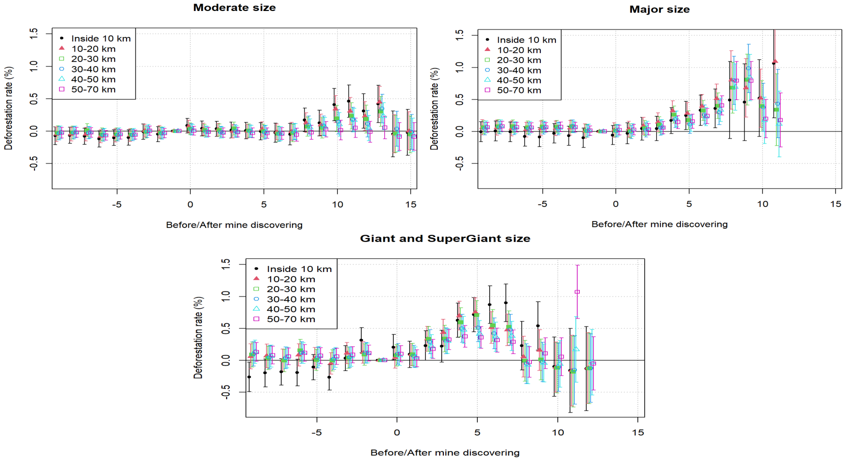
Source: Authors' calculations.

Outline

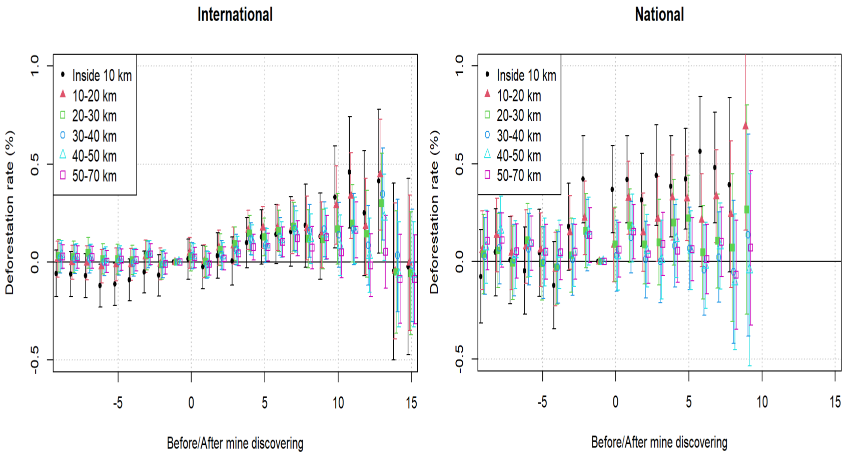
Heterogeneity effect depending on the type of mineral discoveries (1/4)



Heterogeneity effect depending on the size of mineral discoveries (2/4)



Heterogeneity effect depending on Property of mines (4/4)



Source: Authors' calculations.

Outline

Concluding Remarks

- This Paper provides the first quantitative evidence of the forest loss effects, at 30 m spatial resolution, of mineral discoveries throughout the Sub-Saharan Africa (SSA) 2000-2018 period.
- Industrial mining leads to deforestation at district and buffer zone levels.
- Indirect effects at the district and buffer zone levels are more significant and robust than the direct effects.
- Indirect effects decrease with the distance from the mining site
- Transmission channels involve local economic development, agricultural production, urbanization, and population density. The heterogeneous effect on deforestation depends on mines' sizes, the type of minerals, and the number of mines already discovered in the district.

Limitations

1) our study focused only on industrial mining activities and ignored the environmental effect formal and informal artisanal mining activity could cause.

2) We do not have the annual information on mining production, which could better assess the intensity effect of mining activity.

3) We have no data on rehabilitation and reforestation efforts that can mitigate the rate of deforestation.

4) We do not consider all determinants of deforestation.

Thank you for your attention!