The Price of Gold: Impacts of Artisanal Gold Mining on Deforestation in the Brazilian Amazon

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Outline

Research Question

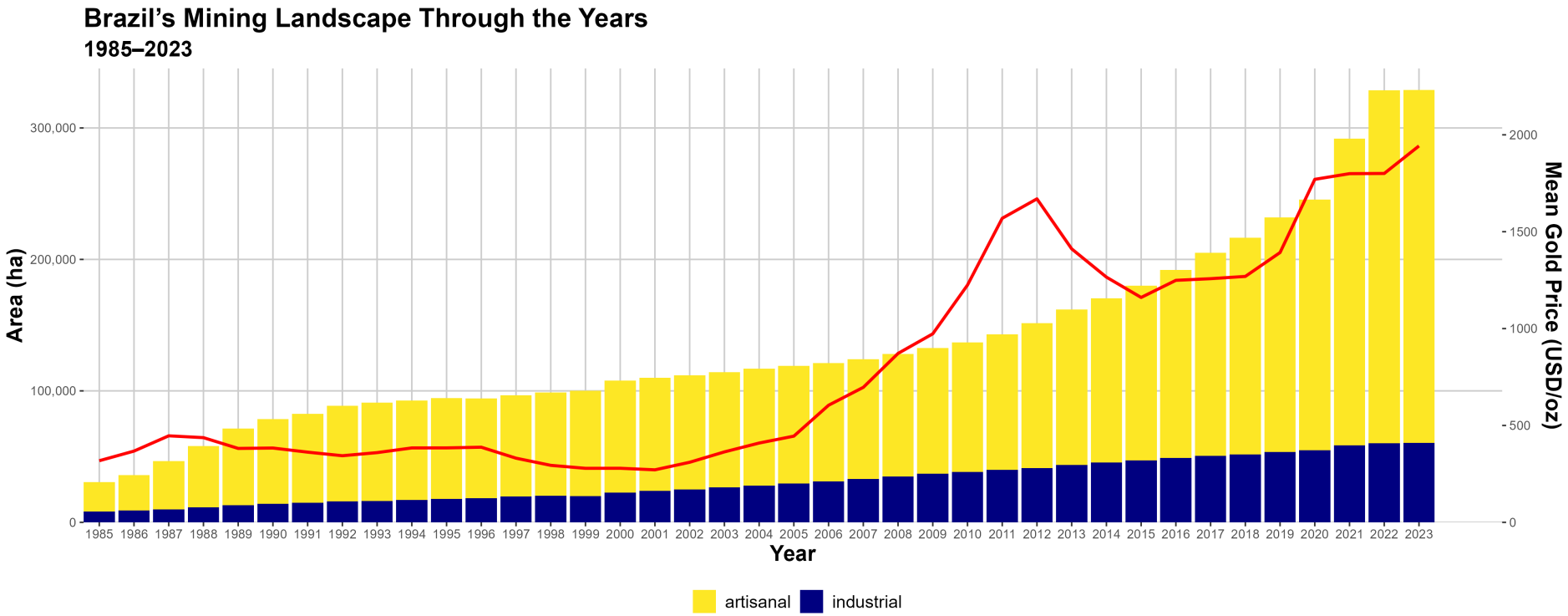
To what extent does artisanal mining contribute to deforestation in the Legal Amazon, and what is the magnitude of direct and indirect effects?

Data

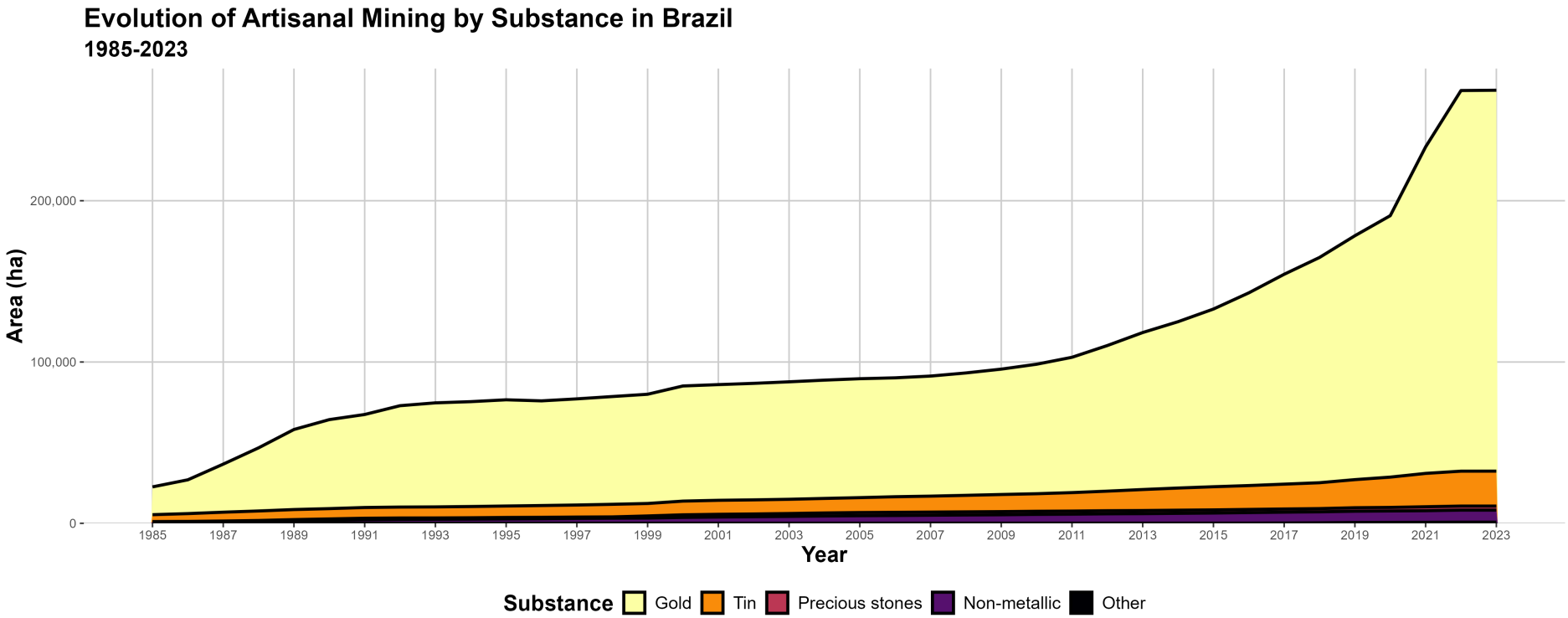
Main sample covers 136 municipalities in the Legal Amazon from 2002 until 2022:

- Artisanal and Industrial Mining (MapBiomas 2024)
- Land cover and land use change statistics (MapBiomas 2024)
- Gold Price in USD (World Bank)
- Protected areas (UNEP-WCMC and IUCN 2022)

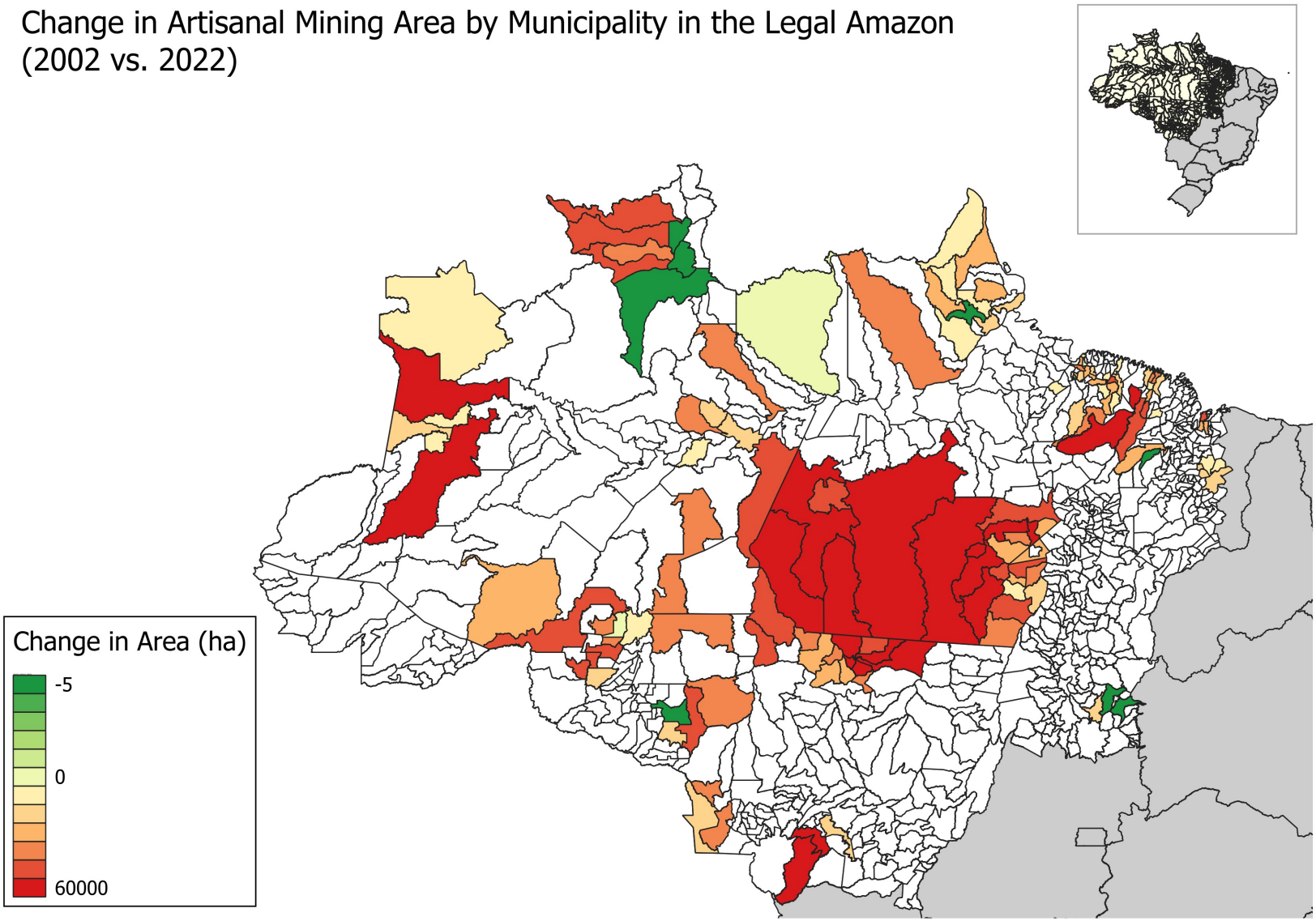
Gold Prices and Mining in Brazil: 1985–2023



Garimpo extraction



Legal Amazon in 2022



First Difference Regression

Original Model:

$$deforestation_{it} = \alpha_i + \lambda_t + \Delta mining_{it} + \gamma X_{it} + \varepsilon_{it}$$

- α_i: municipality fixed effects
- λ_t: Time fixed effects

First Differencing (eliminates α_i):

$$\Delta deforestation_{it} = \beta \Delta mining_{it} + \gamma X_{it} + \lambda_t + \varepsilon_{it}$$

! Endogeneity in $\Delta mining_{it}$: use Shift-Share IV strategy

Two-Stage Estimation

Two-Stage Estimation:

1. **IV Specification:**

$$B_{it} = z_{i,t=0} p_{t-n}$$

   - $z_{i,t=0}$: municipality i's share of total artisanal mining area in 2001 $(t = 0)$
   - p_{t-n}: international gold price with a time lag of $n \in \{1, 2, 3, 4\}$

2. **First Stage:**

$$\Delta mining_{it} = \delta B_{it} + \gamma X_{it} + \lambda_t + u_{it}$$

3. **Second Stage:**

$$\Delta deforestation_{it} = \beta \widehat{\Delta mining}_{it} + \gamma X_{it} + \lambda_t + \varepsilon_{it}$$

First Stage Results

Table 1: First Stage Estimates

	t-1	t-2	t-3	t-4
Bartik	20.178	23.283	22.388+	19.186*
	(15.293)	(13.836)	(10.816)	(8.680)
	(0.202)	(0.108)	(0.052)	(0.039)
Num.Obs.	2489	2489	2489	2489
R2	0.034	0.083	0.123	0.124
R2 Adj.	0.023	0.072	0.113	0.114
R2 Within	0.019	0.068	0.110	0.110
R2 Within Adj.	0.016	0.065	0.107	0.108
Std.Errors	by: year	by: year	by: year	by: year
FE: year	X	X	X	X

Second Stage Results

Table 2: Second Stage Estimates

	t-1	t-2	t-3	t-4
Change in Garimpo Area	17.597*	10.946**	9.570**	9.645***
	(8.380)	(3.807)	(2.517)	(2.437)
	(0.049)	(0.009)	(0.001)	(¡0.001)
Num.Obs.	2489	2489	2489	2489
R2	-0.289	-0.016	0.019	0.017
R2 Adj.	-0.303	-0.028	0.008	0.006
R2 Within	-0.339	-0.056	-0.020	-0.021
R2 Within Adj.	-0.344	-0.059	-0.023	-0.025
Std.Errors	by: year	by: year	by: year	by: year
FE: year	X	X	X	X

Mining drives extensive deforestation in the Brazilian Amazon

Abstract

Mining poses significant and potentially underestimated risks to tropical forests worldwide. In Brazil's Amazon, mining drives deforestation far beyond operational lease boundaries, yet the full extent of these impacts is unknown and thus neglected in environmental licensing. Here we quantify mining-induced deforestation and investigate the aspects of mining operations, which most likely contribute. We find mining significantly increased Amazon forest loss up to 70 km beyond mining lease boundaries, causing 11,670 km^2 of deforestation between 2005 and 2015. This extent represents 9% of all Amazon forest loss during this time and 12 times more deforestation than occurred within mining leases alone. Pathways leading to such impacts include mining infrastructure establishment, urban expansion to support a growing workforce, and development of mineral commodity supply chains. Mining-induced deforestation is not unique to Brazil; to mitigate adverse impacts of mining and conserve tropical forests globally, environmental assessments and licensing must considered both on- and off-lease sources of deforestation.

Thanks for your attention.