

# Reducing the environmental costs of timber production:

Evidence from Forest Management Plans in the Congo Basin

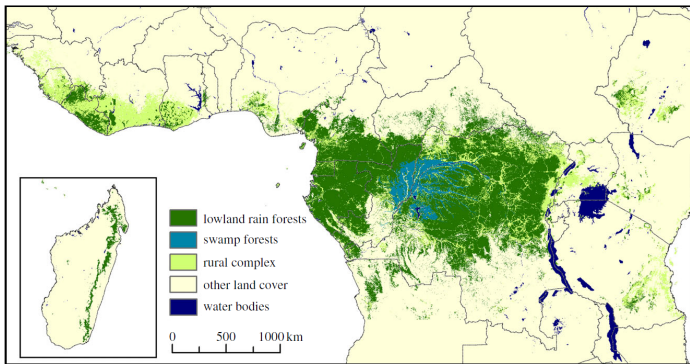
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Namur - Nov. 2023.

# Congo Basin

- Congo Basin ( $\sim 178$  M ha) is the second-largest tropical rainforest after the Amazon.

**Figure 1:** Tropical rainforest in Africa in 2005

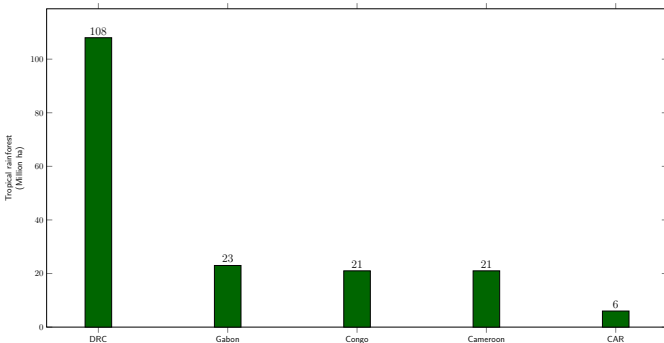


Source: [Mayaux et al. \(2013\)](#).

# Congo Basin

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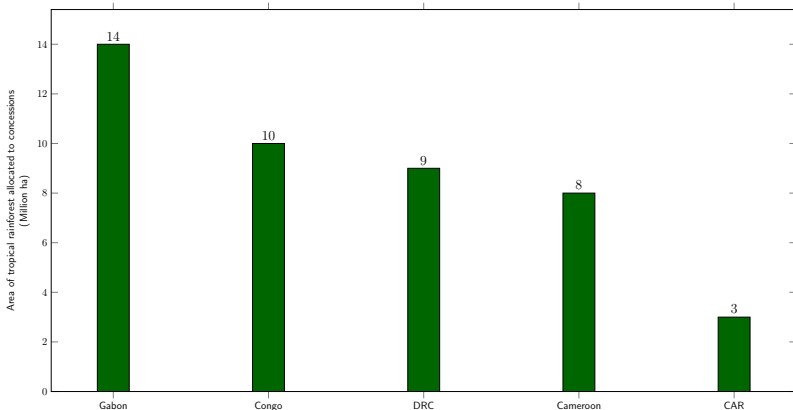
**Figure 2:** Tropical rainforest in the Congo Basin



Source: [Mayaux et al. \(2013\)](#).

# Forest management in Congo Basin

**Figure 3:** Forest area allocated to logging concessions



Source: FRMi (2018)

# Forest Management Plans

- Forest Management Plans (FMP) promote practices that allow extraction of timber while preserving forest resources, biodiversity, ecosystem services, and ensuring socio-economic development (Nasi et al., 2012).
  - FMP allows logging firms to plan their activity over time and use selective logging to reduce over-exploitation (Putz et al., 2012).
  - FMP allows regulator to check logging concessions are complying with the production strategy (Bell et al., 2012; Ezzine de Blas and Pérez, 2008).
  - Sustainable forest management limits competing use of forest resources that produce more deforestation (Agrawal et al., 2008; Angelsen, 2010; Karsenty et al., 2008; Phelps et al., 2013).

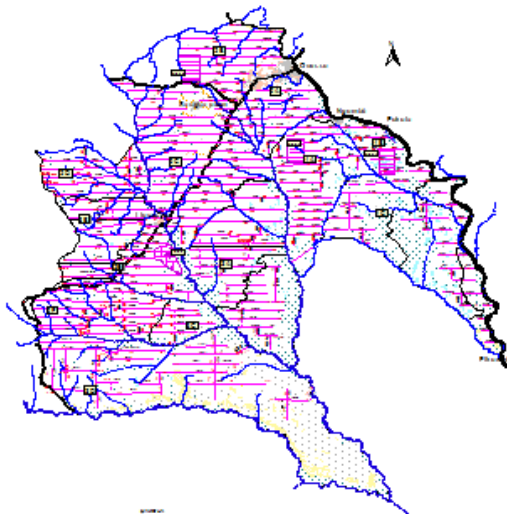
# FMP in practice

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  - Forest inventories describing the distribution of trees species and their characteristics.

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**Figure 4:** Sampling strategy (1/4)



## FMP in practice



**Figure 5:** Survey activities (2/4)

## FMP in practice



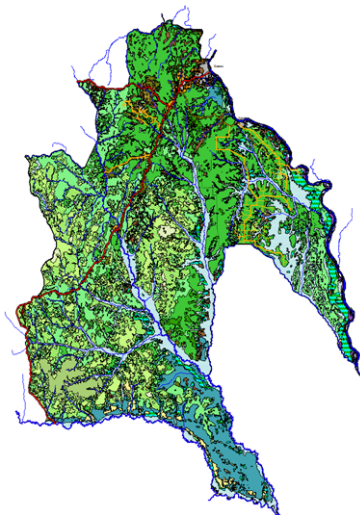
**Figure 6:** Survey activities (3/4)

# FMP in practice



**Figure 7:** Survey activities (4/4)

# FMP in practice

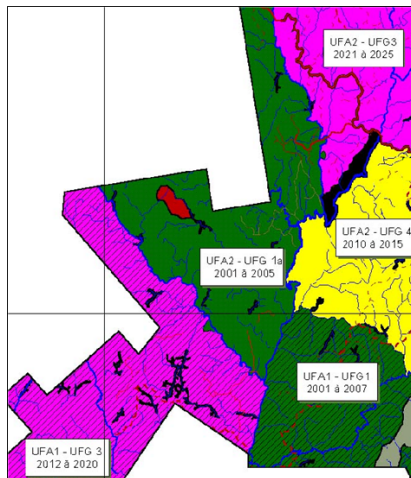


**Figure 8:** Detailed map following forest inventories

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  - Forest inventories describing the distribution of trees species and their characteristics.
  - Based on ecological and social studies, divide each concession into “production”, “conservation” and “community management”.

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**Figure 9:** Defining management series

# FMP in practice

- FMP proceeds in three key steps:
  - Forest inventories describing the distribution of trees species and their characteristics.
  - Based on ecological and social studies, divide each concession into “production”, “conservation” and “community management”.
  - FMPs require that concessions adhere to “social contracts”, redistributing part of the benefits to the local population, either through specific forest taxation or the direct funding of local infrastructure.

## FMP: The process

- FMP is established by logging company on the basis of national standards and under the control of forest administrations.
- After the attribution of forest concessions, logging companies can start logging immediately but have to prepare their FMP within a maximum of three years.
- In practice, this three-year period is poorly-respected.
- Moreover, FMPs may not deliver the expected outcomes:
  - Logging concessions are responsible for the drafting of the FMP, which will thus best fit their strategy (Cerutti et al., 2017).
  - The fact that an officially-approved FMP exists is neither a quality guarantee nor an indication of its implementation on the ground (Karsenty et al., 2017).



## Past studies on the effect of FMP.

Few empirical work on effect of FMP on deforestation.

- **Cerutti et al. (2017)** showed that FMPs in Cameroon reduced carbon emissions from logging operations due to the reduced volumes of timber harvested while presenting logging companies with acceptable financial trade-offs.
- **Karsenty et al. (2017)** and **Brandt et al. (2018)** emphasise the need for more empirical work to understand whether and under which conditions FMPs affect deforestation.
- **Tritsch et al. (2020)** found that deforestation is lower in concessions that have had an FMP for at least five years and in those with FSC certificates. FMP concessions:
  - ◇ avoid over-exploitation of previously-logged areas.
  - ◇ are more likely to better control access into their perimeter.
  - ◇ reduce deforestation around communities.

# This study

- Existing literature does not rule out that concessions that validated their FMP early are selected, leading to two questions:
  1. Do concessions that validated their FMP later (post 2005) have a lower level of forest loss?
  2. Does forest loss avoided decrease over time in concessions with FMP or FSC certificates?
- Going beyond traditional measure of forest loss:
  3. Document how the presence of FMP and FSC certificates affects forest landscapes and degradation in forest concessions in the Congo Basin.

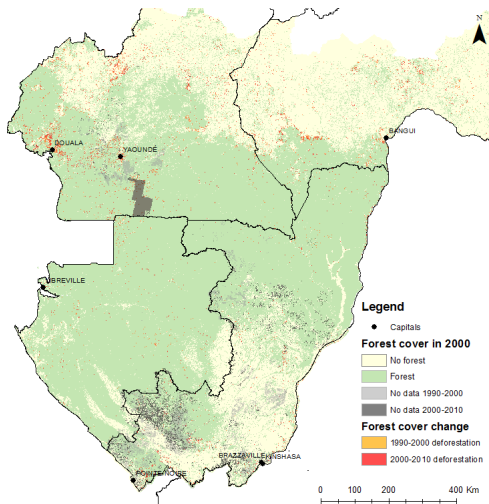
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# Datasets



**Figure 10:** High resolution maps of forest loss in Congo Basin

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# Datasets

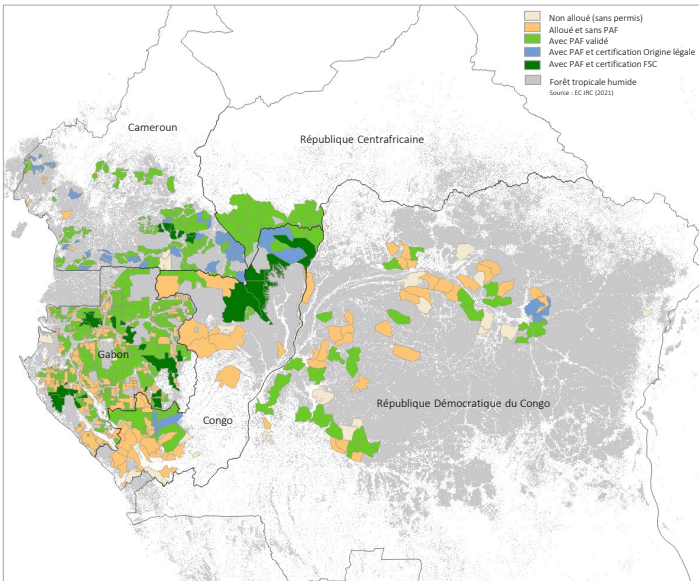
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    - ◇ We use detailed measure of forest loss and forest degraded produced by the JRC (see [Vancutsem et al., 2021, 2020](#)).
  - Detailed information on 465 logging concessions in the study area using the official land-tenure data released by the OFAC and WRI.



# Datasets



## Descriptive statistics of logging companies

	Obs	Min	Mean	s.d.	Max
Number of years of activity	465	5	16.9	7.10	52
Date when FMP was accepted					
- <i>No FMP</i>	465	0	0.45	0.50	1
- <i>2000-2005</i>	465	0	0.12	0.32	1
- <i>2006-2010</i>	465	0	0.13	0.34	1
- <i>2010-2015</i>	465	0	0.14	0.34	1
- <i>2016-2020</i>	465	0	0.16	0.36	1
Distance to nearest road (km)	465	0.42	3.93	3.81	46.7
Distance to market (km)	465	5.65	37.2	18.6	109.8
Distance to capital (km)	465	36.1	318.5	158.1	1254.8
Distance to previous deforestation	465	43	2312.6	1949.7	17054.9
Distance to nearest settlement (km)	465	3.21	15.4	8.78	57.1
Settlement density (nb villages within 20 km)	465	0	7.32	8.94	59.5
Above-ground forest biomass (Mg/ha)	465	4.15	21.7	4.61	32.7
Elevation (m)	465	18	418.1	194.4	910
Slope (%)	465	0.95	5.16	2.62	13.7
Area of concession (1000 ha)	465	1.49	117.9	138.1	1226.3

## Treatment groups

- **Medium to long term impact:**
  - *Treated*: Concessions with an FMP
  - *Control*: Concessions attributed to an active logging company
- **Robustness:**
  - No particular significant pre-treatment trend (parallel btwn control and treatment)
  - *Control*: Active concessions only.

## Econometric Specification: Framework

$Y_{g,t}(1)$  is the area deforested in year  $t$  for logging concession  $i$  with an FMP

$Y_{g,t}(0)$  the analogous figure had the concession not validate its FMP

We want to estimate the average effect of an FMPs in the concessions that have them, i.e. the average treatment effect on the treated (ATT, de Chaisemartin et al., 2022):

$$ATE_g = \Delta_{g,t} = \frac{1}{N_{g,t}} \sum_1^{N_{g,t}} [Y_{g,t}(1) - Y_{g,t}(0)] \quad (1)$$

$$ATT_t = \delta^{TR} = E\left[ \sum_{g,t:D_{g,t}=1} \frac{N_{g,t}}{N(1)} \cdot \Delta_{g,t} \right] \quad (2)$$

## Econometric Specification: Identification

$D_{g,t}$  is a dummy for the concession having an FMP in year  $t$

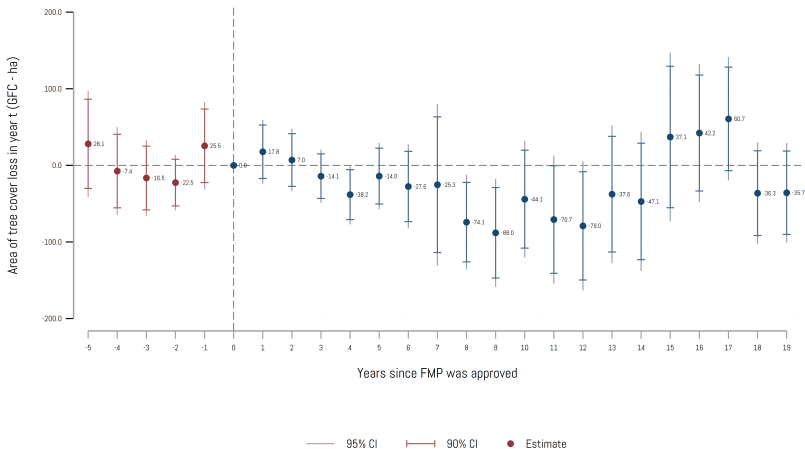
$X$  is a vector of observable characteristics of the logging companies.

In the TWFE regression:

$$Y_{g,t} = \alpha_g + \alpha_t + \beta_{fe} \cdot D_{g,t} + X_{g,t} + \epsilon_{g,t} \quad (3)$$

- FMP were then gradually implemented in the 2000s, and by 2020 (2010) more than 50% (1/4) of the concessions in the study area had an accepted FMP.
- Given the staggered rollout of reforms promoting FMP adoption in the region, it is likely that we will find otherwise-similar concessions with and without FMPs.

# Main results: Tree loss (GFC) and disturbances (TMF)

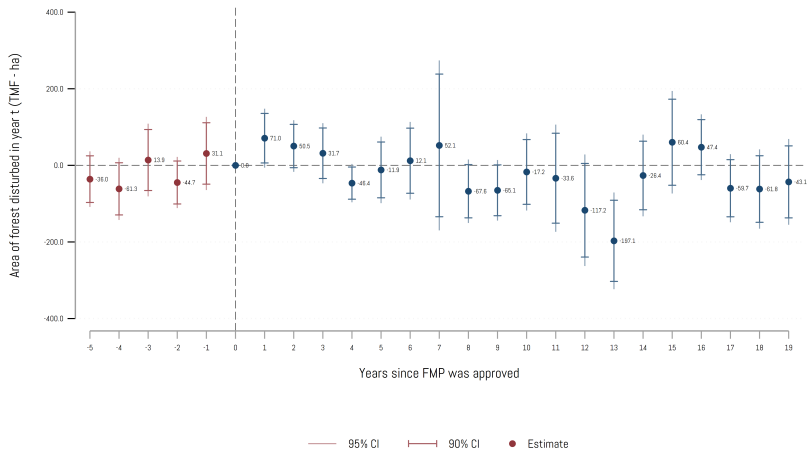


Test of joint nullity of the placebos :  $p$ -value = .407, Test of joint nullity of the effects :  $p$ -value = .004

Source: Authors calculation.

**Figure 11:** All FMP, Tree cover loss (GFC)

# Main results: Tree loss (GFC) and disturbances (TMF)

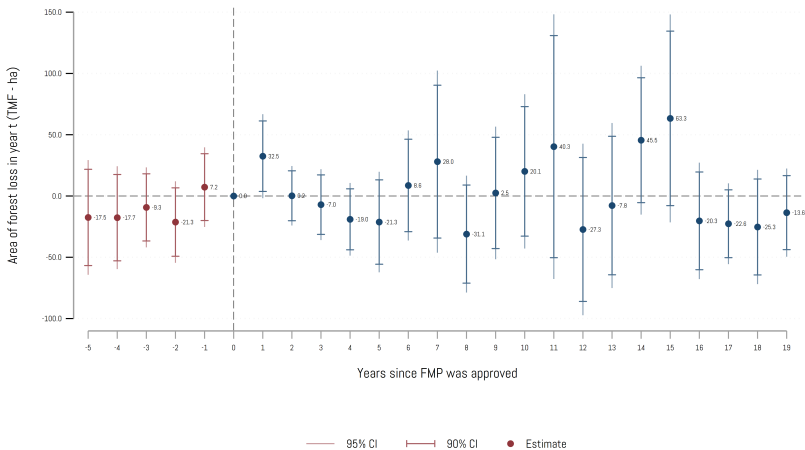


Test of joint nullity of the placebos :  $p$ -value = .197, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 12:** All FMP, Forest disturbances (TMF)

# Main results, Deforestation (TMF)



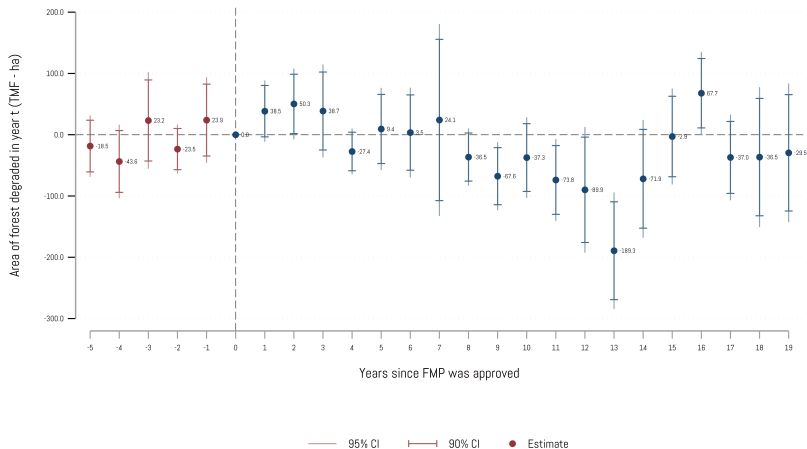
Test of joint nullity of the placebos :  $p$ -value = .661, Test of joint nullity of the effects :  $p$ -value = .007

Source: Authors calculation.

**Figure 13: All FMP, Deforestation**



# Main results, Forest degradation (TMF)



Test of joint nullity of the placebos :  $p$ -value = .174, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

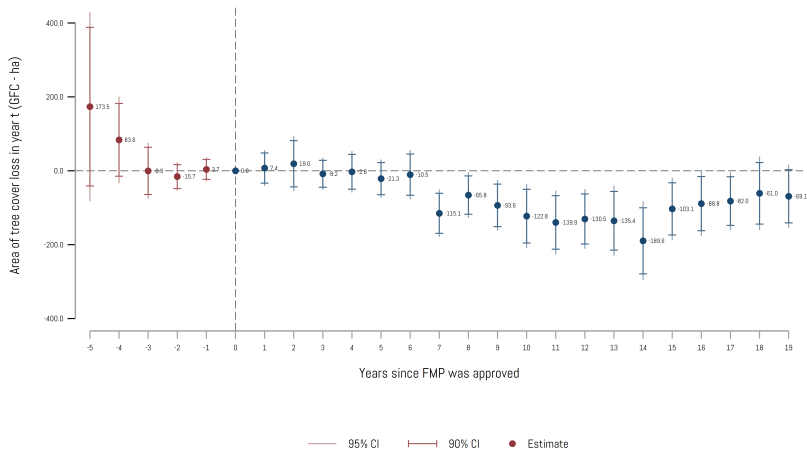
**Figure 14:** All FMP, Forest degradation

# Heterogeneity by FSC Certification

- FSC certification is more recent in the region, starting only in 2005
- Much less treated ( $\approx 10\%$ )
- We consider 2 subsamples of FMP:
  - Those which will be validated by a third party before 2022 (FSC)
  - Those which will **NOT** be validated by a third party before 2022 (no FSC)

and run similar estimations

# Heterogeneity by FSC Certification: Tree cover loss (GFC)

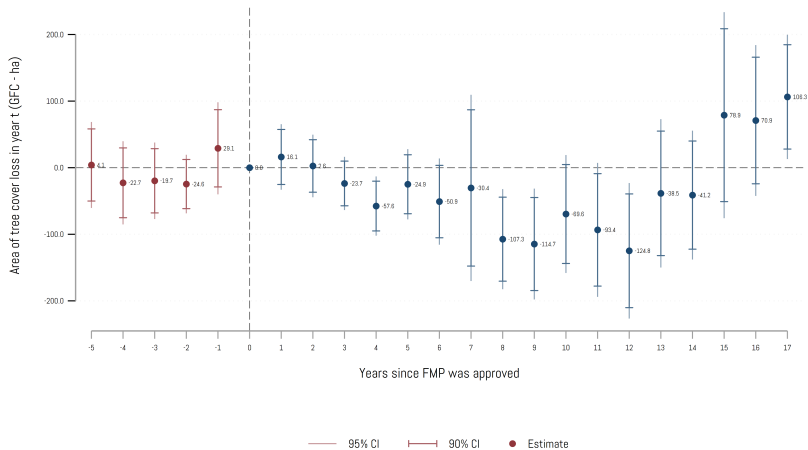


Test of joint nullity of the placebos :  $p\text{-value} = .823$ , Test of joint nullity of the effects :  $p\text{-value} \leq 0.001$

Source: Authors calculation.

**Figure 15:** FMP with FSC certificate, Tree cover loss (GFC)

# Heterogeneity by FSC Certification: Tree cover loss (GFC)

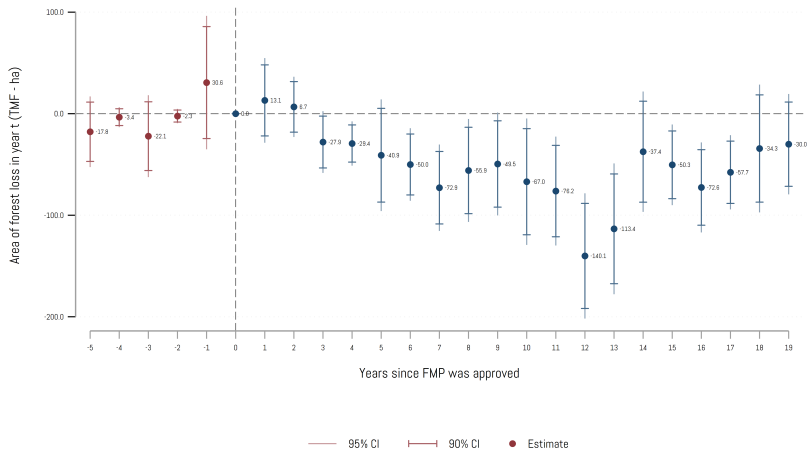


Test of joint nullity of the placebos :  $p$ -value = .587, Test of joint nullity of the effects :  $p$ -value = .002

Source: Authors calculation.

**Figure 16:** FMP without FSC certificate, Tree cover loss (GFC)

# Heterogeneity by FSC Certification: Deforestation (TMF)

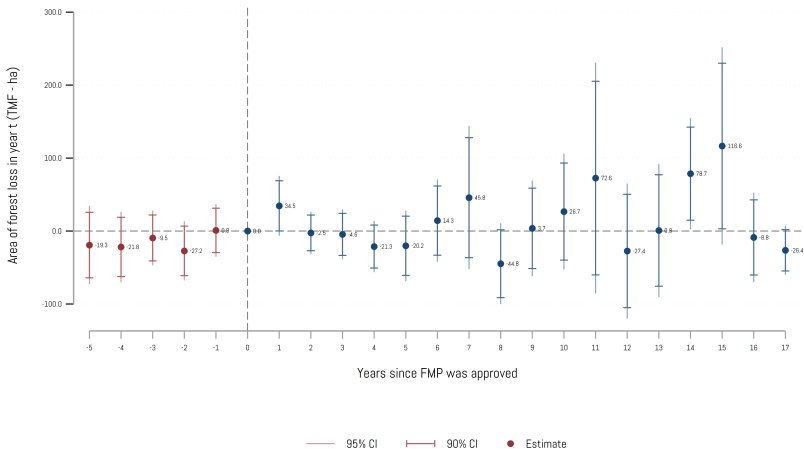


Test of joint nullity of the placebos :  $p$ -value = .495, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 17:** FMP with FSC certificate, Deforestation (TMF)

# Heterogeneity by FSC Certification: Deforestation (TMF)

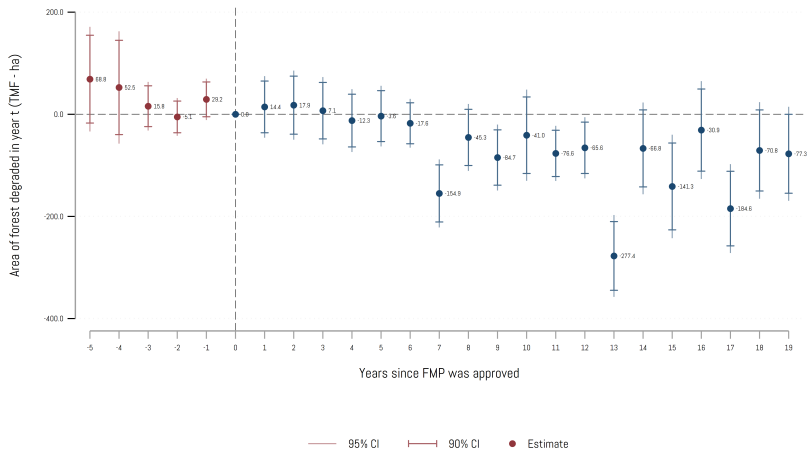


Test of joint nullity of the placebos :  $p$ -value = .748, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 18:** FMP without FSC certificate, Deforestation (TMF)

# Heterogeneity by FSC Certification: Degradation (TMF)

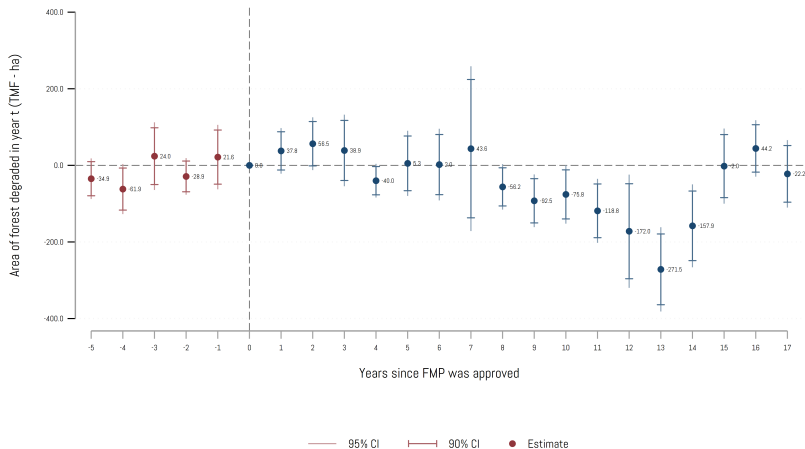


Test of joint nullity of the placebos :  $p\text{-value} = .773$ , Test of joint nullity of the effects :  $p\text{-value} \leq 0.001$

Source: Authors calculation.

**Figure 19:** FMP with FSC certificate, Degradation (TMF)

# Heterogeneity by FSC Certification: Degradation (TMF)



Test of joint nullity of the placebos :  $p\text{-value} = .114$ , Test of joint nullity of the effects :  $p\text{-value} \leq 0.001$

Source: Authors calculation.

**Figure 20:** FMP without FSC certificate, Degradation (TMF)



## Concluding remarks

Lower level of tree cover loss in concessions that adopted an FMP

- mostly driven by reduction in forest degradation ?
- & the results persist over time

We suspect that the effect varies across concessions

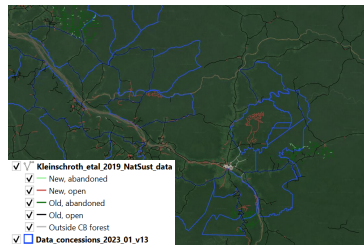
- Further work will investigate that using more structured approach

# Discussion

- TMF (degradation & deforestation) less clear impacts (reducing disturbances)
- General validity tests ?
  - FSC, more clear impacts (more homogenous sample)
  - than without FSC (heterogenous)
  - mechanisms: roads / spatial auto-correlation ...?

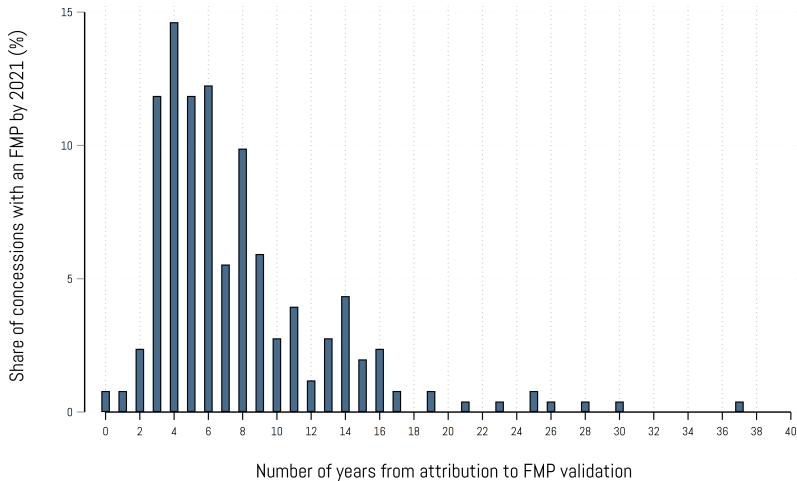
## Impact of FMP & FSC on the road network in concessions

- Landsat 8
- 2003 -> 2018



	Total	Outside concession	Inside Concession	Inside No FMP Concession	Inside FMP Concession	Inside FSC Concession
<b>Expansion (%)</b> <i>New roads / Old roads</i>	66.8	39,9	102,5	87.4	109.1	86.1
<b>Abandoned roads (%)</b> <i>Abandoned roads / Total roads</i>	25,5	12.6	43,5	19.4	51.9	62.3
<b>Net road expansion (%)</b> <i>(New roads open - New roads abandoned) / New roads</i>	20,3	23,3	15,8	54.8	3.7	12.5

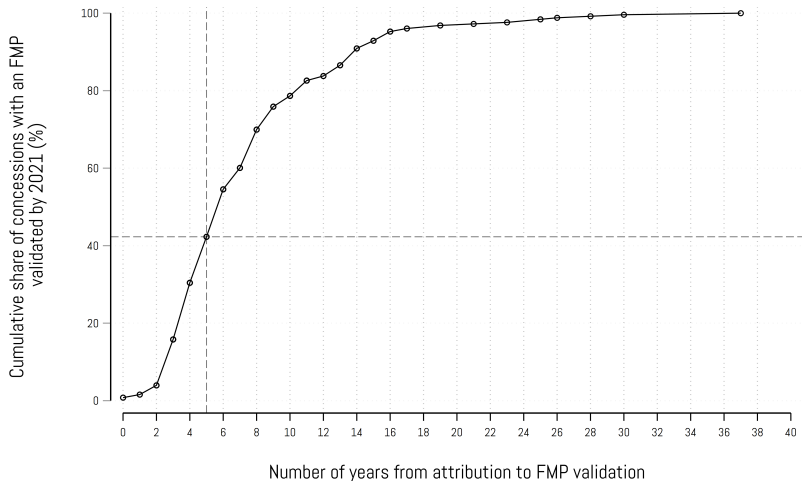
# Years from attribution to FMP



Source: Authors calculation.

**Figure 21:** Time from attribution to FMP validation

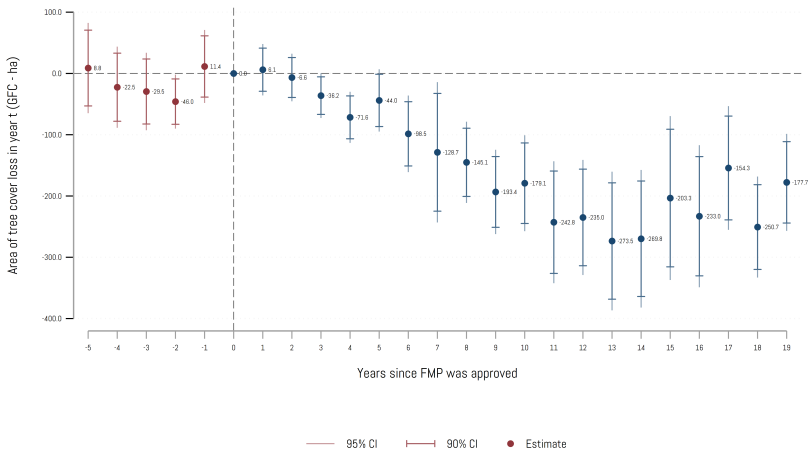
# Years from attribution to FMP



Source: Authors calculation.

**Figure 22:** Cumulative time from attribution to FMP validation

# Robustness: Not adjusted for macro-economic shocks

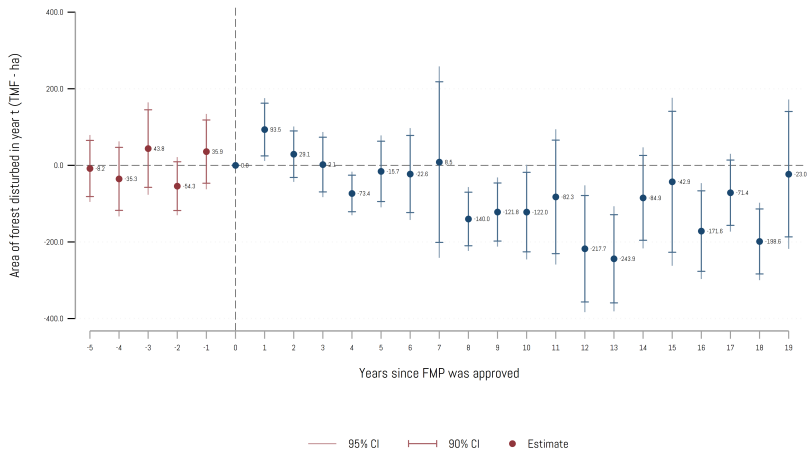


Test of joint nullity of the placebos :  $p$ -value = .116, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 21: All FMP, Tree cover loss (GFC)**

# Robustness: Not adjusted for macro-economic shocks

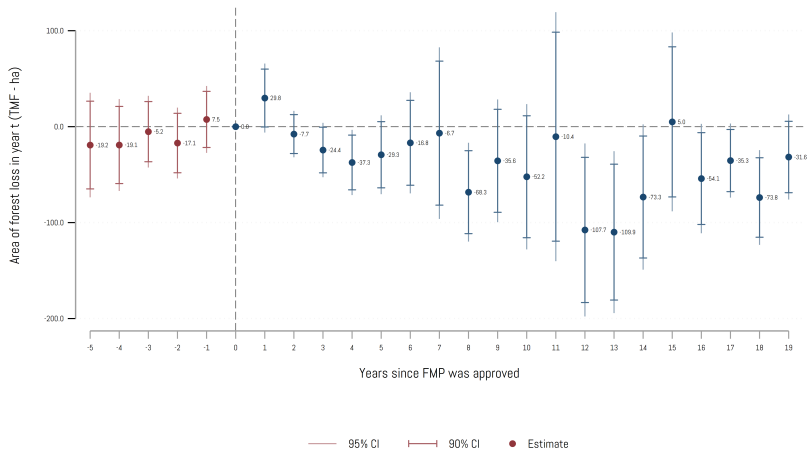


Test of joint nullity of the placebos :  $p$ -value = .109, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 22:** All FMP, Forest disturbances (TMF)

# Robustness: Not adjusted for macro-economic shocks



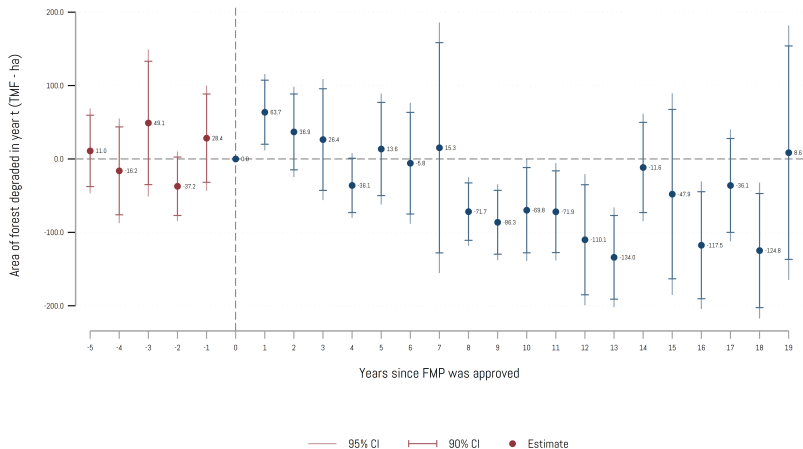
Test of joint nullity of the placebos :  $p$ -value = .707, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 23: All FMP, Deforestation**



# Robustness: Not adjusted for macro-economic shocks

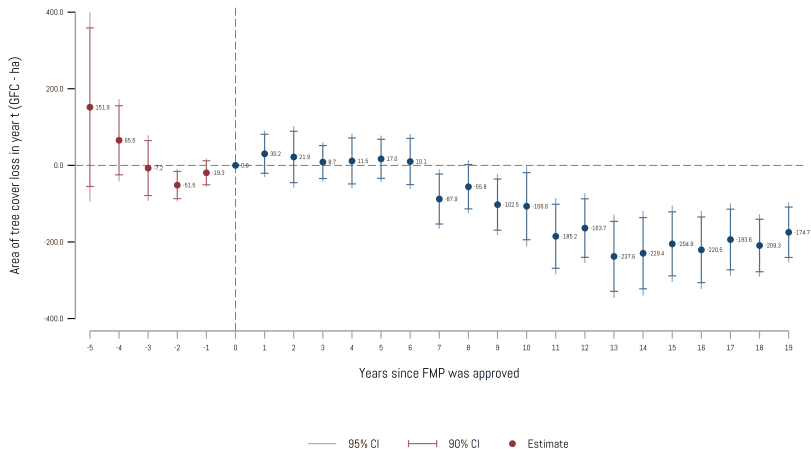


Test of joint nullity of the placebos :  $p$ -value = .023, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 24:** All FMP, Forest degradation

# Robustness: Not adjusted for macro-economic shocks

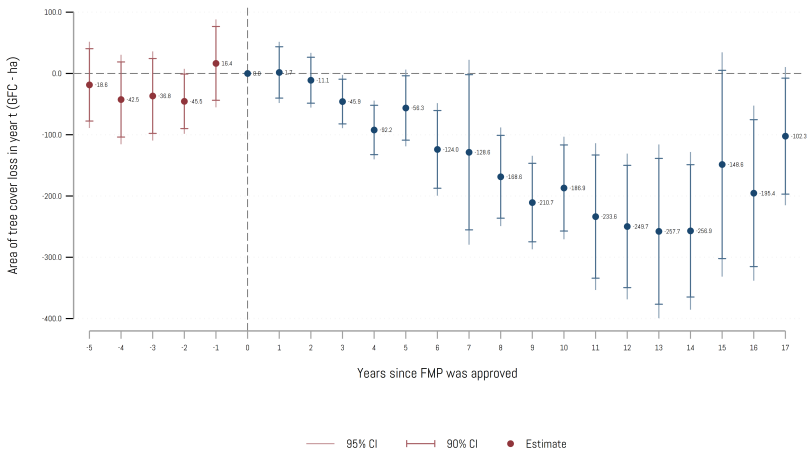


Test of joint nullity of the placebos :  $p$ -value = .002, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 25:** FMP with FSC certificate, Tree cover loss (GFC)

# Robustness: Not adjusted for macro-economic shocks

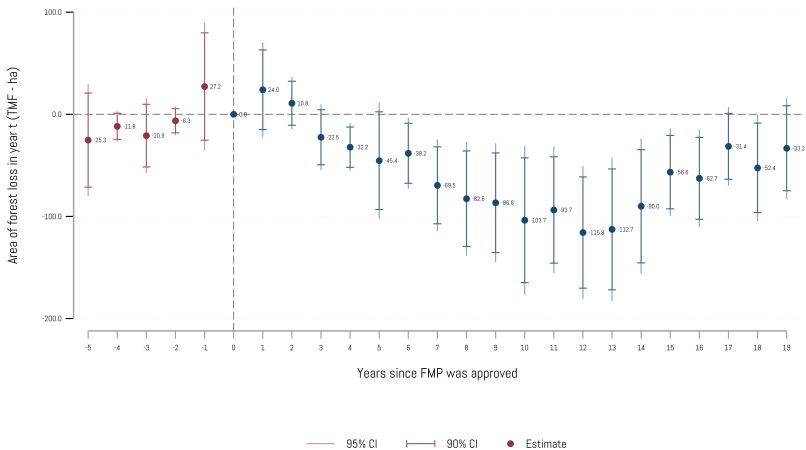


Test of joint nullity of the placebos : p-value = .302, Test of joint nullity of the effects : p-value  $\leq$  0.001

Source: Authors calculation.

**Figure 26:** FMP without FSC certificate, Tree cover loss (GFC)

# Robustness: Not adjusted for macro-economic shocks

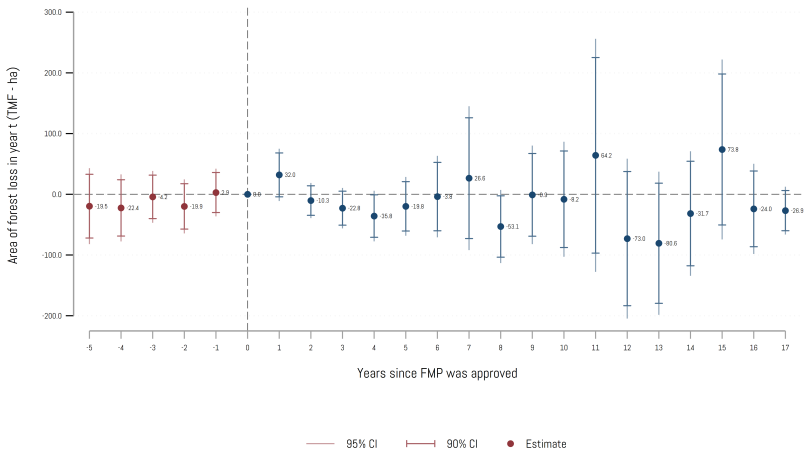


Test of joint nullity of the placebos :  $p\text{-value} \leq 0.001$ , Test of joint nullity of the effects :  $p\text{-value} \leq 0.001$

Source: Authors calculation.

**Figure 27:** FMP with FSC certificate, Deforestation (TMF)

# Robustness: Not adjusted for macro-economic shocks

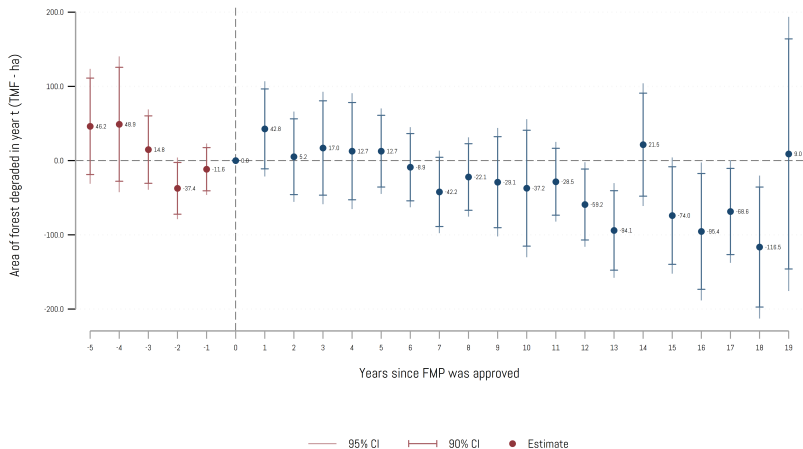


Test of joint nullity of the placebos :  $p$ -value = .792, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 28:** FMP without FSC certificate, Deforestation (TMF)

# Robustness: Not adjusted for macro-economic shocks

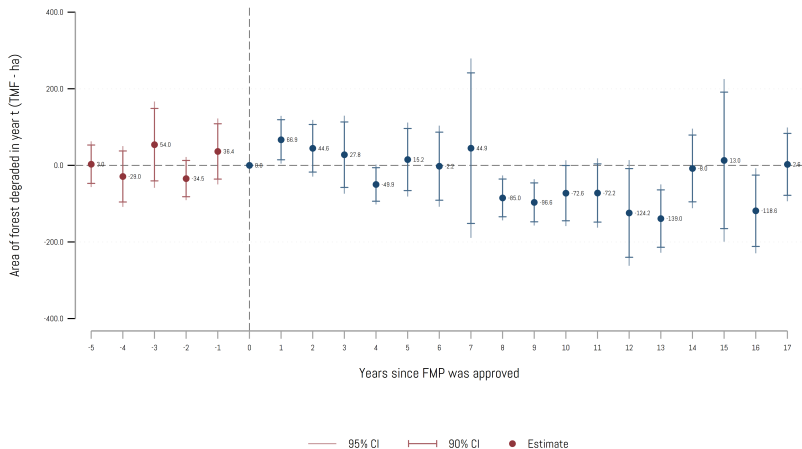


Test of joint nullity of the placebos : p-value = .017, Test of joint nullity of the effects : p-value = .002

Source: Authors calculation.

**Figure 29:** FMP with FSC certificate, Degradation (TMF)

# Robustness: Not adjusted for macro-economic shocks



Test of joint nullity of the placebos :  $p$ -value = .031, Test of joint nullity of the effects :  $p$ -value  $\leq$  0.001

Source: Authors calculation.

**Figure 30:** FMP without FSC certificate, Degradation (TMF)

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