Cease and Disperse: The unintended effect of Indonesia's moratorium on deforestation

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Abstract

Tropical deforestation accounts for roughly 15% of annual carbon emissions, more than the combined emissions from road, rail, air, and marine transportation, worldwide. Any viable effort to mitigate climate change must address tropical deforestation. This paper assesses the impact of Indonesia's 2011 moratorium on new concessions for deforestation in Kalimantan, Indonesian Borneo. The results suggest that, relative to Malaysian Borneo, the moratorium shifted the spatial distribution of deforestation rather than reducing the overall rate, as intended. The price responsiveness of new clusters decreased significantly, relative to the responsiveness of clearing around existing clusters. The price responsiveness of overall clearing activity remained unchanged, suggesting significant leakage associated with the policy. This pattern of deforestation is consistent with leakage through both space and time, as the moratorium has a widely known expiration date of May 2013. The results also suggest that the extension of the two-year moratorium will face much greater opposition from industry than was seen for the initial implementation, as it will have a more significant economic effect.

Initial analysis

The moratorium has been widely attacked as having had no effect on clearing activity. The rate of deforestation has been accelerating since the moratorium; and the overall rate has rebounded to 2010 levels. The aspect that is ignored, however, is that the price of oil palm is astronomically high – even higher than 2008/2009 levels, after a dip in 2010. What was the effect of the moratorium, conditional on the palm oil price — and agricultural prices more generally, which all increased dramatically (which is an argument for an exogenously determined price increase, even though Indonesia accounts for something like 40% of global oil palm production.)

Empirical evidence suggests that the moratorium shifted the spatial distribution of clearing away from the counterfactual. Increases in output price generally increase the spatial dispersion of clearing. A larger proportion of clearing activity takes place in new clusters, rather than on the periphery of existing clusters when the price is high. This makes sense. A higher price will slowly begin to shift developers' expectiations on the return to cleared land, which is an input to production of agricultural products. Assuming a constant and stable marginal cost of clearing, the fixed costs of clearing become more palatable as the price of agricultural products increase: there is more of a chance of a positive return on investment (all in expectation). The proportion of new clearing in *new* clusters, then, will increase with the expected return (price of oil palm) — there is more of a chance that the investment will be made. There will be some lag, some time for developers' expectations to adjust, but even looking at the contemporaneous data, the signal is reasonably clear.

The moratorium reduced the price responsiveness of deforestation in new clusters, relative to old clusters. Less of incremental clearing occurred in new clusters than we would expect, given the sustained and rapid price increase of oil palm. This makes sense, too. The moratorium restricted new concessions for deforestation, but did not restrict clearing activity within existing concessions. On average, only 70% of existing concessions had been cleared; much of the concession area remained untouched, presumably stored for future exploitation [citation needed].

The natural next question is "what are the assumptions that would cause the shift to old clusters to completely offset the overall reduction in new clusters?" The data suggest that the total or overall rate of clearing may have increased after the moratorium was enacted, or equivalently that the *more than offset* the reduction of clearing in new clusters.

Points to make (in no particular order):

1. Tropical deforestation accounts for roughly 15% of annual carbon emissions, more than the combined emissions from road, rail, air, and marine transportation, worldwide.
2. Borneo is 73% Indonesia, 26% Malaysia, and 1% Brunei (which is not considered in this study to keep it compact). It is home to one of the oldest rainforests in the world.
3. The moratorium constrained investment in new deforestation clusters, shifting the spatial distribution of deforestation and ultimately increasing the overall rate of deforestation.
4. Indonesia announced the two-year moratorium in May 2010 to be enacted in January 2011, but it wasn't actually enacted until March 2011 after disputes between government, industry, and environmental advocates. Three stages of the moratorium.
5. The moratorium was catalyzed by a $1 billion promise from Norway, cash on delivery to Indonesia, contingent on a reduction in the deforestation rate. The promise of aid made the government's previously feeble attempts to manage deforestation much more credible.
6. We use the island of Borneo as a social lab, of sorts, given that Malaysian Borneo is similar in weather and agricultural output as Indonesian Borneo, but was not subject to the moratorium. While the border was drawn based on physical attributes of the land – to divide the watersheds – the similarity of the two sides is reasonable. The one complication may be that Indonesian Borneo is three times the size of Malasian Borneo, potentially affecting the possible spatial dispersion.
7. The overall effect of the moratorium was an *increase* in the rate of deforestation, relative to Malaysia, but to decrease the proportion of deforestation due to new clusters. The spatial pattern of deforestation became more condensed, with clearing occuring disproportionately on the periphery of pre-existing clusters.
8. The new paradigm under the moratorium resembles the short-term response to increased supply of cleared land, on the outskirts of existing clusters. Lower cost to clear, no investment. Short-term response to quick changes in the demand for cleared land are met with deforestation near previously cleared clusters.
9. Intertemporal leakage. Induced short-term behavior in place of long-term behavior, potentially waiting out the two-year moratorium. Similar to spatial leakage: Restrictions on clearing in a certain time or place will just induce clearing in a different time or place.
10. The theoretical structure should have the ability to distinguish between alternatives, to select a model based on testable hypotheses: (a) race to the bottom? (b) lower productivity of land near existing clusters? (c) freed up resources due to a lower fixed cost?
11. Use the physical layout of the land to help distinguish between hypotheses. Examine the attributes of the land that was cleared near existing clusters over time, before and after the moratorium was enacted.
12. Potentially cluster the rate-proportion graph, looking to see if the inclusion in each group was sequenced. A different approach to the standard diff-n-diff, potentially providing more intuition about the way the data are clustered through time.
13. Disney has stopped sourcing from suppliers with a poor track record on deforestation.

Model Considerations:

1. Areas around clusters should be modelled with option value, reflecting the fact that short term supply of cleared land is mainly around existing clusters.

2. The return on land cleared around existing clusters is lower than that of new clusters. Thus, to get the same amount of product out of the land, more has to be cleared. **Check this, ask someone else.** Examine the characteristics of land cleared *around existing clusters* to see if the moratorium had an appreciable impact on, say, the slope of cleared land (something related to yield).

3. Dynamic programming problem, with option value and stochastic element. Two types of resources and one investment term that determines the next period's level of new land.

4. Look at the effect of increasing the risk of appropriation associated with new land, drastically lowering the expected return.

5. There is intertia in the data, allow for time to adjust expectations and to realize gains from previous investment.

6. Is the elasticity of supply of cleared land near *existing* clusters greater than the elasticity of supply of cleared land in *new* clusters. Different cost structures of clearing. If so, then a shock in demand will have a more than proportionate effect on the land around existing clusters. (This is seen in the data.) The greater supply elasticity may be due to (a) less time to mobilize resources and (b) excess capacity or inventory of land near existing clusters. Lower marginal costs will imply a greater elasticity of supply.

7. The supply shock that came with restricting new clearing will induce a more than proportionate response in supply (?) Inelastic demand for cleared land. Why doesn't the new supply just flood the market, immediately driving back down the price?

8. Ultimately, the firms will have to invest in new clusters; but they are content to use up their reserves now, knowing that the moratorium is set to expire in May 2013.

Basic results:

1. The moratorium had the unintending consequence of *increasing* short-term clearing activity by shifting the spatial ditribution of deforestation to the periphery of exisiting clusters. Potential cause: lower returns on land around existing clusters, and steady demand for the yield from cleared land.

2. Deforesters are treating the set moratorium period as a short term hit to investment activity, such that they are responding as if there was a short-term increase in the demand for cleared land (which would and has happened in the past). This can be seen from the stratified scatter plots.

3. The implication is that if the moratorium is lifted after two years, then there will be temporal leakage – restricting clearing in one period only pushed it into another. If the moratorium is maintained, however, it may actually reduce long-term clearing, since investment hasn't been made. Another prediction: way more outcry from industry over a long-term moratorium extension than for the initial two-year enactment to respond to the Norwegian aid promise.

4. Much of the effect happens when the moratorium was *supposed* to be enacted, the other half, so far, has occured after the moratorium was *actually* enacted.

Let $x_1(t)$ and $x_2(t)$ be the amount of land cleared in time t, where the subscript 1 indicates that the land is on the periphery of an existing cluster and the 2 indicates that the land constitutes a new cluster. Let $p_1(t)$ and $p_2(t)$ be the respective prices for the cleared land, which are functions of the physical characteristics of the land. We expect that $p_1(t) < p_2(t)$, since new sites of land clearing will tend to locate in land with the highest net return. Landowners will progressively clear less valuable land according to an option value approach, effectively storing the forested land until the return is high enough to merit the marginal cost of clearing. For now, though, consider the simple dynamic programming problem to

$$\max_{x_1,x_2,I} \int_0^T \pi_1(x_1(t)) + \pi_2(x_2(t)) - I(t)\,dt \quad \text{subject to} \quad \dot{R}_2 = f(I(t)) \quad \text{and} \quad \dot{R}_1 = f(I(t-1)) - x_2(t) \tag{1}$$

where $I(t)$ indicates the level of investment in infrastructure or exploration costs in order to create new clusters of cleared land in the following period. For a given amount of land, $\bar{x}$, we assume that $\pi_2(\bar{x}) > \pi_1(\bar{x})$. The profit from the newly cleared land is greater than that of land near older clusters. This gives landowners an extra incentive to clear new land, above and beyond the incentive to expand production. The function f is increasing and maps investment costs into the amount of land available in the new area.

Tables and figures

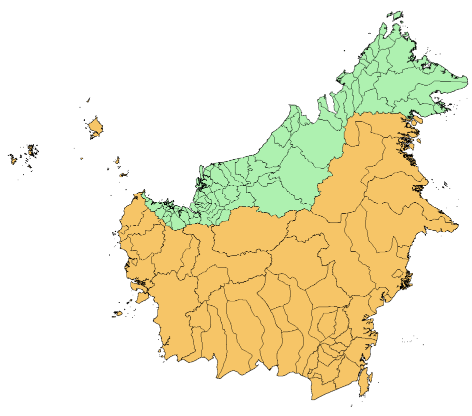

Figure 1: Sample area, Malaysia in green and Indonesia in orange. Borders indicate subprovinces.

Table 1

	(1)	(2)	(3)	(4)
(Intercept)	5.328^{***}	7.487^{***}	5.676^{***}	7.837^{***}
	(0.188)	(0.682)	(0.270)	(0.702)
price	0.177	0.836^{***}	-0.263	0.401
	(0.223)	(0.296)	(0.331)	(0.380)
cntry	2.510^{***}	2.510^{***}	1.760^{***}	1.760^{***}
	(0.092)	(0.090)	(0.381)	(0.373)
post	0.075	0.093	-0.962	-0.909
	(0.121)	(0.118)	(1.016)	(0.993)
cntry:post	-0.808^{***}	-0.808^{***}	1.893	1.893
	(0.152)	(0.148)	(1.437)	(1.404)
idn.exch		-25.692^{***}		-25.751^{***}
		(7.820)		(7.755)
price:cntry			0.949^{**}	0.949^{**}
			(0.468)	(0.458)
price:post			1.104	1.069
			(0.997)	(0.974)
price:cntry:post			-2.828^{**}	-2.828^{**}
			(1.410)	(1.377)
R^2	0.818	0.827	0.823	0.832
Adj. R^2	0.815	0.823	0.818	0.826
Num. obs.	218	218	218	218

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

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Table 2

	(1)	(2)	(3)
(Intercept)	514.159***	557.681***	368.631**
	(15.582)	(44.952)	(167.019)
cntry	84.319***	84.319***	84.319***
	(22.036)	(22.033)	(22.013)
post	102.641***	116.251***	114.658***
	(25.722)	(28.902)	(28.908)
cntry:post	6.006	6.006	6.006
	(36.376)	(36.371)	(36.338)
price		−55.041	−112.746
		(53.327)	(72.455)
idn.exch			2249.745
			(1914.361)
R^2	0.214	0.217	0.223
Adj. R^2	0.203	0.203	0.204
Num. obs.	218	218	218

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

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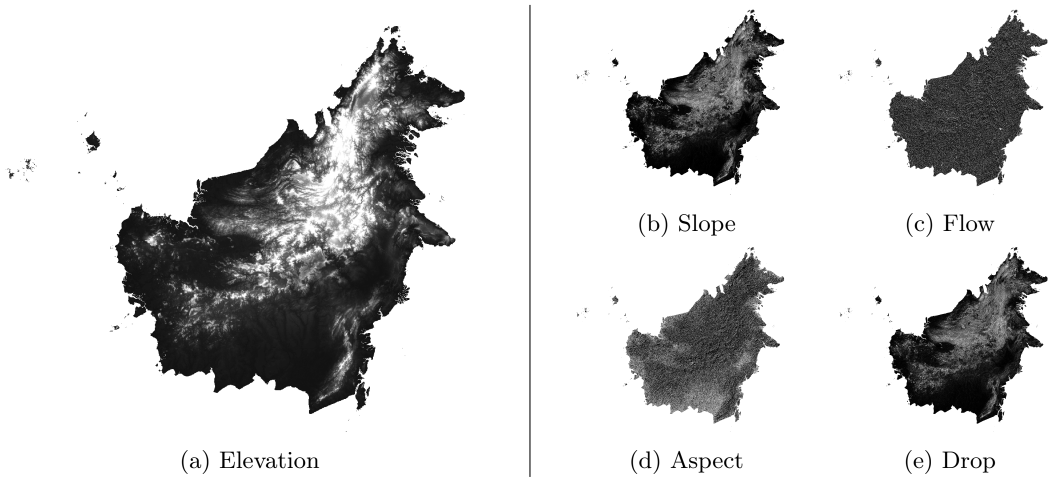
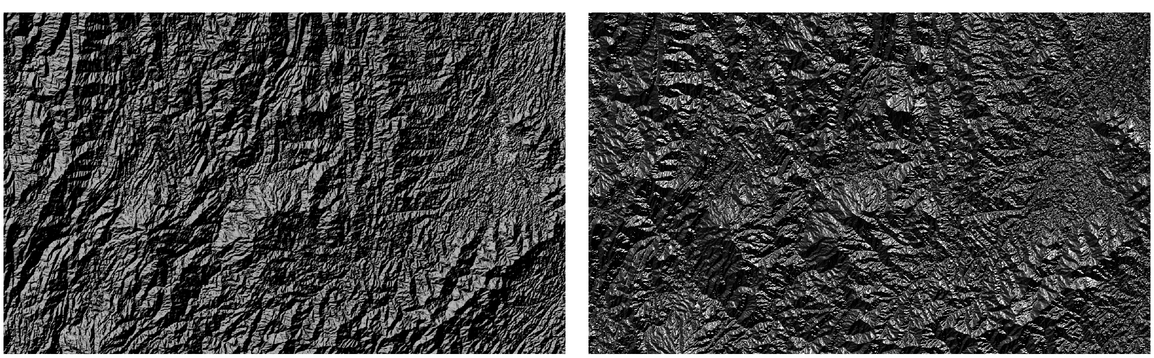


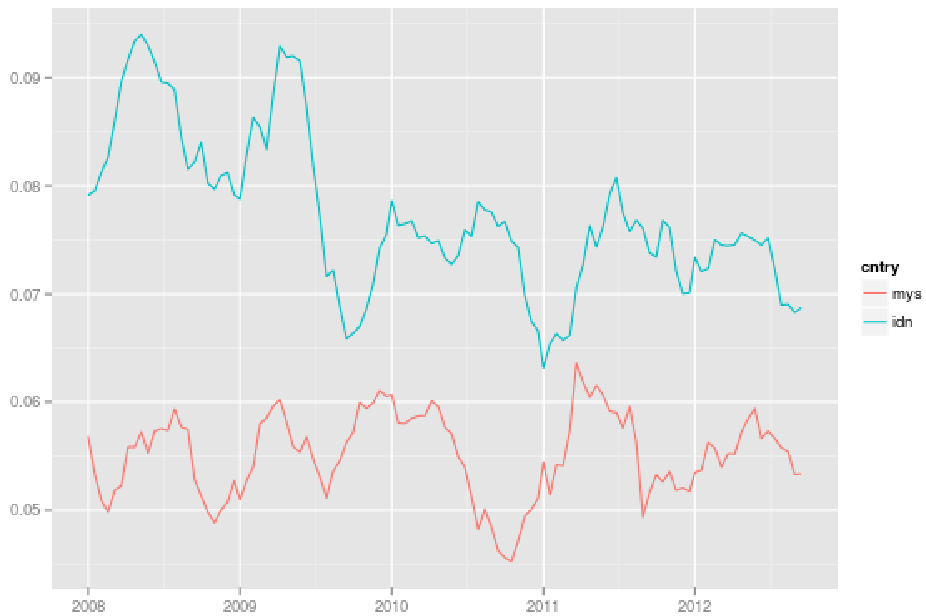
(a) Elevation (b) Slope (c) Flow (d) Aspect (e) Drop

Figure 2: Map of the digital elevation model (left) with derived data sets (right) indicating slope, hydrology, and terrain roughness, 90m resolution.

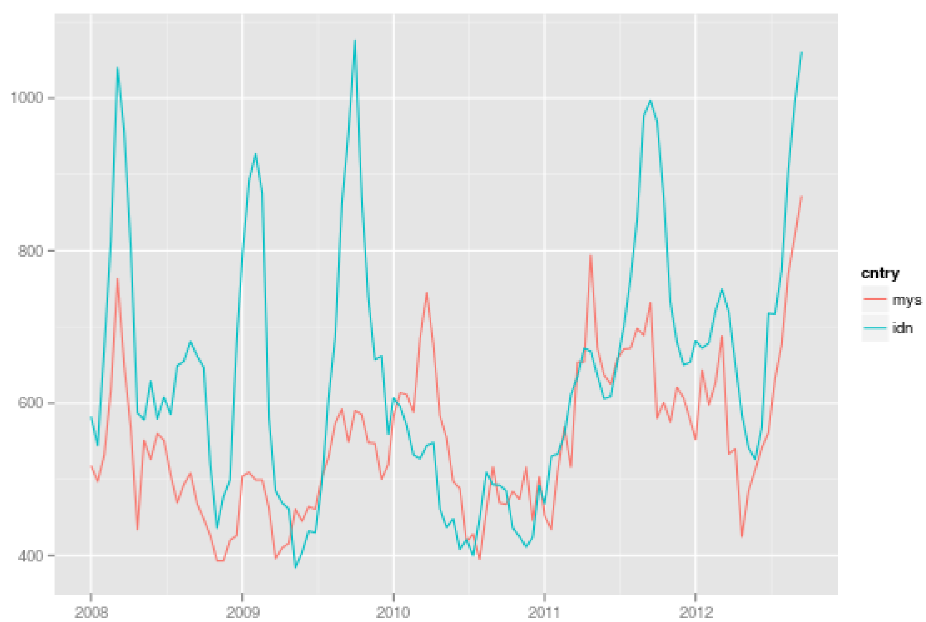


(a) Hillshade (b) Flow direction

Figure 3: Detailed images of two derived data sets for the same area.

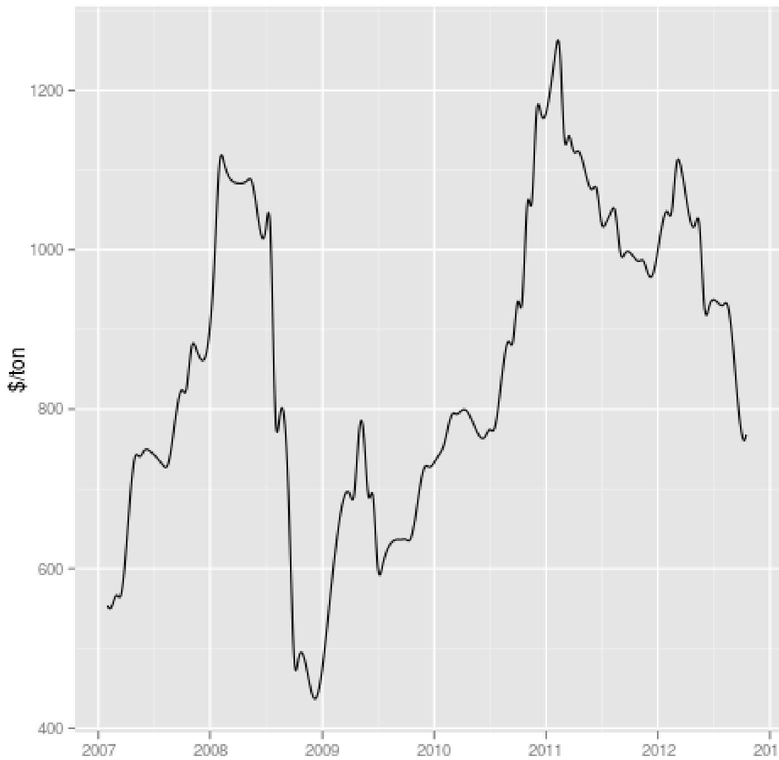


(a) 2-month moving average of proportion measure

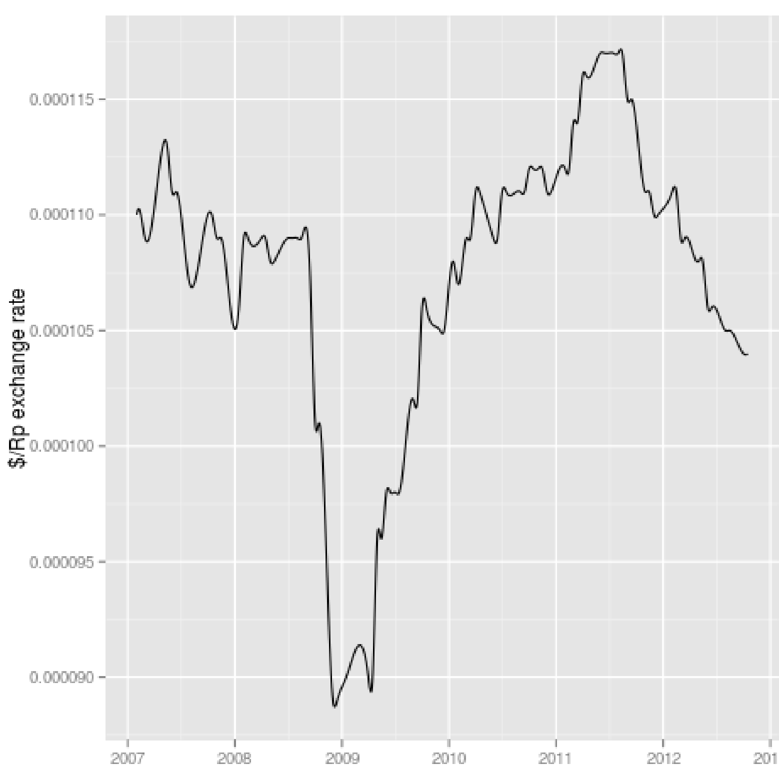


(b) Total number of alerts

Figure 4



(a) Oil palm price



(b) Indonesian exchange rate

Figure 5: Economic indicators.