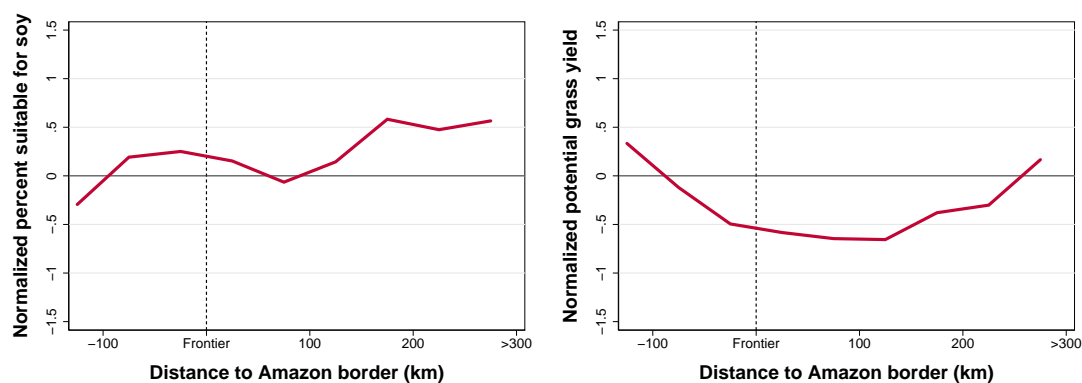


Supplementary Material for: Agricultural Displacement and Deforestation Leakage in the Brazilian Legal Amazon

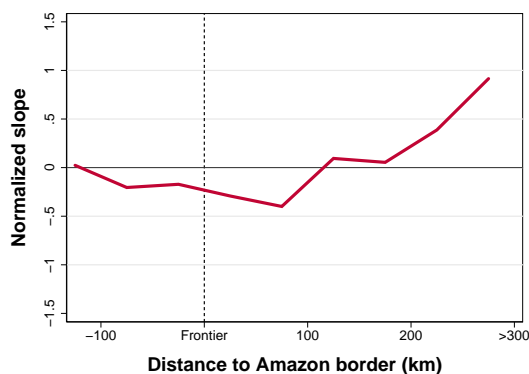
Fanny Moffette and Holly K. Gibbs

A Appendix: normalized measure of soil suitability



(a) Area suitable for soy

(b) Potential grass yield



(c) Slope

Figure A1: Normalized measures of area suitable for soy, potential grass yield and average slope (with mean transformed to equal zero and standard deviation to equal one). Percent of the grid cell that is suitable for soy comes from Soares-Filho et al. (2014) and is based on slope, soils and climate. The average potential grass yield and the slope are extracted from the Food and Agriculture Organization's Global Agro-Ecological Zones (FAO-GAEZ). Measures are calculated per intervals of 50 km and plotted at the mid-distance. We group the regions between 300 and 500 km because they represent less than 10% of the sample. Negative distance corresponds to the Amazon and positive distance to the Cerrado.

B Appendix: robustness checks

Table B1: Different specifications with distance variable

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Cattle/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
Post2006 x Distance	-0.00156** (0.00077)				0.00189*** (0.00069)	
Post2006 x Dist. sq.	0.00000 (0.00000)				-0.00000** (0.00000)	
Post2006 x Inverse Dist.		0.60730*** (0.19000)				-0.53158*** (0.10954)
Post2009 x Distance			-0.00280** (0.00115)		-0.00201*** (0.00047)	
Post2009 x Dist. sq.			0.00000* (0.00000)		0.00000*** (0.00000)	
Post2009 x Inverse Dist.				15.56301*** (4.54005)		0.16907* (0.10147)
R ²	0.07	0.06	0.44	0.46	0.06	0.06
Observations	181,883	181,883	624	624	180,167	180,167
Untransformed pre-period mean	125.348	125.348	180.966	180.966	7.430	7.430
Time x Soil aptitude	X	X	X	X	X	X
Cell fixed effect	X	X			X	X
Municipality fixed effect			X	X		
Year fixed effect	X	X	X	X	X	X

Note: Columns (1), (3) and (5) use the distance and the square of the distance in km. Columns (2), (4) and (6) use $Inverse\ Dist. = 1/(1 + Distance)$, where one is added to $Distance$ in the denominator to ensure the distance is identified when $Distance = 0$. Robust standard errors are in parentheses and are clustered at the municipal level.
 * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B2: Robustness - no differential effect after controlling for protected areas

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Cattle/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
Post2006 x Close	0.28*** (0.05)				-0.03 (0.08)	
Post2006 x Proximity[0,1]		0.60*** (0.12)				-0.19 (0.17)
Post2009 x Close			0.24*** (0.07)		0.12*** (0.03)	
Post2009 x Proximity[0,1]				0.51*** (0.18)		0.19* (0.11)
R ²	0.07	0.07	0.60	0.58	0.06	0.06
Observations	181,883	181,883	624	624	180,167	180,167
Untransformed pre-period mean	125.3	125.3	181.0	181.0	7.4	7.4
Time x Soil aptitude	X	X	X	X	X	X
Time x Protected areas	X	X	X	X	X	X
Cell fixed effect	X	X			X	X
Municipality fixed effect			X	X		
Year fixed effect	X	X	X	X	X	X

Note: Unit of observation is the grid cell for columns (1), (2), (5) and (6), and the municipality for columns (3) and (4). All regressions include flexible trends for both types of protected areas (strict protection and sustainable use). Robust standard errors are in parentheses and are clustered at the municipal level. Calculated for the *Close* group, untransformed pre-period means correspond to soy per 1000 ha in 2005 for columns (1) and (2), to the cattle herd per 1000 ha in 2008 for columns (3) and (4) and to the deforestation per 1000 ha of forest cover in 2005 for columns (5) and (6). * p< 0.10, ** p<0.05, *** p<0.01.

Table B3: Robustness including flexible trends of the baseline forest cover

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Cattle/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
Post2006 x Close	0.26*** (0.05)				-0.04 (0.09)	
Post2006 x Proximity[0,1]		0.56*** (0.10)				-0.22 (0.21)
Post2009 x Close			0.15** (0.07)		0.11*** (0.03)	
Post2009 x Proximity[0,1]				0.19 (0.18)		0.18 (0.12)
R ²	0.07	0.07	0.48	0.47	0.06	0.06
Observations	181,883	181,883	624	624	180,167	180,167
Untransformed pre-period mean	125.3	125.3	181.0	181.0	7.4	7.4
Time x Soil aptitude	X	X	X	X	X	X
Time x BL Forest cover	X	X	X	X	X	X
Cell fixed effect	X	X			X	X
Municipality fixed effect			X	X		
Year fixed effect	X	X	X	X	X	X

Note: Unit of observation is the grid cell for columns (1), (2), (5) and (6), and the municipality for columns (3) and (4). Robust standard errors are in parentheses and are clustered at the municipal level. Calculated for the *Close* group, untransformed pre-period means correspond to soy per 1000 ha in 2005 for columns (1) and (2), to the cattle herd per 1000 ha in 2008 for columns (3) and (4) and to the deforestation per 1000 ha of forest cover in 2005 for columns (5) and (6). * p < 0.10, ** p < 0.05, *** p < 0.01.

Table B4: Robustness - no differential effect after controlling for blacklisted municipalities and distance to protected areas

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Cattle/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
Post2006 x Close	0.12*** (0.04)				0.03 (0.07)	
Post2006 x Proximity[0,1]		0.60*** (0.12)				-0.18 (0.17)
Post2009 x Close			0.18** (0.07)		0.15*** (0.03)	
Post2009 x Proximity[0,1]				0.42* (0.21)		0.19* (0.11)
R ²	0.07	0.07	0.46	0.42	0.06	0.06
Observations	181,883	181,883	624	624	180,167	180,167
Untransformed pre-period mean	125.3	125.3	181.0	181.0	7.4	7.4
Time x Soil aptitude	X	X	X	X	X	X
Dist. nearest PA	X	X	X	X	X	X
Dist. nearest blacklist municipality	X		X		X	
PPCDAm phase 2		X		X		X
Cell fixed effect	X	X			X	X
Municipality fixed effect			X	X		
Year fixed effect	X	X	X	X	X	X

Note: Unit of observation is the grid cell for columns (1), (2), (5) and (6), and the municipality for columns (3) and (4). PPCDAm phase 2 corresponds to the time-period where the blacklisted municipalities program was active, i.e. Post-2008. Robust standard errors are in parentheses and are clustered at the municipal level. Calculated for the *Close* group, untransformed pre-period means correspond to soy per 1000 ha in 2005 for columns (1) and (2), to the cattle herd per 1000 ha in 2008 for columns (3) and (4) and to the deforestation per 1000 ha of forest cover in 2005 for columns (5) and (6). * p< 0.10, ** p<0.05, *** p<0.01.

Table B5: Robustness check that includes a linear trend as a control provides robust results

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Cattle/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
Post2006 x Close	0.27*** (0.05)				-0.04 (0.07)	
Post2006 x Proximity[0,1]		0.60*** (0.12)				-0.18 (0.17)
Post2009 x Close			0.22*** (0.07)		0.12*** (0.03)	
Post2009 x Proximity[0,1]				0.41** (0.20)		0.19* (0.11)
R ²	0.07	0.07	0.44	0.42	0.06	0.05
Observations	181,883	181,883	624	624	180,167	180,167
Untransformed pre-period mean	125.3	125.3	181.0	181.0	7.4	7.4
Time x Soil aptitude	X	X	X	X	X	X
Linear trend	X	X	X	X	X	X
Cell fixed effect	X	X			X	X
Municipality fixed effect			X	X		
Year fixed effect	X	X	X	X	X	X

Note: Unit of observation is the grid cell for columns (1), (2), (5) and (6), and the municipality for columns (3) and (4). Robust standard errors are in parentheses and are clustered at the municipal level. Calculated for the *Close* group, untransformed pre-period means correspond to soy per 1000 ha in 2005 for columns (1) and (2), to the cattle herd per 1000 ha in 2008 for columns (3) and (4) and to the deforestation per 1000 ha of forest cover in 2005 for columns (5) and (6). * p < 0.10, ** p < 0.05, *** p < 0.01.

Table B6: Robustness - controlling for population density does not modify our results

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Cattle/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
Post2006 x Close	0.27*** (0.05)				-0.04 (0.07)	
Post2006 x Proximity[0,1]		0.59*** (0.12)				-0.18 (0.17)
Post2009 x Close			0.21*** (0.07)		0.12*** (0.03)	
Post2009 x Proximity[0,1]				0.41** (0.20)		0.19* (0.11)
R ²	0.07	0.07	0.45	0.43	0.06	0.06
Observations	181,883	181,883	624	624	180,167	180,167
Untransformed pre-period mean	125.3	125.3	181.0	181.0	7.4	7.4
Time x Soil aptitude	X	X	X	X	X	X
Time x Population density	X	X	X	X	X	X
Cell fixed effect	X	X			X	X
Municipality fixed effect			X	X		
Year fixed effect	X	X	X	X	X	X

Note: Unit of observation is the grid cell for columns (1), (2), (5) and (6), and the municipality for columns (3) and (4). Population data are from IBGE (2010) and are divided by the total municipal area. Each regression includes flexible trends of population density. Robust standard errors are in parentheses and are clustered at the municipal level. Calculated for the *Close* group, untransformed pre-period means correspond to soy per 1000 ha in 2005 for columns (1) and (2), to the cattle herd per 1000 ha in 2008 for columns (3) and (4) and to the deforestation per 1000 ha of forest cover in 2005 for columns (5) and (6). * p< 0.10, ** p<0.05, *** p<0.01.

Table B7: Robustness to alternative standard errors calculation (spatial-HAC)

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)
Post2006 x Close	0.27*** (0.03)		-0.04 (0.05)	
Post2006 x Proximity[0,1]		0.60*** (0.06)		-0.18 (0.12)
Post2009 x Close			0.12** (0.05)	
Post2009 x Proximity[0,1]				0.19 (0.14)
R^2	0.02	0.02	0.01	0.01
Observations	181,883	181,883	180,167	180,167
Untransformed pre-period mean	125.3	125.3	7.4	7.4
Time x Soil aptitude	X	X	X	X
Cell fixed effect	X	X	X	X
Year fixed effect	X	X	X	X

Note: Unit of observation is the grid cell. Spatial-HAC standard errors (Conley, 1999; Conley, 2008) are in parentheses, computed with a distance cut-off of 100 km and calculated based on the open-access code provided by Thiemo Fetzer. Calculated for the *Close* group, untransformed pre-period means correspond to soy per 1000 ha in 2005 for columns (1) and (2) and to the deforestation per 1000 ha of forest cover in 2005 for columns (3) and (4). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

C Appendix: alternative specifications tables

Table C1: Alternative specifications - test for parallel pre-trends

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Cattle/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
2001	-0.70 (0.43)	-0.18 (0.21)	-1.54*** (0.33)	-0.08 (0.27)	0.24* (0.13)	-0.43 (0.29)
2002	-0.60 (0.43)	-0.25 (0.20)	-1.37*** (0.33)	-0.19 (0.21)	0.34** (0.13)	-0.03 (0.26)
2003	-0.48 (0.44)	-0.16 (0.18)	-1.23*** (0.34)	-0.28 (0.18)	0.53*** (0.14)	0.38* (0.23)
2004	-0.51 (0.44)	-0.13 (0.14)	-1.22*** (0.34)	-0.24 (0.15)	0.55*** (0.14)	0.61** (0.25)
2005	-0.19 (0.45)	0.04 (0.06)	-1.18*** (0.34)	-0.22 (0.16)	-0.02 (0.11)	0.44*** (0.16)
2006			-1.24*** (0.34)	-0.12 (0.14)	-0.07 (0.10)	-0.33* (0.17)
2007	-0.31 (0.45)	0.10 (0.08)	-1.23*** (0.33)	-0.13 (0.11)	-0.05 (0.12)	-0.05 (0.14)
2008	-0.18 (0.46)	0.31*** (0.10)	-1.22*** (0.34)	-0.16 (0.11)	-0.13 (0.10)	-0.18 (0.17)
2009	-0.21 (0.46)	0.39*** (0.12)				
2010	-0.15 (0.46)	0.46*** (0.14)	-1.06*** (0.32)	0.10 (0.07)	-0.11 (0.10)	0.66*** (0.15)
2011	-0.09 (0.46)	0.55*** (0.15)	-1.00*** (0.31)	0.27** (0.12)	-0.20* (0.11)	-0.30** (0.14)
2012	-0.06 (0.46)	0.67*** (0.16)	-1.00*** (0.29)	0.39* (0.20)	0.13 (0.10)	-0.39 (0.33)
2013	0.10 (0.46)	0.90*** (0.20)	-1.01*** (0.29)	0.26 (0.27)	-0.38*** (0.10)	0.49*** (0.15)
R ²	0.00	0.07	0.14	0.43	0.02	0.06
Observations	181,883	181,883	624	624	180,167	180,167
Time x Soil aptitude		X		X		X
Year fixed effect		X		X		X
Cell fixed effect		X				X
Municipality fixed effect				X		

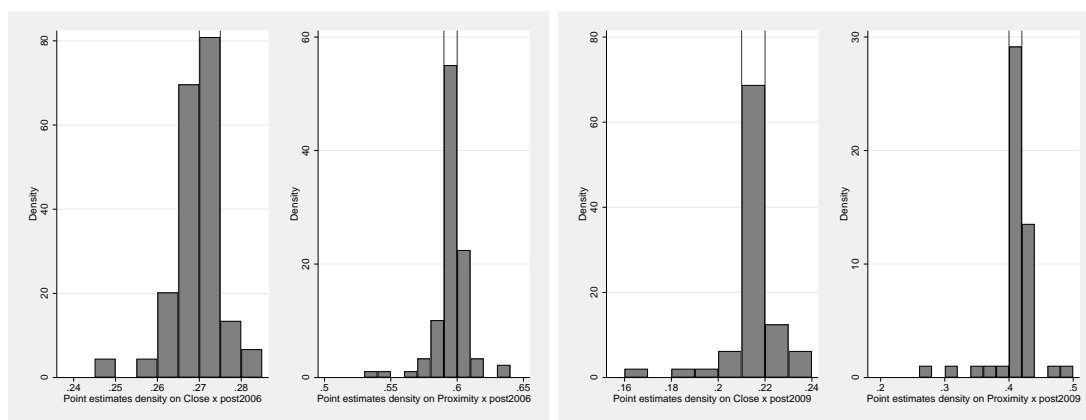
Note: Unit of observation is the grid cell for columns (1), (2), (5) and (6), and the municipality for columns (3) and (4). Robust standard errors are in parentheses and are clustered at the municipal level. Calculated for the *Close* group, untransformed pre-period means correspond to soy per 1000 ha in 2005 for columns (1) and (2), to the cattle herd per 1000 ha in 2008 for columns (3) and (4) and to the deforestation per 1000 ha of forest cover in 2005 for columns (5) and (6). * p< 0.10, ** p<0.05, *** p<0.01.

Table C2: Alternative specifications - test for parallel pre-trends(10 km x 10 km grids)

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)
2001	-1.16 (0.93)	-0.01 (0.08)	0.21 (0.16)	-0.68* (0.35)
2002	-1.04 (0.93)	-0.09 (0.07)	0.39** (0.17)	-0.29 (0.34)
2003	-0.91 (0.94)	0.00 (.)	0.66*** (0.19)	0.23 (0.30)
2004	-0.97 (0.93)	0.05 (0.11)	0.64*** (0.18)	0.55* (0.31)
2005	-0.59 (0.94)	0.12 (0.19)	-0.04 (0.14)	0.29 (0.24)
2006			-0.18 (0.13)	-0.52** (0.23)
2007	-0.71 (0.94)	0.22 (0.15)	-0.17 (0.15)	-0.15 (0.20)
2008	-0.57 (0.95)	0.47*** (0.17)	-0.24* (0.13)	-0.19 (0.22)
2009	-0.62 (0.95)	0.57*** (0.17)		
2010	-0.56 (0.95)	0.65*** (0.17)	-0.23* (0.13)	0.90*** (0.19)
2011	-0.47 (0.95)	0.72*** (0.18)	-0.36** (0.14)	-0.43** (0.19)
2012	-0.44 (0.95)	0.87*** (0.19)	0.05 (0.12)	-0.41 (0.40)
2013	-0.25 (0.96)	1.07*** (0.23)	-0.59*** (0.13)	0.63*** (0.21)
R ²	0.01	0.10	0.04	0.12
Observations	41,700	41,700	45,162	45,162
Time x Soil aptitude		X		X
Year fixed effect		X		X
Cell fixed effect		X		X

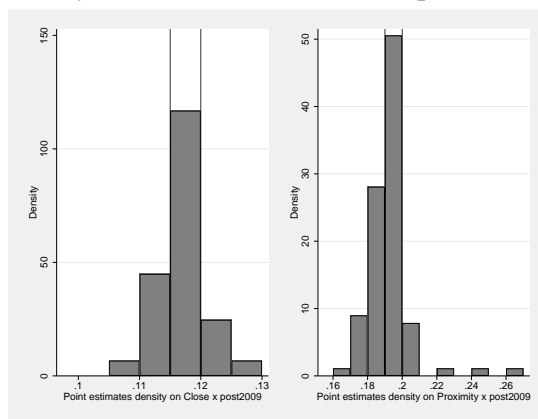
Note: Unit of observation is the grid cell. Robust standard errors are in parentheses and are clustered at the municipal level. Calculated for the *Close* group, untransformed pre-period means correspond to soy per 1000 ha in 2005 for columns (1) and (2) and to the deforestation per 1000 ha of forest cover in 2005 for columns (5) and (6). * p< 0.10, ** p<0.05, *** p<0.01.

D Appendix: sensitivity to municipality outliers (5 km x 5 km)



(a) Dep. var. is IHS(Soy/1000 ha)

(b) Dep. var. is IHS(Cattle/1000 ha)



(c) Dep. var. is IHS(Defor/1000 ha of fc)

Figure D1: Histograms of estimated coefficients when dropping one municipality at a time. Regressions includes unit of analysis fixed effects, time fixed effects and the flexible time trends. Robust standard errors are clustered at the municipal level. Left-hand side graphs present the interaction between *Close* and *PostPolicy*, while right-hand side graphs present the interactions between *Proximity* and *PostPolicy*. Each graphs show the estimated coefficients as a white bar with black sides.

E Appendix: alternative specification for the sensitivity analysis

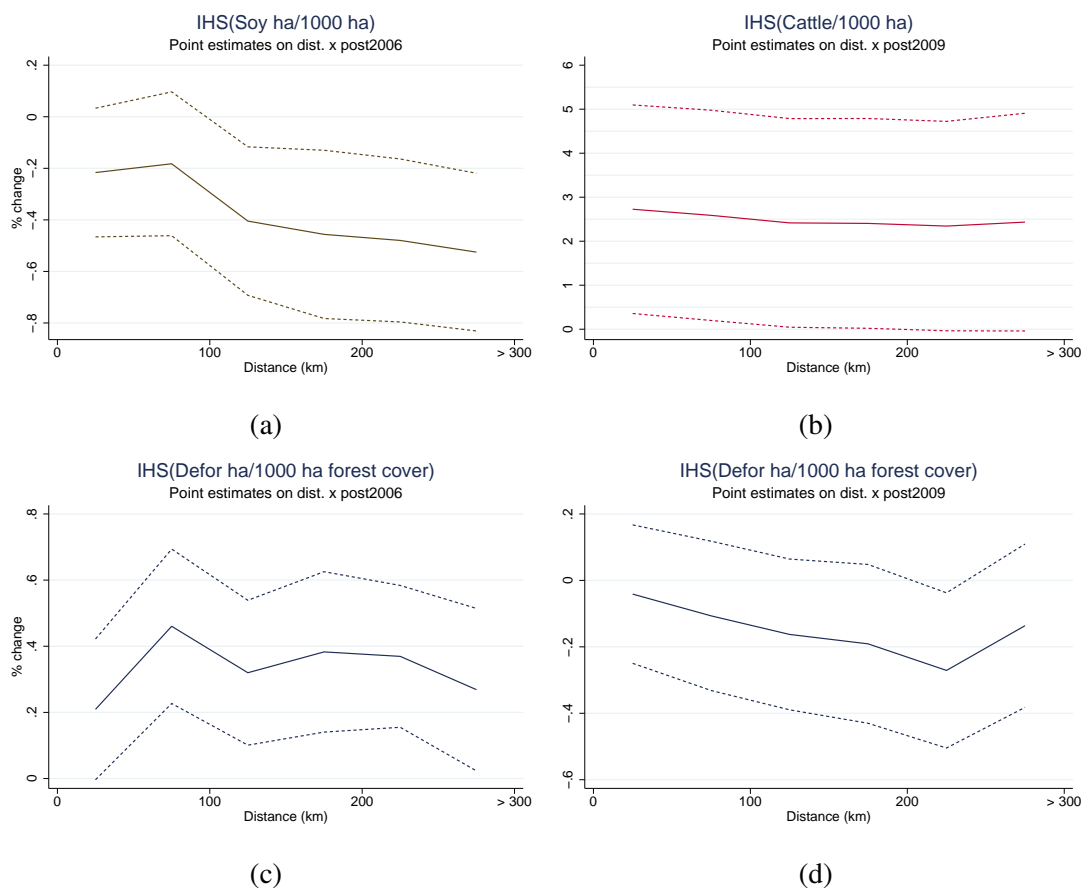


Figure E1: The change in soy, cattle and deforestation by distance to the Amazon frontier in the Cerrado. Graphs a and c plot the coefficients of the regressions of soy and deforestation on the interaction between each 25 km distance indicator and the post-SoyM indicator. Graphs b and c plot the coefficients of the regressions of head of cattle and deforestation on the interaction between the distance indicator and the post-CA indicator. We group the regions between 300 and 500 km because they represent less than 10% of the sample.

F Appendix: robustness on the sample of 10 km x 10 km grids

Table F1: Robustness sensitivity analysis with the 10 km x 10 km grids sample: varying the *Close* indicator

Panel: Soy	(1)	(2)	(3)	(4)	(5)
	50 km	100 km	150 km	200 km	250 km
Post2006 x Close	0.15*	0.31***	0.32***	0.28***	0.25***
	(0.08)	(0.07)	(0.08)	(0.07)	(0.08)
Observations	41,700	41,700	41,700	41,700	41,700
Observations Close	16,302	27,209	32,045	35,646	38,467
Panel: Deforestation					
Post2006 x Close	-0.16**	0.00	0.02	0.06	0.11
	(0.07)	(0.10)	(0.11)	(0.10)	(0.10)
Post2009 x Close	0.15***	0.16***	0.17***	0.14**	0.04
	(0.04)	(0.04)	(0.05)	(0.06)	(0.07)
Observations	45,162	45,162	45,162	45,162	45,162
Observations Close	16,302	27,209	32,045	35,646	38,467

Note: Changes in soy and deforestation by distance to the biome border. Robust standard errors are in parentheses and are clustered at the municipal level. Regressions includes unit of analysis fixed effect, time fixed effects and soil quality flexible time trends. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table F2: Robustness for the soy intensification within Cerrado biome, using the 10 km x 10 km grids sample

	<i>IHS(soy single/1000 ha)</i>			<i>IHS(soy double/1000 ha)</i>			<i>IHS(soy from pasture/1000 ha)</i>		
	(1) 100 km	(2) 150 km	(3) Prox	(4) 100 km	(5) 150 km	(6) Prox	(7) 100 km	(8) 150 km	(9) Prox
Post2006 x Close	0.24** (0.09)	0.34*** (0.10)		0.17 (0.10)	0.01 (0.12)		0.07 (0.06)	0.14* (0.07)	
Post2006 x Proximity[0,1]			0.60*** (0.19)			0.21 (0.24)			0.24* (0.13)
Post2006 x Close	0.15** (0.06)	0.19*** (0.07)		0.18* (0.10)	0.05 (0.11)		-0.00 (0.05)	0.05 (0.06)	
Post2009 x Close	0.17** (0.07)	0.26*** (0.08)		-0.01 (0.04)	-0.06 (0.05)		0.13** (0.05)	0.16*** (0.05)	
Post2006 x Proximity[0,1]			0.32** (0.13)			0.30 (0.22)			0.06 (0.11)
Post2009 x Proximity[0,1]			0.50*** (0.14)			-0.17 (0.11)			0.31*** (0.10)
Observations	45175	45175	45175	41700	41700	41700	41700	41700	41700
Time x Soil aptitude	X	X	X	X	X	X	X	X	X
Cell fixed effect	X	X	X	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X	X	X	X

Note: Changes in single annual soy cropping, double soy cropping and soy planted on pasture by distance to the Amazon frontier in the Cerrado. Unit of observation is the grid cell. Robust standard errors are in parentheses and are clustered at the municipal level. * p< 0.10, ** p<0.05, *** p<0.01.

Table F3: Robustness check - Different specifications with distance variable using the 10 km x 10 km grids sample

	<i>IHS(Soy/1000 ha)</i>		<i>IHS(Defor/1000 ha of fc)</i>	
	(1)	(2)	(3)	(4)
Post2006 x Distance	-0.001933* (0.000989)		0.001607* (0.000944)	
Post2006 x Dist. sq.	0.000002 (0.000002)		-0.000004* (0.000002)	
Post2006 x Inverse Dist.		2.938735*** (1.034557)		-2.596033*** (0.817853)
Post2009 x Distance			-0.002820*** (0.000582)	
Post2009 x Dist. sq.			0.000006*** (0.000002)	
Post2009 x Inverse Dist.				1.657845** (0.790060)
R ²	0.09	0.09	0.11	0.11
Observations	41,700	41,700	45,162	45,162
Untransformed pre-period mean	126.2	126.2	6.7	6.7
Time x Soil aptitude	X	X	X	X
Cell fixed effect	X	X	X	X
Year fixed effect	X	X	X	X

Note: Columns (1) and (3) use the distance and the square of the distance in km. Columns (2) and (6) use $Inverse\ Dist. = 1/(1 + Distance)$, where one is added to $Distance$ in the denominator to ensure the distance is identified when $Distance = 0$. Robust standard errors are in parentheses and are clustered at the municipal level.
 * p< 0.10, ** p<0.05, *** p<0.01.

G Falsification tests

Table G1: Impact of the supply-chain policies on sugarcane and chicken production

Panel: IHS(Sugarcane/1000 ha)	(1)	(2)	(3)	(4)	(5)	(6)
	50 km	100 km	150 km	200 km	250 km	Proximity
Post2006 x Close	-0.00 (0.03)	-0.03 (0.04)	-0.06 (0.05)	-0.09 (0.07)	-0.10 (0.09)	
Post2006 x Proximity[0,1]						-0.22 (0.18)
Observations	181,883	181,883	181,883	181,883	181,883	181,883
Observations Close	72,267	113,633	131,989	145,704	156,741	.
<hr/>						
Panel: IHS(Chicken/1000 ha)						
Post2009 x Close	-0.16 (0.14)	-0.19 (0.22)	-0.22 (0.29)	0.52 (0.48)	0.26 (0.62)	
Post2009 x Proximity[0,1]						0.59 (0.76)
Observations	623	623	623	623	623	623
Observations Close	65	208	299	351	429	.

Note: Changes in sugarcane and chicken production by distance to the Amazon frontier in the Cerrado. Robust standard errors are in parentheses and are clustered at the municipal level. Regressions includes unit of analysis fixed effect, time fixed effects and soil quality flexible time trends. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.