Impacts of nonstate, market-driven governance on Chilean forests

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Global markets for agricultural products, timber, and minerals are critically important drivers of deforestation. The supply chains driving land use change may also provide opportunities to halt deforestation. Market campaigns, moratoria, and certification schemes have been promoted as powerful tools to achieve conservation goals. Despite their promise, there have been few opportunities to rigorously quantify the ability of these nonstate, market-driven (NSMD) governance regimes to deliver conservation outcomes. This study analyzes the impacts of three NSMD governance systems that sought to end the conversion of natural forests to plantations in Chile at the start of the 21st century. Using a multilevel, panel dataset of land use changes in Chile, we identify the impact of participation within each of the governance regimes by implementing a series of matched difference-in-differences analyses. Taking advantage of the mosaic of different NSMD regimes adopted in Chile, we explore the relative effectiveness of different policies. NSMD governance regimes reduced deforestation on participating properties by 2–23%. The NSMD governance regimes we studied included collaborative and confrontational strategies between environmental and industry stakeholders. We find that the more collaborative governance systems studied achieved better environmental performance than more confrontational approaches. Whereas many government conservation programs have targeted regions with little likelihood of conversion, we demonstrate that NSMD governance has the potential to alter behavior on high-deforestation properties.

deforestation | timber | certification | program evaluation | supply chains

Since the 1980s, production of commodities for distant markets has emerged as a dominant driver of deforestation (1–3). As the relative importance of global, rather than local, demand for agricultural and forest products has grown, transnational corporations have become critical actors in influencing land use change. In response, various nonstate, market-driven (NSMD) governance regimes have emerged to improve the environmental and social impacts of commodity production (4–6). Such NSMD governance systems are the result of complex interactions between corporations and nongovernmental organizations (NGOs) (7). These systems take a variety of forms including multistakeholder agreements, land conversion moratoria, and ecocertification schemes. Although voluntary in nature, they derive authority through markets. Credible threats of market exclusion, or promises of price premiums can serve to incentivize more responsible social and environmental practices (8). Such governance structures have been praised for their potential to slow deforestation associated with the production of Brazilian soy and beef (9), Indonesian palm oil (10), and boreal timber (11).

Despite the growing optimism surrounding these NSMD governance regimes, questions remain about their effectiveness in achieving environmental outcomes. For example, environmental benefits may be limited if the producers opting into ecocertification are those already meeting sustainability standards (12). Although direct conversion of forests to soy production in the Brazilian Amazon dropped precipitously after the implementation of the soy moratorium (13), indirect land use changes may have displaced soy expansion, causing deforestation elsewhere (14). The costs of compliance with NSMD regimes may exceed the benefits for landowners, minimizing the potential for large-scale conservation benefits (15). In addition, suppliers may be able to circumvent environmental agreements by segmenting markets and shipping production that fails to meet environmental standards to consumers with weaker environmental concerns (16). Even if initially effective, corporate commitments to environmental practices may wane as public attention turns elsewhere (17).

Such critiques highlight the importance of clear program evaluation to determine the effectiveness of NSMD governance regimes. Most ex-post evaluations of NSMD governance in the forestry sector have focused on the legitimacy of the decision-making process rather than on the environmental outcomes of the regime (18). Clear assessments of the environmental impacts of this new form of environmental governance are lacking (8, 16, 19, 20), due in part to the short history of NSMD governance and confounding effects of broader market dynamics and government policies (9). Previous assessments generally failed to meet basic standards of rigor such as comparison with a credible control (21). Recently, a handful of studies have begun to provide more rigorous assessments of the impacts of NSMD governance on deforestation. These studies indicate that Brazil's zero deforestation cattle agreement (22) and forest certification in Indonesia (23) have reduced rates of deforestation, whereas timber certification in Mexico (24) has had insignificant impacts on deforestation.

Beyond identifying the effectiveness of any one NSMD regime, a comparison of the impacts of different approaches to environmental governance is essential to improve policy design. As with traditional governance systems, NSMD interventions can vary at any of the traditional stages of the regulatory process:

Significance

Global trade in commodities has become an important driver of environmental degradation. In response, there has been a proliferation of nonstate, market-driven governance seeking to reduce environmental degradation through interventions in the supply chain. We provide some of the first quasiexperimental evidence to show that private, market-driven policies can slow deforestation. We compare the impacts of two certification schemes and a deforestation moratorium in Chile using a factorial quasiexperimental design. Our results indicate that governance regimes with greater collaboration between environmental and industry stakeholders achieved better environmental outcomes. In contrast to many public conservation policies, we find that private governance systems can effectively target high-deforestation properties.

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agenda setting/negotiation, implementation, and monitoring/enforcement (25). In the first stage, NGOs must decide how to balance confrontational and collaborative strategies (26). Similarly, industry participants can choose the level of collaboration with which to respond; either participating in multistakeholder negotiations or developing their own standards to compete for legitimacy (4). In both cases, the balance between collaboration and confrontation may shift during the latter stages of the regulatory process. Cooperation in regulatory processes has been found to improve the environmental performance of public policies (27, 28), but relatively little is known about the impact of collaboration on the effectiveness of private governance regimes.

In a policy ecosystem with multiple NSMD governance regimes, individual policies may interact in complex ways. Interactions can be direct (e.g., an individual property owner adopts multiple NSMD governance regimes simultaneously) or indirect (e.g., competition between NSMD governance regimes lead to changes in NSMD governance adoption or rules). Both direct and indirect interactions can affect the outcomes associated with any individual policy as different governance regimes can complement, substitute, or weaken the effectiveness of individual policies (16). As a result, it is important to understand how stacked NSMD governance regimes may differ in their outcomes from individual interventions that are implemented in isolation.

This study addresses three questions: Can NSMD governance regimes achieve conservation outcomes? How do NSMD governance regimes with varying levels of collaboration between stakeholders differ in their effectiveness? Do interacting governance regimes complement, substitute, or weaken individual policies? We use quasiexperimental methods and data on property-level land use change in Chile to assess the impacts of a mosaic of different NSMD governance regimes.

Chile's forestry sector provides a rich history of NSMD governance. By the end of the 20th century, the conversion of natural forests to industrial pine and eucalyptus plantations had become the primary cause of Chilean deforestation (29, 30). Efforts to improve management of natural forests through traditional government policies were often halted. Chile's native forest law spent 15 years in Parliament before being adopted in 2007—longer than any law in Chilean history (31). In response to growing demands from US retailers for more sustainable products, several quasigovernmental agencies worked with the primary forestry trade association to develop El Sistema Chileno de Certificación de Manejo Forestal Sustentable (CERTFOR), a national certification for sustainable forest management that was later endorsed by the Program for the Endorsement of Forest Certification (PEFC). Although the two largest Chilean forestry corporations [Arauco and Compañía Manufacturera de Papeles y Cartones (CMPC)] pursued CERTFOR certification for the majority of their subsidiaries, other corporations began to certify their operations through the Forest Stewardship Council (FSC). The competition between FSC and the producer-backed CERTFOR standard mirrored global discussions about the relative stringency of forest certification standards defined by an industrial sector (as for CERTFOR) or by multistakeholder initiatives where other stakeholders such as environmental NGOs have a strong voice (as for FSC) (20).

As the Chilean corporations began to negotiate and adopt certification standards, many NGOs launched confrontational campaigns to pressure the Chilean corporations to reform (32). In advertisements in the *New York Times*, the environmental NGO ForestEthics encouraged American consumers of Chilean timber to demand an end to forest substitution and to only purchase Chilean timber certified by FSC.* As a result of increasing consumer pressure, the Home Depot helped convene a series of meetings between environmental NGOs, and the Chilean forestry corporations CMPC and Arauco. In 2003, CMPC, Arauco, the Home Depot, and 10 environmental NGOs reached an agreement they referred to as the Joint Solutions Project (JSP), whereby Chilean timber corporations committed not to clear natural forests on their properties.† In 2007, an additional agreement was reached with a third corporation, MASISA, bringing the total share of plantations owned by JSP participants to 64% (33).‡

Although the conditions that gave rise to the three NSMD regimes (CERTFOR, FSC, and JSP) were different, the substance of the forest conversion commitments in each standard were roughly similar. All three policies explicitly prohibited the future conversion of natural forests to plantations† (34, 35) and called for transparency in the form of monitoring by third parties. Each policy included some incentive for compliance, whether in the form of an end to negative publicity in the case of the JSP or access to differential labeling in the case of FSC or CERTFOR certification. One of the few previous comparisons of FSC and CERTFOR found that participants in the two certification schemes introduced similar numbers of institutional changes (36). However, differences in the policies did exist. The JSP included explicit language prohibiting companies from encouraging forest conversion by other property owners. FSC standards went beyond the other two policies by retroactively punishing past substitution through restrictions on the certification of any plantations established on lands that had been natural forests before 1994. Mirroring a global debate about the relative rigor of corporate versus multistakeholder certification schemes (4, 37), many environmental groups expressed concern that the corporate CERTFOR standard was environmentally inferior to the FSC standards (38).

Chilean implementation of the JSP, FSC certification, and CERTFOR certification provides a unique opportunity for the quasiexperimental evaluation of the impacts of NSMD governance. All three policies included a common and clearly observable objective—to halt conversion of natural forests to plantations—by which to judge their effectiveness. Despite widespread public discourse about the merits of the different programs (38, 39), there has been no rigorous quantification of their environmental impacts. Fortunately, the different governance regimes were adopted nearly simultaneously but heterogeneously across the country, allowing for their comparison and the analysis of their interactions (Fig. 1). Finally, rigorous quasiexperimental quantification of these effects was enabled by the relatively long time period since policy adoption, as well as by available data on land use change, and property boundaries and ownership.

Results

At the start of our study period, the sample properties covered 329 thousand hectares of natural forests and 478 thousand hectares of plantation forests. Over the following 25 years, a net deforestation rate of 1.38% per year led to a net loss of 97 thousand hectares of natural forests. In contrast, plantation forests expanded at an annual rate of 2.30%, adding 367 thousand hectares. Between 1986 and 2011, property owners converted 38% of their natural forests to plantations. Across the study properties, the average gross rate of conversion of natural forests to plantations was 2.35% per year during the first time period (1986–2001), dropping to 2.11% during the second time period (2001–2011), but varying by NSMD participation (Fig. 2).

Propensity score models highlighted observable differences in the characteristics of properties participating in each of the different treatments (Tables S1–S3). Potential plantation rents were positively correlated with the likelihood to participate in any of the

*ForestEthics (September 13, 2002) Your dream home in a small clearing in the woods. *NY Times.* Advertisement.

†CMPC Maderas S.A., et al. (2003) Memorandum of understanding.

‡Masisa, ForestEthics (2007) Memorandum of understanding.

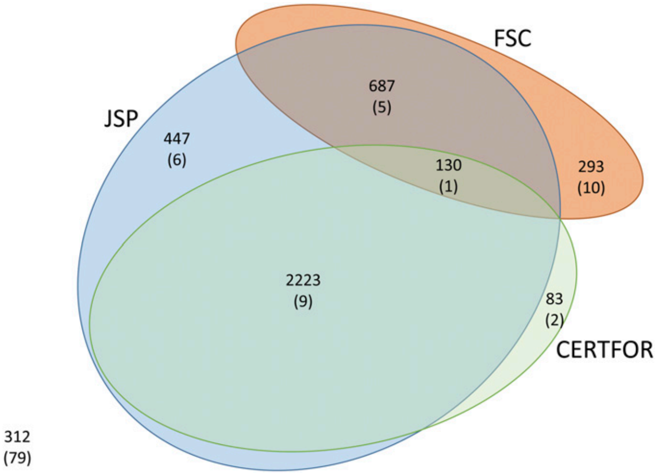

Fig. 1. Number of properties (companies) in each NSMD governance regime.

three NSMD regimes. In addition, properties participating in NSMD governance regimes were generally located closer to markets. They also had higher initial proportions of land dedicated to plantations, more land in the highest land capability classes, and higher pretreatment rates of forest substitution. The multiscale model emphasized that larger companies were more likely to be participants in NSMD governance. Finally, multiple comparisons across the different treatment groups (Table S2, h, j, m, and o) underscored the fact that properties with FSC certification tended to have lower historical rates of deforestation than properties pursuing other NSMD governance regimes.

Using matched difference-in-differences, we estimated the average treatment effect on the treated (ATT), a measure of the gain from the intervention, of each NSMD governance regime (Table S4 and Fig. 3). Pooled together, the ATT on properties governed by any of the three policies ("any policy" group) was a reduction in forest substitution of 0.338 ± 0.294 percentage points (g). This decrease is equal to a 2–23% reduction in the annual rate of forest conversion. Although this result was not significant in the alternate specification of this model using cluster robust SEs ($P = 0.17$), it was moderately significant ($P = 0.10$) in the spatial lag model with cluster-robust SEs. The effectiveness of the any-policy treatment was further supported in the multilevel model that explicitly accounted for company-level covariates (*x*). Although only estimated on the small subset of the overall sample falling on the common support (*Supporting Information*), this model found significant impacts ($P \leq 0.01$) in all three model specifications.

Of the individual assessments, the JSP only (a, -0.508 ± 0.304) and FSC only (b, -0.870 ± 0.373) treatments demonstrated significant reductions in forest substitution rates. No treatments exhibited significant increases in the rate of forest substitution (a–f). Both of these results were evident in all three model specifications.

Paired comparisons between treatment groups were used to evaluate the relative effectiveness of different policies. FSC certification had a greater effect than either JSP participation (h) or CERTFOR certification (m) alone, or the adoption of both the JSP and CERTFOR certification (o). Although all three of these results were evident in the main model and the alternate cluster-robust specification, the spatial lag model yielded less significant differences between FSC certification and (*i*) the JSP-only treatment (h), and (*ii*) the JSP and CERTFOR treatment (o). However, the spatial lag model did indicate that joint implementation of FSC, CERTFOR, and the JSP may have generated greater reductions in forest conversion than implementation of only CERTFOR and the JSP (v). Finally, the comparison between properties adopting only CERTFOR certification and those participating only in the JSP found that the JSP was more effective in reducing forest conversion (i).

Paired comparisons between properties participating in multiple, overlapping governance regimes tended to emphasize a lack of synergy and the possibility of interference between governance regimes. Comparing properties with stacked governance regimes to properties with only some of the same governance regimes tended to find null or counterintuitive results. In the models without a spatial lag, properties participating only in FSC certification demonstrated greater reductions in forest conversion than those participating in both FSC and the JSP (n). Although only significant in a few specifications, our analysis indicated that properties participating only in the JSP may have achieved greater reductions in forest conversion than properties participating in both the JSP and CERTFOR (k), or the JSP and FSC (j). Even in the case where multiple policies did achieve more reductions than properties with a subset of governance regimes (v, spatial lag specification), the stacked treatment effect was less than the additive effects of the individual treatment effects from each policy. We found no evidence that adoption of NSMD governance resulted in leakage to proximate properties. Changes in forest conversion rates on properties without NSMD governance were comparable whether or not those properties were located in close proximity to NSMD participants (s).

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Discussion

Our results show that NSMD governance regimes can slow deforestation. Between 1986 and 2011, 124 thousand hectares of natural forests in the studied properties were converted to plantations. The different NSMD interventions reduced annual rates of forest conversion by 2–23% compared with the no-policy counterfactuals. In aggregate, these policies conserved 3.82 thousand hectares of natural forests. Although NSMD governance reduced deforestation, all three programs sought to end, rather than reduce, the rate of forest substitution. In this context, anything short of 100% reductions in deforestation within NSMD properties could be interpreted as noncompliance with the governance regimes. However, because our treatment time period included several years before the implementation of the NSMD governance regimes, our analysis would tend to underestimate compliance. In addition, given the voluntary nature of the governance regimes, any significant reductions in forest conversion could be viewed as a policy success.

During their initial negotiation and adoption, the JSP, FSC, and CERTFOR governance regimes varied in the level of engagement and confrontation between industry and environmental interests.

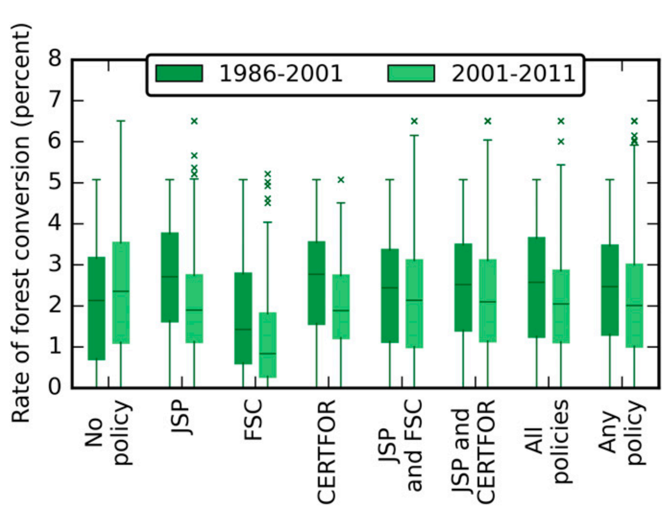

Fig. 2. Unmatched comparison of forest conversion rates by policy.

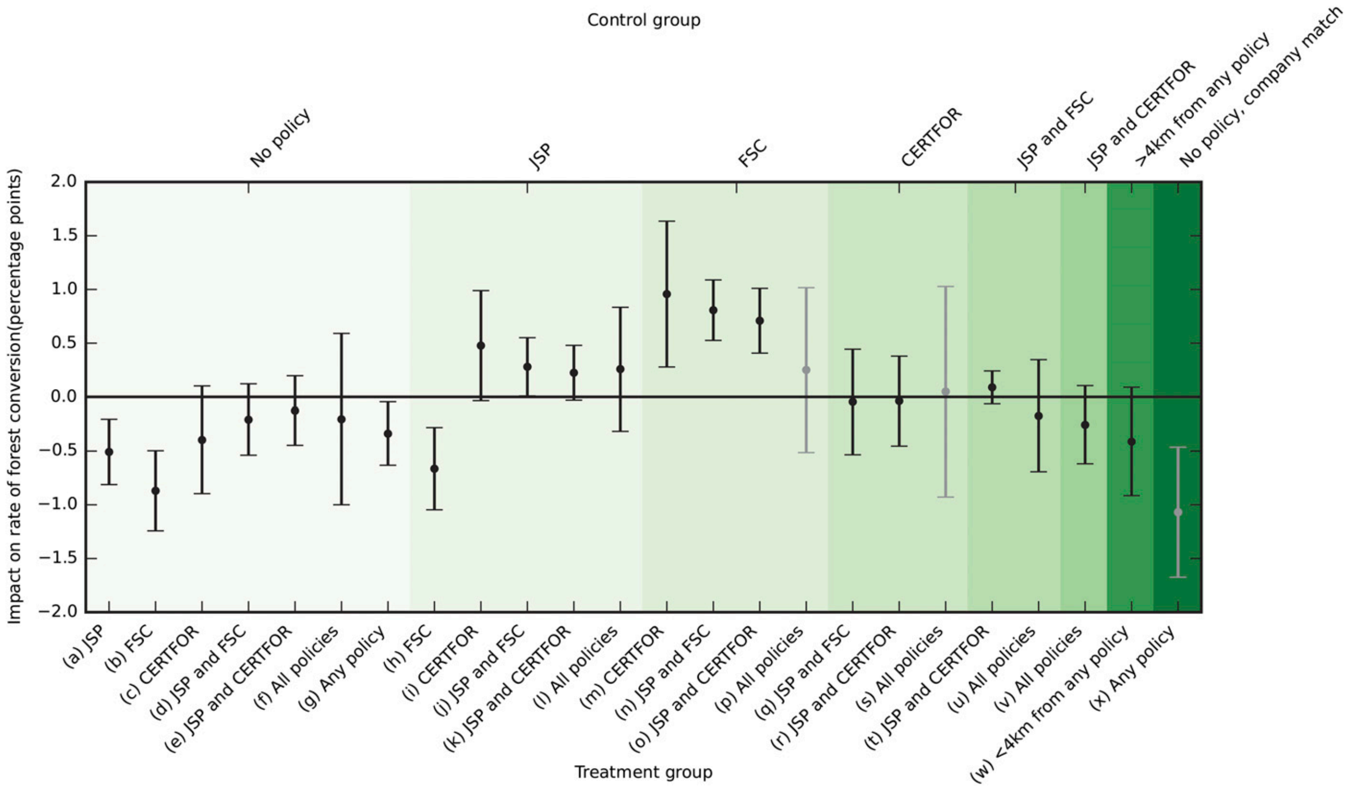

Fig. 3. Comparisons of treatment effects estimated through matched difference-in-differences. Gray bars indicate that propensity score matching failed to achieve acceptable balancing across all covariates. Error bars represent 95% confidence interval using propensity score robust SEs.

As the product of multistakeholder negotiations, FSC certification represented the most collaborative governance regime (40). Nearly all of the companies certified by FSC in its first 5 years of operation in Chile actively participated in the rule-making process for the development of FSC's Chilean standards. In contrast, the CERTFOR certification scheme sought to demonstrate that industry could self-regulate, without participation from civil society. Given their exclusion from the CERTFOR standard-setting process, several NGOs expressed concern over the certification scheme's environmental rigor (38). Finally, the JSP was developed through a combination of confrontational and collaborative strategies. Initially instigated through negative publicity by NGOs, industry and NGO interests eventually collaborated to develop the JSP's commonly agreed-upon standards.

Our results indicate that FSC certification was more effective in slowing forest conversion than either the more industry-friendly CERTFOR standard or the JSP moratorium. Furthermore, the CERTFOR certification standard, which arguably had the least engagement between companies and civil society, was the least effective NSMD policy. Clear identification of a causal relationship between collaboration and environmental performance is complicated by the fact that the choice between collaboration and confrontation is rarely binary. In most cases, actors shift their level of collaboration in different stages of the regulatory process, or different actors may simultaneously adopt different strategies. Given this nuance and the small number of governance regimes analyzed, we are unable to claim a causal link between collaboration and environmental performance. Nevertheless, our results are consistent with theoretical (41) and empirical results (27, 28) indicating that more collaborative forms of governance can lead to better environmental outcomes.

In assessing interactive effects of different policies, we found no evidence to suggest that combining multiple governance regimes on a single property would improve environmental performance. In several cases, properties adopting multiple NSMD regimes exhibited worse environmental performance than properties adopting only one of the constituent regimes. One possible explanation for this outcome would be interference across the different policy regimes. In addition to the direct property-level interactions measured by our quasiexperimental methods, the different NSMD governance regimes also interacted in important ways at the national scale. The existence of FSC certification may have increased the rigor of environmental safeguards in the final CERTFOR standards. Although initial external assessments of CERTFOR noted weak protections of natural forests (42), the final CERTFOR plantation standards included clear language to limit natural forest conversion (35). Second, the NGO campaign that led to the adoption of the JSP may have also accelerated the adoption of FSC certification. The initial market campaign encouraged consumers to purchase only FSC-certified Chilean timber. Arauco and CMPC, the primary targets of the NGO campaign, initially supported the development of the CERTFOR standard as an alternative to FSC. However, after continued NGO criticism of the CERTFOR standard, both companies pursued FSC certification. These interactions at the national level reinforced two existing theories on the adoption of NSMD regimes: (*i*) competition between NSMD governance regimes can strengthen industry-led standards; and (*ii*) NGO campaigns can encourage the adoption of environmental certification (20, 37).

Differences in the implementation of NSMD governance seemed to align with differences in the types of properties affected. Early adopters of FSC had to be willing to collaborate with environmental NGOs and sought to differentiate their products based on environmental performance. In practice, FSC properties tended to have lower rates of pretreatment forest conversion than other plantation properties. In contrast, the JSP was initiated as a campaign to reform behavior. In this case, NGOs targeted specific corporations that they viewed as priorities for reform. High pretreatment rates of forest conversion were a strong indicator of participation within the JSP (Table S2). These differences emphasize a potential strength of NSMD governance regimes. Although protected areas and other public conservation policies have the potential to nearly eliminate deforestation, such interventions typically target regions with relatively low rates of deforestation (43, 44). In contrast to conservation areas located in inaccessible locations, the properties affected by NSMD governance belonged to Chile's largest timber corporations. The pretreatment rate of net deforestation on NSMD properties was 1.83%, more than double the rate of net deforestation across all of central Chile (0.83%). In addition, the properties participating in NSMD governance had higher than average potential rents for plantation forestry.

Theory indicates that the adoption of NSMD governance could lead to multiple forms of spillovers affecting rates of forest conversion on nonparticipating properties. Restrictions on conversion could increase demand for land suitable for plantation forestry, increasing conversion of natural forests on nonparticipating properties. To address such concerns, timber companies participating in the JSP agreed not to undertake actions that would encourage the conversion of natural forests on properties outside their direct control. Ideally, an analysis of the resulting leakage patterns would look at leakage as a process mediated by supply chains and corporate relationships in addition to purely spatial lags. We posit that both the potential negative effects of indirect land use change, and the potential positive effects from policy spillovers would have the strongest impact near participating properties. However, we find minimal leakage from NSMD properties to proximate properties. In addition to market-mediated leakage, environmental campaigns and negotiations that led to NSMD governance may have encouraged broader policy reforms and changes in norms across the entire sector. Such reforms would have more wide-reaching positive effects but are difficult to isolate given the structure of our analysis.

Conclusion

Using quasiexperimental methods, we demonstrated that Chile's NSMD governance regimes were successful in reducing natural forest conversion to plantations by 2–23%. Of the three governance regimes evaluated, the multistakeholder FSC certification standard achieved better environmental performance than either the industry-led CERTFOR standard, or NGO-incited JSP moratorium. In contrast to traditional public conservation policies such as protected areas, these NSMD governance regimes were often implemented on properties with high historical rates of deforestation. Although our case study was focused on Chile, the analysis can provide insights to guide the rapid spread of NSMD governance globally. First, NSMD policies can achieve real improvements in environmental performance despite their voluntary nature. Although compliance with NSMD governance is often less than that achieved through public conservation efforts such as national parks, NSMD policies tend to do a better job in targeting high-deforestation properties. As a result, NSMD governance may serve as a useful complement to traditional, government policies. Finally, greater collaboration between environmental and industry interests in establishing NSMD standards is likely to improve the environmental performance of the resulting policies.

Methods

We sought to measure the impact of NSMD governance in Chile's forestry sector on the rate of natural forest conversion to plantations. To do so, we (*i*) developed a hierarchical dataset identifying properties owned by timber companies and the subset of those properties affected by each NSMD governance regime; (*ii*) calculated the rate of natural forest conversion in pretreatment and posttreatment time periods for each property; and (*iii*) conducted a series of matched difference-in-differences analyses to measure the effect of each policy. We provide a summary of these methods below and a more thorough description in *Supporting Information*.

Sample Selection. To link outcomes to treatment adoption and other associated covariates, we developed a multilevel dataset spanning pixels, properties, subsidiary companies, and their parent corporations. We used government cadastral data to link unstructured spatial data to property boundaries and the names of property owners. We then restricted our study to the set of properties owned by forestry companies. Individual companies were associated with parent corporations using market and corporate reports. By combining this ownership information with primary data sources such as certification records and signed voluntary agreements, we identified properties participating in NSMD governance. Finally, we sorted the properties into eight groups representing properties regulated by the following: JSP only, FSC only, CERTFOR only, JSP and FSC, JSP and CERTFOR, all three programs simultaneously, any of the three programs, and none of the three programs.

Calculation of Natural Forest Conversion. Our outcome variable of interest was the rate at which natural forests were converted to plantation forests within each property. We calculated this rate using land use change maps from ref. 45. For each property, we calculated the annualized rate at which natural forests were converted to plantations during each of the two time periods.

Matched Difference-in-Differences. We measured the average effect of NSMD governance on the rate of forest conversion within properties participating in NSMD governance (ATT) through the use of a series of matched difference-in-differences analyses. For our primary results, we defined our treatment group as those properties participating in any NSMD governance regime, and our control as those properties participating in no NSMD governance regime. We used a biophysical, geographic, and economic controls to preprocess our samples using propensity score matching. Diagnostics indicated that the matching procedure reduced observed differences between treatment and control groups (Fig. S1 and Table S3).

We took advantage of our longitudinal data to control for unobserved, time-invariant characteristics of the properties such as company ownership. We calculated the difference-in-differences estimator of the ATT, adjusting SEs to reflect the estimated propensity scores (46). The benefits of combining matching with panel methods have been confirmed through design replication studies comparing quasiexperimental results to the results generated from random controlled trials (47, 48). Very few studies have used this two-staged analysis for the identification of the effect of policies intended to slow deforestation (49, 50), and even fewer have used this method to measure the impact of NSMD governance of land use (23, 24).

We repeated this process to compare the relative effectiveness of different programs, and to test for complementarities across programs as outlined in ref. 51. For each of the possible pairwise comparisons between the different groups, we assigned one group to the treatment, and the other group to the control. Iterating through all of the possible combinations, and including comparisons to test for spatial leakage and a multilevel specification, we were left with 24 pairwise comparisons for analysis.

To test the robustness of our results, we ran two alternate specifications of each quasiexperiment, and two additional quasiexperiments. First, to account for within-company correlation of errors, we reran all models using company-level cluster-robust SEs. To test robustness to observed spatial autocorrelation, we reran all models with spatially lagged dependent variables. Although our primary models emphasized property-level characteristics, we explored the robustness of our results through a multilevel model that incorporated company-level covariates. Finally, we tested for leakage by comparing forest conversion on proximate, untreated properties to untreated properties located more than 4 km from the nearest property participating in NSMD governance.

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1. Geist HJ, Lambin EF (2002) Proximate causes and underlying driving forces of tropical deforestation. *Bioscience* 52:143–150.
2. Rudel TK, Defries R, Asner GP, Laurance WF (2009) Changing drivers of deforestation and new opportunities for conservation. *Conserv Biol* 23(6):1396–1405.
3. DeFries RS, Rudel T, Uriarte M, Hansen M (2010) Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nat Geosci* 3:178–181.
4. Cashore BW, Auld G, Newsom D (2004) *Governing Through Markets: Forest Certification and the Emergence of Non-State Authority* (Yale Univ Press, New Haven, CT).

5. Nepstad DC, Stickler CM, Almeida OT (2006) Globalization of the Amazon soy and beef industries: Opportunities for conservation. *Conserv Biol* 20(6):1595–1603.
6. Butler RA, Laurance WF (2008) New strategies for conserving tropical forests. *Trends Ecol Evol* 23(9):469–472.
7. Cashore B, Egan E, Auld G, Newsom D (2007) Revising theories of nonstate market-driven (NSMD) governance: Lessons from the Finnish forest certification experience. *Glob Environ Polit* 7:1–44.
8. O'Rourke D (2005) Market movements: Nongovernmental organization strategies to influence global production and consumption. *J Ind Ecol* 9:115–128.
9. Nepstad D, et al. (2014) Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science* 344(6188):1118–1123.
10. Gnych SM, Limberg G, Paoli G (2015) *Risky Business: Uptake and Implementation of Sustainability Standards and Certification Schemes in the Indonesian Palm Oil Sector* (CIFOR, Bogor, Indonesia).
11. Howlett M, Rayner J, Tollefson C (2009) From government to governance in forest planning? Lessons from the case of the British Columbia Great Bear Rainforest initiative. *For Policy Econ* 11:383–391.
12. Blackman A (2013) Evaluating forest conservation policies in developing countries using remote sensing data: An introduction and practical guide. *For Policy Econ* 34:1–16.
13. Macedo MN, et al. (2012) Decoupling of deforestation and soy production in the southern Amazon during the late 2000s. *Proc Natl Acad Sci USA* 109(4):1341–1346.
14. Arima EY, Richards P, Walker R, Caldas MM (2011) Statistical confirmation of indirect land use change in the Brazilian Amazon. *Environ Res Lett* 6:024010.
15. Gullison RE (2003) Does forest certification conserve biodiversity? *Oryx* 37:153–165.
16. Lambin EF, et al. (2014) Effectiveness and synergies of policy instruments for land use governance in tropical regions. *Glob Environ Change* 28:129–140.
17. Devlin J, Tubino DI (2012) Contention, participation, and mobilization in environmental assessment follow-up: The Itabira experience. *Sustainability* 8:106–115.
18. Schlyter P, Stjernquist I, Bäckstrand K (2009) Not seeing the forest for the trees? The environmental effectiveness of forest certification in Sweden. *For Policy Econ* 11:375–382.
19. Miteva DA, Pattanayak SK, Ferraro PJ (2012) Evaluation of biodiversity policy instruments: What works and what doesn't? *Oxf Rev Econ Policy* 28:69–92.
20. Auld G, Gulbrandsen LH, McDermott CL (2008) Certification schemes and the impacts on forests and forestry. *Annu Rev Environ Resour* 33:187–211.
21. Blackman A, Rivera J (2011) Producer-level benefits of sustainability certification. *Conserv Biol* 25(6):1176–1185.
22. Gibbs HK, et al. (2015) Did ranchers and slaughterhouses respond to zero-deforestation agreements in the Brazilian Amazon? *Conserv Lett*, 10.1111/conl.12175.
23. Miteva DA, Loucks CJ, Pattanayak SK (2015) Social and environmental impacts of forest management certification in Indonesia. *PLoS One* 10(7):e0129675.
24. Blackman A, Goff L, Planter MR (2015) *Does Eco-certification Stem Tropical Deforestation?* (Resources for the Future, Washington, DC).
25. Gulbrandsen LH (2014) Dynamic governance interactions: Evolutionary effects of state responses to non-state certification programs. *Regul Gov* 8:74–92.
26. Affolderbach J (2011) Environmental bargains: Power struggles and decision making over British Columbia's and Tasmania's old-growth forests. *Econ Geogr* 87:181–206.
27. Ulibarri N (2015) Collaboration in federal hydropower licensing: Impacts on process, outputs, and outcomes. *Public Perform Manag Rev* 38:578–606.
28. Scott T (2015) Does collaboration make any difference? Linking collaborative governance to environmental outcomes. *J Pol Anal Manage* 34:537–566.
29. Echeverria C, et al. (2006) Rapid deforestation and fragmentation of Chilean temperate forests. *Biol Conserv* 130:481–494.
30. Clapp RA (2001) Tree farming and forest conservation in Chile: Do replacement forests leave any originals behind? *Soc Nat Resour* 14:341–356.
31. Leighton P (2007) Chile approves native forest law after 15 years. *Sci Dev Net*. Available at www.scidev.net/index.cfm?originalUrl=global/policy/news/chile-approves-native-forest-law-after-15-years.html. Accessed on March 2, 2015.
32. Henne A, Gabrielson T (2012) Chile is timber country. *Environment and Citizenship in Latin America: Natures, Subjects and Struggles* (Berghahn Books, New York), pp 149–167.
33. Universidad de Concepción Departamento de Economía (2009) *Análisis de la Cadena de Producción y Comercialización del Sector Forestal Chileno: Estructura, Agentes y Prácticas* (Universidad de Concepción, Concepción, Chile).
34. FSC (2005) *FSC-Chile: Propuesta de Estandar para la Certificacion FSC de Plantaciones Forestales de Operaciones a Gran y Pequena Escala* (FSC, Santiago, Chile).
35. CERTFOR (2007) *CERTFOR Standard Sustainable Forest Management for Plantations* (CERTFOR, Santiago, Chile).
36. Cubbage F, Diaz D, Yapura P, Dube F (2010) Impacts of forest management certification in Argentina and Chile. *For Policy Econ* 12:497–504.
37. Auld G (2014) *Constructing Private Governance: The Rise and Evolution of Forest, Coffee, and Fisheries Certification.* Yale Agrarian Studies Series (Yale Univ Press, New Haven, CT).
38. Ford J, Jenkins A (2011) *On the Ground: The Controversies of PEFC and SFI* (Greenpeace International, Amsterdam).
39. Cousins K (2006) *Principals, Agents, and Distant Markets: The Role of Information in Non-State Market-Driven Public Policy* (University of Maryland, College Park, MD).
40. Waldman KB, Kerr JM (2014) Limitations of certification and supply chain standards for environmental protection in commodity crop production. *Annu Rev Resour Econ* 6:429–449.
41. Emerson K, Nabatchi T, Balogh S (2012) An integrative framework for collaborative governance. *J Public Adm Res Theory* 22:1–29.
42. Hulme S (2004) *Footprints in the Forest: Current Practice and Challenges in Forest Certification* (FERN, Moreton in Marsh, UK).
43. Andam KS, Ferraro PJ, Pfaff A, Sanchez-Azofeifa GA, Robalino JA (2008) Measuring the effectiveness of protected area networks in reducing deforestation. *Proc Natl Acad Sci USA* 105(42):16089–16094.
44. Gaveau DLA, et al. (2009) Evaluating whether protected areas reduce tropical deforestation in Sumatra. *J Biogeogr* 36:2165–2175.
45. Heilmayr R (2015) *Chile's Forest Transition Foreshadowing Changes in Global Timber Markets and Governance* (Stanford University, Stanford, CA).
46. Heckman JJ, Ichimura H, Todd PE (1997) Matching as an econometric evaluation estimator: Evidence from evaluating a job training programme. *Rev Econ Stud* 64:605–654.
47. Ferraro PJ, Miranda JJ (2014) Panel data designs and estimators as alternatives for randomized controlled trials in the evaluation of social programs. Working paper (Georgia State University, Atlanta). Available at www2.gsu.edu/~wwwcec/docs/Ferraro%20and%20Miranda%20Panel%20Data%20Rep%20POST.pdf.
48. Ferraro PJ, Miranda JJ (2014) The performance of non-experimental designs in the evaluation of environmental programs: A design-replication study using a large-scale randomized experiment as a benchmark. *J Econ Behav Organ* 107(Part A):344–365.
49. Arriagada R, Sills E, Pattanayak S, Ferraro P (2009) Combining qualitative and quantitative methods to evaluate participation in Costa Rica's program of payments for environmental services. *J Sustain For* 28:343–367.
50. Wendland KJ, Baumann M, Lewis DJ, Sieber A, Radeloff VC (2015) Protected area effectiveness in European Russia: A postmatching panel data analysis. *Land Econ* 91:149–168.
51. Lechner M (2002) Program heterogeneity and propensity score matching: An application to the evaluation of active labor market policies. *Rev Econ Stat* 84:205–220.
52. Busch J, et al. (2015) Reductions in emissions from deforestation from Indonesia's moratorium on new oil palm, timber, and logging concessions. *Proc Natl Acad Sci USA* 112(5):1328–1333.
53. Ho DE, Imai K, King G, Stuart EA (2007) Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Polit Anal* 15:199–236.
54. Imbens GM, Wooldridge JM (2008) *Recent Developments in the Econometrics of Program Evaluation* (National Bureau of Economic Research, Cambridge, MA).
55. CONAF (2011) *Catastro de los Recursos Vegetacionales Nativos de Chile: Monitoreo de Cambios y Actualizaciones, Periodo 1997–2011* (Corporacion Nacional Forestal, Santiago, Chile).
56. CIREN (2001) *Informe Predial* (Centro de Información de Recursos Naturales, Santiago, Chile).
57. Stavins RN, Jaffe AB (1990) Unintended impacts of public investments on private decisions: The depletion of forested wetlands. *Am Econ Rev* 80:337–352.
58. INFOR (2012) *Anuario Forestal 2012* (Instituto Forestal, Santiago, Chile).
59. Smartwood (2005) *Resumen Público de Certificación de Forestal Anchile Ltda* (SmartWood Program, Rainforest Alliance, New York).
60. Woodmark (2008) *Woodmark Forest Certification Public Report for Forestal Probosque Ltda* (Woodmark Soil Association, Bristol, UK).
61. Bureau Veritas (2004) *Certificación de Manejo Forestal Informe Auditoría de Certificación de Volterra S.A.* (Bureau Veritas, Antwerp, Belgium).
62. SGS Qualifor (2010) *Forest Management Certification Report—MASISA S.A.* (SGS South Africa, Qualifor Programme, Southdale, South Africa).
63. Woodmark (2013) *Informe Público de la Evaluación del Manejo Forestall Según Estándar FSC—Forestal Arauco S.A.* (Woodmark Soil Association, Bristol, UK).
64. Caliendo M, Kopeinig S (2008) Some practical guidance for the implementation of propensity score matching. *J Econ Surv* 22:31–72.
65. Abadie A, Imbens GW (2006) Large sample properties of matching estimators for average treatment effects. *Econometrica* 74:235–267.
66. Rubin DB, Thomas N (1996) Matching using estimated propensity scores: Relating theory to practice. *Biometrics* 52(1):249–264.
67. Fundacion Chile (2005) *Tablas Auxiliares de Producción: Simulador de Arbol Individual para Pino Radiata* (Fundación Chile, Santiago, Chile).
68. INFOR (1987) *Precios Forestales* (Instituto Forestal, Santiago, Chile).
69. CONAF (2004) *Tabla de Costos, D.L. 701* (Corporación Nacional Forestal, Santiago, Chile).
70. INFOR, CORFO (2001) *Sistema de Gestión Forestal: Analisis Económico Financiero en el Manejo Forestal* (Instituto Forestal and Corporación de Fomento de la Producción, Santiago, Chile).
71. Ingenieria CIPRES (2009) *Análisis Económico del Transporte de Carga Nacional* (Ministerio de Transportes y Telecomunicaciones, Santiago, Chile).
72. Cameron AC, Miller DL (2015) A practitioner's guide to cluster-robust inference. *J Hum Resour* 50:317–372.
73. Graeme A (2006) Choosing how to be green: An examination of Domtar Inc.'s approach to forest certification. *J Strateg Manag Educ* 3:37–92.
74. Arpino B, Mealli F (2011) The specification of the propensity score in multilevel observational studies. *Comput Stat Data Anal* 55:1770–1780.
75. Li F, Zaslavsky AM, Landrum MB (2013) Propensity score weighting with multilevel data. *Stat Med* 32(19):3373–3387.
76. Heckman JJ, Ichimura H, Todd P (1998) Matching as an econometric evaluation estimator. *Rev Econ Stud* 65:261–294.
77. Rey SJ, Anselin L (2007) PySAL: A Python library of spatial analytical methods. *Rev Reg Stud* 37:5–27.
78. USGS (2008) *Global Land Survey Digital Elevation Model (GLSDEM)* (Global Land Cover Facility, University of Maryland, College Park, MD).