

Technical Appendix to “Designing Contracts and Sourcing Channels to Create Shared Value”

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Management-Intensive Grazing (MIG). MIG is a grazing practice that mimics natural grazing patterns of wildlife. Rather than letting sheep graze in one place continually with a subjectively-estimated, fixed number of sheep per unit land, MIG requires moving sheep in and out of different pastures depending on the condition of the grasses and soil (The Nature Conservancy, 2016). Implementing MIG requires incorporating conservation science, planning and monitoring into farm management plans. The practice inherits its name from being more management-intensive: it requires more labor to move the sheep around, fences to organize the pastures into management units, planning of sheep grazing, and monitoring of grass and sheep health. We draw on the publicly available “Responsible Wool Standard” to illustrate the different types of costs. Table 1 below summarizes costs in each category, with specific reference to clauses in Textile Exchange (2016) pertaining to Animal Welfare (AW) and Land Management (LM). As illustrated in Table 1, the fixed costs at inception primarily involve farmer training and the development of suitable management plans for animal and land health, and are relatively modest compared to recurring costs. Furthermore, the dominant component of costs overall is the variable one, which we choose to model in our framework.

Fixed Cost, at Inception	Fixed Costs, Recurring	Variable Costs
Farmer training (AW1.4-AW1.5)	Maintain & review records (AW1.7, AW2.3, AW4.3)	Deliver adequate feeding & water (AW2.1,AW2.2,AW2.6-AW2.7)
Develop management plan for sheep health (AW4.1, LM3.1, LM4.1)	Review health management plan annually (AW4.1.1)	Monitor body condition of sheep (AW2.4)
Develop monitoring plan for soil erosion & land health (LM1.5,LM2.1-LM2.4)	Review fertilizer & pest management plans annually (LM3.1, LM4.1)	Monitor & maintain feed & water quality (AW2.8)
	Train external farm workers (AW1.6)	Develop & maintain handling & housing systems (AW3.1-AW3.6)
		Routine animal welfare inspections & humane health treatment (AW4.2, AW4.4-4.19)
		Monitor & manage: soil compaction, erosion, key indicators for land health (LM1.2-1.5), biodiversity, forage resources & infestation (LM2.1-2.4), soil nutrient level (LM3.2)

Table 1: Summary of costs incurred by MIG based on the “Responsible Wool Standard” (Textile Exchange, 2016).

Conservation science and MIG are place-specific; different regions in the world require different grazing

protocols. Although we are not aware of definitive evidence for differences in the relative cost of MIG in New Zealand and Argentina, we rely on the following qualitative evidence. By nature of MIG, grasslands in different ecological regions respond differently; less degraded grasslands generally respond better to MIG than more degraded grasslands. As a result, it is ‘cheaper’ to implement MIG in healthier grasslands: the United Nations Convention to Combat Desertification (UNCCD, 2012) indicates that “it is much more cost-effective to prevent drylands from degradation than to reverse it.” Even within Patagonia, we find that MIG is relatively more expensive in more degraded ecological regions than in others (see Table 2 below). Because the level of grassland degradation in New Zealand is significantly smaller than in Argentina (see, for example, UNCCD, 2012), we therefore expect MIG to be ‘cheaper’ in New Zealand than in Argentina.

Proof of Theorem 1. Let $\mathcal{N} \triangleq \{1, \dots, N\}$ denote the set of farmers, and let $w(S) \triangleq \sum_{i \in S} w_i$ and $\mu(S) \triangleq \mu_0 + w(S)\Delta\mu$, $\forall S \subseteq \mathcal{N}$, and define $[k, N] \triangleq \{k, \dots, N\}$.

Case A: Equilibrium under the commodity contract. We start by examining the farmers’ choices and the resulting equilibrium when only the commodity contract is offered. Suppose that a given subset $S \subseteq \mathcal{N}$ of farmers currently adopt the MIG technology, while the remaining farmers do not, and consider the adoption decision for a particular farmer $i \notin S$. Recall that the payment function under the commodity contract is $c_g^{cc}(\mu) = \frac{c_p(0)}{\mu_0}\mu$, where μ is the average yield achieved by the topmaker. Thus, when only farmers in S adopt MIG, this yield is exactly $\mu(S) \equiv \mu_0 + w(S)\Delta\mu$. In this context, the i -th farmer would adopt MIG if and only if the (per-unit) increase in his payment due to yield improvements would exceed the (per-unit) cost difference, i.e.,

$$\frac{c_p(0)}{\mu_0}w_i\Delta\mu \geq \Delta c_p.$$

This condition is independent of S , and so the set of farmers adopting MIG in equilibrium is given by $S^{cc} \triangleq \{i \in \mathcal{N} : w_i \geq \frac{1}{\varepsilon}\}$, where $\varepsilon = \frac{\Delta\mu}{\Delta c_p} \frac{c_p(0)}{\mu_0}$ is the cost elasticity of process yield.

Clearly, if $S^{cc} = \mathcal{N}$, the topmaker does not need to offer an alternative contract, and extracts a profit of $(c_t - \frac{c_p(0)}{\mu_0})\mu_1$. We thus focus the remainder of the analysis on the case $S^{cc} \subset \mathcal{N}$. WLOG, assume $S^{cc} = [\ell + 1, N]$, i.e. ℓ is the farmer with largest weight not adopting MIG under the commodity contract.

Case B: Incentive contract. Note that, since farmers in S^{cc} would already adopt MIG through the commodity contract, the topmaker would never seek to incentivize them explicitly through this alternative contract. Consider the problem of optimally incentivizing exactly *one* additional farmer $i \notin S^{cc}$ to adopt MIG. In this case, to ensure the uniqueness of the new equilibrium, the payment function c_g^{ic} must satisfy the constraints (we omit the superscript ic for conciseness):

$$c_g(\mu(S^{cc} \cup \{i\})) > c_g(\mu(S^{cc})) + \Delta c_p \tag{IC-1}$$

$$c_g(\mu(S^{cc} \cup \{i\})) > \frac{c_p(0)}{\mu_0} \cdot \mu(S^{cc}) + \Delta c_p \tag{IC-2}$$

$$c_g(\mu(S^{cc} \cup \{j\})) < \max\left\{c_g(\mu(S^{cc})), \frac{c_p(0)}{\mu_0} \cdot \mu(S^{cc})\right\} + \Delta c_p, \forall j \notin S^{cc}, j \neq i. \tag{IC-3}$$

Constraint (IC-1) ensures that farmer i strictly prefers MIG adoption under the alternative contract, and constraint (IC-2) additionally enforces a strict preference for the payoff under the alternative contract over the commodity one. Constraint (IC-3) ensures that no other farmer j is also incentivized to switch and adopt MIG. Since c_g is non-decreasing, the only feasible choice is to incentivize exactly farmer ℓ , since $w_\ell \geq w_j, \forall j \notin S^{cc}$. Also, the payment function that would (asymptotically) induce this outcome at lowest cost to the topmaker is:¹

$$c_g^{\{\ell\}}(x) \triangleq \begin{cases} \frac{c_p(0)}{\mu_0} \cdot \mu(S^{cc}), & \text{if } x < \mu(S^{cc} \cup \{\ell\}) \\ \frac{c_p(0)}{\mu_0} \cdot \mu(S^{cc}) + \Delta c_p, & \text{otherwise.} \end{cases}$$

Thus, the set of farmers adopting MIG would become $S^{cc} \cup \{\ell\} \equiv [\ell, N]$. Furthermore, due to (IC-2) and the fact that $\Delta c_p > \frac{c_p(0)}{\mu_0} w_\ell \Delta \mu$ (by definition of ℓ), it can be readily seen that:

$$c_g^{\{\ell\}}(\mu([\ell, N])) > \frac{c_p(0)}{\mu_0} \mu([\ell, N]).$$

This implies that, in fact, *all* farmers would prefer this incentive contract, since it entails higher payments than the commodity contract. Therefore, the equilibrium induced will see *all* farmers choosing the incentive contract, with farmers in $[\ell, N]$ adopting MIG and farmers in $[1, \dots, \ell - 1]$ not adopting it. The topmaker's profit when this contract is offered thus becomes:

$$\begin{aligned} \Pi^{\{\ell\}} &= c_t \mu([\ell, N]) - \left[\frac{c_p(0)}{\mu_0} \mu(S^{cc}) + \Delta c_p \right] \\ &= \left[c_t - \frac{c_p(0)}{\mu_0} \right] \mu(S^{cc}) + \left[c_t w_\ell \Delta \mu - \Delta c_p \right]. \end{aligned}$$

Since the first term exactly denotes the profit when only the commodity contract is offered, it can be seen that the incentive contract is (weakly) profitable if and only if

$$w_\ell \geq \frac{\Delta c_p}{c_t \Delta \mu}.$$

We can now proceed with the same argument inductively, to determine the optimal number of additional farmers that the topmaker should seek to incentivize. Through a similar argument as before, it can be seen that a topmaker seeking to induce a unique equilibrium where farmers in $[k, N]$ (for some $k \leq \ell$) adopt MIG

¹We briefly note that, while this function is discontinuous, one can readily design a continuous piece-wise linear payment achieving the same equilibrium outcome and topmaker cost, by linearly interpolating the values of $c_g^{\{\ell\}}$ above for arguments x satisfying $\mu(S^{cc} \cup \{\ell\}) - w_{\ell-1} \Delta \mu < x \leq \mu(S^{cc} \cup \{\ell\})$ (we omit the details for space considerations).

would use the minimal payment function:

$$c_g^S(x) \triangleq \begin{cases} \frac{c_p(0)}{\mu_0} \cdot \mu(S^{cc}), & \text{if } x < \mu([\ell, N]) \\ \frac{c_p(0)}{\mu_0} \cdot \mu(S^{cc}) + \Delta c_p, & \text{if } \mu([\ell, N]) \leq x < \mu([\ell - 1, N]) \\ \vdots & \\ \frac{c_p(0)}{\mu_0} \cdot \mu(S^{cc}) + (\ell - k)\Delta c_p, & \text{if } \mu([k + 1, N]) \leq x < \mu([k, N]) \\ \frac{c_p(0)}{\mu_0} \cdot \mu(S^{cc}) + (\ell - k + 1)\Delta c_p, & \text{otherwise.} \end{cases} \quad (1)$$

All farmers would then adopt this incentive contract, with farmers $[k, N]$ adopting MIG and the remaining farmers not adopting it. This would generate a total profit for the topmaker:

$$\begin{aligned} \Pi^{[k, \ell]} &= c_t \mu([k, N]) - \left[\frac{c_p(0)}{\mu_0} \mu(S^{cc}) + (\ell - k + 1)\Delta c_p \right] \\ &= \left[c_t - \frac{c_p(0)}{\mu_0} \right] \mu(S^{cc}) + \sum_{i=k}^{\ell} (c_t w_i \Delta \mu - \Delta c_p). \end{aligned}$$

Thus, the optimal set of farmers which the topmaker should induce into adopting MIG through the incentive contract is exactly:

$$S^{ic} \triangleq \left\{ i \in \mathcal{N} : w_i \geq \frac{\Delta c_p}{c_t \Delta \mu} \right\},$$

and the corresponding payment function is given by (1).

Proof of Theorem 2. If the LP has a solution, it must occur at an extreme point of the set of feasible solutions. The LP in (11) has a single extreme point, which can be found by solving the linear system of two equations in the two variables, $\beta_1(\theta)$ and $\beta_2(\theta)$. By (P2) binding we then have:

$$\beta_1(\theta) = \frac{c_p(0) - \beta_2(\theta) \mathbb{E}[(Y_0 - \theta)^+]}{\mu_0}. \quad (2)$$

Substituting (2) into (P1) and by (P1) binding:

$$\begin{aligned} & \frac{\Delta \mu c_p(0) - \beta_2(\theta) \mathbb{E}[(Y_0 - \theta)^+] \Delta \mu}{\mu_0} + \frac{\beta_2(\theta) \mathbb{E}[(Y_1 - \theta)^+] \mu_0 - \beta_2(\theta) \mathbb{E}[(Y_0 - \theta)^+] \mu_0}{\mu_0} = \Delta c_p \\ \Leftrightarrow \quad & \beta_2(\theta) = \frac{c_p(1) \mu_0 - c_p(0) \mu_1}{\mu_0 \mathbb{E}[(Y_1 - \theta)^+] - \mu_1 \mathbb{E}[(Y_0 - \theta)^+]} \end{aligned}$$

It follows that

$$\beta_1(\theta) = \frac{c_p(0) \mathbb{E}[(Y_1 - \theta)^+] - c_p(1) \mathbb{E}[(Y_0 - \theta)^+]}{\mu_0 \mathbb{E}[(Y_1 - \theta)^+] - \mu_1 \mathbb{E}[(Y_0 - \theta)^+]}.$$

Because we are maximizing the function in (11), it is easy to verify that this extreme point is also the optimal solution. Furthermore, under Assumption 1, it follows that $\beta_2(\theta) \geq (>)0$ if and only if $\varepsilon \leq (<)1$.

Theorem 3 (Optimal Contract) *When $\varepsilon \geq 1$, in equilibrium, the topmaker captures the entire supply chain profit. The optimal contract is given by any bonus threshold $\theta^* \in [\underline{y}_0, \bar{y}_1)$, with corresponding nominal*

rate $\beta_1(\theta^*)$ and bonus rate $\beta_2(\theta^*)$. Furthermore,

- (i) when $\varepsilon = 1$, the nominal rate and bonus rate satisfy: $\beta_1(\theta^*) = \frac{c_p(0)}{\mu_0}$, $\beta_2(\theta^*) = 0$,
- (ii) when $\varepsilon > 1$, the nominal rate and bonus rate satisfy: $\beta_1(\theta^*) > \frac{c_p(0)}{\mu_0} > [\beta_1(\theta^*) + \beta_2(\theta^*)] > 0$.

Proof of Theorem 3. See Theorem 2 for $\beta_1(\theta)$ and $\beta_2(\theta)$. The topmaker's expected cost is:

$$\begin{aligned}\mathbb{E}[c_g(Y_1)] &= \beta_1\mu_1 + \beta_2\mathbb{E}[(Y_1 - \theta)^+] \\ &= \frac{c_p(1)\mu_0\mathbb{E}[(Y_1 - \theta)^+] - c_p(1)\mu_1\mathbb{E}[(Y_0 - \theta)^+]}{\mu_0\mathbb{E}[(Y_1 - \theta)^+] - \mu_1\mathbb{E}[(Y_0 - \theta)^+]} = c_p(1).\end{aligned}$$

Thus, any $\theta \in (0, \bar{y}_1)$ is optimal. Furthermore, $\beta_1(\theta^*) > 0$:

$$\beta_1 > 0 \quad \Leftrightarrow \quad \frac{\mathbb{E}[(Y_1 - \theta)^+]}{\mathbb{E}[(Y_0 - \theta)^+]} > \frac{c_p(1)}{c_p(0)}, \quad (3)$$

which always holds when MIG is cheap and Assumption 1 is satisfied. Furthermore $\beta_1(\theta^*) > \frac{c_p(0)}{\mu_0}$:

$$\begin{aligned}\beta_1(\theta) > \frac{c_p(0)}{\mu_0} &\Leftrightarrow \frac{c_p(0)\mathbb{E}[(Y_1 - \theta)^+] - c_p(1)\mathbb{E}[(Y_0 - \theta)^+]}{\mu_0\mathbb{E}[(Y_1 - \theta)^+] - \mu_1\mathbb{E}[(Y_0 - \theta)^+]} < \frac{c_p(0)}{\mu_0} \\ &\Leftrightarrow \frac{c_p(1)}{c_p(0)} < \frac{\mu_1}{\mu_0},\end{aligned} \quad (4)$$

which always holds when MIG is cheap. From Theorem 2, it can also directly be seen that when MIG is cheap ($\frac{c_p(1)}{c_p(0)} \leq \frac{\mu_1}{\mu_0}$) and Assumption 1 is satisfied, then $\beta_2(\theta^*) \leq 0$. Finally, we show that $\beta_1(\theta^*) + \beta_2(\theta^*) < \frac{c_p(0)}{\mu_0}$:

$$\begin{aligned}\beta_1 + \beta_2 \leq \frac{c_p(0)}{\mu_0} &\Leftrightarrow \frac{c_p(0)\mathbb{E}[(Y_1 - \theta)^+] - c_p(1)\mathbb{E}[(Y_0 - \theta)^+] + c_p(1)\mu_0 - c_p(0)\mu_1}{\mu_0\mathbb{E}[(Y_1 - \theta)^+] - \mu_1\mathbb{E}[(Y_0 - \theta)^+]} \leq \frac{c_p(0)}{\mu_0} \\ &\Leftrightarrow \mathbb{E}[(Y_0 - \theta)^+](c_p(0)\mu_1 - c_p(1)\mu_0) \leq \mu_0(c_p(0)\mu_1 - c_p(1)\mu_0) \\ &\Leftrightarrow \mathbb{E}[(Y_0 - \theta)^+] \leq \mu_0,\end{aligned}$$

which always holds when $\theta > 0$.

Proof of Theorem 4. If the topmaker only switches from commodity-based sourcing to direct sourcing, but uses the nominal commodity rate then the farmer is paid based on his own yield but at a rate that equals the nominal commodity rate. Thus, $c_g(y_1) = \frac{c_p(0)}{\mu_0}y_1$. The farmer then adopts MIG if and only if:

$$\frac{c_p(0)}{\mu_0}\mu_1 - c_p(1) \geq \frac{c_p(0)}{\mu_0}\mu_0 - c_p(0) \quad \Leftrightarrow \quad c_p(0)\mu_1 \geq c_p(1)\mu_0,$$

which is always satisfied when MIG is cheap ($\frac{c_p(1)}{c_p(0)} < \frac{\mu_1}{\mu_0}$). Furthermore, by feasibility of the *commodity contract*, and by supply chain condition (1), this contract will always be feasible. The farmer's expected profit is then strictly positive when $\varepsilon > 1$.

Proof of Corollary 1. If the topmaker only switches from commodity-based sourcing to direct sourcing, but uses the nominal commodity rate then the farmer is paid based on his own yield but at a rate that equals the nominal commodity rate. Thus, $c_g(y_1) = \frac{c_p(0)}{\mu_0}y_1$. The farmer then adopts MIG if and only if:

$$\frac{c_p(0)}{\mu_0}\mu_1 - c_p(1) \geq \frac{c_p(0)}{\mu_0}\mu_0 - c_p(0) \quad \Leftrightarrow \quad c_p(0)\mu_1 \geq c_p(1)\mu_0,$$

which contradicts the assumption that MIG is expensive.

Proof of Theorem 5. See Theorem 2 for the contract parameters and Proof of Theorem 3 for optimal contract parameters $(\theta^*, \beta_1(\theta^*), \text{ and } \beta_2(\theta^*))$. We show that when MIG is expensive (i.e., $\varepsilon < 1 \Leftrightarrow \frac{c_p(1)}{c_p(0)} > \frac{\mu_1}{\mu_0}$) and when $Y_1 \geq_{\text{mrl}} Y_0$, then there exists a $\xi > 0$ such that $\beta_1(\theta) \leq 0$ when $\theta \leq \xi$. Specifically, we have:

$$\beta_1(\theta) \leq 0 \quad \Leftrightarrow \quad \frac{\mathbb{E}[(Y_1 - \theta)^+]}{\mathbb{E}[(Y_0 - \theta)^+]} \leq \frac{c_p(1)}{c_p(0)}. \quad (5)$$

Because we impose the requirement that $c_g(y_1)$ must be a real payment scheme, we then have that the contract is infeasible for all θ where (5) is satisfied. If $\xi \leq \underline{y}_0$, then (5) is satisfied if and only if:

$$\frac{\mu_1 - \xi}{\mu_0 - \xi} \leq \frac{c_p(1)}{c_p(0)} \quad \Leftrightarrow \quad \xi \leq \frac{c_p(1)\mu_0 - c_p(0)\mu_1}{\Delta c_p}, \quad (6)$$

which is always strictly positive when MIG is expensive. Thus, when $\frac{c_p(1)\mu_0 - c_p(0)\mu_1}{\Delta c_p} \leq \underline{y}_0$, then θ^* is bounded from below by \underline{y}_0 because any $\theta \leq \frac{c_p(1)\mu_0 - c_p(0)\mu_1}{\Delta c_p}$ satisfies (6) and (5). Note that $Y_1 \geq_{\text{mrl}} Y_0$ ensures that the LHS of (5) is monotone increasing in θ , as per Shaked and Shanthikumar (2007). Thus, when $\frac{c_p(1)\mu_0 - c_p(0)\mu_1}{\Delta c_p} \geq \underline{y}_0$, then there exists a $\tilde{\theta} > \underline{y}_0$ such that (5) is satisfied for all $\theta \in (\underline{y}_0, \tilde{\theta}]$. However, (5) cannot be satisfied for $\theta \geq \bar{y}_0$, such that it must hold that $\tilde{\theta} < \bar{y}_0$. Hence, we can summarize the results as follows: $\theta^* \in [\xi, \bar{y}_1)$, where ξ satisfies:

$$\begin{cases} \xi = \underline{y}_0 & \text{if } \frac{c_p(1)\mu_0 - c_p(0)\mu_1}{\Delta c_p} \leq \underline{y}_0, \\ \bar{y}_0 > \xi > \underline{y}_0 & \text{otherwise.} \end{cases}$$

From Theorem 2, it can also directly be seen that when MIG is expensive ($\frac{c_p(1)}{c_p(0)} > \frac{\mu_1}{\mu_0}$) and Assumption 1 is satisfied, then $\beta_2(\theta^*) > 0$. Furthermore, $\beta_1(\theta^*) < \frac{c_p(0)}{\mu_0}$, by reversal of condition (4) in the Proof of Theorem 4. Finally, analogously to the proof in Theorem 4, we show that $\beta_1(\theta^*) + \beta_2(\theta^*) > \frac{c_p(0)}{\mu_0}$:

$$\begin{aligned} \beta_1 + \beta_2 > \frac{c_p(0)}{\mu_0} & \Leftrightarrow \frac{c_p(0)\mathbb{E}[(Y_1 - \theta)^+] - c_p(1)\mathbb{E}[(Y_0 - \theta)^+] + c_p(1)\mu_0 - c_p(0)\mu_1}{\mu_0\mathbb{E}[(Y_1 - \theta)^+] - \mu_1\mathbb{E}[(Y_0 - \theta)^+]} > \frac{c_p(0)}{\mu_0} \\ & \Leftrightarrow \mathbb{E}[(Y_0 - \theta)^+](c_p(0)\mu_1 - c_p(1)\mu_0) > \mu_0(c_p(0)\mu_1 - c_p(1)\mu_0) \\ & \Leftrightarrow \mathbb{E}[(Y_0 - \theta)^+] < \mu_0, \end{aligned}$$

which always holds when $\theta > 0$. (Note that the key difference with the proof of Theorem 3 is that the sign flips in the last step of the algebra, because we now have that $c_p(0)\mu_1 \geq c_p(1)\mu_0$.)

Proof of Theorem 6. Under a linear contract, the contract that solves the LP has nominal rate $\beta_1 = \frac{\Delta c_p}{\Delta \mu}$. The topmaker is then better off than under the *commodity contract* if:

$$c_t\mu_1 - \frac{\Delta c_p}{\Delta \mu}\mu_1 > c_t\mu_0 - \frac{c_p(0)}{\mu_0}\mu_0 \quad \Leftrightarrow \quad (c_t\Delta \mu - \Delta c_p)\mu_1 > (c_t\mu_0 - c_p(0))\Delta \mu.$$

Appendix to Empirical Analysis: Stratified Design & Process Yield Estimates The region of Patagonia in Argentina is characterized by 11 ‘ecological regions’, which have been designated using

assigned scores that are based on temperature and moisture distributions in the region. These scores thus reflect the degree of land degradation (the % of bare ground) and ‘dryness’ (wind strength and summer temperatures), and can be used to reflect the health of the region’s soils. Because the success of MIG is expected to differ by ecological region, we stratify our farm-level observations based on ecological region and focus our analyses on within-region differences. However, the farms in our sample are spread across a limited number of ecological regions. We therefore grouped ecological regions that are similar enough into five broader ecological categories (see Table 4). We then restricted the analysis to categories that contained both farms that had adopted MIG and farms that had not adopted MIG, in order to make within-category comparisons. As a result of this process, the analysis is restricted to three ecological categories and the total number of farms included in the analysis is reduced from 142 to 63 (see Table 5 for descriptive statistics about the number of farms in the dataset and the differences in mean yields before stratification). To facilitate interpretation, we renamed the categories in the tables below from ‘least brittle’ (healthy) to ‘most brittle’ (degraded). Table 2 gives the weighted average of top yield differences between farms that adopted MIG and farms that did not in each year and stratified category. Table 3 indicates the corresponding number of farms used in this comparison. All parameters are as in the model description in Section 3 of the main paper, unless otherwise stated. Because the impact of MIG is only recognizable after two years of implementation, we only counted farms who adopted MIG for at least two years towards top yields of ‘MIG-farms’. We note that due to the small sample size, significance levels of Welch’s t-test should be interpreted with caution. A non-parametric alternative to Welch’s t-test (*e.g.* Mann-Whitney-Wilcoxon test) would have *higher* statistical power (Fay and Proschan, 2010; Blair and Higgins, 1980). However, to the best of the authors’ knowledge, there are no well-accepted non-parametric tests when observations have to be weighted and clustered, as is the case here.

$\Delta\hat{\mu}$ (%)	2011	2012	2013	2014	Average ($\Delta\hat{\mu}$)	$\hat{\epsilon}_{\text{PROJ}}$	$\hat{\epsilon}_{\text{MIG}}$
Least Brittle (Cat 1)	6.34	3.61	7.50	8.12	6.72***	0.64	1.13
Brittle (Cat 2)	13.08	5.42	9.08	3.05	9.48***	0.99	1.75
Most Brittle (Cat 4)	-1.09	3.51	3.97	4.27	2.54 [†]	0.22	0.39
Average	5.76***	4.50**	4.96***	5.82 [†]	5.21***	0.52	0.91

Table 2: Estimates of differences $\Delta\hat{\mu}$ in weighted average of top yields Y_f by stratified category and year.

Table Notes: The average within each bin is the weighted average, where the relative weight is determined by the # kg. For the difference in means, *** denotes significance at 1% significance level, ** denotes significance at 5% significance level, and [†] denotes significance at 20% significance level. To calculate significance we used the weighted arithmetic mean and the weighted standard deviation in Welch’s t-test for the comparison of population means. The significance level was computed at the farm level (using clustered standard errors) and is based on a two-tailed t-test. $\hat{\epsilon}_{\text{PROJ}}$ denotes the cost elasticity during the consortium’s project, including incremental costs for MIG *and* certification costs. At the time, the consortium deemed that certification was necessary to be able to command a price premium from the final consumer. $\hat{\epsilon}_{\text{MIG}}$ denotes the cost elasticity when only the incremental costs for MIG are taken into account, which is the case considered throughout the paper.

# of Farms	2011		2012		2013		2014		Total	
<i>f</i>	1	0	1	0	1	0	1	0	1	0
Least Brittle	2	1	2	1	2	1	1	1	7	4
Brittle	2	8	1	10	2	4	1	1	6	23
Most Brittle	1	6	2	3	1	7	1	2	5	18
Total	5	15	5	14	5	12	3	4	18	45

Table 3: Number of farms by stratified category and year when management type is 1 (MIG) or 0 (no-MIG).

Ecological Regions	Category Name
Central District (MSC)	Cat 5
Mata Negra Shrubland (MNG) + Dry Magellan Steppe (EMS)	Cat 4 ('most brittle')
Peninsula Valdez (PVS) + Southern Monte Shrubland (MAU) + Gulf District (GSJ)	Cat 3
Subandean Grasslands (PSA) + Occidental District (SYM)	Cat 2 ('brittle')
Humid Magellan Steppe (EMH) + Complejo Andino (CA) + Fuegian Ecotone (ECO)	Cat 1 ('least brittle')

Table 4: Ecological Region Categories based on similarity between Ecological Regions

	2011		2012		2013		2014	
<i>m</i>	1	0	1	0	1	0	1	0
# of Farms	5	31	6	36	6	31	3	24
$\Delta\hat{\mu}$ (%)	11.53***		8.14***		6.13****		6.65**	

Table 5: Differences in top-making yield between MIG farms and non-MIG farms, by year, non-stratified.

Table Notes: Significance levels for the difference-in-means tests are as follows: *** at 1% significance level and ** at 5% significance level. We used the weighted arithmetic mean and the weighted standard deviation in the two-tailed Welch's t-test for comparison of population means. The significance level was computed at the farm level using clustered standard errors.

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