Forest Policy and Economics 107 (2019) 101923

Contents lists available at ScienceDirect

Forest Policy and Economics

journal homepage: www.elsevier.com/locate/forpol

Competitiveness, certification, and support of timber harvest by community forest enterprises in Mexico☆

Gregory E. Frey[a,⁎], Frederick W. Cubbage[b], Thomas P. Holmes[a], Graciela Reyes-Retana[c,d], Robert R. Davis[c], Carole Megevand[c], Diana Rodríguez-Paredes[c], Yoanna Kraus-Elsin[c], Berenice Hernández-Toro[e], Diana Nacibe Chemor-Salas[e]

[a] U.S. Department of Agriculture Forest Service, Southern Research Station, 3041 E. Cornwallis Rd., Research Triangle Park, NC, USA
[b] North Carolina State University, Department of Forestry and Environmental Resources, Raleigh, NC, USA
[c] World Bank, Latin America and Caribbean Region, Washington, DC, USA
[d] Cornell University, Department of Natural Resources, Ithaca, NY, USA
[e] Comisión Nacional Forestal (CONAFOR), Zapopan, Jalisco, Mexico

ARTICLE INFO

Keywords:
Community-based natural resource management
Government support programs
Sustainable forest management certification
Production functions

ABSTRACT

Local communities own approximately 45% of Mexico's forests and have relative autonomy to manage them. Some of these communities have established community forest enterprises (CFEs) in order to generate benefits, such as jobs. However, if CFEs focus mainly on community benefits, and lose sight of financial competitiveness and ecological sustainability, they may fail in the long run. Government support programs and forest certification mechanisms have been established to address these concerns, but little is known about improvements in financial competitiveness. A detailed 2011 survey of the financial inputs and outputs of 27 CFEs in the predominately pine (*Pinus* spp.) and fir (*Abies* spp.) forests of Mexico was used to create statistical timber harvest production functions. The production functions showed that the CFEs generally fit the model of competitive firms, indicating that they have not lost sight of the importance of financial viability; however, there is also some evidence that CFEs may balance this with the objective of providing community income (employment and other community payments). Participation in capacity development support programs and forest certification jointly have a positive impact on productivity, but the individual impact of each was not possible to parse.

1. Introduction

About one-third of Mexico is forested (FAO, 2010). These forests generate timber output of approximately 5.5–7.0 million m^3/yr, worth about USD (United States dollars) $500 million/year. Local communities own approximately 45% of Mexico's forests and have relative autonomy to manage and utilize them. Community forest enterprises (CFEs) are companies which are owned collectively by community members, and directed by community governance bodies to generate benefits from these community-owned forests (Antinori and Rausser, 2003).

Analyses of community and stakeholder perceptions have suggested that communities have objectives other than strict profitability, such as generating employment for local people (Antinori and Bray, 2005; Carías Vega and Keenan, 2016; Charnley and Poe, 2007; Peredo and Chrisman, 2006). Because of this, there is a perception that CFEs may not be financially competitive, specifically, that their costs may be inflated because of over-utilization of labor. Perceptions of low competitiveness led the Government of Mexico to dedicate financial and technical support towards generating more capacity within the CFEs (World Bank, 2011). More recently, Mexico's government has explicitly identified the goals of increasing timber production from CFEs and improving their productivity and competitiveness (DOF, 2013; CONAFOR, 2014).

Past research showed that CFEs in Mexico do have high average costs relative to other parts of the world with large timber industries (Cubbage et al., 2015a; Cubbage et al., 2015b). Still, an understanding of how CFEs transform factors of production (e.g., labor, capital) into timber output is necessary to understand competitiveness. Furthermore, it is important to understand the impact of various public and market-

☆ This article is part of a special issue entitled."Governing our forests: The evolving political economy of multiple values and multiple stakeholders" published at the journal Forest Policy and Economics 107C, 2019.

⁎ Corresponding author.
E-mail address: gregory.e.frey@usda.gov (G.E. Frey).

https://doi.org/10.1016/j.forpol.2019.05.009
Received 11 April 2018; Received in revised form 4 March 2019; Accepted 13 April 2019
Available online 22 May 2019
1389-9341/ Published by Elsevier B.V.

based programs on the productivity and competitiveness of community-based forest enterprises to determine if and how they might be improved in the future.

The first objective of this research was to examine empirical evidence about the productivity attributable to various factors of production to understand if CFEs were acting as competitive firms or perhaps pursuing a different goal such as maximizing income to the local community. The second objective of this research was to evaluate the impact of voluntary programs including forest certification and capacity development support on the harvest of timber and community income from CFEs in Mexico.

2. Background

2.1. CFE competitiveness

Communities that own forests in Mexico include "*comunidades*", which are indigenous people's communities, and "*ejidos*", which were formed from other groups of previously landless rural people (Kelly, 1994). These *comunidades* and *ejidos* collectively own forestland throughout Mexico, most of which are naturally-regenerated forests of native species (as opposed to plantation forests common in many other countries), and vary in size from hundreds to hundreds of thousands of hectares. CFEs owned by *comunidades* and *ejidos* may have multiple goals, such as "profit, amenities, NTFPs, bequest, jobs, public goods and services" (Antinori and Bray, 2005). Despite this, CFEs still must become financially competitive; otherwise they may lose money and be economically unsustainable for the communities (Treseder and Krogman, 1999). A few past studies have examined profitability of CFEs in Mexico and other Latin American countries. These have documented highly variable profitability between CFEs, such as several Mexican CFEs with apparently high percentage-based returns on investment (ROI), and others with negative ROI (Antinori, 2005; Torres-Rojo et al., 2005). Most financial research on CFEs, however, has evaluated only a handful of case studies, and often use accounting methods that do not include full operating costs and vary significantly from study to study and even from community to community within a single study (Antinori and Bray, 2005; Humphries et al., 2012).

In order to better understand Mexican CFEs' competiveness in the global market, the World Bank, the Mexican Government's *Comisión Nacional Forestal* (CONAFOR), and the Program on Forests (PROFOR) carried out a project gather financial data on forest management, timber harvesting, and sawmilling of CFEs. Results showed that CFEs are profitable through sales in the domestic Mexican market, but costs are high and they would not be able to compete with lower cost international forest plantations (Cubbage et al., 2013b; Cubbage et al., 2015b). Increased volume of timber sales per hectare was shown to be related to lower average costs and higher profits (Cubbage et al., 2015a).

2.2. CFE support programs

A common approach for government agencies and non-profits is to support CFEs by providing financial or in-kind assistance to undertake training, create management and business plans, develop infrastructure, or purchase equipment (Merino-Pérez and Segura-Warnholtz, 2005). CONAFOR is the federal agency responsible for, among other things, providing support to CFEs. The overall goal of the support programs is not simply to subsidize CFEs, but rather, to increase their capacity so they become more efficient and economically sustainable (World Bank, 2011; CONAFOR, 2009, pp. 31–34). For example, these programs have supported efforts to drive down costs through training of employees; management planning; improvements of roads and other infrastructure for management, harvest, transport, and processing; acquisition of harvest equipment; and purchase of information and communication technologies.

The support programs provide different levels of cost sharing with the enterprise and/or community. They are variable in terms of their specific objectives and the type of activities they finance. In 2011, CONAFOR had 36 different support program categories ("*modalidades*") within 6 programmatic areas (CONAFOR, 2010a; CONAFOR, 2011b): Forest Development (including forest studies, silviculture, certification, and commercial forest plantations), Conservation and Restoration (including reforestation and soils, and environmental services), Forest Health (pest and disease control), Chain of Custody Certification, Community Forest Development (including social capital strengthening, human capital strengthening, and development of administrative capacity), and Forest Productive Chains.

Government support for community forestry around the world has mixed results. Payments for ecosystem services (PES) has been found to deter deforestation and increase afforestation in Mexico and Costa Rica (Alix-Garcia et al., 2012; Arriagada et al., 2012), but negatively affect participation in forest management in Nepal (Adhikari et al., 2014). In Gambia, capacity-building programs were perceived as an essential component of success for community forestry (Tomaselli et al., 2012). Past research along these lines has generally not ventured into the effects on financial outcomes.

Government support programs typically are required undergo monitoring and evaluation, including social and economic indicators, and CONAFOR's are no exception. Past evaluations have shown that support for community forestry in Mexico appears to have positive results from both environmental and social/community development perspectives (Vela and Oliver, 2017; World Bank, 2011; World Bank, 2017). However, these evaluations rarely have the resources to conduct the detailed data collection and analysis necessary fully to assess enterprises financially. Therefore, the impact of these programs for community forestry on financial competitiveness specifically has rarely been evaluated around the world.

2.3. Forest certification

Forest certification is a policy approach, based on markets and involving multiple levels of government, that responded to perceptions of timber harvests causing deforestation and environmental degradation, and aimed at greater sustainability and efficiency in forest resource use through (expected) consumer preference and demand (Cashore et al., 2004; Lister, 2011; Wiersum et al., 2013). The basic process of forest certification encompasses an independent assessment of the quality of overall forest management in meeting environmental, social, and economic benefits, in relation to predetermined standards, requirements, or indicators. These govern forest practices such as harvesting, tree planting, and chemical use; economic, management, and planning systems; stakeholder, community, and worker interactions; environmental protection, biodiversity, high conservation value forests, and aesthetics; laws, regulations, and monitoring; and continuous improvement (Moore et al., 2012).

For CFEs in Mexico, forest certification was fostered by the government and non-governmental organizations as a means to encourage sustainable forestry, starting in 1994, viewing certification as an important safeguard to ensure sustainability of forest management (Anta, 2006). Government programs financed many of the initial costs of certification pilots, and the support programs described above to build the necessary capacity (Anta, 2006). As in other countries (Humphries and Kainer, 2006), many Mexican CFEs entered certification with the view that higher prices and better market access would be the primary benefits (Anta, 2006). While stakeholders perceive that those two particular objectives have not yet been met (Anta, 2006; Markopoulos, 1999), communities have seen that certification has increased their power, prestige, and positive perceptions of forestry and CFEs. Further, certification of CFEs in Mexico is perceived to have strengthened administration, lowered production costs, and improved the relationships between CFEs and communities (Anta, 2006; Wiersum et al., 2013).

Currently, there are three main avenues for forest certification in Mexico. These include Technical Preventative Audit (ATP), the Mexican Standard NMX-AA-143-SCFI-2008 ("*Norma Mexicana*"), and the Forest Stewardship Council (FSC). ATP is a more basic system ensuring compliance with a forest management plan approved by the Mexican government, and is often seen as a precursor to one of the other two systems. *Norma Mexicana* is a national certification standard for sustainable forest management, with similar requirements and rules as most international standards, but designed specifically for the Mexican context. FSC is one of the most widely known and recognized international certification systems, and includes both sustainable forest management and chain of custody certification.

FSC certification has been found to generate continuous improvement of forest enterprises in Mexico (Blackman et al., 2014). Social issues (e.g., communications and conflict resolution) accounted for the plurality of corrective action requests (CARs) (44%), followed by forest management (26%) (e.g., regeneration and reforestation) and environmental issues (16%) (e.g., sensitive sites and high conservation value forests) (Blackman et al., 2014). In terms of environmental outcomes, FSC certification in Latin America has had small to modest positive impacts on a range of environmental outcomes (Barbosa de Lima et al., 2009; Kukkonen et al., 2008; Nebel et al., 2005). However, the impact of certification on timber productivity and/or financial competitiveness has received relatively little attention in Latin America. It is difficult to assess whether the act of becoming certified actually improves management, and/or whether forest management units that already exhibit superior performance tend to self-select into certification (Anta, 2006).

3. Data and methods

3.1. Data

Although many Mexican communities simply sell standing timber to a third-party logger and do not harvest their own timber, this project focused on CFEs that manage and harvest their own timber. Guidelines were produced for systematic financial and economic evaluation of these CFEs (Cubbage et al., 2011; Cubbage et al., 2013a). A survey questionnaire was developed based on two workshops with experts and key informants, and a pilot test in the field, which included 205 detailed questions about management, harvesting, sawmilling, and other general attributes and activities. This information included practices, inputs, costs, outputs, and revenues. Additional details of the survey methods can be found in English in Cubbage et al. (2013a); Cubbage et al. (2015a); Cubbage et al. (2015b); or in Spanish, including more details and Spanish-language copy of the questionnaire, in Cubbage et al. (2011); Cubbage et al. (2013b); Giadans and Mollenhauer (2012). A description of data variables used in this research, and a few other variables of interest, are listed in Table 1.

A purposive process was used to select the sampled CFEs. First, the 12 states[1] with the largest number of CFEs and the largest amounts of authorized timber harvest were identified. These states contained a total of 291 CFEs that harvest their own timber. Second, of these 291 CFEs, 36 with a representative range of land area and authorized timber harvest were selected. Thirty of 36 had sufficient records and completed the financial questionnaires. This sample included CFEs managing 210,700 ha of forest, which is approximately 4% of the estimated 5.2 million ha of forest managed for production in Mexico (CONAFOR, 2018). For a somewhat more comparable sample, for the purposes of this analysis, we eliminated the three surveyed CFEs that predominately harvested tropical hardwood species, and instead focused only on the 27 remaining CFEs that predominately harvested pines (*Pinus* spp.) and, to a lesser extent, firs (*Abies* spp.). This is a sample which we believe is one of the largest samples of consistent, detailed financial and production data from CFEs in any country in Latin America, if not the world.

Comprehensive in-person interviews were held with CFE managers on site in their communities, where they had access to their records, in 2012. CFEs also reported financial support for community forestry-related activities they had received from CONAFOR and other sources in 2011. Communities had received support from zero up to nine different programs. We classified these support programs received by the CFEs for forest management and harvesting into groups based on their purpose. We defined seven groups of support programs: capacity development, silviculture, roads, forest restoration and protection, payments for environmental services, timber processing, and tourism. Appendix A shows the classification of the 2011 CONAFOR and other organizations' support program components that were used by the CFEs in our sample.

3.2. Instrumental variables

Participation by CFEs in capacity-building programs or forest certification is voluntary, leading to possible self-selection bias and endogeneity of these variables. Therefore, a simple OLS regression of harvest, value-weighted harvest, or community income from forest on participation in programs and other variables could find positive correlation, but this correlation might simply reflect self-selection bias rather than causation.

To control for this potential endogeneity, we utilize an instrumental variables (IV) two-stage least squares (2SLS) method. In 2SLS, the first stage is to regress the endogenous explanatory variables on the instruments and exogenous explanatory variables. The predicted values of the endogenous explanatory variables are then used in the main OLS regression (Baum et al., 2003; Baum et al., 2007). The 2SLS estimator is consistent for binary or ordinal endogenous explanatory variables such as participation in programs (Wooldridge, 2002, p. 622).

IVs should meet three conditions. First there must be at least as many IVs as there are endogenous explanatory variables. Second, the IVs should be uncorrelated with the error term in the regression. That is, they should affect the dependent variable only indirectly through the variables that are controlled in the model, and not directly or indirectly through an unobserved pathway. This criteria cannot be tested statistically, therefore must be evaluated logically. Third, they should be correlated with the endogenous variables sufficiently to avoid "weak identification". This criteria can be tested statistically.

We considered several potential IVs in our data set: number of CFE community shareholders, kilometers to sawmill, distance to Mexico City (D.F.), distance to CONAFOR main office near Guadalajara, distance to state CONAFOR office, distance to municipality, state technical service providers, and state capacity development budget. The number of shareholders could affect participation in programs if the CFE is able to divide up responsibilities among more community members, or the number of community members creates a larger political presence. These would be otherwise unrelated to timber harvest. However, if more shareholders (ceteris paribus) gives CFEs ability to harvest more in order to have a larger return per shareholder, the instrument might fail the second criteria. Kilometers to mill might be correlated with lower productivity of labor and capital because of a longer amount of time to get to the forest. Therefore we chose not to use those variables.

Distance to access various amenities has often been used as an instrument for use of those amenities (e.g., Newhouse and McClellan, 1998; Card, 1993). Distance to CONAFOR and other federal and state government (in Mexico City, near Guadalajara, or in state capital) or municipal offices could affect participation since CFEs that are closer find it easier to network with CONAFOR or other government staff, obtain information, fill out paperwork, etc. These pathways would be unrelated to the self-selection pathway. It is possible to imagine that these distances might affect timber harvest in other ways, but the

[1] States of Campeche, Chiapas, Chihuahua, Durango, Guerrero, Jalisco, Mexico, Michoacan, Oaxaca, Puebla, Quintana Roo, and Veracruz

Table 1
Variables and summary statistics used from the survey. Data source: financial survey of Mexican CFEs as described in Cubbage et al. (2013b) and other sources as noted.

	Variable		Units	#[a]	Mean	Std dev
Total harvest	TOT_HARV	Total annual volume of timber harvested (2011)	m^3		11,598	11,441
Value-weighted harvest	VAL_HARV	Value-weighted timber harvested (2011), based on average prices for each timber grade (pine first and second; fir first and second)	1000 MXN$ [b]		7520	7598
Community income	COMM_INC	Annual contributions of the CFE to community income (2011): total wages (labor times wage) plus community payments	1000 MXN$ [b]		1906	1655
Labor	LABOR	Number of employees (2011)	FTE [c]		61	70
Capital	CAPITAL	Capital cost (2011) of other items such as machinery for management and harvest	1000 MXN$ [b]		3320	3230
Pine-fir total stock	STOCKPF	Total stock of pine and fir species on land managed by the CFE	m^3		801,462	286,667
North region	NORTH	Dummy for north region. States of: Chihuahua, Durango	0/1 binary	7	0.26	0.45
Capacity development	CAP	Participation in capacity-building program. Number of programs in 2011.	Ordinal (0–3)	11	0.56	0.85
Certified	CERT	Participation in a forest certification mechanism.	Binary (0–1)	10	0.37	0.49
Distance to Mexico City, D.F.	DIST_DF	Distance from CFE to CONAFOR office in Mexico City, D.F. [d] (calculated by Google maps)	Kilometers		661	596
Distance to state office	DIST_STATE	Distance from CFE to CONAFOR state office (calculated by Google maps)	Kilometers		172	131
Distance to municipality	DIST_MUNI	Distance from CFE to municipal town hall [e] (calculated by Google maps)	Kilometers		58	18
Technical service providers	TSP_STATE	Number of approved technical services providers in the CFE's state in 2011 (data from CONAFOR)	Number		134	75

[a] Number of CFEs participating/enrolled in program/activity.
[b] An approximate conversion rate for 2011 is 13 Mexican pesos (MXN$) = 1 United States dollar (USD$).
[c] Full-time equivalent employees.
[d] CONAFOR's main office is located near Guadalajara, Jalisco. Still, distance to Mexico City was used as a proxy for access to better markets and government services in general.
[e] "*Presidencia Municipal*" or "*Honorable Ayuntamiento Municipal*".

imaginable alternative pathways function through utilization of labor and capital, so they would be controlled by inclusion of those factors of production in the model. For example, distance to CONAFOR or municipal offices might be correlated with distance to timber markets – so further CFEs have lower roadside timber prices and less incentive to harvest. But less incentive to harvest mean lower utilization of labor and capital. Distance to markets should not lower the productivity of labor and capital inherently.

State technical service providers could drive enrollment in programs such as certification and capacity development if having more service providers in a state causes those service providers actively solicit their services to CFEs, increasing their likelihood of applying. These variables would fail the second criteria and itself be subject to self-selection endogeneity if service providers intentionally locate in states where they believe CFEs are more likely to want to participate in programs. Similar arguments apply to capacity development budget. Discussion with CONAFOR staff led us to the conclusion that the number of technical service providers and region were thought to be exogenous and fit for an instrument, but budget levels were likely endogenous.

While there is no test to ensure that a proposed instrument is uncorrelated with the error term (second criterion), it is recommended that each proposed instrument be tested to ensure there is significant correlation with the endogenous variables (third criterion). The standard R-squared value, F tests, and *t*-tests of the regressors in the first stage provides a first look at how well the endogenous variables are modeled by the instruments and exogenous variables. Second, the Sanderson-Windmeijer multivariate F and Chi-squared tests of excluded instruments (Sanderson and Windmeijer, 2016) evaluate the null hypothesis that the coefficients of the instruments are all equal to zero. In the final second-stage model, Anderson-Rubin Wald tests for the joint significance of the instrumented endogenous variables (Anderson and Rubin, 1949; Baum et al., 2007).

3.3. Production functions

We describe a single-year short-run timber harvest production model of CFEs on a fixed forest land base and stocking level. *Ejidos* and *comunidades* are endowed with community land, which is generally allocated as naturally-regenerated forest land, agricultural land, and an urban center. Tree planting occurs in some areas for ecological restoration purposes, but tree plantations for commercial purposes are extremely limited in Mexico's community land. Furthermore, while some land may occasionally change uses from forest to agricultural or vice versa, and in some cases it may be possible to acquire new land, for most purposes the forest land base is fixed. CFEs can manage forest land, and invest in silvicultural activities such as thinning, elimination of undesired species, and pest control, which may increase forest productivity in the future. However, in a given year, it is not possible to influence total timber stock.

We assume that all CFEs have access to the same basic timber harvesting technology that utilizes labor and capital inputs; that is, logging practices in the CFEs typically utilized chainsaws and tractors or very simple skidders. Other variables that affect the timber harvest productivity of the labor and capital inputs may vary by firm. Higher productivity of labor and capital could be due to a larger endowment of natural resources available to the firm; more capacity, training, and education of employees; or policies affecting access to or provision of resources or services. Total timber stock of pine and fir (STOCKPF) is a firm-related natural resource endowment potentially linked to higher productivity because it is easier to harvest trees from a large endowment than from a smaller one. Regional location such as the community being the northern States of Mexico (NORTH)[2] rather than Central and Southern Mexico may affect productivity if there is slightly different topography or forest type.[3] Participation in capacity-building support programs (CAP, an ordinal variable representing number of times participating in 2011) may have a positive effect on productivity. Forest certification (CERT, dummy variable) may have a positive or negative effect on productivity. The capacity increase due to the continuous improvement associated with certification may make workers more productive; however, if more labor is spent with relatively low-value paperwork tasks or responding to corrective action requests that are not meaningful, it could decrease productivity. Other support programs

[2] Of the 12 States listed in Footnote 1, the northern States include Chihuahua and Durango.

[3] Numerous other factors may play a role in productivity at the level of the region, state, sub-state, and community level such as population density, culture, socio-economic status and inequality, political heterogeneity, etc. While potentially relevant to this work, exploration of such factors requires detailed field work, and is beyond the scope of the present research.

(payment for ecosystem services, silviculture, roads, restoration and protection, timber processing, and tourism) are mostly related to other outputs or parts of the productive chain before or after the harvest of timber. In the long term, we might expect these programs to have an impact on productivity, but not in the short term.

In order to test for allocative inefficiency between labor and capital, and for changes in productivity potentially due to support programs, we created standard short-run timber harvest production functions to model CFE outputs (e.g., timber harvest volume) as a function of various inputs. Production functions map output as a function of inputs, or factors of production, such as labor and capital, and other variables that affect the productivity of those inputs:

$$Q = f(\alpha_0 X_{i=1} \ldots X_m Y_{j=1} \ldots Y_n Z_{k=1} \ldots Z_r) \tag{1}$$

where Q is the quantity of output produced, α_0 is a constant, X_i are the quantities of the production inputs (labor and capital) that can be increased or decreased by the firm in the short run, Y_j are other continuous variables that affect productivity, and Z_k are dummy or ordinal variables affecting productivity. Empirically, we utilize a variation of the common Cobb-Douglas functional form:

$$Q = e^{\alpha_0} \bullet \prod_{i=1}^{m} (X_i^{\beta_i}) \bullet \prod_{j=1}^{n} (Y_j^{\gamma_j}) \bullet \prod_{k=1}^{r} (e^{\delta_k \bullet Z_k}) \tag{2}$$

$$\ln(Q) = \alpha_0 + \sum_{i=1}^{m} (\beta_i \bullet \ln(X_i)) + \sum_{j=1}^{n} (\gamma_j \bullet \ln(Y_j)) + \sum_{k=1}^{r} (\delta_k \bullet Z_k) \tag{3}$$

In this case, the coefficients β_i represent the output elasticities of labor and capital. Elasticities are typically between zero and one, indicating diminishing marginal returns of individual inputs. If the elasticities sum to one, there are constant returns to scale, which can be tested empirically with an F-statistic test for the expression $\beta_{i=1} + \ldots + \beta_m = 1$; alternatively there are increasing or decreasing returns to scale.

For comparison purposes, we tested three different model specifications:

$$\ln(Q) = \alpha_0 + \beta_L \bullet \ln(LABOR) + \beta_K \bullet (CAPITAL) + \varepsilon \tag{Spec. 1}$$

$$\ln(Q) = \alpha_0 + \beta_L \bullet \ln(LABOR) + \beta_K \bullet (CAPITAL) + \gamma_S \bullet \ln(STOCKPH) + \delta_N \bullet NORTH + \varepsilon \tag{Spec. 2}$$

$$\ln(Q) = \alpha_0 + \beta_L \bullet \ln(LABOR) + \beta_K \bullet (CAPITAL) + \gamma_S \bullet \ln(STOCKPH) + \delta_N \bullet NORTH + \delta_{CAP} \bullet CAP + \delta_{CERT} \bullet CERT + \varepsilon \tag{Spec. 3}$$

where ε is the residual. We used each of the three specifications with three alternative dependent variables (Q), which are different interpretations of the output of the CFEs. Traditionally, the dependent variable would be quantity of physical output, timber volume. Therefore, the first dependent variable modeled was total harvest of timber (TOT_HARV), in m^3. However, CFEs may expend effort to harvest higher quality timber, implying that not all timber harvested is equivalent. There were four timber product classes among our 27 non-tropical CFEs: pine first and second grades; fir first and second grades. Therefore our second dependent variable is a value-weighted measure of timber harvest (VAL_HARV), indexed to average MXN$. The value weighting used a price index of average prices among all CFEs for each timber product class to avoid price endogeneity. Third, perhaps CFEs are not profit-maximizers, but rather seek to maximize some certain benefits for the communities that charter them (Antinori and Bray, 2005).[4] Communities might have the objective of maximizing the total amount of income that they generate for the community (COMM_INC), in terms of the sum payments to the community including distributions to community shareholders, payments for local development projects, and wages paid to local workers.

In reality, all three of these potential dependent variables are linked – greater timber harvest leads to greater revenue, which leads to greater ability to pay wages and other community payments. But stronger correlation of one of these outputs with the inputs would support the idea that CFEs are seeking to maximize that particular output at a given level of inputs.

Microeconomic theory holds that for a competitive firm, the marginal revenue product (*MRP*) of each input should be equal to the price of that input. That is, if CFEs are seeking maximum competitiveness, the revenue generated by an additional unit of input should be equal to its cost:

$$P_Q \bullet \frac{\partial Q}{\partial X_f} - P_f = 0 \tag{4}$$

$$P_Q \bullet \left(e^{\alpha_0} \bullet \beta_f \bullet X_f^{\beta_f - 1} \bullet \prod_{i \neq f} (X_i^{\beta_i}) \bullet \prod_{j=1}^{n} (Y_j^{\gamma_j}) \bullet \prod_{k=1}^{r} (e^{\delta_k \bullet Z_k}) \right) - P_f = 0 \tag{5}$$

where P_Q and P_f are the market prices of the output (e.g., timber price) and input (e.g., wage rate), respectively. In the case of the value-weighted timber harvest dependent variable or community income, the output is expressed directly in Mexican pesos (MXN$),[5] so $P_Q = 1$. Likewise $P_K = 1$ for the case of capital input.

Expression (5) can be tested empirically using a test of nonlinear combinations of parameters. Since value of the left-hand expression above is not constant and varies depending on the values of the *X*s, it is necessary to define those values in order to evaluate the expression, for which purpose we utilized the mean values of the *X*s. If the null hypothesis that expression (5) is equal to zero is not rejected, this does not provide evidence that the firms are not competitive firms. Alternatively, if expression (5) is empirically nonzero, this suggests that the firms are not competitive; an input is being over- or under-utilized compared to a competitive firm. This might be the case, for example, if firms were primarily seeking to provide jobs by increasing labor input, without regard for competitiveness.

4. Results

4.1. Data

Table 1 presents the summary statistics for the variables used in the models. The 27 CFEs displayed diversity in all the various parameters. Those CFEs that were particularly large or small in one variable, were not necessarily so for other variables. The production outputs of harvest volume, value-weighted harvest, and community income had ranges greater than one order of magnitude. The production inputs labor and capital varied to similar extent, with ranges of about 35 times.[6] In the

[4] Other methodologies, such as data envelopment analysis (DEA) can be utilized to model multiple-input, multiple output production. However, DEA is not well-suited for the type of hypothesis testing of cross-sectional data that is the objective of this research. First, it is unknown whether or not CFE managers

(*footnote continued*)
value job creation as an output of the CFEs at all, whereas including it as a DEA output assumes that at least some CFE managers value it; that is, it assumes the very thing we are trying to test. This is a variation of the DEA dimensionality problem discussed in (Han et al., (2018); Hughes and Yaisawarng (2004)). Second, using cross-sectional data of forestry or agricultural producers to test technical efficiency using DEA is problematic because the method requires homogeneity of firms, and there are inherent heterogeneities in terms of geography, topography, soil productivity, etc. (Frey et al., 2012; Han et al., 2018; Just, 2003)

[5] In 2011, approximately USD$ 1 = MXN$ 13.

[6] There is certainly also variability among the CFEs and communities that own them in multiple other ways, including population density, culture, socio-economic status and inequality, political heterogeneity, etc. Exploration of such social factors is unfortunately beyond the scope of the present research.

data we also note that CFEs do substitute inputs for each other. That is, the CFEs among those with the largest (or smallest) amounts of one input are not always among those with the largest (or smallest) amounts of the other. For example one CFE might choose to use a very large amount of labor and minimal capital, while a different CFE might spend a relatively large amount of money on equipment and have few workers. For all the input and output variables the median value was lower than the mean. This corresponds a skewed distribution with many smaller and a few larger CFEs.

Table 1 also summarizes participation in capacity development programs and forest certification. Eleven of 27 CFEs participated in at least one capacity development program in 2011, with two CFEs participating in three programs each. Ten of 27 CFEs participated in forest certification mechanisms in 2011, including 8 in FSC and 2 in ATP.

For comparison purposes, we quantified the peso value of capacity building support to other support programmatic areas. 22 of the 27 CFEs received at least one support program payment in at least one of the seven groups. On average, CFEs received a total of MXN$ 728,000 in 2011 (approximately USD$ 56,000) in payments for support programs in the seven groupings described, including an average of MXN$ 78,000 for capacity development, MXN$ 139,000 for silviculture, MXN $ 87,000 for roads, MXN$ 76,000 for restoration and protection, MXN$ 12,000 for payments for environmental services, MXN$ 199,000 for timber processing, and MXN$ 137,000 for tourism. However, since many CFEs did not receive payments in all these categories, the average payment for CFEs that did receive payments in a particular category was significantly higher. When averaging only CFEs that did receive payments in the specific categories (not shown in Table 1), the average total receipts were MXN$ 192,000 for capacity development (11 CFEs), MXN$ 222,000 for silviculture (17 CFEs), MXN$ 294,000 for roads (8 CFEs), MXN$ 255,000 for restoration and protection (8 CFEs), MXN$ 80,000 for payments for environmental services (4 CFEs), MXN$ 672,000 for timber processing (8 CFEs), and MXN$ 1,850,000 for tourism (2 CFEs).

CFEs could generate community income through direct community payments or forestry employment. Twenty-one of the CFEs reported that they made direct local community payments, although some payments were fairly trivial, and all employed workers, most of whom were local community members. The community payments were mostly for local development projects such as schools, social programs, festivals, roads, infrastructure, etc. The mean community payment was about MXN$ 333,000 in 2011, but the median payment was only MXN$ 50,000 (less than USD$ 4000).

We compared the means of several variables for those that did not participate to those that did participate in capacity development and certification (Table 2). It is important to note that none of these correlations or associations should be seen as causative, but they are illustrative. It is quite noticeable that the CFEs participating in capacity development and certification were significantly larger in terms of harvest (total and value-weighted), total timber stock, and forestland area than those that did not. The certified CFEs also used more labor and capital, but this trend did not hold for capacity development. Certified CFEs did generate more community income than those that

Table 3
First-stage regression of endogenous variables on instrumental and exogenous variables for production function models.

	CAP	CERT
	Coefficient (std err)[a]	*Coefficient (std err)*[a]
DIST_DF	−0.0012*	0.00052
	(0.0007)	(0.00050)
DIST_STATE	0.0021	−0.0021*
	(0.0030)	(0.0012)
DIST_MUNI	−0.0038	−0.00062
	(0.0022)	(0.00084)
TSP_STATE	0.0030***	0.00015
	(0.0007)	(0.00065)
ln(LABOR)	−0.207	0.039
	(0.134)	(0.080)
ln(CAPITAL)	−0.011	−0.030
	(0.091)	(0.056)
ln(STOCKPH)	0.326**	0.146**
	(0.127)	(0.064)
NORTH	1.897**	0.532
	(0.692)	(0.350)
Constant	−2.992	−1.311
	(2.030)	(1.127)
Fit statistics		
R-squared	0.591	0.659
F	9.26***	12.06***
Sanderson-Windmeijer χ^2[b]	55.74***	17.56***
Sanderson-Windmeijer F [c]	12.39***	3.90**

*, **, *** Denote statistical significance at the 0.10, 0.05, and 0.01 alpha-levels.
[a] Standard errors are heteroscedasticity-robust.
[b] Multivariate test of excluded instruments. The chi-squared test will fail to reject if a particular endogenous regressor is undentified (Sanderson and Windmeijer, 2016).
[c] Multivariate test of excluded instruments. The F-statistic test will fail to reject if a particular endogenous regressor is weakly identified (Sanderson and Windmeijer, 2016).

Table 2
Comparison of mean values of several variables among those participating and not participating in capacity development support (CAP) and certification.

Variable [a]	Units	No 2011 CAP	Received 2011 CAP	Uncertified	Certified
CFEs	#[b]	16	11	17	10
AREA	Hectares	4167	10,258	2905	13,014
TOT_HARVEST	m^3	8057	16,748	5939	21,218
VAL_HARVEST	1000 MXN$ [c]	5082	11,068	4068	13,390
STOCKPF	m^3	426,261	1,347,209	313,563	1,630,890
COMM_INC	1000 MXN$ [c]	2023	1736	1518	2566
LABOR	FTE[d]	59.0	24.5	38.3	56.2
CAPITAL	1000 MXN$ [c]	2028	2501	1243	3883
CAP	Ordinal (0–3)	0	1.36	0.24	1.1
CERT	Binary (0–1)	0.19	0.64	0	1

[a] Description of variables are given in Table 1.
[b] Number of CFEs participating/enrolled in program/activity.
[c] An approximate conversion rate for 2011 is 13 Mexican pesos (MXN$) = 1 United States dollar (USD$).
[d] Full-time equivalent employees.

Table 4
Cobb-Douglas short-run production functions with dependent variables total harvest, value-weighted harvest, and community income.

Dependent variable	Total harvest (TOT_HARVEST)			Value-weighted harvest (VAL_HARVEST)			Community income (COMM_INC)		
Model specification	1	2	3	1	2	3	1	2	3
	Coefficient (std err) [a]	*Coefficient (std err)* [a]	*Coefficient (std err)* [a]	*Coefficient (std err)* [a]	*Coefficient (std err)* [a]	*Coefficient (std err)* [a]	*Coefficient (std err)* [a]	*Coefficient (std err)* [a]	*Coefficient (std err)* [a]
ln(LABOR)	0.178 (0.105)	0.191* (0.102)	0.196 (0.193)	0.172 (0.110)	0.184 (0.110)	0.189 (0.182)	0.598*** (0.164)	0.595*** (0.134)	0.589*** (0.149)
ln(CAPITAL)	0.415*** (0.112)	0.091 (0.089)	0.100 (0.114)	0.396*** (0.108)	0.060 (0.072)	0.068 (0.097)	0.106 (0.079)	−0.099 (0.114)	−0.090 (0.129)
ln(STOCKPF)		0.451*** (0.118)	0.302* (0.154)		0.485*** (0.112)	0.362** (0.146)		0.408*** (0.134)	0.184 (0.147)
NORTH		0.661** (0.262)	0.075 (0.634)		0.595** (0.223)	0.110 (0.607)		−0.210 (0.312)	−1.099*** (0.332)
CAP			0.279 (0.377)			0.231 (0.360)			0.371 (0.256)
CERT			0.660 (0.723)			0.545 (0.685)			1.088* (0.557)
Constant (α_0)	2.58 (1.56)	1.09 (1.34)	2.59 (1.98)	9.35*** (1.46)	7.60*** (1.25)	8.85*** (1.73)	10.12*** (1.14)	7.80*** (1.21)	10.18*** (1.49)
Fit statistics									
R-squared	0.456	0.694	0.584	0.439	0.699	0.624	0.415	0.569	0.602
F_0 [b]	10.50***	17.04***	7.55***	10.93***	18.25***	8.54***	8.07***	7.10***	12.62***
Test statistics									
F_1 [c]	9.51***	37.82***	10.08***	11.64***	44.73***	12.60***	2.85	11.89***	6.95**
$MRP_L - P_L$ [d]	15,017	23,995	19,915	1053	7466	5258	−11,326**	−8545*	−11,649**
$MRP_K - P_K$ [d]	0.956	−0.516	−0.525	0.281	−0.776***	−0.770**	−0.946***	−1.060***	−1.046***
Anderson-Rubin F_2 [e]			2.84*			2.01			5.47***
Anderson-Rubin χ^2 [e]			17.02***			12.06**			32.83***

*, **, *** Denote statistical significance at the 0.10, 0.05, and 0.01 alpha-levels.
[a] Standard errors are heteroscedasticity-robust.
[b] F-statistic test of joint significance of regressors (H_0: $\beta 1 = \beta 2 = \ldots = 0$).
[c] F-statistic test for non-constant returns to scale (H_0: $\beta_L + \beta_K = 1$).
[d] Tests of the marginal revenue product of labor and capital, minus their respective prices (P_L = price of labor = average wage; P_K = price of capital = 1) (expression 6) (H_0: $MRP - P = 0$).
[e] Anderson-Rubin Wald tests of joint significance of the instrumented endogenous regressors,

did not, but CFEs participating in capacity development generated less. It is also relevant to note that capacity development and certification seem highly associated, with the certified CFEs participating in capacity support more than those that were uncertified.

4.2. Instrumental variables

We used a 2SLS model to control for endogeneity of CAP and CERT and considered several possible instruments. We found that the combination of distance to Mexico City, D.F., distance to state CONAFOR office, distance to municipality, and number of technical service providers in state did the best job identifying the three endogenous variables among the candidates that were apparently exogenous. The first-stage regressions (Table 3), also include the other explanatory variables of the second-stage production functions.

The Sanderson-Windmeijer chi-squared and F-statistic tests measures the identification of the endogenous variables by the instruments (Sanderson and Windmeijer, 2016). The null hypothesis of the chi-squared test is that the endogenous regressor is unidentified, and the null of the F-statistic test is that it is weakly identified. The null hypothesis was rejected at the 0.05 alpha-level in each case. Furthermore, the overall F-statistics were significant for at least the 0.01 alpha-level in each case. The R-squared values were between 0.5 and 0.7. Overall, the instruments seemed reasonably well correlated with the endogenous explanatory variables for the production functions.

4.3. Production functions

We modeled short-run timber harvest production functions, using a modified Cobb-Douglas functional form, with three alternative dependent variables (production outputs): total harvest (TOT_HARVEST), value-weighted harvest (VAL_HARVEST), and contributions to community income (COMM_INC = wages + CFE payments to community) (Table 4). For each alternative dependent variable there were three model specifications for comparison, as described in the section on Data and Methods. All of the models had statistically significant F-statistics (labeled F_0 in the table to avoid confusion with the F test that the sum of the coefficients is one), rejecting the null that all coefficients were equal to zero. That is, the explanatory variables have some predictive power as to the level of output. R-squared values ranged from about 0.4 to 0.7.

The Cobb-Douglas function has the benefit that the estimated coefficients are elasticities. That is, they indicate the percentage change in the dependent variable (harvest volume, revenue, community income) from a percentage change in the independent variable (labor, capital). None of the output elasticities of labor or capital approach one, or even have 95% confidence intervals that reach one, consistent with diminishing returns for individual inputs.

We conducted two types of statistical tests on the coefficients to better understand this issue of competitiveness. First, we tested whether the sum of the coefficients (elasticities) of labor and capital was different than one, indicated by F_1 in Table 4. A sum of the elasticities greater than 1 indicates increasing returns to scale; less than 1 the converse. With one exception (community income specification 1), the sum of coefficients was statistically less than one, indicating that the CFEs, on average, may be operating under decreasing returns to scale in the short run.

Second, we tested whether the marginal revenue products of labor and capital (MRP_L and MRP_K), minus their respective prices (P_L = price of labor = average yearly wage; P_K = price of capital = 1), are equal to zero (expression 5; Table 4). A value less than zero would indicate that CFEs are over-utilizing that particular input. For the total harvest output, the value of expression (5) for both labor and capital were not significantly different than zero, indicating no evidence that the CFEs are over- or under-utilizing labor or capital, consistent with competitive/profit-maximizing firms. However, the value of expression (5) was less than zero for capital in two model specification for value-weighted harvest, and the values of expression (5) for labor and capital were less than zero for all model specifications in the community income models.

Total stock of pine and fir is included in model specifications 2 and 3 (Table 4). In the short run, total stock is an endowment based on site quality, natural forest factors, and prior forestry activities and harvest levels. Most *ejidos* and *comunidades* are not likely to purchase or sell forestland in the short run, so timber stock is fixed. Still, timber stock is highly predictive of harvest and community income output (with the exception of model specification 3), when controlling for labor and capital employed. Also, the North regional dummy was positively correlated with timber harvest but negatively with community income in most of the model specifications.

The Anderson-Rubin Wald F-test (denoted F_2 in Table 4) (Anderson and Rubin, 1949; Baum et al., 2007) indicated that the endogenous participation in programs (CAP and CERT) were jointly significant at the 0.1 alpha-level for total harvest and community income, and the Anderson-Rubin Wald chi-squared test was significant for all outputs at the 0.05 alpha-level (Table 4, model specification 3). This means that participation in at least one, or joint participation in these programs impacts productivity. Since the coefficients for participation in these programs were positive in the total harvest and value weighted harvest production functions, we can deduce that the joint impact of these programs is to increase productivity; that is, more timber is harvested at any given level of inputs.

5. Discussion

The two objectives of this study were to examine empirical evidence if CFEs were acting as competitive firms and to evaluate the impact of voluntary participation in forest certification and capacity development support. In terms of the first objective, the fit statistics for the total harvest and value-weighted harvest models were generally somewhat better than for community income, suggesting that these CFEs may be tending towards production of more traditional production outputs, as would be the case of competitive firms. Still, the model fit for community income was moderate, so it cannot be discounted completely. Interestingly, the coefficients (elasticities) of individual inputs for outputs related to harvest, showed statistical significance most frequently in the total stock elasticity for model specifications 2–3 and the capital elasticity for specification 1. Yet, labor was statistically significant in the community income models. Taken together, this might suggest that CFEs are balancing multiple objectives - maximizing neither harvest nor community income, but doing relatively well at both.

The marginal revenue products of labor and capital (MRP_L and MRP_K) minus their respective prices (P_L = price of labor = average yearly wage; P_K = price of capital = 1), are typically not statistically different than zero in most of the timber harvest models, yet are consistently less than zero in the community income models. This indicates overutilization of the inputs with respect to community income; presumably money saved on wages and capital could be payed to the community in other ways. As opposed to the evidence from elasticities, this evidence leans away from the concept of balancing multiple objectives and towards the concept that CFEs are acting primarily as competitive firms. Another way of understanding this is that CFEs might generally try to keep costs down, but are open to employing additional community members to help the community overall.

In terms of the second objective, there is relatively robust evidence that capacity development and certification jointly have a positive impact on productivity, as the Anderson-Rubin Wald tests of joint significance of the endogenous variables were statistically significant in all but one instance. Because of the correlation between enrollment in the two types of programs, it is extremely difficult to parse the effects of capacity development and certification. Individually, only certification was correlated with higher community income.

6. Conclusions

Previous studies have shown that CFEs in Mexico are generally profitable, but also have high management and production costs (Cubbage et al., 2015b). However, there has been doubt as to whether Mexican CFEs are competitive internationally, and if various models of support are effective in achieving that goal. Further, qualitative research suggests that profit is only one of numerous objectives of CFEs, including most notably creation of community employment (Antinori and Bray, 2005). We extended quantitative economic analyses with the largest comprehensive financial sample of Mexican CFEs, and modeled economic impacts of government support programs and forest certification with econometric approaches.

Even though our sample size is small in a statistical sense, with only 27 relevant CFEs, the data were a robust set of detailed economic data for a substantial share of the CFEs in Mexico in 2011: about 9% of the total CFEs that harvest their own timber within the 12 states where it is prevalent. They came from extremely detailed field questionnaires and subsequent analyses to estimates costs and returns for each firm. These data have previously shown that a majority of the sampled CFEs were profitable and mostly harvest at a rate lower than or about equal to the annual average growth of timber, meaning it could be sustained over time (Cubbage et al., 2015b), although there was wide variation in costs, returns, and CFE size, with some significant noise that made discerning statistical differences in our key variables of government assistance programs and forest certification difficult. Also, there was high correlation between some of the explanatory variables (e.g., CAP and CERT), which made separating their impacts difficult. Nonetheless, the models help understand aggregate production relationships, and some findings about key variables and policies that affect these relationships.

A limitation is that our data are only from a single point in time. This may not be sufficient to detect the impact of support programs such as those for capacity development, and certainly cannot detect the impact of support for things such as silviculture (whose impact we did not attempt to estimate) because silvicultural interventions take multiple years or even decade to produce measurable increased tree growth. Also, our research is relevant for the situation in 2011; however, circumstances for CFEs and government programs change over time, and the same results may not hold in the future. If resources become available in the future to repeat this exercise, the same CFEs could be re-sampled, because data on the same sample at multiple points in time would allow powerful econometric panel data models. The sample could be broadened in the future to include other CFEs. Finally, future work could include an exploration of the effect on economic outcomes of social factors and diversity, including socio-economic levels and inequality, diversity of viewpoints and conflict, etc.

In terms of production of timber harvest volume or revenue, we found that increasing capital investment and timber stock are correlated with higher timber total harvest volume and value-weighted harvest. Increasing labor was less significantly correlated with increased harvests, potentially indicating that CFEs somewhat over-utilize labor in terms of that objective. Our models using community income as an output instead of timber harvest showed somewhat poorer fits overall. In the community income models, the marginal revenue products of labor and capital were statistically different than their average prices, suggesting that CFEs overutilize the inputs if that is their true objective. In all, this paints a nuanced picture of CFEs balancing multiple objectives – trying to be financially sustainable and competitive, while at the same time providing direct benefits to the community population. We believe the evidence is consistent with a view that CFEs are operating mostly as competitive, profit-maximizing firms, but perhaps do occasionally employ slightly more labor than is absolutely necessary. Certainly more research would be necessary to make this case conclusively, but this work provides first broad, empirical, quantitative evidence in this direction, as all previous work related to this particular question has been qualitative in nature. A potential area of future research might be to model CFEs as profit-maximizing firms subject to a minimum employment constraint, or alternatively as multiple objective firms. There was evidence of decreasing returns to scale on average. That is, in the short run, smaller CFEs give a relatively higher productivity per unit of input.

We used instrumental variables methods to estimate the impact of enrollment in capacity development support programs and forest certification, controlling for potential self-selection bias. Evidence suggests that the two programs jointly do increase productivity of timber harvest and also increase community income. It is more difficult to separate the impact of the two programs, but certification in particular seemed to have a positive effect on community income. We speculate on social acceptability in communities. This finding helps extend prior literature that found forest certification provided not just environmental changes and benefits in forest management, but rather had large social and economic components (Blackman et al., 2014). Capacity development was highly correlated with certification, so it was difficult to separate the two effects; furthermore, we only had data on capacity development for one year. It is possible that the capacity development further amplified the positive effect of certification.

Disclaimer

The views and opinions expressed herein are those of the authors and do not necessarily represent those of the institutions where they are employed, or other institutions supporting this work.

Acknowledgements

Funding: Survey design and data collection was funded by the Program on Forests (PROFOR) project “Community Forestry Enterprise Competitiveness and Access to Markets in Mexico”, through the World Bank Latin America and Caribbean region, in partnership with Mexico's National Forestry Commission (CONAFOR).

We thank colleagues from the World Bank and CONAFOR for their time and collaboration. We thank reviewers for their comments on a draft of this manuscript.

Appendix A. Categorization of CONAFOR and other organizations' support program components

Table A.1
List of support programs received by CFEs, and their classification for the statistical analysis.

Classification	Program category ("*Modalidad*")	Number of instances provided
Capacity development	A1.2: Studies – Program of forest management for timber	2
	A1.4: Studies –Wildlife management plan	1
	A3.1: Certification – Preventative technical audit	1
	CP1: Fairs and expositions	3
	CP2: Writing of charter and bylaws	2
	CP3: Technical studies for reengineering of processes, feasibility, and business plans	1
	CP5: Administrative equipment	1
	CP6: Special projects of strategic interest (temporary employee)	1
	FC1.5: Social capital – Community to community interchange of experiences and seminars	3
	FC1.6: Community forestry consultant	1
	FC2.1: Human capital – Workshops and courses for capacitation of forestry producers	1
	FC3.2: Administrative capacity – Consultant for strengthening community forest enterprises	1
	Other: Environmental impact statement; Technical assistance	2
	Total	20
Silviculture	A2.1: Silviculture – Silviculture for timber production	16
	A2.4: Silviculture – Silvicultural technology	2
	A4: Commercial forest plantations	1
	C4.1: Forest health (pest and disease control)	1
	Other: Nursery	2
	Total	22
Roads	A2.5: Silviculture – Forest roads	8
	Total	8
Restoration and protection	B1: Reforestation and soils (unspecified)	1
	B1.1: Reforestation and soils – Reforestation	6
	B1.2: Reforestation and soils – Maintenance of reforested areas	5
	B1.3: Reforestation and soils – Protection of reforested areas	6
	Other sources: Reforestation, Firefighting	3
	Total	21
Payments for environmental services	B2.1: Environmental services – Water environmental services	4
	B2.2: Environmental services – Conservation of biodiversity	1
	Other	3
	Total	8
Timber processing	CP4: Support for industrialization	7
	CP6: Special projects of strategic interest (machinery)	1
	Other: Sawmill equipment and machinery; Warehouse	3
	Total	11
Tourism	Other	4
	Total	4

References

Adhikari, S., Kingi, T., Ganesh, S., 2014. Incentives for community participation in the governance and management of common property resources: the case of community forest management in Nepal. Forest Policy Econ. 44, 1–9. https://doi.org/10.1016/j.forpol.2014.04.003.

Alix-Garcia, J.M., Shapiro, E.N., Sims, K.R., 2012. Forest conservation and slippage: evidence from Mexico's national payments for ecosystem services program. Land Econ. 88 (4), 613–638.

Anderson, T.W., Rubin, H., 1949. Estimation of the parameters of a single equation in a complete system of stochastic equations. Ann. Math. Stat. 20, 46–63.

Anta, S., 2006. Forest certification in Mexico. In: Cashore, B., Gale, F., Meidinger, E., Newsome, D. (Eds.), Confronting Sustainability: Forest Certification in Developing and Transitioning Countries. Yale School of Forestry & Environmental Studies, New Haven, CT.

Antinori, C.M., 2005. Vertical integration in the community forestry enterprises of Oaxaca. In: Bray, D.B., Merino-Pérez, L., Barry, D. (Eds.), The Community Forests of Mexico: Managing for Sustainable Landscapes. University of Texas Press, Austin, TX, pp. 241–272.

Antinori, C.M., Bray, D.B., 2005. Community forest enterprises as entrepreneurial firms: economic and institutional perspectives from Mexico. World Dev. 33 (9), 1529–1543.

Antinori, C.M., Rausser, G.C., 2003. Does community involvement matter? How collective choice affects forests in Mexico. In: CUDARE Working Paper No. 939. Department of Agricultural & Resource Economics, University of California, Berkeley, Berkeley, CA.

Arriagada, R.A., Ferraro, P.J., Sills, E.O., Pattanayak, S.K., Cordero-Sancho, S., 2012. Do payments for environmental services affect forest cover? A farm-level evaluation from Costa Rica. Land Econ. 88 (2), 382–399.

Barbosa de Lima, A.C., Novaes Keppe, A.L., Maule, F.E., Sparovek, G., Corrêa Alves, M., Maule, R.F., 2009. Does Certification Make a Difference? Impact Assessment Study on FSC/SAN Certification in Brazil. Imaflora, Piracicaba, SP, Brazil 96 pp. Retrieved from: https://www.imaflora.org/downloads/biblioteca/Does_certification_make_a_difference.pdf (Accessed April 15, 2017).

Baum, C.F., Schaffer, M.E., Stillman, S., 2003. Instrumental variables and GMM: estimation and testing. Stata J. 3 (1), 1–31.

Baum, C.F., Schaffer, M.E., Stillman, S., 2007. Enhanced routines for instrumental variables/generalized method of moments estimation and testing. Stata J. 7 (4), 465–506.

Blackman, A., Raimondi, A., Cubbage, F.W., 2014. Does Forest Certification in Developing Countries Have Environmental Benefits? Insights from Mexican Corrective Action Requests. Resources for the Future, Washington, DC, pp. 26.

Card, D., 1993. Using geographic variation in college proximity to estimate the return to schooling. In: Working Paper No. 4483. National Bureau of Economic Research, Cambridge, MA.

Carías Vega, D.E., Keenan, R.J., 2016. Situating community forestry enterprises within new institutional economic theory: what are the implications for their organization. J. For. Econ. 25 (2016), 1–13.

Cashore, B.W., Auld, G., Newsom, D., 2004. Governing through Markets: Forest Certification and the Emergence of Non-state Authority. Yale University Press, New Haven, CT.

Charnley, S., Poe, M.R., 2007. Community forestry in theory and practice: where are we now? Annu. Rev. Anthropol. 36, 301–336.

CONAFOR, 2009. Silvicultura comunitaria: Guía básica para comunicadores. San Juan de Ocotán, Jalisco.

CONAFOR, 2010a. Reglas de operación del programa ProArbol 2011a. In: Diario Oficial de la Federación. Secretaría de Medio Ambiente y Recursos Naturales, Comisión Nacional Forestal, Mexico City 91 pp. Retrieved from: http://www.conafor.gob.mx:8080/documentos/ver.aspx?articulo=1420&grupo=6 Accessed May 23, 2017.

CONAFOR, 2010b. Lineamientos 2011b para otorgar apoyos para el desarrollo forestal comunitario, el desarrollo de la cadena productiva forestal y el saneamiento forestal. Comisión Nacional Forestal, San Juan de Ocotán, Jalisco 45 pp. Retrieved from: http://www.conafor.gob.mx:8080/documentos/ver.aspx?grupo=6&articulo=1408 Accessed December 28, 2017.

CONAFOR, 2014. Estrategia nacional de manejo forestal sustentable para el incremento de la producción y productividad (ENAIPROS): 2013–2018. Comisión Nacional Forestal, San Juan de Ocotán, Jalisco 62 pp. Retrieved from: http://www.conafor.gob.mx/web/temas-forestales/enaipros/ Accessed February 16, 2018.

CONAFOR, 2018. Informe capacidad instalada Febrero 2018. In: Unpublished data. Comisión Nacional Forestal, Gerencia de Formento a la Produccion Forestal Sustentable, San Juan de Ocotán, Jalisco.
Cubbage, F.W., Davis, R.R., Frey, G.E., 2011. Guía para la evaluación económica y financiera de proyectos forestales comunitarios en México. PROFOR, World Bank, Washington, DC 45 p.
Cubbage, F.W., Davis, R.R., Frey, G.E., Behr, D.C., 2013a. Financial and Economic Evaluation Guidelines for Community Forestry Projects in Latin America. PROFOR, World Bank, Washington, DC Retrieved from: http://www.profor.info/content/community-forestry-enterprise-competitiveness-and-access-markets-mexico (Accessed May 23, 2017).
Cubbage, F.W., Davis, R.R., Rodríguez-Paredes, D., Frey, G.E., Mollenhauer, R., Kraus Elsin, Y., ... Chemor Salas, D.N., 2013b. Competitividad y acceso a mercados de empresas forestales comunitarias en México. PROFOR, World Bank, Washington, DC Retrieved from: http://www.profor.info/content/community-forestry-enterprise-competitiveness-and-access-markets-mexico (Accessed May 23, 2017).
Cubbage, F.W., Davis, R.R., Rodríguez-Paredes, D., Frey, G.E., Mollenhauer, R., Kraus Elsin, Y., 2015a. Timber production cost and profit functions for community forests in Mexico. In: Kohl, M., Pancel, L. (Eds.), Tropical Forestry Handbook. Springer Berlin Heidelberg, Berlin.
Cubbage, F.W., Davis, R.R., Rodríguez-Paredes, D., Mollenhauer, R., Kraus Elsin, Y., Frey, G.E., Chemor Salas, D.N., 2015b. Community forestry enterprises in Mexico: sustainability and competitiveness. J. Sustain. For. 34 (6–7), 623–650. https://doi.org/10.1080/10549811.2015.1040514.
DOF, 2013. Plan Nacional de Desarrollo 2013–2018. In: Diario Oficial de la Federacion. Secretaria de Gobernacion, Mexico City May 20, 2013. Retreived from: http://dof.gob.mx/nota_detalle.php?codigo=5299465&fecha=20/05/2013 Accessed February 16, 2018.
FAO, 2010. Global Forest Resources Assessment 2010 Main Report. United Nations Food and Agriculture Organization, Rome.
Frey, G.E., Fassola, H.E., Pachas, A.N., Colcombet, L., Lacorte, S.M., Renkow, M., ... Cubbage, F.W., 2012. A within-farm efficiency comparison of silvopasture systems with conventional pasture and forestry in Northeast Argentina. Land Econ. 88 (4), 639–657.
Giadans, E., Mollenhauer, R., 2012. Manual de aplicación de la encuesta sobre competitividad de las empresas forestales comunitarias (EFC) y anexo 1: procedimientos y control de calidad en la aplicación de la encuesta. World Bank and CONAFOR, Puebla, PU, Mexico, pp. 24.
Han, X., Frey, G.E., Geng, Y., Cubbage, F.W., Zhang, Z., 2018. Reform and efficiency of state-owned forest enterprises in Northeast China as “social firms” J. For. Econ. 32, 18–33.
Hughes, A., Yaisawarng, S., 2004. Sensitivity and dimensionality tests of DEA efficiency scores. Eur. J. Oper. Res. 154, 410–422.
Humphries, S.S., Kainer, K.A., 2006. Local perceptions of forest certification for community-based enterprises. For. Ecol. Manag. 235 (1), 30–43.
Humphries, S.S., Holmes, T.P., Kainer, K., Goncalves Koury, C.G., Cruz, E., Rocha, R.d.M., 2012. Are community-based forest enterprises in the tropics financially viable? Case studies from the Brazilian Amazon. Ecol. Econ. 77, 62–73. https://doi.org/10.1016/j.ecolecon.2011.10.018.
Just, R.E., 2003. Risk research in agricultural economics: opportunities and challenges for the next twenty-five years. Agric. Syst. 75 (2–3), 123–159.
Kelly, J.J., 1994. Article 27 and Mexican land reform: the legacy of Zapata's dream. Columbia Hum. Rights Law Rev. 25, 541.
Kukkonen, M., Rita, H., Hohnwald, S., Nygren, A., 2008. Treefall gaps of certified, conventionally managed and natural forests as regeneration sites for Neotropical timber trees in northern Honduras. For. Ecol. Manag. 255 (7), 2163–2176.
Lister, J., 2011. Corporate Social Responsibility and the State: International Approaches to Forest Co-Regulation. UBC Press, Vancouver, BC.
Markopoulos, M., 1999. Community Forest Enterprise and Certification in Mexico: A Review of Experience with Special Reference to the Union of Zapotec and Chinantec Forestry Communities (UZACHI). Oaxaca.
Merino-Pérez, L., Segura-Warnholtz, G., 2005. Forest and conservation policies and their impact on forest communities in Mexico. In: Bray, D.B., Merino-Pérez, L., Barry, D. (Eds.), The Community Forests of Mexico: Managing for Sustainable Landscapes. University of Texas Press, Austin, TX, pp. 49–70.
Moore, S.E., Cubbage, F.W., Eicheldinger, C., 2012. Impacts of Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) forest certification in North America. J. For. 110 (2), 79–88.
Nebel, G., Quevedo, L., Jacobsen, J.B., Helles, F., 2005. Development and economic significance of forest certification: the case of FSC in Bolivia. Forest Policy Econ. 7 (2), 175–186.
Newhouse, J.P., McClellan, M., 1998. Econometrics in outcomes research: the use of instrumental variables. Annu. Rev. Public Health 19, 17–34.
Peredo, A.M., Chrisman, J.J., 2006. Toward a theory of community-based enterprise. Acad. Manag. Rev. 31 (2), 309–328.
Sanderson, E., Windmeijer, F., 2016. A weak instrument F-test in linear IV models with multiple endogenous variables. J. Econ. 190 (2), 212–221.
Tomaselli, M.F., Timko, J., Kozak, R., 2012. The role of government in the development of small and medium forest enterprises: case studies from the Gambia. Small-Scale For. 11 (2), 237–253. https://doi.org/10.1007/s11842-011-9181-z.
Torres-Rojo, J.M., Guevara-Sanginés, A., Bray, D.B., 2005. The managerial economics of sustainable community forestry in Mexico: a case study of El Balcón, Técpan, Guerrero. In: Bray, D.B., Merino-Pérez, L., Barry, D. (Eds.), The Community Forests of Mexico: Managing for Sustainable Landscapes. University of Texas Press, Austin, TX, pp. 273–302.
Treseder, L., Krogman, N.T., 1999. Features of First Nation forest management institutions and implications for sustainability. For. Chron. 75 (5), 793–798.
Vela, C., Oliver, J., 2017. Evaluación Final del Proyecto “Transformar el manejo de bosques de producción comunitarios ricos en biodiversidad mediante la creación de capacidades nacionales para el uso de instrumentos basados en el mercado (00071603 FMAM –PNUD - PIMS)”. United Nations Development Programme.
Wiersum, K.F., Humphries, S.S., Van Bommel, S., 2013. Certification of community forestry enterprises: experiences with incorporating community forestry in a global system for forest governance. Small-Scale For. 12 (1), 15–31.
Wooldridge, J.M., 2002. Econometric Analysis of Cross Section and Panel Data. The MIT Press, Cambridge, MA.
World Bank, 2011. Mexico - forests and climate change project (P123760). In: Project Appraisal Document. Report no: 65959-MX. World Bank, Washington, DC Retrieved from: http://documents.worldbank.org/curated/en/824921468286797358/Mexico-Forests-and-Climate-Change-Project (Accessed May 23, 2017).
World Bank, 2017. Mexico - Forests and Climate Change Project (P123760). Implementation Status & Results Report. Report No.: ISR28393. World Bank, Washington, DC Retrieved from: http://documents.worldbank.org/curated/en/981791498587100968/Mexico-Mexico-Forests-and-Climate-Change-Project-P123760-Implementation-Status-Results-Report-Sequence-10 Accessed February 28, 2018.