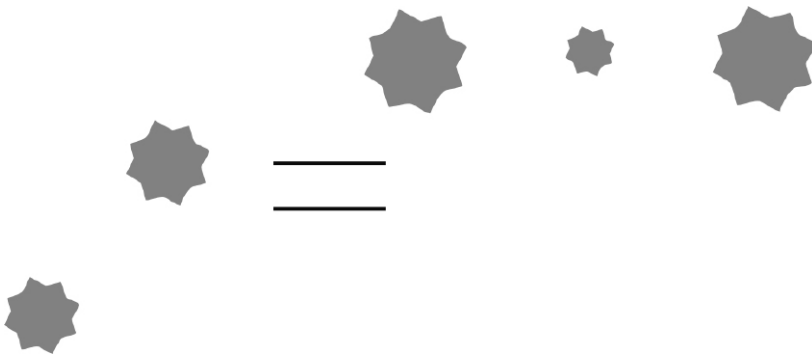


Extended abstract

*Identification of factors influencing
the process of adoption and diffusion
of three technological innovations
in the Chilean forest sector*



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DOI: 10.4422/ager.2021.05

ager

Revista de Estudios sobre Despoblación y Desarrollo Rural
Journal of Depopulation and Rural Development Studies

Highlights:

1. State and leading companies are key drivers of the forestry technology process, especially for SMEs.
2. The pro-innovation competences embedded in human capital are relevant for the adoption-diffusion process.
3. Technology flow is slowing towards the more peripheral actors in the sector.
4. Successful technology adoption also involves recognising the factors that are specific to each technology.
5. Technology management is essential to increase forest competitiveness.

Abstract: The success of the Chilean forest sector has been supported by adequate government policies and an efficient productive system. Large companies lead the technological development processes and, mainly, the adoption of innovations, making the new technologies incorporated into their production processes profitable. Genetic Improvement, the incorporation of Geographic Information Systems, and the implementation of Environmental Management Systems are pointed out by the respondents as the main technological innovations in the sector, especially the forestry subsector. These innovations present a clear process of adoption and diffusion from large forest companies to medium and small owners, in a diffusion flow that is becoming increasingly slow towards the periphery. While the former exhibit an innovative behavior based on the adoption of technologies, the latter two have a rather follower character. This study provides a qualitative-descriptive background on the factors that favor or hinder the processes of adoption and diffusion of technologies identified from developers or early adopters to individual non-corporate peripheral users. Human capital and its level of professionalization, unawareness of technologies, and the non-existence of a pro-innovation culture, especially concerning the most peripheral stakeholders, turn out to be relevant factors for the technological decisions of the adopting units. These and other factors were systematized from the perspective of the market, forest company as an organization, forest nurseries, professionals and contractors, and foresters. The strategy, type of organization and human capital available, level and depth of the networks, and links with entities eliciting knowledge and technology, all seem to constitute cross-cutting factors and key enablers in the process of adoption and diffusion of technological innovations in the sector. The achievements of this study are considered relevant and a contribution to the scientific literature, which has not sufficiently covered this research field, especially regarding the Chilean forest sector.

Keywords: Innovation; Forest Competitiveness; Adoption and Diffusion Factors; Forest Development; Foresters; Chile..

Extended abstract

1. Introduction and background

Innovation has driven technological change and brought about irreversible changes in production processes and factors (Schumpeter, 1939), which are classified according to different criteria. A particularly interesting one is that of Robertson (1967). It centres on the group that covers innovation and considers two main groups: one related to consumption innovations and another to company or technological innovations. The first group is subclassified as discontinuous, dynamically continuous and continuous. The second group is subdivided into technical innovations and organisational innovations. The present research work centres on the perspective of the second group. Thus we indiscriminately employ "technological innovation".

Adoption is an individual process of decision making on accepting an innovation. Diffusion is the process of a group of individuals accepting an innovation with time. Adopting and diffusing technologies respond to gradual systematisable processes. Nevertheless, which factors influence and allow this process to gradually taking place more or less quickly are less clear.

In the Chilean silvicultural forest sector, the factors that would have a more weighted impact on its processes of adopting and diffusing technological innovations are generally unknown. The same can be stated of its specific grouping sources, which is a research opportunity in this area that would allow the revitalising elements of the technological processes in this sector to be understood. This study permitted us to identify the three technological innovations that the key stakeholders believed were relevant for, and the chief adoption and diffusion factors, which influence their transfer process from one management level to another.

2. Objectives, methodology and sources

This study was conducted in the forest macrozone of Chile, specifically in regions of Maule, Bío Bío, Araucanía and Los Ríos. It considered the silvicultural sector,

and all the companies that performed R&D&I tasks on the whole. Non-probabilistic sampling took place based on intention to participate in the study. The objective was to identify relevant technological innovations in this sector, as well as the factors that impact the decisions to adopt them and their diffusion processes.

This work consisted in two phases. The first identified the most relevant innovations for the sector in the last 25 years. An innovation was considered relevant if it met the following characteristic elements: 1) it supported the sector's competitiveness (internally and globally); 2) it presented a clear adoption and diffusion process regardless of the rate at which it occurs, from large forest-related companies to small/medium owners.

The second phase consisted in:

i) Design an instrument based on the literature review. This enabled a minimum and validated number of factors that influence decisions to adopt and diffuse innovations and/or technologies to be determined

ii) Conduct interviews to validate and identify other relevant factors for the sector that have a specific influence (Galindo & Méndez, 2012; Suárez, 2004)

iii) Apply a qualitative analysis programme to large volumes of data, Atlas.Ti (Friese, 2014).

iv) Typification for each identified relevant innovation.

3. Results

Three technological innovations considered essential for the Chilean silvicultural sector's development were identified. All three were developed and/or adopted and implemented by the most important forest holdings in the country. They were:

- a) Genetic Improvement Programmes (GIP) of forest species
- b) Using Geographic Information Systems (GIS)
- c) Environmental Management Systems (EMS) certified according to international standards

The main factors that influenced decisions to adopt and diffuse the three technologies were identified. They were classified by each technological innovation according to the area they apply to and according to where their strongest influence

on these decisions took place. These factors were systematised from the market point of view; a forest company as an organisation; forest nurseries; professionals and contractors and foresters. A group of specific factors was identified for the SGA technology. Not all these points of view were common to all three technologies.

Although the results obtained per technology indicated a high level for the specificity of the factors that influence adopting and diffusing technologies, the analysis of the results allowed some with a generic and cross-sectional scope in relation to the three technologies to be identified, and were preferentially identified in the *market* and *forest company as an organisation* classification types. Nonetheless, it was also possible to identify other relevant factors that cross-sectionally influence both the *forest nurseries* and *professionals and contractors* classification types.

4. Discussion

The Chilean silvicultural sector presents an excellent opportunity to increase its competitiveness by adopting and diffusing technologies, and by adopting applied R&D programmes and public policies that especially address small and medium owners as a way to increase added value and diversification in a context in which the dominant groups are mainly oriented to the production of commodities.

For the identified technologies, the adoption-diffusion processes are active, albeit slow, and work towards the most marginal stakeholders related mainly to service firms, nurseries, professionals and individual foresters. In these cases, the identified factors significantly revitalise these processes.

It is noteworthy that more market factors or those external to companies were identified by the interviewers compared to internal or own organisation factors. This suggests that, despite their leadership, they display an innovation behaviour based on adopting technologies. The PMG technology was identified in the opposite sense: endogenous technology that was valued from a local to a global level.

As those stakeholders closer to the technological domain were determined, the competences factor in favour of adopting innovations and technologies, set up in the human capital acting in the sector, appeared more frequently during interviews as a desirable and necessary addition to trigger technological changes in companies. This factor also catalyses enhancing the relationship between stakeholders from the sector and the centres that generate knowledge and technology to undertake R&D&I projects.

The strategy, type of organisation and human capital, the level and depth of networks, and the link with organisations that generate knowledge and technology seem to constitute cross-sectional factors that make innovation management a dynamic and systemic process. So despite them being difficult to measure, they must be considered with their due weighting if the intention is to promote processes to adopt technologies that ensure successful diffusion in order to improve the competitiveness and sophistication of the Chilean forest sector on the whole.

5. Conclusions

This study is a first attempt to identify the most relevant technological innovations from the Chilean silvicultural sector and their impacts on the different subsectors comprising it, as well as the factors that influence the process followed to adopt and diffuse these technologies, and to also identify the main stakeholders. The followed methodology proved effective for these purposes.

For the three identified innovations, the wide-ranging typical factors of all three that influence their adoption and diffusion stand out. From these factors, those with a positive impact could be selected if, by means of State action, the taken option is to favour public policies that favour and promote technologies to adopt these factors as a way to encourage and advance in their relevance and competitiveness to benefit whose access is more restricted.

The achievements obtained with this study are considered significant because the scientific literature has not covered this research area enough for the forest sector, especially in Chile, and despite its current importance and development status, and its international acknowledgement, particularly in the silvicultural management of the species *Pinus radiata* which, along with the New Zealand species, is a leading species worldwide.

6. Future research lines

These results will serve future research, especially that related to modelling diffusion and technology transfer processes in the forest sector, as a contribution to understand technology flow dynamics in this production sector. They will also help to support private and public decision-making processes about technological management in the forest domain.