JOURNAL OF FOREST BUSINESS RESEARCH

Peer-reviewed research article

Journal of Forest Business Research 3(1), 34-59, 2024

Evolution of Colombia's market for manufactured products of the wood industry

Oscar G. Martínez-Cortés, [a,b*] Shashi Kant [a,b]

a: Institute for Management and Innovation, University of Toronto, Mississauga, ON, Canada.
b: Graduate Department of Forestry, University of Toronto, Toronto, ON, Canada.
**Corresponding author: E-mail: o.matinezcortes@mail.utoronto.ca*

Keywords

Colombia, consumption, demand, exports, forest sector history, imports, market clearing, prices, sawnwood, supply, wood-based panels, wood industry

Citation

Martínez-Cortés OG, Kant S. 2024. Evolution of Colombia's market for manufactured products of the wood industry. J.For.Bus.Res. 3(1): 34-59. https://doi.org/10.62320/jfbr.v3i1.46

Received: 14 January 2024
Accepted: 22 February 2024
Published: 4 March 2024

ABSTRACT

A detailed exploration of the development of Colombia's market for manufactured products of the wood industry since its early days, with an analytical focus on the period 1970-2021, is presented. The examination of early days draws upon historical information, wood industry-specific statistics derived from Colombia's Annual Manufacturing Survey and industrial census, and data from the National Accounts of Colombia (NAC), which offers insightful understanding of the market dynamics up to the end of the 1960s. For 1970 to 2021 comprehensive consolidated data derived from the Supply and Use Tables of the NAC and other sources provides the base for an in-depth examining of the market aspects such as quantities of supply (national production), demand, and the components of demand – including domestic consumption, exports, and imports. The exploration reveals a significant shift in the manufactured products of the wood industry market's dynamics, transitioning from a primarily domestic consuming and export-driven one to a market increasingly reliant on imports to satisfy domestic consumption. Critical factors contributing to this shift are identified, highlighting Colombian forest resource depletion and inadequate nation's wood industry development. The paper synthesizes historical data to articulate the interplay between economic policies and market outcomes, culminating in a discernible need for strategic industry modernization. Furthermore, it offers comprehensive and detailed information, facilitating a thorough understanding of all market aspects without necessitating consultation of additional sources.

INTRODUCTION

The Colombian market for manufactured products of the wood industry (***w*** *market*), an essential part of Colombia's forest sector, has undergone significant transformations throughout its history. Originally focused on the sawnwood, both produced and consumed in Colombia (US Tariff Commission 1945; Contraloría General de la República de Colombia 1947; Van Bottenburg 1952), the ***w*** *market*'s scope has since expanded. It now encompasses a wide range of products manufactured by several industries collectively known as the wood industry, which includes items that are domestically produced, imported, consumed within the nation, and exported. Particular categories within the ***w*** *market*, as per DANE (2023a), now comprise sawnwood, veneers, wood-based panels, both preserved and non-preserved rounded-wood, as well as value-added sawnwood derivatives, including builders' joinery, carpentry, and packaging materials such as cases, boxes, and pallets, with a deliberate exclusion of furniture and its components. A thorough evolution of the products making up the ***w*** *market* since 1970, year in which DANE (Colombia's Statistical Authority) assumed the administration of the National Accounts of Colombia (NAC), is presented in **Appendix A**.

As the product range in the ***w*** *market* expanded, its economic performance also evolved significantly. By 1970, Supply (National Production) of manufactured products of the wood industry (henceforth ***w***) reached 569 billion 2015 Colombian pesos (2015COP) equivalents to USD 215 million.[1] Concurrently, the demand components for ***w***, namely Consumption, Exports, and Imports, measured in the same monetary units, totaled 491 billion (USD 179 million), 15 billion (USD 5.5 million), and 6 billion (USD 2.2 million), respectively.

In that year, the combined value of Consumption and Exports of ***w*** accounted for 14,4%, 12.8%, and 99.8% of the corresponding market value of Colombia's *manufactured wood forest products* (*manufactured* ***WFP***), *wood forest products* (*total* ***WFP***), and *forest products*, respectively. The category *manufactured* ***WFP*** not only includes ***w*** but also products manufactured by the pulp and

[1] The monetary values in this paper are denominated in 2015 Colombian Pesos (2015COP) unless otherwise specified. Some monetary values are also provided in United States Dollars (USD) using the 2015 average annual exchange rate of 2,741.88 COP/USD, as reported by the Banco de la República de Colombia (2023). To streamline the narrative and avoid repetition, subsequent references to monetary values expressed in 2015COP will omit this unit, assuming this denomination by default. In the context of this paper, 1 billion = 1000 million for both currencies, COP and USD.

paper industry (***z*** - pulp is called zellstoff in German) and the furniture industry (***f***). The *total* ***WFP*** encompasses ***w***, ***z***, and ***f***, as well as unprocessed wood for firewood (***FWrw***) and for the manufactured wood products industry and final consumption other than firewood (***MWrw)***. Finally, the category of *forest products* comprises the five groups of products of the *total* ***WFP***, as well as the non-wood forest products and the forest ecosystem services. For an in-depth understanding of the markets for forest products, refer to Martínez-Cortés et al. (2024).[2]

By 2021, according to the latest data from DANE (2023b), Colombia's production of ***w*** was 3,396 billion (USD 1,239 million). In the same year, the consumption, exports, and imports of ***w*** were recorded at 4,563 billion (USD 1,664 million), 99 billion (USD 36 million), and 1,346 billion (USD 491 million), respectively. The aggregate of consumption and exports of ***w*** now represents 17%, 16%, and 85% of the corresponding Colombia's market value for *manufactured* ***WFP,*** *total* ***WFP***, and *forest products*, respectively. Interestingly, the *forest products market* contributed to 5.4% of the value of all products and services consumed and exported in Colombia in 2021. A detailed breakdown of Colombia's national production of ***w***, as outlined in Box 1, provides a comprehensive insight into the contemporary landscape of the ***w*** *market*.

[2] The markets of ***FWrw*** and ***MWrw*** in Colombia are totally supplied by its forest resources comprising 59.5 million hectares of natural forests (IDEAM and MADS 2022) and 0.54 million hectares (Mha) of commercial forest plantations (MADR 2023). Currently, natural forest (59.5 Mha) provides almost entirely the physical volume of wood for the market of ***FWrw***, while forest plantations (0.5 Mha) are source of the 75% of all wood for the ***MWrw*** market, with the rest coming from natural forest mainly (Martínez-Cortés et al. 2022).

*Box 1. Landscape of the **w** market in 2021.*

General division of products included in the *w market*	Subdivision according to the National Accounts of Colombia	Products included	Consumption		National Production		Exports		Imports	
			Value (2015COP billion)	Share (%)	Value (2015COP billion)	Share (%)	Value (2015COP billion)	Share (%)	Value (2015COP billion)	Share (%)
Sawnwood	Group 1	Wood sawn or sliced lengthwise, sliced or debarked, more than 6 mm thick, and wooden sleepers for railways or tramways, not impregnated	1,004	22	951	28	27	27	77	5.7
	Group 2	Wood with continuous profiling along any of its edges or faces; wood wool; wood flour; wood in chips or particles; raw wood, including those treated with paint, stains, creosote or other preservatives; and treated wooden sleepers for railway or tramways	821	18	849	25	23	23	4	0.3
		Subtotal	1,825	40	1,800	53	50	50	81	6
wood-based panels	Group 3:	Boards and panels; veneer sheets of wood; plywood sheets; densified wood	1,597	35	611	18	18	18	1,131	84
value-added sawnwood derivatives	Group 4	Carpentry works and construction parts (such as cellular wood panels, jointed panels for parquet floors, clapboards, and shakes)	639	14	611	18	16	16	54	4
	Group 5	Wooden containers like drawers, boxes, crates, and pallets; wooden reels for cables; cooperage products like barrels and vats and their parts; and other wooden items such as handles, kitchenware, and marquetry	502	11	374	11	16	16	81	6
		Subtotal	1,141	25	985	29	32	32	135	10
		Total	**4,563**	**100**	**3,396**	**100**	**99**	**100**	**1,346**	**100**

Based on data from DANE (2023b).

Amidst this backdrop of diversification and growth, the current state of the ***w*** *market* presents a distinct picture, marked by a dynamic interplay of domestic production and increasing reliance on imports. This shift in the market dynamics, from a primarily inward-looking focus before 1950, and a combination of it and, in some sense, export-oriented emphasis between 1950-1970 (DNP et al. 2020) to a more import-dependent structure, necessitates a comprehensive understanding of the forces shaping the market today. It is within this context that the present paper seeks to explore and elucidate the factors driving the evolution of the ***w*** *market*. The aim of this paper is to dissect the multifaceted layers of the ***w*** *market*'s development, examining its response to both internal economic shifts and external global influences. To this end, the paper offers comprehensive and detailed information about the ***w*** *market*, designed to equip the reader with a thorough understanding of all aspects of the market without the need to consult additional sources of information.

In a broader regional context, our paper is a response to urgent need for more specific and in-depth research into the Latin American forest industries and markets made by Hyde et al. (2022) and Olmos (2022). By delving into the complex dynamics of the ***w*** *market* and the Colombian wood industry, we aim to contribute to a greater understanding of how individual countries within Latin America are navigating the challenges and opportunities of the forest sector. This paper, therefore, not only offers a comprehensive overview of the historical and current state of Colombia's market for manufactured products of the wood industry and the national industry catering to this market, but also serves as an integral part of the wider discourse on forest business, policy, and economics in the Latin American region.

The paper, incorporating substantial content from the first author's doctoral thesis, is organized into four distinct sections beyond this introduction. Section 2 details the research methodology. Section 3, presenting the findings and discussion, is subdivided into three parts: an overview of the ***w*** *market* prior to 1970, its evolution from 1970 up to 2018, a year before the onset of the COVID-19 pandemic, and its developments during the pandemic from 2019 to 2021. Section 4 offers a comprehensive summary of the ***w*** *market* 's evolution. The paper ends with Section 5, which offers conclusions, discusses limitations, and proposes areas for future research.

METHODS AND DATA

In this paper, a multidisciplinary methodology integrating both quantitative and qualitative techniques was employed. The research entailed the thorough collection, consolidation, and analysis of data and information from national accounts, economic reports, and industry documents, some dating back to the late 19th century. To further enrich the analysis, structured interviews with experts from the Colombian forest industry were conducted in 2016 and 2021 (Martínez-Cortés 2016; 2021), yielding valuable insights and perspectives.

In the analysis of the ***w*** market for 1970-2021, the paper utilizes consolidated data for Supply (S) and Demand (D). Supply is defined as National Production, while Demand comprises Domestic Consumption (C) plus Imports (M) minus Exports (X), diverging from traditional national accounts definitions. This approach aligns with the Colombian forest sector model (CFSM), for which the dataset for the ***w*** *market* used in our paper was initially prepared (Martínez-Cortés 2023a; Martínez-Cortés et al. 2024). Within this model, Supply is treated as an independent variable explained by labor, capital, and prices. Consumption aggregates intermediate and final consumption. The paper conducts an analysis of Supply Price of ***w*** (PSw) but excludes analysis on prices of Consumption (PC), Exports (PX), and Imports (PM), which are available with the rest of data used in this paper by request to the corresponding author. All monetary quantities for S, D, C, X and M are reported in 2015 Colombian pesos (2015COP) at purchaser's prices, with PSw, PCw, PXw, and PMw detailed as deflators, using 2015 as the base year. Expressing the S, D, C, X and M purchaser's prices was key to allow for market clearing condition computations.

Raw data for the monetary quantities of S, C, X, and M were sourced from the Supply and Use Tables (SUT) of the NAC for the bases 1975, 1994, 2005, and 2015 (DANE no dated1; no dated2; 2013; 2018a; 2018b; 2023b; 2023d). Physical figures for those aggregated were sourced from FAOstat (FAO 2022; 2023). Statistics specific to the wood industry in Colombia were primarily derived from Colombia's Manufacturing Annual Survey (DANE 1971 – 1979; 1976; 1980-1989; 1990-1999; 2000-2021).

To compile the consolidated data for the ***w*** *market* from 1970 to 2021, estimations and transformations were essential. For 1970 to 1974, the figures for S, C, X, and M of ***w*** were extrapolated by applying the proportion of ***w*** in the aggregated value for 1975 to the combined

figures for ***w*** and ***f*** from the SUT of those earlier years. This was feasible as 1975 was the first year when separate data for ***w*** and ***f*** were available. Additionally, estimates for the 1970 – 2021 quantities of S and M at purchaser's prices were necessary. This involved adjusting these figures from basic prices, as presented in the SUT, to purchaser's prices. The process began by isolating the commercialization and transportation margins for both S and M, which were aggregated in the SUT. To separate these margins, the total value was distributed based on the proportion of each aggregate within their combined sum. Subsequently, the values of the quantities of S and M at purchaser's prices were determined by summing the basic prices with respective taxes and separated margins for each variable. Lastly, the series from 1970-2018 for PSw, PCw, PXw, and PMw were estimated using their deflators. This involved dividing the current monetary values of S, C, X, and M by their constant monetary values, as per Kant et al. (1996).

Data transformation processes were implemented to integrate the data from the four bases corresponding to the years when SUT were available: 1975, 1994, 2005, and 2015. To link these time series in current values, a method of geometric interpolation in reverse was used. This technique ensures the base year values remain unchanged, serving as reference points. It proportionally distributes the difference between the nominal value for the new base year and that of the preceding base year, applying this adjustment specifically to the year when the new base is introduced (DANE 2013; 2020). For linking the time series of the aforementioned bases in constant values, the variation rate method was utilized. This approach preserves the temporal characteristics of the original data (DANE 2013). Graphical analyses were conducted to verify the consistency of the results obtained from these methods.

In this paper, we delineate clearly between the terms "market" and "industry". Here, the first is exclusively used to denote the manufactured products of the wood industry market, referred to as the ***w*** *market*, which encompasses the dynamics of Supply and Demand of ***w***. Conversely, "industry" pertains to the collective of plants or establishments engaged in producing the products referred to as ***w***.

Our paper uses annual growth rates (AGR) to explain the evolution of the market under analysis. Average AGR per decade and for period 1970-2018 were calculated as the average of the AGRs for the years of a decade (e.g. average AGR for the 1980s was computed as the average of the

AGR for each year from 1980 to 1989) and the average of the AGRs for each year from 1971 to 2018, respectively.

Finally, we aimed to benchmark our findings against existing literature. However, this paper represents the inaugural analytical exploration of the Colombian forest markets, leaving us without prior studies for direct comparison.

RESULTS AND DISCUSSION

The *w market* before 1970

The evolution of the ***w*** *market* before 1970 was characterized by an expansion primarily driven by the needs of domestic consumption of these products, accompanied by their limited international trade, with a focus on exports of sawnwood. Historical records indicate that by the late 1800s, Colombia was already commercializing articles manufactured by the wood industry (***w***), such as sawnwood and its value-added derivatives (United States Government 1892), suggesting a robust domestic ***w*** *market*. They also show that by 1937, the country had begun exporting sawnwood for the construction industry (lumber) (US Tariff Commission 1945). However, despite this progress, the national wood industry, serving the ***w*** *market*, continued to be labeled as part of Colombia's "backward manufacturing industry" during the latter half of the 1930s.

By the end of the 1930s and during the 1940s, the ***w*** *market* saw significant expansion, particularly in the domestic supply and consumption of sawnwood. This era of growth, underscored by the domestic concentration, was detailed in Colombia's first industrial census of 1945 (Contraloría General de la República de Colombia 1947), as well as by the international trade data for ***w*** in 1948 (FAO 1949). The census reported a total of 821 establishments within the combined industries of wood and furniture, with their development chronicled as follows: two establishments were founded in 1880, seven between 1881-1900, eight from 1901-1910, 28 during 1911-1920, 89 in the 1920s, 272 throughout the 1930s, and 415 from 1940 to mid-1945. Among these, 147 specialized establishments focused on sawmilling, re-sawmilling and wood preservation, contributing to 43% of the total production value of both industries. As for the year 1948, trade of ***w*** was exclusively in lumber, with imports recorded at 4,000 m^3 (USD 193 thousand) and exports at less than 500 m^3 (USD 9 thousand). This period also highlighted the absence of manufacturing

plants for wood-based panels, a notable gap in the national wood industry's development (FAO 1949; Van Bottenburg 1952).

During the 1950s and 1960s, the ***w*** *market* experienced a period of substantial growth and diversification, marked by increases in domestic supply and consumption of both sawnwood and wood-based panels, alongside a significant rise in the exports of the former. This market expansion was driven by the additional growth of Colombia's sawmilling industry and the establishment and evolution of the national wood-based panels industry. The Pacific Region of Western Colombia, renowned for its vast natural forests, saw a surge in sawmill operations, reaching a total of 92 mechanized sawmills by 1962, with a notable 54% of these located in the Nariño Departmento (Diot 1975). The initiation of Colombia's wood-based panels industry was marked by the establishment of a plywood manufacturing facility, Pizano, in Barranquilla in 1954, utilizing cativo wood (*Prioria copaifera*) (Pizano 2016). This was soon complemented by the creation of fiberboard production by Láminas del Caribe in Barranquilla, using mangle wood (*Rizophora spp.*), and the inception of particle board production by Codemaco in Cali, employing virola wood (*Dialyanthera gracilipes*). The expansion continued into the 1960s with the establishment of four more plants, diversifying the industry's product range to include particle boards (Okal in Bogotá), veneers (Chapas de Colombia in Buenaventura), plywood (Triplex Santander in Bucaramanga), and decorative veneers (Acemar in Bogotá), thereby significantly enhancing the ***w*** *market*'s mix of products (Tecniforest 1999, cited by DNP et al. 2020). Alongside these developments, the exports for sawnwood also escalated from 819 m³ (USD 0.54 thousand) in 1953 to 59,200 m³ (USD 2.8 million) in 1968, with a peak in 1964 at 82,100 m³ (USD 3.1 million) (Diot 1975), indicating a robust expansion of the international aggregates of the ***w*** *market*. The geographical locations of the manufacturing facilities mentioned can be seen in Figure 1.

Figure 1. Location for selected Colombia´s wood industry plants. Note: In capital letters Colombia´s Departamentos. Brown dots: Departamento´s capital cities. In green, capital cities and municipalities where a plant of the wood industry cited in this paper has been deployed. The pacific Region comprises lands in Departamentos of Chocó, Valle del Cauca, Cauca, y Nariño, limiting with the Pacific Ocean.

The expansion of the ***w*** *market* during the 1950s and 1960s is vividly reflected in the figures from the second industrial census of Colombia in 1954, the Manufacturing Annual Survey (MAS) of 1960, and the third industrial census of 1970 (DANE 1956; 1961; 1976). Capturing the growth, the 1954 census detailed 472 wood industry establishments with production valued at COP 41,4 million and a workforce of 4,251, contributing 4.2% to the total industrial establishments and 1.1% to manufacturing production, alongside 2.1% to employment within Colombia's industrial sector. By 1960, the landscape slightly shifted to 430 establishments, yet saw a surge in employment to 5,909. In that year, wood industry gross production amounted to COP 317,8 million. The trend of consolidation continued into 1970, with the industry narrowing down to 347 establishments, segmented into 249 sawmills and related mills, 32 in wooden and cane container manufacturing, and 66 in other wood product manufacturing, collectively employing 7,912 people and generating gross production of COP 606 million. This period marked the national wood industry's increased specialization and productivity, with this industry representing in that year 4.7% of all industrial establishments, 1.0% of the gross production, and 2.3% of the industrial employment in Colombia.

In the development and diversification of the ***w*** *market* until 1970, numerous factors closely tied to Colombia's economic performance and industrialization efforts, as documented by Berry and Thoumi (1975), were instrumental. Between 1900 and 1930, the ***w*** *market* reflected Colombia's broader economic landscape, predominantly satisfying local needs through "cottage shop production" establishments, which usually employed fewer than five workers. The noticeable surge in both consumption and domestic production of ***w*** between 1930 and 1945 aligned with the overall growth of the national economy and the expansion of the Colombian manufacturing industry that spurred by the events of the 1920s. The years of the 1920s are well known in Colombia by an unprecedented economic expansion of the country's economy — the highest in its history, according to Meisel-Roca et al. (2016) —, marked by a substantial shift towards modern, large-scale manufacturing, a preference for protectionism, expansion of the railroad system, a rapid increase in coffee exports, and significant capital inflow. During the 1930-1945, the sawmilling industry, along with other Colombian industries, also benefited from national protective measures in response to the global depression initiated in the US in 1929 and the impacts of World War II. The subsequent expansion and diversification of the ***w*** *market* in the 1950s and 1960s — closely associated with the rise of the national wood-based panel industry and the growth of the existing Colombian sawmilling industry— was largely due to Colombia's strategic shift

towards import-substitution industrialization, supported by import restrictions, governmental aid through bodies such as the Institute for Industrial Development (Instituto de Fomento Industrial, IFI, in Spanish) − which provided financial and technical support to companies, movement into more sophisticated and capital-intensive industries, a significant rise in foreign direct investment, export tax incentives, and the 1960s- second half "shifting towards a more balanced and even pro-export pattern".

The *w market* between 1970 and 2018

The period from 1970 to 2018 in the ***w*** *market* was defined by significant shifts in the demand and supply interplay. The market continued to expand, fueled by increases in domestic consumption of articles manufactured by the wood industry (***w***), accompanied by their active international trade, particularly in wood-based panels.

Demand and supply dynamics

Over the nearly five decades from 1970 to 2018, the market for ***w*** achieved a significant milestone, reaching a market value of 100,514 billion (USD 37 billion). This aggregate value comprised 108,703 billion (USD 40 billion) in consumption, 2,286 billion (USD 0.83 billion) in exports, and 10,443 billion (USD 4 billion) in imports. Concurrently, the supply of ***w*** totaled 112,896 billion (USD 41 billion), highlighting the market's robust economic activity.

This period marked a considerable expansion in both demand and supply for ***w***, as illustrated in Figure 2. The demand for ***w*** (Dw) experienced an average annual growth rate (AGR) of 4.2%, culminating in a six-fold increase to 3,082 billion by 2018. This growth in Dw was detailed across its components: consumption (Cw) at 4,099 billion, exports (Xw) at 119 billion, and imports (Mw) at 1,136 billion. Remarkably, Cw and Xw saw an eight-fold increase, while Mw surged by 183 times, with average AGRs of 4.8%, 14%, and 18.2%, respectively. The supply of w (Sw) paralleled this growth trajectory, registering a five-fold increase with an AGR of 3.9% over the 49 years, reaching 3,112 billion in 2018.

This substantive growth between 1970 and 2018 can be predominantly ascribed to the surge in the consumption of the manufactured products of the wood industry, reflecting Colombia's economic progress during this era. Significantly, Colombia's GDP per capita rose from USD 2,410 in 1970

to USD 6,321 in 2018, with values adjusted to 2010 dollars (2010USD) (World Bank 2023), illustrating the broader economic context underpinning these market dynamics.

Diving deeper into the decade-specific average annual growth rates (AGRs) provides an insightful understanding of the market's evolution. Dw, Sw, and Cw displayed similar growth patterns, with average AGRs fluctuating between -1.7% and 8.3%. In contrast, the growth rates for Xw and Mw were notably higher, ranging between 2.6% and 36.1%, as depicted in Figure 2 (panels b, d, f, h, j). The 1970s and 1990s saw Xw's growth marginally surpassing Mw's. However, the 1980s and 2000s witnessed Mw's AGR exceeding Xw's by about 10 percentage points (pp), with the 2010s showing a slight reduction in this gap to 7.5 pp. The subsequent subsections will delve into the complex interplay between Sw and Dw's components (Mw, Xw, and Cw) across these decades, offering comprehensive insights in monetary (for all aggregates) and physical (for Xw and Mw) metrics, thereby smoothly transitioning from a broad overview to detailed analyses of each component's role in shaping the market landscape.

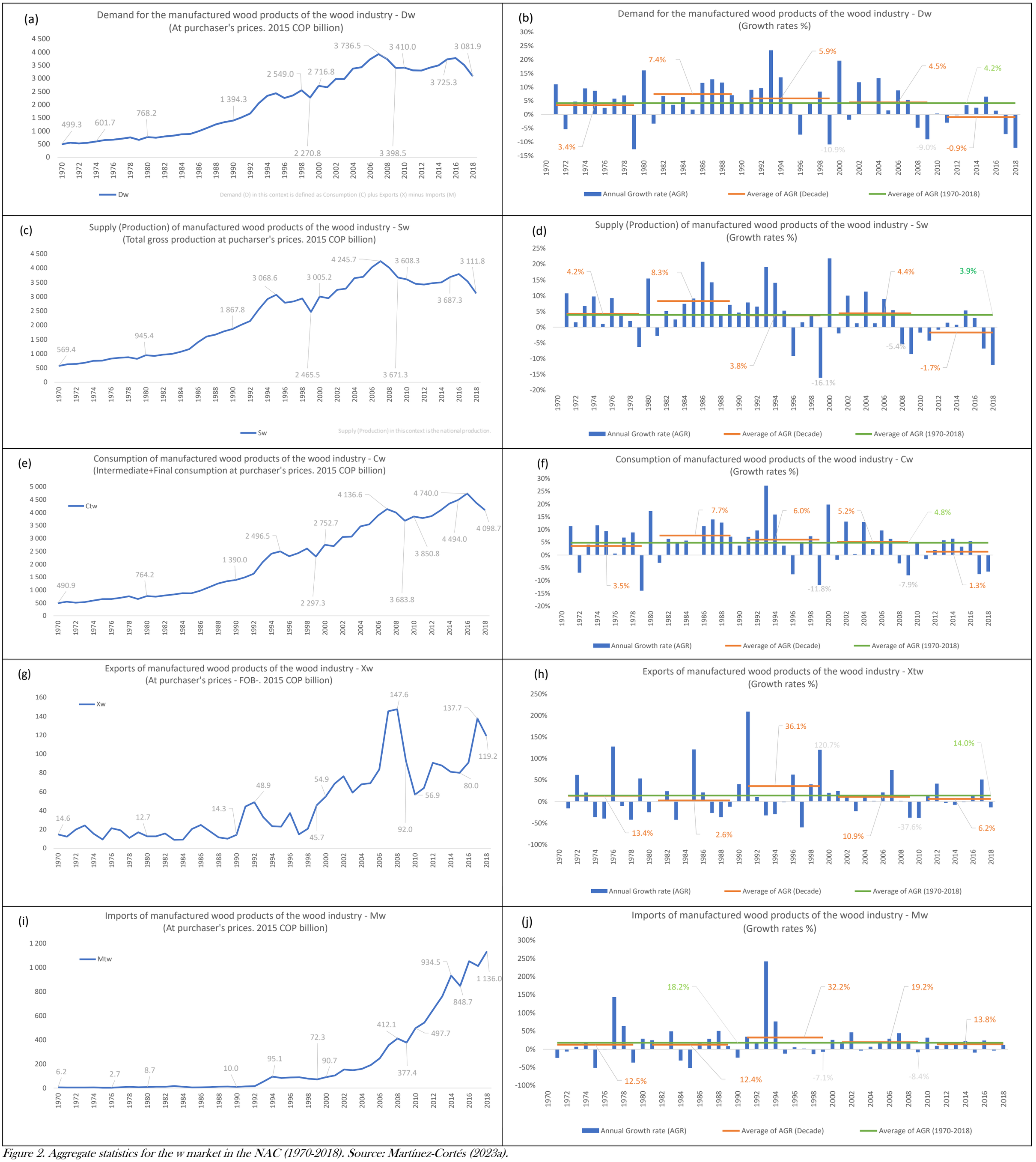

Figure 2. Aggregate statistics for the w market in the NAC (1970-2018). Source: Martínez-Cortés (2023a).

Supply and consumption dynamics

The 1970s

The dynamics of Sw's growth, which achieved an average AGR of 4.2% in the 1970s—outperforming Cw by 0.7 pp as shown in Figure 2 (panels d and f) — are primarily attributed to the burgeoning production within the national wood-based panels industry. This industry's growth effectively offset the decline in production from the Colombian sawmilling industry, which began to falter towards the decade's end. This downturn was precipitated by a scarcity of highly valued tree species (Tecniforest 1999, op. cit.), the enduring impact of export restrictions on certain wood species from natural forests mandated by Resolution 12, 1966, of the Foreign Trade Board of Colombia −Junta de Comercio Exterior of Colombia, JCEC, in Spanish − (JCEC 1966), and the reduction of export subsidies in 1975 (Ocampo 1987).

The statistics from the Manufacturing Annual Survey (MAS) (DANE 1971-1979), alongside the developments in the sawmilling and wood-based panel industries—the two principal segments of the wood industry—provide a clearer understanding of the situation described. As Figure 3 illustrates, there was a notable reduction in the wood industry's infrastructure between 1970 and 1979, coinciding with an increase in wood supply (Sw) during the same period, as detailed in Figure 2 (panels c and d). Specifically, the number of operational facilities (referred to as establishments or plants) employing ten or more individuals witnessed an 18% reduction, dropping from 231 to 190 establishments, as documented in Figure 3. This contraction was predominantly seen within sawmills employing ten or more workers, which declined from 183 in 1971 to 141 in 1979. In a more granular analysis conducted by Tecniforest (1999, op.cit.), an inventory identified 358 sawmills in 1972, evenly split between the Pacific Region and other Colombian regions, consuming 1,453,800 m^3/year. The capacity of these sawmills was categorized as follows: 25% were high production plants (processing 15 to 25 m^3/day), 22% were medium production units (10 to 15 m^3/day), and the majority, 51%, were low production establishments (processing less than 10 m^3/day). Notably, by the close of the 1970s, a significant number of these high-capacity plants

had ceased operations (Tecniforest 1999, op. cit.), indicating a pivotal shift in the industry's landscape.[3]

[3] The 1999 Tecniforest study omits specific measurement units. Typically, Colombian sawmills report consumption in roundwood and production in sawnwood. Some sawmills from the Tecniforest report were likely excluded from the MAS due to not meeting the minimum employee threshold of ten or because they were in remote forest areas, outside the survey's coverage.

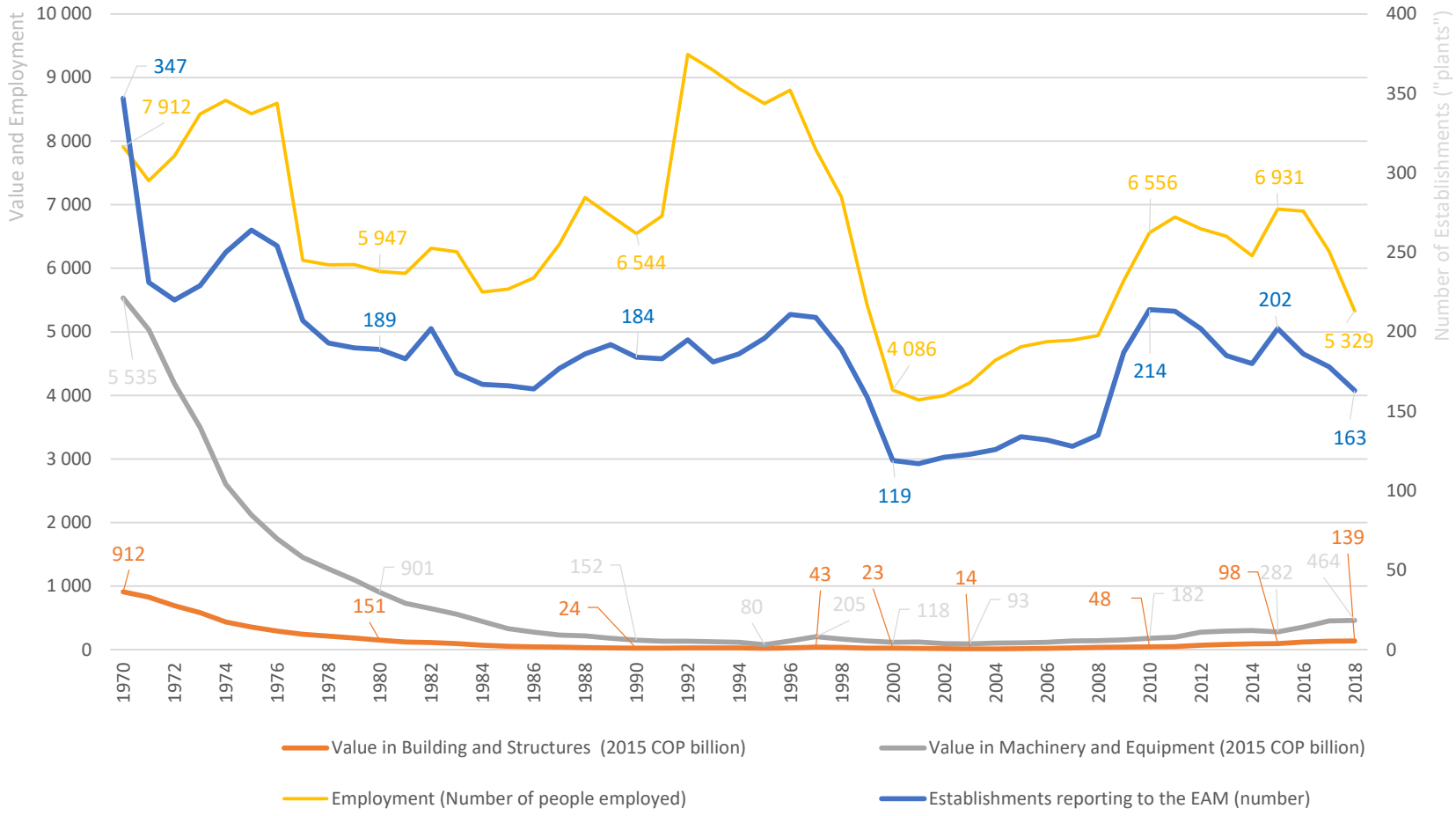

Figure 3. Colombia's wood industry indicators in the manufacturing annual survey. Source: Martínez-Cortés (2023a), based on DANE (1971-1979, 1980-1989, 1990-1999, 2000-2021).

In light of the contraction observed in the number of wood industry plants as recorded by the MAS between 1970 and 1979, the decline in operational facilities of the wood industry could have been more pronounced had it not been for the expansion within the wood-based panels industry. This growth phase introduced nine new plants, bolstering the production of veneers and plywood across Colombia, and mitigating the overall reduction in industry infrastructure. Key developments included the inauguration of Maderas y Chapas de Nariño in Tumaco, Proyecto Carare-Opón in Cimitarra by 1971, and Maderas de Riosucio in Riosucio by 1974, seamlessly integrating into Triplex Urabá. Bogotá emerged as a hub with three significant plants—Pricoma in 1976, Maderería Central in 1978, and Inversiones Omega, whose launch date remains unspecified. Additionally, Barranquilla welcomed Triplex Amazónico, specializing in plywood crafted from imported Peruvian veneers, while Medellín bolstered its industry with Muebles Scandfor and Muebles Hermes, both focusing on producing decorative veneers to meet internal demands (Tecniforest 1999 op. cit.). These strategic additions, alongside existing facilities from the '50s and '60s, culminated in a robust network of 16 operational wood-based panel plants by the decade's end. This network was diversely composed of thirteen plants focused on the production of both decorative and non-decorative veneers and plywood, two dedicated to the craft of particle boards, and one excelling in fiberboard production. Notably, Pizano and Codemaco, initially known for their plywood, expanded their repertoire to include particle board production lines, marking a dynamic evolution in the industry’s capacity and its strategic response to market demands.

The output from these new establishments significantly contributed to the increase in Sw, which by 1979 had risen to approximately 1.5 times its level from the start of the 1970s, as depicted in Figure 2 (panel c). This rise was also fueled by an increase in the Supply Price of $\boldsymbol{w}$ (PSw), which recorded an average AGR of 21.2% during the 1970s (Figure 4, panel b). As portrayed in Figure 2 (panels c, e, g, i), the national wood industry successfully met the escalating Cw during this decade, a period coinciding with an expansion of Colombia's GDP per capita by 1.3 to 2010USD 3,236 by 1979, and even managed to produce marginal surpluses for export.

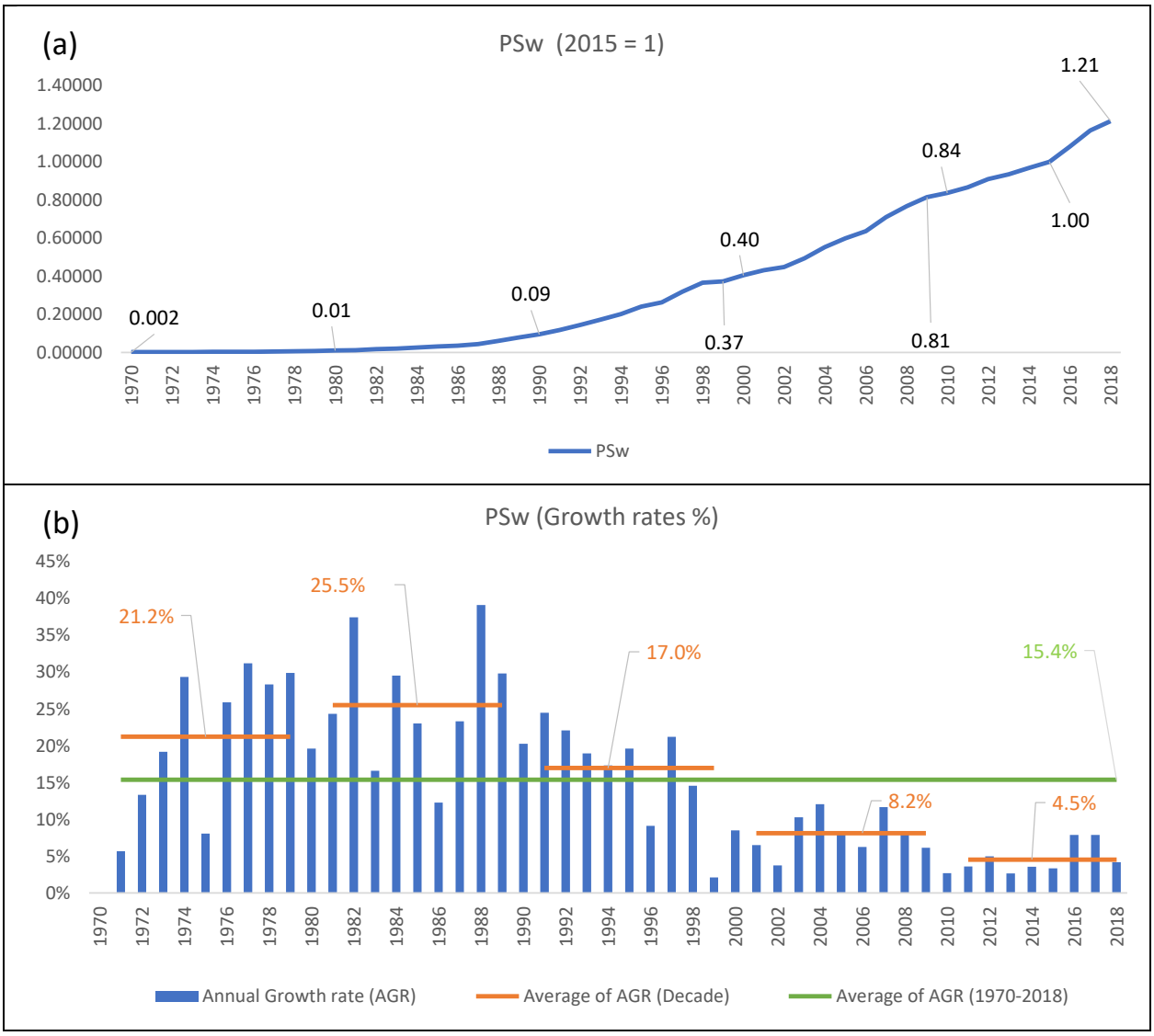

Figure 4. Supply price deflator for manufactured products of the wood industry (PSw). Source: Martínez-Cortés (2023a).

The 1980s

During the 1980s, Sw and Cw experienced a notable acceleration, growing at average AGR of 8.3% and 7.7% respectively, doubling the growth rates of the 1970s (Figure 2, panels d and f). The surge in Sw was propelled for an increase in the physical output of national wood-based panels industry resulting from its expansion and improvements in installed capacity utilization. The growth and optimization of this industry was stimulated by the implementation of trade policies for wood-based panels. As in the 1970s, the production of the national wood-based panel industry

effectively compensated for the continued decrease in production from the Colombian sawmilling industry.

The wood-based panel industry saw substantial growth with the addition of three key board plants early in the decade, a development pivotal for the industry's expansion: Codema in Cúcuta, focusing on veneers and plywood; Industrias Forestales in Bogotá, specializing in wood-cement boards; and Tableros de Colombia – Tablesa in Cali, known for its particle boards from sugarcane bagasse (Tecniforest 1999, op.cit.). Enhanced utilization of installed capacity within the wood-based panel industry was reported for the second half of the 1980s, with this industry reaching peak production levels after 1986 thanks to a 45% tariff on imports of wood-based panels introduced in 1983 and a 12% subsidy on exports from 1987 (Tecniforest 1999, op.cit.). This trade policies were part of the government's strategy to counteract the economic downturn that impacted Colombia in the early part of the decade, a challenge detailed by Ocampo (1987). This recession is closely linked to the observed decline in the number of wood industry establishments reporting to the Manufacturing Annual Survey (MAS) and the subsequent drop in employment until 1986, as illustrated in Figure 3. Moreover, the implementation of the tariff and subsidy is closely aligned with the recovery of these indicators towards the decade's end, ultimately restoring them to levels comparable to the decade's outset.

The national sawmilling industry, however, did not fare as well, with a notable contraction highlighted by the 1986 survey conducted by the National Institute of Renewable Natural Resources and Environment (Inderena, its acronym in Spanish), a former Colombian governmental agency cited by Techniforest (1999 op. cit.). This study revealed a notable decline to 300 sawmills, marking a decrease of 16% from the numbers recorded in 1972. Among these, only four were classified as high production facilities, a drastic reduction to merely 0.5% of the 1972 figure. The survey highlighted that of these sawmills, 168 were located in the Pacific Region, with a quarter of them either underutilized or completely inactive. The overall capacity utilization of these sawmills was estimated at 75%, culminating in an average annual production of 2,000 m^3 in 1986. This downturn in sawmill operations, compounded by the 1980 revelation that approximately 4,000 chainsaws had largely supplanted traditional sawmilling tasks (Techniforest 1999 op.cit.), underscored the precarious condition of the Colombian sawmilling industry during this era.

This additional decline of Colombia's sawmill industry is a key factor in understanding the patterns in the value of fixed assets within the wood industry, as illustrated in Figure 3. These trends are closely associated with the capital infusion into new plants and the refurbishment of existing ones. Investments directed to the three wood-based plants mentioned above were inadequate to offset the depreciating values in machinery and equipment and building and structures of sawmills that had been operational since the 1930s and 1940s, and the wood-based plants founded in the 1950s and 1960s. By the end of the decade, in 1989, the value in these categories of fixed assets had plummeted to 179 billion and 28 billion, respectively. This pronounced drop highlights the severe economic challenges the wood industry faced over the decade.

Despite the recounted challenges and state of the Colombian wood industry in 1980s, Sw multiplied approximately 2 times its level from the start of the 1980s (Figure 2, panel c). This growth, mirroring the trends of the 1970s, was propelled by an increase in national wood-based panel output and a rise in the PSw, this latter seeing an average AGR of 25.5% during the 1980s (Figure 4, panel b). Illustrated in Figure 2 (panels c, e, g, i), the surge in Sw throughout the 1980s adequately met the growing Cw, a demand buoyed by a 1.1-fold increase in Colombia's GDP per capita, from 2010USD 3,291 in 1980 to 3,619 by 1989 (World Bank 2023). Throughout this period, the national wood industry not only fulfilled domestic demand but also managed to produce marginal surpluses for export.

Before concluding our discussion on the 1980s, it's important to acknowledge the role of the treated (or impregnated) wood industry within Colombia's broader wood industry. Not previously mentioned, this segment has been a part of the ***w*** *market* since the 1960s. As such, data of Figure 3 includes national treated industry of which a comprehensive survey was conducted only up to 1987. This study revealed that in the survey's year Colombia had 11 establishments dedicated to wood preservation producing approximately 83,000 m^3, utilizing just 34% of their installed capacity. The treated wood industry was spread across the country, with facilities located in major cities—three in Bogotá, two in Medellín, one in Cali, one in Barranquilla—and one in each of the medium-sized cities of Ibagué, Tunja, and Tuluá. This data, provided by Motta et al. (1994) and cited by Tecniforest (1999 op. cit.), highlights an important yet underexplored aspect of the national wood industry's infrastructure and capacity during this period.

The 1990s

During the 1990s, the average AGR for both Sw and Cw was recorded at 3.8% and 6.0%, respectively, reflecting declines of 55% and 22% from their levels in the 1980s, as shown in Figure 2 (panels d and f). This downturn was significantly influenced by negative AGRs in 1996 and 1999, alongside subdued AGRs in 1997 and 1998. These fluctuations were primarily attributed to the internal real estate and banking crisis, which, according to Gil and Lemus (2015), had been developing since 1996-1997 due to restrictions on external financing and a steady rise in interest rates, culminating in Colombia's severe economic recession of 1998-1999—the most acute in decades, with the real GDP of 1999 dropping by 4.5% relative to 1998. Additionally, the economic liberalization efforts undertaken between 1990-1994 (Gil and Lemus 2015) and a shortage of raw wood (Tecniforest 1999 op.cit.) further exacerbated the ***w*** *market*'s challenges post-1995.

The economic events happening during 1990s had important implications for the national wood industry. Several establishments of the wood industry went out of business in 1999 when the economic downturn was at its deepest level. Data from the MAS (DANE 1990-1999) indicates that in 1990, there were 184 establishments in the wood industry employing 10 or more people, 145 of which were categorized as sawmills, planning, and other wood mills (Table 1). By end of 1999, these numbers had decreased to 159 and 128, respectively, highlighting the immediate impact of the economic crisis on the wood industry. The full impact of the economic recession and the other economic events of the 1990s will be presented in the subsequent section.

Table 1. Evolution of Colombia´s wood industry as per industrial census (1970) and manufacturing annual survey (1980 and 1990).

Industry Description and classification	1970					1980						1990					
	Establishments		Employment		Gross production	Establishments		Employment		Gross production		Establishments		Employment		Gross production	
	Number	Shares (%)	Number of Employees	Shares (%)	Value at basic prices (thousand COP)	Number	Shares (%)	Number of employees	Shares (%)	Value at basic prices (thousand COP)	Shares (%)	Number	Shares (%)	Number of Employees	Shares (%)	Value at basic prices (thousand COP)	Shares (%)
Wood industry	347	6.4	7,912	2.2	606,162	189	2.8	5,947	1.2	4,769,650	0.6	184	2.4	6,544	1.3	55,912,541	0.5
Sawmills, planning and other wood mills (G. 3311 for 1970-1999)	249	71.8	6,204	78.4	479,664	150	79.4	4,979	83.7	4,392,899	92.1	145	78.8	5,427	82.9	51,038,466	91.3
Manufacture of wooden and cane containers and small cane ware (G. 3312 for 1970-1999)	32	9.2	610	7.7	40,704	6	3.2	108	1.8	55,589	1.2	3	1.6	104	1.6	767,465	1.4
Manufacture of wood and cork products not elsewhere classified (G. 3319 for 1970-1999)	66	19.0	1,098	13.9	85,794	33	17.5	860	14.5	321,162	6.7	36	19.6	1,013	15.5	4,106,610	7.3
Manufactured wood (forest) products industry	706	13.0	22,681	6.4	3,762,568	542	7.9	25,086	4.9	36,140,037	4.6	572	7.6	27,333	5.5	519,543,150	5.0
Colombia's total manufacturing industry	**5,429**	**100**	**354,251**	**100**	**71,112,848**	**6,850**	**100**	**516,275**	**100**	**777,876,421**	**100**	**7,533**	**100**	**496,193**	**100**	**10,346,421,076**	**100**

Source: Modified from Martínez-Cortés (2023a), based on data from DANE (1976), DANE (1980-1989), DANE (1990-1999). G: Industrial Group. The 1970 census includes all establishments with five or more employees. For 1970, all establishments with <5 employees were investigated by sampling; however, figures in this table do not include them. Figures for 1980 and 1990 include all establishments with 10 or more employees. The figures might also include those establishments with less than 10 employees but with an annual gross production value of not less than some amount established by DANE each year of the Manufacturing Annual Survey (MAS). The MAS used Industrial Divisions, Groups and Classes from ISIC Rev.1 (1956-1979), ISIC Rev.2 (1980-1996) (DANE 2017). The total Wood Industry and Manufactured Wood (Forest) Products Industry shares in the table are related to Colombia's Total Manufacturing Industry. Shares for each division (industrial group) of the Wood Industry in this table are related to the Wood Industry. Gross production is in current values.

It is crucial to note that until 1999, the MAS data for the category of sawmills, planning, and other wood mills also encompassed facilities from both the wood-based panel and treated wood industries. This grouping poses challenges in isolating the economic impacts specific to each sector during the 1990s. However, the information that follows serves as a foundation for understanding the varied effects on these industries, providing essential context for a detailed analysis in the next section.

In 1993, Inderena conducted a survey of the sawmilling industry, revealing findings similar to the 1986 estimates: the presence of 300 mechanized sawmills across the country, nearly half of which (48%) were located in the Pacific Region. These sawmills had the capacity to produce 2.3 million m^3 of sawnwood annually, yet actual production was recorded at 1.2 million m^3. The wood-based panel industry saw the introduction of two new plants in the early 1990s, specifically for producing particle boards from forest plantation wood—Tablemac S.A. (now Duratex/Dexco) began operations in Manizales in 1992 and in Yarumal in 1997 (Duratex 2022). However, the decade was challenging for other wood-based panel plants reliant on wood from natural forests, many of which were forced to shut down due to supply issues (Tecniforest, 1999 op.cit.) concerning the quantity, quality, and reliability of raw wood. As for the treated wood industry, a 1994 report (Casas 1994, cited by Tecniforest 1999 op. cit.) indicated 14 establishments operating at about 35% of their installed capacity, estimated at 164,456 m^3 per year. This information is compiled in Table 2. It is noteworthy that since the period covered by the studies contributing to Table 2 until December 2023, there have been no further detailed national inventories for the national wood industry or the broader Colombian forest industry.

Table 2. Key data on Colombia´s wood industry in the 1990s (wood-based panels industry in 1999, treated wood industry in 1994, and sawmill industry in 1993).

Number and totals	Firm	City where plant is located	Main products obtained	Year that plant entered in operation	Installed capacity (m^3 of product/year)	Consumption (m^3 roundwood/year)
1	Acemar	Bogotá	Veneers and plywood	1960s	4 000	4 400
2	Triplex (Chapas) San Juan	Cali	Plywood	1991	1 750	1 900
3	Derivados Forestales	Tumaco	Plywood	1988	27 000	29 000
4	Inversones Omega	Bogotá	Veneers and plywood	1970s	5 000	900
5	Láminas del Caribe	Barranquilla	Fiber boards	Second half of 1950s	19 300	21 000
6	Madecen (Maderería Central)	Buenaventura	Plywood	1978	7 200	3 000
7	Pizano S.A. 1	Barranquilla	Veneers and plywood	1954	40 000	62 000
8	Pizano S.A. 2	Barranquilla	Particle boards	1963	130 000	150 000
9	Pricoma	Bogotá	Veneers and plywood	1976	3 000	2 200
10	Tablemac No. 1	Manizales	Particle boards	1992	38 000	111 000
11	Tablemac No. 2	Yarumal	Particle boards	1997	72 000	
12	Triplex Braun	Ibagué	Plywood	1974	3 500	2 700
13	Triplex Santander	Bucaramanga	Plywood	1960s	3 000	4 000
14	Triplex Rubarco	Bucaramanga	Plywood	1984	1 000	1 100
9	**Total Veneers and plywood**				**95 450**	**111 200**
1	**Total fiber boards**				**19 300**	**21 000**
4	**Total particle boards**				**240 000**	**261 000**
14	**Total wood-based panels industry**				**354 750**	**393 200**
14	**Total treated wood industry**				**164 456**	**57 560**
300	**Total sawmill industry (mechanized sawmills)**				**2 300 000**	**2 640 000**

Source: Martínez-Cortés (2023a). Modified from Tecniforest 1999. Data for Tablemac No.2 and year of starting operation was added to original source of Tecniforest. Installed capacity was obtained from an interview conducted in 2016 by Martínez-Cortés (2016). There is no data available for consumption in 1999, however this indicator captured in a 2016-interview reached 82,227 m^3 or underbark roundwood in 2015. Data for treated wood and sawmill industries was added to the original source of Tecniforest using the data published in that study. Consumption was estimated based on rate of use of installed capacity reported by Tecniforest and factors of conversions (1:1 for the treated wood and 1: 2.2 for sawmill). The year that the plant entered in operation for Triplex (Chapas) San Juan, Derivados forestales, Triplex Braun and Triplex Rubarco were handed out in 2023 by Gerardo Lozano who participated in the 1999-Techniforest study.

Before wrapping up the overview of the wood industry in the 1990s, it's essential to discuss the trends in fixed assets and employment presented in Figure 3. The values for buildings and structures and machinery and equipment continue to decline hitting their nadir in 1990 (24 billion) and 1995 (80 billion), respectively. These years corresponded with Tablemac's initial investments in their Manizales and Yarumal plants. The peak values for these asset categories were reached in 1997, at 43 billion (B) and 205B, respectively, shortly before the 1999 economic downturn. This downturn led to a reduction in the number of wood industry establishments with 10 or more employees to 159, employing only 5,422 people—a 44% decrease from 1992.

Despite the downturn in the latter half of the 1990s, Sw experienced a 1.3-fold increase (Figure 2, panel c). This rise can be attributed to the continued increase in the PSw, which saw an average AGR of 17% (Figure 4, panel b). Unlike previous decades, the national wood industry struggled to fulfill the Cw, which, in spite of the economic crisis, expanded by 1.6 times (Figure 2, panel e). This increase in Cw was supported by a growth in Colombia's GDP per capita from 2010USD 3,695 in 1990 to 3,953 by 1999 (World Bank 2023). To address the shortfall, Colombia significantly increased its imports of ***w***, which surged by sevenfold during the decade (Figure 2, panel i). Surprisingly, Xw saw a 3.7-fold rise during the 1990s (Figure 2, panel g). The reasons behind these substantial expansions are further discussed in subsection on *exports and imports dynamics (trade balance).*

The 2000s

In the 2000s, Sw and Cw continued to experience growth, with average AGR of 4.4% and 5.2%, respectively. This represented a slight increase of 16% for Sw and a decrease of 13% for Cw compared to their growth rates in the 1980s, as illustrated in Figure 2 (panels d and f). The growth in Cw was once again influenced by a significant 1.3-fold rise in Colombia's GDP per capita over the decade. However, the relationship between Cw growth and GDP expansion in the 2000s diverged from previous decades, indicating the start of a shift in Colombian consumer preferences away from manufactured products of the wood industry. This shift is explored by Martínez-Cortés et al. (2018), suggesting a changing dynamic in the ***w*** *market*.

To comprehend the growth in Sw during the 2000s, an examination of the Colombian wood industry's trajectory throughout the decade is essential. The onset of the 2000s was marked by continued challenges for the wood industry, including the closure of numerous establishments, a

decline in the value of fixed assets, and the period's weakest employment figures, as depicted in Figure 3. The aftermath of the 1999 economic crisis led to the closure of 42 wood industry units in 2000 and 2001, exacerbated by a sluggish recovery, diminished global prices for Colombian exports, and weakened domestic demand. The valuation of buildings and structures and machinery and equipment experienced a downward trend until 2003, hitting a nadir since 1997 at 14B and 93B, respectively, indicative of the minimal investments during and following the five-year impact of the 1999 economic downturn. Furthermore, employment within the wood industry reached its lowest in 2001, with only 3,929 individuals employed, highlighting the most significant employment slump since 1970.

Figure 3 illustrates a significant recovery in the number of wood industry establishments, employment levels, and the value of fixed assets after 2003. This resurgence was largely fueled by investments in new Wood Processing Plants (WPP) and the expansion of existing wood-based panel plants that weathered the 1999 economic crisis. The newly established facilities expanded beyond traditional sawmills to include advanced machinery and equipment that enhance wood value through processes such as kiln drying, preservation, molding, and finger-jointing. These advancements were predominantly geared towards processing wood from forest plantations.

A notable example of these new investments is the WPP of Núcleos de Madera, inaugurated in 2003 in Yarumal. This plant sources its wood from the pine plantations of Cipreses de Colombia, a pioneer in Colombian forest plantation since 1963 (Martinez-Cortés 2016). The facility boasts an immunization plant with a capacity of 12,000 m^3/year and a modern sawmill equipped with Brazilian and Swedish technology, capable of producing 30,000 m^3/year (Núcleos de Madera 2022). Another significant addition came in 2006 with the establishment of Refocosta's WPPs in Villanueva, Casanare, and Sabanas de San Angel, Magdalena, integrating sawmill operations, kiln drying, and wood immunization (Refocosta 2022; Velásquez 2016).

Further contributions to the wood industry's recovery include a small-sized sawmill launched by Pizano in Barranquilla in 2008, with a production capacity of 500 m^3/month across three shifts (Martinez-Cortés 2016), and a WPP initiated by Inmunizar around 2000 in Puerto Lopez, Meta (Inmunizar 2022). Both Refocosta and Pizano ventured into forest plantations in the 1980s and 1970s, respectively, with Inmunizar joining in the mid-1990s, showcasing a long-term commitment to a more sustainable wood sourcing (Martinez-Cortés 2016; Inmunizar 2022).

The expansion of the installed capacity within the wood-based panel industry saw significant investments from companies like Pizano and Tablemac, as detailed by Martínez-Cortés (2016). Pizano undertook several key projects, including the addition of a second production line for melamine impregnation and a melamine press in Barranquilla (2002), the consolidation of its Bogotá and Tocancipá facilities into a single plant in Tocancipá (2007), and the establishment of a power cogeneration plant in Barranquilla (2008). Tablemac, on the other hand, introduced a foil lamination line and a melamine paper impregnation plant in Guarne, Antioquia (2007), and embarked on setting up Colombia's first Medium Density Fiberboard (MDF) plant in Barbosa, Antioquia, in 2009. By the end of 2009, the landscape had shifted dramatically, with most companies in the wood-based panel market, as listed in Table 2, having ceased operations or stopped producing veneers and plywood.

Figure 3 indicates that the wood industry's establishments, employment levels, and the value of buildings & structures and machinery & equipment were relatively resilient in the face of the Colombian economy's next major challenge: the 2008-2009 downturn triggered by the global financial crisis and subsequent recession. Unlike previous economic shocks clearly reflected in the figures of the wood industry, the effects of this crisis were more discernible in the supply and demand (and its components) metrics of the ***w*** *market* (Figure 2). After a high in 2007, Sw and Dw saw a decrease of approximately 14% by 2009.

To wrap up the discussion on the 2000s, it's noteworthy that during this decade, Sw saw a 1.2-fold increase from its 2000 level, partially fueled by a rise in the PSw, which experienced an average AGR of 8.2% (Figure 4). However, this increase in Sw was insufficient to satisfy the growing Cw. Mirroring the trends of the 1990s, this shortfall was largely compensated for by a significant rise in imports, which quadrupled during the decade (Figure 2, panel i). On the export front, by 2009, levels were nearly equivalent to those of 2000, despite a steady rise until 2008 that saw exports increase by 1.5 times their 2000 figure (Figure 2, panel g). The dynamics underpinning these trends are explored in greater detail in subsection on *exports and imports dynamics (trade balance)*.

The 2010-2018 period

From 2010 to 2018, Cw saw growth, though at a rate markedly lower than in past decades, while Sw experienced its first decline. The average AGR for Cw and Sw were 1.3% and -1.7%, respectively (Figure 2, panel d and f). This shift led to a reduction in growth rates by 75% for Cw

and 139% for Sw compared to their performance in the 2000s, highlighting significant changes in the dynamics of the ***w** market* during this period. The continued expansion of Cw was influenced by a 1.3-fold increase in Colombia's GDP per capita from 2010 to 2018. The correlation between Cw's growth and GDP's expansion remained consistent with the 2000s, suggesting that the trend of substituting wood industry manufactured products persisted through 2010 to 2018.

To understand the decline in Sw from 2010 to 2018, a detailed analysis of the Colombian wood industry's development during this period is crucial, mirroring the approach taken for the 2000s. By 2018, the number of wood industry establishments and their employment levels, as surveyed by the MAS, reverted to the lows seen during the 1999 Colombian economic depression, despite a brief recovery to pre-crisis levels in 2010-2011. In contrast, the values of buildings and structures and machinery and equipment within these establishments experienced significant growth during 2010-2018, increasing by 190% and 155%, respectively, as shown in Figure 3. This notable growth was fueled by substantial investments in wood-based panels facilities and WPPs (the new wood processing plants replacing the old sawmills), spearheaded by companies with forest plantations. These developments are further elaborated on with insights from Martinez-Cortés (2016; 2021).

Dexco/Duratex (former Tablemac) pressed forward with its investments, culminating in the launch of its MDF plant in Barbosa in 2012. This facility boasts an impressive production capacity of 132,000 m^3/year, operating across three shifts daily, and consumes 180,000 m^3 of roundwood annually. In 2013, the company further augmented its operations with a new line for melamine impregnation and pressing linked to its MDF production. Similarly, Pizano advanced its growth strategy by inaugurating a third production line for melamine pressing in Barranquilla in 2012.

Smurfit Kappa, as of 2023 the sole producer of wood pulp in Colombia and a longstanding owner of forest plantations since the 1970s, diversified its portfolio by launching a small WWP in 2016, thus venturing into the sawnwood market. Additionally, a newcomer, Primadera, established a facility in Gachancipá (near Bogotá) in 2016 for producing Medium Density Particle Board (MDP), with an operational capacity of 180,000 m^3 of MDP per year over three shifts (La República 2016). Unlike its competitors, Primadera initially did not own forest plantations, sourcing wood from external plantations and utilizing recycled materials and sawdust from other industries. However, it is now developing its plantations, primarily in the Eastern Plains of Colombia, specifically in Departamento of Casanare. For the geographical locations of the cities,

towns, and Departmentos (an administrative and political division of Colombia) mentioned throughout the analysis in this paper, refer to Figure 1.

In 2013-2014, Maderas Cacerí, part of Reforestadora Cacerí which began its forest plantations in the early 2000s, embarked on establishing a WPP in Planeta Rica, Córdoba, within the Caribbean region of Colombia. According to Cacerí (2022) and Triana et al. (2019), this venture focuses on producing lumber, edge glued panels, kiln dried lumber, and premium doors, among other products, utilizing *Acacia mangium* wood.

Amid these advancements and investments, the wood industry also experienced significant challenges in the period 2010-2018. Notably, three of the industry's oldest wood-based panel plants, which had been established in the 1950s and 1960s by Pizano and Madeflex (the latter associated with Laminas del Caribe S.A., see Table 2), encountered insurmountable difficulties. These issues, stemming from prolonged raw wood supply shortages and financial strain, ultimately led to their shutdown. Pizano, in particular, faced bankruptcy in 2018, resulting in the closure of its Barranquilla operations, including facilities for veneers, plywood, particle boards, and sawmilling. Furthermore, in 2014, Madeflex discontinued its fiberboard production line (H. Bermudez, personal communication, June 25, 2022). The shuttering of these establishments ultimately reduced Colombia's wood-based panel production infrastructure to merely four plants: two dedicated to particle board manufacturing in Manizales and Yarumal, an MDF facility in Barbosa, and an MDP plant in Gachancipá, near Bogotá. As of January 2024, no additional wood-based panel factories had been established.

Concluding the analysis of the years 2010-2018, it is important to highlight that Sw declined by 13% from its level at the beginning of this period, primarily as a result of diminished production following the closure of numerous wood-based panel plants. This decline occurred despite the PSw showing an average AGR of 4.5% (Figure 4). Similar to the trends observed in the 1990s and 2000s, Sw was not adequate to meet the escalating demand for Cw. Furthermore, like in the previous decades, the gap was significantly bridged by an increase in imports, which surged by 2.3 times from 2010 to 2018 (Figure 2, panel i). In terms of exports, there was a notable increase, doubling the levels seen in 2010 by the year 2018 (Figure 2, panel g). The intricacies of these trends are further dissected in subsection on *exports and imports dynamics (trade balance)*.

To summarize the trends in supply and consumption for manufactured products of the wood industry from 1970 to 2018, it's crucial to observe the wood industry's diminishing role within Colombia's broader manufacturing landscape. Data from MAS reveals a marked reduction of the wood industry's share of total manufacturing establishments, employment, and gross production. Specifically, these proportions dropped from 6.4%, 2.2%, and 0.9% in 1970 to 2.1%, 0.8%, and 0.4% by 2018, respectively (refer to Tables 1 and 3). This significant decrease can be attributed to a combination of factors, including the dwindling availability of wood due to the exhaustion of Colombia's natural forests and the insufficient expansion of commercial forest plantations as viable alternatives (see Martínez-Cortés 2023a; 2023b for a detailed discussion on these issues) and the lack of substantial investment (as explained in the preceding sections).

Table 3. Evolution of Colombia´s wood industry as per the manufacturing annual survey (2000-2018).

Industry Description and classification	2000						2010						2018					
	Establishments		Employment		Gross production		Establishments		Employment		Gross production		Establishments		Employment		Gross production	
	Number	Shares (%)	Number of employees	Shares (%)	Value at basic prices (thousand COP)	Shares (%)	Number	Shares (%)	Number of employees	Shares (%)	Value at basic prices (thousand COP)	Shares (%)	Number	Shares (%)	Number of employees	Shares (%)	Value at basic prices (thousand COP)	Shares (%)
Wood industry	119	1.6	4 086	0.8	292,540,964	0.5	214	2.2	6,556	1.0	724,009,030	0.5	163	2.1	5,329	0.8	1,020,887,098	0.4
Sawmilling, planning and treating (immunization) of wood (C. 201 for 2000-2010, C. 1610 for 2018)	57	47.9	1,093	26.7	84,742,553	29.0	77	36.0	1,643	25.1	177,110,256	24.5	45	27.6	1,304	24.5	240,589,692	23.6
Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board and other panels and boards (C. 2020 for 2000-2010, C. 1620 for 2018)	13	10.9	1,528	37.4	143,997,603	49.2	20	9.3	1,762	26.9	338,610,980	46.8	15	9.2	1,158	21.7	504,285,645	49.4
Manufacture of builders' carpentry and joinery (C. 2030 for 2000-2010, C. 1630 for 2018)	22	18.5	724	17.7	42,121,533	14.4	39	18.2	1,301	19.8	83,704,672	11.6	53	32.5	1,483	27.8	131,836,232	12.9
Manufacture of wooden containers (C. 2040 for 2000-2010, C. 1640 for 2018)	14	11.8	361	8.8	13,041,054	4.5	45	21.0	1,184	18.1	85,396,876	11.8	34	20.9	998	18.7	115,237,520	11.3
Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials (C. 2090 for 2000-2010, C. 1690 for 2018)	13	10.9	380	9.3	8,638,221	3.0	33	15.4	666	10.2	39,186,246	5.4	16	9.8	386	7.2	28,938,009	2.8
Manufactured Wood (Forest) Products industry	669	9.2	34,537	6.5	3,828,199,613	6.3	878	8.8	44,028	6.6	8,066,115,537	5.2	647	8.2	46,418	6.5	13,224,199,385	5.1
Colombia's Total Manufacturing industry	**7,246**	**100**	**534,573**	**100**	**61,036,605,397**	**100**	**9,946**	**100**	**665,556**	**100**	**156,527,707,423**	**100**	**7,911**	**100**	**709,507**	**100**	**260,315,152,252**	**100**

Source: Modified from Martínez-Cortés (2023a) based on data from DANE (2000-2021). C: Classes of products. Figures include all establishments with 10 or more employees. The figures might also include those establishments with less than 10 employees but with an annual gross production value of not less than some amount established by DANE each year of the Manufacturing Annual Survey (MAS). The MAS used Industrial Divisions, Groups and Classes from ISIC Rev.3 and CPC Ver. 1.0 (1997-2011) and ISIC Rev.4 and the CPC Ver. 2.0, Adapted for Colombia (2013-2018) (DANE 2017; 2020). The total Wood Industry and Manufactured Wood (Forest) Products Industry shares in the table are related to Colombia's Total Manufacturing Industry. Shares for each division (classes of products) of the Wood Industry in this table are related to the Wood Industry. Gross production is in current values.

Exports and imports dynamics (trade balance)

From 1970 to 2018, Colombia transitioned from being a net exporter to a net importer of manufactured products of the wood industry (***w***). This shift occurred between 1983 and 1992 when the trade balance of ***w*** (TBw) displayed an intermediary behavior (Figure 5, panel a). In 1993, ***w*** imports and exports reached 54B and 33B, respectively, resulting in a negative TBw of -21B. Subsequently, TBw steadily increased to -1,017B by 2018, marking approximately a 48-fold surge over 25 years. TBw notably rose during the 2000s, with an average AGR close to 30%, nearly double the average AGRs observed in the 2010s (Figure 5, panel b). The substantial rise in negative TBw can be attributed to the challenges faced by Colombia's wood industry in meeting the escalating consumption of ***w***, this latter driven by the country's expanding population and rising income levels during this period, as discussed in the preceding subsection in monetary volumes.

In addition to monetary volumes, examining quantities traded for ***w*** in physical terms further elucidates the TBw dynamics. Export and import quantities for ***w*** and its primary product groups (wood-based panels and sawnwood) are depicted in Figure 6. This figure includes data not only for the period from 1970 to 2018 but also for preceding years for which FAO's statistics for Colombia are available. This comprehensive view of TBw aligns with the discussions presented in section *The w market before 1970*. For the sake of brevity, AGR graphs have been omitted from this paper.

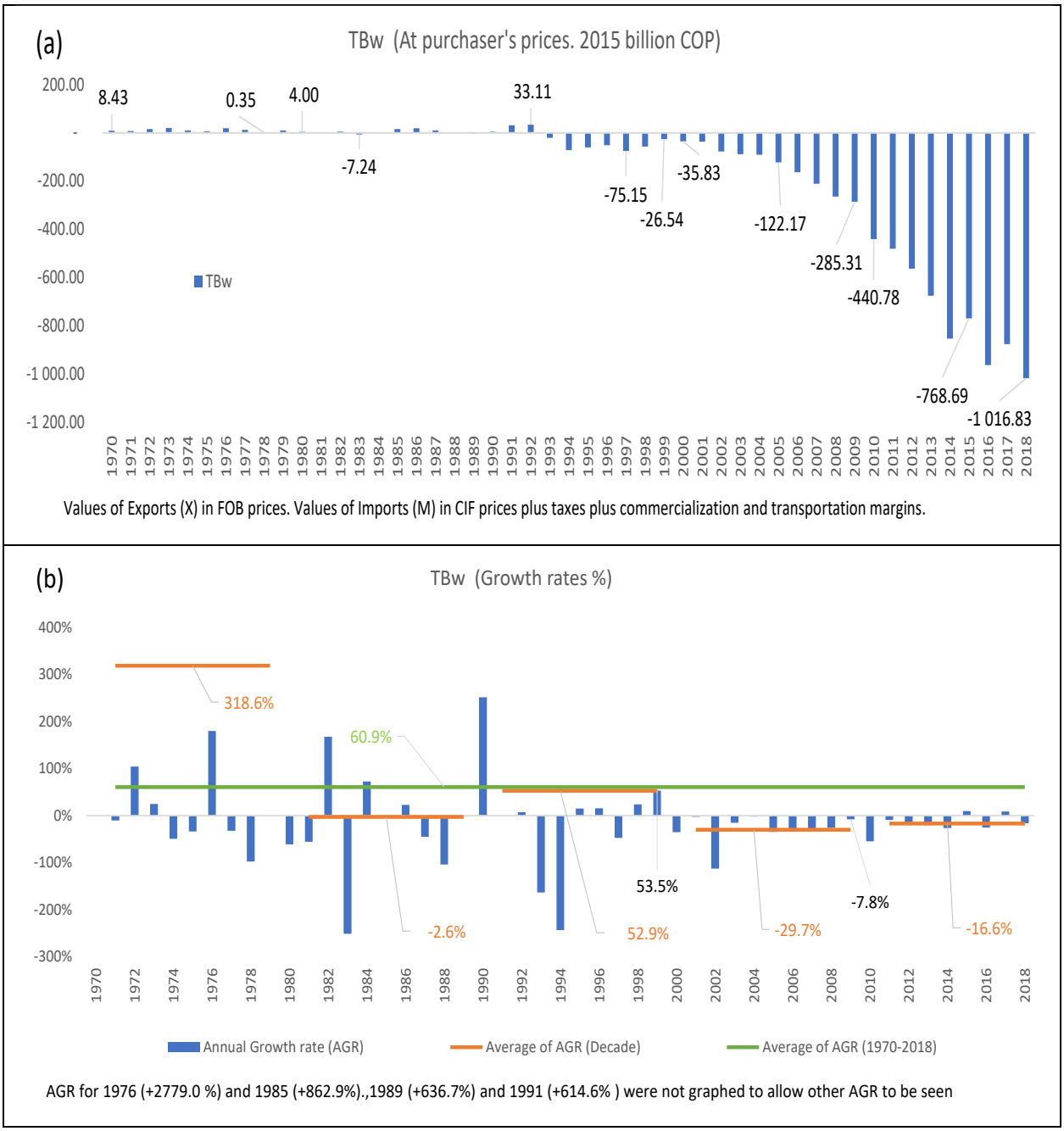

Figure 5 .Colombia´s trade balance for manufactured products of the wood industry (TBw). Source: Martínez-Cortés (2023a).

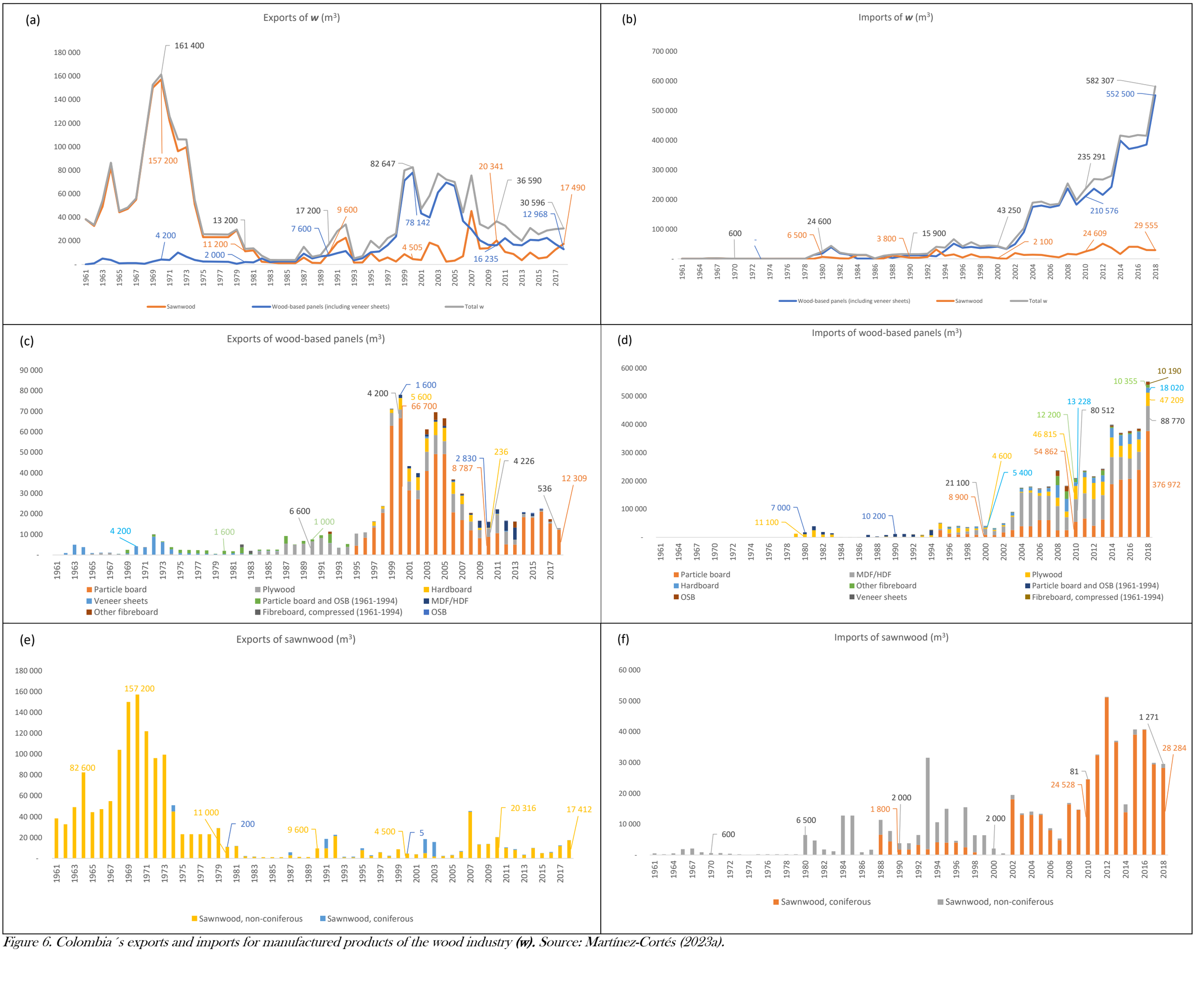

*Figure 6. Colombia´s exports and imports for manufactured products of the wood industry **(w)**. Source: Martínez-Cortés (2023a).*

Between January 1, 1961, and December 31, 2018, excluding pellets and other agglomerates measured in tons, Colombia's export and import quantities of ***w*** reached 2,493,073 and 5,331,931 m^3, respectively. During this period, 64.1% of the total quantity exported corresponded to sawnwood products, 35.8% to products classified as wood-based panels (including decorative and non-decorative veneer sheets), and 0.1% to wood residues, chips, and particles. Imports, on the other hand, comprised 11% sawnwood, 88.9% wood-based panels, and 0.1% wood residues, chips, and particles.

Sawnwood exports

Before 1982, Colombia predominantly exported sawnwood (Figure 6, panel a). These exports, primarily of non-coniferous species (Figure 6, panel e), saw a gradual increase since 1953 (not depicted in Figure 6), peaking in 1970 at 157,200 m^3 before sharply declining by 1975 to just 23,200 m^3—approximately 7-fold less than in 1970. The decline in the sawmill industry was the primary cause, as discussed in preceding subsections. Sawnwood exports continued to plummet to 2,300 m^3 in 1982, hitting a low point of 1,100 m^3 in 1984, coinciding with the peak of Colombia's sawmill industry crisis.

Post-1984, Colombia's sawnwood exports failed to recover. In their best years (1992, 2007, and 2010), they barely exceeded 20,000 to 45,000 m^3/year, akin to levels seen in the 1950s when the Colombian sawmill industry was nascent. For the most part, exports remained below 5,000 m^3 annually. Notably, over the past four decades, especially during the 2000s and 2010s, the majority of exported sawnwood, both non-coniferous and coniferous, originated from forest plantations (Martínez-Cortés 2023b).

Wood-based panels exports

Since 1982, Colombia has primarily exported wood-based panels (Figure 6, panels a and c), with exports resembling roughly half-scale images of its sawnwood exports. Between 1961 and 1998, wood-based panel exports, predominantly particle boards, plywood, hardboard, and veneer sheets, remained under 2,500 m^3. The peak years (e.g., 1972, 1992, and 1995-1998) saw exports reach levels of around 10,000 to 20,000 m^3. Significant growth occurred in 1999, peaking in 2000 at 78,142 m^3, almost four times the previous four decades' peak. Exports fluctuated between 30,000

and 70,000 m^3 from 2001 to 2007, before declining to the levels of the 1995-1998 period, i.e., between 10,000 and 20,000 m^3, and ultimately settling around 13,000 m^3 in 2018.

The surge in exports of wood-based panels during the 1960s and up to 1972, followed by subsequent trends throughout the 1970s, 1980s, and 1990s, can be attributed to several factors elucidated by Tecniforest (1999 op. cit.). In the 1960s, this growth was propelled by a surplus in national production, a favorable exchange rate for the Colombian peso (COP), and protectionism measures, such as the implementation of a Prior Licensing Regime for wood-based panel imports. Although Tecniforest did not explicitly mention income tax incentives for exporting firms and Tax Credit Certificate (CAT, its acronym in Spanish), these fiscal policies likely played a significant role in shaping export behavior during this initial period.

The income tax incentive, established in Colombia in 1961, provided an exemption from income tax on the profits earned by exporting companies, aimed at alleviating tax burdens on industries that had not previously engaged in exports (Cano 2003). Subsequent exchange rate and trade policy reforms in 1967 replaced this incentive with the CAT, which was applicable to exporters of commodities other than coffee and oil. The CAT amounted to 15% of the Free On Board (FOB) value of the export and was utilized for tax payments. Furthermore, CATs were exempt from taxation and could be traded. This new subsidy extended coverage to exporting firms with minimal or no profits that were not eligible for the incentive established in 1961 (Cano 2003).

During the second period (1973 to 1979), Colombia witnessed a decline in its international competitiveness in the global market for goods, prompting the removal of previous import licensing requirements for wood-based panels to adhere to the terms of the Pacto Andino trade agreement. This policy shift resulted in reduced export volumes. Moving into the third period (the 1980s), in 1983, Colombia invoked a safeguard clause within the Cartagena Agreement to reinstate the Prior License Regime for wood-based panels, particularly for imports originating from Pacto Andino member countries, while imposing a 45% tariff on imports from non-member nations. Additionally, starting from 1987, Colombia extended the Tax Reimbursement Certificate at a rate of 12% to all exports of particle boards. These protectionist measures and incentive policies largely contributed to a significant surge in the export quantities of wood-based panels from Colombia, experiencing a 15-fold increase between 1982 and 2000 (Figure 6, panel c).

The Cartagena Agreement, signed by Bolivia, Colombia, Ecuador, and Peru in Cartagena (Colombia) on May 26, 1969, is a foundational treaty that outlines the objectives of Andean integration, defines its institutional system, and establishes its mechanisms and policies. This agreement initiated the Andean integration process, initially known as the Andean Pact and now referred to as the Andean Community (Comunidad Andina 2022). Tax Reimbursement Certificates (CERTs, its acronym in Spanish) were introduced in Colombia in 1983 as flexible export support instruments designed to promote the export of goods and services, encourage diversification, and stimulate domestic industries and productive sectors, replacing the earlier CATs (Cano 2003). CERTs allowed negotiation and usage for the payment of various taxes, including Income and Complementary Taxes, Tariff Levies, Sales Tax, and other applicable fees and contributions. The CERT value was determined as a percentage of the export value, calculated based on the exchange rate at the time of shipment (Cano 2003).

The surge in exports of wood-based panels from 1999 to 2001 aligns with the backdrop of the Colombian economic crisis during that period. In response to the significant downturn in national consumption across various economic sectors, including wood-based panels, domestic producers pivoted towards exporting a substantial portion of their production. This strategic shift helped mitigate the impact of dwindling domestic demand.

Conversely, the prolonged decline in wood-based panel exports from 2001 to 2018 coincides with a concurrent uptick in imports of these products. This decline can be attributed to a combination of factors, notably the resurgence of domestic consumption coupled with the phasing out of the CERTs between 1998 and 2002. As national consumption for wood-based panels rebounded and the regulatory landscape evolved, the dynamics of import and export patterns shifted, contributing to the observed long-term decline in exports during this period.

According to Cano (2003), the dismantling of the CERTs was a topic of deliberation during the 1998–2002 Colombian Government. This decision was prompted by several factors: pressure from the World Trade Organization (WTO) to adhere to international agreements, fiscal challenges within the country, limited effectiveness perceived in the incentives provided by the CERTs, and a need to ensure fairness and non-regressiveness within the tax framework. The same study indicates that during the subsequent presidential administration (2003-2006), the percentage of CERTs was reduced to zero for all exported products. It's important to note, for those unfamiliar

with Colombia, that the WTO agreements referenced were part of the commitments arising from the Economic Openness initiative implemented by the Colombian Government between 1990 and 1994.

Imports of wood-based panels

Imports of wood-based panels in Colombia were virtually non-existent until 1978. FAO statistics reveal that from 1961, when data collection began for Colombia's forest sector in FAOstat, there were no recorded imports of wood-based panels (Figure 6, panels b and d). Even prior to 1961, data from the FAO yearbook of forest products (1947-1963) either indicated no imports of these products or reported figures below 500 m^3. However, from 1978 onward, the import quantity of wood-based panels witnessed a significant upswing, steadily increasing until the conclusion of 2018. In 1979, imports commenced at 13,100 m^3, reaching a peak in 1981 with 39,300 m^3. Subsequently, imports declined until 1983. With the implementation of protectionist and incentive policies in Colombia in 1983, imports plummeted drastically, decreasing by nearly 15 times to approximately 1,000 m^3 in 1984, and remained relatively low until 1993. Following the elimination of CERTs for exports to Bolivia, Ecuador, and Venezuela in 1994 to comply with the Cartagena Agreement regulations, wood-based panel imports, predominantly particleboards (PB) and plywood, tripled compared to 1993, reaching 27,347 m^3. The introduction of MDF/HDF and hardboards imports in 1995, combined with PB and plywood, totaled 51,200 m^3. From 1996 to 2001, imports of this composite mix of boards fluctuated between 33,300 and 41,100 m^3 annually, comparable in magnitude to the peak imports observed in 1981. The primary factors driving the surge in board imports after 1994 were the removal of protectionist and incentive policies, as documented by Cano (2003) and Nieto (2016), following Colombia's economic liberalization efforts that was more intense between 1990-1994, coupled with the domestic wood-based panel industry's inability to meet the escalating domestic demand for its products.

Nieto (2016) presented a comprehensive examination of the import liberalization process initiated in the 1970s, offering a more nuanced understanding of the evolution of wood-based panel imports in Colombia. During this period, there was a notable reduction in average tariff rates, declining from 50% in 1970-1976 to 26% by 1979, accompanied by the dismantling of other trade barriers such as import prior licenses. The proportion of products necessitating import prior licenses also decreased, from 46% in 1979 to 29% in 1982, coinciding with Colombia's definitive accession to

the General Agreement on Tariffs and Trade (GATT) in 1981. However, the pace of import liberalization slowed during the 1980s due to the debt crisis impacting Latin American nations. In the 1990s, a renewed impetus for trade liberalization emerged, aiming to boost exports and their contribution to GDP, while also facilitating access to raw materials and capital goods to enhance the productive capacity of the national industry. This renewed focus resulted in further tariff reductions, notably in 1990, with tariff levels dropping from 23 to 9 and the average nominal tariff decreasing from 26.6% to 21.1%. Subsequently, in 1992, another round of tariff reductions saw levels decline to 4 and the average tariff plummet to 11.7%.

As depicted in Figure 6 (b) and (d), the import volume of wood-based panels experienced a notable increase in 2001, multiplying by 1.5 in 2002 and nearly doubling in 2003 and 2004 compared to previous years, culminating in a total of 175,772 m^3 in 2004. This heightened level of imports persisted at a similar magnitude until 2007 and continued to ascend, reaching 339,500 m^3 in 2014. This trend endured until 2017, a year preceding its peak at 552,500 m^3. The surge in wood-based panel imports can be attributed to two primary factors: a) significant reductions in trade barriers, as highlighted by Nieto (2016), primarily aimed at simplifying tariff schedules and lowering average nominal tariffs, implemented in 2004, 2006, and 2011; and b) the inability of the wood-based panel industry to meet the burgeoning national demand for its products, as discussed in preceding sections.

To gain insight into the ongoing import liberalization in Colombia throughout the 2000s and 2010s, Nieto (2016, p. 87) provides data on tariff schedule levels and reduced average nominal tariffs for Section IX, encompassing wood and its manufactures, wood charcoal, cork, and their manufactures within the Harmonized System. The reported figures are as follows: for the period spanning 2001-2004, tariff schedule level stood at 98 products, with an average nominal tariff of 12.3%; from 2005 to 2006, the levels remained consistent at 98 and 12.3%, respectively; from 2007 to 2011, there was a slight increase to a tariff schedule level of 107 and an average nominal tariff of 12.5%; and since 2012, both the tariff schedule level and average nominal tariff have seen further reductions, reaching 108 and 7.5%, respectively.

Imports of sawnwood

Imports of sawnwood mirrored the trend observed in wood-based panels, with negligible levels until 1978. Prior to this, FAOstat recorded imports fluctuating between 200 and 900 m^3 annually,

with occasional spikes around 2,000 m^3 in 1966 and 1967 (Figure 6, panels b and f). Similarly, data from the FAO yearbook of forest products (1947-1963) indicate minimal or absent sawnwood imports before 1961, typically less than 500 m^3.

Following 1978, sawnwood imports experienced a substantial surge, continuing to rise on average until the end of 2018. Notably, in 1980, imports soared to 6,500 m^3 from a mere 200 m^3 the preceding year. However, import quantities after 1983 displayed less regularity compared to wood-based panels. On average, between 1984 and 1993, imports grew before declining from 1994 to 2001. Peaking at 31,548 m^3 in 1993, imports subsequently plummeted to a low of 500 m^3 in 2001, coinciding with the Colombian economic crisis of 1999. The reasons behind the 1993 peak remain unclear, though they may be linked to tariff reductions in 1990 and 1992, alongside prolonged challenges faced by the sawmill industry in meeting domestic demand. As elaborated in preceding sections, the industry struggled to satisfy Colombian consumption requirements in terms of quality, quantity, and timeliness, a predicament persisting to date (December 2023).

With exceptions in 2006 and 2007, when Colombia imported 8,665 and 5,366 m^3 respectively, import quantities fluctuated between 13,000 and 20,000 m^3 annually. Reforms to Colombia's tariff regimes in 2001, 2004, and 2006 likely influenced positive changes observed in the 2000s. Notably, in 2010, sawnwood imports multiplied by 1.7 compared to the preceding year, setting a new annual import level ranging between 24,000 and 41,000 m^3, except for 2014, when imports were 16,436 m^3.

Additionally, a notable observation from Figure 6 (f) pertains to the species composition of sawnwood imports. Since 2002, imports have predominantly consisted of coniferous species, contrasting with the more balanced mix of coniferous and non-coniferous species prevalent in the late 1990s and early 2000s.

Indications of clearing in the market for manufactured products of the wood industry

As part of the ***w*** *market* evolution, we utilized its extensive consolidated dataset to conduct an analysis of its clearing dynamics, providing insights into the long-term equilibrium of this market. This holds significant importance due to its implications for policy-making (Buongiorno and Uusivuori 1992; Hänninen 1998; Nanang 2000; Yin and Baek 2005; Shahi et al. 2006; Jaunky and Lundmark 2015; Da Silva et al. 2022).

A strict interpretation of the market clearing condition (MCC) dictates that the values of supply should equal those of demand, resulting in a zero difference between the two. Following this, the ***w*** *market* did not achieve clearing between 1970 and 2018. Throughout this period, supply (S) and demand (D) for ***w*** remained notably disparate (see Figure 7, panel a). The gap between S and D fluctuated, ranging from 70B in 1970 to a peak of 633B in 1995, before gradually diminishing, reaching a minimum of 4.4B in 2014 (Figure 7, panel b).

By relaxing the strict interpretation of the MCC to allow for values close to zero, and employing relative values of the Unbalance of MCC (UMCCw) as an alternative to absolute ones, one could argue that the ***w*** *market* approached clearing conditions during the period 2013-2018, with UMCCw varying between 1.8% and -1.0% (Figure 7, panel c). This interpretation considers these values to be sufficiently proximate to zero.

However, under a less stringent interpretation of the MCC, what constitutes "proximate to zero" may vary among researchers and readers. Those adhering more closely to orthodox interpretations might view the average UMCCw for the 2010s and 2000s, ranging from 3.0% to 8.1%, as evidence against market clearing, especially when considering the annual dispersion shown in panel (c) of Figure 7, which oscillated between -1.0% and 5.5% in the 2010s and between 6.9% and 9.6% in the 2000s. Others may argue that the data for the 2010s indicate market clearing, but not necessarily for the 2000s. Less strict interpreters of the MCC might even consider the data for the 2000s as evidence of a cleared market. For most observers, acceptance of market clearing for years preceding 1998, when UMCCw varied annually between 12.1% and 30.1%, appears less plausible.

A crucial insight drawn from Figure 7, panel c, is that UMCCw rates since 1998 suggest an increasingly competitive ***w*** *market*, although not necessarily a perfectly competitive one. This finding aligns with the theoretical limitations of the MCC, which strictly applies to markets for homogeneous products (Delcourt 1955; Murray and Prestmon 2003). Given that the ***w*** *market* comprises various non-homogeneous products such as sawnwood, MDF, MDP, fiberboards, clapboards, shakes, drawers, and pallets, among others, the MCC need not be strictly satisfied for the aggregate ***w*** *market*.

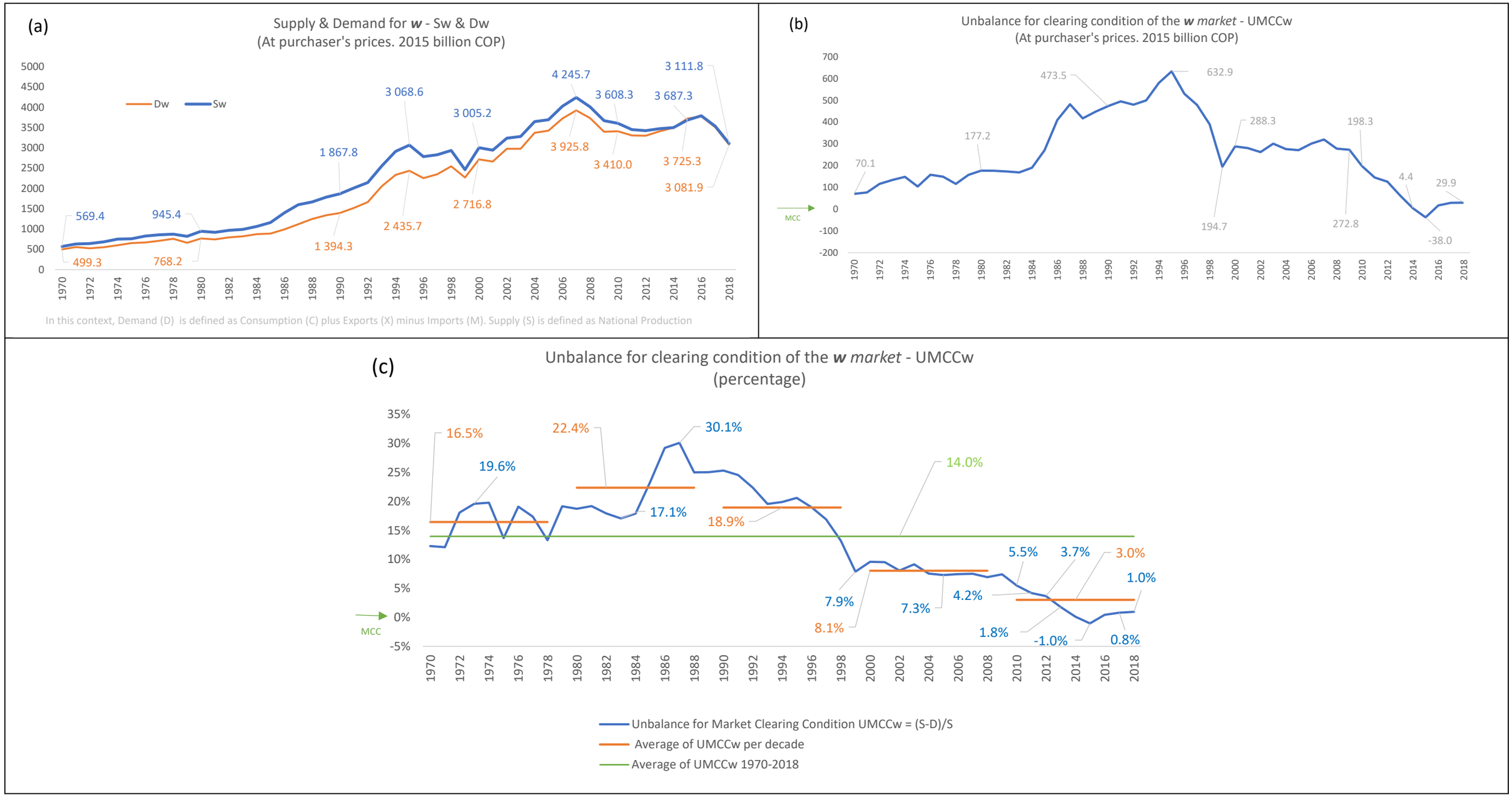

*Figure 7. Clearing in the **w** market. Source: Martínez-Cortés (2023a).*

The *w market* between 2019 and 2021 and the Covid-19 pandemic shock

From 2019 to 2021, the COVID-19 pandemic swept across the world, impacting most countries with severe lockdowns and restrictions that disrupted nearly all markets for goods and services. Colombia's market for manufactured products of the wood industry was not immune, as evidenced by the key statistics presented in tables 4 and 5. In 2020, when the pandemic had its harshest economic effects, supply, consumption, imports, and exports of ***w***, and the number of employees in the wood industry all plummeted, by 8.7%, 12,2%, 13,2%, 16,1%, and 5,3% respectively, compared to 2019 (column 5 of Table 4). In the same year, export and import prices were also importantly affected, increasing by 12.8% and 8.1%, respectively, compared to 2019. This upward trend aligns with observations in several countries for the market for manufactured products of the wood industry, particularly sawnwood and wood-based panels, where prices continued to soar throughout 2021 (ITTO 2021; 2023; UNECE/FAO 2021; 2022).

It appears the impacts of COVID-19 on the Colombian wood industry and the ***w market*** were short-lived in terms of overall indicators. Both experienced significant growth in 2021, with the market supply, consumption, exports, and imports rising by 20-30% and the industry employment by 4.4% (Table 4, column 6). These increases brought the market back to its 2018 levels (see section *The w market between 1970 and 2018*) and the industry's labor statistics close to its 2019 level (see Table 4). Most of the increase in the ***w market*** in 2021 may be attributed to the upsurge of Colombia’s residential and non-residential building construction and manufacture of furniture activities which, as per DANE (2023c), grew 14.8% and 28.8% respectively.

However, considering the ongoing pandemic in 2021, these statistics alone may not fully capture the crisis's complete impact on the ***w market*** and the Colombian wood industry. Specifically, for Colombia's forest sector, two concerning trends emerge from Table 4: the continued increase in import prices (with an $AGR_{2021\text{-}2020}$ of 19.1%) and the rising of the import value of ***w*** (by 29%).

This growth in import value is not solely explained by price increases but also by an increase in the physical volume of imported wood-based panels (Table 5). After falling from 552,500 m^3 in 2018 to 397,771 m^3 in 2019, the volume significantly rebounded to 426,208 m^3 in 2020 and to 552,989 m^3 in 2021. The earlier decline in imports of the three main types of panels imported to Colombia (PB, MDF/HDF, and Plywood) shown in Table 5, along with the fall in supply, consumption, and exports of ***w*** in Table 4 during 2019, can be attributed to two factors: the 3.9%

decline in the Colombian construction sector that year (DANE 2023c) and the closure of Pizano S.A., one of Colombia's largest panel producers, in 2018.

*Table 4. Main indicators of Colombia's market for **w** and wood industry.*

Variable Name and Symbol	Value (2015COP billion)			Annual Growth rate - AGR (%)		
	2019	2020	2021	2019-2018	2020-2019	2021-2020
Supply – Sw	2,883.3	2,633.5	3,395.9	-7.3	-8.7	29.0
Consumption - Cw	3,984.5	3,499.0	4,562.8	-2.8	-12.2	30.4
Exports – Xw	97.3	81.6	99.2	-18.3	-16.1	21.6
Imports – Mw	1,202.2	1,043.2	1,346.0	5.8	-13.2	29.0
Demand – Dw	2,879.6	2,537.4	3,316.0	-6.6	-11.9	30.7
Unbalance of Market Clearing Condition - UMCCw (Supply - Demand)	3.7	96.1	79.9			
Unbalance of Market Clearing Condition as percentage of Supply UMCCw [(Supply - Demand)/Supply]	0.1	3.6	2.4			
Capital of the wood industry - Kw (Value of Machinery and Equipment in the MAS)	493	513	not available	6.3	4.2	not available
Capital of the wood industry - Kw (Value of Building and Structures in the MAS)	146	154	not available	5.0	5.8	not available
Labor of wood industry - Lw (Number of employees as reported in the Annual Manufacturing Survey - MAS)	5,015	4,750	4,958	-5.9	-5.3	4.4
Establishment reporting to the MAS (number)	149	141	141	-8.6	-5.4	0.0
Supply price deflator - PSw	1.343	1.389	1.517	10.7	3.5	9.2
Consumption price deflator - PCw	1.261	1.322	1.484	8.9	4.8	12.2
Export Price Deflator – PXw	0.956	1.078	1.109	4.5	12.8	2.8
Import Price Deflator – PMw	0.971	1.050	1.257	3.1	8.1	19.7

Based on data from DANE (2023a) and DANE (2000 – 2021).

Table 5. Colombia's trade balance for manufactured products of the wood industry.

Product traded	2019		2020		2021	
	Imports	Exports	Imports	Exports	Imports	Exports
Particle board (m^3)	261,741	2,601	278,754	1,946	354,606	1,946
MDF/HDF (m^3)	59,962	236	63,807	118	136,387	368
Plywood (m^3)	40,684	304	35,508	293	33,790	279
Hardboard (m^3)	11,162	9	9,556	-	10.829	-
Other fiberboards (m^3)	21,627	32	33,389	553	3,226	553
OSB (m^3)	1,515	40	4,254	258	13,322	389
Veneer sheets (m^3)	1,080	1	940	-	830	15
Wood chips and particles (m^3)	54	8	74	-	67	
Other agglomerates (tons)	37	496	49	1,414	41	1,193
Sawnwood, coniferous (m^3)	28,705	139	23,965	62	43,839	476
Sawnwood, non-coniferous all (m^3)	1,188	17,481	926	18,934	696	14,775
Wood residues (m^3)	43	25	13	-	17	29
Wood pellets (tons)	27	84	4	20	-	91
Wood-based panels, including veneer sheets (m^3)	397,771	3,223	426,208	3,168	552,989	3,550
Sawnwood (m^3)	29,893	17,620	24,891	18,996	44,535	15,251
Wood residues and wood chips and particles (m^3)	97	33	87	-	85	29
Other agglomerates and wood pellets (tons)	64	580	53	1,434	41	1,284
Total trade of manufactured products of the wood industry (m^3), excluding Other agglomerates and wood pellets	**427,761**	**20,876**	**451,186**	**22,164**	**597,609**	**18,830**

Based on data from FAOSTAT, FAO (2023).

SUMMARY

Our analysis traces the evolution of Colombia's market for manufactured products of the wood industry (***w*** *market*), particularly in wood-based panels and sawnwood, the two main product categories. Initially focused on domestic production and consumption due to limited infrastructure and economic development, the market evolved post-1950. Driven by post-WWII industrialization policies implemented in Colombia to replace imports which later after 1965 shifted towards exports (Berry and Thoumi 1977), the 1950s and 1960s witnessed growth in the national sawmilling industry and the emergence of the Colombian wood-based panel industry, leveraging Colombia's rich natural forests. This period saw rising domestic production and consumption of manufactured products of the wood industry (***w***), with modest expansion of its exports (almost entirely sawnwood). By 1970, the market value, in 2015COP at purchaser's prices, stood at 491 billion in consumption, 569 billion in supply, 15 billion in exports, and 6 billion in imports. These figures have grown significantly by 2021, multiplying by factors of 9.3, 6.0, 6.6, and 224.3 respectively, soaring to 4,563 billion, 3,396 billion, 99 billion, and 1,346 billion, correspondingly. Expansion in consumption reflected Colombia's economic growth, which saw GDP per capita increase, in 2010USD, from 2,410 in 1970 to 6,423 in 2021 (World Bank, 2023).

However, between 1970 to 2021 a structural issue emerged: the national wood industry, chiefly comprised by the sawmilling and wood-based panel industries, struggled to keep pace with domestic demand. In the 1970s, 1980s, and 1990s, the national wood industry mostly met domestic needs despite challenges. The 1970s saw the wood-based panel industry expand, particularly in veneer and plywood production. Conversely, the sawmilling industry experienced a decline, exacerbated by an increasingly severe shortage of preferred tree species that began in the 1960s, further compounded by both export restrictions on certain tree species under JCEC's Resolution 12 of 1966 and the reduction of export subsidies in 1975. By 1979, sawnwood exports had dropped from significantly, from its peak of 157,200 m^3 in 1970 to 29,100 m^3 −a level rarely surpassed in the years since. During the 1970s, imports and exports for sawnwood and wood-based panels in m^3 were 2,800 and 647,900, and 13,100 and 38,510, respectively.

In the 1980s, the sawmilling industry continued to decline due to an even greater shortage of wood from the natural forest, which extended to all type of species not only the most valuables, coupled

with the already for three decades low investment in its machinery and equipment, and building and structures. To meet the domestic demand of sawnwood, Colombia started to import timid volumes of it (around 13,000 m^3 for the years of major imports). Meanwhile, the wood-panel industry continued to expand, and its production and international trade peaked and expanded, respectively, driven by the imposition as of 1983 of a tariff of 45% on the imports of wood-based panels, and of a subsidy of 12% on its exports as of 1987. During the 1980s, imports and exports for sawnwood and wood-based panels in m^3 had shifted to 61,600 and 38,900, and 114,200 and 39,800, respectively.

In the 1990s, three key developments significantly impacted Colombia's sawmill and wood-based panel industries: the intensifying scarcity of raw wood from national natural forests, the economic liberalization from 1990 to 1994, and the severe economic recession of 1998-1999. These factors contributed to the ongoing decline of the sawmill industry and had the wood-based panel industry struggling. By 1993, industry data showed 300 mechanized sawmills, with nearly half in the Pacific Region (the same installed in 1950 and 1960s), but a reduced output compared to their capacity (50% or less). By 1999, at least 22 of these sawmills had ceased operations and many wood-based panel plants relying on natural forest wood had to shut down or reduce operations due to wood supply issues. Only a former wood-based plant (Pizano) that changed its wood procurement to forest plantations and two plants that started operation in 1992 and 1997 (Tablemac in Central Colombia) for producing particle boards from forest plantation wood had a better position at the end of the decade. The three of them directed part of their supply of panels to the international market as palliative of the recession impact, which allow exports of panels to increase around 70.000 m^3 by 1999. During the 1990s, imports and exports for sawnwood and wood-based panels in m^3 had importantly risen to 104,150 and 122,895, and 275,468 and 210,096, correspondingly.

The decade of 2000s began with the closure of numerous plants of both sawmill and wood-based panels industries and a decline in the national wood industry's overall value of fixed assets and employment, largely due to the lingering effects of the 1999 economic crisis. However, after 2003, there was a notable recovery. This resurgence was driven by investments in new wood processing plants (WPP) and the expansion of existing wood-based panel plants, adapting to process wood

from forest plantations, which became more available.[4] Key developments for the sawmill industry included the establishment of Núcleos de Madera's WPP in 2003 (central Colombia) and Refocosta's operations in 2006 (Eastern Colombia), marking a shift towards what was trusted as a more sustainable source of wood, forest plantations. Additionally, major players like Pizano and Tablemac (Duratex/Dexco) expanded their capacities, signifying a renewed vigor in the industry despite the closure of many firms in the veneer and plywood sector by 2009. However, the supply provided by both industries´ expansions of installed capacity was insufficient for meeting domestic consumption and Colombia had to resort to imports of sawnwood, and specially of wood-based panels. During the 2000s, imports and exports, in m^3, for sawnwood were similar to the 1990s (108,704 and 127,766) and had substantially went up (especially imports) to 1,345,282 and 462,691, respectively.

Finally, the 2010s and the early 2020s brought mixed fortunes for Colombia's sawmill and the wood-based panel industry. Significant investments happened during the 2010s in both industries, included Duratex's MDF plant (132,000 m^3 MDF/year of production capacity – p.c.), Primadera's MDP (180,000 m^3 of MDP/year of p.c.), the only Colombian woodpulp producer Smurfit Kappa's entry into the sawnwood market with a small sawmilling (the three in Central Colombia), and a medium size WWP of Maderas Cacerí in Northen Colombia. These investments indicate a shift towards more specialized and high-capacity production facilities, all of them procuring wood from forest plantations. Disinvestment in the wood-based panel industry also happened with the closure of Madeflex (2014) and Pizano (2018), the only pre-1990 panels plants that had survived until 1999. These disinvestments, along with the still insufficient investment in both industries, help to explain why, during the 2010s, imports of both sawnwood and wood-based panels multiplied by 4.0 and 3.5, respectively (in physical terms, compared to the level of 2000s), even though the consumption of ***w*** only grew marginally (0.9% in monetary value) during the decade due to the slowdown of Colombia's economy after 2015. During the 2010s, imports and exports for sawnwood and wood-based panels, in m^3, were 432,408 and 112,254, and 4,768,045 and 169,168, respectively, meaning that Colombia had become import-dependent for meeting the domestic consumption of ***w***.

[4] For a details on the evolution of Colombia's commercial forest plantations refer to Martínez-Cortés (2023b)

The COVID-19 pandemic in 2020 further disrupted not just the Colombia's sawmill and wood-based panel industries but the whole wood industry and the entire ***w*** *market*, leading to significant declines in the annual growth rates across supply (-8.7%), consumption (-12,2%), imports (-13,2%), and exports (-16,1%), and the employment of the wood industry (-5,3%). However, 2021 saw a remarkable rebound, with the market and employment levels recovering to near 2018 levels, driven by the increase in Colombia's residential and non-residential building construction and the manufacture of furniture activities. This period highlighted the industry's resilience and adaptability in the face of global economic challenges, although the full impact of the pandemic remains to be fully understood. Facts presented in this summary, along with other main indicators of the ***w*** *market* are synthetized in Table 6 in order to facilitate the understanding of its evolution.

Table 6. Summary of the Evolution of Colombia's Market for Manufactured Products of the Wood Industry.

Decade/ year	***w market*'s phase**	Key events	Major driver or hindrance	Market dynamics: Values of S, C, X and M (in 2015COP billion) and PSw, both at the initial year of the decade; Average Annual Growth Rate for the decade or for individual year in parenthesis					Colombian wood industry (in parenthesis percentage of Colombia´s manufacturing industry for the first year of the decade, unless otherwise specified)*			Sawnwood (m^3)		Wood-based panels (m^3)		Colombia's GDP per capita (2010USD)	Notes
				Supply - i.e., national production (S)	Consumption (C)	Exports (M)	Imports (M)	Price of supply (PSw) 2015 =1	Establishments in number	Employment in number of employees	Production	Exports	Imports	Exports	Imports		
Before 1950	Domestic Supply & Consumption	Economic boom (1920s) Sawmilling industry development start (1930s) First industrial census (1945)	Colombia's low economic development Limited infrastructure WWWI and II, Other events Policies for Colombia's industrialization	Focused on domestic production and consumption					821 (10.5%)	7,963 (5.8%)	3.0%	less than 500	4,000	-	-	not available	1
1950s and 1960s	Supply & Export Increase	Second industrial census (1953) Sawmilling industry grew (mostly in Pacific Region at the western Colombia, 92 sawmills just in one Subregion (Nariño Departamento) Wood-based panel industry rose (7 plants by 1969)	Post-WWII industrialization policies that shifted towards exports in 1965 (included subsidies). Colombia's rich natural forests close to rivers and sea (Pacific Region) in 1950s leveraging the industry expansion Shortage of preferred tree species reported (1960s) Export restrictions on some tree species (JCEC's Resolution 12 of 1966)	Domestic production and consumption rose importantly Modest expansion in sawnwood exports					472 (4.2%)	4,251 (2.1%)	1.1%	603,900	6,100	15,890	-	1,951 (in 1960)	2
1970s	Supply & Export Increase	Third industrial census (1970) Sawnwood exports peaked (127,200 m^3 in 1970) By 1972 inventory of 358 sawmills (half of them located in the Pacific Region), with production capacity: 25% high (15 to 25 m^3/day), 22% medium (10 - 15 m^3/day), and 51% low (< 10 m^3/day) Most high production plants had closed by 1979 Sawnwood exports dropped significantly (29,100 m^3 in 1979) Wood-based panel industry expanded (9 additional plants for plywood and veneer sheets)	Shortage of preferred tree species for sawnwood exacerbated Export subsidies cut in 1975	569 (4.2%)	491 (3,5%)	15 (13,4%)	6 (12,5%)	0.0015	347 (4.7%)	7,912 (2.3%)	1.0%	647,900	2,800	38,510	13,100	2,410 (in 1970)	3
1980s	Supply, Consumption and Imports Increase - Exports Decline	Sawnwood imports multiplied by 8.7 (in physical terms) Wood-based panel industry's expansion (production peaked and imports increased)	Greater shortage of wood from the natural forest, extended to all type of species not only the most valuables Low investment in machinery & equipment and building & structures of sawmills reached three decades Wood-based panel import tariff (45% as of 1983) and export subsidy (12% as of 1987).	945 (8.3%)	764 (7.7%)	13 (2.6%)	9 (12.4%)	0.0099	189 (2.8%)	5,947 (1.2%)	0.6%	38,900	61,600	39,800	114,200	3,291 (in 1980)	
1990s	Exports, Imports and Consumption Development	Natural forest wood procurement issues, in both sawmill and wood-based industries Many plants reduced operations or shut down Sawmilling industry reduced output (50% or less of installed capacity) Two new plants producing particle boards from forest plantation wood started operations (1992 and 1997) Oldest particle board producer (Pizano) shifted wood procurement to its own forest plantation Sawnwood and wood-based panels international trade expanded, by factors of 3.2 and 5.4 (Exports) and 1.7 and 2.4 (Imports), respectively, in physical terms	National natural forests' wood scarcity intensified Economic liberalization (1990 to 1994) Severe economic recession (1998-1999)	1,868 (3.8%)	1,390 (6.0%)	14 (36.1%)	10 (32.2%)	0.0949	184 (2.4%)	6,544 (1.3%)	0.5%	122,895	104,150	210,096	275,468	3,696 (in 1990)	
2000s	Imports, Exports, Consumption, and Supply Development	Oldest sawmills and wood-based panels plants shut down (first half of the decade) Industry recovery after 2003 New investment in wood processing plants - WPP (replacing the old concept of sawmills) and on existing wood-based panel plants Some surviving small sawmill firms shifted its wood procurement from natural forest to forest plantations entirely or to a mix of both Wood-based panels imports and exports multiplied by 4.8 and 2.2, respectively in physical terms	Lingering effects of the 1999 economic crisis (first half of 2000s) and scarcity of wood from natural forest Wood supply from Colombia's forest plantations became available Wood-based panels, especially MDF/HDF, became more common in replacing sawnwood in construction and furniture sectors	3,005 (4.4%)	2,753 (5.2%)	55 (10.9%)	91 (19.2%)	0.4046	119 (1.6%)	4,086 (0.8%)	0.5%	127,766	108,704	462,691	1,345,282	4,003 (in 2000)	
2010s	Imports Development (Dependency) & Supply Decline	Closure of Madeflex (2014) and Pizano (2018), the oldest Colombian wood-based panel plants which negatively affected Supply (National Production) "Significant" investments in sawmilling and wood-based panel industries Investments shifted towards more specialized and high-capacity production facilities procuring wood from forest plantations, e.g., 132.000 m^3 of MDF/year plant (2012) and 180,000 m^3 of MDP/year (2016) New investment not enough to stop the 2.3% average annual growth rate (AGR) decline of Supply (S) of manufactured products of the wood industry (***w***) Consumption (C) of ***w*** slowdown importantly (0.9% average AGR) compared to previous decades AGR for both Sw and Cw were negative since 2016	Oldest wood-based plants completed several decades facing financial distress which finally ended in bankruptcy General slowdown of Colombia's economic growth in the second half of 2010s, compared to previous half decade and the previous decades	3,608 (-2.3%)	3,851 (0.9%)	57 (3.7%)	498 (13.0%)	0.8363	214 (2.2%)	6,556 (1.0%)	0.5%	112,254	432,408	169,168	4,768,045	5,209 (in 2010)	
2018	Imports Development (Dependency) & Supply, Consumption. and Exports Decline			3,112 (-12.0%)	4,099 (-6.5%)	119 (-13.4%)	1,136 (12.0%)	1.2129	163 (2.1%)	5,329 (0.8%)	0.4%	17,490	29,555	12,968	552,500	6,321	
2019				2,883 (-7.3%)	3,984 (-2.8%)	97 (-18.3%)	1,202 (5.8%)	1.3426	149 (2.0%)	5,015 (0.7%)	0.4%	17,620	29,893	3,223	397,771	6,404	
2020	Supply, Consumption, Imports, and Exports Decline	***w market*** plummeted	COVID-19 pandemic harshest period	2,633 (-8.7%)	3,499 (-12.1%)	82 (-16.1%)	1,043 (-13.2%)	1.3891	141 (1.9%)	4,750 (0.7%)	0.4%	18,996	24,891	3,168	426,208	5,823	
2021	Supply, Consumption, Imports, and Exports Increase	***w market*** recovery	Increase of residential and non-residential building construction (14.8%) and manufacture of furniture activities (28.8%)	3,396 (29.0%)	4,563 (30.4%)	99 (21.6%)	1,346 (29.0%)	1.5174	141 (1.9%)	4,958 (0.7%)	0.5%	15,251	44,535	3,550	552,989	6,423	

Notes: 1: Wood industry figures are for 1945 and include wooden furniture. These figures comprise all establishments having five or more employees or an annual production value of not less than six thousand COP (COP 6000) in 1945. Data for exports and imports are for 1948 (year in which FAO´s forest statistics for Colombia started to be published); 2: Imports and Exports of sawnwood and wood-based panels are for 1961-1969. Wood industry figures are for 1953 and they DO NOT include wooden furniture. These figures comprise all establishments having five or more employees or an annual production value of not less than COP 24000 in 1953; 3. Wood industry figures are for 1970. These figures comprise all establishments with five or more employees censored and those with less than five employees surveyed by sampling. Key events, drivers, hindrances, and data are specific to Colombia unless otherwise specified or generally known.

CONCLUSIONS

The preceding sections have rigorously traced the trajectory of Colombia's market for manufactured products of the wood industry, showcasing significant shifts in its portfolio and dynamics. Over the past ninety years, its focus has moved from primarily sawnwood to wood-based panels. This period also marked a continuous increase in the consumption of the wood industry manufactured products, especially wood-based panels. Additionally, the means of satisfying this domestic demand transitioned from almost exclusively relying on the national wood industry to significantly depending on imports. The market also witnessed brief periods of modest exports in sawnwood and wood-based panels.

The increase in domestic consumption of wood industry products highlights the market's close ties with Colombia's population growth and income trends, with per capita income rising 3.5-fold from 1960 to 2021. The shifts in supply (national production), imports, and exports of these products signal deeper structural challenges within the broader Colombian forest sector and the national wood industry. Key issues include the historical depletion of Colombia's natural forests, the original wood source crucial for developing the nation's wood industry, and delayed investments in domestic industry to adapt to technological advancements. These factors have resulted in the domestic wood industry's inability to meet domestic demand adequately.

In response to the challenges posed by resource depletion and delayed technological updates, stakeholders in the Colombian forest sector have advocated for forest plantations as a sustainable wood source to invigorate the national wood industry. This strategy aimed to encourage new investments to expand and enhance the industry's capacity and productivity. Yet, the industry's response has been tepid, leaving the wood-based panel and sawnwood sectors struggling to meet domestic demand. This led to an increased reliance on imports to satisfy consumption needs, hindering export development. With a current endowment of 59.5 million hectares of natural forests (IDEAM and MADS 2022) and 0.54 million hectares of commercial forest plantations (MADR 2023), the national wood industry situation is a paradox that many of Colombian forest sector stakeholders struggle to grasp. This paints a picture of an industry at a crossroads, needing to strategically reassess its operational and policy approaches in light the current challenges and opportunities.

The analysis in this paper, while comprehensive and reflective of historical trends, acknowledges its limitations. The reliance on historical data provides an extensive overview but may not capture the full complexity of current market dynamics or the nuanced effects of recent policy shifts. Therefore, the conclusions drawn here offer a foundation but also leave space for further, more detailed exploration.

Future research should aim to dissect the underlying causes of the decline in domestic production capacity of the wood industry, exploring a range of factors from macroeconomic policies to specific industrial strategies that could revitalize the industry. Emphasis should be placed on technological innovation's role in enhancing production efficiency and addressing shifts in consumer preferences away from wood products, which appear to have influenced the mismatch between the growth of the consumption of wood industry manufactured products and per capita GDP increase in the last decades in Colombia. Furthermore, upcoming studies ought to examine the socio-economic impacts of the wood industry's evolution, particularly concerning employment, regional development, and the overall health of the Colombian economy. Taking advantage of the consolidated data series for the ***w*** *market* several other market studies should be also included as part of the future research such as those related to the matters of geographic concentration and specialization.

Finally, this paper invites stakeholders in Colombia's wood industry to engage in a collaborative effort to address the identified challenges. By integrating historical insights with forward-looking, sustainable, and innovative strategies, there is an opportunity to chart a new course for the industry. Such a direction not only should seek to revive its legacy of self-sufficiency but also to ensure its enduring resilience and competitiveness in the global market.

CONFLICTS OF INTEREST

The authors confirm there are no conflicts of interest.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support provided by the Natural Sciences and Engineering Research Council of Canada under grant number RGPIN-2019-05199. The first author wishes to extend sincere gratitude to several colleagues and practitioners at the Agricultural Planning Unit of Colombia (UPRA), as well as to Jorge Herrera, Jenny Rosado, Julio Alonso, and Katty Davila from Colombia's Statistical Authority DANE, for their invaluable assistance in collecting the raw data for the ***w*** *market*. Special thanks are also due to Daniel Cuellar for his support in the process of consolidating and visualizing this data. The first author further extends appreciation to the forest sector stakeholders in Colombia who generously participated in interviews conducted in 2016 and 2021. The authors would also like to express their gratitude for the constructive comments and suggestions provided by the two anonymous reviewers. Additionally, they are thankful to the Editor for their valuable suggestions and support throughout the review process.

REFERENCES CITED

Banco de la República de Colombia. 2023. Tasa de cambio representativa del mercado (TRM). 1.1.11. Serie histórica periodicidad mensual. Información disponible desde el año 1991. Fuente de datos: Superintendencia Financiera de Colombia (www.superfinanciera.gov.co). Banco de la República - Gerencia Técnica - información extraída de la bodega de datos -Serankua- el 14/11/2023 19:12:43 br/]

Berry A, Thoumi F. 1977. Import substitution and beyond: Colombia. World Development, 5(1-2), pp.89-109. https://doi.org/10.1016/0305-750X(77)90007-9

Buongiorno J, Uusivuori J. 1992. The law of one price in the trade of forest products: co-integration tests for US exports of pulp and paper. Forest Science, 38(3), pp.539-553.

Cacerí. 2022. Information about Cacerí available at https://caceri.com/en/home/ accessed on May 12, 2022.

Cano CA. 2003. Evaluación de la dinámica e incidencia del Certificado de Reembolso Tributario–CER. Ecos de Economía No. 16. Medellín, Marzo 2003, pp. 95 – 122. Available at https://publicaciones.eafit.edu.co/index.php/ecos-economia/article/download/2002/2008/0.

Comunidad Andina. 2022. Available from: https://www.comunidadandina.org/quienes-somos. Accessed on May 31, 2022.

Contraloría General de la República de Colombia. 1947. Dirección Nacional de Estadística. Primer Censo Industrial de Colombia, 1945, Resumen General y Volúmenes que incluyen los departamentos, intendencias y comisarías de Antioquia, Atlántico, Bolívar, Boyacá, Caldas, Cauca, Cundinamarca, Huila, Magdalena, Nariño, Norte de Santander, Santander, Tolima, Valle del Cauca, Chocó, Meta y Caquetá. Imprenta Nacional de Colombia. Bogotá 1947.

Casas Héctor Ignacio. 1994. La industria de inmunización de maderas. BO-1290 (Monográfica) del Centro de Documentación Ministerio de Ambiente y Desarrollo Sostenible de Colombia.

DANE. No dated1. Equilibrios oferta-demanda para la silvicultura, madera y papel de la base 1975 de las Cuentas Nacionales de Colombia. Años 1975-1989. A precios corrientes y constantes de 1975. Fuente: Dirección de Síntesis y Cuentas Nacionales – DANE. Unpublished Excel Files.

DANE. No dated2. Equilibrios oferta utilización de productos precios corrientes y constantes de 1994 (6 dígitos). Años 1990– 2005. Base 1994. Cuentas Nacionales de Colombia. Excel Files available at https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-anuales/cuentas-nacionales-bases-anteriores/cuentas-nacionales-base-1994. Accessed on April 25, 2020.

DANE (1971 – 1979). Industria Manufacturera 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979. República de Colombia. DANE, Departamento Administrativo Nacional de Estadística. Documentos digitales disponibles en la biblioteca virtual del DANE.

DANE (1980 – 1989). Industria Manufacturera 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989. República de Colombia. DANE, Departamento Administrativo Nacional de Estadística. Documentos digitales disponibles en la biblioteca virtual del DANE.

DANE (1990 – 1999). Anuario de Industria Manufacturera 1990, 1991, 1992, 1993, 1994, 1995 y datos en formato magnético para la Encuesta Anual Manufacturera 1992-1999. República de Colombia. DANE, Departamento Administrativo Nacional de Estadística. Documentos digitales disponibles en la biblioteca virtual del DANE y archivos de datos digitales disponibles en la página oficial del DANE.

DANE (2000 – 2021). Anexos de la Encuesta Anual Manufacturera en formato magnético 2000-2021. República de Colombia. DANE, Departamento Administrativo Nacional de Estadística. Documentos digitales disponibles en archivos de datos digitales disponibles en la página oficial del DANE. Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/industria/encuesta-anual-manufacturera-enam/eam-historicos, accessed in November 2023.

DANE. 1956.Anuario General de Estadística Colombia 1956. Departamento Administrativo Nacional de Estadística. 1956.

DANE. 1961.Anuario General de Estadística Colombia 1961. Departamento Administrativo Nacional de Estadística. 1961.

DANE. 1976. III [i.e. Tercer] censo industrial 1970. DANE, 1976. Departamento Administrativo Nacional de Estadística de Colombia, DANE. 111 pages.

DANE. 2013. Documento metodológico y resultados de la retropolación 1975 – 2005 Base 2005. 41 págs.

DANE. 2017. Metodología general encuesta anual manufacturera EAM. Dirección de Metodología y Producción Estadística – DIMPE. Julio 2017. CÓDIGO: DSO-EAM-MET-01. VERSIÓN: 5. FECHA: 01-07-2017. 115 p.

DANE. 2018a. Componentes de la Oferta y Utilización de productos*, Base 2005 Precios constantes de 2005 por encadenamiento** - a dos dígitos. Año 2000– 2016 provisional. Cuentas Nacionales de Colombia. Fecha de actualización: 15/02/2018. Excel Files available at https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-anuales/cuentas-nacionales-cuentas-de-bienes-y-servicios-base-2005#balances-oferta-utilizacion-base-2005-2000-2016p . Accessed on April 25, 2020.

DANE. 2018b. Balances Oferta - Utilización de productos (BOU), Base 2005 Precios corrientes a seis dígitos. Año 2000– 2016 provisional. Cuentas Nacionales de Colombia. Fecha de actualización: 15/02/2018. Excel Files available at https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-anuales/cuentas-nacionales-cuentas-de-bienes-y-servicios-base-2005#balances-oferta-utilizacion-base-2005-2000-2016p. Accessed on April 25, 2020.

DANE. 2020. Metodología general encuesta anual manufacturera EAM. Dirección de Metodología y Producción Estadística – DIMPE. Mayo 2020. CÓDIGO: DSO-EAM-MET001 VERSIÓN: 8 FECHA: 13/May/2020. 38 p.

DANE. 2023a. Nomenclatura de actividades económicas y nomenclatura de productos de las cuentas nacionales de Colombia. Tablas en archivos digitales disponibles en DANE - Cuentas nacionales anuales. Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-anuales#nomenclatura-de-actividades-y-productos. Accessed on Dec 6 2023.

DANE. 2023b. Cuadro oferta - utilización a precios corrientes Base 2015. CUENTAS NACIONALES ANUALES. Cuadro oferta-utilización 2021 provisional a seis dígitos. Cuadros 31 y 32. Valores a precios corrientes. Año 2021p. Base 2015. Miles de millones de pesos. Fuente: DANE, Cuentas Nacionales. P: cifra provisional. Actualizado el 15 de febrero de 2023. Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-anuales#cuadros-oferta-utilizacion. Accessed on November 26, 2023.

DANE. 2023c. Producto Interno Bruto - PIB. Cuadro 2. Series encadenadas de volumen con año de referencia 2015. Cuentas Nacionales. 2005-2021p. p: cifra provisional. Actualizado el 15 de febrero de 2023. Available from https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-anuales#cuadros-oferta-utilizacion. Accessed on December, 6, 2023.

DANE. 2023d. Cuadro oferta - utilización a precios constantes del año anterior. Cuentas Nacionales de Colombia. Año 2015– 2020 p. Excel Files available at https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-anuales#cuadros-oferta-utilizacion . Accessed on October 13, 2022.

Da Silva BK, Tanger S, Marufuzzaman M, Cubbage F. 2022. Perfect assumptions in an imperfect world: Managing timberland in an oligopoly market. Forest Policy and Economics, 137, p.102691. https://doi.org/10.1016/j.forpol.2022.102691

Delcourt GV. 1995. Global softwood lumber trade: a spatial equilibrium model (Doctoral dissertation, University of British Columbia).

Diot J. 1975. Estadísticas históricas concesiones forestales 1900-1968. Seminario permanente de problemas colombianos. In Boletín mensual de Estadística No. 285 DANE. Abril 1975. Pag 88-155.

DNP (Departamento Nacional de Planeación de Colombia), Misión de Crecimiento Verde y ONF Andina. 2020. Diagnóstico sintético del sector forestal en Colombia: Principales características, barreras y oportunidades para su desarrollo. Forest economy studies in the framework of the Green Growth Taskforce in Colombia. 255 p.

Duratex. 2022. Nosotros, information about Duratex available at https://duratex.com.co/nosotros/ accessed on May 12, 2022.

FAO. 1947-1963. Yearbook of Forest Products Statistics. Sixteen different books published between 1948 and 1964 available at https://www.fao.org/forestry/statistics/80570/en/

FAO. 1949. Yearbook of Forest Products Statistics. Washington DC, USA. 1949. 195 p.

FAO. 2022. FAOSTAT Forestry Data Base. Food and Agriculture Organization of the United Nations, Rome. Available from: http://faostat3.fao.org/download/F/FO/E. Accessed on May 22, 2022.

FAO. 2023. FAOSTAT Forestry Data Base. Food and Agriculture Organization of the United Nations, Rome. Available from: http://faostat3.fao.org/download/F/FO/E. Accessed on Dec 5, 2023.

Gil M, Lemus A. 2015. Fragilidad financiera en Colombia y las decisiones de política monetaria del Banco de la República, 1996-2012. Semestre Económico, 18(38), 37-66. https://doi.org/10.22395/seec.v18n38a2

ITTO. 2021. Biennial review and assessment of the world timber situation 2019–2020.

ITTO. 2023. Biennial review and assessment of the world timber situation 2021–2022.

Hänninen RH. 1998. The law of one price in United Kingdom soft sawnwood imports--a cointegration approach. Forest Science, 44(1), pp.17-23.

Hyde WF, Olmos VM, Robalino J, da Gama ZAGP, Susaeta A, Yin R. 2022. Latin America: A regional perspective on its forest policy and economics. Forest Policy and Economics, 141, p.102760. https://doi.org/10.1016/j.forpol.2022.102760

IDEAM and MADS. 2022. Actualización de cifras de monitoreo de la superficie de bosque – Año 2021. Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM). Ministerio de Ambiente y Desarrollo Sostenible (MADS). Bogotá DC, Colombia Julio de 2022.

Inmunizar. 2022. Quienes somos-reforestación, information about Inmunizar available at https://inmunizar.com.co/sitio/reforestacion/ accessed on May 12 2022.

Jaunky VC, Lundmark R. 2015. Dynamics of timber market integration in Sweden. Forests, 6(12), pp.4617-4633. https://doi.org/10.3390/f6124391

Kant S, Nautiyal JC, Ai-Ameen W. 1996. The Canadian forest product sector: A sectoral econometric model. Canadian Journal of Forest Research, 26(7), 1122-1134. https://doi.org/10.1139/x26-125

La República. 2016. Primadera inaugura la primera planta de madera aglomerada en el país. Newspaper interview to Priamdera´s CEO. In La República Newspaper of Colombia. Available at https://www.larepublica.co/empresas/primadera-inaugura-la-primera-planta-de-madera-aglomerada-en-el-pais-2357371. Accessed on October 23, 2022.

JCEC. 1966. Resolución No. 12 de 1966. Abril 12. Expedida en Bogotá D.E., a 5 de abril de 1966. Junta de Comercio Exterior of Colombia, JCEC. 3 págs. Available from: https://fedemaderas.org.co/wp-content/uploads/2023/08/Resolucion-12-de-1966_CONIF_SEIDAL1.pdf

MADR. 2023. Estadísticas. Eslabón de la silvicultura y extracción de madera. pp 3 – 15. In 7 boletín estadístico forestal Marzo de 2023. Ministerio de Agricultura y Desarrollo Rural de Colombia (MADR). Bogotá DC. 25 de mayo de 2023. Available from https://observatorio-economia-forestal-3-mads.hub.arcgis.com/pages/documentos.

Martínez-Cortés OG. 2016. Síntesis de las entrevistas a actores claves del sector forestal Colombiano conducidas durante 2016 en el marco del proyecto “Formulación y ajuste de la metodología general para la zonificación de plantaciones forestales con fines comerciales que direccione y oriente la inversión del sector agropecuario”. Unpublished reports. Unidad de Planificación Rural Agropecuaria -UPRA. 2016.

Martínez-Cortés OG. 2021. Evaluación de la oferta de crédito forestal de la banca de primer y segundo piso en Colombia. Informe de consultoría para el Instituto Global de Crecimiento Verde – GGGI. Bogotá D.C., 16 de

septiembre de 2021. Anexo de entrevistas semiestructuradas a 35 actores claves (47 personas) de los sectores financiero y forestal en Colombia conducidas en 2021 en el marco de la consultoría. 87 págs. Informe y anexo no publicados.

Martínez-Cortés, Oscar Geovani. 2023a. The Colombian Forest Sector Model–An analysis of forest plantation policy in Colombia (Doctoral dissertation, University of Toronto Canada). 257 p.

Martínez-Cortés OG. 2023b. El modelo del sector forestal colombiano y algunos indicadores estadísticos de las plantaciones forestales comerciales de Colombia 1954 – 2018. in 7 Boletín Estadístico Forestal - Marzo de 2023 (Cifras con corte a Diciembre de 2022). Ministerio de Agricultura y Desarrollo Rural de Colombia. Bogotá DC. pp. 27-52. Available from: https://observatorio-economia-forestal-3-mads.hub.arcgis.com/documents/MADS::bolet%C3%ADn-estad%C3%ADstico-forestal-marzo-2023/explore

Martínez-Cortés OG, Castro L, Flórez A, Fonseca M, Garcés E, Gutiérrez É, Toro Á. 2018. Plantaciones forestales con fines comerciales para la obtención de madera y su cadena productiva: lineamientos de política. 19 pg. Bogotá: UPRA. Available from: http://www.upra.gov.co/documents/10184/13821/PLANTACIONES+FORESTALES+CON+FINES+COMERCIALES+PARA+LA+OBTENCI%C3%93N+DE+MADERA+Y+SU+CADENA+PRODUCTIVA/051c6fbc-ae53-4bf6-8e45-a0d64939c391

Martínez-Cortés OG, Kant S., Isufllari H. 2022. An analysis of wood availability under six policy scenarios of commercial forest plantations in Colombia. Forest Policy and Economics, 138, 102722. https://doi.org/10.1016/j.forpol.2022.102722

Martínez-Cortés OG, Kant Shashi, Isufllari Henrieta. 2024. Addressing the lack of forest sector models in tropical countries. Manuscript submitted for publication.

Meisel-Roca A, Ramírez-Giraldo MT, Jaramillo-Echeverri J. 2016. Too late but profitable: Railroads in Colombia during 1920–1950. Investigaciones de Historia Económica-Economic History Research, 12(3), pp.165-180. https://doi.org/10.1016/j.ihe.2015.07.009

Motta MT, Rodríguez JE, Cardona O. 1994. Plan indicativo industria forestal VIII: industria secundaria. Informe final. BO-0129 (Monográfica) del Centro de Documentación Ministerio de Ambiente y Desarrollo Sostenible de Colombia.

Murray BC, Prestemon JP. 2003. Structure and efficiency of timber markets. Forests in a market economy, pp.153-176. https://doi.org/10.1007/978-94-017-0219-5_10

Nanang DM. 2000. A multivariate cointegration test of the law of one price for Canadian softwood lumber markets. Forest Policy and Economics, 1(3-4), pp.347-355. https://doi.org/10.1016/S1389-9341(00)00028-9

Nieto VM. (2016). Una nota sobre la evolución de la estructura arancelaria de Colombia 2002-2014. tiempo&economía, 3(2), 79-113. https://doi.org/10.21789/24222704.1135

Núcleos de Madera. 2022. Aserrío y panta, information available at https://nucleosdemadera.com/quienes-somos/ accessed on May 12 2022.mos VM. 2022. Forestry and the forest products sector: Production, income and employment, and international trade. Forest Policy and Economics, 135, p.102648. https://doi.org/10.1016/j.forpol.2021.102648

Ocampo JA. 1987. Crisis and economic policy in Colombia, 1980–5. In Latin American debt and the adjustment crisis (pp. 239-270). London: Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-18671-6_8

Pizano. 2016. Historia. Information available at http://www.pizano.com.co/nosotros/#historia, accessed on Nov 8, 2016. Refocosta available at ttps://www.refocosta.com/conocenos/ accessed on May 12, 2022.

Tecniforest. 1999. Evaluación de la oferta y la demanda nacional de productos forestales maderables y no maderables. Informe final. Contrato de Consultoría. Colombia. Ministerio del Medio Ambiente- Dirección Técnica de Ecosistemas MMA. Santafé de Bogotá, TECNIFOREST, 1999.

Triana S, Londoño A, Rivera M, Hernandez D, Tirado A. 2019. Reforestadora Cacerí. Madera tropical reforestada. Revista Aldea Global 1. Pensamiento empresarial. Business School CEIPA. Agosto de 2019. Available at https://fliphtml5.com/es/ljqwj/nsut/basic. Accessed on August 23, 2022.

Shahi C, Kant S, Yang FE. 2006. The law of one price in the North American softwood lumber markets. Forest Science, 52(4), pp.353-366.

UNECE/FAO. 2021. Forest products–Annual market review 2020-2021.

UNECE/FAO. 2022. Forest products–Annual market review 2021-2022.

United States Government. 1892. Handbook of Colombia. (1892). In Reports of Explorations Printed in the Documents of the United States Government. Bureau of the American Republics.

US Tariff Commission. 1945. Mining and manufacturing industries in Colombia. One of a series of reports on Mining and Manufacturing Industries in the American Republic. Washington 1945. 45 pgs. Available from: https://books.google.com.co/books?id=f1ZpvgAACAAJ&printsec=frontcover#v=onepage&q&f=false

Van Bottenburg M. 1952. La situación forestal de Colombia. Unasylva Vol. 6 No. 2. Available from: https://www.fao.org/3/x5363s/x5363s05.htm#la%20situaci%C3%B3n%20forestal%20de%20colombia, recovered April 4, 2022.

Velásquez Ramos YP. 2016. Diagnóstico y evaluación de la industria del aserrío en Refocosta s.a.s proyecto La gloria, corregimiento de Monterrubio, municipio de Sabanas de San Ángel, departamento de Magdalena. Informe final de pasantía. Universidad Distrital Francisco José de Caldas, Facultad del Medio Ambiente y Recursos Naturales. Proyecto curricular de Ingeniería Forestal. Abril DE 2016. 102 p.

World Bank. 2023. Constant GDP per capita for Colombia [NYGDPPCAPKDCOL], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NYGDPPCAPKDCOL, December 11, 2023.

Yin R, Baek J. 2005. Is there a single national lumber market in the United States? Forest Science, 51(2), pp.155-164.

APPENDIX A

AppendixA_1-4