JYX
JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

This is a self-archived version of an original article. This version may differ from the original in pagination and typographic details.

Author(s): Watanabe, Chihiro; Naveed, Kashif; Neittaanmäki, Pekka

Title: Digital solutions transform the forest-based bioeconomy into a digital platform industry : a suggestion for a disruptive business model in the digital economy

Year: 2018

Version: Accepted version (Final draft)

Copyright: © 2018 Elsevier Ltd.

Rights: CC BY-NC-ND 4.0

Rights url: https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the original version:

Watanabe, C., Naveed, K., & Neittaanmäki, P. (2018). Digital solutions transform the forest-based bioeconomy into a digital platform industry : a suggestion for a disruptive business model in the digital economy. Technology in Society, 54, 168-188. https://doi.org/10.1016/j.techsoc.2018.05.002

Accepted Manuscript

Digital solutions transform the forest-based bioeconomy into a digital platform industry - A suggestion for a disruptive business model in the digital economy

Chihiro Watanabe, Nasir Naveed, Pekka Neittaanmäki

PII: S0160-791X(18)30009-5

DOI: 10.1016/j.techsoc.2018.05.002

Reference: TIS 1054

To appear in: *Technology in Society*

Received Date: 16 January 2018

Revised Date: 9 April 2018

Accepted Date: 8 May 2018

Please cite this article as: Watanabe C, Naveed N, Neittaanmäki P, Digital solutions transform the forest-based bioeconomy into a digital platform industry - A suggestion for a disruptive business model in the digital economy, *Technology in Society* (2018), doi: 10.1016/j.techsoc.2018.05.002.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Digital Solutions Transform the Forest-based Bioeconomy into a Digital Platform Industry
- A Suggestion for a Disruptive Business Model in the Digital Economy

Chihiro Watanabe,[a,b], Nasir Naveed,[a], Pekka Neittaanmäki[a]

[a]Faculty of Information Technology, University of Jyväskylä, Finland
[b]International Institute for Applied Systems Analysis (IIASA), Austria

Abstract

With the notion that the transformation of the forest-based bioeconomy in recent years provides insightful suggestions not only on the bioeconomy, but on business innovation, this paper conducts an empirical analysis of the transformation and attempts to extract suggestions for a digital-solution-driven, disruptive business model in the digital economy.

Notwithstanding the potential broad cross-sectoral benefits, the natural environment, locality constraints, and incessant challenge of distance have impeded the balanced development of the bioeconomy.

However, driven by digital solutions, the bioeconomy has taken big steps forward in recent years. Digitalization has enabled real-time, end-to-end supply chain visibility, improved delivery accuracy as well as stock level optimization and alignment with demand planning. The advancement of e-commerce has also led to the elimination of distance between both the upstream and the downstream of the chain.

This paper demonstrates a transformative stream observed at the forefront of the forest-based bioeconomy chain. An empirical analysis focusing on the core business activities at the forefront, both upstream and downstream of the chain, is conducted.

A new insight common to all industries in the digital economy is thus explored for constructing a creative disruption platform by embracing digital solutions.

Keywords: Forest-based bioeconomy; Transformation; Digital solutions; Creative disruption platform; Digital platform industry.

Corresponding author
Chihiro Watanabe (watanabe.c.pqr@gmail.com)

ACCEPTED MANUSCRIPT

1. Introduction

The bio-based economy[1] can be defined as the economy encompassing the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy (EC 2012). The forest-based bioeconomy is an important sub-sector of the bio-based economy where forests are anticipated to deliver a significant contribution of biomass (Hetemaki, 2014; Scarlat et al., 2015). The forest-based sector has an opportunity to take the lead in the sustainable development of the bio-based economy (Wolfslehner at al., 2016).

However, notwithstanding the potential broad cross-sectoral benefits to both industrialized and growing economies, natural environments, locality constraints, and the incessant challenge of distance have impeded balanced development of the forest-based bioeconomy.

The recent advancement of digitalization has enabled real-time end-to-end supply chain visibility and improved delivery accuracy as well as stock level optimization and alignment with demand planning. Thus, a creative disruptive platform can be created by embracing digital solutions (Watanabe et al., 2017*c*). The advancement of e-commerce has also eliminated the distance between the upstream and the downstream of the chain. Increasing diversification corresponds to eco-consciousness and peoples' preference for a shift in, which induce the transformation of the forest-based bioeconomy into a consolidated platform[2].

Transformation of this economy (the bio-based economy, particularly of the forest-based bioeconomy) is not about natural resources and technologies but about the complex future potential, especially concerning the trajectories of societies, industries, businesses and consumers. This should include not only techno-economic perspectives but also socio-cultural and ethical perspectives (VTT, 2017). The service strategies of this economy can be extended from mere technological and material processes to wider socio-economic transformations (Pelli et al., 2017).

The concept of this economy enables the following thinking, which is essential for constructing a new business model in the digital economy:

(i) Recognizing complexity, phenomena-driven policy and new social dynamics;
(ii) Understanding global interdependencies that require multilevel thinking, and knowledge of the significance of the co-evolution of technologies, economy and society; and
(iii) Re-understanding traditional regimes and regions as several fields of potential industrial convergence that can emerge.

To date, many studies analyzed the systems nature of the forest-based bioeconomy. Wolfslehner et al. (2016) gave insights on the potential use of forest-based indicator sets in Europe and how

[1] "Bioeconomy" and "green economy" are used to describe a similar concept.
[2] UPM (Forest-based industry leader in Europe) in Finland has taken strong initiative in restructuring its business model to digital solutions-driven approach towards circular economy in the beginning of the second decade of this century.

bioeconomy indicators can be designed in the future. They posited that the forest-based sector has an opportunity to take the lead in the sustainable development of the bio-based economy, as it has powerful tools that can be adapted and further developed for application in the bio-based economy as a whole. Hetemaki et al. (2014) and Hetemaki (2016) pointed out that the European forest-based sector confronted creative destruction. They identified the fact that production of some of the traditional forest products was declining rather than growing in Europe. At the same time, they noticed that many more value-added engineering wood products have shown strong growth in recent years despite the economic slump, thus creative destruction emerged, as postulated by Schumpeter. Consequently, they stressed the significance of investment in social sciences-related R&D by warning that knowledge on economics, politics, markets and marketing, and social studies has become essential to understand opportunities, barriers, challenges and implications, and to support business and policy strategies. With an understanding that European pulp and paper industry (PPI) confronts megaforces such as climate change, material resource scarcity and ecosystem decline, Patari et al. (2016) provided a similar view that these megaforces were perceived more as opportunities than threats for European PPI businesses.

The advancement of digital innovation has changed the way we conduct business and our daily lives and provided digital solutions to utilize the aforementioned opportunities. Prompted by such solutions, the authors conducted an empirical analysis of the core business activities at the forefront of both the upstream and downstream of the forest-based bioeconomy chain and demonstrated a transformative stream in constructing a creative disruption platform by embracing digital solutions (Watanabe et al., 2017). While this analysis provides new insight into the forest-based bioeconomy in the digital economy, digitalization does not stop the transformation stream as PPI produces more diversified products (Toppinen, et al., 2017), actors from different sectors interact and play different roles (Giurca et al., 2017), and all stakeholders involved in the forest-based bioeconomy need to be considered (Mustalahti, 2018). However, this stream may transform the forest-based bioeconomy into a digital platform industry and the consequences of that transformation are not yet known.

Envisioning this industry provides new insight into not only the forest-based bioeconomy but all industries in the digital economy in constructing a creative disruption platform by embracing digital solutions. With this expectation, this paper conducts an empirical analysis by focusing on the core business activities in the leading firms at the forefront of the upstream and the downstream of the chain. The process of consolidating a platform similar to a “super digital-biofore computer” by consolidating upstream and downstream as well as producer and consumer (prosumer) is envisioned, wherein “biofore” implies a bio-forest that grows sustainably.

The structure of this paper is as follows: Section 2 reviews perspectives on the forest-based bioeconomy. Section 3 analyzes structural change in the supply chain of the forest-based bioeconomy. Perspectives on the transformation toward a creative disruption platform are presented in Section 4. Section 5 briefly summarizes insightful findings, implications and suggestions for future works.

2. Perspectives on the Forest-based Bioeconomy

2.1 Structure of the Bioeconomy

Fig. 1 illustrates the scope of the bio-based economy. The forest-based bioeconomy has a significant share in this economy.[3] Most forest-based products include raw materials and intermediate products that can be transformed into products that fulfill customer needs. Services such as recreation, nature-based tourism and various other activities are also important for local economies (Pettenella et al., 2006; Näyhä et al., 2014).

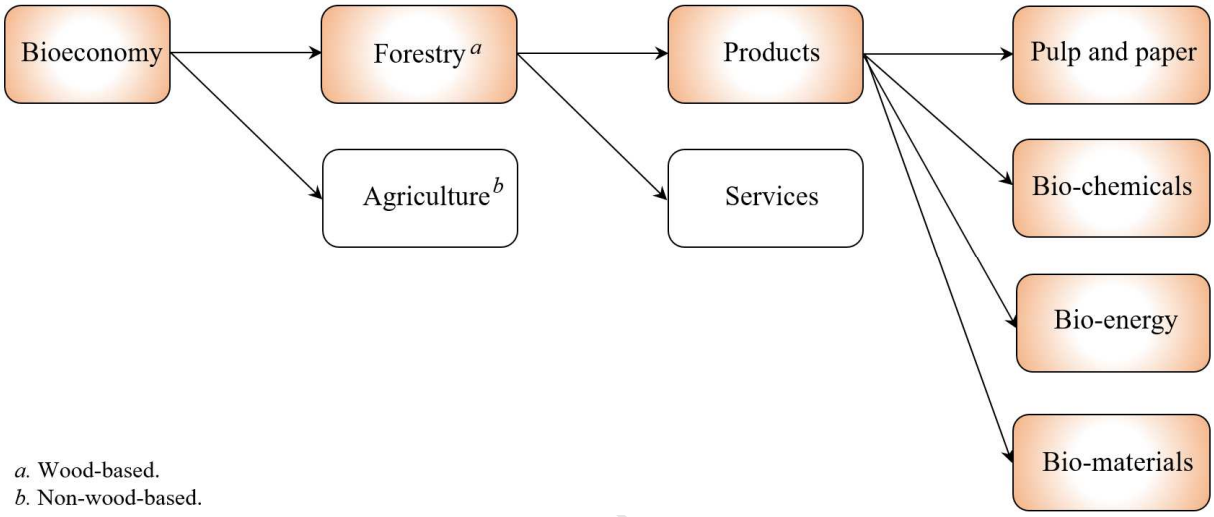


Fig. 1. Scope of the Bio-based Economy.

2.2 Increasing Expectations of the Forest-based Bioeconomy

The forest-based bioeconomy challenges the current crucial aspects associated with sustainability and minimizing environmental impact. The shift toward resource efficiency and sustainable production will not only benefit the environment but also encourage economic benefits through innovation and the emergence of new sectors, such as bio-chemicals and bio-materials (Mubareka et al., 2016). This economy has become a real global asset to both industrialized and growing economies as energy efficiency, fuel switching, green transport, demand flexibility and breakthrough technologies have become priority issues in attaining a sustainable decarbonized society worldwide (IDDRI, 2017).

Within the forest-based bioeconomy, the pulp and paper industry plays a central role in Europe that contributes considerable amount of the Gross Domestic Product (GDP) of the European Union (CEPI, 2014).

The forest industry in forest-dependent countries, particularly industrialized countries, has undergone a major structural change due to decline in demand for the biggest segment, printing

[3]Bio-based economy output in Finland was 63 billion euros in 2014 (16% of GDP), 47 billion euros (75%) of which was derived from the forest-based bioeconomy (VTT, 2017).

paper. This has forced the industry to not only restructure its existing businesses but also to develop entirely new products and businesses, and to be dynamic in establishing research-related ecosystems. Today, the forest industry offers sustainable and recyclable products made from wood that reduce dependency on non-renewable raw materials, contributing to the development of low-carbon societies.

2.3 Geographical Structure of the Forest-based Bioeconomy

Fig. 2 illustrates global leaders in production and consumption of the forest-based bioeconomy in 2015. It is evident that Asia accounts for the largest share in both production and consumption, while they are depending on traditional system with respect to digital solutions. Contrary to Asia, Europe (particularly Finland) and the US take pivotal role in digital solutions leading them leaders of upstream and downstream for digital solutions (CEPI, 2015).[4]

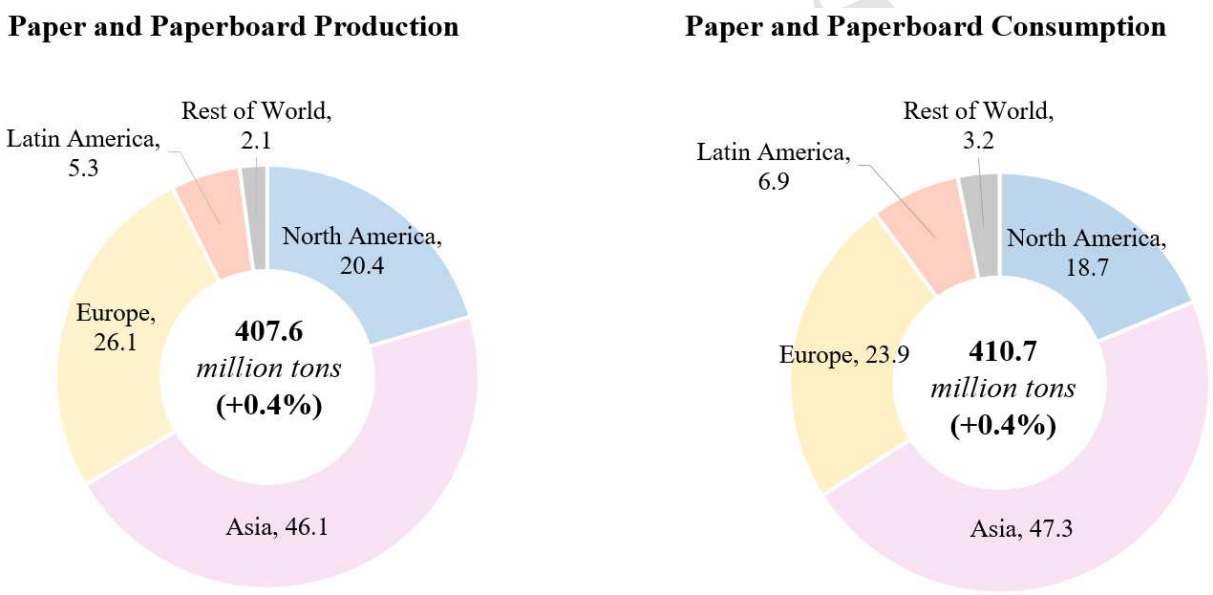


Fig. 2. Global Leaders in Upstream and Downstream in the Forest-based Bioeconomy (2015).
Source: CEPI (2017).

Until the 1990s, the global forest industry did not confront critical competition and was supported by markets and a low degree of internationalization at its leading firms. Their focus was business-to-business products under long-term business relationships (Ojala et al., 2007).

[4]World pulp and paper industry leaders and their digital ability (2015)

Production (Wood pulp)	**Export** (Paper and paperboard)	**Consumption** (Paper and paperboard)
1. USA (7)	1. Germany (13)	1. China (62)
2. Canada (11)	2. USA (7)	2. USA (7)
3. Brazil (84)	3. Finland (2)	3. Japan (10)
4. Sweden (3)	4. Sweden (3)	4. Germany (13)
5. Finland (2)	5. Canada (11)	5. India (89)

The figures in parenthesis indicate World ICT ranking (WEF, 2015).

The business dynamics, customer needs, global competition, policies and strategic orientation of the forest industry have evolved over time in four distinct stages: forestry orientation, production orientation, market orientation and sustainability orientation (Toppinen et al., 2013).

However, nowadays, Latin America, Southeast Asia and China have intensified global competition in the pulp and paper industry with a low cost of production for pulp and paper. Thus, to maintain their competitiveness, pulp and paper industries need to innovate their business models, products, services and processes as a system.

Under such circumstances, the sustainability of the upstream value chain can be attributed to the raw material from the forest to the primary production of wood, pulp, paper and paperboard, while the downstream value chain can be attributed to the manufacture of printing paper to the final products provided for customers.

2.4 Possible Resurgence of the Forest-based Bioeconomy

Figs. 3 and **4** demonstrate trends in the production and consumption of paper products (paper and paperboard) in the world over the last five decades. Fig. 3 also highlights trends in Finland as a leading upstream country in the value chain (see **Appendix 1** yearly statistics for the 1961-2015 period).

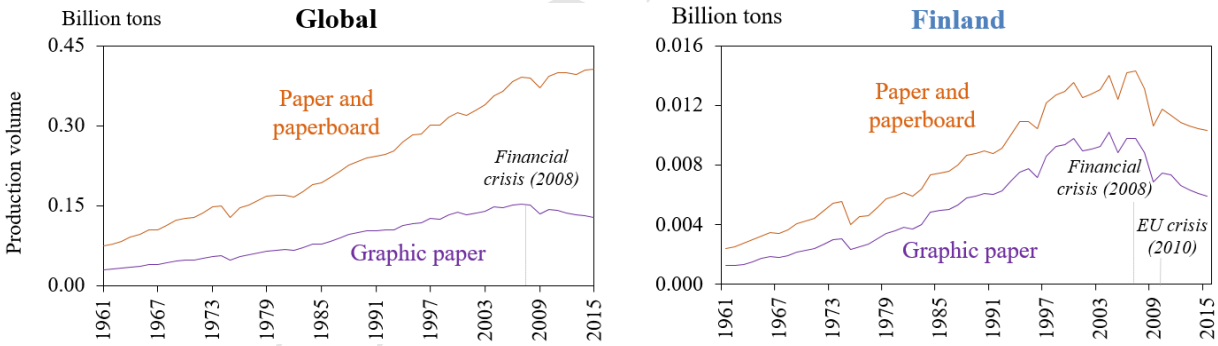


Fig. 3. Trends in Production of Paper Products – Global and Finland (1961-2015).
Source: Forestry and Agriculture Organization (2016).

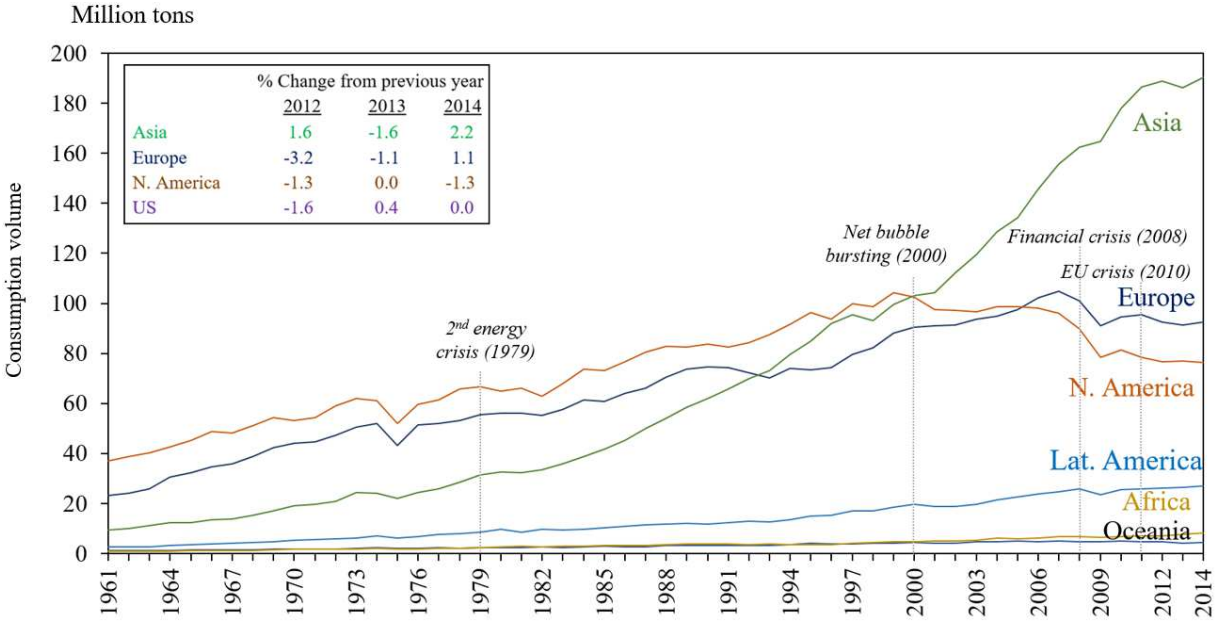


Fig. 4. Trends in Paper Products Consumption by Global Region (1961-2014).
Source: Finnish Forest Industries (2016).

These figures suggest that the global structure for the production and consumption of paper products dramatically changed after the Lehman shock of 2008, particularly in Europe and North America. While global production of paper products continued to reflect steady growth initiated by these global leaders, corresponding to a consumption increase before the Lehman shock, these initiatives were substituted by emerging economies, particularly Asia.

In addition to economic stagnation after the Lehman shock of 2008, increasing concern about de-carbonization accelerated a consumption decline in global leaders and a subsequent production decrease by these leaders, as typically observed in Finland, which contributes 6-8% of global pulp production. The such decline in global leaders corresponds to the digitalization of the economy, as clearly observed in North America, which demonstrates an explicit production decline corresponding to the net bubble bursting in 2000.

However, if we look at Fig. 4 (and also Figs. 10-2 and 11 in the next section) carefully, we note that the decreasing pace of production in Europe and North America has stagnated, yet the signature of resurgence has been observed very recently (PTT, 2016). This possibility of resurgence possibility inspires us with the hope that digital solutions may overcome the long-lasting impediments to a forest-based bioeconomy.

3. Structural Change in the Supply Chain

3.1 Supply Chain: Embracing Digital Solutions

The forest-based companies are shifting their business strategies by introducing the performance improvement programs as they are facing variety of challenges within the value chain ranging from equipment reliability to lack of analytics in commercial operations (Accenture, 2015). There is much more to gain by deploying digital technologies (IOT) to address the focus areas of the industry including:

(i) Optimize plantation and forestry operations to increase the yield and quality demands.
(ii) Ease supply constraints to downstream processing activities and decrease working capital tied to the supply chain.
(iii) Enable technology transfer and skills development across the global organization.
(iv) Boost the customer experience and engagement to improve customer retention.

The potential digital solution for impediments to the forest-based bioeconomy, is based on the maturity of the following conditions:

(i) A sophisticated global value chain of the pulp and paper industry consisting of upstream and downstream chains;
(ii) Inspiring interactions between upstream and downstream chains; and
(iii) Each player in the supply chain embracing the capacity of digital innovation.

Fig. 5 illustrates the structure of the value chain of the forest-based bioeconomy that enables players in the chain to embrace the advancement of digital innovation.

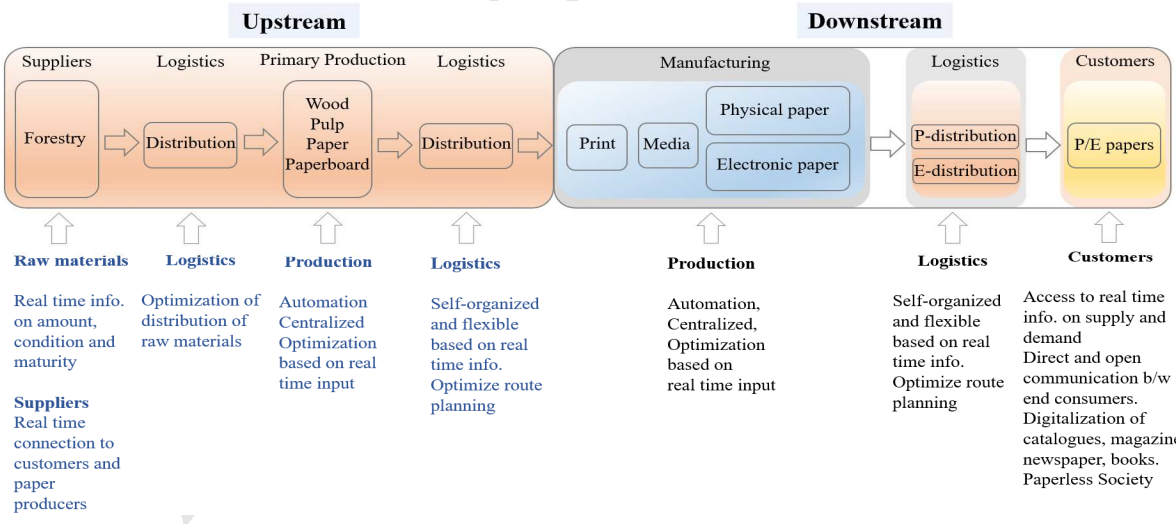


Fig. 5. Value Chain Structure of the Forest-based Bioeconomy focusing on Pulp and Paper Industry. Source: Authors' elaboration based on Beamon (1998) and CEPI (2015).

With a structure that facilitates the advancement of digital innovation, digital solutions have been incorporated in both the upstream and downstream of the value chain, as illustrated in **Fig. 6.** thereby facilitating the transformation of the forest-based bioeconomy.

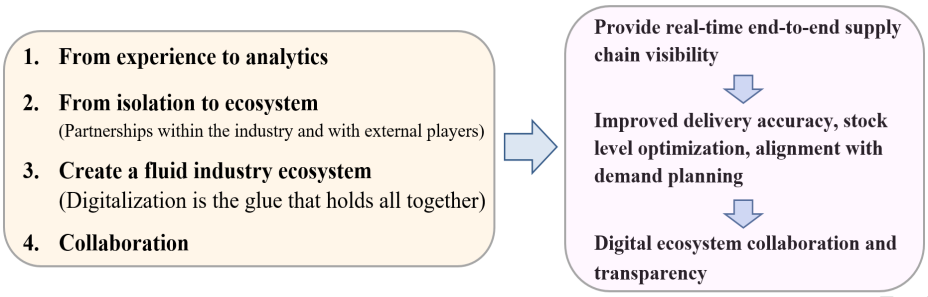


Fig. 6. Digital Solutions Enabling Supply Chain Transformation in the Forest-based Bioeconomy. Original source: Tieto (2017).

3.2 Structural Change in Downstream

3.2.1 Market Structure in Book Industry – *P-books Renaissance*

To analyze structural change in the downstream of the forest-based bioeconomy due to digitalization-driven upstream transformation, structural change in the U.S. book industry, (a prime customer of forestry production) was analyzed first. **Fig. 7** reviews trends in sales volume, sales revenue[5] and book prices by type in the U.S. (see the detailed Table in **Appendix 2**).

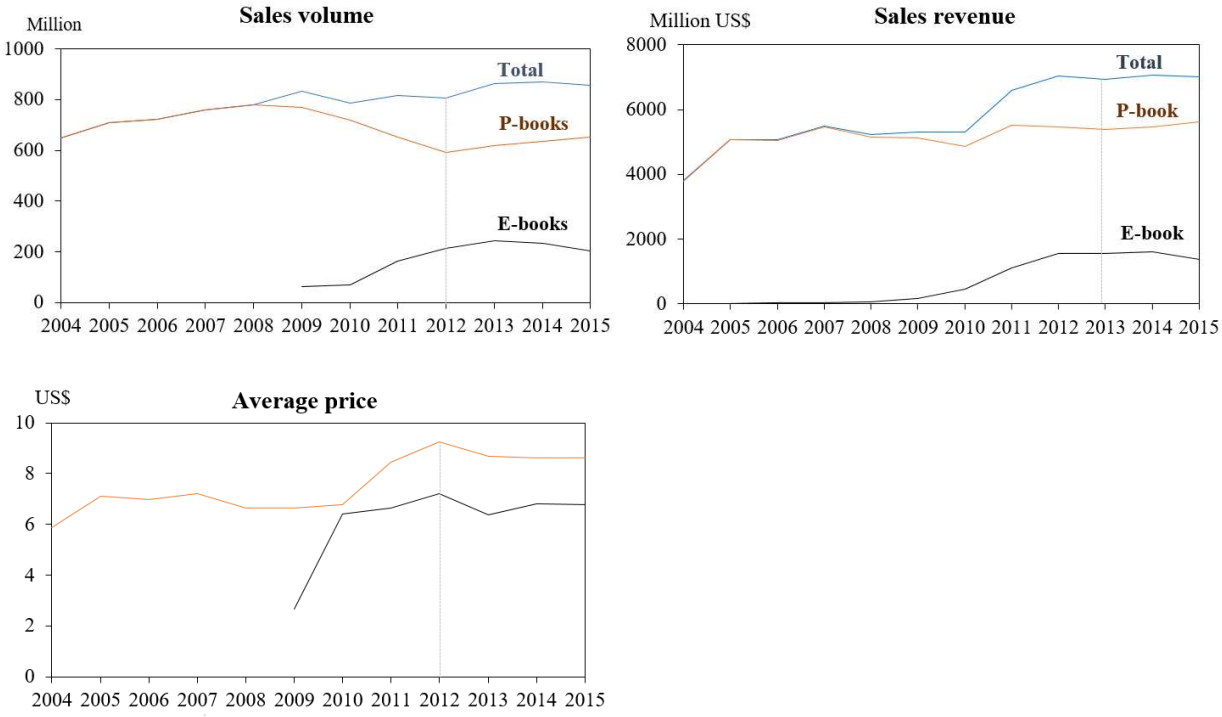


Fig. 7. Trends in Sales Volume, Sales Revenue and Book Prices in the U.S. by Type *(2004-2015).* Sources: Nielsen BookScan U.S./Pub Track digital U.S. and AAP – Monthly Statshot.

[5]Sales revenue data does not include professional publishing, K-12 instructional material and higher education course materials.

Fig. 7 indicates that book sales by both volume and revenue have been sustained by the e-books popularized in 2008 and substituted for traditional print (physical) books (p-books). However, this substitution changed in 2012. As opposed to re-gaining popularity like p-books, sales volumes and subsequent sales revenues of e-books have stagnated.

This "renaissance" of p-books, which assimilated digital innovation initiated by e-books, reminds us of the resurgence of the US music industry initiated by the "renaissance" of live music through the assimilation of digital innovation initiated by digital music (Naveed et al., 2017). Inspired by this notable "renaissance" in p-books, **Fig. 8** reviews trends in the sales volume of p-books and e-books in the U.S. over the 2004-2015 period.

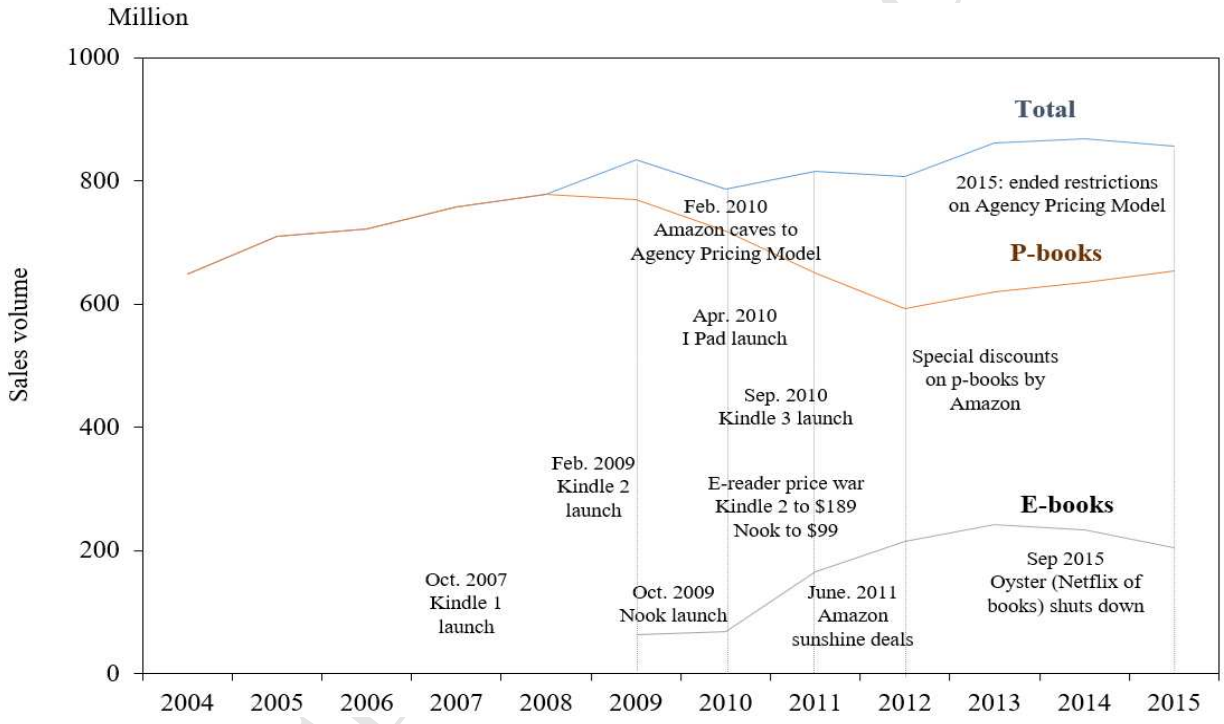
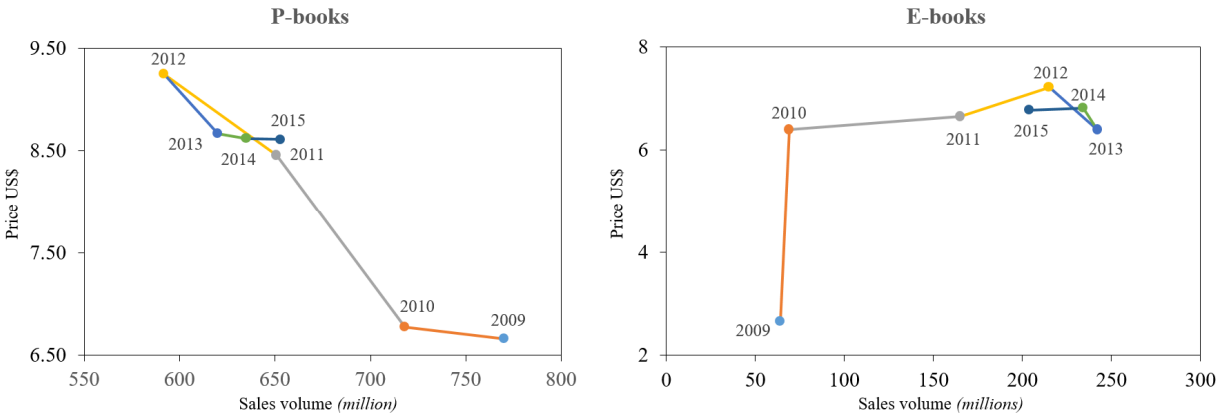


Fig. 8. Trends in Print-Book and Electronic-Book Volume in the U.S. *(2004-2015).*
Source: Nielsen BookScan U.S./PubTrack Digital U.S.

Fig. 8 demonstrates the "renaissance" of p-books and the contrasting fading popularity of e-books that emerged in 2012. These trends proceeded together with the advancement of digitally-rich environments and the activation of e-commerce giant Amazon in finding solutions to active digital challenges.

In order to further analyze the dynamism leading to the "renaissance" of p-books in digitally-rich environments and Amazon's digital solutions challenge, **Fig. 9** compares dynamism between price decrease and sales volume increase in p-books and e-books.



Correlation between Prices and Sales Volume of P-books and E-books in the U.S. (2009-2015).

Fig. 9. Dynamism between Price Decrease and Sales Volume Increase in P-books and E-books.
Source: Authors' calculation of the prices based on sales volume and sales revenue of p-books and e-books from Nielsen BookScan U.S./Pub Track digital U.S. and AAP – Monthly Statshot.

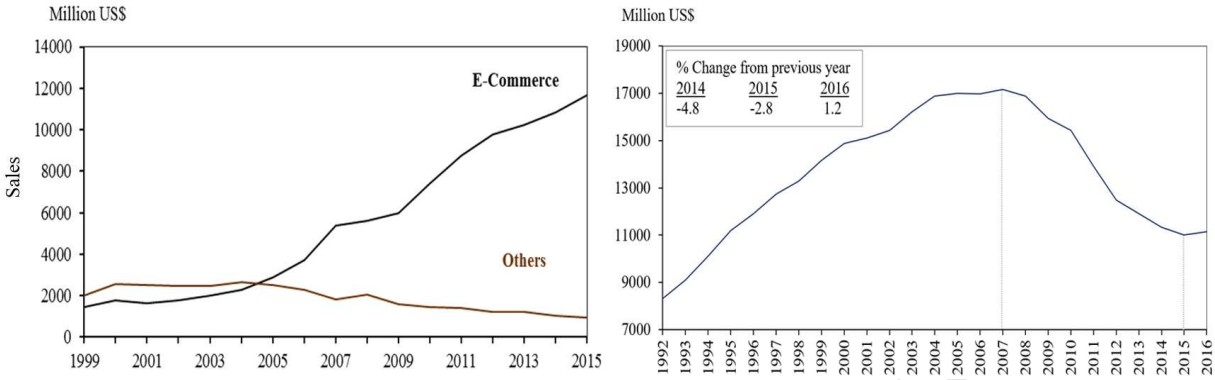
Fig. 9 demonstrates that contrary to e-book trends, p-books constructed a virtuous cycle between price decrease and sales volume increase after 2012, while they suffered a vicious cycle previously. This dynamism may be the source of p-books' "renaissance" and this can largely be attributed to Amazon's digital solution-oriented strategy (Johnson et al., 2017).

3.2.2 Change in Customers' Buying Behavior

(1) Renaissance to Brick and Mortar

In the book industry, Amazon plays a decisive role by holding 70% of market share worldwide (Nielsen BookScan, 2015). Amazon pays special attention to customers' propensity for the following practices: "*We read our news on tablets and phones, work all day on screens, but at the end of the day, we might just want something on paper – a book, magazine or newspaper – to read and relax*" (Enso, 2017). Given that p-books' "renaissance" can largely be attributed to Amazon's digital solutions-oriented strategy based on customers' propensity, customers' buying behavior should be analyzed.

With this postulate in mind, **Fig. 10** analyzes customers' books-buying behavior in the U.S. by demonstrating a continuous increase in e-commerce in terms of book buying and changes in books sale by bookstores, which increased in 2016 for the first time since declining from 2007 forward. The biggest bookseller "Amazon" has been making a strong push towards brick and mortar by opening bookstores in U.S.



Trends in Book Sales in the U.S. by Buying Behavior *(1999-2015).*

Trends in Bookstore Sales in the U.S. *(1992-2017).*

Fig. 10. Changing Trends in Customers' Books Buying Behavior in the US.
Source: United States Census Bureau.

This change from a p-book renaissance to brick-and-mortar buying behavior demonstrates one of the institutional sources of the renaissance, similar to that of live music in the U.S. music industry (Naveed et al., 2017).

(2) Increase in Prosumers

These noteworthy observations suggesting that people's preferences shift should not be overlooked in considering the transformative direction of the forest-based bioeconomy chain. The forest-based bioeconomy is driven by both supply and demand side impacts, as illustrated in Fig. 5. Customers' preferences shift to bio-products, such as organic food, wood-based construction materials and textiles, in corresponding to eco-consciousness, which is growing not only in industrialized countries but also in developing nations (Wesseler and Von Braun, 2017).

A similar trend can be observed with pulp and paper products, as represented by the conspicuous increase in wrapping-packaging paper consumption as demonstrated in **Fig. 11**. This increase corresponds to peoples' preference shifts to socio-cultural and aspirational values.

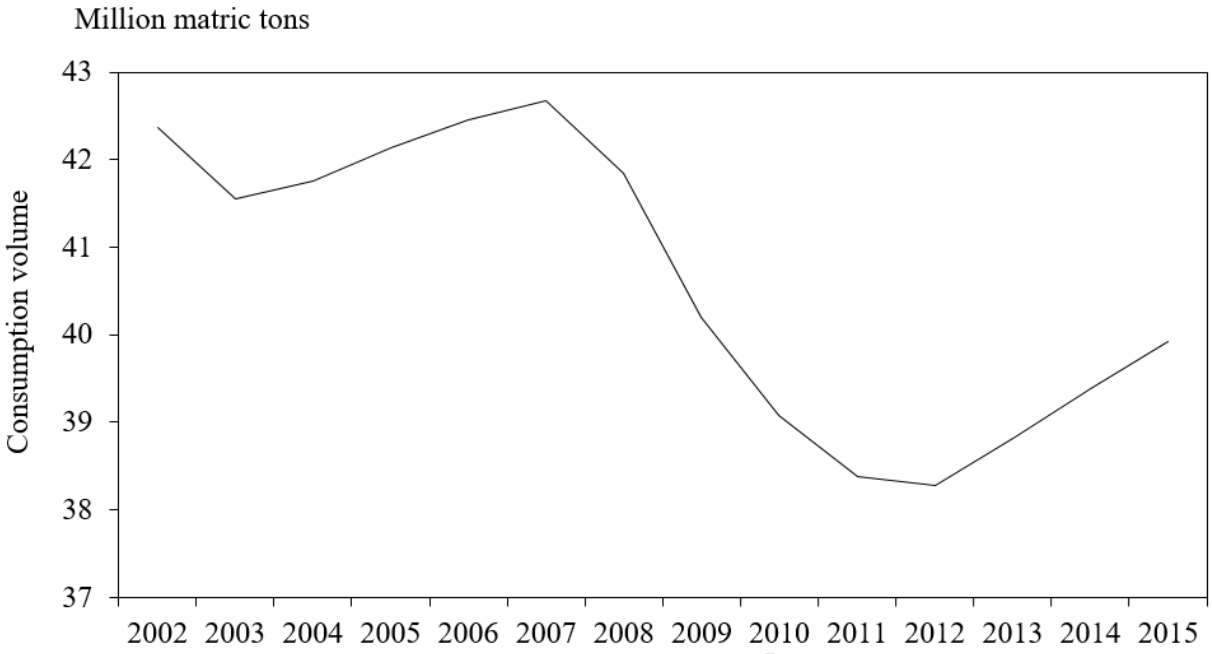


Fig. 11. Trend in Wrapping-Packaging Paper and Paperboard Consumption in the U.S. (2002-2015, 4 year moving average).
Source: FAO (2017).

As a consequence of the general shift from a commodity-oriented society to a service-and information-oriented society, peoples' preference are also generally assumed to steadily shift from an economic functionality-driven preference (captured by GDP) to a supra-functionality preference, which extends beyond economic-value-driven preference. Here, supra-functionality encompasses social, cultural, aspirational, tribal and emotional values, which are not necessarily captured by the GDP (McDonagh, 2008).

Such a shift in preference is further driven by the promotion of bio-based products, related tax policies and regulations, such as the U.S. preference for bio-products in public procurement (http://www.gsa.gov/portal/content/105368). The retail industry is also responding to this shift in demand (Wesseler and Von Braun, 2017). The demand for organic food is increasing in super markets (Ministry of Economic Affairs and Employment of Finland, 2017).

Furthermore, the fast flow of information through social websites, such as Twitter, blogs, Facebook, YouTube and curators' feedback, have enabled virtual communities to share their views on what is ethical, sustainable and eco-friendly. Peoples' preferences are changing as they rely on digital technologies and trust advice obtained online from virtual communities. The increasing role of digital technologies and social concerns are transforming individuals from consumers to prosumers (*producer + consumer*).

Prosumers are likely to admire companies that deliver a great experience, help customers find ways to waste less, and are more conscious of their environmental impact. For example, Hennes and Mauritz (H&M) launched a global garment collecting initiative in 2013 to collect used clothes, which were later resold as is or transformed into new products (http://www2.hm.com/en_gb/ladies/shop-by-feature/8eb-bring-it-on.html). IKEA turned its Facebook page into a digital flea market, enabling customers to resell their furniture (http://adage.com/article/creativity-pick-of-the-day/ikea-creates-platform-hand-furniture-sales/244980/). Amazon offers plenty of services for individuals, such as self-book publishing on Kindle and selling services (Electricians, House cleaning, and Assembly etc.), to Amazon customers using Amazon's digital platform.

The above trends in the downstream of the forest-based bioeconomy have significant impacts on the upstream of the economy, suggesting that all stakeholders in the value chain need to focus on customer orientation and adopt customer-driven business models. Users' involvement in the innovation process is likely to improve the acceptance of new products and solutions (EC, 2013c).

3.2.3 Disruptive Business Strategy in Downstream – The Case of Amazon

Being one of the biggest retailers, Amazon, with its disruptive business strategy, plays a significant role at the forefront of the downstream to trigger customers' demand worldwide, which ultimately influences the upstream side of the bioeconomy chain. Amazon tracks customers' behavior by using the big data analytics that it gathers on them from its platform. Thus, customers encounter a list of recommendations for future purchases based on their browsing history. This helps Amazon to sense customers' demands and tailor its business strategies accordingly.

Amazon is responsible for the distribution of goods and services, though it does not have its own manufacturing facilities, However, it has constructed a sophisticated business model by closely collaborating with manufacturing firms. Amazon physically enters into the manufacturer's facilities and thereby assume control over the online retail logistics for the manufacturer. Amazon's business strategy is driven by its reaction time to changes in customer demand and preferences. Each transaction tailors the experience for both retailers and customers.

Amazon is the world's largest online retailer and is a pioneer in the online retailing business. Although Amazon started as an online bookstore in 1994, its success encouraged it to diversify into selling anything that can be sold online, as shown in **Fig. 12**.

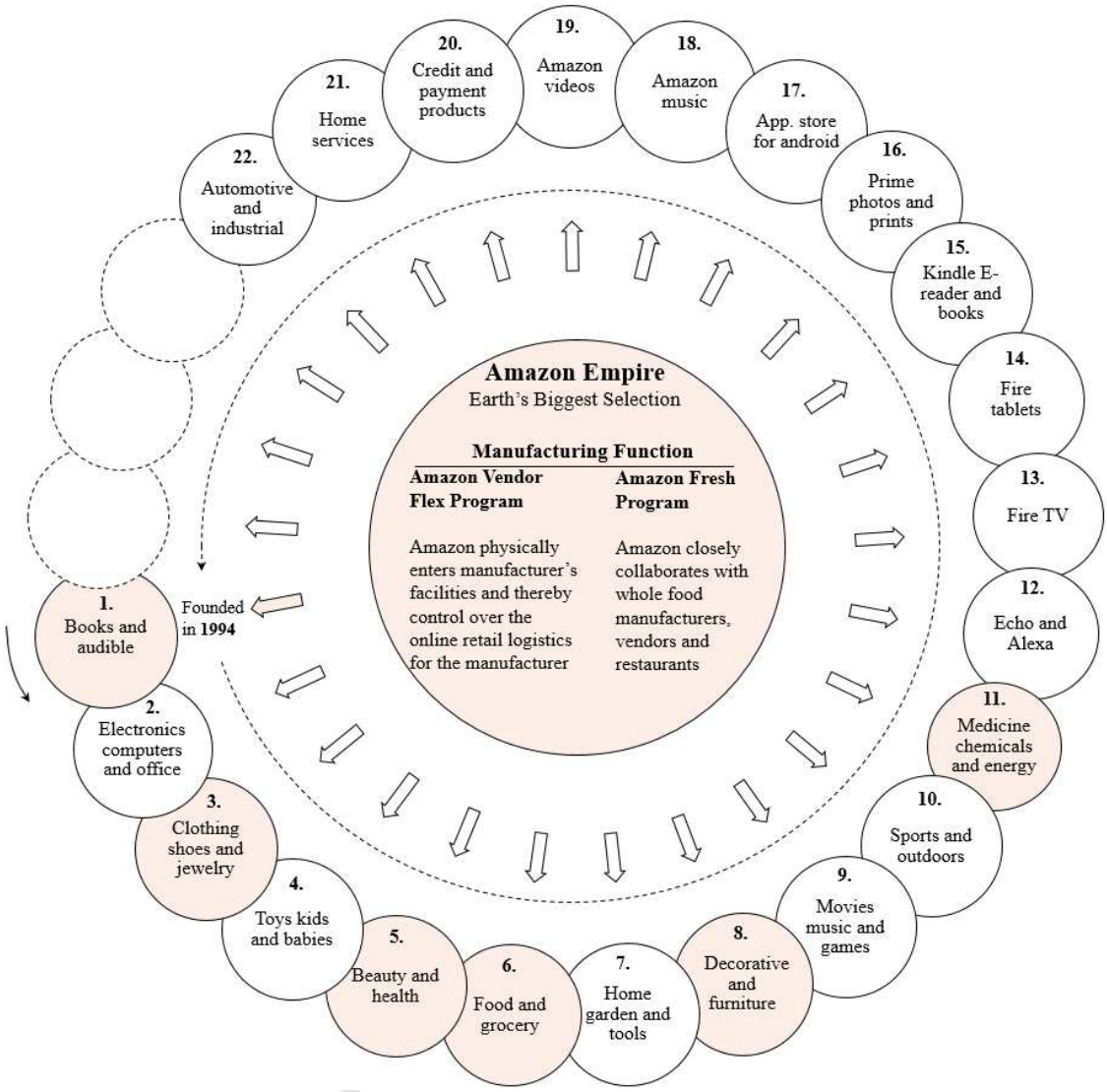


Fig. 12. Amazon's Growing Empire (by final product category).
Source: Authors' elaboration based on Kenney (2003) and Amazon (2017).

Its transformative trajectories in books and derived products are reviewed as follows:

(1) Books

As described earlier, Amazon plays a decisive role in the book industry with approximately 70% of market share worldwide (Nielsen BookScan, 2015). Amazon is aggressively pursuing the strategy of opening brick-and-mortar bookstores at different places in the U.S. to integrate the benefits of online and offline shopping for customers, considering peoples' preference shift from e-books and e-commerce to p-books obtained by brick-and-mortar shopping. In 2015, Amazon opened its first brick-and-mortar store, which later increased to 13 by the end of 2017, as demonstrated in **Fig. 13.**

	Bookstore Location	State	Opening
1	Seattle	Washington	November 2, 2015
2	San Diego	California	September 7, 2016
3	Portland	Oregon	October 25, 2016
4	Dedham	Massachusetts	February 28, 2017
5	Chicago	Illinois	March 23, 2017
6	Lynnfield	Massachusetts	April 14, 2017
7	New York Columbus Circle	New York	May 25, 2017
8	Paramus	New Jersey	June 14, 2017
9	Bellevue	Washington	August 24, 2017
10	San Jose	California	August 24, 2017
11	New York City 34th St.	New York	August 29, 2017
12	Los Angeles	California	October 3, 2017
13	Walnut Creek	California	November 2, 2017

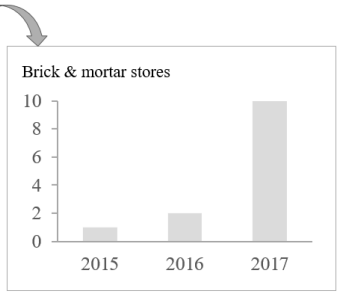


Fig. 13. Amazon's Brick and Mortar Stores Location in the US.

Source: Amazon (2017).

Three more bookstores are ready to open soon in Maryland, Texas and Washington D.C. Amazon has plans to open 300-400 new bookstores (Lavecchia et al., 2016). Amazon bookstores are different from conventional bookstores in many ways. All books in these stores are selected based on customer ratings, pre-orders and curator evaluations. Books are displayed face-out, accompanied by a customer review card. Amazon offers shopping discounts to its Prime members in stores and through electronic devices such as Kindle, streaming TV devices and Echo smart speakers that are available at the bookstores to test and buy. Tutorials are offered on weekends (Amazon, 2017). By contrast, Amazon is also opening book-less campus stores to provide students centralized pickup locations. Students order books online and come to these stores to pick them up, which reduces the shipping cost.

(2) Derived Products

As reviewed earlier, Amazon's digital-oriented strategy has had significant impact on p-books' "renaissance" in the U.S. With its basic principle of "merging net and real," Amazon has enact an ICT-driven disruptive business strategy. In line with this strategy, Amazon acquired a giant physical store, Whole Foods, in June 2017 (Yglesias, 2017). Later in 2018, Amazon and Whole Foods Market have announced that Amazon's acquisition of Whole Foods Market has ended and two companies will collaborate to implement the vision of making Whole Foods Market's high-quality, natural and organic food affordable for everyone. The Whole Foods Market's products will be available on Amazon.com, AmazonFresh, and Prime Now. Amazon and Whole Foods Market are inventing together to integrate Amazon prime into the Whole Food Market point-of-

sale system and in future, companies will invent in other areas including merchandising and logistics. (Amazon, 2018)

Amazon's business ecosystem has expanded worldwide, and it currently operates through its globalized delivery and logistics platforms. From the operational perspective, inventory inefficiencies are virtually eliminated and from the customer's perspective, there is a never-ending supply of inventory. Amazon has leveraged technology as a source of competitive advantage and gained the benefits of the economies of scale in addition to leveraging the synergies between its internal resources and external drivers. **Table 1** summarizes Amazon's disruptive business strategy.

Table 1 Amazon's Disruptive Business Strategy

Amazon Business Strategy *(It's all about customers)*		
	Action	**Impact**
Eliminate	• Traditional retail distribution channel • Manual billing and shipping	• Direct relationship with customers • Accelerated transaction time
Raise	• Online shopping platform • Products range • Customer shopping experience • Quality of service	• Reinvented the traditional retail business model and fundamental dynamics of how customers shop • Gives customers unprecedented choice, scope and value
Create	• Amazon Web Service (AWS) offering • Features like "1-click checkout" • Product recommendations system	• Makes web-scale cloud computing cheaper and more accessible • First-mover advantage and high company growth
Reduce	• Product prices • Short-term profitability	• Massive market share and scale • Drive down costs and increase profitability in future • High emotional switching costs for customers • Extremely high barriers for competitors in the future
Acquisition of a giant physical store, Whole Foods – merging net and real *(cf. Co-evolution of live music and streaming music)*		

Original source: Johnson et al. (2017).

Amazon is a pioneer in innovations, such as with Amazon Prime, Amazon Web Service (AWS), Market-place, Prime Now, Prime Air, customer reviews, Dash Button, Frustration Free Packaging, the Mayday-button, kindle, fulfillment centers and so on. This indicates that Amazon adheres to cost leadership strategy with constant business diversification and product innovation.

3.3 Structural Change in the Upstream

3.3.1 Impacts of Potential Resurgence on the Downstream

Inspired by the foregoing possibility of resurgence in the pulp and paper industry in the downstream of its value chain, particularly in the U.S. p-books market, this study analyzed structural change in upstream of the chain by focusing on the industry's leader, Finland.

Fig. 14 demonstrates trends in paper product exports from Finland over the 1960-2016 period. This figure illustrates that the sharp decline of Finland's exports due to Lehman shock of 2008 changed to a slight upturn from 2015 forward. While we should carefully monitor the trend, the Finnish forest industries federation has positive prospects with respect to the nation's exports, as the industry has been transforming by embracing digital solutions (PTT, 2016).

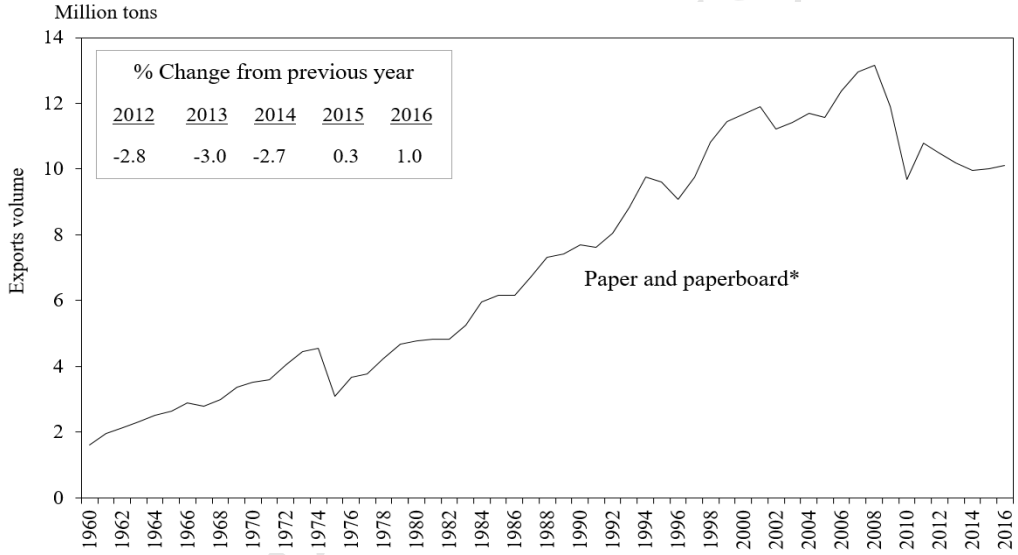


Fig. 14. Trends in Paper and Paperboard Exports from Finland *(1960-2016).*
*Paper includes printing, writing, newspaper and other paper.
Source: Finnish Forest Industries (2016).

A possible sign of resurgence in the downstream market, as observed with p-books and the U.S. wrapping-packaging paper market provides confidence in its prospects. Furthermore, the transformation trend observed in the whole value chain of the pulp and paper industry toward digital solutions and Amazon's ICT-driven disruptive business strategy, as reviewed in the previous sub-section, suggests the possibility of a creative disruption platform embracing digital solutions throughout the value chain of this industry.

As reviewed earlier, UPM (forest-based industry leader in Europe) has taken strong initiative in restructuring its business model to digital solutions–driven approach towards circular economy and accomplished world top net income in 2015 and sustainable increase in market capitalization since 2012.

3.3.2 Embracing Digital Solutions for Competitiveness and an Eco-Friendly Approach

Corresponding to the anticipation of digital solutions, a noteworthy solution to a digital challenge can be observed in leading forest firms in Finland. **Table 2** demonstrates a solution to a digital challenge initiated by leading forest firms in Finland, such as UPM, Stora Enso, Metsä and new bioproduct mills KaiCell Fibers and Finnpulp. By utilizing advanced digital innovation, such as digital maps, GPS, online wood trade, drone helicopters and virtual reality, these leading firms have been endeavoring to replace traditional non-renewable materials with renewable, recyclable and low-impact alternatives.

Table 2 Noteworthy Digital Solutions Challenge in Leading Forest Firms in Finland

Digital maps, GPS, Online wood trade, Drone helicopters for forest inventory, Virtual reality	
UPM	Versatile use of renewable wood biomass, combined with innovation, resource efficiency and sustainability aimed at replacing non-renewable materials with renewable and low-impact alternatives.
Stora Enso	Transforming from a traditional paper and board producer to a renewable materials growth company by means of a strong customer focus and new innovation approaches.
Metsä	Asset management to be accessible at any time or place, thereby making forest management easier. Resource efficiency, vast potential of renewable raw materials and value of products.
KaiCell Fibers	Versatile and competitive biorefinery with novel bioproduct applications, optimized capacity based on a local fiber approach, cultivated bio-products out of chemical softwood pulp and the bioecosystem of circular economy meeting economical requirements.
Finnpulp	Digital ecosystem provides advantages related to raw material and delivery chain management, improving the efficiency of the mill's support functions and optimizing production quality and quantity. This concept further improves the facility's occupational safety and environmental performance.

Sources: UPM (2017), Stora Enso (2017), Metsä (2017), KaiCell Fibers (2017), Finnpulp (2017).

In the context of this new eco-friendly approach, each ingredient of wood is refined into an end use that deliver high value-added products to the market. Finland is on the forefront of implementing such a vision. The traditional forest mills are transforming, and new production concepts and business models are emerging, such as next-generation bio-refineries and bio-product mills (Hurmekoski and Hetemäki, 2013).

The concept of a bio-refinery hub allows the integrated manufacturing of new bio-products, the resource-efficient use of side streams from the industrial processes, and the formation of a novel bioeconomy ecosystem. **Fig. 15** demonstrates the bio-refinery industrial ecosystem,

encompassing a network of companies utilizing pulp, and process side-streams in the production of new bio-products.

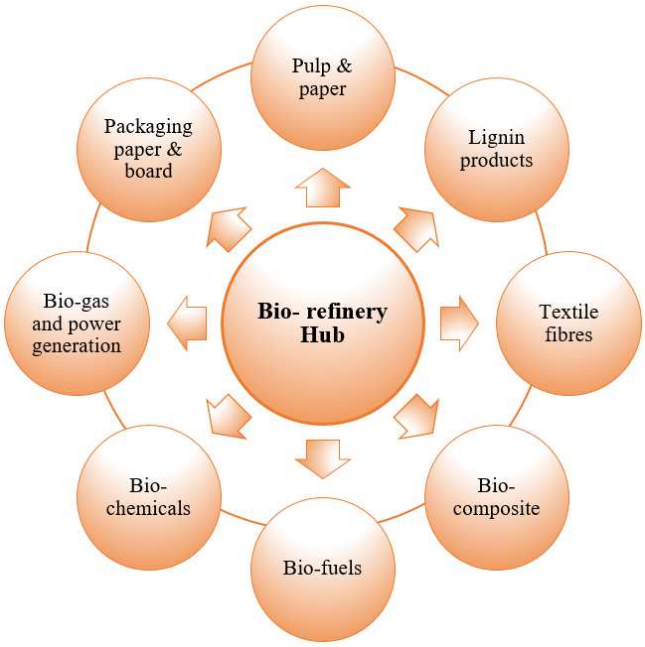


Fig. 15. Unique Bio-refinery Ecosystem.

Source: Authors' elaboration.

The business ecosystem of bio-refineries encompasses start-ups and research-based spin-offs. Heavy investments in pilot projects and demonstration facilities enable start-ups and big firms to trial their inventions and speed up the pace of transition from research to commercialization. For instance, Marimekko (Finnish clothing brand) and Spinnova (Finnish fiber technology company) are collaborating on the development and commercialization of wood-based textiles. Spinnova is currently the only company in the world that is able to convert pulp directly into textile fiber without chemical solvents (Marimekko, 2017).

Similarly, one of the leading Finnish forest firms, Stora Enso, is planning to invest 94 million euros to grow renewable materials to increase the competitiveness of customer board and biomaterials. A total of 52 million euros will be invested to enhance the dissolving pulp production capacity at Enocell mill and 42 million euros will be invested to increase the chemi-thermomechanical pulp at Imarta mill (Stora Enso, 2017). Both sites are located in Finland.

It is generally noted that for bio-product research and development, forest companies must focus on research-related ecosystems comprising research institutes, technology providers and universities (Ministry of Economic Affairs and Employment of Finland, 2017). Rametsteiner and Weiss (2006) identified the fact that limited cross-institutional coalitions restrained innovation in the forest sector. The future of the forest-based industry lies in cross-industrial collaborations and

the creation of a new value network by blurring the industry borders, as there is broad agreement within the industry that development requires collaboration (Hohenauer, 2017). Digital solutions and services are expanding beyond traditional boundaries and bringing collaboration partners (universities and startups) into the mix. For example, Tieto and UPM collaborated to organize a hackathon in Finland, which came up with new ideas to resolve the business issues that the forest industry was facing.

3.3.3 Disruptive Business Strategy in the Upstream

(1) UPM

UPM has changed its business model from a vertically integrated forest industry to a company with six separate business areas, as UPM has a versatile business portfolio and good geographic spread. The versatile use of forest biomass and a focus on competitiveness and innovation will continue to advance its biofore (bio-forest) strategy. In line with this strategy, UPM has signed an investment agreement with the Uruguayan government on the construction of a new pulp mill larger than Äännekoski mill. The preliminary estimate of the investment costs is about 2 billion euros (KSML, 2017). UPM's biofore strategy includes continuous improvement programs and short-term actions to drive performance and mid-term growth projects as well as mid- to- long-term development work to create new, high- value-added growth (UPM, 2016).

With such an endeavor supported by the advancement of digital innovation, an ICT-driven disruptive business strategy, similar to the leading challenge observed in the downstream of the value chain initiated by Amazon, has been undertaken by leading firms in the upstream of the chain. **Table 3** demonstrates the leading endeavor initiated by UPM. Its eco-friendly approach consists of eight steps: (i) selection of low impact materials, (ii) reduction of material usage, (iii) optimization of production techniques, (iv) optimization of distribution systems, (v) reduction of impact during use, (vi) optimization of initial lifetime, (vii) optimization of end-of-life system, and (viii) new concept development. Advanced innovation has been deeply involved in each respective step and systems integration has been accelerated, thereby the effects of digital solution can be maximized.

Table 3 UPM's Eco-friendly Approach

1. Selection of low-impact materials	Selection of low-impact materials, for example, by replacing fossil fuels with bioenergy and fossil raw materials with sustainable options.
2. Reduction of material usage	Reduction of material usage by applying smart production techniques, designing longer-lasting products with less material and reusing components.
3. Optimization of	Optimization of product techniques by continuously improving operational

production techniques	performance, for example, by reducing energy and water consumption and by sharing services and utilities.
4. Optimization of distribution systems	Optimization of distribution systems, for example, by using lighter and reusable packaging in end-product delivery.
5. Reduction of impact during use	Reduction of impact during use by lowering the environmental impact of customer processes, for example, by offering lighter paper grades to reduce the fuel consumption of distribution.
6. Optimization of initial lifetime	Optimization of initial lifetime by offering extended-life products that are multifunctional and recyclable, easy to maintain and repair.
7. Optimization of end-of-life system	Optimization of end-of-life systems by selecting non-toxic, reusable materials that are easily separated and sorted for reuse.
8. New concept development	New concept development, for example, thinking of new ways to use the product already in the design phase, without forgetting multi-functionality and shared use.

Source: Eco-designed Products (UPM, 2017).

At UPM, the transformation of business strategy, business portfolio and business performance started back in 2008. UPM has yielded the following benefits in recent years:

1) Transparency and accountability – commercial strategies, benchmarking, target setting, incentives.
2) Cost competitiveness – agility, improved efficiency, optimized sourcing.
3) Growth – focused investments with attractive returns and a clear competitive advantage.

UPM aims to add value to its business with competitive and responsible operations, global market reach and business agility by building a global platform. To achieve this goal, UPM has contracted a collaboration agreement with Tieto, which builds e-commerce solutions. Under this agreement, Tieto is responsible for end-to-end service delivery from design, development and integration, thus it bringing UPM flexibility and simplicity. Since Tieto has been collaborating with Amazon for the co-utilization of Amazon's Amazon Web Services (AWS) and Tieto's eCommerce Cloud for the advancement of e-commerce solutions, by means of this contract between UPM and Tieto, a virtual link between upstream leader UPM and downstream leader Amazon has been enabled via e-commerce, as illustrated in **Fig. 16.** Thus, e-commerce solutions led to the elimination of distance between the upstream and the downstream of the forest-based bioeconomy chain.

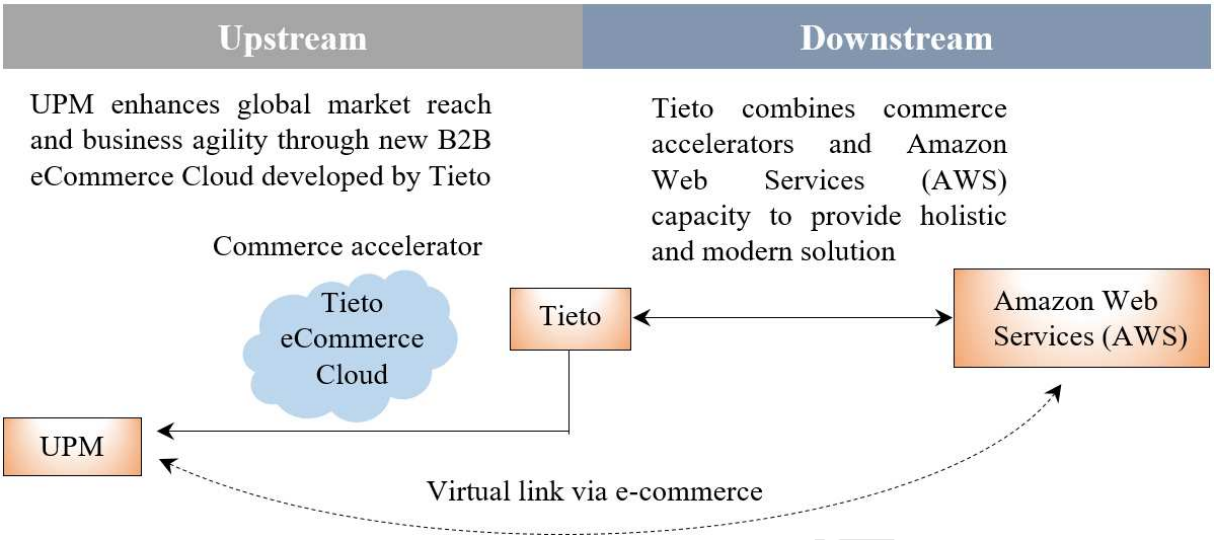


Fig. 16. Scheme Accelerating Global Market Reach between Upstream and Downstream.

(2) Metsä

As discussed in the previous section, the Finnish forest industry is transforming into a system of bio-product mills wherein companies are continuously improving existing products and adding new products to their portfolio. Metsä has invested 1.2 billion euros in the establishment of the world's first next-generation bio-product mill in Äännekoski, Finland. This is the largest investment in the history of the Finnish forest industry. The bio-product mill, inaugurated on October 18, 2017, aims to maximize resource efficiency by utilizing the raw wood material in a manner that allocates half for main product pulp and the rest for other product streams (Metsä, 2017). With its network of partners, the Bioproduct mill will process the wood ingredients used to produce the value-added products.

Metsä Fibre explained that the current ecosystem of Äännekoski bio-product mill has the potential to manufacture the bio-chemicals, bio-energy and various bio-materials from pulp. The Äännekoski bio-product mill business ecosystem is still expanding to produce the new bio-products (Ministry of Economic Affairs and Employment of Finland, 2017). **Fig. 17** demonstrates the scope of new products in Äännekoski bio-product mill.

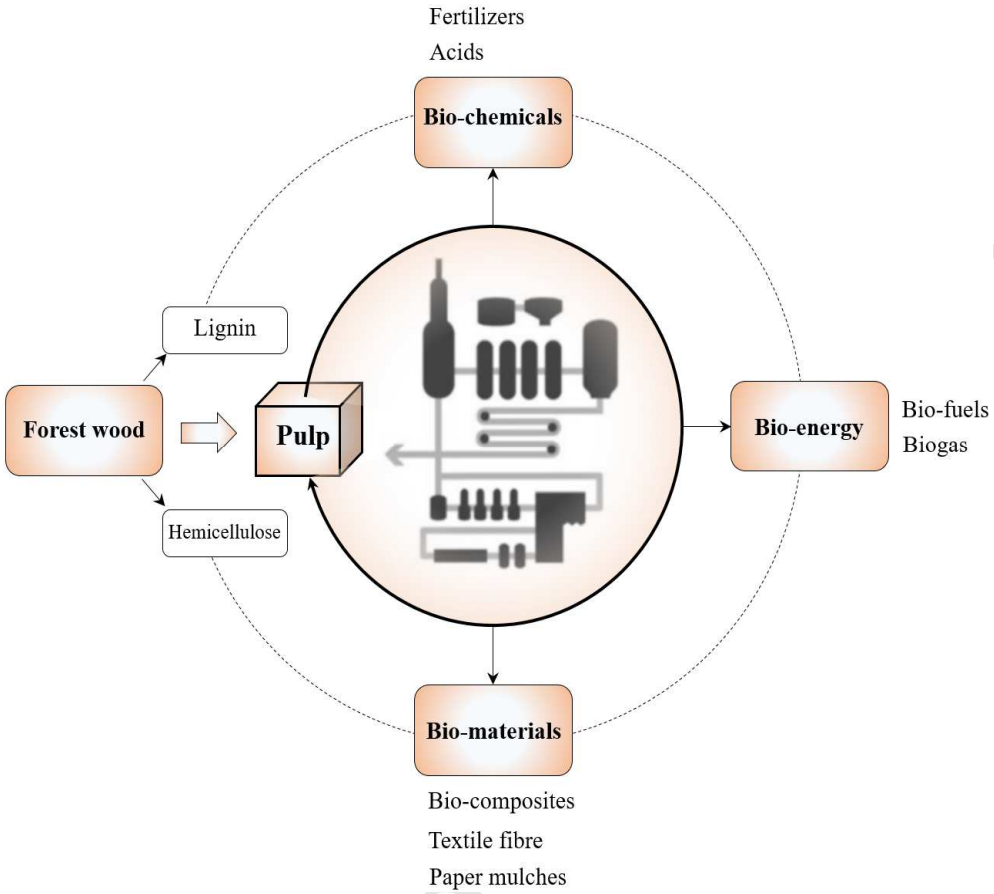


Fig. 17. Scope of Products in Metsä's Äännekoski Bio-product Mill.
Source: Adapted from Metsä Fibre Limited.

New bio-products, such as bio-composites, biofuels and paper mulches, have recently been launched. The existing raw materials being used by various companies can potentially be replaced with wood-based materials (pulp, lignin and hemicellulose) to manufacture eco-friendly products; for example, wood-based textile fibers can replace cotton in the clothing industry.

3.4 New Value Chain Ecosystem of Forest-based Bioeconomy

On the basis of the preceding analysis, new value chain ecosystem of the forest-based bioeconomy can be expected to extend in a transformative direction, as demonstrated in **Fig. 18.**

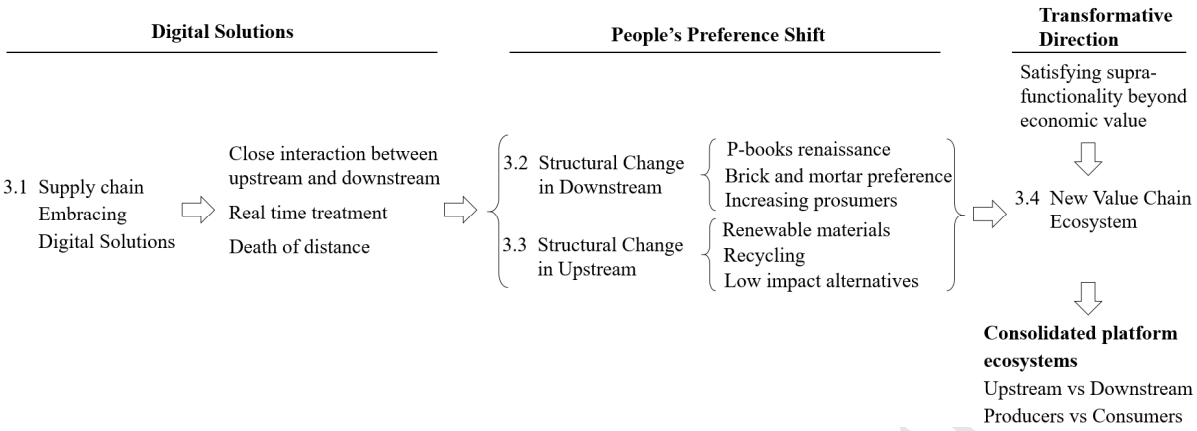


Fig. 18. Scheme Leading to New Value Chain Ecosystem.

The fast flow of information through social media, such as Facebook, YouTube and blogs, has enabled virtual communities to share their views on what is ethical, sustainable and eco-friendly. People's buying behavior and preferences are changing as they rely on digital media and trust advice obtained online from virtual communities. The increasing role of digital technologies and social concerns are transforming individuals from customer to prosumers. These concerns are not only growing in industrialized countries but also in developing nations (Wesseler and Von Braun, 2017).

Currently, supply chains have become increasingly vertically and horizontally integrated (Wesseler, 2014), thus a new value chain ecosystem for the forest-based bioeconomy encompassing both upstream and downstream industries can be anticipated, as described in **Fig. 19.**

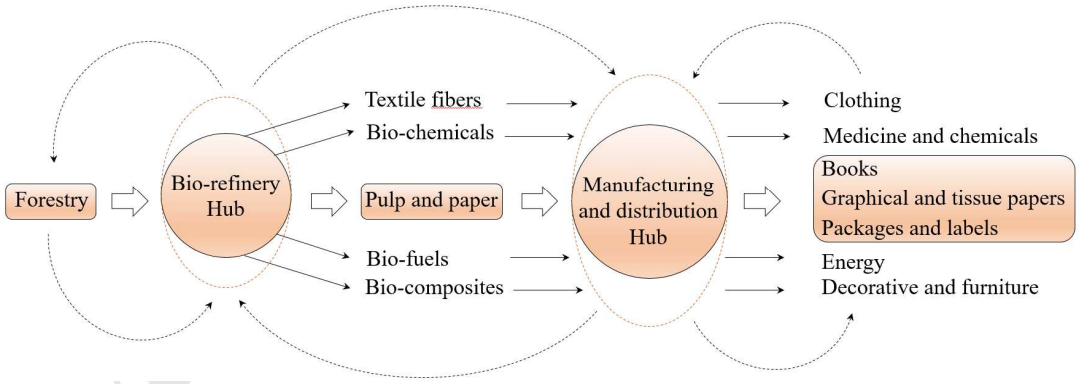


Fig. 19. New Value Chain Ecosystem of the Forest-based Bioeconomy.
Source: Authors' elaboration.

The advancement of digital solutions leverages industrial convergence among diversified industrial sectors, leading to strengthened consolidation between the upstream and downstream as well as producers and consumers within the scope of the new value chain ecosystem of the forest-based bioeconomy (VTT, 2016).

4. Transformation toward a Creative Disruption Platform

4.1 Creative Disruption Strategy

Given the digital solutions initiated at the forefront of the downstream and upstream of the value chain ecosystem of the pulp and paper industry, as reviewed in the preceding section, a creative disruption platform embracing digital solutions can be anticipated. **Fig. 20** illustrates the concept of this platform. The advancement of digital innovation leverages the reconstruction of traditional institutional systems in the forest-based bioeconomy, leading to (i) a low-performance production system, (ii) rigid rules and conventional customs, (iii) traditional business models, and (iv) laws and regulations applicable to non-digital economies.

Reconstructed institutional systems in turn create new business systems, such as (i) new digital technologies, (ii) products and services, (iii) new business models, (iv) new management and operational models, (v) transparency and openness in operations, (vi) anticipatory decision-making, and (vii) collaborative governance of natural resources. These new business systems accelerate the reconstruction of traditional institutional systems. Thus, a mutually inspiring virtuous cycle between disruption and creation emerges, leading to the construction of creative disruption platform embracing digital solutions.

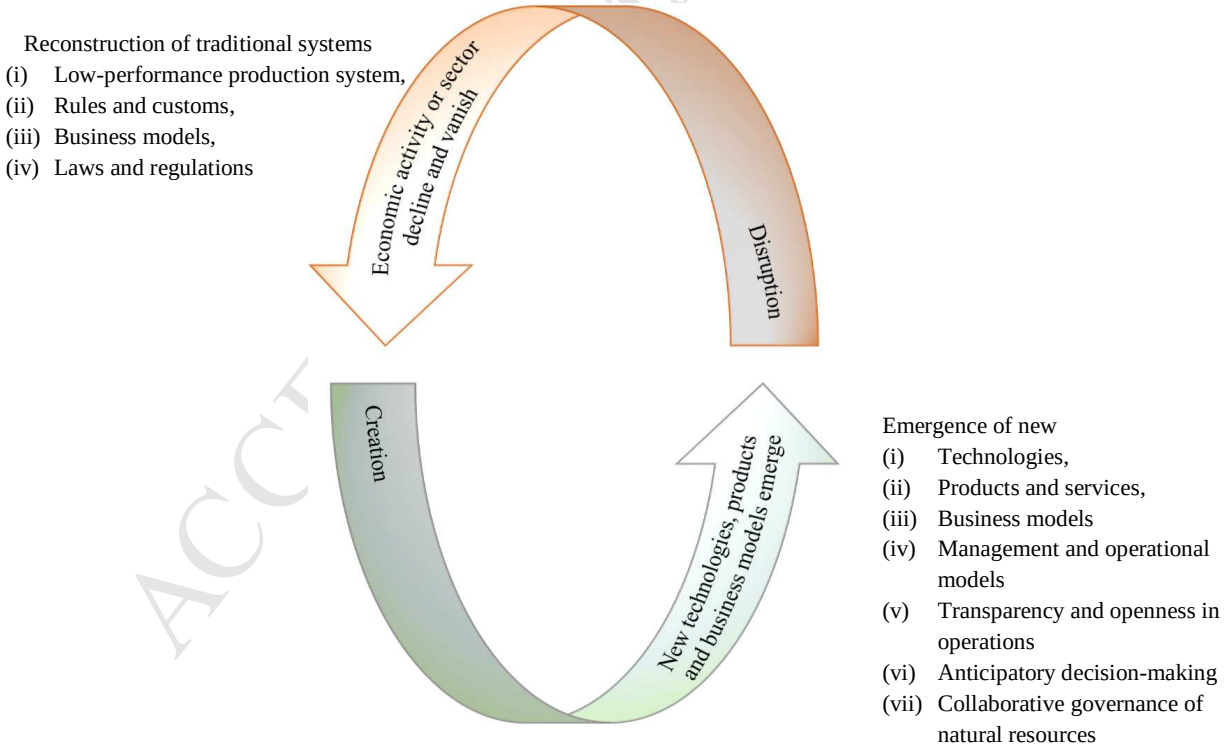


Fig. 20. Creative Disruption Platform Embracing Digital Solutions.
Source: Authors' elaboration based on Hetemaki (2016).

4.2 Digital Solutions for Transformation into a Creative Disruption Platform

The advancement of digital innovation thus transforms the value chain of the forest industry into a creative disruption platform in a stepwise way as illustrated in **Fig. 21.**

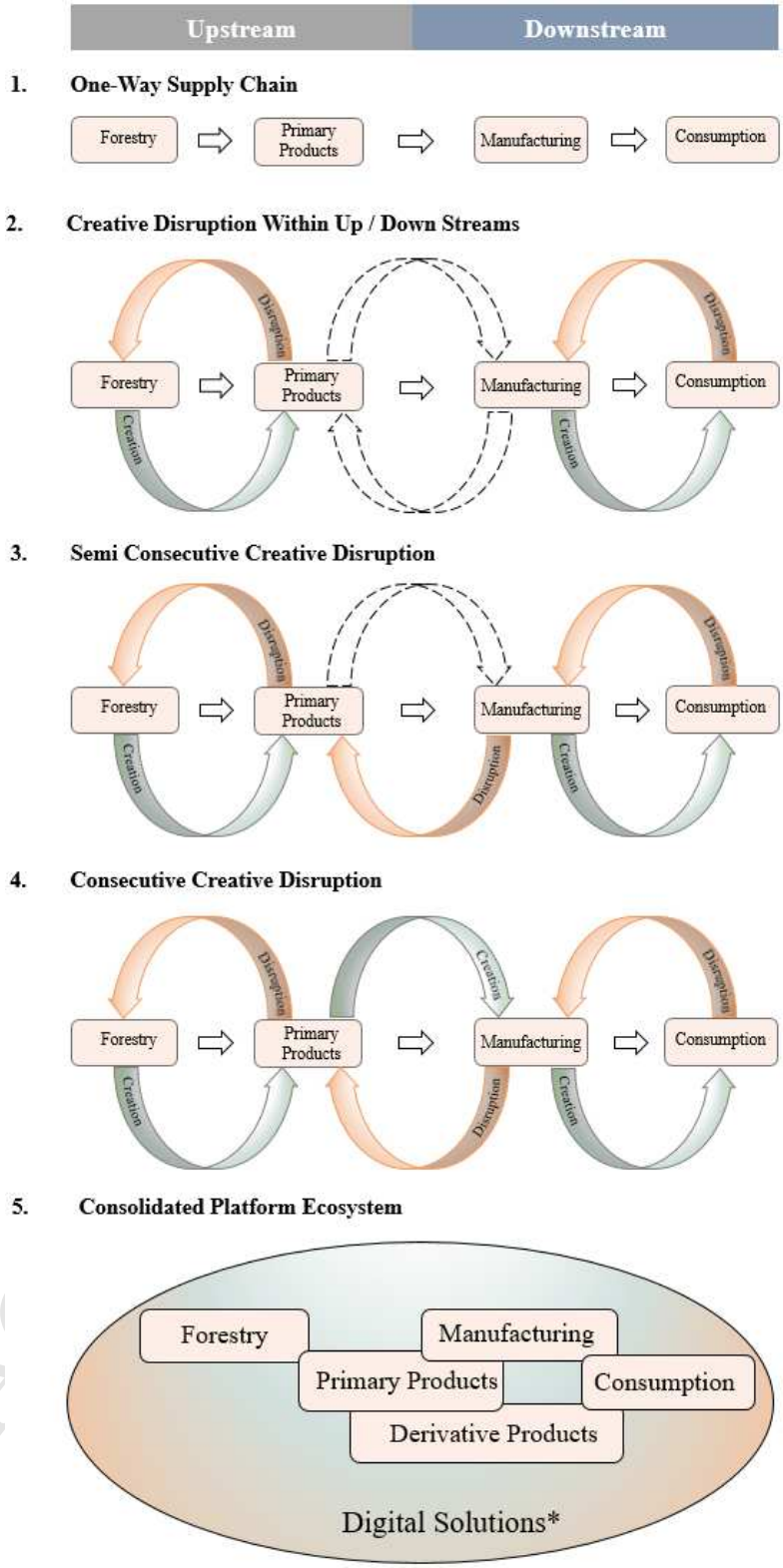
The traditional one-way supply chain from forestry to consumption through primary products and manufacturing (step 1) transforms into creative disruption platforms. However, it remains within the upstream and downstream, respectively as demonstrated by the broken-line arrow in Fig. 21 (step 2). Further digital solutions in the downstream leverage disruption of the upstream with confidence of the resurgence of the forest industry (step 3). This disruption in the upstream reacts by inducing new business system creation in the downstream as typically observed in Amazon's growing empire (step 4). Thus, the emergence of a creative disruption platform throughout the value chain of the forest-based bioeconomy can be expected.

Furthermore, streams such as (i) diversified production corresponding to increase eco-consciousness and preference shifts, (ii) actors from different sectors interacting and playing different roles, and (iii) all stakeholders involved in the disruption of the forest-based bioeconomy accelerate the consolidation of upstream and downstream as well as producer and consumer, leading to the transformation of the forest-based bioeconomy into a digital platform industry (step 5). The advancement of e-commerce solutions leads to the elimination of distance between upstream and downstream, enabling such consolidation.[6]

By embracing digital solutions, the creative disruption platform is expected to address challenges related to forest management, production, compliance to customer needs, market demands and sustainability in both upstream and downstream industries. European forest industries are diversifying their business models and product portfolios by developing new products and services (Näyhä et al., 2014).

For example, UPM shifted its business model from the vertical integrated forest industry to six separate business units and its eco-friendly approach towards circular economy. On the downstream side, Amazon is aggressively embracing digital solutions to diversify its products and improving users' experience. The degree of specialization and diversification is expected to increase both in upstream and downstream industries in the future, underlining the need to construct a creative disruption platform.

[6]This is similar to a notable co-evolutionary, complementary leap between Silicon Valley ("Mecca" of software) and Shenzhen in China ("Mecca" of hardware).



* Enabler of real-time, end-to-end supply chain visibility, improved delivery accuracy, stock level optimization, alignment with demand planning, and e-commerce solutions.

Fig. 21. Steps in Constructing a Creative Disruption Platform by Embracing a Digital Solution.
Source: Authors' elaboration based on Beamon (1998) and Hetemäki (2016).

4.3 Analysis of Creative Disruption Platform Construction

To demonstrate the hypothetical expectation with respect to the potential transformation of the forest-based bioeconomy into a creative disruption platform, an empirical analysis was conducted on the effects of creative disruption in the downstream on the upstream market. **Fig. 22** outlines the framework of this analysis. Aiming to demonstrate the emergence of creative disruption, the analysis focused on the effects of Amazon's creative disruption efforts in the downstream, as reviewed in 3.2.3 on the market capitalization of UPM, on leading firms in the upstream, as reviewed in 3.3.3 (see the details of yearly statistics **Appendix 2**).

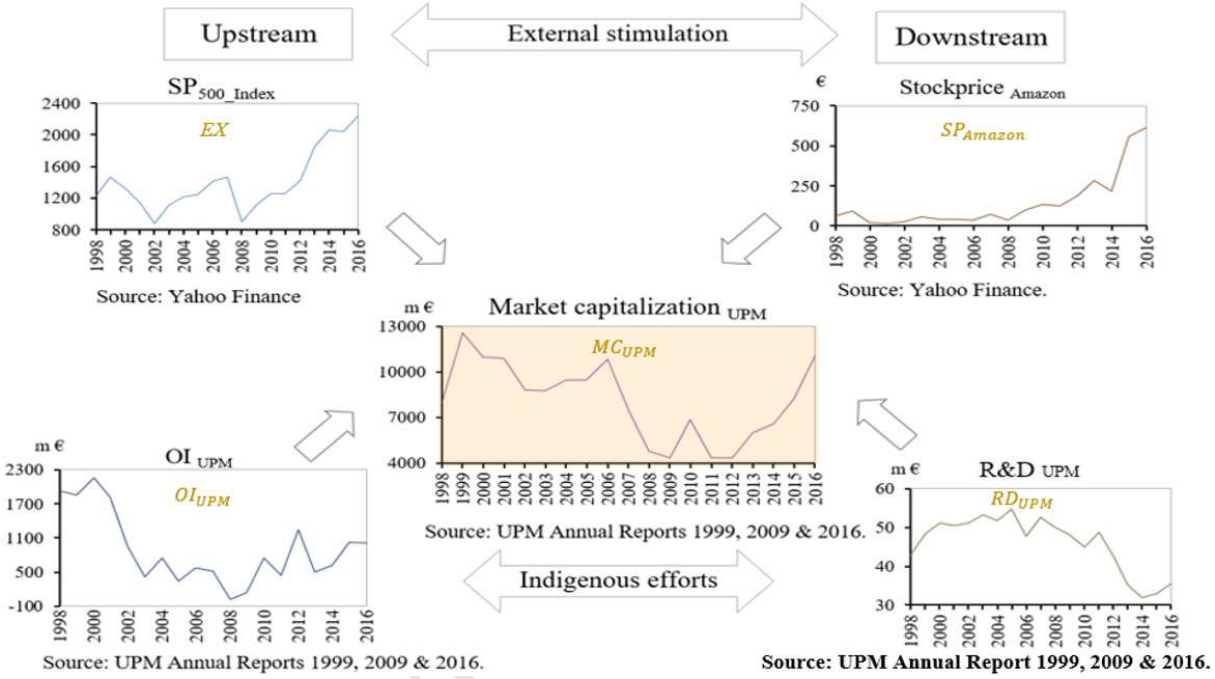


Fig. 22. Effects of Creative Disruption in Downstream on the Market Value Increase in Upstream Firms – The Case of UPM (1998-2016)**.**

It is generally postulated that the market capitalization of UPM is governed by its indigenous efforts as represented by its operating income improvement and increase in R&D investment. It is also subject to external situations such as the economic environment represented by the SP_500 Index in the EU. Furthermore, given the creative disruption between upstream and downstream, such as virtual link between UPM and Amazon enabled via e-commerce as reviewed in Fig.17, the market capitalization of UPM should be influenced by Amazon's creative disruption efforts in the downstream as represented by its stock price.

Based on these postulates, a correlation analysis identifying the governing factors of the market value of UPM was conducted. **Table 4** summarizes the results of the correlation analysis between the market value of UPM and governing factors of this value both in upstream and downstream over the 1998-2016 period.

Table 4 Correlations between Market Value of UPM and Governing Factors in both Upstream and Downstream (1998-2016).

$$\ln MC_{UPM} = \underset{(-1.15^{*3})}{-4.59} + \underset{(4.03^{*1})}{0.16\, D_1 \ln OI_{UPM}} + \underset{(1.11^{*3})}{0.56\, D_2 \ln OI_{UPM}} + \underset{(2.27^{*2})}{1.94\, D_1 \ln RD_{UPM}} + \underset{(1.02^{*3})}{0.80\, D_2 \ln RD_{UPM}}$$
$$+ \underset{(3.03^{*1})}{0.83\, D_1 \ln \mathrm{EX}} + \underset{(-0.91^{*4})}{0.59\, D_2 \ln EX} - \underset{(-2.40^{*2})}{0.23 \ln SP_{Amazon}} + \underset{(1.01^{*3})}{0.43 \ln SP_{Amazon}} \qquad adj.\ R^2\ 0.933$$

D: dummy variables; D_1: $1998 - 2011 = 1$, otheres $= 0$; D_2: $2012 - 2016 = 1$, otheres $= 0$.
The figures in parenthesis indicate t-statistics: Significant at the $*^1$ 1%, $*^2$ 5%, $*^3$ 20% and $*^4$ 30% level.

While this effect represented negative impact on UPM market value up until 2011, it changed to a positive inducement from 2012 forward, corresponding to Amazon's creative disruption efforts during these years, as reviewed in 3.2.3. This positive reaction could be considered evidence of the emergence of creative disruption between the downstream and the upstream of the value chain. **Fig. 23** demonstrates the correlation between the stock prices of Amazon and UPM and supports the forgoing correlation analysis. Given a virtual link between UPM and Amazon enabled via e-commerce, it is evident that Amazon's stock price increase contributed to sustainable increase in UPM's market capitalization since 2012.

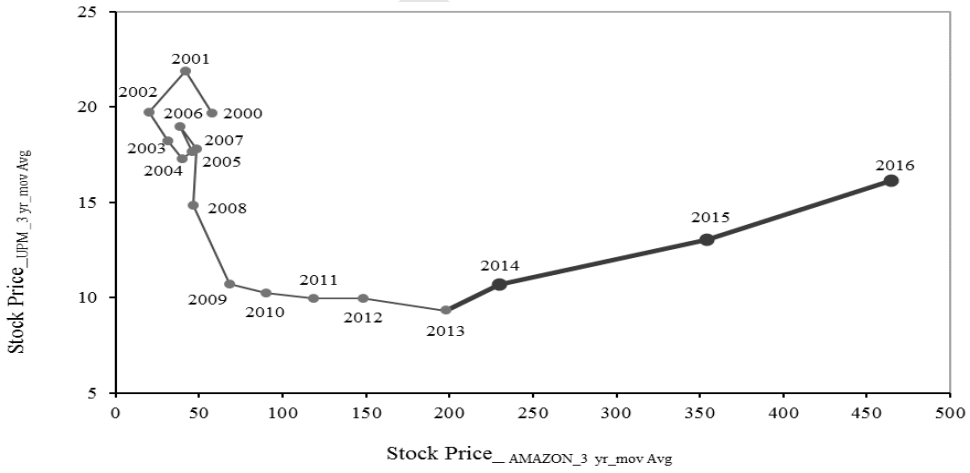


Fig. 23. Correlation between Stock prices of Amazon and UPM (2000 – 2016).
Three-year moving average.
Sources: Yahoo Finance and Nasdaq Helsinki Stock Exchange.

On the basis of the foregoing analyses, a consecutive creative disruption between Amazon and UPM was demonstrated, as illustrated in **Fig. 24.**

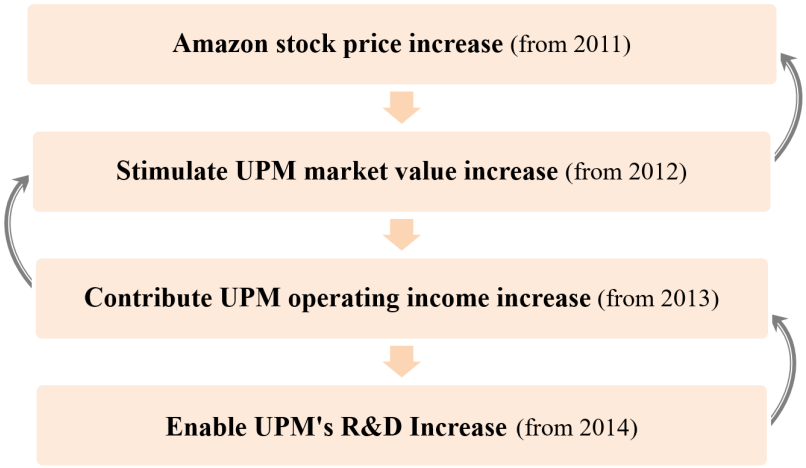


Fig. 24. Consecutive Creative Disruption between Amazon and UPM.

In order to confirm this transformation process, the future prospect of consolidation between the upstream and downstream was estimated. **Fig. 25** demonstrates the prospects of stock price correlation between leaders in the upstream (UPM and Metsä) and downstream (Amazon). Fig. ~~28~~ 25 demonstrates that this correlation changed from a vicious cycle to a virtuous cycle from 2011/2012 in both cases (Amazon vs. UPM and Amazon vs. Metsä) and continued to strengthen.

The correlation estimate for the 2017-2020 period was conducted by depicting stock prices as a function of the time trend summarized below in **Table 5.**

Table 5 Correlation between Stock Price and Time Trend (2000-2016).

$$adj.\ R^2 = 0.750$$

$$SP_{UPM} = \underset{(19.85)}{20.555} - \underset{(-7.05)}{0.173}t^2 + \underset{(6.58)}{0.0007}t^4$$

$$adj.\ R^2 = 0.811$$

$$SP_{Metsä} = \underset{(15.04)}{7.628} - \underset{(-8.40)}{0.734}t + \underset{(7.52)}{0.0002}t^4$$

$$adj.\ R^2 = 0.925$$

$$SP_{Amazon} = \underset{(2.83)}{55.840} - \underset{(-2.22)}{0.823}t^2 + \underset{(6.38)}{0.008}t^4$$

SP: Stock price, t: Time trend

The figures in parenthesis indicate t-statistics: All are significant at the 1% level.
The backward elimination method with 10% significant criteria was used.

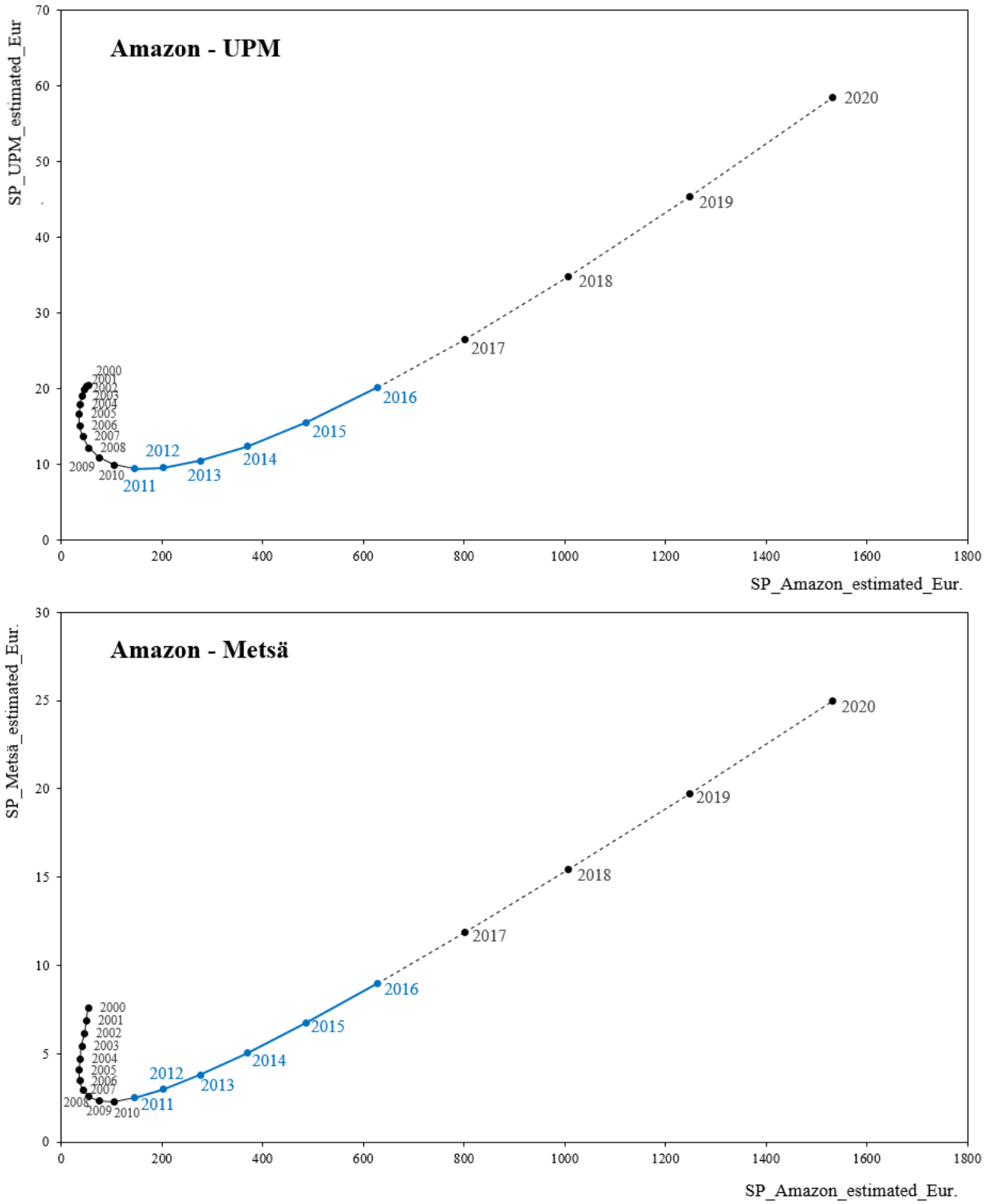


Fig. 25. Correlation of Stock Prices between Upstream and Downstream Leaders.
(2000-2016 and 2017-2020 (estimate)).

The above dynamism transforming the forest-based bio-economy into a digital-solution-driven creative disruption platform may provide a method to construct a "super digital-biofore computer" that incorporates the identical functions of this platform, as illustrated in **Fig. 26.** Here, "biofore" implies a bio-forest that grows sustainably.

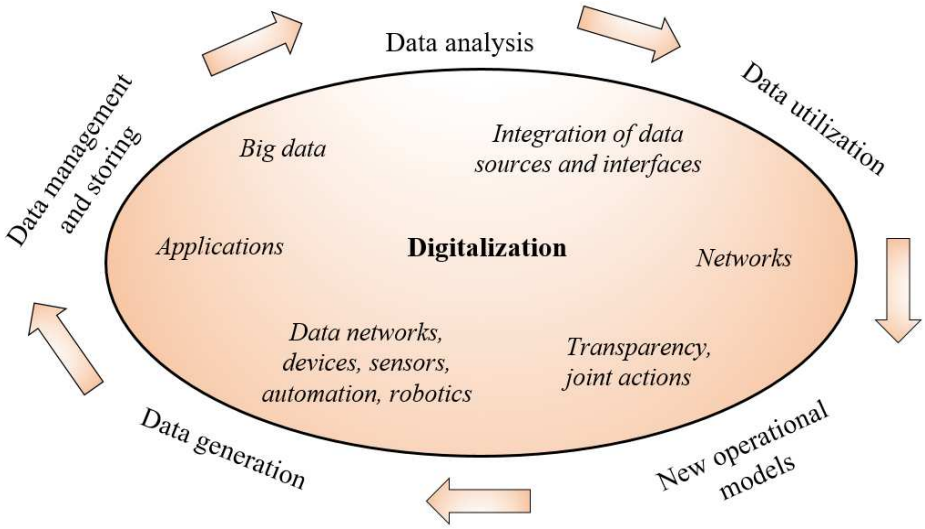


Fig. 26. Concept of a "Super Digital-Biofore Computer" Suggested by the Forest-based Bioeconomy Transformation.

Source: Authors' elaboration based on VTT (2016).

5. Conclusion

With the notion that transformation of the forest-based bioeconomy in recent years provides insightful suggestions for business innovations, this paper conducted an empirical analysis of this transformation and attempted to extract suggestions to construct a digital-solution-driven, disruptive business model in the digital economy.

An empirical analysis focusing on the transformative business activities observed at the forefront of both the upstream and the downstream of the value chain ecosystem by embracing digital solutions was conducted. UPM and Metsä (Finland's leaders) and Amazon (a U.S. leader) were used to represent the respective streams. Insightful findings include the following:

(i) Similar to the music industry, the trend of resurgence has been observed in recent years in the book industry.
(ii) This was initiated by a renaissance of p-books.
(iii) This renaissance can be attributed to peoples' preference shift from excessive e-books to p-books and also from e-commerce to brick-and-mortar shopping.
(iv) Digital innovation enabled the satisfaction of this requirement by constructing a virtuous cycle between price decrease and purchase increase in p-books.
(v) In addition, the diversification of products and services corresponding to increased eco-consciousness and peoples' preference shifts has become distinct in recent years.
(vi) These streams increase prosumers by consolidating producers and consumers.
(vii) Corresponding to this transformation stream, e-commerce giant Amazon has facilitated creative disruption by merging net and real retail through acquiring giant physical stores.
(viii) Induced by such a significant transformation stream at the forefront of the downstream of the forest-based bioeconomy, a similar digital-solution--driven transformation stream has impacted the upstream of the economy.
(ix) Forest and its product industries have also been transforming by embracing digital solutions.
(x) Traditional forest-based mills are transforming into next-generation bio-refinery hubs.
(xi) The bio-refinery hubs permit integrated manufacturing of new bio-products, resource-efficient use of side streams from the industrial processes, and the formation of a new bioeconomy ecosystem.
(xii) This transformation, in turn, further accelerates the transformation of the downstream of the economy.
(xiii) The advancement of e-commerce solutions has led to the elimination of distance between the upstream and downstream.
(xiv) Thus, the creative disruption platform has had significant impact on the whole value chain ecosystem of the forest-based bioeconomy.
(xv) Consequently, the forest-based bioeconomy has been transforming into a consolidated platform industry by consolidating upstream and downstream as well as producers and consumers.

(xvi) All can be attributed to the digital innovation that enables real-time end-to-end supply chain visibility, improved delivery accuracy, stock level optimization, alignment with demand planning, and advanced e-commerce solutions.

These findings gave rise to the following insightful suggestions for industries confronting the transformation stream:

(i) Given that the largest share of production and consumption of the forest-based bioeconomy depends on Asia, a U.S. and Europe-initiated digital-solutions-oriented transformation should be transferred to growing economies centered on Asia.
(ii) Through such transference efforts, this transformation should trigger worldwide collaboration between industrialized and growing economies.
(iii) In addition, this endeavor should be a prototype of construction for creative disruption platforms across industries.
(iv) Similar platforms should be considered in fields with strong social demands, such as healthcare, education and transportation.
(v) Co-evolution between business model transformation and further advancement of digital solutions, leading to self-propagating dynamism, should be accelerated.
(vi) It should be fully recognized that such endeavor leads to underpin regional economies and promote the formation of new business agglomerations of a world standard.
(vii) Dynamism in transforming to a consolidated platform should be further elucidated, conceptualized and operationalized as a "super digital-biofore computer" that is applicable to business innovations.

This research thus explores new insights into not only the forest-based bioeconomy but all industries by embracing digital solutions.

However, due to constraints of reliable data on the very latest business activities, successive careful monitoring is strongly recommended.

Further work should focus on complementing these constraints and unexplored analysis as well as in-depth analysis of success and failure trajectories with respect to creative disruptive platforms. The "super digital-biofore computer," a soft innovation resource created by the transformation of the forest-based bioeconomy, should be developed through interdisciplinary efforts on a priority basis. In this context, digitalized bio-economy initiated by UPM's planned obsolescence-driven circular economy enabled by co-evolutionary coupling between digital-bio coupling and up-down stream coupling would be worthwhile to analyze.

Acknowledgement

The research leading to these results has received funding from the Strategic Research Council at the Academy of Finland under grant agreement 293446 – Platform Value Now: Value capturing in the fast emerging platform ecosystems.

Appendix 1. Trends in Production and Export of Paper Products: Global and Finland (1961-2015).

	Production Quantity[1]				Export Quantity[1]
	Finland		Global		Finland
Year	Graphic Paper	Paper & Paperboard	Graphic Paper	Paper & Paperboard	Paper & Paperboard
1961	1.24	2.40	29.96	74.15	1.96
1962	1.26	2.51	30.81	77.43	2.13
1963	1.34	2.75	32.73	82.26	2.30
1964	1.50	2.98	34.85	91.05	2.51
1965	1.71	3.21	36.62	96.53	2.67
1966	1.84	3.47	40.08	103.84	2.90
1967	1.78	3.39	40.31	105.02	2.82
1968	1.93	3.63	42.94	113.12	3.04
1969	2.14	4.07	46.37	122.07	3.43
1970	2.29	4.27	48.04	125.64	3.56
1971	2.38	4.43	48.09	127.51	3.65
1972	2.70	4.97	51.22	136.67	4.09
1973	3.01	5.45	55.19	147.36	4.49
1974	3.05	5.52	56.60	149.51	4.60
1975	2.33	3.99	48.58	127.03	3.14
1976	2.52	4.55	54.67	146.30	3.70
1977	2.67	4.62	57.13	151.15	3.82
1978	3.03	5.14	61.33	158.93	4.30
1979	3.39	5.74	64.71	167.80	4.74
1980	3.60	5.92	66.63	169.36	4.87
1981	3.80	6.14	67.71	169.12	4.91
1982	3.67	5.90	66.42	166.23	4.90
1983	4.00	6.39	71.22	176.43	5.32
1984	4.85	7.32	77.24	189.06	6.06
1985	4.98	7.45	78.53	192.05	6.26
1986	5.01	7.55	83.05	202.36	6.28
1987	5.32	8.01	88.96	213.70	6.87
1988	5.77	8.65	95.79	226.59	7.27
1989	5.92	8.75	98.84	232.20	7.39
1990	6.11	8.97	102.26	239.36	7.63
1991	6.01	8.78	102.98	243.43	7.52
1992	6.24	9.15	103.94	246.37	7.86
1993	6.93	9.99	104.67	252.47	8.59
1994	7.54	10.91	113.14	268.67	9.50
1995	7.74	10.94	116.38	282.29	9.23
1996	7.16	10.44	117.53	284.31	8.53
1997	8.59	12.15	125.71	301.12	10.16
1998	9.24	12.70	124.96	301.96	10.98
1999	9.39	12.95	132.22	315.55	11.21

2000	9.81	13.51	138.35	324.59	11.64
2001	8.96	12.50	132.80	318.93	10.88
2002	9.09	12.79	136.25	329.81	11.45
2003	9.26	13.06	139.47	338.88	11.73
2004	10.19	14.04	147.43	355.82	12.71
2005	8.82	12.39	146.92	365.01	11.16
2006	9.79	14.19	151.43	382.02	12.91
2007	9.77	14.33	153.67	391.76	13.10
2008	8.84	13.13	150.54	389.86	11.85
2009	6.86	10.60	135.12	370.64	9.64
2010	7.47	11.76	143.34	392.51	10.82
2011	7.32	11.33	141.08	400.18	10.45
2012	6.62	10.85	136.59	399.06	9.88
2013	6.31	10.59	132.85	396.72	9.86
2014	6.09	10.41	130.57	404.04	9.74
2015	5.92	10.32	128.05	406.30	9.85

[1]Quantity in million tons.
Source: FAO (2016).

ACCEPTED MANUSCRIPT

Appendix 2. Trends in Sales Volume, Sales Revenue and Book Prices by Type in the U.S. (2002-2015).

	Revenue *(millions US$)*			**Quantity Unit** *(millions)*			**Price/Unit**				
Year	**P-book**	**E-book**	**Total**	**P-book**	**E-book**	**Total**	**P-book**	**Change rate**	**E-book**	**Change rate**	**Total**
2002	3897.70	2.10	3899.80								
2003	3838.30	6.00	3844.30								
2004	3794.70	9.30	3804.00	648		648	5.86				5.87
2005	5058.50	16.00	5074.50	710		710	7.12				7.15
2006	5036.40	25.20	5061.60	721		721	6.99				7.02
2007	5457.90	31.70	5489.60	758		758	7.20				7.24
2008	5158.12	61.30	5219.30	778		778	6.63				6.71
2009	5127.43	169.50	5296.50	770	64	834	6.66		2.65		6.35
2010	4864.22	441.30	5305.30	718	69	787	6.77		6.40		6.74
2011	5506.81	1097.60	6604.40	651	165	816	8.46		6.65		8.09
2012	5476.13	1551.20	7027.30	592	215	807	9.25	9.35 %	7.21	8.46 %	8.71
2013	5374.92	1547.20	6922.10	620	242	862	8.67	-6.28 %	6.39	-11.39 %	8.03
2014	5473.81	1595.20	7069.00	635	234	869	8.62	-0.57 %	6.82	6.63 %	8.13
2015	5623.74	1381.90	7005.60	653	204	857	8.61	-0.09 %	6.77	-0.63 %	8.17
								-2.31 %		**-1.80 %**	

Sources: Nielsen BookScan U.S./PubTrack Digital U.S.

American Association of Publishers (AAP) – Monthly Statshot.

ACCEPTED MANUSCRIPT

Appendix 3. Yearly Statistics on the Factors Governing Creative Disruption Centered by UPM (1998-2016).

Year	UPM MC (Eur Mil.) Real Value	UPM Net O/I (Eur Mil.) Real Value	UPM R&D (Eur Mil.) Real Value	S&P 500 Index December	Amazon Stock Price (Eur) Adj. for Splits & Inflation Base year 2010	UPM Stock Price (Eur) Adj. for Splits & Inflat. Base year 2010
1998	7891.65	1928.28	42.85	1229.23	61.31	14.21
1999	12573.00	1854.76	48.34	1469.25	90.37	23.58
2000	11024.29	2157.99	51.05	1320.28	20.87	21.21
2001	10869.63	1812.17	50.53	1148.08	14.62	20.92
2002	8851.45	957.42	51.15	879.82	23.90	17.01
2003	8784.86	408.34	53.26	1111.92	54.41	16.78
2004	9460.82	755.50	51.84	1211.92	40.49	18.04
2005	9469.32	347.52	54.64	1248.29	41.71	18.10
2006	10834.84	580.46	47.65	1418.3	33.58	20.71
2007	7465.15	508.99	52.69	1468.36	70.42	14.56
2008	4784.59	24.54	50.10	903.25	35.72	9.20
2009	4341.17	135.47	48.17	1115.1	98.04	8.35
2010	6874.00	755.00	45.00	1257.64	135.90	13.22
2011	4353.50	447.44	48.74	1257.6	121.94	8.30
2012	4386.73	1247.94	42.61	1426.2	187.77	8.34
2013	5998.59	505.96	35.08	1848.36	284.30	11.34
2014	6596.91	611.93	31.78	2058.9	217.65	12.37
2015	8206.73	1019.59	33.03	2043.94	561.01	15.38
2016	11031.89	1005.56	35.44	2238.83	615.69	20.68

MC: Market capitalization.
O/I: Operating income.
R&D: Research & Development.
S&P: Standard & Poor.

Sources: [1]UPM Annual Reports: 1999, 2009 and 2016.
[2]Yahoo Finance.
[3]Nasdaq Helsinki Stock Exchange.

ACCEPTED MANUSCRIPT

References

[1] Accenture, 2018. *Digital's Promise for Forest Products Industry*, https://www.accenture.com/fi-en/insight-improving-performance-forest-product-companies-digital-technologies Retrieved 09 April 2018.

[2] Amazon, 2017. *Earth's Biggest Selection*, https://www.amazon.com/gp/site-directory/ref=nav_shopall_btn Retrieved 25 December. 2017.

[3] Amazon, 2018. *Whole Foods Market + Amazon*, https://www.amazon.com/b?ie=UTF8&node=17235386011 Retrieved 09 April, 2018.

[4] American Association of Publishers (AAP), 2016. *Monthly Statshot*. AAP, New York.

[5] Beamon, B., 1998. Supply Chain Design and Analysis: Models and Methods. *International Journal of Production Economics*. 55(3), 281-294.

[6] CEPI (Confederation of European Paper Industries), 2014. *Key Statistics 2014*: *European Pulp & Paper Industry*. CEPI, Brussels.

[7] CEPI (Confederation of European Paper Industries), 2015. *What Digital Can Do for the Paper* Industry. CEPI, Brussels.

[8] CEPI (Confederation of European Paper Industries), 2017. *Key Statistics 2016*: *European Pulp & Paper Industry*. CEPI, Brussels.

[9] EC (European Commission), 2012. *Innovating for Sustainable Growth: A Bioeconomy for Europe. COM(2012)60 final*. Brussels.

[10] Enso, S., 2017. *A Focused Strategy*. Stora Enso.

[11] Enso, S., 2017. *Stora Enso Invests EUR 94 Million To Grow in Renewable Materials*. https://www.pulpandpaper-technology.com/news/stora-enso-invests-to-grow-in-renewable-materials. Retrieved 26 October 2017.

[12] Finnish Forest Industries, 2016. *Statistics*, https://www.forestindustries.fi/statistics/industry/ Retrieved 2 March. 2017.

[13] Food and Agriculture Organization (FAO), 2016. *Statistics, FAO*. Rome.

[14] Giurca, A., Späth, P., 2017. A Forest-based Bioeconomy for Germany? Strengths, Weaknesses and Policy Options for Lignocellulosic Biorefineries. *Journal of Cleaner Production* 153, 51-62.

[15] Hansen, E., Breede, B., 2016. *How Innovation Happens: Practical Insights from Cox Industries, Inc*. Bioprod. Bus. 1, 32–41

[16] Hetemäki, L., 2016. *Role of Sustainable Forest-based Bioeconomy in Europe*. Think Forest, 15 November 2016, Brussels.

[17] Hetemäki, L., Hoen, H.F. and Schwarzbauer, P., 2014. Future of the European Forest-based Sector and Bioeconomy, in Hetemaki, L. edt., *Future of the European Forest-based Sector: Structural Changes towards Bioeconomy*. European Forest Institute, Joensuu.

[18] Hohenauer, T., 2017. *The Future of Pulp and Paper: From Experience to Analytics, From Isolation to Ecosystems*. Tieto Corporation, Espoo.

[19] Hurmekoski, E., Hetemäki, L., 2013. Studying the Future of the Forest Sector: Review and Implications for Long-term Outlook Studies. *For. Policy Econ.* doi:10.1016/j.forpol.2013.05.005

[20] Johnson, N., Miller, O., Moffitt, D., 2017. *Disruption at the Gates: Monitoring the Threat of Amazon Business*. Applico, 1-18.

[21] Kenney, M., 2013. The Growth and Development of the Internet in the United States. In: Cogut B, Ed. The Global Internet Economy. *MIT Press*, Massachusetts.

[22] KSML, 2017. *UPM kaavailee toista sellutehdasta Uruguayhin – "Suurempi kuin Äänekosken tehdas"* http://www.ksml.fi/talous/UPM-kaavailee-toista-sellutehdasta-Uruguayhin-%E2%80%93-Suurempi-kuin-%C3%84%C3%A4nekosken-tehdas/1066682. Retrieved 8 November 2017.

[23] McDonagh, D., 2008. Satisfying Needs Beyond the Functional: The Changing Needs of the Silver Market Consumer. *Proceedings of the International Symposium on the Silver Market Phenomenon – Business Opportunities and Responsibilities in the Aging Society*, Tokyo.

[24] Marimekko, 2017. *Marimekko and Spinnova Start Cooperation*. https://www.marimekko.com/eu_en/the-brand/latest-news/marimekko-and-spinnova-start-cooperation. Retrieved 10 November 2017.

[25] Metsä, 2017. *About the Bio-product Mill*. http://bioproductmill.com/about-the-bioproduct-mill. Retrieved 12 November 2017.

[26] Ministry of Economic Affairs and Employment of Finland, 2017. *Wood-Based Bioeconomy Solving Global Challenges.* Enterprise and Innovation Department, Ministry of Economic Affairs and Employment of Finland.

[27] Mubareka, S., Jonsson, R., Rinaldi, F., Azevedo, J. C., de Rigo, D., Sikkema, R., 2016. *Forest bio-based economy in Europe.* (Eds.) European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg.

[28] Mustalahti, I., 2018. The Responsive Bioeconomy: The Need for Inclusion of Citizens and Environmental Capacity in the Forest-based Bioeconomy. *Journal of Cleaner Production*, 72, 3781-3790.

[29] Naveed, K., Watanabe, C., and Neittaanmäki, P., 2017. Co-evolution between Streaming and Live Music Leads a Way to the Sustainable Growth of Music Industry – Lessons from the US Experiences. *Technology in Society, 50*, 1-19.

[30] Näyhä, A., Hetemäki, L., and Stern, T., 2014. New Products Outlook, in Hetemäki, L. (Ed.), *Future of the European Forest based Sector: Structural Changes towards Bioeconomy*, W*hat Science Can Tell Us 6*. 43-54.

[31] Nielsen, 2016. *Nielsen BookScan /Pub Track Digital US*. Nielsen, New York.

[32] Ojala, J., Lamberg, J., Ahola, A., and Melander, A., 2007. The Ephemera of Success: Strategy, Structure and Performance in the Forestry Industries, in Lamberg, J. Näsi, J. Ojala, J., and Sajasalo, P. (Eds.), *The Evolution of Competitive Strategies in Global Forest Industries: Comparative Perspectives.* World Forests. Springer, Dordrecht.

[33] Pelli, P., Haapala, A. and Pykalainen, J., 2017. Services in the Forest-based Bioeconomy: Analysis of European Strategies. Scandinavian *Journal of Forest Research*, online 17 Feb March 2017.

[34] Pettenella, D., Ciccarese, L., Dragoi, S., Hegedus, A., Hingston, A. 2006. NWFP&S Marketing: Lessons Learned from Case Studies in Europe. In: *Niskanen A, editor*. *Issues Affecting Enterprise Development in the Forest Sector in Europe*. Joensuu: Faculty of Forestry, University of Joensuu, 367-403.

[35] Pöyry, 2017. *The Pulp and Paper Industry in Finland*, Pöyry, Vantaa, Finland.

[36] PTT, 2016. *Finland's Forest and Paper Industry Continues Structural Change*. Paper Age. http://www.paperage.com/2016news/10_19_2016finland_pulp_paper_forecast.html Retrieved 2 March 2017.

[37] Rametsteiner, E., and Weiss, G., 2006. Innovation and Innovation Policy in Forestry: Linking Innovation Process with Systems Models. *Journal of Forest Policy and Economicsicy 8(7),* 691–703.

[38] Roos, A., Lindström, M., Heuts, L., Hylander, N., Lind, E., Nielsen, C., 2014. Innovation diffusion of new wood-based materials – reducing the "time to market." *Scand. J. For. Res*. 29, 394–401. doi:10.1080/02827581.2014.931454

[39] Scarlat, N., Dallemand, J., Monforti-Ferrario, F., Nita, V., 2015. The Role of Biomass and Bioenergy in a Future Bioeconomy: Policies and Facts. *Journal of Environmental Development*, 15, 3-34.

[40] Tieto, 2017. *Introducing Forest Hub: Digitalizing Wood and Fiber Supply*. Tieto Corporation, Espoo.

[41] The Institute for Sustainable Development and International Relations (IDDRI), 2017. *Developing Decarbonization Strategies in the EU: Insights on Good Practice from National Experiences*. IDDRI, Paris.

[42] Toppinen, A., Wan, M., and Lähtinen, K., 2013. Strategic Orientations in the Global Forest sector, in Hansen, E., Panwar, R., and Vlosky., R. (Eds.), *The global forest sector: Changes, Practices, and Prospects*, New York: Taylor and Francis Group.

[43] Toppinen, A., Patari, S., Tuppura, A., Jantunen, A., 2017. The European Pulp and Paper Industry in Transition to a Bio-economy: A Delphi Study. *The Journal of Policy, Planning and Futures Studies* 88, 1-14.

[44] UPM, 1999. *Annual Report*. http://web.lib.hse.fi/FI/yrityspalvelin/pdf/1999/Eupmkymmene1999.pdf Retrieved 30 June 2017.

[45] UPM, 2009. *Annual Report*. http://assets.upm.com/Investors/Documents/2009/Annual_Report_2009_UPM_VSK_EN.pdf Retrieved 30 June 2017.

[46] UPM, 2016. *Aiming Higher with Biofore: Annual Report 2016*. http://hugin.info/165629/R/2081401/784910.pdf Retrieved 30 June 2017.

[47] UPM, *Ecodesigned Products,* http://www.upm.com/Responsibility/Product-stewardship/ecodesigned-products/Pages/default.aspx Retrieved 2 August 2017.

[48] Nasdaq Helsinki Stock Exchange, *UPM Stock Prices.* http://www.nasdaqomxnordic.com/aktier/microsite?Instrument=HEX24386 Retrieved 28 July 2017.

[49] United States Census Bureau, 2017. *Data: Bookstores.* https://www.census.gov/data.html Retrieved 23 June 2017.

[50] VTT, 2016. The Making of Bioeconomy Transformation. VTT, Helsinki.

[51] VTT Visions 11, 2017. *Bittejä ja Biomassaa: Tiekartta Digitalisaation Vauhdittamaan Biotalouteen*. Juvenes Print, Helsinki.

[52] Watanabe, C., Naveed, K. and Neittaanmäki, P., 2016. Co-evolution of Three Mega-trends Natures Un-captured GDP: Uber's Ride-sharing Revolution. *Technology in Society*, 46, 164-185.

[53] Watanabe, C., Naveed, K. and Neittaanmäki, P., 2017*a*. Consolidated Challenge to Social Demand for Resilient Platforms: Lessons from Uber's Global Expansion. *Technology in Society*, 48, 33-53.

[54] Watanabe, C., Naveed, K. and Neittaanmäki, P., 2017*b*. Co-evolution between Trust in Teachers and Higher Education toward Digitally-rich Learning Environments. *Technology in Society*, 48, 70-96.

[55] Watanabe, C., Naveed, N. and Neittanmäki, P., 2017*c*. Transformation of the Forest-based Bioeconomy by Embracing Digital Solutions, *Journal of Technology Management for Growing Economies* 8 (2), 191-214.

[56] Wesseler, J., 2014. Biotechnologies and Agrifood Strategies: Opportunities, Threats and Economic Implications. *Bio-based Appl. Econ.* 3 (3), 187-204.

[57] Wesseler, J., and Von Braun, J., 2017. Measuring the Bioeconomy: Economics and Policies. *Annual Review of Resource Economics* 9, 275-298.

[58] Wolfslehner, B., Linser, S., Pulzl. H., Bastrup-Birk, A., Camia, A and Marchetti, M., 2016. Forest Bioeconomy – A New Scope for Sustainability Indicators. *European Forest Institute*. From Science to Policy 4, 1-31.

[59] Yahoo Finance, *Amazon Stock Prices*. https://finance.yahoo.com/chart/AMZN Retrieved 25 July 2017.

[60] Yahoo Finance, *S&P 500 Index*. https://finance.yahoo.com/chart/%5EGSP Retrieved 28 July 2017.

[61] Yglesias, M., 2017. The Real Reason Amazon Buying Whole Foods Terrifies the Competition.https://www.vox.com/policy-and-politics/2017/6/20/15824718/amazon-whole-foods-profit-margin Retrieved 5 July 2017.

ACCEPTED MANUSCRIPT

Authors Curriculum Vitae

Chihiro Watanabe graduated from University of Tokyo, Japan and is currently Professor Emeritus of Tokyo Institute of Technology, Research Professor of University of Jyväskylä, Finland, and also a Research Scholar, International Institute for Applied Systems Analysis (IIASA). (watanabe.c.pqr@gmail.com)

Nasir Naveed is currently the Ph.D. student in the Faculty of Information Technology, University of Jyväskylä, Finland. He graduated from Tampere University of Technology, Finland in Industrial Engineering and Management and he has a Bachelor of Science degree in Agricultural Engineering from the University of Agriculture – Faisalabad, Pakistan.
(nn.ghumman@gmail.com)

Pekka Neittaanmäki graduated from the University of Jyväskylä in Mathematics and is currently Professor of the Faculty of Information Technology, University of Jyväskylä, Finland. (pekka.neittaanmaki@jyu.fi)

ACCEPTED MANUSCRIPT

ACCEPTED MANUSCRIPT

Highlights

Digital solutions transforming the forest-based bioeconomy into a digital platform industry were analyzed.

Suggestions for a digital solution-driven disruptive business model were extracted.

Transforming stream observed at the forefront of the forest-based bioeconomy chain was demonstrated.

An empirical analysis on the noteworthy business activities at upstream and downstream was attempted.

Amazon’s business model was analyzed.

ACCEPTED MANUSCRIPT