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Evaluation of location-based capital cost adjustment factors in the pulp and paper industry

Master's Thesis

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Abstract

Given the increased global competition and declining margins in several product categories in the pulp and paper industry, it is important for companies to understand the factors affecting total investments costs. To accurately evaluate investment alternatives, investment cost estimates should incorporate the effects of location at the pre-feasibility level.

In this study, present methods to determine location cost factors were examined and their applicability for estimating investment costs in the pulp and paper industry were indicatively assessed. This assessment was conducted through an extensive literature review and through interviews with cost estimation experts in the field. Additional interviews were conducted with three companies representing different stakeholders in investment projects within the pulp and paper industry to determine further cost elements resulting in cost escalation associated with the chosen project location. It was found that generally, themes related to project labor costs were the main source of escalated costs reported by the interviewed parties. Estimating the cost of local labor and evaluating the availability of labor were the main sources of contention.

Since the 21st century, there has been an increasing number of reported statistics tracking both country and industry-specific cost developments. Many of the recently available indexes were indicatively argued to be better suited for establishing relative price levels between countries. More appropriate inflationary cost indexes to observe cost developments in the major cost elements of pulp and paper investment projects were identified. Methods to incorporate previously unquantified location cost factors in the investment cost model at AFRY Management Consulting were presented. Tracking the level of foreign direct investment inflow in smaller economies was argued to function as an indicative indicator for labor shortages in pulp and paper projects. A collection of general recommendations to ensure validity and accuracy of pre-feasibility level location cost adjustment factors within the investment cost estimation model used at AFRY Management Consulting Oy were presented.

Keywords Cost estimation, Cost level, Location cost factor, Pulp and paper, Index.

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Tiivistelmä

Maailmanlaajuisen kustannuskilpailun kiristyessä ja voittomarginaalien laskiessa monella tuotealueella, on sellu- ja paperiteollisuuden yrityksille yhä tärkeämpää olla tietoisia tekijöistä, jotka vaikuttavat investointikustannuksiin. Eri investointivaihtoehtojen arviointi edellyttää sijaintitekijöiden huomioimista jo varhaisessa vaiheessa, jotta investointikustannusarviot olisivat tarkempia.

Tässä työssä tarkasteltiin nykyisiä menetelmiä, joilla arvioida sijainnin vaikutuksia investointikustannuksiin. Menetelmien soveltuvuutta paperiteollisuuden investointikustannuksiin tarkasteltiin. Arviointi suoritettiin laajan kirjallisuuskatsauksen ja alan kustannuslaskennan ammattilaisten haastattelujen perusteella. Kustannuslaskennan ammattilaisten haastatteluiden lisäksi työssä haastateltiin kolmen metsäteollisuuden yrityksen edustajaa, selvittääkseen mitkä kustannusalueet investointiprojekteissa ovat tuottaneet lisäkustannuksia. Haastattelut paljastivat työvoimakustannusten arvioinnin olevan asia, joka on yleisimmin johtanut toteutuneiden kustannusten ylittämisiin alkuperäiseen kustannusarvioon verrattuna. Paikallisen työvoimakustannusten taso ja sen saatavuuden arviointi olivat pääasiallisia virheiden lähteitä, jotka vaikuttivat kustannusarvion epätarkkuuteen.

Sekä maakohtaisten kustannustasojen että toimialakohtaisten kustannuskehitystä seuraavien indeksien saatavuus on parantunut merkittävästi 2000-luvulla. Työssä arvioitiin, että tällä hetkellä on olemassa parempia julkisesti saatavalla olevia indeksejä, jotka osoittautuvat paremmiksi maakohtaisten hintatasojen kehittymisen vertailussa. Työssä perusteltiin sopivampia vaihtoehtoja aikaisempiin käytössä oleviin inflaatioindekseihin, jotka kuvaavat paremmin sellu- ja paperiteollisuuden investointiprojektien pääkustannustekijöiden kustannuskehitystä. Myös maakohtaisten hintatasojen vertailuun soveltuvampia indeksejä esitettiin työssä. AFRY Management Consulting Oy:n kustannusarviotyökaluun aiemmin vaikeasti määritettävissä olevien kustannustekijöiden sisällyttämiseen tarjottiin menetelmiä. Lisäksi työssä esitettiin tapa, jolla arvioida työvoiman saatavuutta seuraamalla suorien ulkomaaninvestointien määrää määrätyllä ajanhetkellä. Tämä arvioitiin soveltuvan pienempien talousmaiden työvoimapulan indikoimisessa sellu- ja paperiteollisuuden projekteissa. Lopuksi esiteltiin yleisiä ehdotuksia kustannusarviointityökalun sijaintikohtaisten kustannustekijöiden oikeellisuuden ja tarkkuuden säilyttämiseen ja tarkkuuden parantamiseen.

Avainsanat Kustannusarvio, Kustannustaso, Sijaintikorjaustekijä, Sellu- ja paperiteollisuus, Indeksi

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Titel Utvärdering av justeringsfaktorer på basis av geografiskt område för investeringskapital inom pappers- och massaindustrin.

Utbildningsprogram Master's Programme in Chemical, Biochemical and Materials Engineering

Huvudämne Biomass Refining

Ansvarslärare Prof. Jouni Paltakari

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Sammandrag

Med tanke på den ökade globala konkurrensen och minskande vinstmarginaler inom vissa produktgrupper i pappers- och massaindustrin är det viktigt för företag att förstå faktorer som påverkar totala investeringskostnader för nya projekt. För att kunna utvärdera investeringsalternativ på ett korrekt sätt, bör investeringskostnadsberäkningar inkludera placeringsrelaterade kostnadseffekter.

I arbetet granskades nuvarande metoder för att avgöra placeringsrelaterade kostnadsjusteringsfaktorer och bedömdes deras lämplighet att justera investeringskostnader inom pappers- och massaindustrin. Utvärderingen utfördes genom omfattande litteraturgranskning och intervjuer med experter inom området för kostnadsberäkning. Därtill intervjuades representanter för tre olika företag inom pappers- och massaindustrin, för att identifiera ytterligare kostnadselement vilka har resulterat till kostnadsförhöjningar förknippade med den utvalda placeringsplatsen. Det visade sig att kostnadselement angående arbetskostnader skapade huvudsakligen kostnadsförhöjningar inom projekt enligt de intervjuade parterna.

Sedan början av 2000-talet har statistik på både land- och branschspecifika kostnadsutvecklingar gjorts allmänt mer tillgängligt. Många av de nyligen tillgängliga indexen argumenterades indikativt vara bättre lämpade för att etablera relativa prisnivåer mellan länder, jämfört med tidigare använda metoder inom AFRY Management Consulting Oy. Dessutom avgjordes flera mer lämpliga kostnadsindex för att observera kostnadsutvecklingar i de viktigaste kostnadselementen inom investeringsprojekt i pappers- och massaindustrin jämfört med tidigare använda kostnadsindex. I arbetet presenterades metoder för att inkludera tidigare icke-kvantifierade kostnadsjusteringsfaktorer i beräkningsmodellen för investeringskostnads på AFRY Management Consulting Oy. En indikator på arbetskraftsbrist förevisades i arbetet genom att spåra inflytandet av utländska direktinvesteringar till länder med mindre ekonomier. Allmänna rekommendationer redogjordes för att säkerställa giltigheten och noggrannheten av de placeringsrelaterade kostnadsjusteringsfaktorer inom beräkningsmodellen för investeringskostnader på AFRY Management Consulting Oy.

Nyckelord Kostnadsberäkning, Prisnivå, Kostnadsfaktor, Pappers- och massaindustri, Index

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To all my friends from the Forest Products Guild at Aalto University, thank you! You have all made my years studying unforgettable, and I hope we stay in touch long after our studies have ended.

Last but not least, I could not have come this far without the amazing support of my family and my partner Noora. Thank you Noora for always being there for me, even though sometimes stress brings out the worst in me. I know you are as excited for this writing process to end as I am!

Helsinki, 24 January 2023

Henrik Lindberg

Contents

Abbreviations

AACE	Association for the Advancement of Cost Engineering
BLS	Bureau of Labor Statistics
CAPEX	Capital Expenditure
CCI	Construction Cost Index
CPI	Consumer Price Index
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
OECD	Organization for Economic Co-operation and Development
OPEX	Operational Expenditure
PPP	Purchasing Power Parity

1 INTRODUCTION

Investment cost estimates are fundamental tools used to determine project viability. While it is impossible to account for all the unknown variables when estimating the level of capital needed to execute a project, it is vital to utilize all methods available to lessen the degree of uncertainty when estimating investment expenditures.

While there is a large body of research on how chosen project location affects the required investment capital in investment project, it is still a relatively poorly understood concept. The existing models of approximating the impact remains largely unquantified and suffer from ambiguity. All too often, the additional costs associated with the project location is often simply tied to the overall project contingency by cost estimators.

To account for constantly decreasing margins within investment projects in the pulp and paper industry, it is essential to further understand the underlying cost drivers leading to differing price levels in countries regarding investment capital expenditures to incorporate these effects into estimates. This thesis aims to create a pragmatic approach to better account for some of the unaccounted variables which cause price level changes based on location in the pulp and paper industry.

1.1 Research Problem and Structure of the Thesis

The primary research problem of the present study can be expressed as the following question: “What are the underlying drivers, in terms of location, that affect capital costs in pulp and paper investments, and how can they be realistically accounted for in early-stage estimates?”

The subject matter can further be divided into three major research questions:

1. What are the fundamental cost drivers that cause differing in price levels between countries?

2. How are location-based cost adjustment factors currently managed in the field of cost estimation?

3. How can cost estimates better take price level developments into account in practice?

The general structure of the thesis is divided into two main sections. The first section is a comprehensive literature study that aims to answer the first two research questions. Recent developments and trends within investments in the pulp and paper industry are discussed. Subsequently, a general framework of investment planning, cost classification and drivers are presented to contextualize and set a baseline to the latter section of the thesis.

The second section builds upon the framework set in the literature section and focuses on answering the latter two research questions. This section contains interviews which are conducted with professional cost estimators and other industry professionals to assess how estimators currently approach the issue of incorporating costs related to project location, and to discuss what topical developments have occurred in this field. Lastly, this section reviews how AFRY Management Consulting Oy (hereinafter "AFRY") approaches this issue through their proprietary cost estimation tool and includes recommendations on how the tool could be developed further.

1.2 Objectives and Scope of the Thesis

Correspondingly to the research questions posed in the previous subchapter, the objectives of this thesis are presented below.

The objectives of this thesis are to:

- identify and summarize elements giving rise to differing price levels between countries and/or regions
- present existing methods used to account for project location

- determine the fundamental elements for predicting the development of location cost factors
- give insight to improve the accuracy of the proprietary cost estimation tool at AFRY Management Consulting Oy

An additional objective of the thesis is to recommend procedures for continuous updating of input data of the cost estimation tool at AFRY.

The scope of this thesis is limited to analysing the effects of location on capital expenditures and does not consider price level variance resulting in other areas which may be of consideration when selecting for a location for investments, such as operational expenditures. The applicability of the results obtained in this thesis onto other aspects relating to investment expenditures are not evaluated.

A summary of the research problem, required inputs and objectives of this thesis is presented in Table 1.

Table 1. Summary of the research problem, inputs, and objectives of this thesis.

Research problem	Inputs	Objectives
What are the fundamental cost drivers that cause differing in price levels between countries?	• Literature • Interviews with professionals	• To identify and summarize elements giving rise to differing price levels between countries and/or regions
How are location-based cost adjustment factors currently managed in the field of cost estimation?	• Literature • Interviews with professional cost estimators in the pulp and paper industry	• To present existing methods used to account for project location • To determine the fundamental elements for predicting the development of location cost factors
How can cost estimates better take price level developments into account in practice?	• Literature and interview findings • Actual project data from previous projects managed by AFRY • Cost estimation tool at AFRY	• To give insight on how the accuracy of the proprietary cost estimation tool can be improved

SECTION I –
INDUSTRY OUTLOOK AND
COST ESTIMATE FORMING

2 RECENT DEVELOPMENTS IN THE PULP AND PAPER INDUSTRY

Forest-based industries form the foundation of the Finnish bioeconomy and across the globe it is a significant contributor to national gross domestic product in several countries. The pulp and paper industry is one of the oldest manufacturing industries in Europe, spanning nearly a thousand years of recorded history. Although the pulp and paper industry is an established and mature manufacturing industry, it is currently undergoing significant structural changes globally. This chapter contextualizes the recent developments and trends within the pulp and paper industry investments and markets. Trends within investment planning processes and cost estimation are presented in later chapters.

2.1 Background and Characteristics

In the 20th century, Finland, Sweden and Norway became the dominant European players in the pulp and paper industry (Lundmark, 2003). This market dominance is mainly attributed to the development of more efficient production facilities and logistics as well as the abundant access to forest resources across Scandinavia (Romme, 1994). The pulp and paper industry has historically used many different raw materials e.g., flax, bamboo stalks, and straw, to manufacture products (Lundmark, 2000). However, wood continues to be the main source of fibers for producing products. Wood demand and utilization has been increasing globally and is expected to continue to grow in the coming decades (FAO, 2009). The largest share of production and demand growth in the global context is within the packaging paper segment. A compound line graph depicting the development of total graphic paper and packaging paper production volumes in various regions is presented in Figure 1.

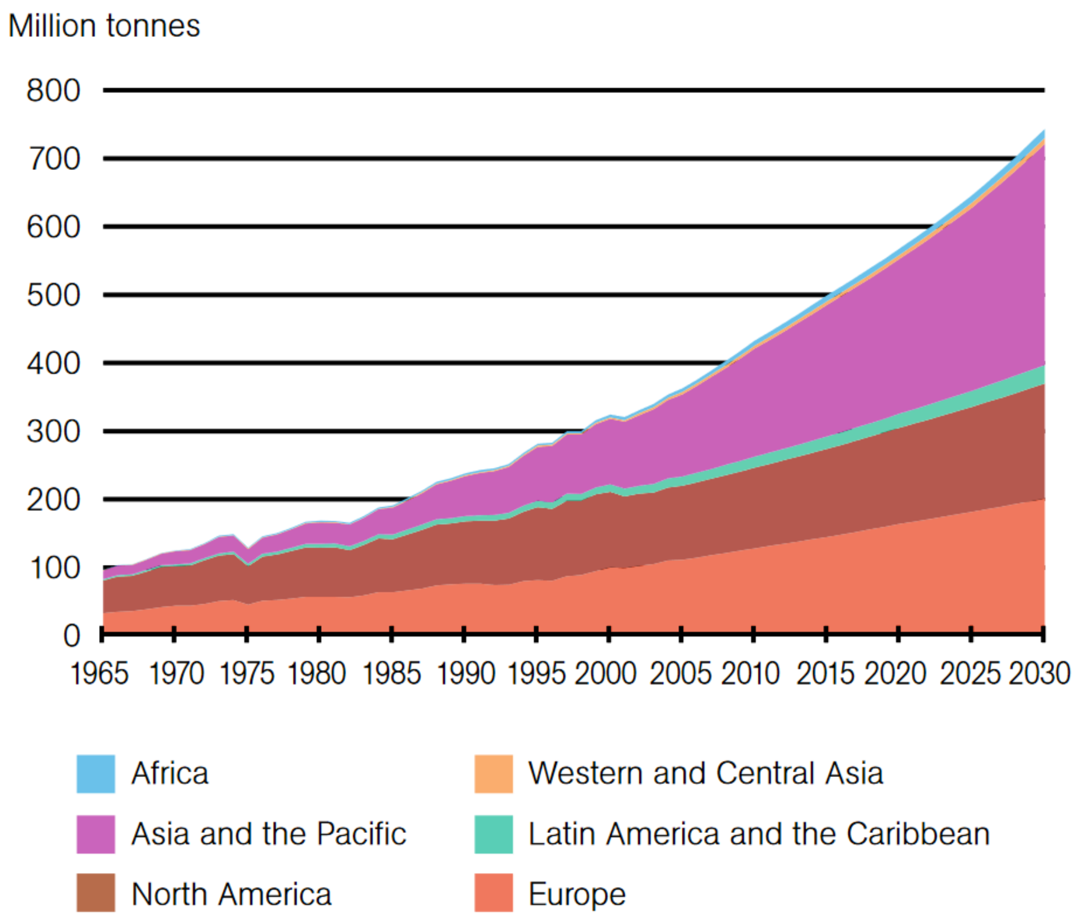

Figure 1. Global graphic paper and packaging paper production from 1965–2030. (FAO, 2009)

Paper and paperboard products are one of the most globalized commodity groups with a diverse portfolio of products for various end uses. In the 2020's, wood and processed wood products can, in more diverse ways than before, replace non-sustainable products and fuels that speed up climate change. An example of the main categories of products in the pulp and paper industry are presented in Table 2. The list is in no means exhaustive, as the subcategories can be further split into product categories. Some of the key features defining the pulp and paper industry are presented in Table 3.

Table 2. Pulp and paper product categorization.

Main Category	Further Categorization
Pulp	
Chemical pulp	• Sulphate (Kraft) pulp • Sulphite pulp
Mechanical pulp	• Groundwood pulp • Thermomechanical pulp • Chemithermomechanical pulp
Recycled pulp	• By raw material
Paper	
Graphic papers	• Newsprint • Printing and Writing paper
Tissue papers or Personal care	• Consumer • Commercial & Industrial • Specialty grades
Packaging papers	• Boxboard • Containerboard • Specialty board
Specialty papers	• Various grades for multiple applications

Table 3. Summary on the key characteristics of the pulp and paper industry. Based on Uronen (2010).

Key characteristic	Comment
Produces intermediate products	• Products usually require further converting
Highly diversified industry and products	• Wide range of products with differing raw materials, qualities, and end-uses
Capital intensive	• Ranks as one of the most capital-intensive industries • Long investment planning horizon (~20 years) • Costs of greenfield mill investments range from ~400−500 million EUR (paper) to ~1 billion EUR (pulp)
Cyclicality	• High capital intensity leads to simultaneous investments during prosperous times leading to overcapacity • Typically follows a 5–7-year business cycle as overcapacity gets absorbed by the market
Seasonality	• Lower demand of most products during the summer months and highest demand at the end of the year
Regionality	• Traditionally very modest trade between main producing regions
Ease of technology and knowhow transfer	• Outsourced R&D to chemicals and machinery suppliers • Few proprietary patents and IP rights • New technology freely available to purchase globally

2.2 Recent Developments

The twenty-first century has in many ways demonstrated that the pulp and paper markets are not impervious to change. The global pulp and paper markets are undergoing significant structural changes due to several factors. Hetemäki, Hänninen and Moiseyev (2013) outline some of the shifts the pulp and paper markets have been experiencing since the last few decades and are presented in Table 4.

Table 4. Current structural changes taking place in the global pulp and paper markets. (Lundmark, 2003; Uronen, 2010; Hetemäki, Hänninen and Moiseyev, 2013; Hetemäki and Hurmekoski, 2016)

Change	Cause
Communication paper consumption declining in OECD countries	• Citizens in countries with high income & internet adoption are substituting printed media to digital media consumption
Increased paper and paperboard consumption in non-OECD countries	• As living standards increase, overall consumption of commodities increase • Increased consumption of packaged products including food and ecommerce
Companies in OECD countries diversifying into new products	• As the relative share of global paper and paperboard consumption is decreasing OECD countries, companies are seeking to renew their business models • New novel products include second generation e.g., biofuels, and biochemicals
Declining real prices of paper and paperboard products	• Increased production of virgin pulp and improved sourcing of recycled pulp driving costs down

Share of hardwood pulp in total pulp production increasing rapidly	• Increased pulp production in South American countries using eucalyptus supplanting the relative share of softwood pulp in global markets
Increasing share of exported goods in total pulp and paper production	• Developments in global logistics networks has enabled sourcing from further distances
Globalization	• Combined with the declining consumption in OECD countries and decreasing profit margins have led traditionally regional producers to search for lower operation costs and increased access to more abundant and cheaper raw materials, thereby funneling investments into developing countries

As presented in the table above, there are numerous significant changes ongoing in the global pulp and paper industry and markets. The most significant changes are happening in the field of graphic papers including newsprint and printing and writing papers. As such, it is important to investigate this issue further to ascertain how the associated markets (and as an extension, investments) might develop in the future.

Since the last two decades is that graphic paper consumption (viz., newsprint consumption) has started to decrease in most OECD countries since the turn of the millennium (Latta, Plantinga and Sloggy, 2016; Chiba, Oka and Kayo, 2017; Berg and Lingqvist, 2019). Historically the most prominent pulp and paper industry regions (i.e., North America, Western Europe, and Japan) have lost their relative importance both as producers and consumers compared to the emerging economies such as China, Brazil, India, and Indonesia (Hurmekoski and Hetemäki, 2013).

China has recently surpassed the historically prominent pulp and paper industry regions (i.e., North America, Northern Europe, and Japan) as the world's leading producer of paper and paperboard (Bajpai, 2016). Between 2000 and 2010, China saw an extraordinary growth in both paper and paperboard consumption and production. Concurrently as total consumption grew by 143%, production grew by 182%, essentially accounting for the growth in the domestic market increase during the decade (Hetemäki, Hänninen and Moiseyev, 2013). The relative growth of Chinese paper and paperboard production and consumption has seen a slowdown during the last decade, although still expected to maintain a compound annual growth rate (CAGR) of 0–2% in packaging paper production and a CAGR >2% in hardwood and softwood pulp production (Berg and Lingqvist, 2019).

Figure 2 and Figure 3 depict the absolute and relative change in newsprint production by major regions since the 1980's.

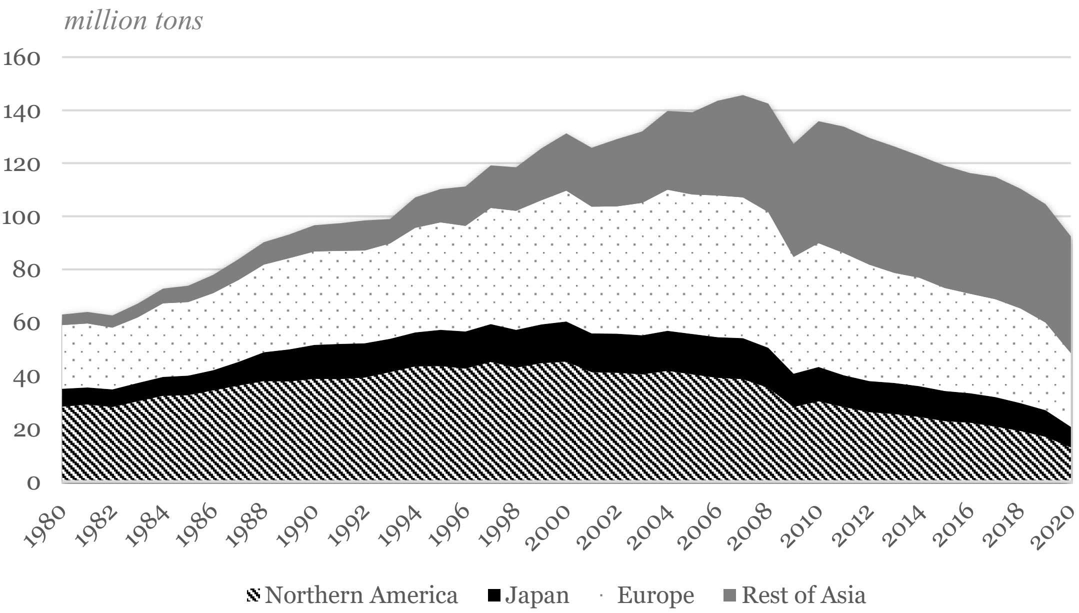

Figure 2. Newsprint production in by major region 1980-2020. (FAOSTAT, 2022)

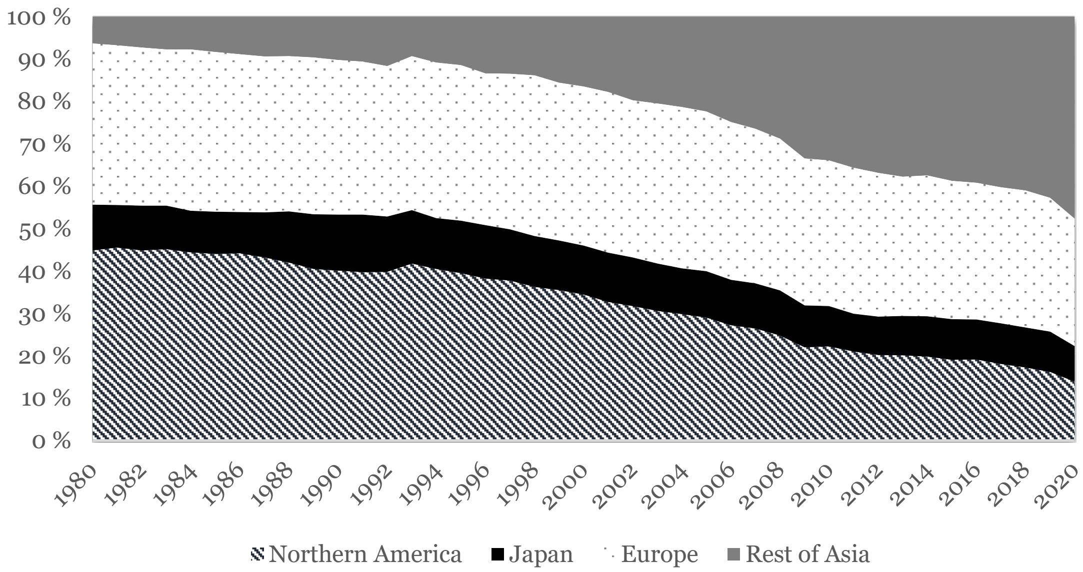

Figure 3. Relative total newsprint production by major region 1980-2020. (FAOSTAT, 2022)

Reasons for why the consumption of graphic papers have seen such a dramatic shift over the last two decades are manifold, however the change is mainly attributed to the rise in internet use across economically developed countries (Latta, Plantinga and Sloggy, 2016; Chiba, Oka and Kayo, 2017). As discussed by Chiba, Oka and Kayo (2017), while it is demonstrated that an increase in total internet usage has a substitution relationship with newsprint consumption, the reductive effect begins to manifest at different levels of economic prosperity (per US$/person). There is still contention in the scientific literature on what other variables dictate the reductive effect on graphic papers together with internet use. The findings of Chiba, Oka and Kayo (2017) and Hujala (2011) have differing conclusions on if the amount of internet use is statistically significant on the printing and writing paper demand. This is in contrast to newsprint consumption, where the main body of research agrees that internet use has a reductive effect in similar levels of economic prosperity. Figure 4 shows the observed consumption changes in newsprint, printing and writing paper, together with internet adoption levels in both OECD and non-OECD regions.

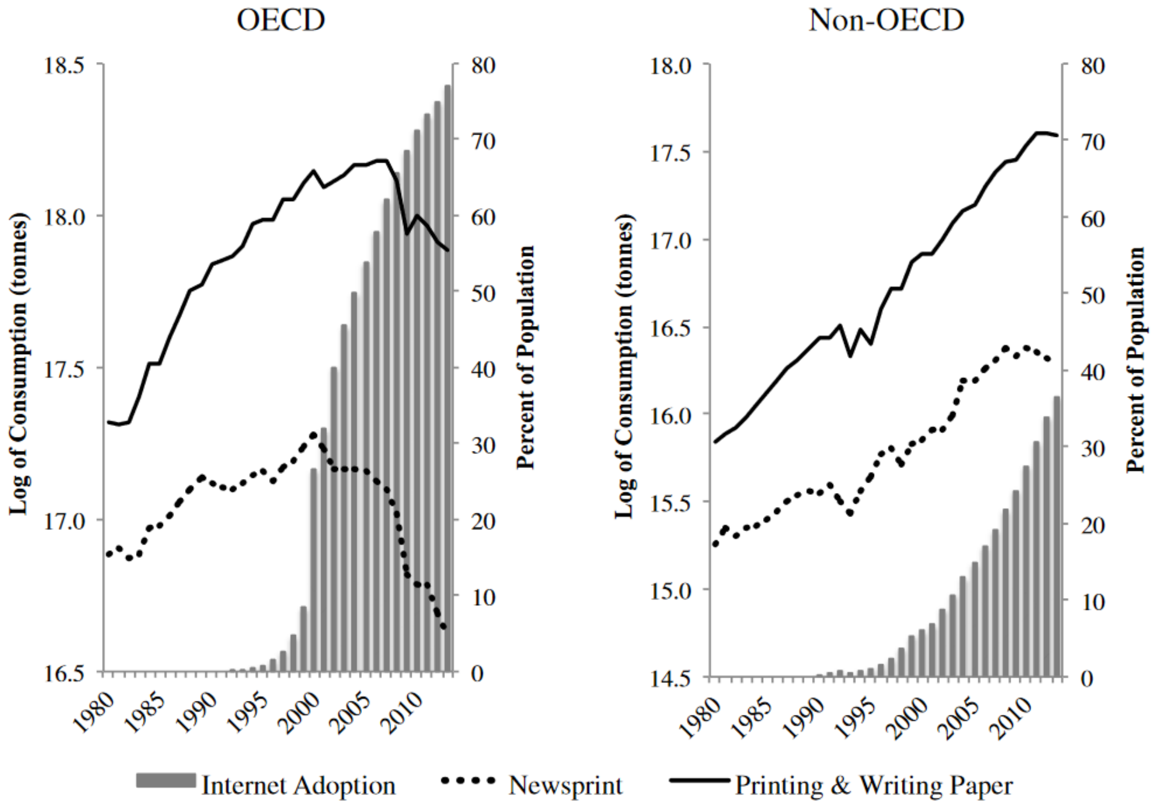

Figure 4. Observed newsprint consumption, printing and writing paper consumption, and Internet adoption for OECD and non-OECD regions, 1980–2013. (Johnston, 2016)

Historically, an increase in real national gross domestic product (GDP) has resulted in higher newsprint consumption (Hujala and Hilmola, 2009). Thus, forecasting newsprint consumption have mainly been based on macroeconomic growth indicators e.g., GDP. However, this is no longer the case as graphic paper demand has seen its growth rates turn negative regardless of GDP growth in developed countries. This negative shift in correlation can be observed in most developed countries during 1980's and the decades following, as seen in Figure 5 and Figure 6. Changes to the long-term GDP elasticities for the US and EU newsprint and printing and writing paper consumptions are presented in Table 5.

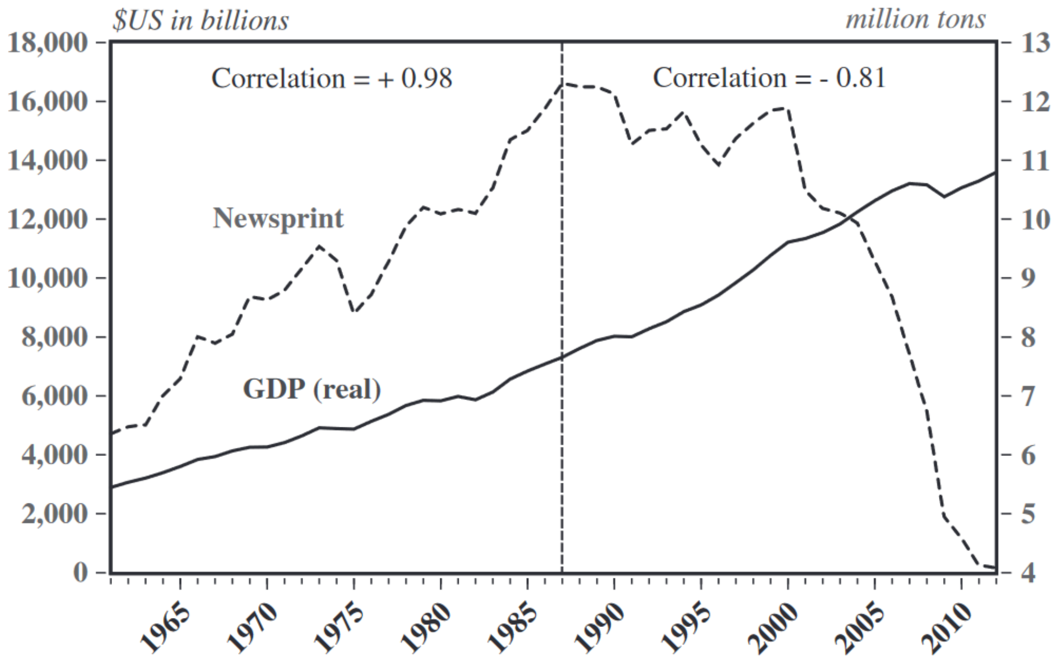

Figure 5. The US newsprint consumption and real GDP in 1961–2012. (Hurmekoski and Hetemäki, 2013)

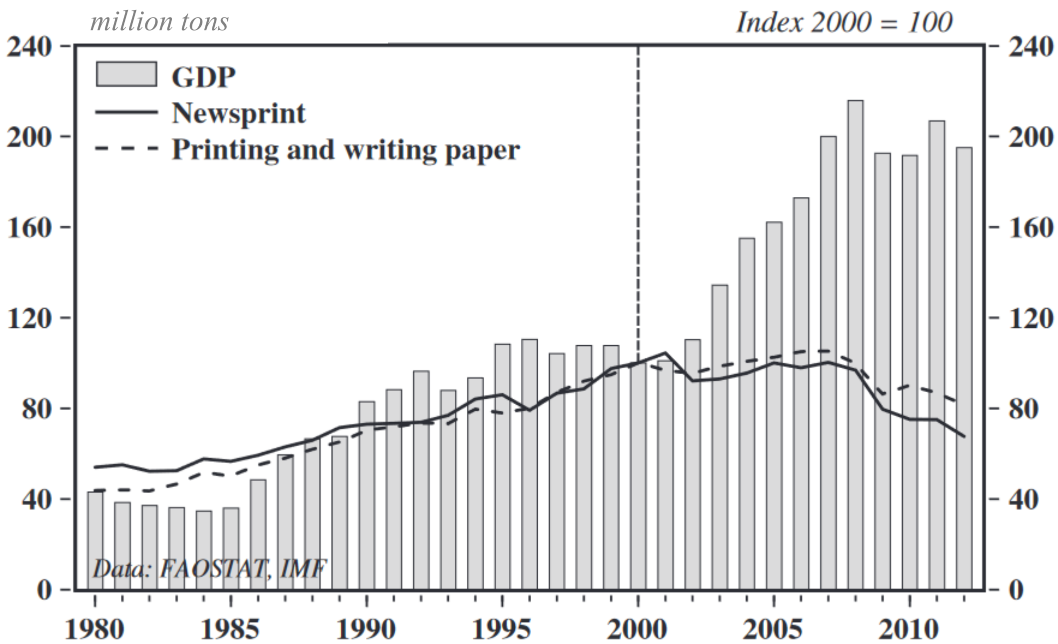

Figure 6. The EU newsprint and printing and writing paper consumption and GDP in 1980–2012. (Hetemäki and Hurmekoski, 2016)

The dramatic changes to the GDP elasticity in the graphic paper sector has made long-term forecasting demand and consumption increasingly difficult. Essentially all long-term outlook studies made before the 2000's are no longer viable for most OECD countries. The implications of this discussion for future outlook studies are at least two-fold. Firstly, uncertainties regarding the use of long-run GDP development in the pulp and paper sector outlook models are high. Secondly, the discussion that has started in the field of economics as regards the need to update the macroeconomic models, resembles, and could act as an example of, the similar need in forest sector outlook studies to develop the models to better conform with the structural changes taking place in global forest products markets. (Hurmekoski and Hetemäki, 2013)

Table 5. Long-term GDP elasticities for the US and EU newsprint and printing and writing consumption. (Hurmekoski and Hetemäki, 2013)

Study	**Estimation period**	**Newsprint GDP elasticity**	**P&W paper GDP elasticity**
US			
Shushuai *et al.*, (1998)	1961–1994	+0.45	
Hetemäki (2005)	1988–2004	-0.44 to -0.24	
Hurmekoski and Hetemäki (2013)	1988–2012	-0.79	
Hurmekoski and Hetemäki (2013)	1980–1997		+0.59
Hurmekoski and Hetemäki (2013)	1998–2012		-0.53
EU			
Hurmekoski and Hetemäki (2013)	1980–1999	+0.42	+0.55
Hurmekoski and Hetemäki (2013)	2000–2012	-0.24	-0.1

Paperboard markets have been found to be less affected by economic recessions compared to graphics papers markets, despite both being influenced by global economic changes. Over the past 20 years, the global consumption of packaging paper and paperboard has been consistently increasing at an average annual rate of 3.4%. The global growth of paperboard production is largely driven by the increasing demand for containerboard, which is used to package industrial commodities in bulk. The global paperboard market has undergone a significant structural shift due to the rapid economic development and corresponding increase in consumption and production in Asia, particularly China. This has resulted in a decline in consumption in the United States and Western Europe, as production of consumer and industrial goods has been increasingly outsourced to emerging economies. As a result, packaging production has also migrated to these regions. However, a significant portion of packaging board produced in China is exported to the United States and Western Europe. (Hetemäki, Hänninen and Moiseyev, 2013) Regional paperboard consumption and production figures for the years 1992-2010 are presented in Table 6.

Table 6. Paperboard Consumption and Production by Regions (in Million Metric Tons). (Hetemäki, Hänninen and Moiseyev, 2013)

	Consumption			Production		
Region	**1992**	**2000**	**2010**	**1992**	**2000**	**2010**
Africa	2	2	4	1	2	2
Asia	26	41	84	24	39	82
North America	37	44	40	41	48	46
Latin America	5	9	14	5	7	10
Eastern Europe	4	6	12	5	6	10
Western Europe	23	30	30	24	31	34

2.3 Profitability and Investments

The overall profitability of the pulp and paper industry has been seen a downturn since the turn of the millennium, especially in companies situated in North America and Western Europe. Although there are differences between individual companies, during 2003 and 2008 the ten biggest pulp and paper companies averaged 4.7 % of earnings before interest and taxes. The median return on assets (ROA) levels of the 22 largest producers in Western Europe, North America and Japan were 2% between the years 2000–2010. (Hujala *et al.*, 2015) Average ROA percentages across product categories in the selected pulp and paper industry producers are depicted in Figure 7 below.

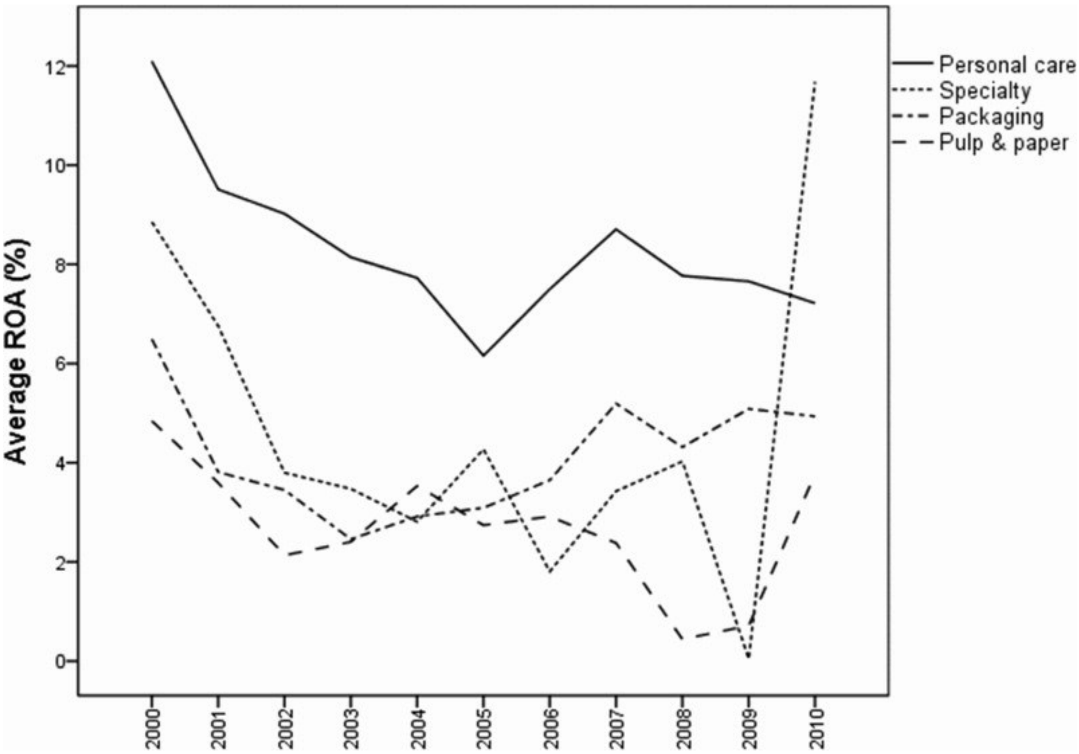

Figure 7. Average Returns on Assets (ROA) from 2000–2010 by product category in the pulp and paper industry (Hujala *et al.*, 2015)

Most paper and board grades are in the mature phase of their life cycle, with demand growing below that of the GDP (Uronen, 2010). The sharp decline in e.g., newsprint and printing demand and prices has resulted in the closing of many paper machines in the North America. Similarly, many paper machines in many paper grades have been closed in Europe during 2003–2008 due to poor profitability and lack of competitiveness, resulting in significant losses in employment. (Hujala *et al.*, 2015)

As demand for pulp and paper products on a global scale is still growing, pulp and paper markets have seen a dramatic shift in the share of inward foreign investment (FDI) flows in developed countries during the last few decades. As described in the previous subchapter, the industry has undergone a reallocation of production capacity through mergers and acquisitions (M&A) and greenfield projects to emerging markets. Foreign trade and FDI exhibit a close relationship, as they both complement and substitute each other through resource-seeking, market-seeking and efficiency-seeking motives. (Toppinen *et al.*, 2010) Mill-scale projects carried out between 1995 and 2012 within the 22 largest pulp and paper industry (PPI) companies in North America, Western Europe and Japan are presented in Table 7.

Table 7. Geographical locations of projects for the 22 largest PPI companies in North America, Western Europe and Japan between 1995 and 2012 at the mill level. (Hujala *et al.*, 2015)

	Asia (excl. China)	**China**	**Latin America**	**North America**	**Europe (excl. Russia)**	**Russia**	**Other**	**Total**
Closure	32	3	4	47	32	-	3	**121**
New	7	7	5	1	2	2	-	**24**
Idled	1	-	1	5	2	1	-	**10**
Restart	16	1	-	5	2	-	-	**24**
Rebuild	1	-	4	2	6	-	-	**13**
Total	**57**	**11**	**14**	**60**	**44**	**3**	**3**	**192**

Contrary to the conventional reasons for globalization, i.e., shifting production to countries striving for lower production costs, the findings of Uronen (2010) paints a different picture. According to the findings of the study, production costs are found not be markedly lower in emerging markets. Instead, the main strategic objective for producers investing in emerging markets are increasing capacity i.e., absolute growth, tapping into growing markets and ensuring raw material availability. (Uronen, 2010) Due to the regional nature of the industry, upheld mainly by relatively high logistics costs and service level demand by customers, investing in conventional bulk products within markets with export deficits and risk of overcapacity is generally not profitable (Laaksonen-Craig, 2004; Uronen, 2010; Hujala *et al.*, 2015). Net trade balances for international paper and board trade are shown in Figure 8 below.

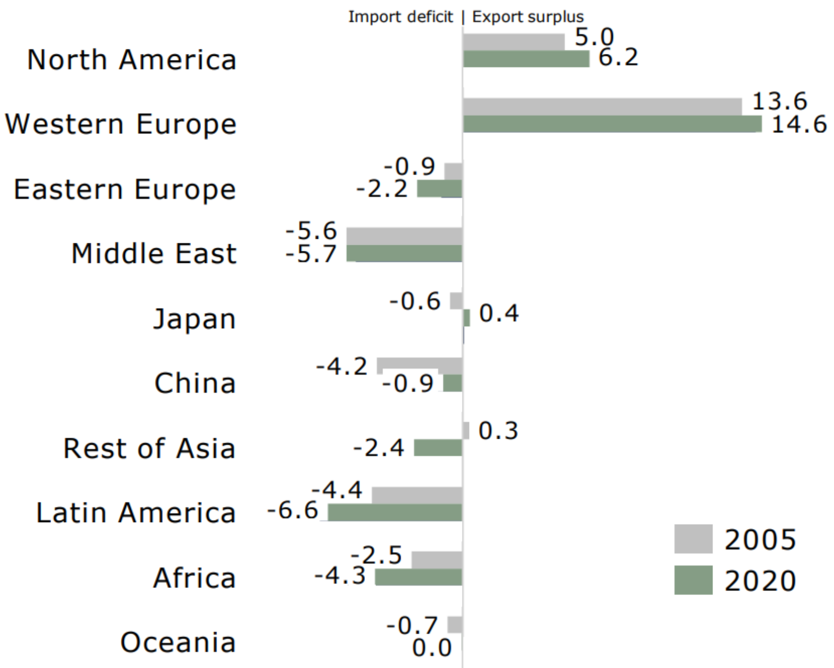

Figure 8. Net trade balance for international paper and board trade in 2005–2020. (AFRY, unpublished)

Producers in North America and Western Europe could theoretically still find new sources of profit in the declining regional markets. With increasing environmental regulation and strives to decarbonize industries and countries, producers in these regions could benefit from these trends by developing new innovative and sustainable products or processes that either serve a completely new purpose or by substituting fossil-based products. (Korhonen *et al.*, 2015) However, there is yet to be any significant strives to increase R&D intensity within producers in the pulp and paper industry, as measured by R&D spending to sales. As seen in Figure 9, R&D spending across major product categories have been around 1% of total sales. This is in stark contrast to industries such as the biotechnology and pharmaceuticals industry, with R&D spending amounting to around 15% of total revenues (Towler and Sinnott, 2022). There are many reasons for the lack of enthusiasm in increasing R&D activity in the industry. One of the issues is the rapid diffusion of benefits gained from new innovations to competitors as know-how transfer is characteristic for the industry. Even though R&D spending is generally at a lower level compared to many other industries, there are plenty of new innovative products entering the market, especially targeting the constantly more stringent environmental requirements of both consumers and institutions.

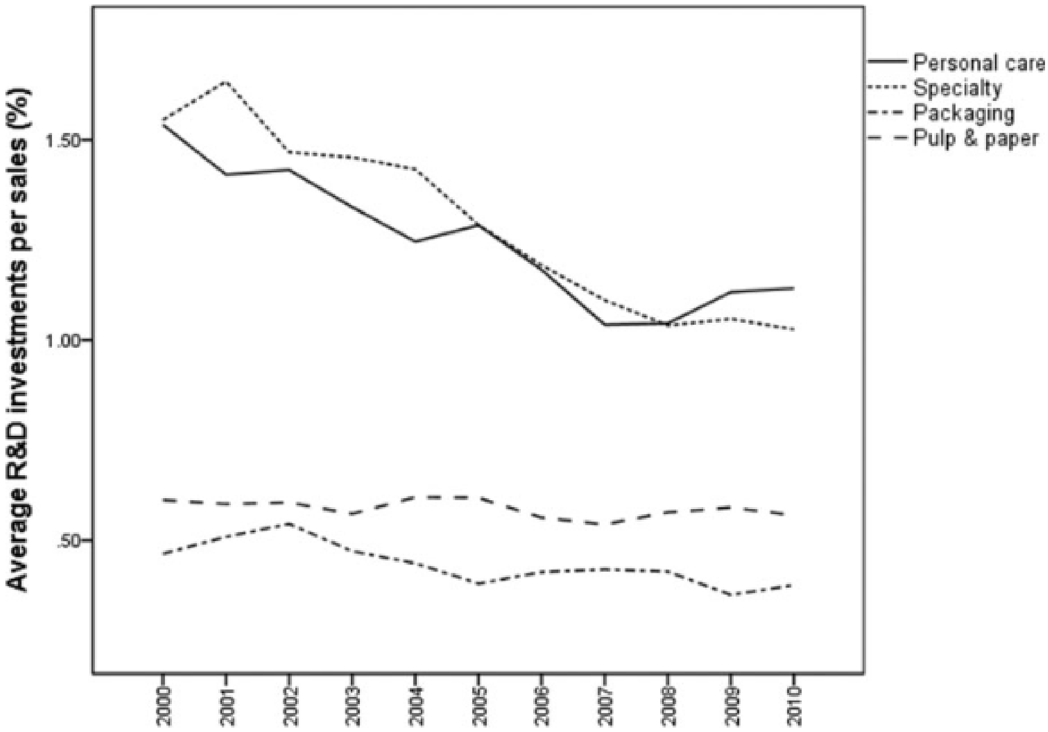

Figure 9. Average R&D investments per sales (%) for different product segments in the pulp and paper industry.

3 THE INVESTMENT PLANNING PROCESS

A thorough planning process is essential to be carried out to mitigate project risk and maximize the return on the investment before any final decisions are made. There is a plethora of variations on the investment planning process, some established by academic professionals, and some developed inhouse in e.g., consultancies or by project owners. This chapter will be presented through the lens of AFRY's investment planning process, which is built around the frond-end loading methodology. The key aspects are described together and some of issues leading to cost escalation and estimate inaccuracy will be discussed. The investment cost estimation model developed at AFRY Management Consulting is mainly applied in pre-feasibility and feasibility studies to determine a preliminary cost estimate. The methodology of the cost estimation model will be described in more detail in chapter 8.

3.1 General Framework

Front-End Loading (FEL) is an investment planning methodology comprised of three classes which vary in scope, objectives, and deliverables with increasing cost accuracy. These classes are commonly labeled as FEL1, FEL2, and FEL3 respectively. However, depending on the industry and variation of the methodology, some choose not to follow the original naming scheme or division. For example, The Association for the Advancement of Cost Engineering (AACE) splits FEL1 into two separate classes in order to distinguish different cost accuracy levels within the scope of FEL1, and the naming scheme follows consecutive "classes" instead "FEL-X" (AACE, 2020). In the context of the pulp and paper industry, the investment planning steps are frequently referred to as conceptual or pre-feasibility studies (FEL1), feasibility studies (FEL2) and pre-engineering or basic engineering phases (FEL3). An overview of the front-end loading methodology and different naming schemes are presented in Figure 10.

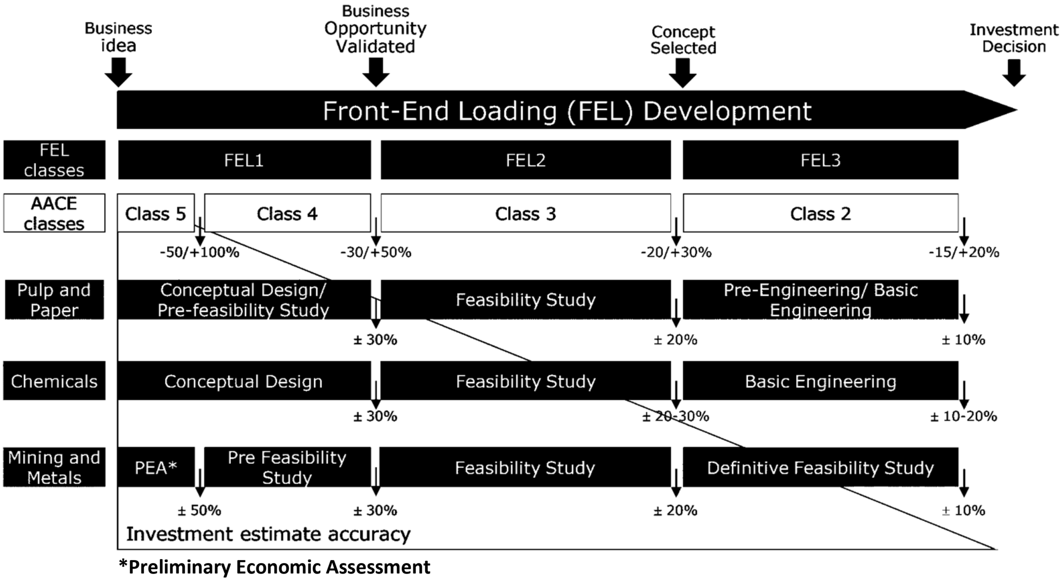

Figure 10. Overview of the Front-End Loading methodology with step aliases in different industries. (AFRY, unpublished)

The purpose of utilizing front-end loading is to achieve a sufficiently detailed understanding of the project at hand to minimize changes made later in the project e.g., within the start-up, construction and production engineering phases. The methodology aims to measure and increase project definition by defining how the scope of the capital project meets the investment objectives. Poor levels of project definition is among the primary causes for cost escalation, leading to e.g. site-specific issues, incomplete deliverables, project execution planning (McFadden, 2013). Issues regarding cost escalation is described in more detail in subchapter 3.4. Generally, a successful utilization of front-end planning increases the probability of project success in terms of operability, scheduling and costs (Saputelli *et al.*, 2013).

Objectives, deliverables, and activities of front-end planning may vary depending on the proposed project. However, there are some general key elements to take into consideration when using the methodology regardless of the project at hand which are listed in Table 8. According to a survey conducted by the Construction Industry Institute (CII) in 2009, following these key components together with the methodology resulted on average an 8% reduction in overall project costs, shorter delivery time and fewer changes in later project phases (CII, 2012).

Table 8. Key considerations for successful front-end planning. (CII, 2012)

Focus area	Key considerations
General	• Develop and consistently follow a defined front-end planning process • Use established planning tools • Provide leadership at all levels for the front-end planning process, including executive and project, owner, and contractor • Ensure adequate scope definition prior to moving forward with design and construction
Organization	• Build the project team, including owner stakeholders and consultants • Align the project team, including key stakeholders • Include involvement from both owners and contractors • Staff critical project scoping and design areas with capable and experienced personnel
Risk mitigation / Strategy	• Define existing conditions thoroughly • Select the proper contracting strategy early • Identify and understand risks of new project types, technologies, or locations • Address labor force skill and availability during planning

The degree of accuracy of capital cost estimates are stated as estimate ranges. These ranges depict some range that the costs of the finish project is expected to fall under and are based on a confidence interval (or equal standard deviations) that the project team has defined based on the risk assessment. In early-stage estimates, the accuracy range is at its highest as the least number of definite choices have been made to the proposed project. As more information is fed into the estimation methodology the accuracy of the estimate increases. Concurrently, the required number of manhours needed to complete the estimation also increases, as estimates in or after the feasibility study may, e.g., incorporate bidding processes for main equipment to satisfy the desired level of accuracy range. As the investment cost estimation tool at AFRY Management Consulting is primarily used for pre-feasibility and feasibility estimates, Table 9 provides a summary of the characteristics of said estimate classes.

Table 9. Cost estimate classification matrix for process industries. Based on (AACE, 2020)

CHARACTERISTIC	ESTIMATE CLASS	
	Pre-feasibility study	Feasibility study
Expected cost accuracy range	Lowest: -20% to -50% Highest: +30% to +100%	Lowest: -15% to -30% Highest: +20% to +50%
Maturity level of project definition deliverables (% of complete definition)	0% to 2%	1% to 15 %
End usage	Concept screening	Study or feasibility, concept selection
Methodology	Capacity factored, parametric models, professional judgement, or analogy	Equipment factored or parametric models

3.2 Pre-feasibility Study

The aim of the pre-feasibility study is to evaluate the viability of different concepts of industrial operation of the target project. The viability is primarily assessed by considering the market outlook, access to raw material resources, and through order-of-magnitude cost estimates of the proposed concepts. The intended result of the pre-feasibility phase is to select one or more concepts to analyse in more detail in the feasibility phase.

As generally these estimates are based on limited information, the expected accuracy of cost estimates in the pre-feasibility phase is between from -50% to +100% of actual project costs. Estimates made in this phase are usually inexpensive and fast to conduct depending on the methods used. Detailed process design or descriptions are reserved for the later phases in the investment planning process (generally after the feasibility study), as the objective is simply to form a basis for further economic calculations on the chosen concepts (BRG, 2012). Generally, pre-feasibility cost estimates use stochastic estimation models including:

- Cost curves
- Capacity factors
- Lang factors
- Hand factors
- Chilton factor

Some of the listed estimation models will be presented in chapter 4.

As the pre-feasibility cost estimates have considerable inaccuracy, investment decisions should never be made solely based on these estimates. In order to start the cost estimation process in pre-feasibility studies, the grade, scope and capacities should be known or projected.

3.3 Feasibility Study

Feasibility studies aim to present the technical and economic considerations for the proposed investment project. Within this stage of the project planning prose, chosen project alternatives from the pre-feasibility studies are compared in more detail and ranked according to their overall observed feasibility, strategic value, projected profitability, and other factors that the project owner deems as being favorable (BRG, 2012).

The expected accuracy range of the feasibility study is between -30% up to 50% to the actual cost estimate. In this phase, the methodologies used to formulate the cost estimate are equipment factored or parametric models. Stochastic estimation methods can also be used if equipment-level capacity details are still unknown. (Matthews, 2016) The capital cost estimates are prepared for more detailed economic calculations, such as profitability and sensitivity analyses and cash flow statements. The objective after the feasibility study is to decide on a concept which to continue with into the basic engineering phase.

3.4 Cost Escalation and Estimation Inaccuracy

Project cost increases, also known as cost escalation, can be caused by a variety of factors that have been identified in previous studies (Lawrence, 2007; McFadden, 2013; Towler and Sinnott, 2021). These factors, which contribute to inaccurate estimates and cause problems with cost estimation, vary depending on the phase of project development and the complexity of the project. By identifying the key factors that lead to cost escalation, measures can be taken to mitigate their impact on project and program costs.

There are several internal factors that can contribute to the underestimation of project costs during the planning and design development stages. These factors include bias, the procurement approach, changes to the project schedule, engineering and construction complexities, scope changes, scope creep, and poor estimating. Additionally, there may be issues with the inconsistent use of contingencies. Project cost escalation can also occur during construction, and it is important to focus on these internal factors early on in order to reduce the likelihood of cost growth at the bid time or during construction. (Shane *et al.*, 2009) A figure depicting the compounding issues which may substantiate when not accounting for the risk-negating factors in early-stage planning is pictured in Figure 11.

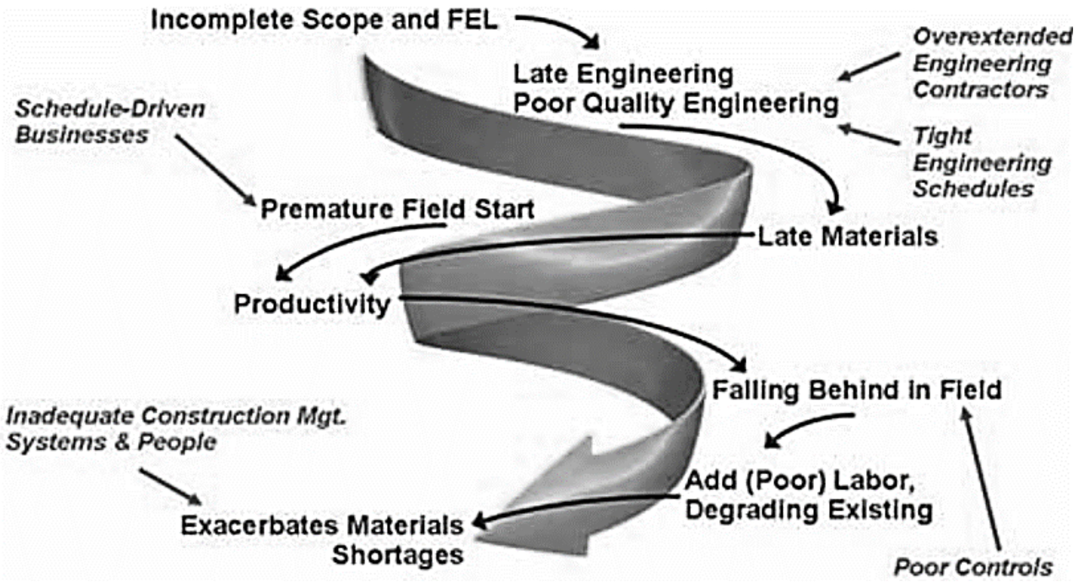

Figure 11. The 'downward productivity spiral' found in large construction projects. (McFadden, 2013)

Factors that impact the cost estimate for each phase of a project's development can be divided into two categories, into internal and external factors. Internal factors are those that the agency or owner can control, while external factors are those that exist outside the agency or owner's direct control. This arrangement of factors is shown in Table 10. The order in which the factors are presented should not be interpreted as a ranking of their effects on the cost estimate. It's worth noting that while some of the factors relate to difficulties in accurately estimating labor and material costs, many of them relate to influences that impact the scope and timing of the project. (Shane *et al.*, 2009)

Table 10. Cost escalation factors by cause and development phase. (Shane *et al.*, 2009)

Source	Cost escalation factor
Internal	• Bias • Delivery/procurement approach • Project schedule changes • Engineering and construction complexities • Scope changes • Scope creep • Poor estimating • Inconsistent application of contingencies • Faulty execution • Ambiguous contract provisions • Contract document conflict
External	• Local concerns and requirements • Effects of inflation • Scope changes • Scope creep • Market conditions • Unforeseen events • Unforeseen conditions

In addition to the factors presented above, estimate accuracy is also driven by other systemic risks such as:

- Level of familiarity with technology
- Unique or remote nature of chosen project location
- Quality of reference cost estimating data
- Time and level of effort budgeted to prepare the estimate
- Currency exchange
- The accuracy of the composition of the input and output process streams.

In order to account for small project overruns because of the reasons discussed, project estimates usually entail some level of contingency charge.

Contingencies are a natural part of any project cost estimate, as they are by nature imprecise. Contingencies are used to decrease the risk of overshoots in the real project costs compared to the base estimate. However, contingency should not be equated to estimate accuracy. The aim of including contingency is to bridge the gap between the base cost estimate (the "most likely" point, or the mode) and the outcome probability point that the project team is expected to control to (usually the 50/50 outcome point, or the median) as depicted in Figure 12 (Lawrence, 2007).

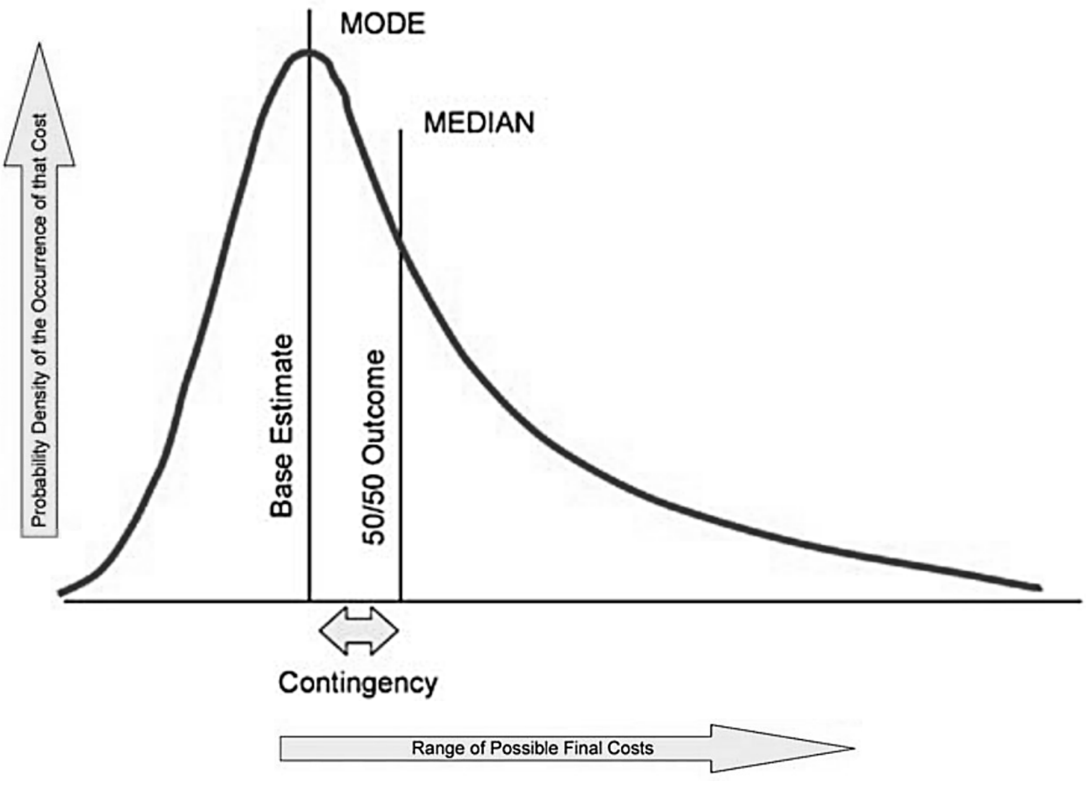

Figure 12. A distribution curve illustrating how contingency bridges the gap between the mode and median of the investment cost estimate. (Lawrence, 2007)

Still, the role of contingency is a very contested topic both in literature and in practice. In addition to the role of accounting for practically unaccountable factors affecting the base estimate (e.g., equipment cost increase because of rising raw material prices, currency fluctuation, labor disputes), some authors claim contingencies should also account for minor changes in project scope (Towler and Sinnott, 2021). Conversely, other authors explicitly state that contingency should not account for any scope changes, and should only be applied to the original scope put forth in the original estimate (Lawrence, 2007). Instead, estimate accuracies of individual cost should be defined in a way that accommodates minor changes to the scope.

4 CLASSIFYING AND ESTIMATING REQUIRED INVESTMENT CAPITAL

Deciding how investment costs should be categorized in industrial investment projects is highly dependent on the scope, magnitude, and nature of the investment in question. Similarly to investment planning methods, there is no single "correct" way to categorize investment costs, as there are numerous methods that fit the tasks at hand; Some methods are developed inhouse in consultancies (e.g., AFRY) and others by professional cost estimation organizations (e.g., the AACE). An overview of the main methods of categorization and the basis of estimating costs within these categories are presented in this chapter. The categorization method in place at AFRY is also presented. Quantifying the impact of chosen project location on the appropriate cost areas is discussed in chapter 7.

4.1 Cost Categorization and Estimation Methods for Investment Projects

While investment costs can be categorized as seen fit, there are certain established methods to categorize required investment capital for industrial projects outlined by e.g., Towler and Sinnott (2021). A general example is given on a cost categorization breakdown in Figure 13 which is based on the general framework by the same authors. In this approach, the total investment capital (TIC) is divided into two major cost categories, namely the fixed capital and working capital cost areas. As can be seen in the figure, the fixed capital costs can further be divided into four major cost categories, which will be presented in the following subchapters. These also give insight into what sub-cost areas exist within this main division and how they are estimated.

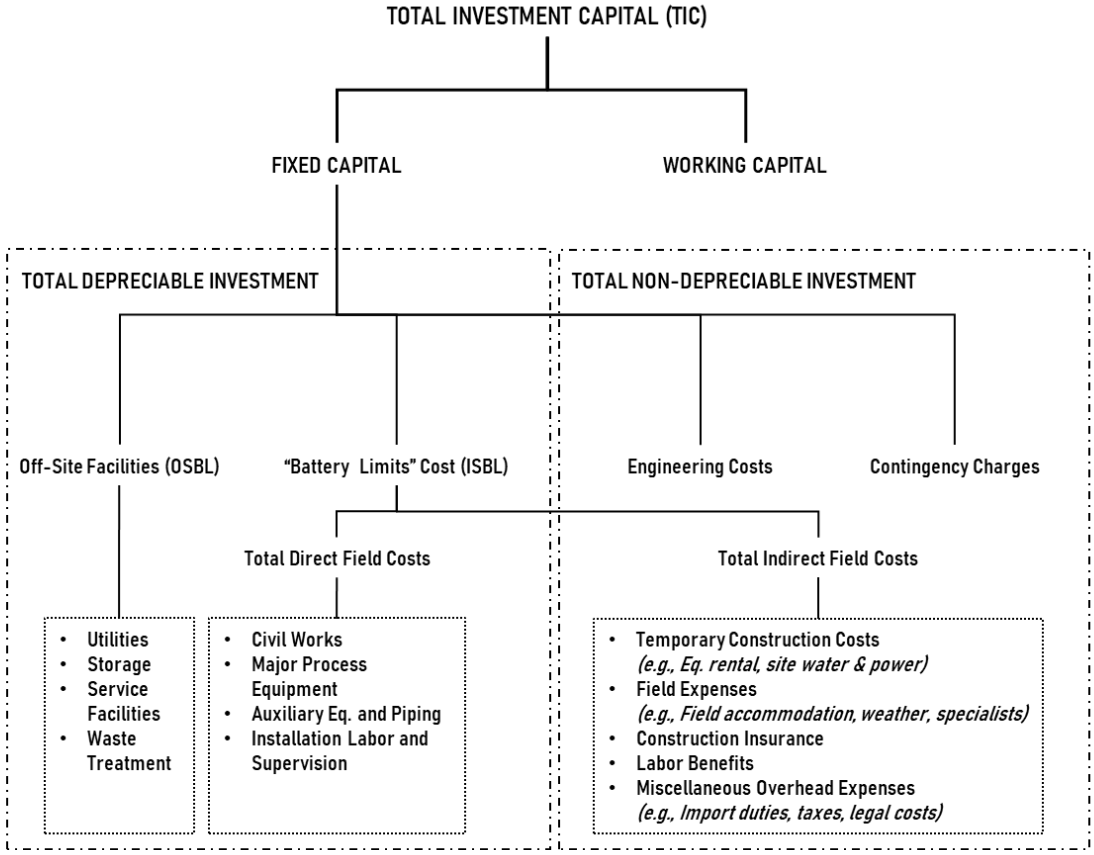

Figure 13. General example of a capital investment breakdown. Modelled after the research of Towler and Sinnott, (2021).

It is important to note that the categorization efforts may vary depending on the application of the finished estimation. Early investment cost estimations may choose to aggregate cost areas instead of attempting to consider and quantify individual costs for each category (especially sub-cost categories), as there is generally limited information available. However, by aggregating cost areas together, cost estimators may lose the ability to individually consider how e.g., location affects some particular sub-cost area. These caveats and considerations are discussed in more detail in chapter 5.

4.1.1 Fixed Capital

The fixed capital investment costs consist of the total costs accrued from the installment and procurement of the plant itself (inside battery limits costs, "ISBL"), auxiliary site infrastructure and equipment (outside battery limits costs, "OSBL"), design and engineering costs, and contingency charges.

Inside battery limits or ISBL costs includes all costs related to the procurement and installation of the new plant or expansion. ISBL plant costs are generally further categorized as indirect and direct field costs.

Direct field costs contain:

- all major process equipment
  (e.g., main machinery, vessels, columns reactors, heat exchangers),
- bulk items
  (e.g., valves, piping, instruments, paint),
- civil works
  (e.g., road construction, foundations, buildings),
- installation and supervision labor.

In addition to direct costs included in ISBL, the indirect field costs include:

- indirect construction costs
  (e.g., rental equipment, temporary water and power sources, workshops)
- field expenses and services
  (e.g., accommodation, canteens, specialists' costs, adverse weather costs, overtime pay),
- construction insurance
- diverse labor benefits and burdens
  (e.g., workers compensation, social security)
- other miscellaneous overhead items
  (e.g., legal costs, import duties, local taxes, patent fees).

ISBL plant costs are generally estimated by utilizing the so-called cost curve method. The basis of the estimation method is to scale some factor of a plant with known costs (from previously conducted investments or a reference plant from literature) with similar technological basis the proposed plant. The factor most commonly used is the capacity of the proposed plant. The ISBL plant costs can be related to capacity using Equation 1:

$$\mathrm{CAPEX_{new}} = \mathrm{CAPEX}_{old}\left(\frac{C_{new}}{C_{old}}\right)^{n} \tag{1}$$

Where $\mathrm{CAPEX_{new}}$ = ISBL capital cost of the new plant with capacity of $\mathrm{C_{new}}$

and $\mathrm{CAPEX_{old}}$ = ISBL capital cost of the old plant with capacity $\mathrm{C_{old}}$.

The exponent n is typically between 0.6–0.9 depending on the process. There are many publicly available sources for exponent values for various applications (such as Garrett (1989) with cost-plant capacity curves for more than 250 processes). However, if no suitable exponent is found in literature or proprietary sources, it is generally recommended to use 0.6 as the exponent value. This is also where the common name for Equation 1 is derived from, namely the "six-tenths rule". There are many versions of the six-tenths rule, and the equation should be modified to account for unique differences between applications. According to Towler and Sinnott (2021), it is recommended to represent the relationship of capacity and cost with a log-log plot instead if sufficient information is available for the process in question.

Outside battery limits (OSBL, also referred to as off-site) costs refers to all other improvements made to the investment project site. Improvements or modifications to the project site infrastructure are usually required when dealing with larger expansions or greenfield projects.

OSBL costs are usually estimated by either using so called Lang-factors, or simply using a common factor applied against the ISBL cost. Deciding what estimation method one should use is based on the desired estimation accuracy level. For conceptual and pre-feasibility studies with low requirements on the estimate accuracy, the common factor against ISBL cost is generally sufficient. Some factor ranges are presented in Table 11. However, it is important to note that these factors have vast differences between authors depending on the applied industry. For instance Towler and Sinnott (2021) provide factor ranges spanning from 20% to 100% which are instead based on plant complexity and site conditions instead of planned project scope as provided by Kinney and Gauche (2006). Thus, estimators should ideally only refer to factors developed specifically to the industry under consideration.

Table 11. OSBL cost estimation factors as a percentage of ISBL costs. (Kinney and Gauche, 2006)

Scope	Factor Range (as a percentage of ISBL costs)
New Greenfield Plant (stand-alone)	60% to 120%
New Process (new technology) in an existing plant	40% to 100%
Incremental Expansion (using existing plant technology)	20% to 60%
Retrofitting or Revamping (replacement of previous unit)	20%

Engineering and design costs are also necessary to include as a project owner to the total investment cost estimate, as operating companies rarely have enough engineering staff to carry out detailed cost estimates internally (with the exception of small investment projects) and therefore require outside contracting to carry out the detailed design of the plant. Remer and Buchanan (2000) has provided an indicative model to estimate the cost of performing cost estimates. The model is based on the estimated total project cost, desired accuracy of the estimate, number of cost elements and the maturity of the technology in question. However, professional engineering firms and consultancies working in plant design and cost estimation usually base the estimates for the cost of designing on professional experience. This is commonly done by comparing previously conducted projects with similar scope to give an estimate on the required manhours to complete the design and estimates without methodological basis.

Contingency charges are generally estimated through a factor based on the OSBL and ISBL costs. According to Towler and Sinnott (2021), it is recommended to use at least a charge equal to 10% of total ISBL and OSBL costs for contingency and up to 50% if there are uncertainties in the technology used in the proposed investment concept. The reason and roles of project contingency was discussed in more detail at the end of subchapter 3.4.

4.1.2 Working Capital

Aside from the fixed capital required to design and construct a plant, some capital is required to maintain plant operations after the initial investment project has been finished. All aspects requiring capital tied to ensure operations are considered as working capital including maintaining inventories for spare parts, products, and raw materials. However, it is important to distinguish working capital from utilities and other costs which are instead considered as being part of the operational expenditure (OPEX) of the plant. All assets contained in working capital are considered essentially illiquid, and their costs are recovered only if the plant is shut down.

Estimating the required amount of working capital in investment cost estimations are mainly based on either as a factor of annual operating costs (~10–20% of annual OPEX) (Garrett, 1989) or by approximating 7 weeks of production costs subtracted by 2 weeks of feedstocks (e.g., raw material) costs (Towler and Sinnott, 2021). Both methods are used as initial estimates, but as further information of the aforementioned factors materialize estimates should be updated to yield a more exact value for the working capital required. To illustrate, the cost of spare parts is tied to the prices of material and labor required to produce them, and prices may develop differently as opposed to operational costs. Thus, estimations for working capital based on OPEX should only be used as rough estimates in early cost estimates.

4.2 Cost Categorization in Mill Investment Projects at AFRY

At AFRY, the main cost elements of capital investments are categorized in the same vein as the example in the previous subchapters. Engineering costs are considered in the capital expenditure estimates at AFRY, even though these costs fall onto the operating company which has commissioned AFRY to conduct the estimate for the investment project. More detailed estimation of engineering costs are part of the detailed investment cost estimates in later project phases (practically considered after FEL2, feasibility study).

The general method of categorizing cost elements in pulp and paper projects at AFRY is based on cost breakdown matrixes. In the pre-feasibility and feasibility cost estimates, the individual matrix categorizes costs firstly into direct and indirect costs. Indirect costs are estimated as a share of the total direct costs accrued in the estimate. Direct costs are then divided into so called “process areas”, which are made up of subdivisions of the proposed plant concept. Within these process areas, costs are broken down further into civil costs, main machinery and equipment costs, piping and supporting costs, electrical equipment and cabling, process control equipment (instrumentation and automation systems), spare parts and special tools.

This two-dimensional cost breakdown is used in the cost estimation of every department incorporated in the investment. An example of the cost categorization model is presented in Figure 14.

Area	0 Unclassified	1 Civil Works	2 Machinery	3 Piping	4 Electrical Equipment	5 Automation	6 ICT	7 HVAC	8 Installation	9 Spare Parts	0 to 9 Total
Bale Storage, Pulper and Stock Preparation, 2 Machines											
Paper Machines											
Converting											
Power Sub Station											
Boiler Plant											
Raw Water Handling											
Effluent Treatment and Sludge Handling											
Maintenance Workshop and Roll Storage											
Mill Site											
General											
Temporary Facilities and Services											
Engineering											
Project Management and Const. Manag.											
Training and Start-up											
Total											
Contingencies	10 % excl. TM										
TOTAL											
Canteen	Client estimate										
Dormitory	Client estimate										
Office building	Client estimate										
Parking area	Client estimate										
Fence	Client estimate										
Earthworks	Client estimate	missing									
GRAND TOTAL											

Prices include construction & installation tax, service VAT, goods VAT and transportation VAT — The total sum of taxes is approximately

Figure 14. Typical cost estimate summary sheet, with illustrative process area and cost account structure. (AFRY, unpublished)

SECTION II –

ADJUSTING INVESTMENT COSTS BASED ON LOCATION

5 STATISTICS FOR GLOBAL CAPITAL PROJECTS BENCHMARKING

Indexing is a core element in financial markets used to statistically measure, track and compare economic data. The act of indexing is to compile a set of data into a single metric ("benchmark") and to then compare sets of data onto the benchmark to observe relative change. Only recently since the conception and common adoption of the internet, open and easy access to e.g., regional inflation cost, and relative price level indexes have been made available for both consumers and businesses. There are several different indexes compiled by both national statistics institutes and private enterprises for a wide range of use cases. Understanding which indexes to utilize in which end-purpose is vital to ensure the validity of cost forecasts or cost developments in estimates.

In this chapter, different price index types and their structures are presented. A compilation of commonly applied indexes in industrial investment planning are discussed and presented in this chapter. The intended use cases and caveats for each index presented are also discussed.

5.1 Index Types

5.1.1 Composite Indexes

A composite index is a type of statistical index that combines the values of multiple individual indicators to produce a single, aggregated value. This aggregated value can be easily understood and interpreted and can help to identify trends and patterns in the data. Composite indexes are often used to measure the performance or health of an economy, a market, or a specific industry, and to compare the performance of different economies, markets, or industries. Some of the most prominent composite indexes used are e.g., the consumer price index (CPI), producer price index (PPI) and the GDP deflator (Sorrels and Walton, 2017).

Composite indexes are typically constructed by weighting the values of the individual indicators, based on their relative importance or significance. For example, a composite index of macroeconomic performance might include indicators such as GDP growth, unemployment rate, and inflation, with each indicator being assigned a specific weight based on its importance in measuring the overall health of the economy. The weighted values of the individual indicators are then added together to produce the composite index value. (OECD/European Union/EC-JRC, 2008)

However, it's important to remember that a composite indicator is simply the combination of its individual components. The effectiveness and reliability of a composite indicator are largely determined by the quality of the underlying variables. One of the major challenges in creating a composite indicator is the lack of sufficient statistics. Data may not be available because it is difficult to measure certain phenomena or because no one has attempted to measure them. Moreover, the data that is available may only exist for a limited number of countries and not be comparable across countries. Because of the time and resources needed to develop internationally comparable performance indicators, composite indicators often have to rely on data sources of lower quality. As a result, these indicators may only capture the most obvious and easily accessible aspects of performance. (Freudenberg, 2003)

When using composite indexes, cost estimators must consider whether the measurability, relevance to the phenomenon being measured, and comparability between countries are sufficient. Additionally, composite indicators have a tendency to obscure data problems rather than transparently presenting statistical issues because of data aggregation. As such, a composite indicator is, above all, only a sum of its parts. The strengths and weaknesses of a composite derive largely from the quality of the underlying variables. By their nature, composite indicators can mask data problems rather than present statistical issues transparently. (Freudenberg, 2003; OECD/European Union/EC-JRC, 2008) It is important to use a clearly defined methodology for determining weights and to transparently explain this methodology behind the weighing when constructing composite indexes. This ensures that estimators can assess if the aggregated data is suitable for each use case, and what caveats may exist when utilizing said data.

5.1.2 Sub-Indexes

A sub-index is a type of statistical index that is either derived from or functions as an input to composite index. Sub-indexes are often used to focus on specific aspects or components of the larger index, and to provide more detailed or granular information about a particular aspect or component. For example, a composite index of economic performance might include sub-indexes for various sectors of the economy, such as manufacturing, retail, and finance. These sub-indexes would provide information about the performance of each sector and allow for more detailed analysis and comparison of the sectors.

Sub-indexes are typically constructed by selecting a subset of the data used to construct the larger, composite index, and then weighting the values of the individual indicators within the subset. The weighted values are then added together to produce the sub-index value. Sub-indexes are useful tools for providing more detailed or granular information about specific aspects or components of a larger index. They allow for more focused analysis and comparison and can help to identify trends and patterns within a specific subset of the data.

5.2 Prominent Indexes Utilized in Investment Cost Estimations

In this subchapter, common indexes used in investment cost estimation models in the pulp and paper industry are presented. Additionally, potential caveats when using these indexes in terms of adjusting for project location are discussed.

5.2.1 Consumer Price Index

The consumer price index (CPI) is one of the most common indexes used to compare price level developments in a country. The CPI is a measure of the average change over time in the prices of a basket of goods and services that are consumed by households. It is used to track the cost of living and is often used as an indicator of inflation. As the basket of goods and services included in the CPI is meant to be representative of the purchases made by households, it is updated periodically to reflect changes in consumer spending patterns. The prices of the goods and services in the basket are usually collected from a sample of retail outlets and service providers. The CPI is typically released on a monthly basis by national statistical agencies.

There are known and academically well-established biases related to the CPI. The most studied bias is the commodity substitution bias (White, 1999). The commodity substitution bias occurs naturally in any fixed basket index, as consumers may choose to alter their normal consumption levels because of price hikes, thus making the original consumption basket out of date. Especially during periods of high inflation, the substitution bias is expected to be higher (White, 1999).

The CPI can be and is used as a general indicator of inflation, however, may be misapplied to try to extrapolate cost information in other areas. As stated by Remer *et al.* (1998), general inflation indexes are limited in scope for a specific industry or segment, and may inaccurately describe cost developments in industries that require more specific inputs to accurately encompass changes in costs. Likewise, Sorrels and Walton (2017) argue not using the CPI as a metric for inflation in capital projects, as the index has little relevance to the forms of costs accrued from industrial investments, e.g., raw materials. Thus, the use of CPI should be limited to situations where no more appropriate cost index is found.

5.2.2 GDP Deflator

The gross domestic product (GDP) deflator is a measure of the average change in the prices of all goods and services produced in an economy. The GDP deflator is calculated by dividing the nominal GDP of an economy by its real GDP. Nominal GDP is the value of all goods and services produced in an economy, measured at current prices, while real GDP is the value of all goods and services produced in an economy, measured at constant prices (expressed in terms of a base period).

As both the GDP deflator and CPI are used to measures the general level of inflation, both are used interchangeably. However, as shown in Figure 15, the GDP implicit price deflator in the United States has increased at a slower rate compared to the CPI-U (CPI for urban consumers) over time (2% per year for the GDP price index and implicit price deflator, compared to 2.4% per year for the CPI-U). This is partly due to the fact that the CPI-U uses a Laspeyres aggregation method, while the GDP implicit price deflator uses a Fisher ideal aggregation (Church, 2016).

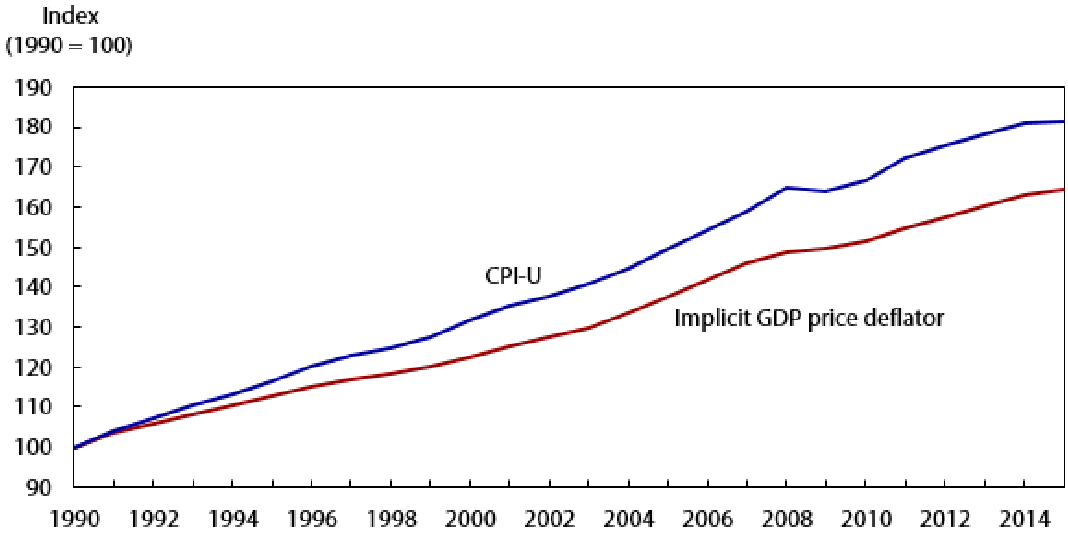

Figure 15. US Consumer Price Index fo All Urban Consumers (CPI-U) and gross domestic product (GDP) implicit price deflator, 1990–2015. (Church, 2016)

The GDP deflator is a measure of the overall level of prices in the economy, while the Consumer Price Index (CPI) measures the cost of a specific basket of goods and services consumed by households. The basket of goods and services used to calculate the CPI is meant to represent a typical consumer's spending patterns, while the basket of goods and services used to calculate the GDP deflator includes all goods and services produced within the domestic economy, regardless of who consumes them.

Another difference between the two measures is the way they are calculated. The CPI is based on the cost of a fixed basket of goods and services at a given point in time, while the GDP deflator is based on the cost of all goods and services produced in the economy during a given period of time. The GDP deflator is therefore a more comprehensive measure of price changes in the economy, as it accounts for changes in both the quantities and the prices of goods and services produced. However, as argued in the previous subchapter, cost estimators should always opt for indexes tracking costs developments more specific to the cost area in question, as price developments may differ significantly from the macroeconomic developments of a country.

5.2.3 Producer Price Indexes

Producer price indexes (PPIs) are measures of the average change over time in the selling prices received by domestic producers of goods and services (BLS, 2011). Compared to e.g., the CPI, PPIs measure price change from the perspective of the seller and not the buyer. Many national statistics institutes publish industry and product specific PPIs, which can function as a better replacement to aggregate cost level indexes.

However, there are some important aspects to consider when using PPIs to adjust cost elements in estimates. One of the major caveats of PPIs is that the indexes only measure the price changes of goods and services within the domestic economy, so they may not accurately reflect the overall level of prices in the economy if there are significant import or export flows. Thus, PPIs should only be applied to cost elements which are known to be domestically sourced.

5.2.4 Labor Cost Indexes

Labor cost indexes (LCIs) are measures of the changes in the cost of labor over time. LCIs are calculated by comparing the wages, salaries, and other labor costs of a fixed basket of jobs in a given period to the costs of the same basket of jobs in a base period. LCIs are used to analyze changes in the cost of labor, which can be an important factor when estimating labor costs for different cost elements in a project.

LCIs are produced by national statistics institutes in many countries, including the United States Bureau of Labor Statistics (BLS), which publishes the Employment Cost Index (ECI) (BLS, 2022). The BLS also publishes LCIs for specific industries and occupations, such as the LCI for construction workers and the LCI for professional and technical workers.

Labor cost indexes suffer from the same issues as other fixed-basket aggregate indexes, namely the coverage and potential exclusions of costs. If no industry specific LCI is found in a country, the index may not be representative of the cost developments associated with the particular industry. In addition, LCIs typically only include wages and salaries in the calculation of labor costs and exclude other costs such as employer contributions to social security and other benefits. As a result, LCIs may not fully capture the total cost of labor to employers.

5.2.5 Construction Cost Indexes

Construction cost indexes (CCIs) are utilized for cost estimates, bid preparation and ultimately investment planning decisions within the construction sector. (Ashuri, Shahandashti and Lu, 2012) Most CCIs are based on the average price of a weighted aggregate of constant quantities of labor, materials, and equipment used in construction projects. These indexes may differ slightly in terms of their specific methods of calculation, but the general principle holds true. CCIs are an important tool for construction professionals, as they can help to track changes in construction costs over time and provide valuable insights into the economic factors that influence the construction industry. This information can be used to make more accurate projections about future construction costs, which can be useful for a variety of purposes, including budgeting, planning, and investment decision making. In addition, construction cost indexes can be used to compare the cost of building in different regions or at different times, providing valuable insight into the state of the construction industry and the broader economy (Shahandashti, 2014).

In some countries there may not be any construction cost databases available provided by a national statistics institute. Instead, these countries may use construction input/output price indexes or tender price indexes as a substitute (Zhang *et al.*, 2019). Other non-governmental agencies or private third parties may opt to report and develop indexes changes independently, with access typically through a paid subscription. The European construction cost index is a statistic that is used to measure the trend in the cost of building new residential properties in the European Union (EU). It is considered a business cycle indicator and is updated on a quarterly basis according to Regulation 2019/2152. This regulation requires EU member states to report on construction costs for new residential buildings (excluding community residences). Some countries may not have complete data on the associated costs in the construction of new residential buildings, in which case they may use the construction producer price indexes (CPPI) as an approximation.

While Regulation 2019/2152 only calls for member states to publish cost developments of constructing new residential buildings, some EU member states such as Finland report cost developments in specific sectors of the construction industry, e.g., in costs associated with constructing new industrial buildings (Official Statistics of Finland, 2022).

The same caveats as previously discussed in this chapter apply to the use of CCIs as with other composite indexes.

5.2.6 CEPCI

Apart from government statistics, there are several private entities that publish cost indexes. These indexes are more often than not modified versions of publicly available cost indexes provided by national statistics institutes.

The chemical engineering plant cost index (CEPCI) is a composite index comprising of a weighted average of four sub-indexes. The CEPCI is calculated from Equation 2:

$$\text{CEPCI} = 0.50675\,E + 0.29\,CL + 0.1575\,ES + 0.04575\,B \tag{2}$$

where E = equipment index, B = buildings index, ES = engineering and supervision index, and CL = construction labor index (Vatavuk, 2002).

As the name suggests, the CEPCI is particularly used in the estimation of chemical process industry plant construction costs but is applied across a broad range of industries. As the CEPCI includes labor and productivity inputs in its composition, an important caveat to keep in mind is that the index is based on the price levels in the United States, as the most inputs to the sub-indexes are sourced from the U.S. Department of Labor's Bureau of Labor Statistics. Thus, CEPCI will most likely overestimate total investment costs in countries with comparatively lower price levels to the United States.

5.3 Purchasing Power Parity

In order to equate relative price levels between countries, there are two main methods to achieve the objective: Either through nominal exchange rates, or real exchange rates. The nominal exchange rate is the rate at which one currency can be exchanged for another currency. It is determined by the supply and demand of the two currencies in the foreign exchange market. The real exchange rate, on the other hand, is the nominal exchange rate adjusted for the relative prices of a basket of goods and services locally produced in the two countries. In other words, it reflects the purchasing power of one currency in relation to another.

Purchasing power parity (PPP) is an economic theory that compares the purchasing power of different currencies by measuring the amount of goods or services that a unit of currency can buy in different countries. PPP states that the exchange rate between two countries should equal the ratio of the two countries' price levels, so that a person can buy the same basket of (locally produced, of equivalent quality and quantity) goods in either country for the same price and thereby eliminating the price level differences between countries. (OECD, 2012) The theory argues that should there be a price level difference, arbitrage will correct the variance in international markets. As the PPP is solely derived from producer prices, it does not consider factors such as transportation costs, taxes, and the cost of labor as they do not contribute to the GDP, which by definition is the aggregate of all products and services produced in a country.

However, there are several criticisms of the PPP theory. One criticism is that PPP assumes that prices of goods and services are the same across countries, which is often not the case. In reality, prices can vary significantly depending on a variety of factors, such as transportation costs, taxes, and the cost of labor. PPP also does not consider differences in the quality of goods and services between countries. Another criticism of PPP is that it assumes that the exchange rate between two countries will adjust to equalize the price levels of the two countries. However, exchange rates do not always reflect PPP (Taylor, 2003), and can be influenced by a variety of other factors, such as interest rates, government policies, and market speculation.

One way to address the criticism that PPP does not consider differences in the quality of goods and services is to use quality-adjusted price indexes. These indexes adjust for differences in the quality of goods and services by using "hedonic regression" techniques, which attempt to estimate the value that consumers place on different features of a product. By using these techniques, analysts can, in theory, adjust for differences in the quality of goods and services, which can provide a more accurate comparison of price levels between countries. There are many other techniques recognized to circumvent the issues with the PPP theory, including using long spans of data, which have been proven to show a pattern of mean reversion with exchange rates. The PPP theory is however, still a highly contested subjected in the field of exchange rate economics. (Taylor, 2003) Nevertheless, it is widely accepted that PPP adjusted price level comparison provide a more robust basis for international comparison of prices compared to nominal exchange rates (Best, 2010). A general summary on the appropriateness of use cases for PPPs are listed in Table 12.

PPPs at the GDP level are often used to compare the output of different countries. While they can be useful for e.g., converting construction costs between countries to a common base, they have limitations and should not be relied upon for industry-level productivity comparisons. However, there are an increasing amount of PPPs available for industry specific cost level comparison e.g., through the International Comparability Program (ICP). These will be discussed in more detail in the next subchapters.

Table 12. Use of purchasing power parities. (Best, 2008)

	Examples of use cases
Recommended uses of PPP	• Spatial volume comparisons of GDP, GDP per head, GDP per hour worked, size of economies • Grouping of countries by volume index of GDP • Spatial comparisons of relative price levels
Use of PPP with limitations	• Time series analysis of relative GDP per capita or relative prices • Analysis of price convergence • Cost of living index across countries • Use of PPP established for expenditure categories for the deflation of other values, e.g. household income
Non-recommended use cases of PPP	• As a precision tool to establish rankings between countries • As a way of constructing national growth rates • As a measure to generate output and productivity comparisons by industry (unless there are industry specific PPP) • As a measure to undertake price level index comparisons at detailed level • As an indicator for the over- or undervaluation of a currency • As equilibrium exchange rates

5.3.1 Price Level Indexes

Price level indexes (PLIs) are used to compare the relative cost of living in different countries by expressing the purchasing power parities of each country as a ratio to their exchange rates. It's important to note that PLIs are not meant to be used to rank countries strictly. In fact, they only provide a rough indication of the relative cost of living in different countries, especially when the PLIs are all clustered around a similar range. The uncertainty of the basic price data and the methods used to calculate PPPs can affect the minor differences between PLIs and result in rankings that are not statistically or economically significant. (Eurostat, 2022a)

5.3.2 International Comparability Program

The International Comparison Program (ICP) is a statistical initiative that aims to compare the purchasing power of the currencies of countries around the world. The ICP is coordinated by the World Bank and involves participating countries collecting and comparing price data for a common set of goods and services. The resulting data is used to calculate purchasing power parities (PPPs) for each country, which can be used to compare the real purchasing power of different currencies.

Some of the main contributors to the program, Eurostat and the OECD, provide purchasing power parities (PPPs) and national expenditures at the basic heading level on the condition that the ICP respects the fixity of the results when they are published, that global results for participating countries are not published at a lower level of aggregation than shown in Eurostat's and OECD's public databases. The PPPs and national expenditures provided by Eurostat and the OECD should not be disseminated without the prior agreement of both organizations. This is done in order to ensure the proper use and dissemination of the data provided by Eurostat and the OECD. (OECD and Statistical Office of the European Communities, 2007)

The International Comparison Program's (ICP) results, while not completely reliable, are widely considered to still be more accurate than any other available data. The GDP and GDP PPP data in the ICP are generally deemed to be more reliable, while data on the components of GDP e.g., construction expenditure data, may be less reliable. The ICP has already taken steps to address some of the recommendations made by stakeholders to improve the reliability of heading level price levels. However, it is worth noting that there are limitations in the ICP's methodology, including uncertainties in item selection, price collection, and weighting, which all can affect the quality of the results. When these uncertainties are combined, they may exacerbate any individual errors or inaccuracies. (Meikle, 2019)

5.4 Summary and Discussion

In this chapter, different publicly available inflation indexes were presented which are commonly used to adjust project costs in industrial investment projects. The main appeal of utilizing publicly available indexes from the lens of a cost estimator is two-fold:

Firstly, the burden of updating costs related to specific areas is shifted to the indexing agency instead of the cost estimator. Prices rarely stay static for extended periods of time and thus, must at least be adjusted for inflation. There are various inflation indexes available to the public, each one compiled to best represent cost developments in their respective areas and use cases. Additionally, as indexing agencies update the underlying basket of indexes, specific industry indexes should also account for cost savings related to e.g., technological developments (such as more efficient extraction of raw materials) and other factors not included in the CPI.

Secondly, as rates of inflation and price level differences develop distinctly in different countries, indexes are compiled to best represent the cost developments in the country in question. Thus, indexes are an excellent source for assessing inflationary cost escalation (and de-escalations) in countries which's practices in some cost area (such as construction) might not be familiar to the cost estimator. Using PPPs for spatial comparisons of relative price levels are also recommended, as it is a huge task (and risk of inaccuracies) to determine which inputs to measure and how to weigh said inputs in each location for each cost area.

However, as argued by Remer *et al.* (1998), inflation indexes are typically limited in scope for a specific industry or segment, and may inaccurately describe cost developments in industries that require more specific inputs to accurately encompass changes in costs. CAPEX prices in the process plant industry are often not closely correlated with those tracked by government agencies and economists as this sector can be considered a micro-economy with its own unique characteristics (Hollmann and Dysert, 2008). Even when using industry specific indexes such as construction indexes, the indexes may aggregate data within the industry and therefore have in-built bias towards cost elements not related to the sought "sub-industry". Thus, cost estimators may choose to develop a proprietary composite index by weighing relevant cost components to better encompass industry specific cost escalations. This aspect is briefly discussed in subchapter 8.2.2.

6 COMPANY INTERVIEWS

In this chapter, the findings of interviews conducted with professional cost estimators are presented. The interviews were carried out to establish a baseline of the level of insight and approaches that cost estimators currently have when accounting for location in projects.

6.1 Methodology

The interviewees were selected to represent different stakeholders in investment projects within the pulp and paper industry. The aim was to observe how the different stakeholders confront the price level variance issue depending on the project location. Six interviews were conducted in total, which were performed through phone-interviews in the fall of 2022. Of these six interviews, three were conducted with cost estimation professionals within the Process Industries Division at AFRY Finland, two with prominent European pulp and paper equipment manufacturers and one interview with a global pulp and paper producer. As the investment cost estimation tool at the Management Consulting department is primarily used for conceptual and pre-feasibility studies, the current methodology of the tool may aggregate costs which are instead considered separately in the detailed engineering phases. Thus, it was important to investigate if the methodologies in place at the Process Industry division may include cost elements that location has an effect on, and which could be pragmatically included in the conceptual and pre-feasibility investment cost estimates. The cost estimation tool used in AFRY Management Consulting Oy will be presented in more detail in chapter 8.

The interviews were centered around four questions:

1. How does location affect investment cost estimates? In which project phase should location be considered?

2. Which cost areas are considered when adjusting for location?

3. If cost indexes are used, which indexes are utilized and where are they sourced from?

4. If there is no previous data for a project country, how do you estimate price levels in said country?

Although the four questions were equally posed to all interviewees, the aim was to have a free-flowing discussion to potentially find other aspects not originally accounted for in the intended question battery.

6.2 Key Findings

In this subsection, the key findings from the conducted interviews are presented. The findings are divided according to the industry representation correspondingly of the interviewee.

6.2.1 AFRY Finland Oy

AFRY Finland Oy (hereinafter "AFRY Finland") is a supplier of engineering, design, and advisory services within Finland. AFRY Finland operates in 29 locations across Finland and employs around 2 800 industry experts. AFRY Finland's competences cover projects in the fields of process industries, energy, transport and infrastructure, water and wastewater, environment and construction.

AFRY Finland is a separate entity within AFRY AB and should not be confused with AFRY Management Consulting Oy. From the lens of the project planning process, AFRY Management Consulting Oy primarily offer capital cost estimation services in the conceptual and pre-feasibility phases (FEL1) for projects. AFRY Management Consulting Oy is rarely involved in cost estimation efforts in later stages of the investment planning process, namely the pre-engineering and basic-engineering phases (FEL3) which are usually carried out by AFRY Finland. While both parties conduct similar services, such as producing investment cost estimates, their implied accuracies, tools, methodologies, and ultimately their outcomes differ significantly from another (due to the differences in approach and goals). Thus, it was of interest to interview professional cost estimators at AFRY Finland to observe if there are factors later down the investment cost estimation pipeline related to project location that could be pragmatically incorporated in early cost estimates in the conceptual and pre-feasibility phases at AFRY Management Consulting Oy. The subjects interviewed were situated within the project control and process engineering departments at AFRY Finland.

All investment considerations and calculations at AFRY Finland are guided by a proprietary methodology, *the AFRY Project Model*, developed within the corporation. The estimation model covers the entire investment planning process from preliminary estimates, risk assessment, planning and design to project management and project control. The methodology is used in all cost estimations within the Process Industries Division at AFRY Finland.

Special consideration for location in conducted capital expenditure estimations is limited. Generally, investment cost estimates at AFRY Finland are largely based on project references, inhouse-developed cost models for e.g., equipment and labor, and industry experience that are used as inputs and adjusted to the needs of the current project. The most straightforward method to conduct cost estimates are to simply add an inflationary factor to a previously conducted project with a similar technological concept. However, the diversity of projects and processes make comparing different projects relatively difficult. While it is possible that similar projects have been conducted in a sufficiently recent timeframe for negligible change to have occurred in price levels between the two projects, estimations of total project costs through factorial methods based on previous projects are rare and usually require input through the developed cost models, industry experience and/or through direct quotes from machine suppliers (contrasted to the approach found at AFRY Management Consulting, where quotes from vendors are more uncommon in investment cost estimate preparation).

Consequently, universal location cost factors (or similar) are not systematically employed in detailed investment cost estimations. Location is naturally still considered in investment cost estimates by conventional means through sourcing the needed cost information from local professionals through requested cost quotes for e.g., equipment or construction.

In summary, all investment cost estimations prepared at AFRY Finland are based on the proprietary methodology, *the AFRY Project Model*. This methodology requires various inputs by the cost estimator, e.g., project references, vendor quotes, and specific know-how about the technologies used in the investment project in question. AFRY Finland Oy maintains a data bank with cost information from earlier projects. Location specific information is sourced from the target country through cost quotations for major cost components where the location-specific costs are included.

6.2.2 Pulp and Paper Equipment Manufacturers

The two interviewed parties within the pulp and paper equipment manufacturers represent leading companies in Europe. The companies are developers and suppliers for process technologies, automation and services for the pulp, paper and energy industries and have local offices across all major market regions (North America, South America, EMEA, China and Asia-Pacific). Due to the business-critical nature of the subject, the companies remain anonymous in this study. The findings from both interviews are aggregated since the cost estimation practices and challenges were very much aligned between the two manufacturers.

Equipment manufacturers' cost estimates are conducted to ensure own profitability when participating in bidding processes. The range of responsibilities vary between projects and is mainly dependant on the project country. If the proposed project is meant to be carried out in the main business regions of the equipment manufacturers, installation may be a part of the deliverables of the manufacturer. However, installation of the equipment is usually carried out by either the project owner or third-party consultancy.

The cost estimation processes in place at the equipment manufacturers are primarily based on first-hand information. Akin to the practices at AFRY Finland, equipment manufacturers stated that as they have a robust global network of local offices, it is much easier to inquire information about the local price levels from the vendor in or regionally close to the project country to acquire real costs for said equipment, instead of basing estimates on e.g., indexes or other means of estimating cost variance.

It is important to note that as the equipment manufacturers are less likely to include installation fees as part of the purchasing agreement, it falls on the purchaser to consider costs accrued from these sources. The interviewees recalled accounts where the purchaser had (in their opinion) failed to consider the effects that installation fees had on the overall costs associated with the purchased equipment. As such, it is especially important for the purchaser to consider these effects, as the equipment manufacturer simply provides what has been stated in the agreements of delivery.

From the point of equipment manufacturers (or when purchasing process equipment), special considerations associated with the chosen project country are mainly the level of preassembly of the equipment, equipment manufacturing location (within the project country or outside), local labor price levels, and availability of skilled labor. The manufacturing costs of the equipment themselves have negligible impact due to location in the global context, as material prices are generally stable across global markets and the interviewed manufacturers can dynamically utilize production sites located in regions to account for regional differences in materials costs.

Considerations for the level of preassembly is determined by mainly two factors, firstly on how freight (or general logistics) costs increase or decrease depending on the size of the equipment, and what the local labor prices are compared to other manufacturing sites owned by the manufacturer. As an example, if the project does not have a locality clause (i.e., some share of total investment must be locally sourced), it is good to consider if the equipment could be preassembled in countries with lower labor costs to circumvent higher total costs associated with the installation of said equipment in the project. This is especially apparent in countries such as the United States, where share of installation costs relative to the total equipment costs may be remarkably high compared to other countries. However, as previously mentioned it is up to the purchaser and/or project owner to consider these matters as the equipment manufacturer is rarely fiscally responsible for the costs accrued from installation of the equipment.

Access to sufficiently skilled labor for the target project were one of the most contentious issues regarding location. Both interviewees stated that, relatively speaking, the largest cost escalations stemmed from the inability to gain access to skilled labor in the project country. Labor costs for civil works were by some accounts many times greater than originally estimated. The issue propped up in previous greenfield investment projects in South American countries, although were not limited just to that region. Depending on the familiarity of the local workforce in pulp and paper projects, there may be a limited pool of contractors capable of efficiently executing the required civil works and installation. These capable contractors may be preoccupied in another construction project, also outside the pulp and paper investment projects. According to one of the interviewees, e.g. mining projects in Chile pay up to three times the salary for the local labor compared to pulp and paper projects. Determining the availability of capable labor has proven to be difficult to account for in estimates, as there are mostly only preliminary scoping for available labor during the bidding process.

6.2.3 Pulp and Paper Producer

The pulp and paper producer interviewed in this study is global producer of pulp, paper and other forest products based in Europe. The producer has conducted several greenfield investments during the last decade with a global focus. The interviewee requested to remain anonymous for this study.

The interviewed producer has not developed its own systematic procedures or robust models to estimate location-specific costs for investment projects. Investment cost information from earlier projects is always used as a basis for new projects. The investment management department within the corporation does not concentrate on detailed investment cost estimation for new capacity investments, and instead focuses more on market-strategical opportunity analysis. As new capacity investments and greenfield projects are exceptional investment decisions and occasionally require huge amounts of manhours to complete, cost estimation efforts for investments of this scope are often outsourced to consulting firms in the forest industry sector.

As the company regularly externalizes cost estimation efforts to outside consultancies, there are no proprietary methodologies in place that account for location-specific costs for investment estimates in any meaningful capacity. Different country-specific and project-specific issues are evaluated and allocated to the investment costs of the investment alternative on a very general basis. Approved capacity increases and other larger investment decisions are rarely decided solely on the CAPEX estimate, as considerations for raw material availability and operational expenses are often more important factors to consider when selecting for new investments in capacity increase. Naturally, it is still imperative for the producer to have reliable information on the amount of capital required to actualize the proposed investment to make the best decision between different alternatives.

6.3 Summary of Conducted Interviews

The companies included in the interviews represent a sample of large Finnish process industry corporations in different areas of business within the investment value chain. The interviews revealed that, while the methods used to estimate investment costs of manufacturing plants differ, the general approach to investment cost estimation is the same. It was apparent that the main method utilized to incorporate costs associated with location is through direct quotes, thus circumventing the need to develop separate cost escalation factors based on project location. In general, the location cost factor approach applied at mill-level appeared to be too generic for capital cost calculation and not suitable for the companies' investment cost estimates.

However, the interviews did highlight some issues regarding cost escalations stemming from project location. It was found that generally, themes related to project labor costs were the main source of escalated costs. Estimating the cost of local labor and evaluating the availability of labor were the main sources of contention in regard to project location.

In the following chapter, quantifying and adjusting the costs related to chosen project location will be presented. In chapter 8, proposed solutions to some of the issues discussed in the interviews will be examined through the lens of the cost estimation model at AFRY Management Consulting.

7 QUANTIFYING LOCATION PRICE LEVELS IN SELECTED COST AREAS

There are numerous factors that cause investment cost differences between geographical location of the project in question. Some of the cost elements can be estimated on a regional level, and some can be approximated on a country-specific level. However, many project-specific elements cannot be pragmatically considered at the investment cost estimations at the pre-feasibility and feasibility phases. The reasons behind this have to do with the categorization decisions made by the cost estimator, simply due to the reason that available information is limited and that the manhours used to complete the estimate are kept at a reasonable level. This naturally entails a lower total accuracy on the final cost estimate.

As outlined in subchapter 3.1, cost estimates made during the early phases in the investment planning process do not have a great deal of defined project deliverables. However, as it is desirable to conduct as accurate cost estimates as possible in all project phases, it is vital to focus efforts on incorporating elements which have large implications on the final estimate, and elements which are sufficiently simple to incorporate within the estimate without large amounts of manual labor involved. Teir (1998) identified some of the investment cost elements in pulp and paper projects. The elements are plotted against the function of their indicative variability between regions and their effect on the total investment costs is found in Figure 16. While some of the elements have arguably shifted since the figure's conception, it serves as a good basis of assessment when selecting for elements which to incorporate into early cost estimates.

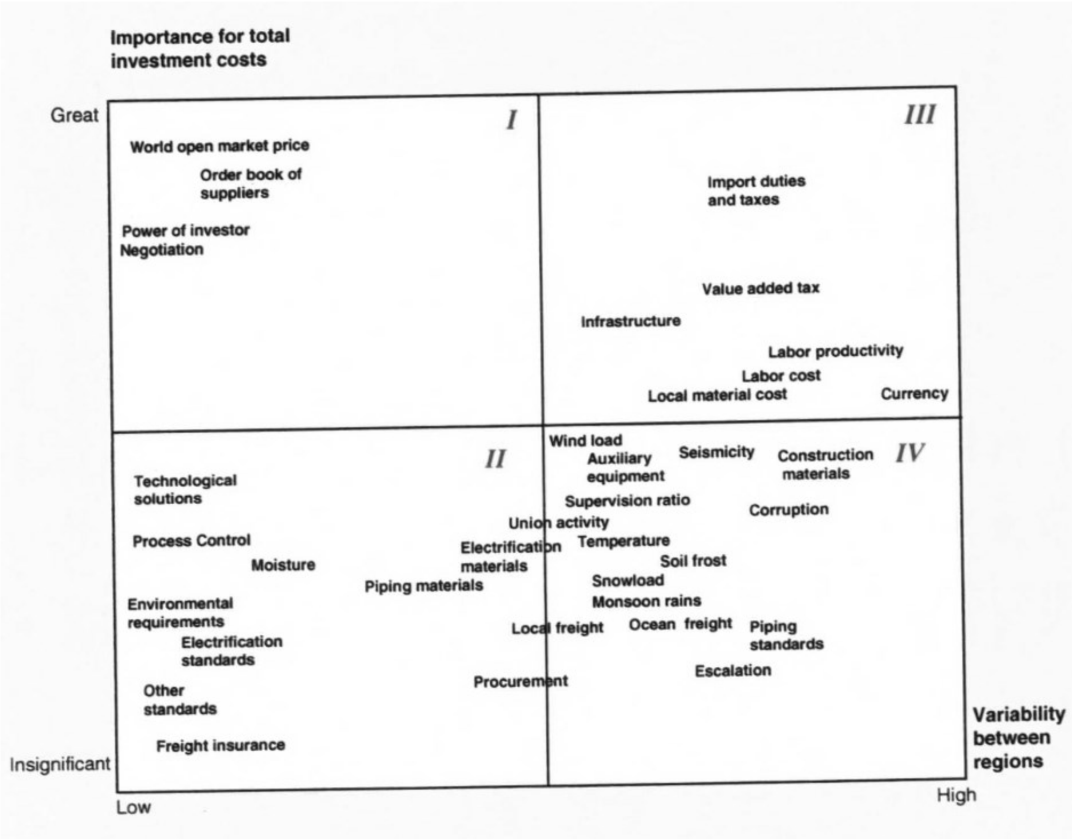

Figure 16. Importance and variability of investment cost elements in pulp and paper projects. (Teir, 1998)

In this chapter, quantifying important and/or pragmatically incorporable cost elements will be presented and assessed. As discussed previously in this thesis, indexes are the primary source for up-to-date information on how costs on an aggregate level have developed as a function of time. Indexes also shift the burden of individually assessing cost changes occurred between times of reference to the index compiler, which saves time when conducting the estimate. Thus, tracking cost developments in destinated project countries will be done primarily by utilizing said indexes.

In order to apply cost indexes to observe relative change in prices over time, it is necessary to establish a baseline which to apply the cost index. Baseline prices for countries are best sourced from real costs observed from previous projects. However, it is not reasonable to expect finding a previously conducted, comparable project in the targeted investment country. To circumvent the need for constant quotes for prices in each location, estimating the relative price levels between countries can be achieved by e.g., using purchasing power parities published the ICP. Suggestions on where and how relative price levels can be determined in each major cost area used in the cost estimation tool at AFRY Management Consulting will be discussed and relevant inflationary price indexes to track relative change over time are presented.

7.1 Machinery Costs Levels

Machine suppliers have long been consolidated in the pulp and paper industry, with few vertically integrated companies leading the market share in the industry (Leppänen, Kraslawski and Avramenko, 2011). Main machinery costs can thereby, with satisfactory accuracy, be assumed to be procured from the same suppliers regardless of project location, at an internationally set price. However, as local procurement of main machinery for the pulp and paper industry is not possible worldwide, equipment costs arguably should not be corrected through purchasing power parities and should instead use nominal exchange rate adjustments when applicable.

The Federal Statistical Office of Germany provides producer prices for machinery for papermaking. As Germany is one of the main exporters of paper machines in the world (Gaulier and Zignago, S., 2010), this price index can be used to indicatively track cost developments in main machinery costs worldwide.

However, main machinery costs can still vary due to fluctuations in currency exchange rates and differences in taxation and tariffs policies. As cost for main machinery accounts for roughly 50% of the total investment costs in pulp and paper projects (Leppänen, Kraslawski and Avramenko, 2011), freight, duties and taxes will have a major effect on the final cost estimate. Information on potential duties and taxes are easily accessible, e.g., through trade organizations' websites.

Differences in freight cost can be significant, depending on the origin of the machinery or equipment. Naturally, the exact method of freight depends on the location of the project country. In addition to container freight if procured equipment travels by sea, landlocked countries use trucks for machine freight. There are some publicly available indexes tracking costs related to freight. For example, the U.S. Bureau of Labor Statistics provide an index tracking the producer prices for general freight trucking costs (BLS, 2003). Cost indexes tracking container freight costs are also readily available e.g., FBX Global Container Freight Index published by Freightos (2023).

A potential method to quantify location price levels for freight costs could be done by first regionally assessing where major exporters of main machinery are located, and indicatively assessing the distance from the main exporter to the project location. However, it is recommended that information on the regionality of main machinery production should be validated either directly from the suppliers or through previous project experience, as freight costs have a major impact on the final cost estimate.

7.2 Construction Cost Levels

It is difficult to accurately compare construction prices due to a variety of factors that can significantly impact their level and comparability. These factors include context-specific variables such as location, time period, and project-specific details, as well as market conditions, local standards and regulations, and physical factors like weather and ground conditions. Additionally, prices for completed projects may only be available and these prices may be influenced by the above factors. Furthermore, many construction projects are unique and may not be strictly comparable across countries or regions. Finally, there is often a lack of comparable units of measurement for various construction types. (Meikle, 2019)

The ICP provides aggregate price levels internationally for construction costs. This includes e.g., material costs, labor costs, and as a proxy, all location specific elements affecting the construction of the building. This can be seen as both a pro and a con, as if the price level information is applicable and valid, it could be easily incorporable into established estimation procedures. However, there are many questions still open about transferring the values to real world applications, especially when industry-specific factors are considered.

García and Breton (2013) conducted a case study to determine if the relative construction prices of the 2005 ICP publication had an inbuilt underestimation bias against developing countries due to methodological issues. The findings of the case study pointed at a very high degree of underestimating costs compared to actual costs based on quotes gathered in the case study. The authors speculate the reasons for the underestimation of the relative price levels for developing countries are the following:

- As the ICP calculates relative construction prices by determining the cost of each category of construction in a given country and combining them to create an overall price, this approach may not accurately reflect the true cost of construction due to variations in construction characteristics and quality across countries, as well as within certain types of construction. For example, the construction of modern office buildings is typically similar across countries, while the construction of residential structures can vary greatly.
- If the price of a low-quality, primitive dwelling in a developing country is compared to the price of a high-quality dwelling in a developed country, the relative construction price in the developing country will be underestimated.

As the ICP construction aggregate cost heading covers expenditures for residential buildings, non-residential buildings and civil engineering works, it is a major disappointment is the lack of publishing more detailed sub-heading level data, such as separate price levels for non-residential buildings which could be used to correct for regional price level differences in industrial building construction in e.g., pulp and paper projects (ICP, 2012). While the reasons for this is likely due to comparability issues resulting from incomplete input data from participating countries, even more specific industry data is required in construction price level estimates. The ICP prices are generated through a complex methodology that involves regional assumptions about productivity and construction techniques, as well as proprietary prices for building components. There is no publicly available information about the prices estimated for individual countries, and it is not possible for users to assess the accuracy of these prices (García and Breton, 2013). This is hopefully elaborated in the future in order to make better assessments on the suitability of IPC price levels also for pulp and paper investment costs estimation.

However, while the price levels published by the ICP are not completely reliable, are widely considered to still be more accurate than any other available data. Especially between developed economies with similar domestic availability of construction raw materials and labor, ICP values should provide a decently accurate estimate. As the price weights set for construction costs are grouped by Gross National Income (GNI), it is to be expected that the ICP values provide more accurate price levels for larger economies. Thus, price levels for construction costs for larger economies can be indicatively calculated with values provided by the ICP. It is recommended that construction costs are separately determined for developing countries, either by using real cost data from previous projects, or by indicatively assessing the validity of ICP values against values previously set by AFRY and manually correcting values based on professional experience.

A comparison on the differences between price levels set by AFRY in 2005 and 2017 ICP values are presented in Table 13. In addition to labor cost and productivity factors, the calculation tool at AFRY Management Consulting uses fixed seismic and climate factors to derive the complete location cost factor for civil costs. However, the ICP price level for construction should account for the local climate and seismicity in the value. Thus, cost estimators should revisit if these factors are necessary if aggregate price level index values e.g., derived from the ICP are to be used in the future.

Table 13. Static location cost factors for civil works at AFRY's cost estimation model for 10 countries compared to ICP (2017) values.

Country	AFRY (2005)	ICP (2017)	Difference ($\frac{\text{AFRY}}{\text{ICP}}$, %)
Argentina	0.60	0.51	15 %
Australia	1.03	1.29	-25 %
Austria	1.00	0.74	26 %
Brazil	0.59	0.40	31 %
Canada	1.24	0.91	27 %
Chile	0.82	0.46	44 %
China	0.54	0.44	19 %
Germany	0.92	0.92	0 %
South Africa	0.68	0.28	59 %
Uruguay	0.64	0.66	-3 %

8 IMPROVING THE INVESTMENT COST ESTIMATION MODEL AT AFRY

In this chapter, improvements on the validity and accuracy of the investment cost estimation model at AFRY Management Consulting will be presented. The implied improvements to the precision of the calculation model are based on the literature explored in this thesis, and the findings of the conducted company interviews.

8.1 Cost Estimation Model Methodology

AFRY Management Consulting's estimation model is divided into "blocks" which represent separate mill departments which can be considered as individually functioning units in a pulp or paper mill akin to Figure 14 described in subchapter 4.2. Currently, there are over 100 different blocks developed within the model representing e.g., debarking, chipping, pulp drying and pulp bailing, etc.

More blocks can be retroactively implemented to the tool, and parameters within the blocks can also be customized. The costs for each block are calculated separately. The final output of the tool is a summary table containing cost information for each block categorized in civil, machinery and labor costs, together with indirect, contingency, and total investment costs for the entire project. Indirect costs account for cost items such as engineering, construction management, supervision and administration, start-up and training, and taxes and duties. Estimating indirect costs and level of contingency is done manually based on and is added onto the final cost estimate. The level of contingency and indirect costs is based on industry experience of the cost estimator and is dependent on the project phase (e.g., conceptual studies typically require a higher amount of contingency due to a greater amount of undefined project deliverables as established previously in this thesis).

8.1.1 Location Cost Factor Composition

In addition to the individual cost blocks, the costs for main machinery, auxiliary equipment, civil works, piping, and labor are separately adjusted based on a proprietary location cost factor. This factor comprises of both static price level factors and dynamic inflationary factors whose weights were set by professional cost estimators at AFRY Management Consulting in 2005. In addition to these factors, a nominal currency exchange is applied. All parts of the location cost factor is given equal weights. An example of the methodology for a location-based factor for civil works in a European country is shown in Figure 17.

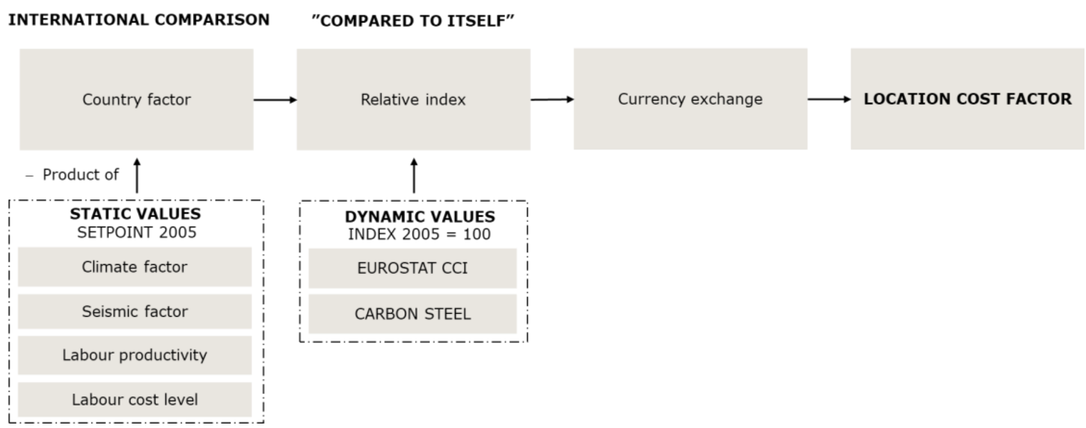

Figure 17. Current methodology for location cost factor development for civil works in a European country.

The static 'country factors' are meant to compare the relative price level for the cost area in question (e.g., civil works or labor) which is affected by the location. For instance, main machine costs are only adjusted by an estimated freight cost factor, while civil costs are adjusted by a climate factor, seismic factor, labor productivity factor and labor cost level factor. The price levels are expressed relative to Finland.

The relative inflationary index is then applied to account for cost developments in said country at the relative price level. Indexes used to account for cost developments vary between the cost area and country.

8.1.2 Current Limitations and Challenges

The main issues currently facing the cost estimation model is with validation and updating the model. As both the static and dynamic factors were set by professional cost estimators at AFRY Management Consulting in 2005, it is implausible to assume that relative price levels developments between countries would have been captured by the inflation cost indexes used in the model. Many of the indexes currently used to inflate costs in specific cost areas incorporate different indexes, some of which are not constructed for the intended purpose (e.g., using the consumer price indexes instead of construction cost indexes). The reasons for the differences in inflation index use was simply do to the fact that in 2005, industry-specific price indexes were not available for all countries. Thus, many of the countries have been set to primarily follow a macroeconomic price index such as the CPI or the GDP deflator.

8.2 Proposed Improvements to the Cost Estimation Model

8.2.1 Updating Static Price Levels

Some of the location cost factors are based on static values that have been determined by professional cost estimators. However, there is no methodology in place to update these factors. A robust control practice for inaccurate or outdated information should be developed in order to ensure the methodology for determining price levels between countries stays consistent and up to date. A general recommendation is to update the relative price levels of countries every 3-5 years. However, as the estimate accuracy makes room for small inaccuracies, relative price level data can be reasonably utilized around 10 years. However, as seen by increases in materials costs and logistics costs by the affects of the COVID-19 pandemic, black swan events may force price levels to be re-evaluated on an earlier basis to ensure sufficient validity.

The proposed methods on quantifying price level differences between main machinery, construction and installation costs were discussed in chapter 7. Thus, updating the static price levels in the cost estimation tool at AFRY Management Consulting is recommended to follow the methodology and suggestions listed in the chapter.

8.2.2 Utilizing Appropriate Indexes for Cost Areas

Currently, the cost estimation model uses tailored weights of different inflation indexes even in the same cost areas. While this was done by force as industry-specific indexes were not available for all countries, there is a reason why estimates have still retained accuracy since the baseline year. Ashuri and Shahandashti (2012) concluded that many of the macroeconomic indicators also used in the estimation model to substitute missing industry-specific indexes such as the CCI are significantly correlated with the CCI at a 1% significance level. Thus, it is plausible to assume that if an industry-specific index is not found, opting to use macro-economic indexes such as the GPD deflator is a sufficient substitute for the accuracy requirements for the estimations produced by the model.

However, as argued previously in this thesis, cost engineers should utilize appropriate cost indexes for each purpose, and not fall into the trap of using either too specific indexes or too broad indexes that fail to consider the major cost drivers for the area in question. In some cases, the underlying sub-indexes of an aggregate index have significantly different underlying cost structures, as discussed in the previously in this thesis. Thus, cost estimators must pay close attention when opting to use aggregate indexes in cost estimation models, and regularly seek to validate if the currently used index is the most applicable one.

Accounting for the increased amount of steel used in the construction of industrial buildings, the calculation model at AFRY Management Consulting uses additional tailored weights to publicly available composite indexes. That is, in addition to the CCI used to track inflationary effects to prices, the model incorporates the price of carbon steel and assigns weights based on the country in question. However, as this composite index is not regularly updated, changes in the relative use of construction materials in industrial buildings might not be sufficiently covered, as e.g. in Finland the relative share of steel used industrial building construction has increased from roughly 30% to 40% since 2010 (Vainio and Ala-Kotila, 2021).

In the European Union, statistics on developing construction prices in member states are provided quarterly through the CCI as described in subchapter 5.2.5 (Eurostat, 2022b). However, as member states are only required to source construction cost information in terms of new residential buildings, the index may not represent costs concerning the development of industrial buildings, as manufacturing facilities commonly utilize a larger share or steel in construction compared to dwellings (Vainio and Ala-Kotila, 2021). As steel prices have seen a surge in price partly due to the recent supply chain disruptions due to the pandemic, the industrial buildings index has risen at a higher rate compared to the aggregate as pictured in Figure 18.

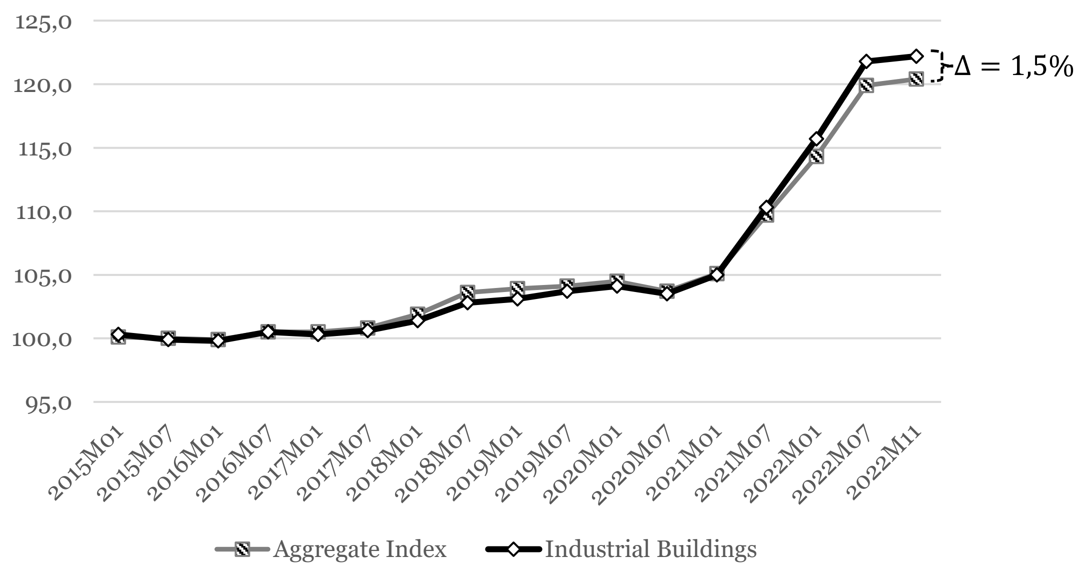

Figure 18. Finnish building cost index by type of building 2015=100, months 1 and 7. (Official Statistics of Finland, 2022)

As more countries e.g., in the EU publish indexes tracking construction costs for industrial buildings separately from aggregated construction cost indexes, the estimation model should make use of them instead of the aggregate. For countries with only aggregate values on construction costs available, re-weighing could be done by comparing neighboring countries with similar economic prosperity and domestic construction raw material production to equate cost developments.

However, re-weighing indexes does pose some issues. Changes made to weights assigned to individual indicators within inflation indexes should be made with caution, as the burden of updating weights (e.g., because of technological shifts or underlying cost structure changes) is shifted to the cost estimator. The risk of overexaggerating the effect some cost components increase as additional tailored weights are set onto an index already containing said cost component in its composition. For instance, if an additional weight of carbon steel prices is added to a composite index already tracking steel as part of it, index restructuring may overemphasise steel in the new composite (as was the case in the Finnish CCI) if weights are not updated on a methodological basis. The appropriate weights will depend on the specific area being studied and should be based on either a theoretical foundation or on statistical or econometric analysis of relevant relationships. These methods can also address issues such as non-linear relationships, interactions between variables, the risk of double-counting, and the influence of missing variables.

8.2.3 Indicative Indicator for Installation Labor Availability

As recognized in the conducted interviews with pulp and paper manufacturers, the largest individual cost area escalations within greenfield pulp and paper investment projects stemmed from poor labor availability. While there is a body of research linking inadequate labor availability to escalated project costs both qualitatively and quantitively (Karimi *et al.*, 2018), there is a lack of quantitative indicators predicting the availability to help cost estimators account for this factor. The lack of existing predictors for regional labor availability may be due to a general disinterestedness to account for this effect. E.g., the study by Hatamleh *et al.*, (2018) found that both contractors and consultants in Jordan ranked the relative importance of labor availability seemingly low compared to other factors.

There appears to be no publicly available indexes or escalation factors in literature that track or estimate cost increases for regional skilled labor availability. This comes as no surprise, as national statistics institutes rarely produce such specific indexes for any industry.

However, as the cost estimation model is designed to carry out estimates with minimal manhours required, it is unreasonable to expect the cost estimator to carry out a separate investigation on what the level of labor availability is at the time of conducting the estimate. A potential solution is to integrate a preliminary quantitative indicator to determine if there is potential risk for lack of labor availability.

Foreign Direct Investment (FDI) inflow is calculated as the total amount of foreign capital that is invested in a country. This can include investments in the form of capital, such as building factories or purchasing equipment, as well as investments in the form of ownership, such as buying a stake in a company. FDI inflow can also include investments made through mergers and acquisitions, joint ventures, and other business partnerships.

The effects of UPM's Fray Bentos project and Botnia's Montes Del Plata project in Uruguay can be seen in the country's level of foreign direct investment inflow in their respective years (2006, 2012) in Figure 19 and Figure 20. In addition to the Montes Del Plata pulp mill project in 2012, there was simultaneously an ongoing iron mine project, thus pushing FDI inflows as high as 12% of the total GDP (Bertelsmann Stiftung, 2014).

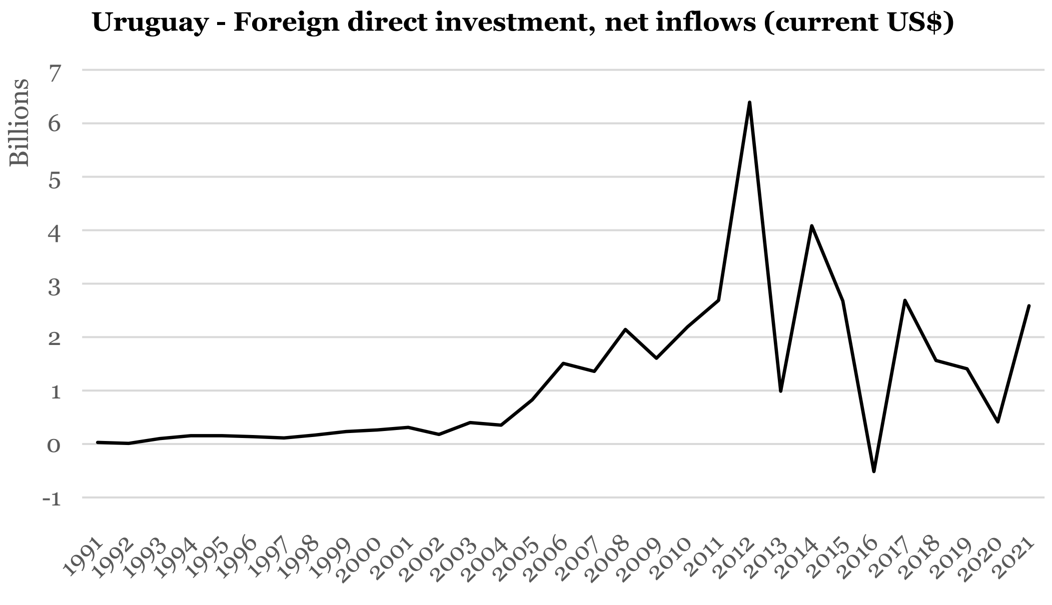

Figure 19. Net inward foreign direct investment for Uruguay, years 1991-2021. (World Bank, 2022)

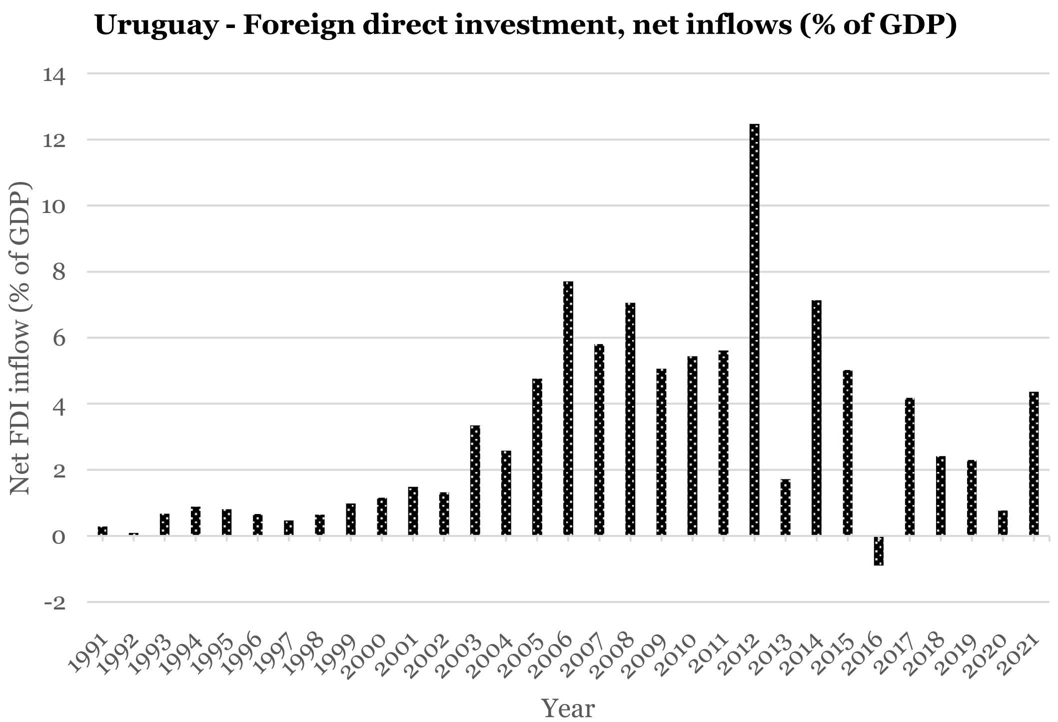

Figure 20. Net inward foreign direct investment as a percentage of annual GDP for Uruguay, years 1991-2021. (World Bank, 2022)

To validate the applicability of the proposed indicator, actual labor cost increases due to poor labor availability must be sampled and preferably compared to instances where labor unavailability was not a causal factor for escalated costs in the same project country. Then, it should be possible to set an indicative level for the risk of labor unavailability, e.g., when the FDI exceeds 8% of total GDP.

However, extrapolating this information through the FDI inflow is not without huge caveats to keep in mind. As the FDI inflow also measures e.g., M&A activity, exceeding the set baseline for FDI's may show false positives. However, for smaller economies, it should be a sufficiently easy task to find out if sudden spikes in FDI levels are due to M&A activity or large-scale industrial projects. Additionally, the suitability of using FDI as a labor availability indicator must also be separately assessed for larger economies, as the relative impact individual investments diminishes as the total GDP increases. Moreover, larger economies may be more resistant to shortages of skilled labor, and thus not exhibit drastic escalations in costs caused by labor availability. Lastly, as the FDI does not account for domestic projects, there is a potential risk of ignoring large ongoing infrastructure projects which may tie available labor to said project, thus decreasing the available labor pool for e.g., pulp and paper projects.

Nevertheless, if using FDI inflow could be used as an indicator for smaller economies with known issues regarding labor availability, a significant accuracy increase in estimating labor costs could be reached. Cost estimators may choose to only apply an additional cost escalation factor due to labor unavailability onto installation labor, as this was cited to be most affected compared to civil construction labor costs, which do not require as special skilled labor. Thus, predicting labor availability must in practice incorporate some level of professional experience to determine the appropriate amount of additional costs caused by the lack of labor availability. Cost escalation stemming from labor unavailability could be approximated as a simple cost escalation factor of total estimated labor costs for the project, or as a decrease in the productivity factor part of the location cost factor in the estimation model.

Additional consideration in the use of this indicator is choosing in which project phase to implement said indicator, as labor availability is highly contextual to the timing of the investment. Installation of main equipment rarely exceeds two years even in major greenfield investment projects. Thus, even if there are ongoing investments tying skilled installation labor in other projects, it is reasonable to assume the effects of ongoing projects cease to affect future labor availability in the following couple of years. As there is a considerable time lag (in excess of two years) between conceptual or pre-feasibility studies and the actual construction of the proposed investment project, this indicator is more appropriate to use in the later stages of the investment planning process, with the installation phase of the project commencing within two years of the estimate.

9 CONCLUSIONS AND RECOMMENDATIONS

This thesis aimed to give further insight on three areas regarding location-based capital cost adjustment, as presented in the introductory chapter. Cost elements which are affected by project location were identified and presented throughout this study. The main cost areas in which location-specific costs can be pragmatically considered in preliminary cost estimations were determined to be within machinery costs and construction costs. Interviews were conducted with professionals throughout the investment value chain to assess how the chosen project location is currently accounted for in strategic decision making and cost estimation. The interviews revealed that project location is rarely considered in cost estimates through a general location cost factor, and that location-specific costs are usually accounted for through direct cost quotes from e.g., machine suppliers to circumvent the issue of separately approximating relative cost levels between countries. Lastly, the aim was to determine some of the vital aspects to consider when developing location cost factors. Publicly available sources for setting price levels for countries in a global context together with relevant cost indexes for adjusting said price levels in distinct cost areas were presented.

Since the 21st century, there has been an increasing number of reported statistics tracking both country and industry-specific cost developments. Many of the recently available indexes were indicatively argued to be better suited for establishing relative price levels between countries. Proposed improvements to the investment cost estimation model used at AFRY Management Consulting provided in this study. Improvement suggestions were mainly surrounded by the issue of setting new baselines for comparative price levels and cost index usage in cost areas. The model's accuracy is expected to be improved by the development work, and thereby providing a more solid basis for pre-feasibility level investment cost estimation. The general validity of this thesis is good, as numerous sources of information were reviewed. However, the relative importance and regional variation of cost elements are mainly based on the prevailing ideas in the literature and through the conducted interviews. It is conceivable that some cost elements are still unable to be identified and accounted for in preliminary cost estimation models.

Procedures for updating the data were introduced. Public indexes are sufficient to determine the price escalation for the cost categories incorporated in the model, but public data are rarely completely representative for the categories' cost level determination for projects in the pulp and paper industry. It is recommended that AFRY Management Consulting increases its information gathering of realised investments costs from the process industries division, as this is valuable information that can be used as inputs for further customization of both cost and price level indexes.

Estimating labor productivity factors and more generally, labor cost levels in pulp paper projects were found to be the main source of contention. This study was not capable of qualitatively assessing how well e.g., ICP's aggregate price level indexes translate to construction costs associated with pulp and paper mill investments. It was still deemed as a good starting place. However it was recommended that cost estimation professionals must determine if these values hold up, especially in developing countries. This is one area which would greatly benefit from information on actual costs, as price levels could be derived from this data.

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