# Resolving Inter- and Extra-group Discord Between Forestry and Milling Industries Using Photo-optical Technology


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# DECLARATION

I, Rohan Bierman, declare that this consultancy report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

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Rohan Bierman

Signed at …Centurion……………………………………………

On the ……30th……………………….. day of ……March…………………… 20.22..

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# SUPPLEMENTARY INFORMATION

| | |
|---|---|
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| | Interview transcripts |
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# EXECUTIVE SUMMARY

TWK Agri timber mills purchase significant volumes of timber from the forestry division of the group and external plantations. A process is followed when timber arrives at a mill to determine the volume of timber to pay in tons, and this process utilises a conversion factor to convert cubic meters to tons. This conversion factor, 1.37 $m^3$/ton, has been in use for many years, although recently it has become apparent that timber suppliers are dissatisfied with this value as they believe it to be longer representative of the state of timber being supplied to the mills. Importantly, the conversion factor has a direct impact on the amount that suppliers are compensated. The implications of low trust relationships with disgruntled suppliers of a key raw material cannot be overstated: if suppliers withdraw from supply agreements, the timber mills will be unable to meet the demand of the mining industry and other markets.

This consulting report is concerned with investigating whether the conversion factor is still representative or should be adjusted. The means of conducting this investigation is using a photo-optical mobile device application, Timbeter, which can determine the volume of timber on a truck through photographing every stack and inputting the length of the logs. The application can identify each log and size it accordingly to calculate volume. The implication is that it has greater accuracy than the current manual method to determine volume.

Using volume data from the Timbeter application of trucks measured from February to October 2021, along with weighbridge data, the actual factors were statistically analysed in comparison with the current factor, as well as reviewing other variables of stack density for varying timber diameter classes, species, and season. It is shown that the current factor is no longer suitable and should be adjusted to 1.24 $m^3$/ton. This will have a profound impact on suppliers in terms of additional revenue; using volume measurements from Timbeter with the new factor the timber mills would pay a minimum additional R7.2 – R7.8m to all suppliers combined. However, with better recovery from lower input volumes calculated, the timber mills can calculate lower cost prices for products, thereby increasing gross profit.

It was also imperative to investigate the perceptions of key individuals employed at the timber mills in relation to technology and the implementation of Timbeter as a technological solution to calculate timber volume on trucks. This qualitative study was conducted through semi-structured interviews and identifying the main themes into which the response data could be grouped. Four main themes were identified, covering operational challenges, supplier treatment, training and implementation and acknowledging the issues that arise with new technology implementation. The main conclusions from the quantitative and qualitative components of the consulting project were presented.

Finally, recommendations were made in respect of the conclusions from the quantitative and qualitative components.

Keywords: photo-optical; conversion factor; density; stack; volume; weighbridge; recovery; E.Grandis; E.GxN; E.Dunnii; mining timber; specials; roundwood

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# 1. INTRODUCTION

This Applied Research Project will be completed in the form of a consultancy report. The target company is TWK Agri (Pty) Ltd, which is a diversified group of companies with a primary focus on forestry and timber product manufacturing and marketing and has been investing in expanding its footprint of timber sources, and vertically integrating to own the facilities of production of timber products. This consulting engagement seeks to solve a management problem regarding discord between the timber milling division and forestry division of the group and of external suppliers over the use of a standard factor to convert volume of timber delivered from the plantation and received by the timber mill to tons and the associated compensation received by plantations, and the extant risk for the group associated with this discord.

The consulting approach will be to statistically analyse available data collected using a photo-optical technology ("Timbeter") currently being trialled to accurately measure volume to confirm if the current conversion factor is valid, and recommend a new, precise factor if it is statistically shown to be invalid. Furthermore, it will be tested if it is appropriate to use a single factor value across seasons and timber species; recommendations will be made in respect of these variables. Finally, the applicability of full-scale roll-out of Timbeter will be assessed based on the operational context of the timber mills and the perceptions of the timber mill employees using the technology, with recommendations made to ensure success or alternatives.

## 1.1 Background

The South African forest industry is a R38 billion sector of the economy. Forestry and related products account for 4.9% of South Africa's manufacturing GDP and R29 billion in export product value, based on 2018 data (Forestry South Africa, 2019). Corporate ownership of all plantation area of 1.19m hectares in South Africa was 51.4%, while other commercial farmers held 14.8% (Godsmark & Oberholzer, 2019). TWK Agri owns more than 30,000 hectares of plantations, which it manages, harvests and markets. Strategically, the company is highly vertically integrated, and every part of a tree harvested has a market within its own stable of companies. In addition to the company's own plantations, there are independent plantation owners associated with the group that also provide timber to the group's businesses that manufacture timber products. This is because there is only a limited area of plantations that can be felled at any given time, and it is in increasing the available harvest that the group ensures timber availability for all its businesses. While far smaller organisations individually, these external plantation companies combined manage a total area of plantations greater than the group, so they are a significant stakeholder.

TWK Agri also owns and operates three timber mills in Mpumalanga province, which are the customers of the forestry division of the group and external plantation owners. These timber mills are referred to as mining timber mills as they primarily manufacture mine support products. A focus on vertical integration led to the acquisition of a company that supplies timber mine support products to all major gold and platinum mining companies; this company is again the customer of the mining timber mills of the group. Timber mine support products refers to timber columns or packs that are utilised in underground mining to support the roof as mining progresses.

Raw material ordered by the company from plantations arrives at its timber mills on trucks in the form of logs of various lengths and diameters. However, at this point, there is a major consideration of the compensation that is provided to the plantation company for the timber. The procedure for determining this compensation, as described below, utilises a conversion factor which is under dispute between the forestry and milling divisions of the group, and between the milling division and external plantation companies. Resolving this discord is at the core of this consultancy report.

## 1.2 Problem Statement

### *1.2.1 Conversion Factor*

A resolution of the dispute between milling and forestry divisions of the group and with external plantation companies regarding the conversion factor is required to foster sound working relationships based on trust and cooperation. This problem statement is borne out of the context given below.

To ensure that the timber mill does not pay for “wet” timber, i.e., timber with a very high moisture content, by paying in tons as the unit of measurement preferred by the plantation companies, a simple protocol is followed of volumetric measurement of the incoming timber in $m^3$ and dividing by a conversion factor of 1.37 $m^3$/ton, which results in a ‘measured’ tons to pay the plantation company. This is to negate the possibility that the timber mill would be paying an inflated price for timber due to moisture. The factor of 1.37 has been used in the mining timber milling industry for many years and is intended to represent the ideal state of moisture content of timber, between “wet” and too dry. Upon volumetric and mass measurement (by weighbridge) of the timber on the truck, if the actual factor of $m^3$/tons of the timber on the truck is below an acceptable range around the factor of 1.37, indicating that the timber has a high moisture content, measured tons is used for payment. Within the acceptable range, the mass over the weighbridge is paid as the timber is deemed to be at the correct moisture content. Above the acceptable range, it reverts to measured tons. This is a means to ensure the supplier is not penalised by supplying dry timber. Despite the compensation of measured tons, and not actual tons, for dry timber, this protocol to determine compensation for incoming timber from plantations favours the timber mills if the greater proportion of timber deliveries to the timber mills falls below the acceptable range.

While this mechanism to determine financial compensation for timber delivered has been accepted by all stakeholders, the specific component which has been under dispute for some time is the conversion factor used. The result is that there is a low level of trust and discord between the milling and forestry subsidiaries of the group, and indeed between the milling subsidiary and external plantation companies. From a group perspective, commercial disputes between subsidiaries represents a risk to effective operation and utilisation of group assets and execution of group strategy. Due to the importance of the external plantations in supplying timber to the mill to meet its demand, a supply relationship perceived by these stakeholders as unfavourable and characterised by low trust and discord signifies a further risk to the group’s business interest in the milling division as these external suppliers can find alternative markets for their timber. An equitable solution that ensures fairness for all stakeholders is needed.

#### *1.2.2 Volume Measurement*

Furthermore, the contention is that the current manual method of volumetric measurement of incoming timber is inaccurate. To facilitate rapid processing of incoming timber loads, physical length, breadth, and height measurements of timber stacks are taken; thereafter, the resulting volume is multiplied by a 'density' factor of 0.69 to obtain the solid mass volume and disregard the free space between individual logs. It is a rudimentary method that has been used for many years due to its simplicity, but it has not been questioned whether it is suitably accurate for the purpose of determining volume for transactional purposes. Sophisticated technology developed to accurately measure volume of logs on trucks is available, but it is prohibitively expensive. However, with advancement in sensor and photographic technology and accessibility comes possible viable and inexpensive options to deliver the same results as, or acceptably close to, the sophisticated options. One such photographic technology has been implemented at the mills on a trial basis since the beginning of 2021. Any new proposed digital system of volume measurement would have to be easy to use and allow processing of incoming timber deliveries as rapidly as the current method or it is unlikely to be adopted as a standard operating procedure, yet no work has been done to assess this in respect of the new technology.

## 1.3 Summary

The problem statement can be summarised as follows:

1. *Resolve to ameliorate the risk posed by low trust relationships causing discord between the timber milling and forestry subsidiaries of the group, and of the timber milling subsidiary and external plantation companies, by investigating the possibility of an adjustment to the commercial transaction mechanism to determine financial*

*compensation to forestry, in respect of the utilisation of an equitable conversion factor based on actual timber supply data.*

2. *Investigate the technology being trialled to measure volume of timber stacks on incoming trucks compared with the manual volume determination method, assess the likelihood of adoption of the technology within the company's processes and make recommendations in view of the approach to utilising the technology.*

# 2. APPLICATION OF PRIOR RESEARCH

## 2.1 Introduction

This literature review will be conducted in respect of the main sub-problems identified in the previous section, namely, (a) customer-supplier relationships and business risk associated with discord or a lack of trust between customer and supplier group subsidiaries and with external suppliers, and (b), the application of technology for the purpose of volume measurement of timber stacks on incoming deliveries of roundwood logs to the timber mill, and the management problem of applying a new technology in practice when less accurate manual measurement methods are easier to do and are trusted by individuals in management of operations of the timber mill.

## 2.2 Background

In the South African forestry industry, the sale of timber is completed in the unit of measurement of tons. This is simply because plantations use a weighbridge to measure the weight of the unladen truck as it enters to load logs, and again when it is loaded (the difference is the weight of the timber). However, since it commenced operations, the company has been using a conversion factor of 1.37 $m^3$/ton to calculate the tons of timber that must be paid to the supplier. However, to apply the conversion factor, the mill must first determine the volume of the logs on the truck. To do this, the mills utilise a method that has been applied since it has been in operation: measuring the width, length, and height, measured from four corners per stack and averaged, to calculate a gross volume in $m^3$, and then multiplying this volume by a conversion factor of 0.69 to disregard the voids between logs and find the solid volume of timber within this volume.

This method is established in the forestry industry to deal with transactional timber appraisals (Câmpu et al.., 2015). Fonseca (2005), as cited in Câmpu et al. (2015), suggest a general conversion factor of 0.78 for wood without bark. Câmpu et al. (2015) would go on to show an average conversion factor of 0.58 – 0.71 and 0.55 – 0.67 for 2m and 3m large diameter roundwood, and 0.52 – 0.6 and 0.48 – 0.57 for 2m and 3m small diameter roundwood respectively, using a xylometric method, i.e., volume determination by water displacement, widely regarded as the most accurate method. The mills' current factor 0.69 appears to be on the higher end of a possible range of conversion factor for long-length, large diameter roundwood.

By dividing the solid volume by 1.37 $m^3$/ton, the tons to pay is calculated. Also, the timber is again weighed by means of a weighbridge, which, when paired with the measured volume, enables calculation of an actual factor per truck load.

No part of the process to determine tons to pay has undergone any change since the company started operating in 1997, most notably in the method of determining volume of timber and in the 1.37 factor used.

## 2.3 Discussion – Sub-problem 1

### *2.3.1 Customer-supplier Trust, Asymmetry and Disputes*

From a supply chain management perspective, the relationship between customer and supplier has many different facets of interest in this study. According to Laaksonen et al. (2007), customer-supplier relationships have levels of trust and interdependence respectively that can each range from low to high, with each permutation of such a two-axis matrix describing a particular relationship ranging from market-based (low-low), opportunistic (low-high), recurrent contracting (high-low) and relational contracting (high-high). However, Ring and Van de Ven (1992) describe the same permutations but refer to “reliance on trust” and “risk of the deal”. Indeed, Mouzas et al. (2007) posits yet another manner of describing the duality of business relationships, namely through constructs of trust and reliance where trust is inter-personal, and reliance is inter-organisational. With these respective constructs, permutations of a fragile (low-low), expedient (low-high), personal (high-low) or stable (high-high) relationship result. An absence of trust is not a hindrance to a business relationship if inter-organisational reliance is present; these expedient relationships can exhibit high levels of co-operation and interdependence (Mouzas, 2007). However, in asymmetric relationships, Munksgaard et al. (2015) argue that trust is indeed an essential component of the relationship where joint effort in working toward collective interests of economic objectives and relational performance is concerned. Pure dependence of one partner on another in an asymmetric relationship can be seen as negative when coupled with high switching costs and low trust levels. Dependence results from restriction on choice of partner, and in particular long-term dependence in asymmetric relationships can be problematic as they create inertia, dormant conflict, and poor levels of trust in the partner (Johnsen & Lacoste, 2016). In contrast, Caniëls et al. (2018) found that in asymmetric customer-supplier relationships where there is a reasonable level of interdependence, these dependence asymmetries have the positive effect of creating high levels of satisfaction in the supplier due to the perceived benefits of the relationship with the larger partner.

Fairness is a key aspect of customer-supplier relationships, and in this respect the research suggests that companies should attempt to ensure fairness in their relationships with suppliers while negotiating competitive market prices, as fairness in compensation was necessary for sustainability of suppliers and there is a real risk that they will end the relationship if the price is set too low (Schleper et al., 2015; Jokela & Söderman, 2017). Regarding supplier-customer disputes, Lumineau & Henderson (2012) found that where the parties had a cooperative relationship, increasing control governance through contracts led to an increase in competitive negotiation strategy when disputes arose; conversely, competitive relationships could benefit from increasing contractual control of parties’ behaviour in the relationship via a concomitant increase in cooperative negotiation strategy. Coopetitive relationships, which exhibit traits of competition and cooperation simultaneously and describe most cases, can naturally have tension (Tidström, 2014). Through case study research, Tidström (2014) found that, while collaboration (win-win) is the ideal outcome to manage tension, this is presupposed on the existence of trust and commitment in the relationship; in practise most instances of tension are managed by competition (win-lose) or avoidance.

### *2.3.2 Intra-group Disputes or Conflict*

Relevant to this study is the issue of intra-group, or inter-departmental organisational disputes or conflict. The research literature describes three modes of conflict: relationship, task, and process. Relationship conflict exists where there are interpersonal issues in the relationship between members of a group. Task conflict relates to disagreement in the way certain organisational tasks are performed, i.e., the content and goals of a task. Process conflict is described as disagreement in the "how, namely distribution of work responsibilities or the means of approaching a task. (Chaudhry & Asif, 2015; Jehn, 1997; Jehn & Bendersky, 2003). Bercovitch (1983) presents a different typology, namely intrapersonal, interpersonal, and interdepartmental; organisational departments may have mutually exclusive interests and interaction based on functional interdependence, and in this situation the conditions exist for conflict. However, task interdependence and task conflict between organisational units can increase overall performance as it increases constructive debate and discussion over ideas and alternate viewpoints, which increases collaboration and communication (Chaudhry & Asif, 2015; Jehn, 1997; Jehn & Bendersky, 2003). However, De Drue and Weingart (2003) contend that increased productivity resulting from task conflict is moderated by task uncertainty, specifically task conflict involving tasks of high uncertainty is needed for increased groups' effectiveness. In their meta-analysis, de Wit et al. (2012) purport that a positive relationship between task conflict and group performance is associated with a higher management level in an organisational hierarchy, while a negative relationship exists at lower management levels, as members of top management are better able to avoid task conflict turning into relationship conflict. Studies also showed task conflict and performance relationships were more positive when performance was framed in terms of quality of decision-making or financial performance (de Wit et al., 2012).

Sherif et al. (as cited in Bercovitch, 1983) suggest two approaches to resolving interdepartmental or organisational structure related conflict. One is to identify a “common enemy”, which may be a competing firm, as it supersedes interdepartmental conflict and transforms it into the greater focus and effort of interorganisational conflict. Second is establishing a “superordinate” goal, one which all departments aspire to but can only be realised by combining efforts and resource (Bercovitch, 1983). Thakore (2013) considers superordinate goals as one among several resolution tactics, namely properly defining and arranging interdependencies to either increase or eliminate them, increasing common resources, creating collaboration through mutual problem solving, imposing authority, or increasing interactions to promote positional understanding between parties. While the literature states that collaboration in problem solving as task conflict resolution creates more effective groups, De Drue and Weingart (2003) suggest this is true for tasks of high uncertainty, while low uncertainty tasks are generally reliant on “a priori principles and working assumptions” (p. 160). Collaboration in problem solving on low uncertainty tasks can be effective when the parties have made incorrect assumptions or heuristics, but often these are best handled through a “rights-based” approach by determining what “standards, assumptions or approach to the problem” will be used to reach a distributive agreement (De Drue & Weingart, 2003, p.160).

The literature on conflict in distribution channels is based on organisational behaviour literature and applies to inter- and intra-organisational settings; in particular, these settings should be seen as complementary rather than divergent, and where conflict in one area is likely to spill over into the other (Webb, 2002).

The question raised by a review of the literature for sub-problem 1 is as follows: will a review of actual timber supply data representing the real state of timber being supplied to the timber mills result in a possible adjustment of the conversion factor, whether net positive or negative for suppliers, that can foster supplier relationships based on high levels of trust, fairness, and interdependence?

## 2.4 Discussion – Sub-problem 2

### *2.4.1 Timber Volume Measurement*

Volume measurement of timber is a critical component of controlling the procurement process, as well as in managing production of raw material, book-keeping, and inventory management (Kärhä et al., 2019). Efforts have been made to apply technology to the problem of roundwood volume measurement, particularly since this is a critical part of the value chain of the forestry and timber milling industry (Cremer et al., 2020; Pásztory et al., 2018). Measurement methods must offer a high degree of efficiency and accuracy, while also being verifiable and understandable. One such method is using photo-optical measurement technology, which has gained in prominence in recent times, either as a camera system attached to a vehicle or a digital camera on a mobile device with an application to evaluate the images (Pásztory et al., 2018).

It is shown that a mobile device application using photo-optical methods can be very effective at measuring large volumes of roundwood and are strongly correlated to well-established manual methods of measurement (Cremer et al., 2020). Others have determined that such photo-optical methods give greater accuracy and faster measurement times than manual methods, as well as having the advantage of having stock data in digital form; however, disadvantages are higher cost and needing an educated operator (Pásztory & Polgár, 2016). Acuna and Sosa (2019) investigated photogrammetry, the use of photography for mapping of physical objects or environments, for truck volume measurement. By utilising a drone to take aerial photos of a truck and image processing software to create a 3D model of the truck, which could then be further analysed, solid roundwood volume measurement was found to have similar accuracy to laser scanning systems (Acuna & Sosa, 2019).

Kärhä et al. (2019) investigated the availability of commercial mobile applications using photo-optical, also referred to as machine-vision, measuring and found that there are seven on the European market, namely:

1. AFoRS,
2. Fovea,

3. HD Silva,
4. Logsize,
5. sScale,
6. Timbeter,
7. Trestima Stack.

Using one of these applications to measure timber stacks, the authors similarly found that machine-vision based measurement is more accurate and faster than traditional timber measurement techniques and could recommend the use of these applications for timber inventorying (Kärhä et al., 2019).

### *2.4.2 Technology Implementation Management*

A consideration with introducing any type of technology into a production environment is the implementation and execution thereof. Change management "is the process of continually renewing an organization's direction, structure, and capabilities to serve the ever-changing needs of external and internal customers" (Moran & Brightman, 2001). Technology management is commonly defined as ''a process, which includes planning, directing, control and coordination of the development and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization (Centindamar et al., 2009). Clearly, there are commonalities in these definitions, which suggests that theories of change and technology management have areas of overlap that are complimentary. As an example, Kearns et al. (2005) propose a model of technology management that includes management of change as one of six components to successful implementation. It is suggested that technology management theory is most applicable to the problem statement of implementing a new type of timber measurement using a mobile device application where there may exist a level of scepticism over its accuracy and usefulness compared to traditional manual, paper-based measurement techniques.

In terms of organisational factors that are shown to lead to successful implementation of technology, a strategic emphasis on operational flexibility is important (Stock & McDermott, 2001). This places the emphasis on the organisation, whereas Becker

(2010) places the emphasis on the people factor. Particularly, the need to provide adequate support and training to individuals throughout the implementation process and not purely be seen as recipients. Interestingly, there is also an element of providing the skills and understanding to “unlearn” old ways to enable technological change to be embraced and so ensure successful implementation. Regarding individuals’ perceptions, Bellamy (2007) espouses the need by management to complete proper assessment and planning processes of the technology *prior* to implementation, which will to a large extent manage these perceptions for better outcomes, but an organisational “climate” of innovativeness is most significant in influencing perceptions of the effectiveness of new technology implementation.

There is a process to unlearning organisational routines, as described by Fiol and O’Connor (2017), which typically takes the form of an initial destabilising event, followed by continual experimentation of new behaviours and discarding the old until a new routine is embedded. Simply destabilising without continual reinforcement will not be sufficient, implying that leadership intervention is required to remain focussed. It is suggested that, while each unlearning process is unique, such intervention should focus on the costs of not discarding an old routine, a positive view of possibilities and engagement. Maintaining a new routine long-term requires recognition, also a leadership imperative (Fiol & O’Connor, 2017).

### *2.4.3 Timber Roundwood Metrics*

Despite the cost of logs being the greatest operating expense for a timber manufacturing company, understanding roundwood metrics remains a challenge due to “counterintuitive trends, complicated and inconsistent measurement logic, tremendous variability between regions, species, products, sizes, age classes, and the misnomers that exist regarding the units of measure” (Fonseca, 2005, p. 1). Furthermore, regarding volume conversions to other reporting units, Winn et al. (2020) state that certain methods of conversion consider the multiple dependent variables that exist, while the majority are performed using only a single factor. Kofman (2010) suggests that one such dependent variable is moisture content, and that timber that has been left to dry for a few weeks in the hotter months can lost 10-20% of its moisture; other variables suggested are tree species, site type and silviculture, which all determine timber density.

In respect of sub-problem 2, there appears to be minimal literature available regarding best practice in using conversions of volume to other reporting units. However, it is evident that the question that arises from the above is, can photo-optical technology assist in defining a new conversion factor for plantation/mill raw material transaction in the context of the company and group, and will this conversion factor change with the introduction of choice dependent variables?

The question raised by a review of the literature for sub-problem 2 is as follows: will the introduction of a new photo-optical technology at the company's mills for the purpose of truck stack volume measurements increase accuracy and speed over the manual method, and can the implementation of such technology be successfully managed using technology and operations management theories?

# 3. CONSULTING RESEARCH

## 3.1 Analysis of Consulting Engagements

Following is a review of literature on previous consulting engagements with their basis in South Africa's ecological resources, which relate to the improvement of the management thereof or the impact of it in the lives of the people that rely on these resources. Görgens and Wilgen (2004) sought to collate and review the research approaches that have been conducted on the implications of invasive alien plant species on water resources. The authors took a very holistic approach in proposing a hierarchical FAIM knowledge-generation framework for evaluating previous work done in this field, starting with fundamental research, then applied/predictive research, research of integrative tools and finally management support research. For each aspect, the authors described the studies that had been conducted, the approaches followed, how it contributed to current understanding of water use by invasive species and then addressing gaps in the current knowledge. This is a robust framework that organises knowledge in a systematic manner according to the appropriate scale or breadth of the research. While the research conducted by the authors confirmed the negative impact of invasive species on water resources, the framework highlighted areas where the existing knowledge can improve controls to remove invasive species. Importantly, the Working for Water programme has proposed using the FAIM framework to prioritise areas for funding research into invasive species and water resources. The conceptualisation of the framework is useful for consulting engagements as it synthesises knowledge from lower to higher levels of application.

Ham (2000) provides an insightful perspective on woodlots, or small-scale forestry generally for the supply of fuelwood and poles for local rural communities at low prices. The author investigated the significance of two woodlots in the Eastern Cape to local communities, entrepreneurs, and indigenous forest conservation, and considered the implications of transfer of ownership of the woodlots from the state to the communities. The consultants conducted a mixed method study, conducting interviews with individuals from the local communities of both woodlots and collecting data of sales of poles and fuelwood from the woodlots. The qualitative study, as the core of the research, would have presented the best outcome for evaluating the perceptions of the woodlots by the individuals that access it. The authors described the success factors and pitfalls of the woodlots in supplying poles and fuelwood to local communities and businesses. However, the possible interventions presented will have limited success given the finding that infrastructure and geographic placement of the woodlot play major roles in the success of a woodlot. An important outcome from the research was that people living in areas where there were no woodlots complained of indigenous forest devastation.

Damm and Triebel (2008) looked in detail at the use of fuelwood by rural communities and its availability as an energy source. The authors combined different sources of available quantitative data in a desktop study to determine total fuelwood consumption and the value to rural households. The authors also presented the sociological factors that play a role in the collection and use of fuelwood. The approach of analysing existing data, in particular census data in this instance, to extract information of fuelwood consumption is novel and efficient as it does not require that the authors incur great expense and time collecting information. The authors also identified areas for further research that is more focussed on fuelwood, as it was identified empirical data was lacking. Most interesting of these are in supply and demand oriented research; supply relates to research in low smoke wood species for healthier communities, while demand relates to technologies to increase efficiency of fuelwood or substitution to decrease demand. It is appreciated that the authors were specific in which areas could be most impactful for the benefit of rural communities. Specific interventions are lacking due to the desktop nature of the study to synthesise information for a regional programme and its direction of future research and interventions.

## 3.2 Consulting Research Methods

By and large, consulting research takes the form of qualitative or quantitative studies, or a mixture of both. If quantitative, it typically involves collating, reviewing, and analysing existing data from pre-defined sources, whether from empirical studies or human subjects such as in a Likert scale questionnaire. If the study is purely qualitative, commonly participants with an interest in the research topic are interviewed and their responses grouped according to themes that elucidate perceptions toward a particular issue. While these “traditional” methods have been tried and tested for decades and have delivered successful outcomes for consulting engagements and interventions, there are certainly opportunities for innovation.

In many instances, gathering reliable data is challenging, as it is either existing data that may not be ideally suited to the direction of the research, or data must be generated which is usually time-consuming and costly. The use of technology to accumulate data is one such area of innovation. This report may be an example of this approach, as an application was utilised that enabled real-time data collection of operational variables while such operations were ongoing. As a user-friendly and accurate technological solution, the task of data collection could be outsourced without compromising the quality of the data.

# 4. DATA COLLECTION AND ANALYSIS

This section will detail the project plan and approach to executing on the sub-problems listed in Section 1. It should be noted that the project will entail the application and evaluation of a mobile application – Timbeter – that uses a mobile device's camera to detect timber poles in a stack and return valuable dimensional and volumetric information, as well as for an entire truck loaded with multiple timber stacks. This application was implemented at the company's three sawmills on a trial basis in January 2021.

The overarching project plan will follow a mixed paradigm, employing both qualitative and quantitative methods. It is suggested that each method studies a different phenomenon, but which can be complementary rather than seeking to compensate for a weakness in either method. Importantly, a mixed method approach can be carried out simultaneously (Sale et al., 2002). This description fits with the approach that will be followed, as the study of the technology implementation aspect will be best conducted qualitatively since it will be designed to collate and assess the opinions of the individuals interacting with it. In contrast, a study of the review of the actual conversion factor of cubic meter to tons of incoming timber deliveries to the company's timber mills relative to the single accepted factor currently being employed will be completed quantitatively, as it will rely on collection and analysis of a dataset of measurements.

The assumption in utilising a mixed method approach is that the findings will in combination better describe the phenomenon studied than either approach alone, and that validity and reliability is acceptable in both. If these assumptions are met, it can be said that that mixed approach was appropriate.

## 4.1 Sub-problem 1

For sub-problem 1, Timbeter will be used to measure the volume of incoming timber deliveries to create a dataset of measurement results. This implies a statistical modelling approach on the available data to elucidate the problem statement. The advantage of this is that it will enable rigorous evaluation of the actual volume to mass conversion factor using data obtained in the operational environment. The disadvantage is that the data is obtained by other individuals using the application in practice through necessity, inferring a delegation of responsibility to ensure accuracy in taking photographs and analyses.

Regarding the quantitative study, using longitudinal data collected from actual measurements of incoming timber truck deliveries using the Timbeter application, statistical modelling will enable determination of whether the standard conversion factor of 1.37 $m^3$/ton is generally applicable and subject to seasonal and species variation.

For the quantitative study, the following data will be collected using the Timbeter application and from the mill's timber receivable notes per incoming truck delivery to the three mills where Timbeter has been implemented on a trial basis:

1. A density and volumetric measurement per stack
2. Timber species
3. Actual weight of timber according to weighbridge

The sample frame is all measurements conducted using the Timbeter application, while the sampling method will be such as to extract only the measurements based on clear, correctly taken photographs. It is envisaged that there will be between 100 and 150 data points for the quantitative study. The photographs below show an example of the output from the first measurement listed above. The important pieces of information provided per stack measurement is the volume of the stack and the density of the stack, as shown highlighted in Figure 2 below. Density can be interpreted as the proportion of solid mass of timber to voids within the bounds of the entire stack demarcated by the yellow line.


*Figure 1*. Timber stack density and volume measurement using Timbeter

Currently the mills employ a manual measurement method whereby the height of each stack as seen in Figure 2 is physically measured at the four corners and averaged, which is then multiplied by the length of the logs and the width of the stacks to find a gross volume. This value is then multiplied by a factor of 0.69 to equate to the solid volume of timber, with this value divided by 1.37 to equate to the *measured* tons. Accepting that volume measurement by photo-optical methods such as the Timbeter application has greater accuracy than a physical measurement and a single density factor, not least of which because it identifies each individual log and estimates its diameter according to a reference placed in the photograph (in this case a 1m pole), the total volume of timber on a truck from Timbeter is then paired with the actual weighbridge measurement to find the *actual* $m^3$/ton factor for that truck. The factor based on the manual volume measurement and weighbridge data will also be captured and referred to as the *calculated* $m^3$/ton factor. Payment of the supplier is currently determined as follows: if the *calculated* factor falls in a range 1.30 – 1.44 (1.37±5%), the weighbridge tons is paid; if the *calculated* factor is below 1.30 or above 1.44, the *measured* tons is paid. This is intended to ensure that, below 1.30, the company does not pay for moisture in the timber, and above 1.44 the supplier is not penalised for delivering dry timber. Within the range of factors 1.30 to 1.44, the moisture content is deemed to be at the correct level and usually occurs after two weeks of drying in the plantation after felling.

It should be noted that each stack photograph will be reviewed and modified where necessary so that log detections by the application are a close fit to the actual log circumference, as certain artifacts such as shadow, foliage and bark remnants can cause deviations. Photographs with incorrect light exposure which do not enable accurate detections of logs will be discarded from the analysis.

Data has been collected with the Timbeter app since the start of the trial in February 2021 and continued until October 2021. This data is longitudinal, enabling possible variations of the factor to be observed with the seasons – a wet summer and a cold, dry winter – and accounts for variations in timber species. This data will enable comparison to the standard industry factor of 1.37 $m^3$/ton. Descriptive and inferential statistics will be the methods of analysis applied to the quantitative dataset. Data variables that will be collected includes mass, actual volume, actual factor (calculated from mass and actual volume), calculated factor, season (summer/winter), timber species and timber mill.

To test the overall sample data against the industry standard factor to determine its validity, a single sample t-test will be applied. Per Gerald (2018), “a researcher can use one-sample t-test to compare the mean of a sample with a hypothesized population mean to see if the sample is significantly different” (p. 52). Similarly, to evaluate the suitability of using a single density value for all timber diameters, a single sample t-test will be conducted on the dataset of stack density measurements from the Timbeter application, comparing it to the standard density value of 0.69.

To test the difference in the means for wet and dry seasons, a two-sample t-test will be conducted. Finally, a one-way Analysis of Variance (ANOVA) parametric test will be conducted to compare the means of the actual factor between the independent categorical variable of species, based on the assumption that the dependent variable will be normal. With this, any effect of the independent variable on the dependent variable will also be seen if one exists (Mishra et al.., 2019). All the above analyses will be conducted using Microsoft Excel.

The interpretation of the results is intended to settle the dispute over the conversion factor, as it will be based on statistical analysis of a comprehensive dataset of results using an accurate method of volume measurement. It will also establish if it is appropriate to utilise a single factor for all variations of species and seasonal changes. The qualitative study will assess the human challenges potentially facing full implementation of the application and where focus will need to be applied in training or education to overcome these challenges.

## 4.2 Sub-problem 2

In the case of sub-problem 2, the study will be conducted qualitatively through administering a semi-structured interview among the specific group of users that interact with the application or are involved in the management thereof. The disadvantage is that the number of potential respondents is limited to the users of the application in the company, as Timbeter, or other similar applications, have not yet been adopted in the South African forestry and timber industries.

The population for data collection is the group of company employees who interact with or manage the use of the Timbeter application. The sampling frame and sample in this instance are the same, as the number of potential respondents to the survey are limited to the people already known to interact with the application within the context of the company. In the same vein, defining a sampling method is redundant as the sample was predetermined from the implementation of the application among a select few employees. This sample is appropriate as it contains the only individuals in the company who have experience of using, or managing the use of, the application in the operating environment and who would be able to offer inputs. The aim is to garner at least ten respondents within the company, and they will participate since they are the employees tasked with the implementation of the application in the company or data collection. Table 1 lists the potential respondents to the interview.

Table 1

*Potential Respondents to Qualitative Study*

| Number | Respondent |
|---|---|
| 1 | Mill 1 Application User |
| 2 | Mill 1 Manager |
| 3 | Mill 2 Application User |
| 4 | Mill 2 Manager |
| 5 | Mill 3 Application User |
| 6 | Mill 3 Manager |
| 7 | Production Manager |
| 8 | Mill 4 Manager/Application User* |
| 9 | Fibre Supply Manager |
| 10 | Manager: Supply Chain |

The qualitative study will follow a thematic analysis approach. This will enable objective analysis of the results to reveal the perceptions of the people on the ground and in management in relation to the Timbeter application. The result of the thematic analysis is also likely to reveal the probability that implementation of this application from experimental to full-scale rollout within the operating environment will be successful given the challenges highlighted in the background to the research. The semi-structured interviews will be conducted using an interview guide. This guide will contain a series of questions intended to address certain issues around the implementation of technology and the Timbeter application. The responses to the questions in the interview guide and any further questions that may be included in the interview will be studied to extract the main themes describing the data. All interviews will be recorded, and transcripts created for each interviewee to enable analysis on the qualitative data.

The Matrix Method will be employed to collate all responses in the form of a raw matrix, where the axes of the matrix are interviewees and the interview questions. All relevant data taken directly from the transcripts per interviewee’s response to the questions in the interview guide are placed into the cells of the raw matrix. Thereafter, coding is done on the raw matrix: an analysis of the raw data identifies the sections of the data that are illuminating of the main objectives or research question intended to be answered, and attaches a label to this (Groenland, 2016). Thereafter, a thematic analysis is conducted: the codes are distilled into the main themes which capture the essence of the coded data; the themes are then described in detail to comprehensively elucidate the perceptions and opinions of the individuals (Braun & Clarke, 2012).

## 4.3 Validity and Reliability

The external validity of this study is assessed on the following criteria proposed by Lucas (2003):

Table 2

*Assessment of External Validity of Proposed Study Per Lucas (2003)*

| Criteria | Assessment of proposed study |
| --- | --- |
| Construct validity | The measures envisaged will reflect the concepts intended to be measured, both from a qualitative and quantitative point of view. Similarly, the construct of both analytical approaches and statistical tests as proposed are expected to result in the outcomes that will provide clarity on the business problem as discussed. |
| Relevance | Relevance is within the South African timber milling industry due to the specific climatic conditions and timber species grown, specifically where transactions of receipt of raw timber logs by mills from forestry are governed by a conversion factor to determine sale value. Therefore, the relevance may extend beyond mining timber milling from a transactional perspective. As the literature shows, the conversion of measurement units from forestry to mill is a global timber industry matter. However, the significant relevance of the study to the group and its subsidiary and the potential benefit to inter-group transactions is the overriding consideration. |
| Reproducibility | The study, if repeated within the same context and with the same construct measures, would be expected to produce the same findings. However, within the timeframe of 10 – 20 years it is possible that climate change, species change, and other factors may render the findings of this study invalid. However, that is sufficiently distant in time that it should not influence the methodology of the current study. |
| Consistency | Consistency is maintained in this study as the observations will be consistent with each other and with the theory regarding photo-optical measurement techniques and technology management. Review and correction of detections in photographic analyses by the application are a measure to increase consistency. |
| Confirmatory status | There have been studies done to assess the applicability of photo-optical techniques to timber volume measurement in diverse settings. Also, unit conversion factors have been investigated in many countries with a large timber industry consisting of many different timber species. Therefore, this study is sufficiently confirmatory of other studies that have been done. |

Of course, internal validity is a requirement for external validity. The main criterion for internal validity is that the observations are representative of the reality of the population of truck measurements and not due to methodological errors (Patino & Ferreira, 2018). This will be ensured by detailed review of the photographs analysed by the application and modifying the detections (seen in Fig. 1) to be as close fitting to the actual log circumferences as on the photograph. This negates the impact that measurement error could potentially have on the study outcomes.

While it is expected that there will be a large sample of data for the quantitative study, all of which will be divided between the two main climatic seasons, it remains to be seen that sufficient data is collected for various species of timber to be able to effectively run the various parametric tests including the variation of species. However, only those photographs that have been taken within correct parameters for accuracy will be brought into the dataset; this will only become evident once the data is being collated, but this will require that every stack photograph is assessed.

Thatcher (2010) provides a definition of reliability which refers to the consistency of a measuring procedure to produce the same results in repeated measurement, and in this respect the proposed quantitative study will be reliable as the measurement instrument is a digital interface that analyses each photograph in the same manner. At the same time, review of the analyses will focus on refining the log detections for accuracy where deviations are observed to ensure the population of measurements are reliable for use.

In terms of the qualitative study, while validity is expected to be high, concerns around reliability are relevant due to the semi-structured nature of the instrument. Concerns around reliability are reduced with increased responses to particular issues; a review of the qualitative data would establish whether these issues are suitably addressed (Ahlin, 2019).

There are minimal concerns over ethical issues related to the qualitative study as the respondents are employees of the company and have been tasked with interacting with the application on some level as part of their job tasks, and the questionnaire is an extension of that. The questionnaire may assess the respondents' level of comfort with using technology.

# 5. RESULTS

## 5.1 Sub-problem 1 - Quantitative

### *5.1.1 Preamble*

The results of the quantitative study of the measurements conducted using the Timbeter application at the three mills will be presented. The data was collected in the period from February to October 2021. Only verifiable results were included in the quantitative study, which implies only those complete measurements where all photographs per stack on the truck were clear, taken perpendicularly and the reference stick was present. Also, the accompanying timber received note completed by the mill administrator must be available. This implies that one truck with a multitude of stacks will have volume measurements from Timbeter and the current manual method, as well as current paid tons using the mechanism described in Section 3.1. A complete truck measurement, which constitutes one data point, is shown in Table 3 below.

Table 3

*Complete Set of Data Per Truck Measurement*

| Truck Measurement | | | Stack 1 | | Stack 2 | | Stack 3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Type | Species | Current measured volume ($m^3$) | Density | Volume ($m^3$) | Density | Volume ($m^3$) | Density | Volume ($m^3$) | Total Timbeter Volume ($m^3$) | W/bridge (tons) | Actual Factor |
| Mining timber | E.Grandis | 26.50 | 0.6440 | 8.17 | 0.5942 | 7.38 | 0.6247 | 7.58 | 23.13 | 17.76 | 1.30 |

The resulting dataset of complete truck measurements was constituted as follows:

Table 4

*Verifiable Data Per Timber Mill, Species and Season*

| Timber Mill | Species | | | Season | |
|---|---|---|---|---|---|
| | Eucalyptus Grandis | Eucalyptus Grandis x Nitens Clone | Eucalyptus Dunnii | Dry | Wet |
| Rutland | 76 | | | 64 | 12 |
| Glenthorpe | 19 | | | 10 | 9 |
| Piet Retief | 24 | 6 | 2 | 17 | 15 |
| Total | 119 | 6 | 2 | 91 | 36 |

It is evident from Table 3 that the vast majority of data consists of measurements on trucks delivering Eucalyptus Grandis (E.Grandis) to the timber mills. From the outset, it is envisaged that the analysis of actual factors using Timbeter volume from differing timber species will not be statistically meaningful given the small number of samples for the other two species; however, the analysis will be conducted. Although skewed toward the dry season, there is a usable amount of data points from both seasons to enable analysis to be conducted. For reference, the dry season was correlated to the 6-month period from beginning of April to end of September, where rainfall in Mpumalanga is the lowest, as shown in Figure 3 below, with the wet season spanning the periods before and after this.

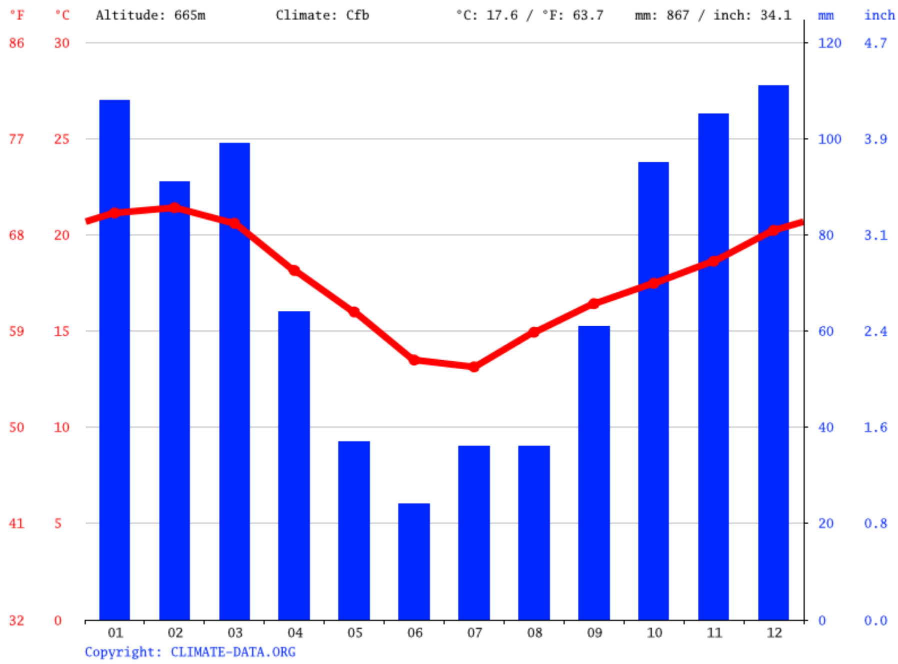


*Figure 2.* Rainfall Data for Mpumalanga (Climate-data.org, n.d.)

Section 3.1 and Table 3 details how the actual factor dataset is created from the various data points collected from Timbeter and the accompanying timber received note. Given that E.Grandis constitutes the majority of the data, and also makes up the highest proportion of species entering the timber mills, the main analysis will be conducted on this species. When calculating the actual factor from the Timbeter volume and weighbridge mass, if this value was lower than 1 or higher than 1.75, the data point was removed. The reason is that a factor of less than 1 indicates the timber's moisture content is exceedingly high and should not have been delivered to the mill in that state. A factor of higher than 1.75 is also considered unusual. Therefore, 1.0 – 1.75 was considered acceptable to include the range of valid results.

### *5.1.2 Analysis*

#### *5.1.2.1 Actual Factors Relative to Standard*

As stated in Section 3.1, the current conversion factor used by the timber mills to convert volume of timber on the truck in $m^3$ to tons, as the suppliers are paid in Rands per ton delivered, is 1.37 $m^3$/ton. The first, and arguably most important statistical test, is to determine if this factor is still valid and representative of the actual state of timber coming into the timber mills during the period under review. For this purpose, a single sample t-test was conducted to determine if the group of measurement results is significantly different from a known, hypothesised value. The known value is the current conversion factor, 1.37. To test for normality, a histogram of the set of 119 measurements of actual factors for all E.Grandis was created which is shown below, followed by the descriptive statistics of the dataset of measurements in Table 5.

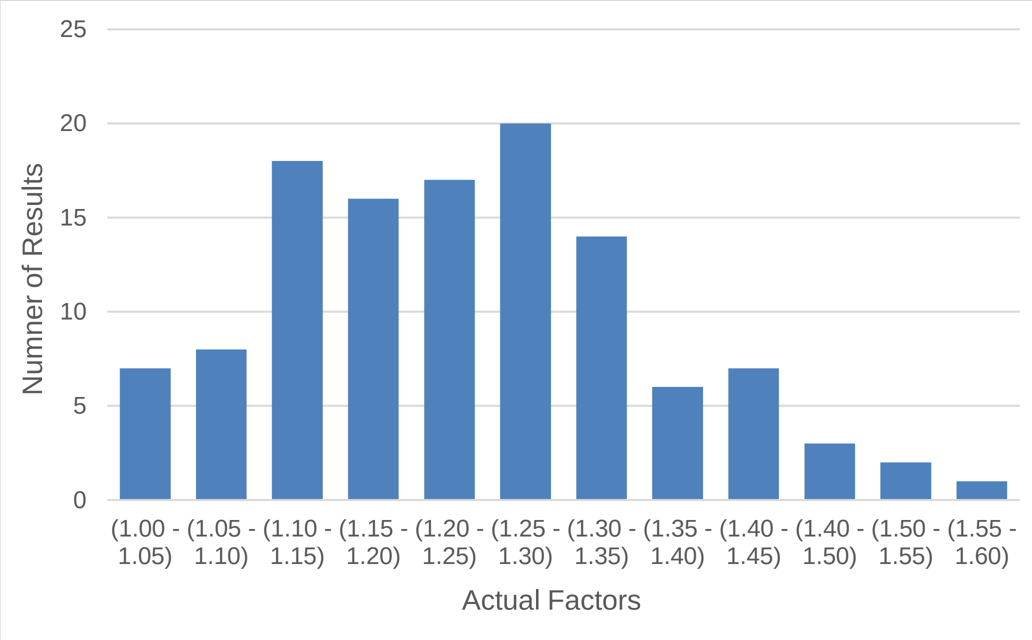


*Figure 3.* Histogram of actual factors

Table 5

*Descriptive Statistics for Dataset of Actual Measurements*

| *Descriptive Statistics* | |
|---|---|
| Mean | 1.2377 |
| Standard Error | 0.0110 |
| Median | 1.2392 |
| Standard Deviation | 0.1199 |
| Sample Variance | 0.0144 |
| Kurtosis | -0.1943 |
| Skewness | 0.3891 |

It is apparent that the dataset of actual factors forms an approximately normal, if positively skewed, distribution. The median is greater than the mean despite being positively skewed as the distribution is not unimodal. However, combined with a large sample size, the normality assumption holds. The null and alternative hypotheses are as follows:

*Null Hypothesis $H_0$: Mean of Sample of Actual Factors = Current Standardised Mean Value, 1.37.*

*Alternative Hypothesis $H_1$: Mean of Sample of Actual Factors ≠ Current Standardised Mean Value, 1.37.*

As can be seen in the structure of the hypotheses, the t-test is two-tailed: at this point it is unknown if the sample mean is below or above 1.37. Based on the result of the single sample two-tailed t-test, it is determined that the difference between the group of calculated actual factors with a mean of 1.24 and the standard factor of 1.37 is statistically significant, with $t(118) = -12.04$, $p < .05$.

The result of the two-tailed test can be confirmed by a directional test. The output from the single sample t-test shows a t-statistic of -12.04. A t-statistic less than 0, where the sample of actual factors is compared to the known value, indicates that the mean of the sample of actual factors is less than the known value. Considering the t-test as left tailed, the critical t value is -1.66 compared to -1.98 for a two-tailed test, resulting in a reduction of the *p* value as the critical t value moves further away, or more positive, from the t-statistic. However, the change in the critical t value makes little difference when considering the significant number of standard deviations from the t-statistic and a *p* value orders of magnitude less than .05.

From this result, it is deduced that the standard factor of 1.37 is no longer valid and should be adjusted to 1.24. The distribution of results around the mean is an important result: it could be argued that for the period under review there was a higher proportion of timber deliveries received where the harvesting crews did not allow the logs to dry sufficiently in the plantation, but the amount of actual factor data points below and above 1.24 is 61 and 58 respectively. Also, the mean and median are similar at 1.238 and 1.239 respectively. Evidently, the spread of “wet” and “dry” timber deliveries is roughly equal around the mean of 1.24.

Using the current mechanism to determine supplier payments, with the application of a smaller $m^3$/ton conversion factor the resulting tons to pay the supplier will be higher. It should be noted that 1.24 falls outside of the range 1.37±5% currently used; hence, it is sufficiently far from the current range to warrant adoption as the new conversion factor to calculate *measured* tons. When applying the new conversion factor, the same principle applies, i.e., 1.24±5% or 1.18 – 1.30.

#### *5.1.2.2 Effect of Seasons and Timber Species*

With respect to the effect of seasons on the actual factor, this was determined through a within-group two sample t-test assuming equal variances. The two sample datasets contain the data from actual factors, grouped by wet and dry season Since the data stems from the set of actual factors, the two sample datasets were assumed to have equal variances. The null and alternative hypotheses are as follows:

*Null Hypothesis $H_0$: Mean of Sample of Actual Factors from Dry Season = Mean of Sample of Actual Factors from Wet Season.*

*Alternative Hypothesis $H_1$: Mean of Sample of Actual Factors from Dry Season ≠ Mean of Sample of Actual Factors from Wet Season.*

Running this test on the two datasets, it is determined that the difference in the means between the groups representing wet and dry seasons is statistically insignificant with $t(117) = -0.14$, $p = 0.89$. It was expected that the dry season would result in lower moisture content of harvested timber, but it is apparent that within the time frame from harvesting to delivery to a mill, around two weeks, the effect is insignificant.

As previously mentioned, there is insufficient data of timber species other than E.Grandis to perform a meaningful statistical test of the differences in the actual factors. However, for the purposes of observing any indicative results, an Analysis of Variance (ANOVA) test was performed on the actual factors for the three timber species as shown in Table 4. The hypotheses are given below, followed by the result of the ANOVA test shown in Table 6.

*Null hypothesis $H_0$: There is no difference in the means of samples of actual factors from E.Grandis, E.Dunnii and E.GxN.*

*Alternative hypothesis $H_1$: At least one of the means of E.Grandis, E.Dunnii and E.GxN is different from the others.*

Table 6

*Results of ANOVA on Different Timber Species*

| *Groups* | *Count* | *Sum* | *Average* | *Variance* | | |
|---|---|---|---|---|---|---|
| E.Grandis | 119 | 147.285 | 1.238 | 0.014 | | |
| E.Dunnii | 2 | 2.041 | 1.020 | 0.021 | | |
| E.GxN | 6 | 6.782 | 1.130 | 0.026 | | |
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
| Between Groups | 0.154527 | 2 | 0.077263 | 5.185927 | 0.006871 | 3.069286 |
| Within Groups | 1.847432 | 124 | 0.014899 | | | |
| | | | | | | |
| Total | 2.001959 | 126 | | | | |

From the result shown in Table 6, it is evident by the means of the groups that they are different; therefore, it is not unexpected that the ANOVA test would return a $p < .05$ which allows rejection of the null hypothesis. However, the power of this test is low due to a very small sample size for E.Dunnii and E.GxN, to the extent that the null hypothesis may be incorrectly rejected. A larger sample size will be required for E.Dunnii and E.GxN to confirm the result of the ANOVA test. This presents an opportunity for further research.

#### ***5.1.2.3 Review of Stack Densities Per Timber Type***

Having established that the correct, representative conversion factor is 1.24, it was further intended to establish if the single density figure of 0.69 also is correct for the two main types of timber contained in the dataset. Timber classification types included in the dataset were “mining timber” and “specials”. This classification depends purely on the diameter range of the timber logs received; mining timber refers to logs in a diameter range of 10 – 16cm, while specials refers to logs in a diameter range of 16 – 23cm. Another class of timber, referred to as dunnage, not included in the set of data, ranges in diameter from 7 – 12cm. These timber diameter classes are used for different products and typically go through different manufacturing processes in the mills. It was expected that, due to the large difference in the range in diameters, a single density value is not suitable.

To achieve this, the entire set of density measurements per stack for mining timber and specials was analysed using a single sample t-test. As in the case of the conversion factor, as stated in Section 3.1, a standard density value of 0.69 is used to convert the truck gross volume to solid timber volume. This value is utilised for all timber types delivered to the timber mills. In both instances, the null hypothesis is that there exists no difference between the measured densities and the standard value while the alternative is that a difference exists which is statistically significant. To ensure the normality assumption holds for both tests, the datasets of mining timber and specials densities were graphed to observe if normality is exhibited. The graphs are shown in Figures 4 and 5 below. In total, 360 density measurements were available for mining timber stacks, and 112 for specials.

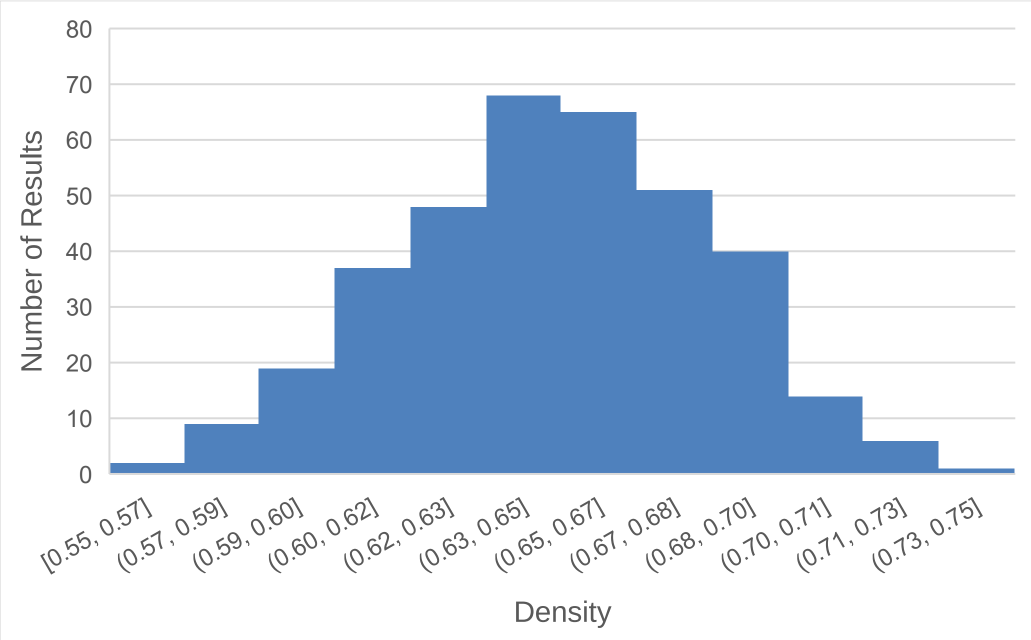


*Figure 4.* Histogram of mining timber stack densities

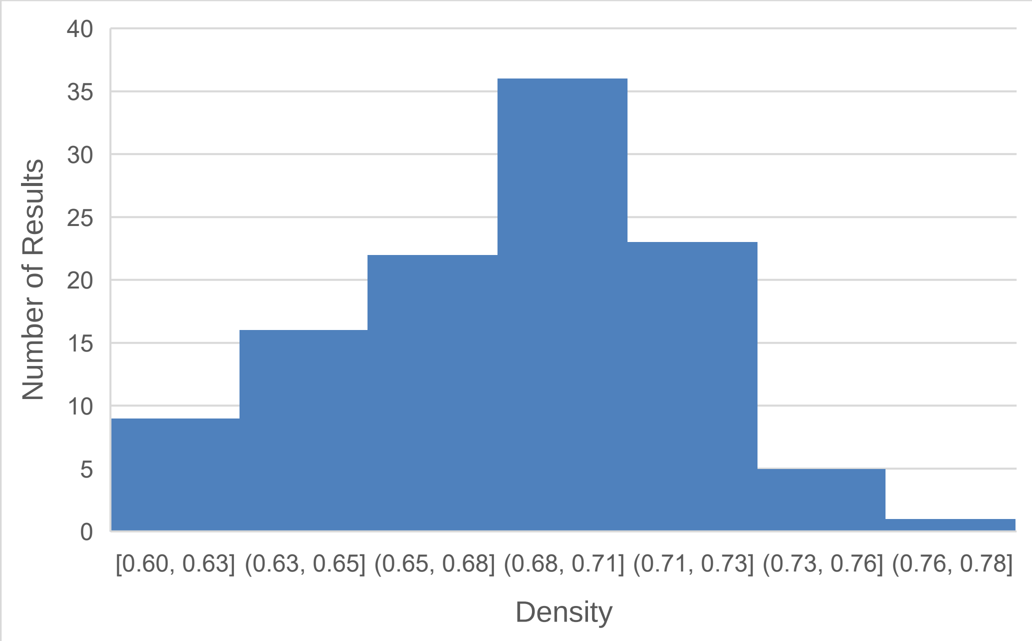


*Figure 5.* Histogram of specials stack densities

It is evident from Figures 4 and 5 that the normality assumption holds as both datasets are approximately normal; therefore, it is appropriate to conduct a t-test on the datasets. Accordingly, the hypotheses for the single samples t-tests are:

*Null Hypothesis $H_0$: Mean of Sample Density Measurements for Mining Timber and Specials = Current Standardised Density Value, 0.69.*

*Alternative Hypothesis $H_1$: Mean of Sample Density Measurements for Mining Timber ≠ Current Standardised Density Value, 0.69.*

*Alternative Hypothesis $H_2$: Mean of Sample Density Measurements for Specials ≠ Current Standardised Density Value, 0.69.*

Performing the single sample t-test on the dataset of mining timber density results, it is determined that the null is rejected and alternative hypothesis $H_1$ is accepted: the difference between the set of data and the given density value of 0.69 is statistically significant, with $t(359) = -24.15$, $p < .05$. The replacement value is the mean of the dataset of mining timber density results, 0.65. Performing the same test on the dataset of specials density results, the null hypothesis is rejected with $t(111) = -2.14$, $p = .03$. However, at 0.683, it was decided that the mean of this dataset is not sufficiently far from the current value of 0.69 to warrant a change.

#### 5.1.2.4 Financial Considerations

Finally, it was sought to establish how the various changes to certain factors discussed above would impact the company and suppliers financially. In this respect, three scenarios were envisaged. For this section's analyses, all verified actual factor results were included, i.e., below 1.0 and above 1.75, as it is intended to evaluate the impact on actual deliveries during the period. The scenarios are based on the established supplier payment mechanism, i.e., volume is converted to tons paid, as this is what all parties are familiar with. The three scenarios will be benchmarked against the current factors that determined actual tons paid for the deliveries included in the dataset, as described in detail in Section 3.1. Therefore, the metric of comparison will be paid tons.

Table 6

*Scenarios for Financial Calculations*

| | | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Component | Current | New Conversion Factor | Timbeter Volume & New Conversion Factor | New Density Factor & New Conversion Factor |
| Volume method | Manual stack measurements | Manual stack measurements | Timbeter | Manual stack measurements |
| Density factor | 0.69 | 0.69 | N/A[a] | 0.65; 0.69 |
| Conversion factor | 1.37±5% | 1.24±5% | 1.24±5% | 1.24±5% |

[a]Since Timbeter gives a complete volume measurement, a density factor is not applicable

Table 7 below shows the paid tons based on the complete dataset of verified measurements. Scenario 1 states that 1.24±5% replaces 1.37±5% in the payment mechanism. Scenario 2 states that Timbeter volume is used with 1.24±5%, while scenario 3 states that density factors of 0.69 for specials and 0.65 for mining timber is used and 1.24±5% replaces 1.37±5%.

Table 7

*Paid Tons for Current Factors and Scenarios 1 – 3*

| | Current | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Paid Tons | 2,852.75 | 3,222.76 | 3,004.57 | 3,088.44 |
| Difference | - | +13.0% | +5.3% | +8.3% |

Scenarios 1 – 3 increase the paid tons compared to the current situation, mainly due to the smaller $m^3$/ton conversion factor. It is also important to consider the difference in the volume of timber "accepted" based on the current situation and compared to scenarios 1 – 3. Of significance to note is that the actual allotment of timber received on the truck per measurement is a constant; it is the method and/or factors applied to quantify the volume of timber on the truck input to the mill's manufacturing process which differed, resulting in differing values.

Table 8

*Timber Volumes for Current Factors and Scenarios 1 – 3*

| | Current | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Timber Volume | 3,989.42 | 3,989.42 | 3,711.83 | 3,824.64 |
| Difference | - | 0% | -7.0% | -4.1% |

The current factors and scenario 1 result in the same volume as there is no difference in the method, as shown in Table 6. Scenario 2 dispenses with the manual measurements and density factor in favour of Timbeter volume, while scenario 3 uses manual measurements with a new density factor for mining timber (0.65). The implication of less timber volume "accepted" is discussed later. The indicative $m^3$/ton factor for the actual tons paid from Table 7 and volume of timber accepted using current factors from Table 8 is 1.40. To determine the total impact of additional tons paid according to Table 7, the total volume of timber delivered to the mills must be established. Using available spreadsheets of incoming timber deliveries recorded for each mill for the period January to July 2021, the total annual volume of timber is estimated as follows.

Table 9

*Annual Paid Tons Per Timber Type – Descriptive Statistics*

| Paid Tons Per Month | Timber Type | | |
|---|---|---|---|
| Month | Mining | Dunnage | Specials |
| Jan-21 | 6878 | -[a] | 4221 |
| Feb-21 | 8701 | -[a] | 4994 |
| Mar-21 | 9761 | 811 | 3430 |
| Apr-21 | 6592 | 305 | 3715 |
| May-21 | 9134 | 415 | 3608 |
| Jun-21 | 9573 | 687 | 4192 |
| Jul-21 | 10333 | 1273 | 5418 |
| Mean | 8710 | 698 | 4225 |
| % Split | 64% | 5% | 31% |
| Sample Variance | 2083847 | 144355 | 548374 |
| Mean Monthly Tons | | 13634 | |
| Mean Annual Tons | | 163605 | |
| Sample SD[b] | | 1666 | |
| Sample Annual SD[c] | | 5772 | |
| Interval Tons -[d] | | 157833 | |
| Interval Tons +[d] | | 169377 | |

[a]Information for these months not available

[b]Sample SD is derived by calculating the square root of the sum of sample variances

[c]Sample annual SD is derived by multiplying sample SD by square root of 12 (twelve months)

[d]Lower and upper bound of interval of mean and SD

Using the interval values, the annual expenditure on timber based on the current situation is given below.

Table 10

*Current Timber Expenditure Per Timber Type*

| Timber Type | Rand/ton | Percentage | Lower bound (tons) | Upper bound (tons) | Lower bound (Rands) | Upper bound (Rands) |
|---|---|---|---|---|---|---|
| Mining Timber | 825 | 64% | 100,835 | 108,211 | 83,189,028 | 89,273,810 |
| Dunnage | 825 | 5% | 8,084 | 8,675 | 6,668,899 | 7,156,689 |
| Specials | 939 | 31% | 48,914 | 52,492 | 45,930,086 | 49,289,598 |
| | Total | | 157,833 | 169,377 | 135,788,013 | 145,720,096 |

Given the percentage increase in paid tons per scenario, the lower and upper bounds can be calculated and the total increase over the current situation assuming the total allotment of timber delivered by the suppliers to the mills is unchanged.

Table 11

*Increase in Timber Expenditure Per Timber Type*

| Scenario | Increase in paid tons | Lower bound (Rands) | Upper bound (Rands) | Increase (Rands) | |
|---|---|---|---|---|---|
| 1 | 13.0% | 153,399,714 | 164,619,989 | 17,611,702 | 18,899,893 |
| 2 | 5.3% | 143,014,268 | 153,474,909 | 7,226,255 | 7,754,813 |
| 3 | 8.3% | 147,006,443 | 157,759,088 | 11,218,431 | 12,038,992 |

Finally, given the paid tons interval values for the current situation in Table 9 and the indicative factor calculated earlier, 1.40 $m^3$/ton, it is determined that the volume of timber accepted was 220,966 – 237,128 $m^3$. For reference, the timber mills delivered 193,377 $m^3$ of finished product to the market for the 2020/21 financial year, implying a recovery of 82 – 88%. Now, using the volume adjustments for scenarios 2 and 3, the following recovery improvements result assuming the total volume of finished product delivered to market is unchanged.

Table 12

*Volume Accepted for Scenarios 2 and 3*

| Parameters | Scenario 2 | Scenario 3 |
|---|---|---|
| Volume Decrease | -7.0% | -4.1% |
| Volume Lower Bound | 205,590.21 | 211,838.54 |
| Volume Upper Bound | 220,627.91 | 227,333.26 |
| Recovery Lower Bound | 94% | 91% |
| Recovery Upper Bound | 88% | 85% |
| Recovery Increase - | 6.5% | 3.8% |
| Recovery Increase + | 6.1% | 3.5% |

*Note.* Scenario 1 did not adjust the volume of timber accepted compared to the current situation.

It is evident from Table 11 that using factors that are a more accurate representation of the physical properties of the timber being delivered to the mills by suppliers, the expenditure on raw material timber logs will increase. It is argued that the most accurate methodology to determine volume, and accordingly paid tons, is represented by scenario 2, namely using Timbeter to measure volume directly and applying the new factor to convert volume to paid tons. Although scenario 2 results in the lowest increase in paid tons, an additional R7.2 – 7.8m expenditure per annum for the company is significant. However, the significant impact this additional revenue will have for suppliers must also be considered.

From Table 12, scenario 2 also results in the largest decrease in volume of timber calculated and accordingly used as input to the manufacturing processes of the mills, and subsequently provides the largest improvement to recovery. An improvement in recovery implicit in quantifying a lesser volume of timber input to the manufacturing processes than the current methodology, for the same output, implies a more efficient process than previously estimated.

A financial model was compiled to determine the cost of the recommendations, i.e., a change of factor from 1.37 to 1.24 and the subsequent increase in paid tons to the timber suppliers according to scenario 2. Product costings in the model include the new factor and recovery to convert the timber price in tons to a price per cubic meter after processing into a final product. The mid-point of the range of values in Tables 10 – 12 were used in the financial model.

Table 13

*Financial Model According to Scenario 2*

| **Current Volume** | **Tons** | **Sales Volume (m3)** |
|---|---|---|
| Mining | 104,707 | 124,602 |
| Dunnage | 8,180 | 9,734 |
| Specials | 50,718 | 60,354 |
| Total | 163,605 | 194,690 |

| | |
|---|---|
| Current factor (actual) | 1.4 |
| Current recovery | 85% |

**Sales volume = tons x factor x recovery**

| **Cost of sale** | **Total** | **CoS/m3** |
|---|---|---|
| Wages | 19,872,535 | 102.07 |
| Trans | 32,949,280 | 169.24 |
| Direct overheads | 10,296,650 | 52.89 |
| Indirect overheads | 1,647,464 | 8.46 |
| Total | 64,765,929 | 332.66 |

**Cost of sale/m3 = Total CoS/total sales volume**

**Determine cost of sale of timber:**

| | **Current** | | | **New** | | |
|---|---|---|---|---|---|---|
| **Cost of sale - Timber** | **Mining** | **Dunnage** | **Specials** | **Mining** | **Dunnage** | **Specials** |
| Paid tons | 104,707 | 8,180 | 50,718 | 110,257 | 8,614 | 53,406 |
| Price | 825 | 825 | 939 | 825 | 825 | 939 |
| Cost | 86,383,440 | 6,748,706 | 47,623,779 | 90,961,762 | 7,106,388 | 50,147,840 |
| | | Total | 140,755,926 | | Total | 148,215,990 |
| | | | | | Increase | 7,460,064 |

**Determine sales price of product:**

| | **Current** | | | **New** | | |
|---|---|---|---|---|---|---|
| | **Mining** | **Dunnage** | **Specials** | **Mining** | **Dunnage** | **Specials** |
| Timber price/ton | 825 | 825 | 939 | 825 | 825 | 939 |
| Factor | 1.37 | 1.37 | 1.37 | 1.24 | 1.24 | 1.24 |
| Recovery | 85% | 85% | 85% | 91% | 91% | 91% |
| Timber price/m3 | 708.46 | 708.46 | 806.35 | 731.12 | 731.12 | 832.15 |
| Wages | | | 102.07 | | | |
| Transport | | | 169.24 | | | |
| Direct overheads | | | 52.89 | | | |
| Indirect overheads | | | 8.46 | | | |
| **Total Cost/m3** | **1,373.78** | **1,373.78** | **1,471.68** | **1,396.45** | **1,396.45** | **1,497.48** |
| Margin | 9% | 9% | 9% | 9.8% | 9.8% | 9.8% |
| Price/m3 | 1,509.65 | 1,509.65 | 1,617.23 | 1,548.17 | 1,548.17 | 1,660.17 |
| Margin | 135.87 | 135.87 | 145.55 | 151.72 | 151.72 | 162.70 |
| Total Revenue | 188,104,875 | 14,695,693 | 97,606,057 | 192,904,157 | 15,070,637 | 100,197,854 |
| | | | 300,406,626 | | | 308,172,649 |
| | | | | | Increase | 7,766,023 |

| **Product** | | **Product volume (m3)** | **Price - old** | **Price - new** | **Increase** |
|---|---|---|---|---|---|
| Mining | 110 x 12cm Slab | 0.019 | 28.68 | 29.42 | 2.6% |
| Dunnage | 75cm x 2.4m dunnage | 0.016 | 23.85 | 24.45 | 2.6% |
| Specials | 1.8m x 18-20cm Pole | 0.054 | 88.13 | 90.47 | 2.7% |

*Note.* A constant factor was used in certain calculations as the information is confidential

It can be seen from the financial model that using the new factor of 1.24 and the increased recovery contingent with using the Timbeter application (scenario 2), the increase in paid tons for timber to suppliers would amount to R7.46m. However, by using the new factor and recovery in product costings, together with a 0.8% increase in the margin applied to the different classes of products, the increase in revenue completely offsets the increase in cost of sale of raw material purchases. One product of each class was used to determine the increase in product prices for the customer. It is shown that the customer would only see a 2.6 - 2.7% increase in the price of their products, which is not significant and could be motivated based on an increase in the price of raw material.

### *5.1.3 Conclusions*

1. An analysis of the dataset of truck measurements completed using the Timbeter application has shown that the physical state of the raw timber logs received at the mills conforms to a $m^3$/ton factor of 1.24, rather than the current factor used of 1.37.

2. Season did not influence the conversion factor, which is an advantageous result as the personnel responsible for the calculation of paid tons do not have to remember to adjust the factor throughout the year.

3. Insufficient data was available to correctly analyse the difference in actual factors for varying species of timber, but with further research the tendency of the data to indicate the existence of such a difference may be confirmed.

4. The single density factor of 0.69 applied to all types of timber was also shown to be flawed – mining timber has a lower density than specials. Mining timber density was determined to be 0.65, while specials remain at 0.69.

5. Three difference scenarios were envisaged to determine the financial implications of an adjustment to the factors above: scenario 1 simply adjusts the conversion factor but uses the current volume determination method; scenario 2 uses the technological solution, Timbeter, to measure volume directly on incoming timber deliveries rather than rely on manual measurement process and density factor; and scenario 3 uses manual measurements but with new density factor for mining timber

and conversion factor. Ultimately, all scenarios would still result in the metric of paid tons which could be compared.

6. The total volume of raw logs currently purchased in tons annually by the timber mills was estimated with uncertainty, which enabled the financial impact of the three scenarios to be determined. All scenarios resulted in an increase in paid tons because of the change to the 1.24 factor, by 13.0% for scenario 1, 5.3% for scenario 2 and 8.3% for scenario 3.

7. The increase in paid tons varied from to R17.6 – 18.9m for scenario 1, R7.2 – 7.8m for scenario 2 and R11.2 – 12.0m for scenario 3. However, scenarios 2 is considered the most accurate as it is derived from an accurate volume measurement.

8. By estimating the current annual volume of timber purchased by the timber mills in $m^3$ with uncertainty, the change in volume of timber “accepted” with scenarios 2 and 3 could be determined.

9. The decrease in volume varied from 7% lower for scenario 2 and 4.1% lower for scenario 3. While scenario 3 is the most accurate methodology to determine timber volume which is still based on manual measurements, scenario 2 is the most accurate outcome as Timbeter measures volume directly.

10. A reduction in timber volume input into the mill’s manufacturing processes for the same output of finished product implies an increase in recovery, or the volume of finished timber product to the volume of raw input timber. An increase in recovery suggests that the timber mill’s processes are more efficient than initially estimated. However, the inference that the mills can purchase less timber as a result is not correct: the same allotment of timber is required to deliver the same volume of finished product; the way the timber is measured volumetrically would differ, resulting in a smaller total volume of timber as input and a higher recovery.

11. Since raw material and recovery are components in product costings, an advantage for the timber mills with better recovery is an offset in the increase in raw material cost in product cost price, or cost of sale per product sold, with the use of Timbeter.

## 5.2 Sub-problem 2 – Qualitative

### *5.2.1 Preamble*

The results of the qualitative study of the semi-structured interviews conducted with the participants to the trial of the Timbeter application at the three timber mills will be presented. The questions included in the interview guide are intended to elicit responses in respect of the individuals' perception and opinion in relation to technology, the Timbeter application and its implementation in the timber mills.

A total of 11 individuals were interviewed. The final list of respondents interviewed is shown in Table 3. These individuals had either performed measurements themselves, trained others in the use of the application or had managed or overseen the trial of the application in their mills; therefore, they were suitably aware of the application, its intended function, and implications of implementation within the current operating environment. Also, these individuals are aware of the current supplier payment mechanism employed which relies on manual tape measurements.

Table 13

*Final Respondents to Qualitative Study*

| Number | Respondent | Years' Experience |
|---|---|---|
| 1 | Artisan (unqualified) | 3 |
| 2 | Fibre Supply Manager | 11 |
| 3 | Production Manager | 15 |
| 4 | Supervisor | 2 |
| 5 | Store Supervisor | 0.5 |
| 6 | Mill Administrator | 3 |
| 7 | Mill Manager | 28 |
| 8 | Production Manager | 39 |
| 9 | Dispatch Supervisor | 5 |
| 10 | Mill Manager | 13 |
| 11 | Supply Chain Manager | 32 |

Specific questions were put to each interviewee according to an interview guide. The interview guide is included as an appendix to this report. All interviews were recorded and transcribed to enable a thematic analysis to be completed on the response data. Further probing questions that were not on the interview guide may have been asked to fully clarify an interviewee's viewpoint on an issue. The interviewees were interviewed at three timber mills over a period of three days. After the second day of interviews, an additional question was added to the interview guide for the final day's interviews after a high proportion of the interviewee's indicated that the operational demands of the mills are high. It was intended to obtain data specifically around the issue of time availability, or the ability to set aside a period in which focussed effort may be put toward the implementation of the application as a form of new technology. It is intuitive to consider that this is a necessity for successful implementation. Therefore, the addition of this question was intended to explore this issue.

After all data was coded, a review was conducted to search for the main themes that synthesise the many codes that were generated and which together "tell the overall story about the data" (Braun & Clarke, 2012). From this process, four main themes were identified. These themes are described below.

### *5.2.2 Themes*

*Theme 1. Time pressure and operational challenges of the timber mills create inertia to change.*

This theme maps the interviewees' experience of the demands of managing or running the timber mills, either in respect of the general lack of time available in any given period to give focus to all functional responsibilities that require attention or having a high baseline level of pressure in attending to all the operational challenges that arise in keeping the timber mills operating daily, and their statements that speak to a reluctance to bring about change in such an environment and add to the already high levels of pressure.

*Theme 2. The importance of fairness and inclusion to maintain supplier trust relationship and avoidance of conflict.*

The interviewees that are at managerial level spoke of the importance of the customer-supplier trust relationship for the sustainability of the mills' operations. In particular, the need to ensure that the processes that delineate the supplier compensation mechanism are fair toward all parties. This theme also maps interviewees' views regarding the importance of making the suppliers an integral part of technology implementation, where it has a potential financial or operational impact on them, to maintain high levels of trust and avoid potential conflict and non-compliance that could arise from unilateral implementation, and expectation of the supplier to "fall in line".

*Theme 3. Supporting personnel during technology implementation is about more than just training.*

The interviewees made mention of the support that needs to be extended to personnel during the implementation of Timbeter as a piece of new technology. Mainly, the issues mentioned spoke of a need to go beyond simply providing training in the use of the application. It is intuitive to consider that investment of time and a personalised approach to training of the individuals that need to be at the forefront of applying the new technology, as in the case of Timbeter, will bear fruit in the long run.

*Subtheme 4. Favourable opinions of technology and Timbeter does not imply that new technology implementation can be steamrolled when there are identified challenges.*

This theme maps the interesting dichotomy revealed in the interviewees' responses when presented with questions intended to navigate their positive and negative perceptions of technology in general and the Timbeter application. It is to be expected that with any discussion involving technology, there is bound to be tension between the views that espouse the benefits thereof and acknowledge the negative, perhaps unintended consequences or challenges of the implementation in the operating environment.

However, having any valid negative perspectives implies that new technology implementation cannot be forced unless these issues are addressed.

### *5.2.3 Theme 1 – An Environment of Daily Operational Challenges Discourages Employees to Consider New Technology Implementation*

In response to warm-up questions at the beginning of the interview, the interviewees spoke regularly of the unpredictable and high-pressure nature of their work environment, whether in a positive sense – "you've got to think on your feet every day, and it keeps your mind awake", "it's challenging, so every day (is) something new" – where complacency is a state best avoided, or negative: "the pressure"; "sometimes it gets really hectic, so one does get frustrated"; "finding ways to get above and meet your targets, sometimes it's a bit demanding". A variation of the negative aspect of pressure put forward by two interviewees was their assertion that they are involved in matters outside of their job description. There were also numerous responses related to the pressures of industrial relations, and these were generally framed as negative.

The overriding concern for most interviewees in respect of the challenge of implementing the Timbeter application was the disruption it would cause to processing and offloading incoming timber, due to the length of time taken to photograph all the stacks on a truck, and the subsequent decrease in operational efficiency of the mills. Taken in context of the previous paragraph, it is telling that a process that was perceived to add to the baseline pressure already experienced would be highlighted as a concern. One respondent noted that every employee involved in the operations of the mills would feel this additional pressure as part of their work routine, particularly suggesting aggrieved transporters over poor truck turnaround time and inefficient incoming timber processing leading to material shortages for manufacturing; their own pressure as a manufacturing manager would result from mill managers "battling".

Even though the respondents were unanimous in stating that the mills' employees that would be involved in the implementation of Timbeter would have the necessary capability to do so, three respondents in mill management positions expressed the view that success would not be guaranteed: the "time delay" would need to be rectified, or put another way, "if the right changes are made…". Importantly, "normal conditions" were said to be required to rectify the challenges faced by the application. The inference is that the current pressure experienced in the mills are not "normal conditions". In addition, one respondent did acknowledge that mill management would have to drive the process and avoid having a negative attitude to the application. In response to whether there is sufficient time to complete the implementation, two respondents in mill management positions noted that time is in short supply due to operational challenges; only once "normal conditions" are realised will there be time available to invest in the implementation, or, alternatively, more man-hours need to be created by employing more people. There was no timeline offered as to when "normal conditions" would prevail.

After providing their opinions of the challenges with Timbeter, the interviewees were asked if there was anything that could be done to overcome the identified challenges. Of the nine interviewees whose concern was related to the increased time to process incoming timber deliveries, only two were able to offer a thoughtful response beyond simply putting more resources and costs to the task, which is unlikely to achieve the objectives. This is likely a result of their reluctance to introduce a change within the prevailing conditions of the operating environment; having concluded internally that the system is unlikely to succeed given the main challenge identified, the interviewees could not see a way to an effective solution because of the anticipated time and effort that would be required to implement it.

The data grouped in this theme speaks to a general concern of the additional pressure expected because of the decrease in operational efficiencies due to the perceived challenge of implementing Timbeter, as well as a lack of time to successfully do so. The result is that there is a distinct reluctance of the interviewees in mill management to consider a change of the system to process incoming timber deliveries, despite the shared belief among all interviewees that the necessary skills and competence exist in the employees that would be tasked with effecting the change. The reluctance shared by mill management is particularly revealing – considering one interviewee in a mill management position stating "something like this should be driven by us as management" – ostensibly because they have the greatest responsibility over the operations of the mills.

#### *5.2.4 Theme 2 – Key Suppliers Affected by New Technology Implementation Must be Engaged to Facilitate Buy-in Based on Demonstrable Benefits of Accuracy and Fairness*

An important consideration in respect of the topic of this report was the interviewees' views regarding the treatment of suppliers impacted by the implementation of the Timbeter application, and how important they viewed issues of supplier trust and disputes. Suppliers in this case can include external and group plantations. With reference to processing incoming timber deliveries to the mill, the supplier payment mechanism requires determination of the total volume of timber on a truck. Section 3.1 details the current approach and by way of using the Timbeter application. The leading question to this theme was why the interviewees viewed the issue of accurate measurements of timber volume on incoming timber deliveries as important. While the preponderant response was relating to the importance of accurate raw material volumes as the input to the production process, six interviewees also alluded to issues of supplier payment in their responses, and these were of great interest. The essence of these statements was that accurate volume measurements ensured that the timber mills paid only for what they received – avoiding either over- or underpaying the supplier for timber. However, two of these interviewees made interesting remarks. To quote: (1) "over the last 40 years that I've been involved in this business, there's always been fights and people blaming each other for not measuring right and we're inaccurate, (so) I would say to a large extent supplier relations"; and (2) "we are paying our suppliers by measured tons so if our tons are not accurate, then it might happen that the supplier is losing and they can come back and complain". It is evident from the collective responses that fair supplier compensation is a multi-layered and important issue, which is further detailed below.

The logical progression from the leading question was to further explore the interviewees' views on the supplier relationship. Accordingly, they were questioned whether the mills should be comfortable paying suppliers based on the Timbeter measurement. Most interviewees responded that the mills should be comfortable to use Timbeter to determine the volume of timber on a truck as there is a general perception that it is more accurate than the current method. In fact, when asked what the benefit to the mills would be in implementing Timbeter, seven interviewees named accuracy as one. However, there was an equally high proportion that believed the suppliers will need to be engaged with such a change to secure their buy-in and maintain trust. Three interviewees, who had among the most years' experience in the timber industry, were of the opinion this was borne of an aversion to change, preferring to use a system they've "stuck with for years" and being "more comfortable with things they could touch and understand", i.e., the current method utilising manual measurements. It is telling that the interviewees ostensibly with the longest relationship with suppliers would have the belief that the individuals involved in these companies may not easily accept technology in a process that has an impact on them when the current process is easily understood. The remainder of the interviewees opined that it would simply be good business practice to ensure the supplier is comfortable with the new process utilising technology. Therefore, it is understandable in this context that the interviewees believed the supplier is an integral part of the implementation to maintain trust and avoid conflict. Two interviewees remarked on what is at the core of the issue: "you don't want to shoot the company in the foot because it's going to make us happy using the new technology, but our supplier in timber is not going to be happy"; "you gonna have to explain it to the suppliers, otherwise you're gonna have guys withdrawing from supplying timber because they're not happy with what's happening."

Three interviewees felt no need to involve suppliers; one believed the supplier will simply prefer a "computer related thing than a human being", while the remaining two did not consider the supplier at all. Interestingly, these interviewees had among the least experience in the timber industry. Two interviewees did not agree with the leading premise; however, this was based on an incorrect understanding of the outcome of the Timbeter measurement relative to the manual measurement method. This was an unintended, yet insightful result: if the mill employees do not fully understand the implications of the technology, they are also unlikely to support it. This is the same issue that suppliers would face with the implementation of the technological system, so it should it be expected that they would respond similarly. According to four interviewees, to facilitate the process of implementation with suppliers' buy-in, testing or calibration would a prudent exercise. Two felt that the supplier should be actively involved in testing so that they may observe the process, to "…prove to your supplier, this is how accurate it is" as "they would obviously want to see and compare what was on the timber meter

(Timbeter) and what was the actual measurements taken on the truck (manual measurements)".

The questioning around fairness between suppliers and mills went further to explore this important issue in more detail. In this respect, all interviewees agreed that a system that is more accurate in determining the volume of incoming timber is fairest toward all parties. To test the limits of the interviewees' support of fairness, the question was posed: in utilising the Timbeter application as opposed to the current method of physical measurements, if the results reveal that suppliers must be compensated more – this may be because the factors used in the payment mechanism described in section 3.1 change in favour of the supplier – should this be realised? The interviewees who were asked this question responded in the affirmative. This is a profound result; it is apparent that the employees who understand the importance of timber suppliers to their operations would be willing to pay more for their raw material in the pursuit of fairness if the new system is shown to be working and the measurement results dictate as such. One interviewee put it in very simple terms: "it is totally wrong to use a method and actually be stealing from a client or from a supplier or supplier stealing from you unknowingly. That can happen (with the current system)".

The substance of the data grouped in this theme is very clear. The interviewees were comfortable asserting that Timbeter had the requisite accuracy to be used as part of the process to determine supplier payments, but that the supplier, for their importance to the mills' operations, must be involved in the implementation. Unilaterally implementing the application would be placing the operations at risk with suppliers potentially withdrawing from supplying timber because of mistrust of the process, particularly because of their familiarity with the current method. However, it was suggested that if the supplier is included in the implementation and it can be demonstrated that the new system is more accurate, and therefore fairer toward both parties, whether net positive for the supplier or the company, the trust relationship would be maintained, and conflict avoided.

### *5.2.5 Theme 3 – New Technology Implementation Requires a Management Team as Active Participants in a Multilateral, Empathetic Approach to Training*

Theme 3 collates the response data from the interviewees in respect of their views of the treatment of the employees of the mills that will be impacted by the implementation of the Timbeter application to process incoming timber deliveries. The question put to the interviewees was to provide their insight regarding the organisational level where the responsibility for successfully changing from the old to new system would ultimately reside. While the interviewees spoke of measures to be taken beyond simply training, and this is the focus of this theme, it was acknowledged that training will be the foundation of the implementation process. Beyond training, most interviewees believed that management is ultimately responsible for successful implementation. Four interviewees insisted that management must take time out from their day-to-day activities to engage with the individuals training in the use of the application. This would include being available to rectify any problems, conduct follow-ups and adjustments to procedures and provide technical and organisational support; they should not be "left alone" with their problems. One of the senior interviewees provided an interesting perspective: managers should also have empathy for the individuals in training. This includes listening to them when they have a problem, in fact "you've got to go right down to the person and he's got to understand, and you've got to make certain he understands – 90% of the time, the guys say they understand, because they're too shy to say they don't understand". According to the interviewee, this function may be a dedicated training appointment rather than the manager. Most importantly, the intention is to avoid "that guy sitting over there with that app in his hand, he's going to have a problem and there's nobody he can talk to". Another interviewee suggested that it is about management of the process rather than individuals, specifically noting that sufficient time should be taken to ensure that individuals understand and are comfortable with the new technology before moving to full implementation as many in the mills are uneducated. This also speaks to an empathetic approach, namely understanding your employees and how they are likely to experience the disruption of technology in the workplace.

The second aspect of this theme was to enquire with the interviewees whether they believed it would be important that management makes the effort to explain to the individuals involved in the implementation why the company is seeking to explore the new technological system. The interviewees were unanimous – it is of critical importance that this is part of the implementation process; of greatest significance is that it is only by creating understanding with the individuals engaged in the implementation that their advocacy for the process will be ensured. Moreover, five interviewees believed that it transcends simply good practice and that the individuals concerned are deserving of knowledge. Their assertion lies in rejecting the notion that the employees would be trained in the use of the application and then instructed unilaterally to carry out measurements. One interviewee expressed it well: “I would not like somebody to tell me to come and make a change and just say, do it. You need to understand. If you understand it and management says to you why, it's so easy (to get) buy-in”.

The reasons given by the interviewees that would facilitate understanding range from: a) job security in the face of technological advancement (“we want to adapt and don't want to stay behind”); b) greater accuracy (“do we have enough material to do the job entirely?”); c) opportunity for growth (“he understands it, he's going to use it to get himself better”); d) simplifying their work (“you got to show them that it works and making life better”); e) being a company of integrity, it is about doing things in an honest manner (“I think it’s a good thing for them to know that this is a fair operation, for peace of mind; we are honest people, and we base our operations on honesty”); f) benefits for the self and the company (“I think it's important to tell them, the company is going to benefit, but we want to ensure you benefit as well”). One interviewee added an interesting point; by involving the individuals in the decision-making to implement Timbeter, they are more comfortable to express their opinions of where the application or the procedures can be improved. These opportunities are lost with a unilateral implementation.

The data distilled in this theme provides a firm understanding of the views of the interviewees around thinking about the individuals affected by the implementation of the Timbeter application. It is encouraging that even in a high-pressure industry such as sawmilling, the individuals in positions of supervision or management would support a multilateral approach to implementation. Ultimately, the interviewees believed that, beyond training, the key to supporting personnel to successful implementation is a hands-on approach by management. Aside from this, the interviewees all agreed that it is very important to bring the individuals in training into the conversation around why

Timbeter is being implemented to ensure their advocacy. However, albeit all are relevant, they differed on the proposed rationale that would best achieve this.

### *5.2.6 Theme 4 – Rational Positivity Around New Technology Implementation Accepts that Reasonable Issues Will Arise that Must be Addressed*

This theme collates the positive views as well as the counterpoints of the interviewees in respect of the Timbeter application and technology in general. As part of the set of warm-up questions, the interviewees were asked about how they perceived technology and the way it integrates into their daily lives. All were unanimous in their support of technology, and the reasons did not vary greatly. The greatest number of responses fell into categories of "it's the way of the future", "technology makes our lives easier" and "you can't live without technology". Within this context, the next question sought to bring the conversation around technology closer to the interviewees, specifically the advantages they thought would be realised by bringing more technology into the mills' operations. Again, the interviewees were unanimous in their support of greater technology implementation in the mills. Of the advantages named, the greatest number of responses fell into categories of increased operational efficiency, reduced overheads (reduced workforce) and increased production. A smaller proportion fell into categories of reducing accidents and providing opportunity for upskilling personnel. It is to be expected that in the high-pressure environment of the mills that an increase in efficiency and production would be the most valued outcome of increased use of technology. Furthermore, contraction of the workforce would present an opportunity to increase profit margins when paired with increased production. For the interviewees in management positions, increasing profit margins is their daily focus so the statements made are indicative of this. However, when asked to elaborate on the potential negative aspect of greater technology implementation in the mills, all but two interviewees cited job losses as the biggest disadvantage. This is not surprising in the South African context, particularly so in Mpumalanga, where the mills are situated and where the interviewees called home, where unemployment is higher than the national average (BusinessTech, 2021).

In a previous section, it was described that the interviewees viewed accurate volume measurement as very important. The three questions that followed were intended to delve into the interviewees' views on various aspects of the application in the broader context of their perception of technology. Having also established in a previous section that interviewees believed that Timbeter is accurate for the task of volume measurement, possibly more so than the current system, four of the interviewees had caveats to their responses, while another would not be drawn to answer. The first stated simply that they could not comment on the accuracy of the application until they have thoroughly tested it. The other three interviewees commented that they believe the application is accurate but is also influenced by human error.

Trust of technology was expected to be a relevant construct, so in this sense the interviewees were asked whether they are comfortable with the processes happening in the background of the application to deliver a measured result, which was framed in a broader sense of, do they trust technology? All but one of the interviewees agreed that they are comfortable trusting Timbeter, and that this is borne of a trust in technology. In a general sense, the responses were variations of "technology is pervasive in our lives, and we use and rely on it, so by implication we have to trust Timbeter", although a number of these were thought-provoking. On learning more about the technology: "I think we have to use it, but it's never a bad thing to learn a little bit more about it for your own sake… so I will say I'll trust the new technology, but I want for my own sake just some more information as well". On relying on people with specialised knowledge to develop technologies: "we don't always need to understand all the technology, that's why there are people that basically know what to do and how to develop this… you've got to depend on other people that build these apps or these machines and utilise them". On the pace of technology advancement: "I think with technology growing so fast, I think that you can look at it… I mean, if you look at what the technology is doing currently, I've got no problem in believing that the figures it's giving (Timbeter) is more or less accurate". On artificial intelligence: "I feel comfortable because I know it's the program itself will improve itself, that how I'm feeling… that's what AI is, to get better, you know? I'm happy with it, I'm not concerned".

Aside from the sole interviewee who is diametrically opposed to the others, commenting "I'm not comfortable because I don't see how it calculates in the background and the other things that it's using to measure all those things", a few interviewees who are trusting had some contrary words: "I'm still old-school so I'm sceptic about some of the technology, but yeah, I'm using technology… so, I suppose I do trust it to some extent"; "I don't know what outside interference there may be that can cause it to give alternative readings or not accurate readings". One interviewee in a mill management position added that the mills would all need to succeed in implementing the system, it cannot be a piecemeal approach; not only that, but the mills also need to obtain the same accuracy of results, else volume per given quantity of timber logs will differ. However, given the broad spectrum of interviewees in terms of age and functional level, it is both surprising and encouraging that there is almost unanimous trust in technology and the application, which is supported by rational concepts.

At the essence of their perception of the Timbeter application was whether, if presented with a volume difference between the current system and Timbeter on the same supplier delivery, which one are they more likely to believe? Interestingly, while there was a general perception that Timbeter is accurate, this question revealed that six interviewees would rather trust the application, three would rather believe the current system of manual measurement and, of the final two, one was undecided, and one declined to answer. The reasons given by interviewees for preferring the current system were familiarity ("I'm still on the old system, I do not have a lot of experience on the new technology") and the belief that Timbeter is too influenceable by human error. The undecided interviewee believed that both systems are prone to human error ("both are dependent on what the input is from the human being"). Therefore, three divergent responses were related to human error. Clearly, human error is a strong motif within this theme.

A high proportion of interviewees believed Timbeter is accurate and trust the algorithms of the application and technology in general, so why is there not a higher proportion that would rather believe it over the current manual system when presented with differing volume measurements? The interpretation of this dichotomy of opinions on accuracy is that when used correctly, Timbeter is more accurate than the current system. However, the perception may be that Timbeter is more prone to human error in respect of inputs to the system than the current system consisting of manual measurements as it is a technological solution, and accordingly requires a more methodical approach to achieve the desired result.

The data discussed in this theme speaks to the positive comments made by the interviewees in relation to technology implementation, while also addressing the negative aspects raised. A previous section spoke to the operational challenges of implementing Timbeter, whereas this theme drew on the interviewees' more conceptual thoughts on the issue of technology implementation. The combination of responses to the questions put to the interviewees presents a narrative of rational positivity toward technology, tempered with reasonable caveats that relate to issues that can, and should be addressed if Timbeter is to be implemented as the only tool to conduct volume measurements.

### *5.2.7 Matrix and Correlations*

To determine where the balance of the conversation lies in respect of the interviewee responses, a binary matrix was created. Then, using the binary matrix, correlations could be established for the four themes. The matrix and table of correlations are shown in Tables 14 and 15.

Table 14

*Binary Matrix – Themes*

| Person | Theme 1<br>*Time pressure and operational challenges of the timber mills create inertia to change.* | Theme 2<br>*The importance of fairness and inclusion to maintain supplier trust relationship and avoidance of conflict.* | Theme 3<br>*Supporting personnel during technology implementation is about more than just training.* | Theme 4<br>*Favourable opinions of technology and Timbeter does not imply that new technology implementation can be steamrolled when there are identified challenges.* |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 0 |
| 3 | 0 | 1 | 0 | 1 |
| 4 | 1 | 1 | 1 | 1 |
| 5 | 0 | 0 | 0 | 1 |
| 6 | 1 | 1 | 0 | 1 |
| 7 | 0 | 1 | 1 | 0 |
| 8 | 0 | 0 | 1 | 1 |
| 9 | 1 | 0 | 0 | 1 |
| 10 | 1 | 0 | 1 | 1 |
| 11 | 1 | 0 | 0 | 1 |
| Totals | 7 | 6 | 6 | 9 |

Table 15

*Theme Correlations*

| | *Time pressure and operational challenges of the timber mills create inertia to change* | *The importance of fairness and inclusion to maintain supplier trust relationship and avoidance of conflict* | *Supporting personnel during technology implementation is about more than just training* | *Favourable opinions of technology and Timbeter does not imply that new technology implementation can be steamrolled when there are identified challenges* |
|---|---|---|---|---|
| Time pressure and operational challenges of the timber mills create inertia to change | 1 | | | |
| The importance of fairness and inclusion to maintain supplier trust relationship and avoidance of conflict | 0.167 | 1 | | |
| Supporting personnel during technology implementation is about more than just training | 0.167 | 0.167 | 1 | |
| Favourable opinions of technology and Timbeter does not imply that new technology implementation can be steamrolled when there are identified challenges | 0.102 | -0.408 | -0.408 | 1 |

The conversations by the interviewees were reasonably equally balanced between the four themes as seen in Table 14. This shows the interviewees had a balanced view of the issues around technology implementation and the Timbeter application. However, the conversation was weighted higher on theme 4, primarily due to greater agreement by all interviewees around the issue of possible negative implications of technology implementation and the Timbeter application. Table 15 shows that correlations between the themes are not strong, with those between themes 2 and 4 and themes 3 and 4 being only moderately strong. This indicates that the themes speak to discrete issues.

### *5.2.8 Ethics*

Since the qualitative study was based on interviews with human subjects, ethics was an important consideration. This is especially true considering that the subjects were all employees of the group for which the consulting report was done. In this respect, to maintain exemplary ethical standards, informed consent was obtained from each individual prior to conducting the interview. This included explaining the nature and purpose of the study being conducted and assuring each person that their responses would be completely anonymous. Most importantly, because confidentiality is strictly maintained, their participation in the study would in no way affect their job in any way. Also, their consent was asked to record the interview and explained as necessary only to enable analysis of the responses given. After confirming their willingness to participate after all the above was discussed and understood, each individual signed a consent form.

### *5.2.9 Conclusions*

1. Theme 1 represented the views of the interviewees regarding the implementation of the technology in the timber mills. Due to high operational demands, there was a clear hesitancy expressed by interviewees regarding the Timbeter application, as it was deemed to decrease operational efficiency. Interviewees in management believed implementation would only be possible once normal conditions were attained in the timber mills, with the implication that the current operational demands were not considered normal, even though they acknowledged that management

would have to drive the process and the personnel have the competence to be able to make it a success.

2. It is apparent that, to secure the backing of the mill employees and ensure the implementation of Timbeter is successful, a solution must be found for the delay in processing timber deliveries resulting from using the application.

3. The second theme is arguably of greatest importance: how the interviewees perceived the supplier relationship in respect of the impact of the Timbeter application. In general, the interviewees were very positive on creating systems that provided equitable compensation of suppliers and they believed Timbeter would provide this due to its increased accuracy over the current method. In fact, the interviewees felt that, if an equitable solution results in greater compensation to the supplier, this would be acceptable.

4. The interviewees believed the supplier must be an integral part of the implementation of the new technology to ensure that trust is maintained, and conflict avoided.

5. The data from theme 2 speaks to the interviewees placing high importance on the supplier relationship. It is evident that operating timber mills requires a consistent and sustainable flow of raw material from suppliers, and ensuring a relationship based on trust and fairness is a strategic imperative.

6. Theme 3 was concerned with the personnel at the mills and how best to support them during the implementation. The interviewees agreed that, if training is in place, successful implementation is ultimately the responsibility of management. They need to be hands-on with the process and involved with the individuals on the ground to remove their obstacles.

7. According to the interviewees, it is of vital importance to secure buy-in of the personnel that will receive training and conduct measurements by explaining why the company is seeking a technological solution to the timber processing system. It

should not be perceived as a unilateral instruction. The interviewees gave several cogent grounds to assist the personnel to accept the technological solution.

8. Theme 4 dealt primarily with the interviewees' opinions on technology. All were supportive of the use of technology, including in the mills to improve operational efficiencies, production and reduce overheads.

9. Trust of technology was a pertinent discussion in the context of the Timbeter application as a technological solution, on which most interviewees were positive. However, their opinions of whether to believe Timbeter or the current method should a large deviation in volume be observed did not exhibit the same level of support of technology. It was apparent that the interviewees that were doubtful believed human error of inputs to the Timbeter application was problematic as it requires a methodical user, even if the current method of manual measurements is arguably far more susceptible to human error.

# 6. RECOMMENDATIONS

1. To resolve disputes with inter- and extra-group suppliers of timber and ensure long-term sustainability of the supply of timber to its timber mills, the company should consider utilising the Timbeter application to directly measure timber volume on all incoming timber deliveries from suppliers. Timbeter results in the lowest increase in timber supply costs, yet the most accurate determination of volume.

2. The conversion factor should be adjusted to 1.24 $m^3$/ton to reflect the physical state of timber received from suppliers and ensure equitable compensation of suppliers as a result.

3. If the company resolves to adopt the Timbeter application, it would be beneficial to engage the suppliers to change the payment mechanism to pay per volume of timber received rather than the current process of converting volume to tons. This would be the most empirical approach as the value would be based on the physical properties of the timber as received, rather than applying the complex structure to determine whether measured tons (based on conversion factor) or weighbridge tons must be paid.

4. In implementing Timbeter, the company must first seek to establish the changes that need to be made to the timber processing system to enable the application to be implemented successfully, primarily in terms of expediting photographing stacks individually, to allay the concerns of the management staff.

5. If the company resolves to adopt Timbeter but cannot find a workable solution to circumvent the processing delay problem, it should be considered to move the initial stock photographing stage back to the plantations and during the loading process. The analysed photographs can be sent to the mills prior to the truck arriving at the mill. This would have the added benefit of being able to observe if theft of timber logs from the truck had occurred during transit.

6. Regarding personnel, mill management should consider appointing a dedicated training resource, whether they are from the company that developed the

application or a “tech-savvy” member of staff of the mills. As part of the training programme, it would be important to educate the recipients on the fundamentals of the application and on proper inputs to obtain the highest accuracy, as this will increase credibility of the application and trust in the outputs.

7. Mill management must endeavour to follow a hands-on approach to training and implementation in support of the transition of the affected personnel from the current process they are familiar with to the new system. Management must also take care to effectively explain to the affected individuals why the company is seeking a technological solution to a process that had been completed manually for many years.

8. Mill management must ensure that the suppliers are engaged during the implementation process, ideally through a series of tests conducted to verify the accuracy and the assurance that the changes made to the incoming timber processing and payment system will be to their benefit.

9. If the company resolves not to implement Timbeter and continue using the current method of manual measurements, adjustments to the conversion factor to 1.24 $m^3$/ton and density factor for mining timber to 0.65 should be enacted. However, the cost of timber supplied would increase by roughly R4m per year compared to a Timbeter system.

10. With the increase in recovery for the manufacturing processes implicit in quantifying lower input volumes, the mills must determine the cost price, or cost of sale, for every product manufactured considering the increase in raw material timber costs and the increase in recovery. It would need to be determined to what extent this increase in recovery would offset the increase in raw material timber cost in the cost of sale calculation of the products so that gross profit is not materially affected.

11. An opportunity for further consulting engagement and intervention would be to expand the research to determine the difference in the actual factors for the different species that are supplied to the timber mills. Initial investigations into the different species indicated very different factors. Defining the actual factors for all species

supplied to the timber mills would be an important consideration to further refine the model and ensure greater accuracy of incoming tons and equitable compensation.

12. If the decision is made to implement Timbeter on a larger scale, an important avenue for further research would be to evaluate supplier engagement and endorsement of the new technology in an industry historically reluctant to accept change and advise on strategies to improve outcomes. The qualitative study indicated that this is an important point to consider in a roll-out of the technology.

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