AN OVERVIEW OF SUGARCANE PAYMENT SYSTEMS, ECONOMICS AND THEIR INFLUENCES ON THE LENGTH OF THE MILLING SEASON

WP Mafunga

Submitted in partial fulfilment of the requirements for the degree of MSc Bioresources Systems

School of Engineering
University of KwaZulu-Natal
Pietermaritzburg
2014

Supervisor: Prof CN Bezuidenhout
Co-supervisor: Prof GF Ortmann
I. Wadzanai Penlope Mafunga declare that

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ABSTRACT

In any sugarcane industry, the cane payment system is one of the major mechanisms that governs revenue distribution between growers and millers. There are various types of cane payment systems that have evolved over the years. The main types of cane payment systems include: (a) the fixed cane price system, (b) the sucrose payment system, and (c) the recoverable value payment system. Despite their variability, all systems consist of four components, which are the division of proceeds, the cane quality definition and the parameters used for quality payment, sugar prices and a global payment formula.

In South Africa domestic prices are determined by the South African Sugar Association. The division of proceeds is determined by mutual agreement between the growers and millers, the proceeds which are shared is the income from local and export sales. Two types of revenue agreements exist, which are the variable revenue sharing arrangement and the fixed revenue sharing arrangement. South Africa divides the revenue from sugar and molasses sales to millers and growers using a fixed revenue sharing arrangement. The current ratios are 35.6325% for millers and 64.3675% for growers and these change from time to time. This form of revenue sharing can potentially discourage both growers and millers from improving their technical performance since any improvements in cane quality or technical efficiency are shared.

After the division of proceeds, a cane payment system is used to distribute revenue to individual growers. The majority of countries have shifted from the fixed cane price payment to quality based payment systems. South Africa uses a Relative Recoverable Value payment system based on the Estimated Recoverable Cost (ERC) formula by Van Hengel (1974). While the system motivates growers and millers to improve technical efficiency, it can lead to a lack of urgency to keep the milling season short. Relative payment potentially conceals the fast drop in RV% at the start and end of the season. Both growers and millers may lose sight of the effect of the rapid drop in RV% thus weakening the determination to maintain a short milling season.
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<td>Length of the Milling Season</td>
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<td>SASA</td>
<td>South African Cane Growers Association</td>
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<td>SIA</td>
<td>Sugar Industry Agreement</td>
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<tr>
<td>BOTT</td>
<td>Board on Tariffs and Trade</td>
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<td>Department of Trade and Industry</td>
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<td>South African Sugarcane Research Institute</td>
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<td>MGB</td>
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<td>SACGL</td>
<td>South Africa Cane Growers Association Levy</td>
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1. INTRODUCTION

Background to this study

The Length of the milling season (LOMS) refers to the duration required to complete all harvesting and crushing processes in a sugar producing area. Over the years, there have been heated debates on the optimal length of the milling season, which date back to the 1930s (Moor and Wynne, 2001). Milling season lengths vary across countries. Columbia for example, crushes its cane all year round and in Louisiana, the length of the season can be as short as 14 weeks (Hildebrand, 1998). In South Africa, the LOMS ranges from 30 to 38 weeks, running from April until December (Bezuidenhout and Singels, 2007). Variations in the length of milling seasons are attributed to several factors, some of which include: agronomic practices, climatic conditions, cane quality variations, harvesting costs and the nature of the cane payment system (Hildebrand, 1998; Moor and Wynne, 2001).

Various researchers in South Africa have designed models for the optimisation of season length. Moor and Wynne (2001) and Wynne and Groom (2003) are amongst the researchers who have conducted research to this effect. However, there has not been a simulation model which took into account how the nature of the cane payment system itself may affect the LOMS.

This research aims to identify the influences of the cane payment system on the LOMS. Various cane payment systems have evolved over the years and each type can potentially encourage or discourage efficiency drives among either growers or millers in the sugar industry (Saranin, 1975; Burrows, 1998; cited by Keerthipala and Thomson, 1999). Cane payment systems aid revenue distribution between millers and growers. Additionally, they can affect the industry’s technical performance and the incentives to increase productivity (Todd et al., 2004). For the miller, cane is the raw material used in sugar production, while to the grower, cane is the final saleable product of cane farming. Overall, the proceeds from the whole sugar manufacture process should cover the costs of cane production and processing. The grower’s costs include overheads in current inputs, labour and land amongst other issues. The miller’s costs on the other hand encompass milling, materials, administration and capital depreciation, to mention a few. Eventually, an acceptable margin of profit for both parties is expected. The payment system should target to achieve these objectives (Keerthipala and
Thomson, 1999). Figure 1.1 below briefly summarises the concepts to be covered in this review and aids the reader to understand what a cane payment system is. It is important to note that this is a very simplified diagram since at present in the sugar industry, industrial charges are deducted before the distribution of net proceeds. In addition, before the growers distribute their revenue, Regional Levies, South African Cane Growers Association (SACGA) costs and Cane Testing Service costs are also subtracted (Anon, 2013).

Figure 1.1 Simplified illustration of the distribution of the total proceeds in the sugar industry

After raw sugar is produced in South Africa, the bulk is sold on the local market and about 25% is exported (SASA, 2013). The proceeds from these sugar sales are shared between growers and millers by a method termed the division of proceeds. The arrangement with which the proceeds are divided are not the same for each country (Todd et al., 2004). Once the proceeds have been shared, growers distribute their share of the money through a cane payment system.

The entire process from division of proceeds to when growers are paid is crucial to the sugar industry and can motivate millers and growers to improve technical efficiency. Moreover, the manner in which growers are paid in the industry significantly impacts the decision to grow the industry at both factory and field levels. This has an overall impact on the LOMS, since cane tonnage and milling capacity are functions of the milling season’s length (Moor and Wynne 2001; Todd et al., 2004).
In this research, the LOMZI model will be used to identify the influence of the RV cane payment systems on the length of the milling season as well as other issues specific to two chosen mill areas. The first version of this stochastic model was created by Boote (2011) in a study which evaluated the potential effect of a stockpile outside the Umfolozi mill. The factors that were captured in LOMZI emphasised environmental risks. Based on this knowledge, the current research will focus on the influence of cane payment systems on the length of the milling season with the aid of the LOMZI model.

Lejars and Azoux (2010) state that cane payment systems, despite their variability, incorporate four components. These components include: (a) sugar prices, (b) revenue sharing arrangement between growers and millers, (c) the definition of ‘cane quality’ and parameters used for quality payment and (d) a global payment formula. Chapter 2 of this review examines each of these components, as well as their influences on the sugar industry. An analysis of the weaknesses and strengths of the types of cane payment systems will be outlined. Much emphasis will be on the cane payment system used in South Africa as this is the main focus of the study.

The objectives of this review are to:
(a) Define cane payment systems,
(b) Outline and describe the components of cane payment systems,
(c) Describe the impact of each component to the sugar industry, and
(d) Describe the strengths and weaknesses of each payment system.

The final chapter in this document contains an MSc project proposal for the research which further explains the aims, objectives, methodology, resources required and projected timescale of the proposed research project.
2. A REVIEW OF THE SUGAR CANE PAYMENT SYSTEMS AND THEIR INFLUENCES ON THE LOMS

In any sugarcane industry, the cane payment system is one of the major existing mechanisms as it governs how revenue is distributed between growers and millers (Keerthipala and Thomson, 1999; Todd et al., 2004). The revenue obtained arises from sugar sales and other sugarcane by-products, such as bagasse and molasses (Lejars et al., 2010). Growers and millers are mutually reliant on each other for the production of high quality sugar, although in most sugar industries they exist as independent and separate economic entities (Doner and Ramsay, 2004; Anon, 2011). The two participants in this industry, thus, share the risk and reward on sugar revenue. Competition and conflicts are inevitable in such a scenario as both parties desire a fair distribution of the revenue obtained from sales (Masuku, 2009; Hildebrand et al., 2013).

Hildebrand (1998) states that growers aim to maximise their returns through shortening the harvesting season and reducing harvesting costs. Millers, on the other hand, desire a relatively small installation and to extend the length of the milling season because of the high associated fixed costs. Therefore, in order to attain economic efficiency, it is essential for both parties to cooperate with each other. Cane payment systems aim to ease the conflict by providing a compromise between the objectives of growers and millers. The payment systems should aid growers to maximise the sugar content in the cane and millers to maximise mill capacity utilisation, as well as the recovery of sucrose at the factory (Moor and Wynne 2001; Todd et al., 2004).

Various payment systems exist and differ between countries (Lejars et al., 2010). In Brazil, payment is based on cane mass and the total sugar content of the cane, rather than sucrose content, because of ethanol production. Where ethanol is not produced, the best cane payment systems pay for recoverable sugar content of cane (Meyer et al., 2012). SASA (2013) stated that in South Africa high quality sugar production is the main focus. The type of cane payment system used is inclined towards encouraging production of good quality sugar.
Lejars et al. (2010) and Lejars and Auzox (2010) note that despite the variability in payment systems, they generally depend on four main components which are discussed in detail in the following section.

2.1 Sugar Prices in South Africa and the world

Tomek and Robinson (1990) state that prices determine consumption and production patterns. Farm product prices have been continuously affected by governments since the 1930s and free market forces no longer determine the prices of many agricultural products. It is important however, to note that pricing decisions have significant economic consequences and therefore need to be made cautiously (Tomek and Robinson, 1990). In the sugar market, there are two clearly defined markets which are: (a) the freely traded raw sugar market, and (b) the controlled market. The free sugar market is open to market signals which draw demand and supply towards equilibrium (Anon, 2006). The controlled market is managed under a wide range of government interventions. Sugar consumption levels, its production and even trade are subject to government controls in various countries (Anon, 2006).

The world market supply is significantly affected by government policies in the industrialised economies of the European Union and the United States (Spencer, 2004). In addition, Smutka et al. (2013) established that global sugar supply is regularly influenced by (a) sugar production volume, (b) the recent price in the former period, and (c) sugar reserves. The global demand on the other hand is mainly influenced by the increase in the global population, real income and price growth as well as prices of substitute sweeteners (Anon, 2006).

The determinants of the sugar price on the world market consist of the following:

(a) the sugar supply consisting mainly of refined sugar,
(b) sugar consumption (the demand for sugar),
(c) foreign trade in sugar, and
(d) the historic prices of sugar in previous periods (Rumankova and Smutka, 2013).

The growing demand for sugarcane for the fuel and energy industry has led to highly volatile sugar prices (Higgins et al., 2007). Government policies and changes in production, consumption and trade have also triggered world price volatility. Figure 2.1 illustrates the fluctuations in prices from 2005-2012.
Figure 2.1 Monthly world raw sugar prices in US cents per pound (after Illovo Sugar, 2014)

Major sugar producing countries similarly affect the trend in world sugar prices. Brazil for example, supplies half of its raw sugar to the export market. This dominance of the market greatly influences the international price of sugar traded (Anon, 2006; Rocha, 2013). The distorted world sugar price has created a desire for the South African Government to protect its local industry. Government support comprises intervention with tariff protection against low world sugar prices (Anon, 2011). Tariffs are used by many countries to ensure that the domestic price of a commodity remains higher than the world levels. The domestic industry thus enjoys greater profits as compared to the profits obtained under free trade (Pindyck and Rubinfeld 1995). The Swaziland and South African industries are sustained through a reference price tariff system based on the dollar. The tariff system only provides protection when the world price falls below a reference price. The Board on Tariffs and Trade (BOTT) and the Department of Trade and Industry (DTI) in South Africa have tasked themselves to the setting of an import tariff as a result of the distorted nature of the world sugar market (SASA 2013; Anon, 2013). It should be noted that in the absence of tariff protection, the S.A sugar industry will probably shrink significantly if not disappear in total.

According to the South African Sugar Industry Agreement, the South African Sugar Association (SASA) determines notional local market prices for brown and refined sugar as well as molasses. Anon (2013) define the notional price as, “the proxy (academic) price determined in the division of the net proceeds and is based on the volume of saleable sugar
sold.” Industry proceeds between millers and growers are calculated using this notional price. The notional price also provides the basis for redistribution of proceeds amongst millers in order to ensure an equitable exposure to world markets (Anon, 2011).

The SA sugar industry exports about 25% of its sugar to the world market at prices which are significantly lower than the domestic sugar price (SASA, 2013). The profitability of the industry’s exports to the world market is frequently influenced by an oversupply of global production due to subsidies (Smutka et al., 2012; Rumankova et al., 2012). Both local market sales and export sales are considered in the distribution of proceeds. The export market sales call for a redistribution of proceeds and this is effected via SASA to equally distribute exposure to the world market amongst millers and growers (SASA, 2013). The next section sheds more light on the division of proceeds.

2.2 The Division of Proceeds

The division of proceeds is the revenue distribution between millers and growers from sugar sales and sometimes cane by-products as well. In Colombia and Australia, millers keep all the revenue obtained from molasses sales, while Thailand and South Africa make an arrangement for this revenue to be distributed between growers and millers (Todd et al., 2004). Brazil acquires its revenue from ethanol and sugar sales, which is shared between growers and millers (Todd et al., 2004). In South Africa, the division of proceeds has been the means of sharing the industry’s earnings since 1936 (Jordan, 1992). Revenue sharing arrangements can either be based on a variable revenue sharing or a fixed revenue sharing configuration (Todd et al., 2004, Lejars et al., 2010). The growers’ share of the proceeds is then distributed to individual growers through a specific cane payment system used in that country or region (Ravnø, 2000).

2.2.1 Fixed revenue sharing

Fixed revenue sharing is performed through a predetermined percentage distribution between growers and millers. In this system, sugar prices are linked to the cane prices and millers’ margins (Todd et al., 2004). South African milling companies manufacture a variety of other products from cane processing and these include animal feeds and chemical products like alcohol and furfural (SASA, 2013). These are not included in the division of proceeds.
Instead, only the total sales from the export market and domestic market for molasses and sugar are accounted for by the South African Sugar Association. Once determined, administration costs are deducted and the net proceeds are distributed amongst millers, growers and refiners in terms of a fixed division of proceeds stipulated in clause 166 of the Sugar Industry Agreement (SIA) (Moor and Wynne 2001; Anon, 2013). In South Africa, the total revenue from sugar and molasses is distributed based on a fixed ratio of 35.6325% to millers and 64.3675% to growers (Sugar Industry Agreement, 2000; Le Gal et al., 2005). These ratios, however, vary from one country to another, depending on local circumstances. Some of the factors include whether the returns are shared from white or raw sugar, whether the revenue to be shared includes molasses and other co-products, and cane transport responsibility (Meyer et al., 2012). Figure 2.2 illustrates how the proceeds are distributed in South Africa.

![Diagram of proceeds distribution in South Africa](image)

**Figure 2.2** Distribution of proceeds in South Africa (after Anon, 2013)

This form of revenue sharing can reduce the incentive for better technical performance for the millers and growers. Todd et al. (2004) argued that sharing any additional sugar output with the mill in this arrangement may be a disincentive for the growers to improve cane quality. For the millers, sharing can also discourage them from improving their technical efficiency.
Another major issue is that mills receive a comparatively lower share of the revenue for any extra sugar produced, yet investment into equipment that aids in sucrose recovery is costly. This could discourage millers from focusing on investments that would improve sugar recovery (Todd et al., 2004). It is for this reason that millers channel their efforts towards low cost investments, rather than those that improve sucrose recovery rates. The existence of growers and millers as separate economic entities worsens conflicts concerning season length under this type of revenue sharing arrangement. Either party’s active pursuit of long-term season length strategy will be at the detriment of the other and may reduce total returns to the mill area (Moor and Wynne, 2001). In South Africa and Swaziland this type of revenue sharing agreement has led to the industry players becoming fairly slow to increase the value of the current raw sugar output (Todd et al., 2004).

2.2.2 Variable revenue sharing

Todd et al. (2004) indicate that in a variable type of revenue sharing, a standard level of factory efficiency and cane quality is set. The formula ensures that any additional improvement in cane quality beyond this point is exclusively to the grower’s benefit, and any improvement in sucrose recovery in the factory beyond the benchmark level benefits only the miller. This type of arrangement offers significant technical and economic advantages compared to fixed revenue sharing. Australia, Guatemala, Colombia and Mexico are examples of countries where this has been implemented with positive results. It is interesting to note that when this type of revenue sharing arrangement was introduced in Australia, in the 1980s, refined sugar production and capacity increased substantially. Variable revenue sharing is, however, more complex and expensive to administer (Todd et al., 2004). The following section describes how cane quality is incorporated into cane payment systems.

2.3 Cane Quality

Several authors have defined quality in various ways. Feigenbaum (1983) described quality as being about value while Crosby (1979) termed it conformance to standards, specifications or requirements. Parasuraman et al. (1985), on the other hand, described quality as being concerned with meeting or exceeding customer expectations. Sila et al. (2006) identified a link between product quality and price since he termed quality, “a function of the value received for the price paid for a product.” Most importantly, it becomes clear that quality is
an essential factor in the production of products across the supply chain and value-adding process of delivery (Sila et al., 2006).

Cane quality is an important factor which has the potential to increase sugar industry profitability (Legal et al., 2008). Payment systems are capable of creating incentives to improve cane quality, cane yield and milling performance (Lejars et al., 2010). In terms of quality, the systems are frequently based on sophisticated and complex formulae (Lejars et al., 2010). The formulae shall be described later in this review, but at this stage it is essential to understand the components of sugarcane as these influence the quality of the crop.

2.3.1 Sugarcane components

The cane plant comprises of the stalk, roots, leaves, a growing leafy top and the remains of dead leaves (trash). Sugarcane, as a raw material entering the mill, constitutes 70% water and 30% dry matter and the miller is interested in the stalk only (SASRI, 2000). Dry matter comprises all the solids which are: (a) fibre (b) sucrose, and (c) water soluble impurities. Fibre is the part of cane that is not soluble in water. It includes extraneous matter such as tops, trash and soil. Some of the fibre becomes part of bagasse, while the other exits as filter cake. Bagasse is the industrial term for the fibrous waste that remains after the crushing and extraction of sugar juice (Smouse et al., 1998). It is normally used to energise the mill, but can also be used in the production of electricity, paper and board as well as for furfural and animal feeds. A number of technologies are being developed that are expected to add considerable value in the future to sugarcane fibre (Wynne et al., 2009).

The non-combustible portion of the dry matter in the sugarcane, which may include sand, is known as ash. Ash and ethanol contents in cane are only occasionally measured in South Africa. The presence of ethanol signifies a breakdown of sucrose under anaerobic conditions, and can be used to indicate the degree of cane deterioration (SASRI, 2000).

The total soluble solids which are sucrose and water soluble impurities are termed brix. A refractometer is used to measure the brix in the cane juice. The term purity refers to the amount of sucrose within total soluble solids (brix) and is expressed as a percentage. A diagrammatic presentation of the components of sugarcane is provided in Figure 2.3 below.
Figure 2.3 The typical composition of sugarcane (after SASRI, 2000)

The major value element of sugarcane is known as sucrose (pol), a disaccharide. Sucrose can be measured using a polarimeter or saccharimeter and precisely by gas chromatography. It must be noted that Pol is essentially the same as sucrose. Most of the sucrose is mostly recovered as sugar while some is lost to bagasse, to final molasses, in the filter cake and some lost through undetermined losses. The other impurities or non-sucrose are processed into the saleable by-product called molasses (Wynne et al., 2009).

The most important factors contributing to a high recovery of sugar are: high sucrose levels, high purity, low fibre, and low non-sugars (Brokensha, 1996; SASRI, 2000). The level and nature of non-sugars impacts on the cost of processing and refining sugar. Polysaccharides, which include gums, starches and dextrans, can negatively affect raw sugar processing, and may lead to further problems in refining (Meyer and Wood, 2001; Eggleston, 2002).

Various cane quality measures have been used all over the world. These include Sucrose % cane (Suc), Estimated Recoverable Crystal % cane (ERC), Commercial Cane Sugar % cane (CCS), Recoverable Value % cane (RV) (Culverwell, 1992; Lejars and Azoux, 2010). The ERC and RV cane quality measures will be explained in Section 2.4.4 of this review.
2.3.2 Cane quality and the length of the milling season

The length of the milling season in its simplest form is defined by Moor and Wynne (2001) as a function of cane tonnage divided by average weekly milling capacity. This definition, however, is not conclusive as there are several other factors influencing the LOMS which include climatic limitations, agronomic practices, economic factors and industry structure (Hildebrand 1998; Moor and Wynne, 2001). Some of the above mentioned issues have an impact on cane quality, which unavoidably affects the LOMS. However, cane quality is only one component of all the factors affecting the LOMS and must be balanced against several other factors.

As highlighted earlier, good cane quality is characterised by high sucrose content and low fibre. It should be noted that sucrose content, non-sucrose content and fibre content of sugarcane delivered to the mill follow seasonal patterns (Salassi et al., 2002; Wynne et al., 2009). As season length is increased, the season’s average sucrose content tends to decrease. This is because additional milling takes place when sucrose levels are low at the beginning and end of the season (Masuku, 2009; Todd et al., 2004; Stray et al., 2012). Figure 2.4 demonstrates the changes in average sucrose content for different season lengths under a typical sucrose percent curve. The highest point on the sucrose curve coincides with the midpoint of the harvest season. From the diagram, the 5-month average cane sucrose content is noticeably higher than the 9-month average cane sucrose content, this is due to the shape of the sucrose curve (Todd et al., 2004).

![Figure 2.4 A stylised version of a sucrose curve and seasonal average sucrose contents for different milling season lengths (after Todd et al., 2004)](image-url)
Average recovery rates are usually also at their lowest at the beginning and end of the season. The main reason is that wet weather is more prevalent during these periods. Early and late summer milling encompasses many challenges which include:

- Higher fibre because cane is growing more profusely.
- Higher sand or soil content in the cane because of muddy conditions.
- Increased deterioration due to higher temperatures.
- Increases in non-pol content stemming from deterioration and profuse growing.
- More mill stops caused by rain and inaccessible fields.

The soil in the cane has a negative impact on the milling process and the high amounts of soil and non-pol lower sucrose recovery (Mann, 1996; Purchase, 1996; Grunow et al, 2007). Fig 2.5 illustrates how average recovery rates in the mills are affected by season length.

![Figure 2.5 A stylised sucrose recovery curve for a 5 month and 9 month season (after Todd et al., 2004)](image)

Having discussed the effect of season length on cane quality and subsequently, the relationship between average recovery rates and season length, it is important to discuss the types of payment systems used to distribute revenue to individual growers. Cane payment systems have a significant capability of aiding in the improvement of technical performance. The next section sheds more light on these systems with a special emphasis on South Africa.
2.4 Types of Cane Payment Systems

Once the revenue from industry proceeds has been divided between growers and millers, a cane payment formula is used to allocate income to individual growers. Several cane payment systems have been developed and are used in the world (Saranin, 1975; Burrows 1998, cited by Keerthipala and Thomson, 1999). They have evolved from flat rate payments where cane is paid based on a pre-set rate per tonne to more sophisticated quality based payment methods.

The types of cane payment systems that are discussed in this section are: (a) fixed cane price, (b) sucrose cane, and (c) recoverable value payment systems. Before this assessment, the characteristics of an ideal payment system are outlined in the section that follows.

2.4.1 Characteristics of an ideal cane payment system

According to Buchanan (1977), Wynne (2001) and Rein (2007), an ideal cane payment system includes the following:

- The system ought to advance the profitability of the supply chain as a whole.
- Growers and millers should split the proceeds from the sale of sugar on an agreed basis, so that they share the risk of variable sugar and/or ethanol prices.
- The system should be simple and easy to understand.
- There should be adequate reward to both growers and millers for their efforts.
- The system should be fair and equitable.
- The grower should be rewarded for his recovery of sugar from cane, good or bad, and should not be affected by the performance of the other growers who supply cane.

Having considered these characteristics, a review of the payment methods used in distributing revenue to individual growers is carried out in the following sections.
2.4.2 Fixed cane price payment system

A fixed cane price payment system is whereby growers are paid on a negotiated price per tonne of cane (Wynne, 2007). South African sugarcane growers were paid based on the quantity of sugarcane delivered to the mill at a fixed price per tonne of cane until the 1925/6 season (Wynne et al., 2009). In India, where sampling cane from every grower is not feasible, this type of payment system is still used. Pakistan and China are other examples of countries where the fixed cane price is still in use. The exact type of fixed cane price payment system varies within and between countries (Todd et al., 2004).

A widely-accepted form of this type of cane payment system was the "sugar in the bag" system. This system shared the sugar produced between the miller and the grower. The cane tonnage delivered in that season determined the growers’ share of the sugar (Saranin, 1975; Burrows 1998, cited by Keerthipala and Thomson, 1999).

In a study by Kroes and McFadden (2004), a decline in the Pure Obtainable Cane Sugar (POCS) was realised in Fiji due to the use of this type of payment system. An average POCS of 13.1% cane for the first five seasons of the Fiji Sugar Corporation’s existence between 1970 and 1974 reduced to 11.2% cane for the seasons of 1997 to 2002. This was directly due to the payment system, which offered no incentive for the growers to deliver good quality cane during that time. Yang and Ho (1977) also identified this type of payment system as the root cause of a decline in cane quality in Taiwan over a 15 year period. Being paid on weight encourages the grower to select a cane variety that is heavy, regardless of sucrose content (Kroes and McFadden, 2004).

There is no link with the actual sugar price in this system and it creates a scenario whereby the price risk between growers and millers is not shared. The fixed cane price also burdens the miller in an environment with high price volatility. Millers’ margins will be eroded during periods when the sugar price falls since the price variations are not filtered through to the growers (Todd et al., 2004).

The greater part of the revenue generated through quality improvement by a single grower is shared according to weight delivered amongst a number of growers. This system also
encourages burning and even rewards farmers who push the limits of extraneous matter, considering that it adds onto the weight of the cane (Kroes and McFadden, 2004).

The weaknesses of this payment system led to the development of a quality based payment scheme, known as the sucrose payment system. In the next section, a description of this system is provided.

2.4.3 Sucrose based cane payment systems

In this type of system, payment is made for the amount of sucrose or more precisely ‘pol’ in the cane at a fixed price per tonne of sucrose. In South Africa, the sucrose based cane payment system was introduced in the 1926/27 season and continued until 1999/2000 (Robertson and Donaldson, 1998; Wynne et al., 2009).

Growers are incentivised to maximise the quantity of sucrose delivered to the mill with minimal consideration of the recoverable sugar content of the cane (Brokensha, 1996; Moor, 2002). Depending on the cost of transporting the cane to the mill, growers in close proximity to the mill have the incentive to top higher than growers further away from the mill. Topping above the meristem reduces recoverable sugar in cane, but increases sucrose tons. As a result, the miller incurs the losses in the recovery of sugar. This is due to the fact that the sucrose payment system rewards growers and millers for sucrose content rather than the actual sugar recovered from the cane. Another weakness of this type of payment system is that growers do not fully bear the cost of extreme delays and, as such, lack an incentive to reduce delays for the period between harvesting and crushing. A major reason for this is that sucrose deterioration which is the basis for this cane payment system, is slower than the decline in recoverable sugar from the cane stalk (Moor, 2002).

Although in the literature there is mention of this type of payment system no reference could be found of any country that is currently still using it. In South Africa, as time progressed, it was noted that this type of payment system reduced the competitiveness of the sugar industry as cane quality eventually deteriorated. The SASA Cane Quality Task Group (CQTG) analysed the payment system, and made recommendations to improve it (Groom, 1999; Moor, 2002). This resulted in the use of another payment system termed Recoverable value (RV) payment system. The section below explains the RV payment system in detail.
2.4.4 The Recoverable value payment system

According to Peacock and Schorn (2002) and Wynne et al. (2009), the Recoverable Value (RV) payment system substituted the sucrose payment system at the start of the 2000/01 season. The recoverable value refers to the value of the molasses and sugar that is recovered from the sugarcane delivered by an individual grower. The RV cane payment system was developed by an industrial committee and is based on the Estimated Recoverable Crystal (ERC) formula by Van Hengel (1974). This formula recognises the effect of non-sucrose and fibre on sugar recovery.

In this system, growers are paid solely for the estimated sugar which is recovered from their cane (Groom, 1999). It is vital at this stage to understand that in the sugar recovery process, some sucrose is lost. Sucrose losses occurring within a mill are mainly during the extraction process when sucrose is lost to bagasse, to final molasses, in the filter cake, and through undetermined losses (Peacock and Schorn, 2002). Undetermined losses often include chemical (acid) and enzymic inversion reactions, which involves the microbial breakdown of the sucrose molecule (Eggleston, 2002).

The ERC formula is a factory performance measure which predicts the actual recovery of crystal realisable from a given supply of cane by a factory that is operating at a set point of efficiency. It is based on an uncomplicated set of cane quality parameters and signifies the real value of cane supplied to the miller. Van Hengel (1974) illustrated the relationship between the recovery of crystal and cane quality using Equation (2.1) below:

\[
ERC = aS - bN - cF
\]

where \( S \) is sucrose % cane, \( N \) is non-sucrose % cane, \( F \) is fibre % cane, \( a \) is the undetermined loss of sucrose from sugar production, including filter loss, \( b \) is the loss of sucrose from sugar production per unit of \( N \) and \( c \) is the loss of sucrose from sugar production per unit of \( F \).

The parameters \( a \), \( b \) and \( c \) are specific to each factory, although very similar for each mill (Murray, 2000). Brokensha. (1996) states that ERC is recommended in the estimation of the
quantity of sucrose in cane that will be recovered as sugar because it gives a clear indication of the cane constituents which reduce sugar recovery. In addition, it is straightforward and has a sound, practical technological basis.

In the RV formula, for payment purposes the \( a \) coefficient is omitted. This is because these undetermined losses in the factory involve the miller, and growers have no power to control such losses. In addition, the formula acknowledges that the final molasses produced by a sugar mill is of economic importance (Peacock and Schorn, 2002). The \( b \) coefficient also had to be modified to make provision for the value of molasses that arises from each unit of \( N \) delivered. The \( b \) coefficient is therefore multiplied by the ratio of molasses value per unit of \( N \) relative to the sugar value lost per unit of \( N \). This results in the RV \( d \) coefficient and the resultant RV formula is shown in Equation (2.2):

\[
RV = S - dN - cF \quad (2.2)
\]

where \( S \) is sucrose \% cane, \( N \) is non-sucrose \% cane, \( d \) is the relative value of sucrose which each unit of non-sucrose redirects from sugar production to molasses and \( c \) is the loss of sucrose from sugar production per unit of fibre.

The coefficients \( d \) and \( c \) are calculated for each season and are currently in the region of 0.4 and 0.02, respectively (Anon, 2013). The \( d \) coefficient is calculated monthly and is based on current sugar and molasses price estimates. The \( c \) coefficient is calculated once per annum and is based on a three season rolling average. The industrial prices of sugar and molasses vary from one month to the other and are beyond the individual grower’s control. This makes it difficult to compare a grower’s RV \% cane on a monthly basis in order to monitor agronomic performance since the RV\% is obtained from the industrial prices of molasses and sugar. Other cane quality parameters like sucrose, fibre and non-sucrose can however be monitored by the growers in order for them to determine any improvement in cane quality. (Anon, 2013).

After the division of proceeds between growers and millers, an RV price is calculated by the formula illustrated in Equations (2.3):

\[
RVP = \frac{G - L}{T} \quad (2.3)
\]
where $RVP$ is the recoverable value price, $G$ is the grower’s share of 64%, $L$ is the South African Cane Growers Association Levy (SACGAL) and $T$ is the tons of RV produced.

This is as required by the Sugar Industry Agreement (SIA), which states that “in each year, the price per tonne of recoverable value payable by mills to growers for cane deliveries shall be equal to the recoverable value of such cane calculated by dividing the total proceeds determined as payable by mills to growers in accordance with the provisions of clause 169 by the total tonnage of the recoverable value of cane delivered during the year concerned”. The RV price is used for payment to growers for every tonne of RV produced by each grower.

The recoverable value basis of cane payment creates the needed incentives for upgrading the quality of the sugarcane delivered to the mill. Growers seek ways to maximise sucrose production and concurrently minimise non-sucrose and fibre in their cane deliveries (Donaldson, 2002).

One drawback of the RV system is that it joins together payment terms and cane evaluation into one concept. The $d$ coefficient in the RV formula includes pricing terms for final molasses and marketable sugar. Furthermore, even if the real performance of the mill remains constant, the measured value recovery (VR, a measure of factory efficiency) of a sugar mill varies monthly and this results in changes in the relative prices of molasses and raw sugar (Peacock and Schorn, 2002). Hence, while VR rightly indicates the economic outcome of mill operations, it is an ineffective tool for assessment of the processing performance in a sugar factory. It has also been acknowledged that the ERC and RV formulae do not effectively account for the influence of the non-sucrose fraction in the cane on molasses production (Peacock and Schorn, 2002).

The seasonal patterns that sucrose, non-sucrose and fibre components portray have a major effect on RV and other quality based cane payments. As discussed in Section 2.3.2, recovery rates are lowest at the start and end of the season. This would lead to a very short harvesting season to optimise the amount of RV supplied to the mill. It is however not sustainable since the logistics associated with labour and machinery utilisation in cane haulage and milling operations extend the season towards 35 to 37 weeks.
Cane supply has to be regulated to avoid instances when the mill either has too much cane to process or insufficient cane. Rateable deliveries or use of the relative scheme are regulatory measures used to ensure cane supply consistency. The next section explains the two above mentioned supply regulatory measures.

### 2.4.5 Relative payment scheme

This payment scheme compensates for the growers who deliver cane at the end and beginning of the season. Wynne et al. (2009) defines relative payment as, “the adjustment of each grower’s actual RV% cane to accommodate for the time period in which the cane was delivered”. Relative payment was structured in order to control deliveries when payment is quality based. This scheme is a feature in a number of cane payment systems in countries like Australia, Mauritius, Jamaica and South Africa (Chin 1973; Todd et al., 2004). Relative payment was introduced in 1975/76 in Queensland as a method of discouraging growers from delivering cane when their cane quality is high (Buchanan, 1977; Legal et al., 2005; Wynne et al., 2009).

Wynne et al. (2009) indicate that the relative payment scheme exists in two forms, namely the additive approach and the multiplicative approach. In South Africa the additive approach compares individual’s growers weekly percentage average RV with the mill average for the season and the week as illustrated in Equation (2.4) below:

\[
RRV = \overline{RV}_g - \overline{RV}_w + \overline{RV}_s
\]  

(2.4)

where \( RRV \) is relative recoverable value percentage, \( \overline{RV}_g \) is a grower’s weekly average recoverable value percentage, \( \overline{RV}_w \) is the mill’s weekly average recoverable value percentage and \( \overline{RV}_s \) is the mill season average recoverable value percentage.

The system uses the formula above to even out the seasonal variations in sugar content. More money is made by the grower if he consistently outperforms the mill’s weekly average. The introduction of this system has diluted the incentive to harvest cane when sugar-levels are high (Stray et al., 2012).
It is possible that a grower can deliver cane with hypothetically zero RV%. In such an instance, with the additive approach they will still be paid. At this point the multiplicative relative payment approach mitigates this problem. Equation 2.5 illustrates this.

\[
RRV = \frac{\overline{RV}_g}{\overline{RV}_w} \times \overline{RV}_s
\]  

(1.5)

where \( RRV \) is relative recoverable value percentage, \( \overline{RV}_g \) is grower’s weekly average recoverable value percentage, \( \overline{RV}_w \) is mill weekly average recoverable value percentage and \( \overline{RV}_s \) is mill season average recoverable percentage.

The approach encourages each grower to deliver cane with an RV% that is as high as possible compared to the mill weekly average RV%. The unavoidable consequence, however, is that the mill weekly average rises to its best possible potential. This consequently optimises revenues that are distributed to both growers and millers. Wynne et al. (2009) note that this approach has not been used anywhere in the world so far.

Relative payment flattens the natural seasonal RV% pattern by comparing the grower’s deliveries to the overall mill area average. Todd et al. (2004) and Wynne et al. (2009) state a number of benefits associated with this scheme:

- Non-rateable deliveries do not prejudice smaller scale growers
- Haulage and harvesting logistics can be freely mobilised by large scale growers on their farms or estates.
- Growers can form haulage and harvesting groups, such as those done in Australia.
- Cash flows are smooth for growers who deliver rateably.
- Milling capacity utilisation is improved.

Wynne et al. (2009) highlight that the weakness of the relative payment system is that it conceals the fast drop in RV% at the beginning and end of the season. Both growers and millers become less sensitive to the effect of the fast drop in RV% and this weakens their determination to maintain a short milling season. Season length can be extended resulting in a lower season average RV%. A significant financial impact is realised on the growers when
the full mill area cane tonnage is multiplied by the mill season average RV\% loss. The problem is worsened by the delayed computation of the actual mill season average RV\% as well as the lack of accuracy in the interim season estimates of the mill season average RV\%.

2.4.6 Rateable deliveries

Mill Group Boards (MGBs) in South African sugar mills have the mandate to administer cane supply matters. The MGBs’ responsibility encompasses season planning and ensuring cane supply consistency to the mill. The MGB estimates the size of the crop and the capacity of the mill (Gaucher et al., 2004; Schorn et al., 2005).

Daily or weekly rateable deliveries are allocated to each grower, based on the grower’s crop estimate. The main aim of this system is to ensure full capacity utilisation of the mill. However, many growers fail to meet their targets, especially at the beginning and end of the season (Wynne, 2001).

2.5 Global payment formula

The fourth component of the payment systems, which is the global payment formula, is the same across countries. Total cane tonnage is used as the basis for payment (Lejars et al., 2010).

To summarise this review, an outline of the strengths and weaknesses of the different payment systems are tabulated in Table 2.1 on the following page.
Table 2.1 An outline of the strengths and weaknesses of the types of payment systems

<table>
<thead>
<tr>
<th>Types of payment systems</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Simple</td>
</tr>
<tr>
<td>Fixed cane price system</td>
<td>✓</td>
</tr>
<tr>
<td>Sucrose payment system</td>
<td>✓</td>
</tr>
<tr>
<td>Recoverable value payment system</td>
<td>×</td>
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</tbody>
</table>
3. DISCUSSION AND CONCLUSIONS

Cane payment systems are complex and incorporate different components which contribute to the sustainability of the sugar industry. Each component has its own effect on the overall decisions to either expand or shrink the industry. In South Africa, the sugar industry contributes significantly to the economy and needs to remain internationally competitive. The different components of the payment systems are sugar prices, the type of revenue sharing agreements, the definition of cane quality parameters and the global payment formula.

Growers and millers, despite their conflicts, have an overall aim of generating profit from their respective production processes. Sugar prices and the type of revenue sharing arrangements determine the total revenue due to both the growers and millers. These two components significantly affect the profitability of the industry. It was outlined in the literature that the domestic sugar market is exposed to a wide range of interventions from the government. Sugar consumption levels, production and even trade are susceptible to governmental controls in various countries. The profitability of the South African’s industry’s exports to the world market is continuously influenced by global overproduction induced subsidies, leading to highly distorted prices.

The division of proceeds arrangement can demotivate growers and millers towards better technical performance. Research has shown that numerous technologies are currently being developed that are expected to add significant value to sugarcane fibre. Presently, in South Africa, other sugarcane co-products such as animal feeds, chemical products, paper and furfural are not considered in the division of proceeds. The fixed revenue sharing arrangement may become a contentious issue as a result of these other by-products. In Australia, research has shown that refined sugar production and capacity increased substantially when the variable revenue sharing arrangement was introduced. Perhaps in South Africa, this type of revenue sharing arrangement should be considered to incentivise growers and millers to improve technical efficiency.

The type of payment system has a major influence on sugarcane quality. The literature review revealed that there are three types of payment systems namely: (a) the fixed cane price payment system, (b) the sucrose based payment system, and (c) the recoverable value payment system.
payment system. Of the three payment systems, the fixed cane price payment system has been shown to lead to a deterioration in cane quality. Countries like Fiji and Taiwan reported a reduction in cane quality after usage of this type of payment system over a 15 year period. This has resulted in the majority of countries adopting quality based payment systems (sucrose payment system and the recoverable value payment system). These do not really possess all the characteristics of an ideal payment system, but they do encourage cane quality improvement. The recoverable value payment system is more advanced as it measures the value of sugar that can be recovered from the cane. An improvement in cane quality has positive implications for the sugar industry. Some commercial buyers consider crystal shape, ash, filterability, colour and reducing sugar levels as some of the quality parameters when purchasing raw sugar.

The relative scheme has been in existence since 1975/6 in Queensland and was introduced to compensate growers that deliver cane at the beginning and end of the season. It is a feature of a number of cane payment systems in countries like Mauritius, Jamaica and South Africa. It evens out conflicting objectives in season length by the grower or miller. However, the relative payment approach can partially disguise the rapid drop in RV% at the start and end of the season. This can have financial implications when the mill season average percentage loss is multiplied by the complete mill area cane tonnage. A high degree of inaccuracy in mill season average RV% estimates and the delay in calculating the actual mill season average RV% exacerbates the situation. The consequences of this are that the mill season length can be extended due to the lack of urgency to keep the season length short.

In conclusion, the nature of the cane payment system indirectly affects the length of the milling season. Different components of the cane payment system have the potential to incentivize either growers or millers to improve technical efficiency. This could lead to increased cane production and quality on the part of the growers or increased milling capacity and efficiency on the part of the millers. Both aspects are functions of the milling season length and adjustments made can possibly shorten or increase mill season length. However, it must be noted that several factors determine the LOMS and the nature of the cane payment system is only one.
4. PROJECT PROPOSAL

This study forms part of research that proposes the development of a model to determine the optimal mill season length for different mill areas in South Africa. The appropriate milling season length has been a contentious issue for many years. Several models have been employed to determine the optimal season length. However, despite the range of research in this area, there still has been no appropriate solution to some of the issues.

4.1 Rationale

The Length of the milling season (LOMS) refers to the duration of time required to complete all harvesting and crushing processes in a sugar producing area. Over the years there have been heated debates on the optimal length of the milling season which dates back to the 1930s (Moor and Wynne, 2001). In South Africa, milling season lengths at various sugar mills became the main focus in the late nineties (Bezuidenhout et al., 2012). The debate will continue because growers and millers exist as separate economic entities who pursue different season length objectives. To the grower, the milling season length should be short to maximise sucrose content, while to the miller it should be long enough to maximise mill capacity utilisation (Lejars et al. 2008; Le Gal et al. 2004). These conflicting season length objectives are sometimes worsened when both parties aim to maximise their individual returns.

Mill season length is determined by various factors which include the agronomic practices, climatic conditions, cane quality variations, harvesting costs and the nature of the cane payment system (Hildebrand 1998; Moor and Wynne, 2001; Higgins and Muchow, 2003). Diversions though not mentioned in literature have become an issue to consider as affecting season length. Moor and Wynne (2001) and Wynne and Groom (2003) developed models using linear programming and economic modules to determine an optimal milling season. These models aimed at moulding a situation whereby both growers and millers benefited. Inefficiency problems in the system were to a lesser extent resolved using these models. However, these models did not incorporate the nature of the cane payment system as a factor yet it plays a pivotal role in the LOMS.
According to Moor and Wynne (2001) the LOMS incorporates two factors which are cane tonnage and mill capacity. The milling season length can be theoretically calculated using these factors. For example, if a sugarcane area that produces three million tons per season, with the mill crushing a maximum of 10 000 tons a day, the LOMS will be 300 days long. However, the formula alone is not sufficient to define mill season length. The factors highlighted in the previous paragraph also influence the milling season. In most cases, this results in sugar industries experiencing erratic milling seasons.

Considering that the South African sugar industry is facing challenges to remain competitive internationally, there is need for additional research on optimal season length (Le Gal et al., 2004). To this effect, this particular research focuses on one of the major mechanisms in the industry that has the potential to affect industry profitability, the cane payment system.

4.2 Project Aim

The aim of this research is to propose viable LOMS options for the two milling regions in South Africa (Umfolozi and Union Co-op Limited (UCL)). A stochastic model will be constructed for Umfolozi and UCL which will include a range of other important factors, after which various scenarios could be executed for each milling area. The results should provide a solution as to the appropriate season length for the milling region. The expected output is an increase in the supply chain efficiency leading to a general increase in industrial profitability.

4.3 Objectives

The specific objectives of the research are:

(a) To conduct a literature review on the components of cane payment systems and outline their effect on industry profitability

(b) Identify the main issues affecting mill season length at UCL and Umfolozi through a mill area survey.

(c) Input the factors into the LOMZI model using formulated assumptions, trends and relatively simple algorithms within a stochastic simulation framework.

(d) Evaluation of the model outcome and critically analyse other additional benefits and limitations to the results.
(e) Give feedback of the results obtained in the milling region as well as recommendations.

4.4 Methodology

A relevant literature review will be carried out after which the researcher will focus on two sugar mills which are Umfolozi and UCL. Various stakeholders will be selected and these include amongst others, the mill management, cane growers, local economists, mill board members and contractors. Interviews will commence sometime in April to aid in the information gathering process. The information will mainly comprise of factors affecting the milling season, specifically in that area.

After the identification of the factors influencing milling season length, a Theme Network approach developed by Bezuidenhout et al. (2012) will be used to synthesise the data. The next step will involve modelling and calibrating important relationships between different factors in each sugar milling area. At this stage, the researcher will give feedback to the relevant stakeholders. Together they will reflect and discuss the outcome of the results. This enables an accurate review of the issues to be considered in the LOMS assessment in the milling area.

A stochastic model incorporating the LOMZI modelling approach (Boote, 2011) will be customised for the specific mill. It will comprise factors that were previously not included in the LOMZI, such as, the cane payment system. The model will be applied for each of the mills, Umfolozi and UCL. Several scenarios could be simulated for each sugar mill area depending on what is applicable in that mill area. An appropriate milling season length for UCL or Umfolozi will be determined using the results of different scenarios.

An account of the results obtained will be presented to the milling area. Limitations and additional benefits that were not simulated will be included in a final synthesis. At the end of this research, it is expected that the stakeholders in the milling area will be provided with a detailed and customised account of issues as well as recommendations. Additionally, they will be aware of the sensitivities and associated costs of the different factors that presently direct their specific system.
4.5 **Resources Required**

A personal computer, a desk, and office space, as well as travel and telephone expenses are the resources required for the project. The funds for the project have been sourced and are administered by Professor Carel Bezuidenhout. The expected time period for the project is approximately 18 months (from January 2014 to July 2015). Table 4.1 outlines the project time-scale.

Table 4.1 Gantt chart depicting project time-scale

<table>
<thead>
<tr>
<th>List of Activities (Jan 2014-Jul 2015)</th>
<th>Month</th>
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<tr>
<td>Literature review and project proposal draft</td>
<td>Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun</td>
</tr>
<tr>
<td>Literature review and project proposal</td>
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<tr>
<td>Project proposal presentation</td>
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<td>Development of the model</td>
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<td>Validate the model</td>
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<td>Sensitivity analysis</td>
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<td>1st draft submission</td>
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<tr>
<td>Final thesis submission</td>
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