VALUE CHAIN RESEARCH IN SUGAR—LESSONS FROM THE PAST AND OPPORTUNITIES FOR THE FUTURE

By

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Abstract

Many agricultural industries in Australia consider value chain research a key to improving efficiencies, responsiveness and ultimately market competitiveness. In the Australian sugar industry, value chain research has expanded significantly in the past decade. We have reviewed 16 past and current R&D projects from Australian and overseas sugar industries, which primarily focused on the sectors connecting the farm to the mill. The review has shown that value chain research methodologies have improved considerably in that time, as has industry understanding, acceptance and adoption of the opportunities. Several challenges are also highlighted, including the need to evaluate hard-to-quantify benefits that value chain research produces, accommodate influences from events external to the project and address the high cost of conducting and implementing some value chain research.

Introduction

This paper presents a review of value chain research conducted in sugar industries in Australia and other countries, focusing mainly on advances made in the past 10 years. We aim to help improve and re-focus value chain research for the Australian industry, to increase benefits that will be obtained from research in this field. This paper also formulates challenges for the industry to consider in the next phase of its value chain research and development.

It is important to have a clear definition of value chain research. We consider a value chain project (or issue or opportunity) as one that changes decision making in the value-adding processes in more than one sector of the chain, and which generates improved outcomes for the chain participants and value to the ultimate consumer (Mentzer et al., 2001). For example, we regard optimising season length as a value chain issue because a change in season length requires alternative operational/tactical planning in the growing, harvesting and milling of cane, which can affect the value of the intermediary and final products. Other issues, such as harvest best practice and new varieties have often been considered under a value chain banner. While they lead to benefits to more than one sector of the industry chain (e.g. increased yields and adjusting operations to handle these yield changes), the changed decisions take place in one sector only so we do not consider them to be value chain issues.

Value chain research in the Australian sugar industry has evolved considerably in the past decade. This evolution is illustrated in Table 1, which summarises the main Australian and overseas sugar industry projects conducted from 1997 to 2005. Projects are arranged in ascending order of start date. Projects 1 to 11 are from the Australian sugar industry, while 12 to 16 are from other sugar industries.
Table 1—Summary of value chain projects conducted in the Australian and overseas sugar industries in the past 10 years, giving the issues addressed and sectors considered (F-Farm, H-Harvesting, T-Transport, M-Milling, S/M-Shipping and Marketing). Note: Projects are listed in chronological order of project start time. See Higgins et al. (2005) for a more detailed description of these projects.

<table>
<thead>
<tr>
<th>Project title</th>
<th>Main issues addressed</th>
<th>Sector</th>
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<tbody>
<tr>
<td>Domestic</td>
<td></td>
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<tr>
<td>Implementation of Improved harvest/transport system utilising developed optimisation models.</td>
<td>Harvest and transport logistics</td>
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<tr>
<td>Sugar North/Operations Research group</td>
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<td>✔</td>
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<tr>
<td>Harvest scheduling for increased sugar production. CRC Sugar Program 3.2</td>
<td>Logistics to increase yield</td>
<td>✔</td>
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<tr>
<td>Implementation of the Rocky Point strategic plan as a model for local area industry development. SRDC BSS247</td>
<td>Regional expansion</td>
<td>✔</td>
</tr>
<tr>
<td>Integrating and optimising farm-to-mill decisions to maximise industry profitability. SRDC CSE005</td>
<td>Harvest and transport logistics and rationalisation</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A regional partnership approach to developing a sustainable sugar cane system. SRDC MAS001</td>
<td>Logistics, rationalisation and diversification</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>Integrated value chain scenarios for enhanced mill region profitability. SRDC CSE010</td>
<td>New markets through co-generation</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>A co-operative systems model for the Mackay regional sugar industry. SRDC MSA003/Mackay Sugar</td>
<td>Information transparency, new payment formulae</td>
<td>✔ ✔ ✔</td>
</tr>
<tr>
<td>Scheduling at the milling-marketing interface of the Australian sugar supply chain. QSL/CSIRO</td>
<td>Logistics</td>
<td>✔ ✔</td>
</tr>
<tr>
<td>Achieving world’s best practice harvesting and transport costs for the NSW sugar industry. SRDC NSC006</td>
<td>Logistics and expansion</td>
<td>✔ ✔</td>
</tr>
<tr>
<td>Adoption of optimal season length for increased industry profitability –SRDC BSS264</td>
<td>Logistics and rationalisation</td>
<td>✔ ✔ ✔</td>
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<td>Overseas</td>
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<tr>
<td>Optimisation of harvest and crop renewal in Brazil. Barata et al. (1998)</td>
<td>Harvesting logistics</td>
<td>✔ ✔</td>
</tr>
<tr>
<td>Integer programming for sugarcane factory supply allocation in Indonesia. Yosnual and Supsomboon (2004)</td>
<td>Supply chain logistics</td>
<td>✔ ✔ ✔</td>
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</table>

There are some notable trends in Table 1. In recent years, there has been an increase in the breadth of the sectors considered. Thus projects 6–9 involve more sectors than projects 1–3. Another trend has been the strong emphasis on the harvesting and transport sectors of the chains evident in both the Australian and overseas projects.
Benefits and success

Logistical opportunities

Harvesting and transport provide more logistical challenges than do the other sectors upstream of the mill, and hence have attracted a large amount of R&D as illustrated by the number of projects in Table 1. Many opportunities in these sectors (such as harvester/siding rosters, time window of harvesting, just-in-time scheduling) have economic benefits that are easy to quantify, and some can be addressed with some of the more traditional supply chain methodologies used in manufacturing and mining systems. These types of opportunities can be adopted with less extensive change to current value chain arrangements than other opportunities for increasing value chain efficiency, such as harvester rationalisation and business integration. Such logistics projects have shown potential economic benefits between about $1.00 and $2.50 per tonne of cane (Higgins et al., 2004; Grimley and Horton, 1997), as well as up to a 95% reduction in bin delivery delays, depending upon the level of operational, tactical and strategic change.

Over the past five years, there has been a rapid increase in the adoption of improved logistics at the harvesting-transport interface, particularly for siding rosters or increased time window of harvesting (Mackay, Mossman, Mourilyan, Maryborough). Two regions, Herbert and NSW, plan to invest in improving transport infrastructure, with assistance through Government funding. In NSW, modelling work (Prestwidge et al., 2006) has suggested harvesting cost savings of $1 476 000 over 5 years (across the three mills) from investing in additional loading pads at optimal locations.

In the Herbert, a recent analysis (Higgins et al., unpublished data) has shown an average reduction in harvesting costs of $0.27/tc (or a predicted $1 350 000 per year given a 2005 size crop) from reduced waiting time for bins and larger sidings. There is also the potential for significant savings in transport costs in this region from an estimated 60% reduction in shunting times and spreading the demands on locomotives across the 24 hour day.

One project (9) aimed to improve logistical efficiencies at the milling marketing interface of the sugar chain, particularly focusing on the assignment of ships to the terminals and scheduling the type of sugar that each mill produces each day. The modelling work predicted a reduction in costs of $5.5 m per year when applied to the Australian industry for years 2002–2005 (Higgins et al., 2006). The cost of the project ($18 000) was low compared to logistical projects upstream in the chain, mainly due to Queensland Sugar Ltd being the only decision maker that the project team needed to work with. We recommend that the industry learns of the potential benefits from value chain modelling down-stream of the mill.

Non-logistical opportunities

There have only been three projects (4, 7 and 8 from Table 1) addressing non-logistical issues such as increasing information transparency, building new markets, or business process integration. These types of projects are beginning to have success in the Australian sugar industry. An excellent example is the Co-operative Systems project (project 8) in the Mackay region, which has led to the implementation of a new cane payment formula in the 2005 harvest season, which better promotes growing region-wide revenue and dividing revenue more equitably. The project has also led to a heavy investment in information technologies to more effectively collect, store and communicate information to growers and harvesters. An aim is for better decision making towards a more integrated chain. The use of information technology to improve chain decision making has considerable future potential in the sugar industry. Other agriculture and food commodity industries have invested in information technologies to improve chain wide decision making and integration, and the literature has several examples of success stories. A couple of examples relevant to the sugar industry are worth noting. A keynote paper by Thysen (2000) gave a description of
how information technology has led to greater transparency of decision making in the farming sector, and greater product traceability across the chain for improved quality control. Salin (1998) shows how inter-business information networks can be used to allow information sharing across businesses, leading to better management of performance across the businesses within the chain.

There is limited published material highlighting non-logistical value chain work in the Australian sugar industry, though Milford (2002) highlights priority areas, particularly in business integration, and Thorburn et al. (2006) explore the value chain impacts of cogeneration of electricity. Other agriculture and food commodity chains have focused on non-logistical opportunities in business integration, response to price signals and product traceability. Good examples are in Shrivastava et al. (1998) for the swine industry, Verbeke and Viaene (2000) for beef, and Phillips (1998) for canola. The work in other industries highlights that addressing the non-logistical issues first provides an improved platform for even greater efficiency gains from subsequent logistics improvements.

Feedback from industry participants of past projects

In order to obtain a better understanding of people’s experience with, and attitudes towards, value chain research in Australia, interviews and focus groups were conducted with people from the farm, harvest, transport and mill sectors in the Herbert and Maryborough regions. In Maryborough, a focus group of five participants representing growing, harvesting and milling was used, plus two interviews of two participants (growing and harvesting).

In the Herbert, a focus group of seven participants representing growing, harvesting and milling was used, plus two interviews involving four participants. These regions were selected to represent the contrasting chains (e.g. road vs rail transport, single vs multi-mill) and differences in experiences in past value chain projects (a relatively long involvement in Maryborough and a relatively recent involvement in the Herbert). The topics covered in the interviews and focus groups included: definitions of value chain research, achievements, strengths, limitations and success factors of value chain research, areas for improvement and future opportunities for value chain research. A summary of key findings is as follows:

- There were contrasting attitudes towards value chain research in the Herbert and Maryborough regions, mainly due to their experience and exposure in the value chain projects.
- Some participants noted that value chain research had achieved some improvements in communication and cooperation within and between industry sectors in the Herbert, which was identified as a key strength.
- Most participants in Maryborough felt that the value chain research in their region had increased their understanding of their industry system.
- When asked to identify future opportunities of value chain research, there was diversity in the feedback from participants in the two mill regions. The commonly known opportunities were mainly suggested, such as ethanol production and harvesting pricing, though the Maryborough participants did emphasise value-adding opportunities such as bio-plastics. Several non-value chain issues were also suggested, which suggests the need for increased understanding of value chain research across the industry.

Participants from the Herbert and Maryborough identified the following factors as necessary ingredients for successful value chain research:

- Each industry sector understand the factors and drivers influencing the other sectors and the connections between these.
- Value chain models should be available to provide and aid an increased understanding of these factors and drivers.
- Value chain research be region-driven with committed relationships between
industry sectors that are transparent, honest and open and involve the appropriate people.

- Value chain research needs to be seen as a partnership between the industry sectors and researchers and have clear communication.

Based on the analysis of people’s experiences of and attitudes towards value chain research in these two mill regions, there are some lessons that have emerged about value chain research. These are:

- The social and historical context of value chain research has an important influence on the process and outcomes of such research.
- Value chain research should pay attention to both technical and social dimensions in order to find an appropriate balance between innovations in technical procedures and novel social and organisational arrangements.
- Processes such as conflict resolution, social learning and negotiation should be a part of value chain research.

Lessons for the future

This section focuses on several key common messages from the projects that the Australian sugar industry (and its R&D providers) can learn from.

All projects have been influenced by events external to the project. Often the priorities in the region evolve and influence the priority of some of the project objectives, as seen in the integration of harvesting/transport in the Mourilyan region (project 5) which progressed to a three-region plan to include Babinda and South Johnstone. In some instances, there has been the availability of additional funding after the start of the project (and not foreseen at the project start) to enable adoption (e.g. siding upgrades in the Herbert and building new loading pads in the NSW region), particularly in terms of funding from the federal government to implement infrastructure changes.

Improvements in relationships between industry sectors have led to more adventurous value chain opportunities to be addressed. This has been notable in the Mackay region with the recent Co-operative Systems project, compared to the earlier harvest scheduling project (2). The Herbert (projects 5 and 11) region is currently exploring optimal season length opportunities, harvester partnering, and siding rostering. Feedback from many of the 80+ participants at season length optimisation workshop (hosted by BSES Herbert) held at Ingham on 31st January, was that it would have not been possible to hold such a successful workshop 5 years ago.

Many projects have produced hard-to-quantify benefits and legacies, which are not well defined and are difficult to describe using a quantitative evaluation. These include the local industry developing an increased understanding of their own value chain and increased co-operation between millers and growers. The section ‘Feedback from Industry Participants’ highlights these types of benefits that have been generated. Some projects have influenced other regions to start looking at their own chain. This is particularly evident in the harvesting and transport logistics opportunities first considered in the Mossman and Mourilyan regions, which are now being expanded/considered in the Herbert, Maryborough, Mulgrave, South Johnstone, Babinda, and Tully regions, as evidenced by SRDC projects and proposals developed in 2005 and subsequently.

The integrated value chain scenarios project (7) produced unforeseeable outputs and outcomes. The outputs included the value chain framework model (Thorburn et al., 2006) and improved capacity for value chain thinking (SRDC CSE010 final report). It was not a ‘silver-bullet’ project, as many people hoped for, and the benefits are larger than what can be objectively evaluated. For example, the project stopped the Maryborough region from making a costly investment in co-generation with probable negative outcomes for the mill region, and the process gave rise to a regional green cane trash blanketing scenario as a
possible alternative. Participants in the process noted that they had a much better understanding of the impacts of changes in one sector of the value chain on other sectors, and had also developed much greater trust within the working groups. Future projects will need to take into account that these types of intangible benefits may be achieved and are extremely valuable.

_Compared to improving logistics, it is more difficult to provide an objective evaluation (i.e. supported by factual data) of value chain projects leading to improved information technology and business integration._

It is difficult to isolate economic and social improvements in chain performance from those attributed from other changes in the chain. This could be an issue for the Australian sugar industry in assessing the benefit to cost ratio for investing in such value chain projects. Hoek (1998) and Cooper et al. (1997), among other authors, have argued the need for methodologies and metrics to measure improvements in the economic and social performance in value chains.

The scientific and technical modelling in value chain research has been very complex and expensive. From a modelling and computational perspective, it is difficult to capture decision making between the farming and milling sectors (inclusive), while considering scales of interactions at a paddock and a mill level simultaneously. This has been done using multi-agent approaches (Thorburn et al., 2006), which aimed to linked up existing sugar industry models representing each of the sectors. While the approach taken in this work is generally applicable, the model was built specifically for analysing the impacts of whole-of-crop harvesting in Maryborough and Burdekin. Analysis of other issues would require assembly of another agent-based model.

What would possibly be more attractive, but require a large amount of further investment/development, is a more generic tool that can address a wide range of value chain opportunities. To do this, a value chain model would ideally be modularised and designed to capitalise the use of component models. A modularised modelling approach is expensive, e.g. the farming system model, APSIM (Keating et al., 2003), the result of investment of millions of dollars over a decade or more. In forestry, which has many logistical and spatial analogies to sugar, modularised value chain models are well developed (see Frayret et al., 2005 for examples and a review) and used within the industry.

Supply chain research in forestry is very extensive compared to sugar (Sjöström, 2001) and it is worth considering why this is the case. In forestry, a major investment in value chain R&D is easily justified for two major reasons. Firstly, the global economic value of forestry and forest product is much larger than sugar. In the United States alone, the total value of solid wood shipments was US$147 billion in 1997 (Hodgetts and Freese, 2000). Secondly, the production sector of forestry chains has control or a strong influence on decisions (e.g. logistics, harvesting timetables) made upstream of the production sector (Carlsson and Ronnqvist, 2005). This significantly reduces the amount of change management required to improve supply chain efficiencies.

The projects reviewed have shown a rapidly growing industry acceptance and desire to employ a rigorous value chain modelling approach in preference to a simplified analysis that misses many of the cross-chain impacts. This was highlighted in the ‘Feedback from Industry Participants’ section.

An increased industry understanding of the impacts of co-generation of electricity in Maryborough (project 7) has led to the industry participants (and research team) using the tools to explore further value chain ideas (e.g. partial trash removal, operational logistics plans for transporting full trash to mill). In NSW (project 10), increased understanding of the consequences of optimally locating new loading pads has led to exploration upgrading some existing loading pads instead of just adding more.
Projects in other sugar industries

Value chain issues are being considered by other sugarcane producing countries as well. For this paper, an overview of overseas value chain research was restricted to recent published literature available in English. While our current perception, in general, is that value chain research from other countries is not broadly applicable to the Australian sugar industry, valuable supply chain tools may emerge which can be adapted.

The South African sugar industry is pursuing value chain research with some success. Their value chain work to date has focused largely, but not exclusively, on improving the quality of sugar cane by reducing the time between harvesting and milling, and by developing more efficient interaction between harvesting and transport (Perry and Wynne, 2004; Hansen et al., 1998). Using simulation methods, up to a 40% reduction in duration between harvesting and milling could be achieved by coordinating harvest/delivery activities with total cane delivered to the mill (Hansen et al., 1998).

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The Sugar Logistic Improvement Programme (SLIP) modelling project (Perry and Wynne, 2004) could prove valuable in terms of concepts transferable to an Australian context. Some elements of the model development might be adapted for Australian sugar supply chain modelling. The capability of the Arena simulation system to generate the general model from flowcharting could expedite the capture of specific characteristics of individual mill regions. These preliminary results show the potential of their whole-system modelling approach. This investigation confirms the value of simulation methods in modelling the complex interactions of the sugar supply chain. However, it does not go far enough downstream to include end products nor economic value of the processes. Thus there is no way to tie the current functioning of the system to some meaningful optimum.

The value of this research to the Australian industry includes the potential establishment of standards for sectors and sugar supply chains. This tool would be valuable in encouraging adoption of efficient standard practices across industry. It would also be valuable in the rationalisation process for determining how mill regions should be changed. The Indonesian value chain work (Yosnual and Supsomboon, 2004) had little applicability to Australian needs. The linear programming work they conducted was highly sensitive to operations, such as cutting and loading, and assumed unlimited transport. Furthermore, due to low mechanisation and poorer scheduling in their market, such improvements could improve cane quality and sugar yields. However, one would expect the value for Australia to be lower given its much higher logistical efficiencies.

Summary and future directions

The following important conclusions are drawn from the review of past projects in this paper:

- R&D methodologies and knowledge base have been improving with newer projects.
- The sugar industry understanding and acceptance of value chain opportunities has been increasing.
- Evaluating the hard-to-quantify benefits will be an on-going challenge, though it is important for future investment.
- The scientific and technical modelling in value chain research is complex and expensive. Despite the market in the Australian sugar industry being relatively small compared to forestry, the complexity is not less.

We expect value chain research in sugar to progress quite rapidly over the next 10 years in terms of industry-wide adoption of technologies currently being considered in some regions, thus decreasing the variability of value chain structures/systems between regions. We expect that innovation of new value chain solutions in some regions will be accepted by other regions.
It is likely that the Co-operative System's project in Mackay aimed at improving information availability for improved chain-wide decision making will be a concept examined closely across the industry. Initiatives towards business integration are likely to gain momentum over the next 5 years, and there is already evidence of this in the harvesting sector through harvesting group partnering (e.g. Plane Creek, Mackay, Herbert). It is likely to be extended to business integration across sectors, more likely at the harvesting-milling interface rather than the grower-harvester interface, providing a chain structure closer to Australia’s international competitors. It is difficult to forecast future research opportunities, other than through looking at what is happening in other industry value chains. Some research needs being considered by other agri-industries that were identified at a CSIRO agriculture supply chain workshop (14th September 2005, involving 18 participants from sugar, viticulture, horticulture, beef, textiles and research) include: forecasting impacts of global climate change; forecasting markets well in advance and taking account of demographic and consumer insights; matching requirements across the chain and chain traceability; developing products that give a competitive advantage for Australian producers; eco-labelling; adding value to the livestock industry from wastes.

The first five points may not be possible in the Australian sugar industry at the moment, though that may change as the industry adopts new technologies and becomes more integrated across its sectors. The participants at the workshop also noted the need for continual improvement in logistical efficiencies. For increased investment in future value chain research/opportunities within the Australian sugar industry, there will need to be a more objective evaluation of the full range of benefits to chain participants in some existing projects. Since value chain research is expensive, improved objective evaluations will lead to an increase in tangible benefits and a decrease in hard-to-quantify benefits, thus increasing the identifiable benefit-to-cost ratio for new value chain research. Objective evaluation of improving supply chain performance is challenging (Hoek, 1998) and will be particularly difficult in the Australian sugar industry due to the social structures and high systems uncertainty.

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