Background

The Canadian forestry sector is facing significant changes that are disrupting its global competitive position. A strategic transformation is needed, driven by changes in the current business model through (a) process and product diversification (“technology disruption”), and (b) long term competitive strategies definition supporting product planning and new business model development (“business disruption”). Business disruption must be executed (a) in the short term through implementing novel supply chain (SC) operating policies and exploiting production flexibility, and (b) in the long term through employing advanced ERP and other decision making tools for SC management. In the short term and in order to mitigate the risks against market volatility, companies should focus on improving their margins through applying margins-based SC operating policy and better exploiting the process capability for flexible production via using detailed knowledge of the process and its cost structure, and then utilizing advanced SC optimization techniques for product planning over different time horizons and for identifying the trade-offs between product orders and anticipated supply and demand. This underlines the importance of advanced cost accounting systems that are capable of reflecting the cost of decisions at the decision making level, and which are essential for short term decision making activities. For the longer term, companies should make their strategic SC–related decisions using a bottom-up approach, i.e. designing/redesigning the SC based on the impact on the tactical and operational activities. These two approaches to short-term and longer-term aspects of biorefinery implementation, i.e. the margins-based approach and bottom-up approach, imply profound changes in the way forestry companies do business today.

Objectives

The overall objective of this project is to develop a SC-based analysis framework that enables decision-makers to systematically analyze forest company biorefinery strategies from a SC perspective, for biorefinery strategic design. These biorefinery options will be based on the specific company profile, biomass and product price forecasts, the assets of the company’s existing SC, the potential of the company’s SC for biorefinery implementation given the latest developments in biorefinery technologies, and
eventually, the SC potential for partnership with another company. The developed SC-based methodology examines these options, and reveals the value that can potentially be unleashed by the realization of different biorefinery options.

Specific issues to be addressed include the following:

- How can the product portfolio definition, process design, and techno-economic studies be integrated with SC design?
- What level of flexibility is beneficial for a biorefinery manufacturing system? How can this level be quantitatively estimated?
- How will this flexibility of the biorefinery manufacturing system change for the cases of commodity products and value-added products?
- How must the SC network be designed at the near-term strategic level, to be able to serve the tactical and operational activities?
- How can the designed flexibility be exploited at the tactical and operational level?
- How can this flexibility be integrated with the contractual flexibility to maximize the value chain performance?
- How can a scenario-based approach be applied for the strategic design of the forest biorefinery SC? How can this approach be utilized for the incremental implementation of the forest biorefinery?

Proposed Approach

A margins-based operating policy exploits the capability of the manufacturing system for flexible production at the operational level in order to maximize the margins at the tactical-operational planning level. A SC-based analysis using this policy can demonstrate how flexibility should be managed and exploited at the operational level to maximize SC profit. At the near-term strategic SC design level, flexibility must be designed in a way that ensures the best performance at the operational level, i.e. maximize the SC profit. From a SC design perspective, SC network must be designed so that it enables the operating policy to exploit flexibility. In other words, the SC network should be designed in a way that it "serves" managing and exploiting the flexibility for the profit maximization. Hence, the challenge is to develop a SC-based analysis which achieves the following:

- The analysis can be employed, at the design stage, to reflect the SC profitability as a design metric in the flexibility design, and
- The analysis can be used at the tactical-operational level, to improve the SC profit by exploiting flexibility.

Based on these critical elements, the project methodology will focus on the following:

Manufacturing flexibility targeting. The objective of this phase of the study is to design the manufacturing flexibility of a biorefinery strategy in order for it to be responsive to different market conditions, and to mitigate risks of market volatility. For doing so, the methodology involves four steps; (1) to determine the upper bound for production capacity, (2) to characterize the manufacturing system in terms of product and volume flexibility, (3) to generate design alternatives that handle different turn down ratios, and (4) to calculate capital investment as well as operating cost for each design alternative.

SC network design. The objective of this phase of study is to strategically design
the SC network for the forest biorefinery. The methodology for this phase includes
three steps; (1) to identify the specifications of the new SC based on the
characteristics of the new product options, (2) to define SC network alternatives, and
(3) to combine the SC network alternatives with process design alternatives defined
in the previous part of the methodology. The combination of process design
alternatives and SC network alternatives introduces biorefinery options that can be
implemented by a forestry company.

To evaluate different biorefinery options. The objective of this phase of the study
will be to evaluate defined process design/SC network alternatives. The outcome will
be the profitability of each alternative, for the case of different market scenarios. This
involves four steps; (1) to generate price/supply/demand scenarios representing the
price and demand volatility, (2) to calculate SC profit for each alternative via SC
optimization for the case of each scenario, (3) to calculate the profitability of each
alternative for each scenario, and (4) to compare the alternatives based on their
profitability, and screen out the less-profitable ones.

Fit within Network Program

This project clearly responds to VCO Theme 2 objectives as described below, and as
well, links to the expressed priorities of FPInnovations for the VCO Network. There will
be an important collaboration between Ecole Polytechnique (pulp and paper sector) and
Imperial College London (process optimization), and the PhD student Behrang
Mansoornejad will spend a work term at Imperial College in London. As well, this project
is complementary to the VCO project now underway at McMaster University, under the
direction of Professor Chris Swartz. Whereas the project of Professor Swartz seeks to
explore how biorefinery manufacturing flexibility can be achieved in biorefinery process
design, this project targets desired manufacturing flexibility from the SC perspective. A
close collaboration is planned between these two projects.

Anticipated results and application

The main result of the project will be a generalized methodology for evaluating the SC
policy for different biorefinery options to be implemented by forestry companies. Some
examples of results include the following:

- characterization of product strategy and linkages with SC design,
- definition of key criteria for targeting desired manufacturing flexibility, and
- identification of key factors for success at the operational level.

This methodology will be applied in a mill-specific case study context, for a forestry
company actually undergoing this evaluation.
**VCO Network Research Theme: Integrated forest and industry strategies for the modern bioeconomy**

*Value chain policies:* What are the hierarchical «rules-of-the-game» for different business units that seek to maximize the performance of the overall value chain, in future forest industry business scenarios? How will this change for commodity versus value-added products? What are the implications of moving towards a margins-based SC policy from the current manufacturing-centric operating policy?

**VCO Network Research Theme: Agile logistics and manufacturing**

*Vertically integrated company:* Integrated value chain performance will be considered in this project including assessment of agility, risk, and SC uniqueness, for different biorefinery strategies in a case study example.

*Designing collaborative value chains:* How can forest sector companies capture value through partnerships and collaborative mechanisms? What successful business models can be built on these? These key questions will be addressed in this project, especially in the context of the case study.

*Development of a holistic forest value chain model:* A sequential design method systematically targeting critical value chain issues will be developed as a consequence of this project.

**Schedule Milestones and Deliverables**

This project has been initiated, and we are requesting financial support following the guidelines of the VCO Network, and then the student has committed to staying on working on VCO network projects thereafter (as a post-doc, for which we are requesting only the equivalent of PhD funding). In addition to the VCO Network deliverables identified in the table below, it is expected that the PhD student will deliver at least 3 publications and a book chapter.

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestones/Deliverable</th>
<th>Expected Delivery Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Detailed methodology approach Preliminary case study approach</td>
<td>March 2011</td>
</tr>
<tr>
<td>2012</td>
<td>Detailed SC model Detailed case study definition Detailed defined biorefinery options and their implementation strategy Presentation of final thesis and publications</td>
<td>2012</td>
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