Flexible Interface for Supply Chain Optimisation Model

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Abstract

Norske Skog Australasia has been utilising a powerful tactical supply chain optimisation model, known as PIVOT, for a number of years. Since 1999 users of PIVOT relied on spreadsheets for constructing input data files and creating reports. Recently a menu driven interface was developed for PIVOT using a Microsoft Access database. Input data is extracted directly from the database and solutions are written back to the database each time the model is solved for reporting purposes. Users are able to easily configure PIVOT to suit their particular need. In this paper we describe the aspects of the design of the system and demonstrate the flexibility that its development has provided to the supply chain planning team.

1 Introduction

The PIVOT model has been described in previous publications [1] and we provide only a brief review here. PIVOT stands for Paper Industry Value Optimisation Tool, and is a comprehensive tactical supply chain optimisation model. PIVOT is fundamentally a generic supply chain model. A number of features that are specific to the paper industry have been included. The paper industry supply chain begins with wood procurement in forests and saw-mills and waste paper collection from the kerb side. These and other raw materials are purchased and delivered to large mills where they are converted firstly into pulp, and ultimately into paper. Finished paper products are delivered to customers either directly or via several intermediate locations and possibly by a number of modes of transportation. PIVOT makes decisions regarding the products to supply to various customers so that the overall company revenue is maximised. Its solutions balance trade-offs between raw material, manufacturing, freight and other costs.

A simplified diagram of the paper-making process is shown in Figure 1. This diagram represents the processes and plant specific to the Boyer mill in Tasmania.

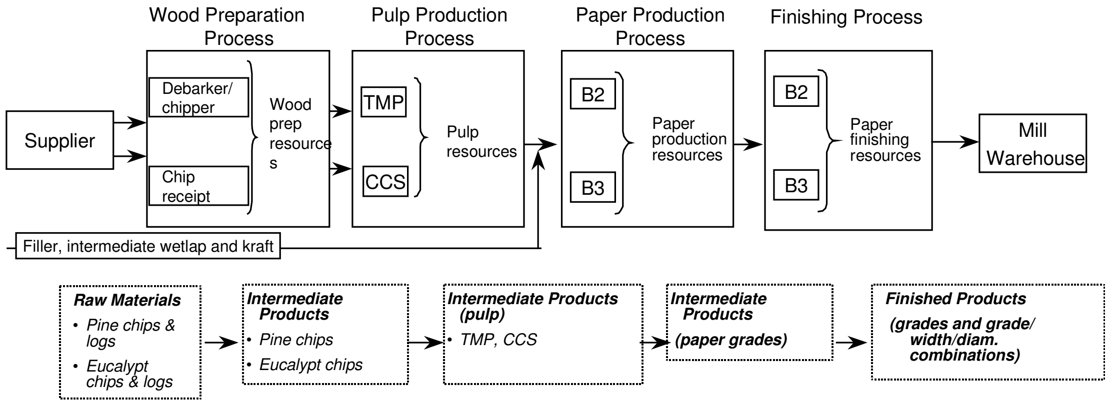

Figure 1: Paper-making processes at the Boyer mill

PIVOT has been developed with ILOG's AMPL (2) mathematical programming language. Being a tactical model, a degree of data aggregation is undertaken before data is provided to PIVOT. Nevertheless there are more than 10,000 individual data parameters in a single period model. When PIVOT was first developed in 1999 all of this data was presented to AMPL by way of text files, and involved linking data via spreadsheets and cutting and pasting into data files. This approach had a number of disadvantages:

- Errors could be made in the manual cutting and pasting process.
- Whenever a new set element such as a product or a market was added to the model the spreadsheets were required to be altered in numerous locations. Errors could easily be introduced.
- Relatively minor changes in data required specialist expertise.
- A simple change to data normally required the entire data file to be re-built.
- Users were required to open AMPL and type in commands in order to run the model
- Relationships between data were not easy to observe from the spreadsheet.
- The model interface was unprofessional in appearance.

Due to the above data preparation issues, only the model developers or highly-trained users could run the model. In addition to these points there became a need to alter PIVOT so that it optimised over multiple periods. This would have required major changes to the data spreadsheets. To overcome these difficulties it was decided to develop a Microsoft Access database to manage the model data and present it to AMPL, and also to store solutions and create reports.

2 System Design

The PIVOT system has grown to:

- 48 tables describing the Model
- 20 tables required to hold solution output.
- 26 primary screens with an additional 24 embedded sub-screens
- Approximately 150 queries supporting screens, reports, and the PIVOT Model
- 32 Reports

The user interface has been built so that it is driven by configuration tables representing all underlying business data. Where a change to the underlying data representation would require an associated change to the AMPL model, no user interface is provided, and the tables are hidden from the user.

Screens can be broadly grouped into three categories.

- Reference Data – a small number of reference tables that provide "world" data, common across all scenarios
- Model Data - the information required to specify the business problem. This contained:
  - physical plant (e.g. mills, machines, raw material storage capability and costs)
  - product information (e.g. types of product, product codes)
  - production information (e.g. the products that can be made on each machine, allowed combinations and the inputs required to create the products)
  - supplier information (e.g. the raw materials available from each supplier and the associated costs)
- Time-dependent data - the information within the business problem that varies with time. This is to allow the model to reflect the real impacts of exchange rate variations, changes in costs of inputs and changes in market demand and product pricing. This meant that much larger volumes of data had to be handled.

Due to the complex inter-dependent nature of the data, most high-level forms had one or more sub-forms, often accessed by tabs, in order that the data relationships were obvious. Figure 2 shows a screen containing two sub-forms, managing the data in three tables.

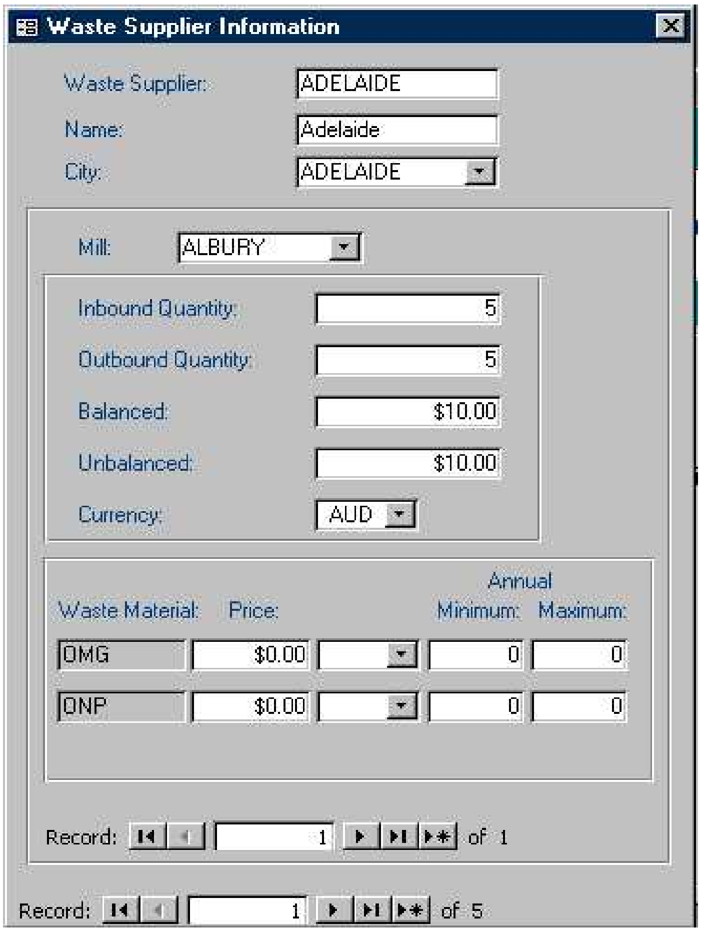

Figure 2: Waste Supplier Information screen

Figure 3 shows use of tabs to simplify display and maintenance of large quantities of data.

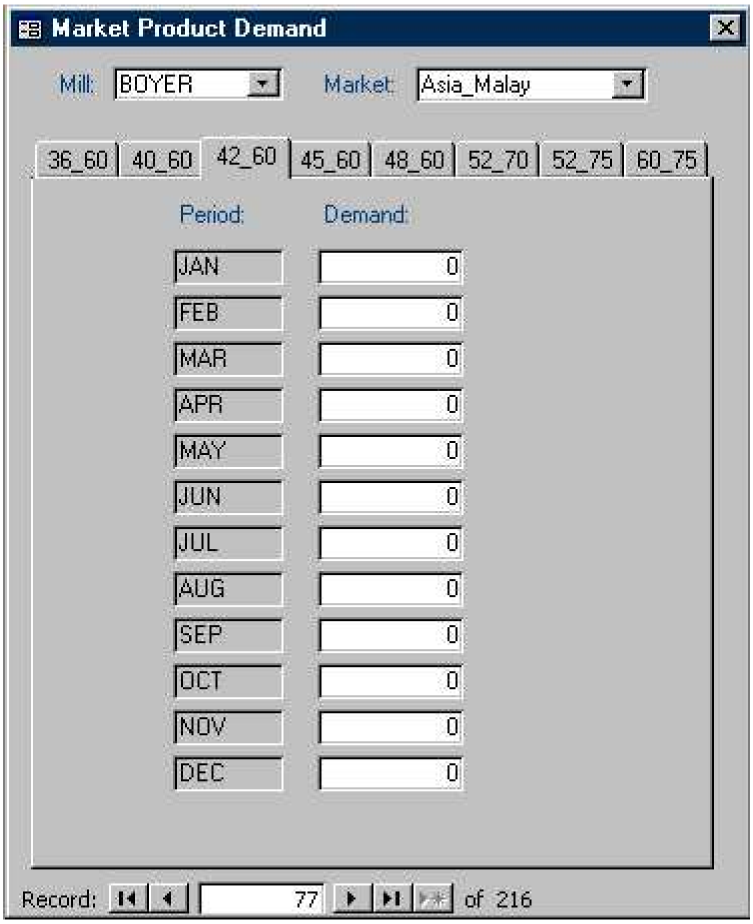

Figure 3: Market Product Demand by time period screen

2 Datamodel

Two fragments of the datamodel are shown to indicate the complexity of the processes being described.

The datamodel fragment shown in figure 4 is used to describe:

- the processes available at each mill with associated and the capacities and costs
- the machines at each mill
- the products capable of being made on each machine
- recipes of fibre mixes required for each product on each machine and fibre costs
- additional machine efficiencies achieved from manufacturing various combinations of products on each machine

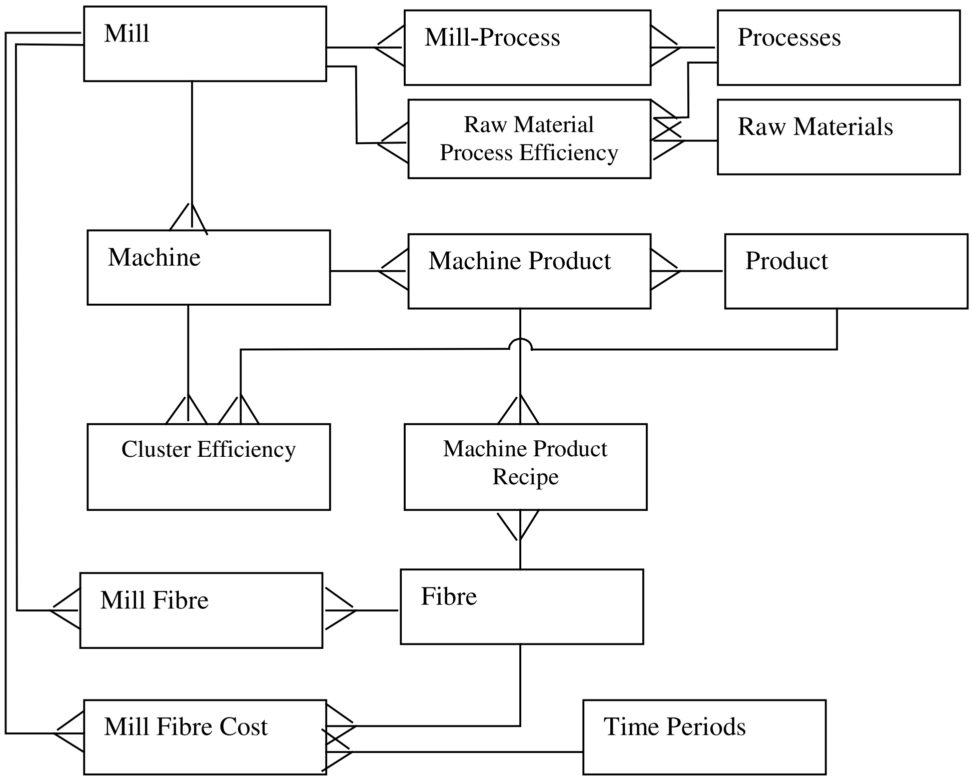

Figure 4: Production-related data model

The datamodel fragment shown in figure 5 is used to describe

- Raw materials available from suppliers to each mill with associated costs
- Waste materials available from suppliers to each mill with associated costs
- Waste Material freight costs, for one-way and back-haul operations
- Revenue available from selling surplus waste materials at source.

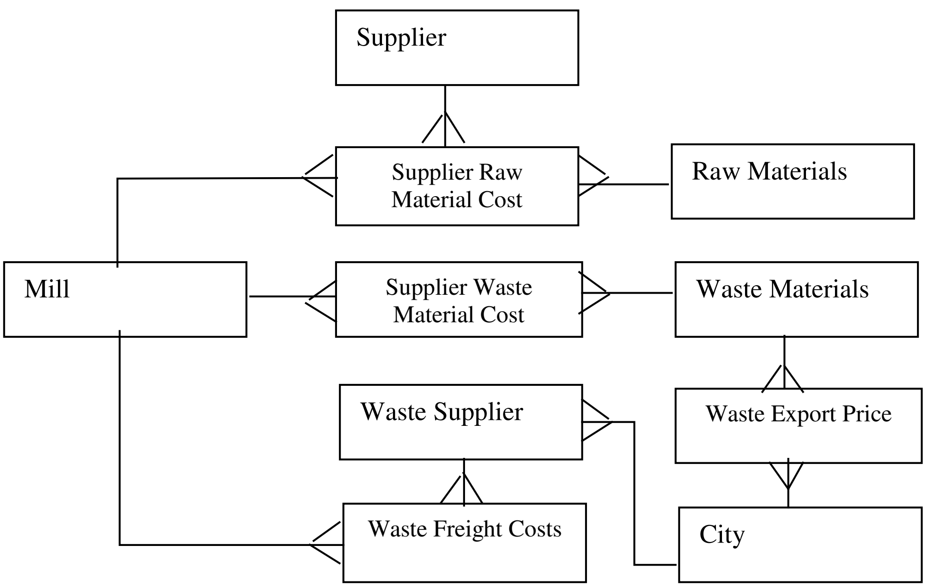

Figure 5: Supplier-related data model

3 User Selection Of Constraints

A common use of PIVOT is to identify the value of certain constraints which reflect self-imposed business practices and formal contracts with suppliers or customers. In practice this has been achieved by setting parameters to switch constraints in and out of the model, and also to teach users how to edit AMPL model files and "comment out" unwanted constraints. This process has at times produced unintentional mistakes.

To provide a more robust mechanism a table whose records consist of sections of AMPL code that comprise user constraints has been created. Users can select the constraint(s) they wish to add to the model (see Figure 6). The AMPL code representing these constraints is then written out, and loaded into the model at the appropriate time.

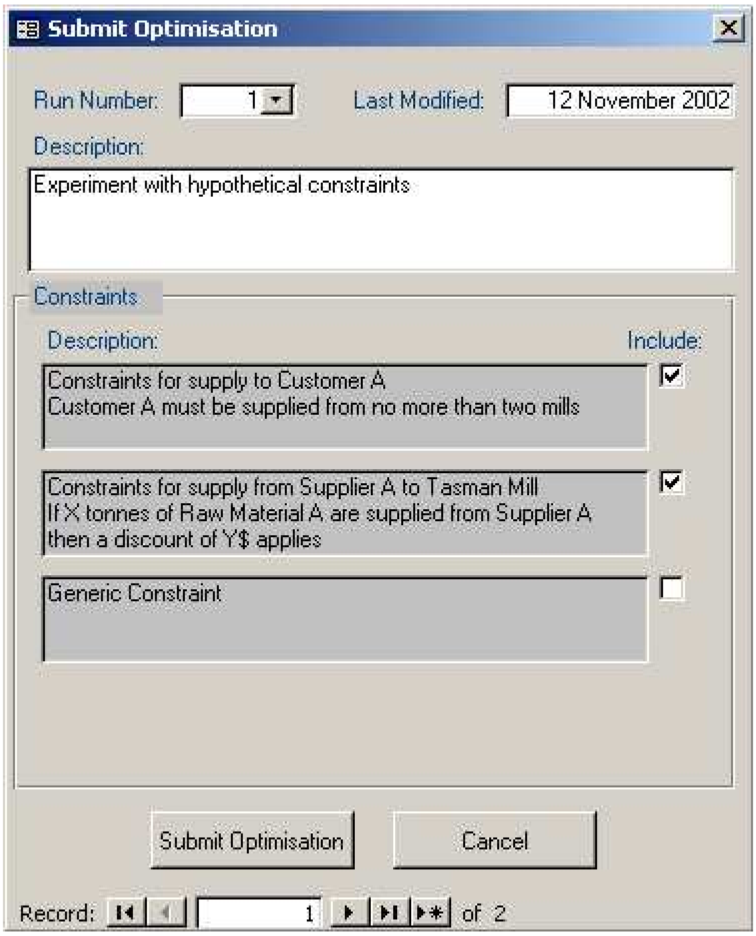

Figure 6: User Selection of Constraints

3 AMPL Interface

3.1 Reading Data into AMPL

Recent releases of AMPL incorporate Open Database Connectivity commands (ODBC), which allow data to be directly linked between AMPL and other files. This is achieved by creating database queries that present data in the format required by AMPL table commands. This process is straight forward and well explained in the AMPL manual (see [3]).

3.2 Writing Solutions To Access

After PIVOT solved we wished to save the solution in the database in a convenient format to allow reports to be easily created. Most of the information supplied to the database was simply the value of variables at optimality. However further calculations are performed to present information in a meaningful business context. For example, a common measure in the paper industry is mill gate cash cost. This is the cost to produce a tonne of paper at the mill and includes fixed and variable costs. PIVOT handles fixed and variable costs separately and therefore mill gate cash cost is not defined.

We wished to to be able to compare solutions from different runs of PIVOT. This required altering the standard table command to append records, instead of replacing them. We achieved this by use of the AMPL setof command with indices excluding run number. An example AMPL table command is shown in Figure 5

A large number of variables had a value of zero at optimality. In the interests of keeping compact database tables only non-negative records were passed to the Access database.

```
table WoodPrep {s1 in 1..scenarioNumber, r1 in 1..runNumber:
s1=scenarioNumber and r1=runNumber} "ODBC" (reportdb)  "tbWoodPrep" :
{setof{p in PROCESS, n in MILL, w in WOOD, t in
T:WoodThroughput[p,n,w,t] >0} (s1,r1,p,n,w,t)} ->
[lScenarioNumber, lRunNumber, p ~ sProcess, n ~ sMill, w ~
sRawMaterial, t ~ sPeriodName],
WoodThroughput[p,n,w,t] ~ WoodThroughput;

write table WoodPrep;
```

Figure 5: Example AMPL table command

4 Project Benefits

The disadvantages of the previous version of PIVOT outlined in the Introduction have been overcome with the new database. An additional benefit was that the close inspection of the data structures during the analysis phase led to revision of many of the original model assumptions, and a number of improvements to the model.

PIVOT can now be used more readily by Supply Chain staff without the need to rely on specialists. The improved presentation of the software package has enhanced the credibility of PIVOT and has contributed to growing interest in supply chain optimisation in other parts of the Norske Skog organisation.

References

[1] Philpott, A.B. and Everett, G.R. – "Supply chain optimisation in the paper industry", Proc. 34th ORSNZ Conference, Hamilton, NZ (1999).

[2] www.ilog.com

[3] www.ampl.com