# “US Pulp Business Market: Demonstrating The Increased Relevance For The Evaluation Of Pulp Properties”

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# EXECUTIVE SUMMARY

The market pulp industry is predominantly a commodity one and has a very price-focused mentality. The current lack of importance placed on studying pulp properties as well as the inability to validate the potential cost savings due to a superior pulp (to pulp buyers) contributes a lot to this. Instead of worrying only about "Can The Supplier Meet My Schedule?" and "How much do I have to pay for it?", while choosing pulps, mills should be asking one more question "What value does a superior pulp represent to me?". We have chosen napkins as the product category to illustrate the answer to this question and highlight the relevance of studying pulp properties

Depending on the particular paper grade and process capabilities, it is possible to make significant improvements in product performance by selecting say the best Northern Bleached Softwood Kraft (NBSK) from the "commodity" pulps available in the marketplace. A more careful evaluation of pulp properties is currently needed with market pulp fiber morphology as well as handsheet information being used as inputs into optimal pulp selection

Further, even if the importance of studying pulp properties to generate superior products is understood, it is imperative to validate the potential cost savings realized due to a superior pulp. A Customer Value Model is needed (and has been developed in this report) to showcase the impact that a superior pulp offering has on the paper mill's cost structures or revenues.

Any superior value delivered by a pulp can be measured in terms of higher contribution margins[1] and operating rates for the paper mills. A superior pulp can thus

- Increase operating rates (due to better runnability which translates into higher production rates and lesser machine downtime)
- Increase operating rates (due to more orders)
- Increase contribution margin (due to higher quality product, lower production costs)

Further, a model is needed (and has been developed in this report) to measure the increase in end consumer demand attributable to the use of a superior pulp based product and the subsequent increase in operating rates as well as contribution margin for the paper mill. The conjoint based model introduced, measures the relative value or importance that the users attach to the superior quality produced in the product (by a better pulp). Given the competing products, it then converts this to estimate the increased demand from the consumers to purchase this product

Ultimately, the effect of increased operating rates as well as contribution margin (for a paper mill due to the use of a superior pulp) should be (and has been though another model in this report) expressed in terms of the required % increase in pulp price needed to neutralize the additional gain. This would clearly demonstrate the true value of a superior pulp and thus the increased relevance of evaluating its properties.

Note: The model developed in this report helps to demonstrate the true value of a superior pulp. However, it must also be understood that the inefficiencies of the pulp and paper marketplace (which includes factors like uneven bargaining power, resistance to change etc) may only permit a percentage of the actual value to be reflected in the pulp price.

[1] Contribution margin is sales revenue less variable costs. It is the amount available to pay for fixed costs and provide any profit after variable costs have been paid.

# ACKNOWLEDGEMENTS

This report would not have been possible without the patient support extended by David Hillman and Dr. Alan Button over the course of several interviews with them. David Hillman also helped arrange several interviews which were essential to understanding the dynamics of the pulp and paper industry. Thanks is also due for the advice and suggestions offered by Dr. David White and Dr. Patrick McCarthy.

# INTRODUCTION

*Chapter Outline*

- *Demand And Supply Scenario In The Market Pulp Industry*
- *Market Pulp Buying Process*
- *Current Treatment Of Market Pulp As A Commodity Product*
- *The Tissue/Napkin Product Category As A Case To Illustrate The Increased Relevance For Evaluation Of Pulp Properties*

## DEMAND AND SUPPLY SCENARIO IN THE MARKET PULP INDUSTRY

The global market for market pulps exceeds 39 million tons involving over 35 producing companies in 22 countries. Pulps are generally selected on the basis of price and less on their benefits and distinctive properties. Pulp buyers continue to use pulps that they are most comfortable with even though the pulp being used may be sub-optimal for the product being produced, thereby losing millions of dollars in the process. Unfortunately, there is little knowledge publicly available to evaluate the use of alternative pulps and demonstrate their commercial viability.

North America represents about 52% of total woodpulp production and 84% of world market pulp capacity. The U.S. also is the world's single largest pulp market. Printing/writing papers account for about 50% of all chemical paper-grade market pulp consumed in the U.S. The rest of the pulp demand comes from three other sectors: tissue and toweling (27%), fluff pulp-based products (13%), and specialty packaging and industrial converting (10%).

## THE MARKET PULP BUYING PROCESS

The purchasing agent for the pulp buyer essentially has to get approvals from three people, The Quality Department, The Production Manager & The Sales Manager. Initially, a list of approved pulps is validated by technicians through standard tests followed by a test run. Any further pulps that sellers may throw at buyers may also be qualified. Then depending on price, delivery negotiations and existing relationships, a pulp supplier gets chosen. There is rarely any bidding and most customers are repeat customers

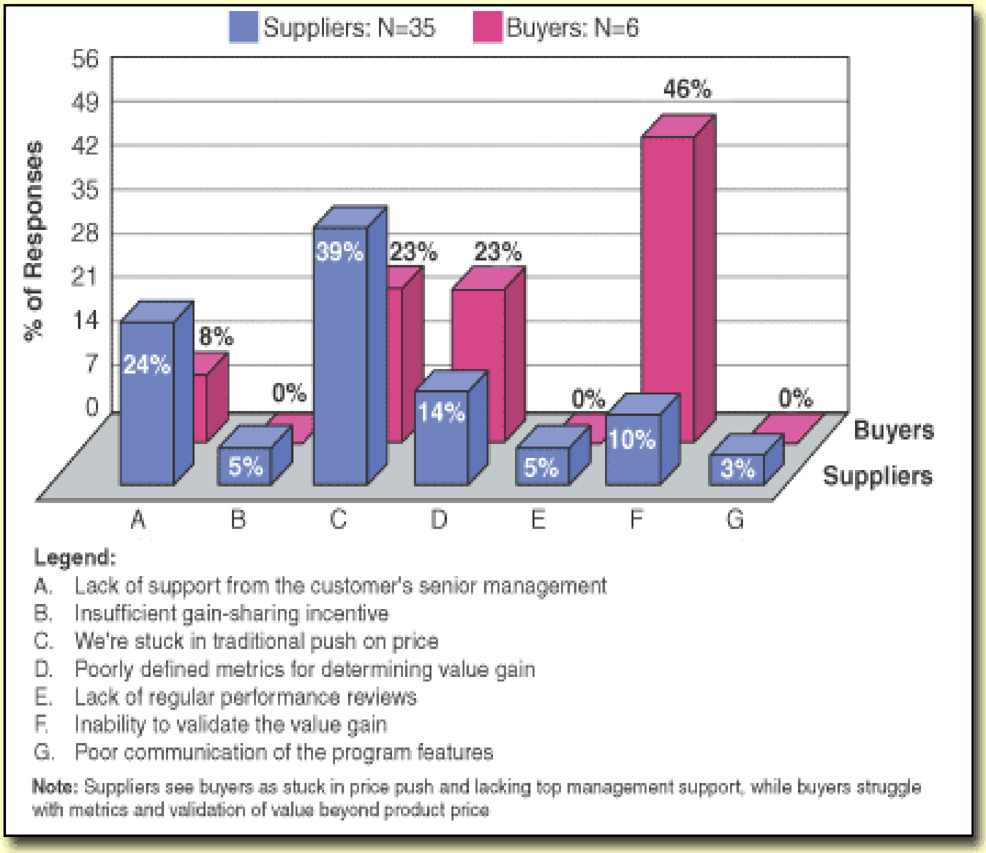
## CURRENT TREATMENT OF MARKET PULP AS A COMMODITY PRODUCT

Many pulp suppliers have resigned themselves to the fact that they have little to no pricing power in the market. The majority of pulp buyers or paper mills[2] believe that the inability to validate the

[2] Paper Mills is a general term used here and in the report to describe any mill which converts a pulp into an end customer product

potential cost savings and lack of fundamental total cost measures continue to add to the predominantly price-focused mentality

**What Are The Impediments To Collaboration?**




Source: November 2002 feature - Financial Strategies, Pulp & Paper

This document attempts to develop a framework to validate the potential savings obtained by using a superior pulp. We have chosen to demonstrate this for the napkin segment.

## THE TISSUE/NAPKIN PRODUCT CATEGORY AS A CASE TO ILLUSTRATE THE INCREASED RELEVANCE FOR EVALUATION OF PULP PROPERTIES

We chose to illustrate the validation of cost saving due to the use of superior pulps by considering the case of the tissue industry and within it the napkin grade. This was done as napkins have higher margins, a greater choice of pulps besides a prestige associated with them. The napkins segment is a relatively small, but certainly lucrative, part of the tissue sector. For instance, according to SCA (Svenska Cellulosa Aktiebolaget), napkins account for 58% of a total North American food service market of $1.2 billion/yr.)

### TYPES OF TISSUES

Retail (Consumer) and Away From Home (AFH) account for 95% of all tissue production in the U.S. . Consumer tissue accounts for 65% of the entire US tissue market. While the AFH market represents most of the remaining shipments and is sold to janitorial supply companies, hotels, offices, restaurants, schools, and government. (Source: 1 February, 2004, Pulp & Paper)

All of this falls into one of four primary grades: toilet tissue (47%), toweling (35%), napkins (11%), and facial (7%). The remaining 5% goes into industrial applications, absorbent products, wadding, wrapping, etc. (Source: 1 February, 2004, Pulp & Paper). Another way to classify tissues could be:

Class A:
Premium Facial Tissue

Class B:
Specialty Tissue

- Air Laid non-wovens for high quality products for Country Clubs. (like premium napkins)
- Machine Glazed Label tissue
- Toilet Seat Cover

Class C:
Bath Tissue

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# PART I
# ASSESSING THE IMPACT OF SUPERIOR PULPS ON COSTS/REVENUES OF PAPER MILL'S BUSINESS

# BREAKING OUT OF THE COMMODITY TRAP – THE CUSTOMER VALUE MODEL

Many pulp suppliers have resigned themselves to the fact that they have little to no pricing power in the market. The majority of pulp buyers or paper mills believe that the inability to validate the potential cost savings and lack of fundamental total cost measures continue to add to the predominantly price-focused mentality

This section of the document discusses what it will take for suppliers to break out of the commodity trap. A product or service is a commodity when customers (here paper mills) perceive no difference between it and competitive offerings.

A Customer Value Model showcases the impact that the offering has on customers' cost structures or revenues. For the pulp and paper industry, any superior value delivered by a pulp can be measured in terms of higher contribution margins and operating rates. A superior pulp can thus

- Increase operating rates (due to better runnability which translates into higher momentary production rates and lesser machine downtime)
- Increase operating rates (due to more orders)
- Increase contribution margin (due to higher quality product, lower production costs)

In order to evaluate these factors, we have to understand the industry's demand/ supply conditions as well as the supply chain and purchasing functions for each of it's components. We have chosen to illustrate this by taking the example of the premium napkins grade.

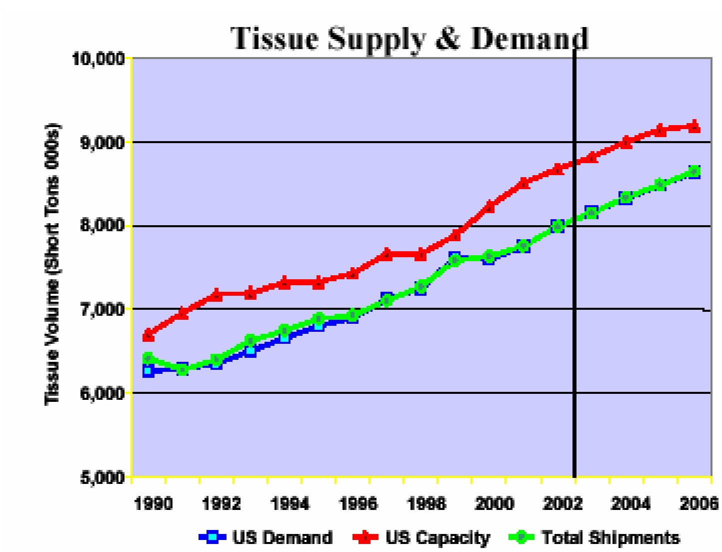
# CHAPTER ONE
# THE STATE OF THE PRODUCT CATEGORY INDUSTRY

*Chapter Outline:*
- *The Industry Demand And Supply Conditions*
- *The Industry Supply Chain*
- *The Procurement Function For Paper Mills*

## 1.1 THE INDUSTRY DEMAND AND SUPPLY CONDITIONS (TISSUE/NAPKIN)

The demand and supply conditions prevailing in the pulp and paper industry for any particular end product can be understood by looking at two indicators:
Paper Mill Operating Rates
Pulp Fiber Prices (which translates into Paper Mill Production Costs)

**OPERATING RATES**
Operating Rates depends on both market demand and available capacity. For the tissue industry, new machine starts in 2001 from Procter & Gamble and Kimberly-Clark (and soon from Georgia-Pacific) were as damaging to operating rates as was the sluggish product demand. Yet the U.S. tissue industry was spared record-setting (low) operating rates at the end of 2001, compliments of the shutdown of ATI's (American Tissue Inc.) mills. Also, as some of these grades are luxury goods, when income rises by a certain percent, demand for napkins and towels should jump even higher which could help give a boost to the operating rates.




**PRODUCTION COSTS**

The distinction in the tissue industry is that there is no direct correlation between fiber cost, price of parent rolls, or the converted products. Each has its own supply and demand equilibrium and behaves independently of one another. In the event of an adjustment, there could be a lag period of as much as six months before the impact of one is felt on the chain of command.

The need to boost tissue prices will grow more urgent (especially for non-integrated producers) as NBSK prices explode from $535/tonne during 3Q03 to perhaps $730/tonne by late-2004. Benchmark NBSK is the bellwether grade because its long fiber length provide a premium to consumers

While pulp is a more readily available commodity, fiber cost and pulp prices will remain the dominant factors in cost and profitability for all tissue producers. Hence, producers of tissue would easily feel the pinch when increases in fiber cost are not offset by adjusting the prices of converted products. —like any other industry.

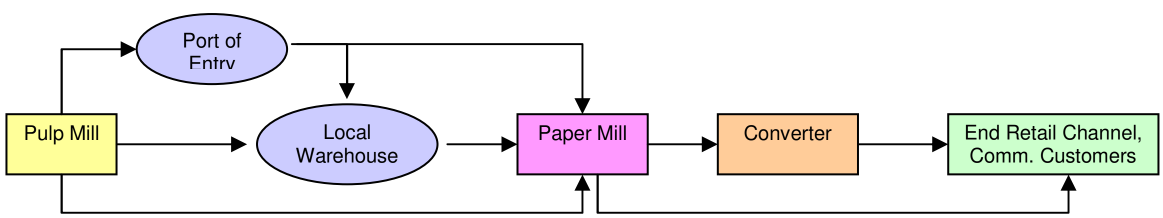
Thus, with paper mill capacity exceeding demand and increased pulp fiber costs, there would be an acute need for paper mill owners to manage a cost plus inflation by developing the ability to raise prices.

**MAJOR SEGMENTS**

Food service represents 40% of this segment and is projected to bring the fastest growth of 3-4% in the coming years. This is followed by healthcare with 15% of the market, office buildings with 12%, education with 10%, and lodging and all others accounting for the remainder

## 1.2 THE PULP & PAPER INDUSTRY SUPPLY CHAIN (ILLUSTRATED FOR NAPKINS)

### THE SUPPLY CHAIN (OR HOW CUSTOMER DEMAND IS MET IN THE PULP AND PAPER INDUSTRY)




The napkin industry is completely demand driven. i.e it follows a JIT (Just in Time) system.

Production starts only after the order is received (whether it is for a paper mill or a pulp supplier). Thus neither the paper mill nor the pulp supplier produces or stocks inventory. Only in cases, when a mill expects say downtime in a particular future month, will they produce more than the demand or received orders. [Note: This is not true for commodity items however like say bond paper, they order pulp and convert before, hoping to sell to varied customers to meet a predictable demand]

Most of the large producers rely on their own equipment to convert most of their product into finished goods sold by the case. However, there is ample tonnage to employ a host of independent converters as well. Mills sometimes enlist the help of independent brokers to sell their parent rolls to these converters. Roughly 8 to 10% of all U.S. tissue production is traded in this manner.

#### THE CONVERTER/END CUSTOMER TO PAPER MILL TRANSACTION

Order Cycle: Orders are given monthly. Lead time to fulfill an order varies from 2-4 weeks. Contracts are for 1-3 years with prices usually reviewed quarterly.

Credit Period: Credit period can be anywhere between 30 -45 to even 90 days from the day the invoice is generated, depending on the equilibrium between demand and capacity. For a new product or pulp to be approved, it might take even a year till the converter gets the nod from his customer who agrees to say pay extra for the added softness

#### THE PAPER MILL TO PULP SUPPLIER TRANSACTION

Order Cycle: There exists roughly a monthly order cycle for pulp.

Credit Period: Credit period can be anywhere between 30 - 45 to even 90 days depending on demand and capacity.

## 1.3 THE PROCUREMENT FUNCTION FOR PAPER MILLS

### THEIR OBJECTIVE

The procurement function for the paper mill is concerned about two main things:

1. **Can The Supplier Meet Their Schedule?**
2. **How Much Do They Have To Pay For It?**

Paper mills typically never buy 100 % from a pulp supplier. Usually 3 or 4 suppliers are involved.

Besides the above considerations which are currently used to choose pulp suppliers, there also exists a huge inertia in changing pulp suppliers (not only due to relationships and long contract periods, but also due to risk that a production manager wants to avoid in trying out a new pulp) Most of the suppliers are repeat suppliers. New fiber has to be either substantially cheaper by say more than $10-20 per ton or there has to be a new grade and hence different pulp requirements to consider a change

### THE PROCESS

| Prescreening Pulps | > PFI[3] Mill Tests For Pulp Properties | > Paper Mill Test Run | > Terms Of Sale |
|---|---|---|---|
| Quality<br>Purchasing | Quality | Production | Purchasing<br>Accounts |

(Departments Involved)

[3] Process Facilities Inc.

Steps:

- Request a sample from the pulp maker which comes with its own specs (which as it is not standardized is not of much use).
- Decide to run a PFI Mill test on it to evaluate the pulps handsheet & morphological properties. Test data entered and compared against numbers of commonly used pulps
- Request a truckload of pulp and run it on the actual paper mill. This is important as a lot of the end product properties depend on how their machines process the pulp and not the properties of the pulp itself.
- Negotiate Terms of Sale. Ideally, the mill's purchasing agent, production manager, sales person and accountant should all sit together and decide whether it is feasible to go for the new pulp

Steps in Greater Detail:

**1. PRESCREENING**

Mills look for pulps which are superior or similar in "key" properties as compared to their commonly used pulps. They have standard furnishes for a particular grade which have been used for years. By experience thus, it is known that certain pulps are well suited. Some questions that are thus asked to compare incoming pulp samples and prescreen them (without actually testing them are):

- The pulping process (Bleached, Unbleached, Chemical or Mechanical)
- The nature of the wood (Softwood or Hardwood)
- The nature of wood growth: (Plantation grown (more uniform as more carefully grown) or Natural)
- The number of different species (For uniformity)
- The region pulp is harvested from. (From the north or south. Northern pulps are thinners and less stiffer as they have lesser growing seasons)

For any completely new pulp, they tend to go more by checking if other mills have used them.

**2. PFI MILL TESTS**

They test for the end properties which are indicated by Sales as important. For the case of premium napkins, they are Softness, Bulk, Absorbency, Printability & Runnability

**Softness:** Is a general term that describes the presence or absence of the pleasant soft feel against the skin. Bulk softness is defined as the perception of softness obtained when the sheet is crumpled by the hands. Surface softness is defined as the perception of softness obtained when the fingertips are lightly brushed over the surface of a tissue sheet. The following tests are carried out to test for the property:

- Compressibility and Recovery Test or testing whether the bulk come back on releasing from compression
- Drape or good hand test

**Absorbability:** is a term that is used to describe either Total Water Intake (How much water before it begins to drip) or Channeling (Ability to move laterally to fill the napkin). Appropriate tests are carried out to evaluate this property.

**Printability:** Refers in part to the ability of the sheet to absorb ink in a uniform manner without opposite side show-through. Printing dots should be sharp and clear without significant spread. It demands for a smooth surface, high brightness and a porous structure which does not allow the printing ink to penetrate the sheet.

**Dust Free:** Refers to fibers not sticking or separating onto the rubber plate on the printing press It is checked by checking if fibers stick up when seen in slanting light. Dust freeness varies for a pulp with each paper mill and their machines

**Runnability:** Refers to the ability to get a sheet through the paper machine (presses, dryers) and subsequent converting / printing operations. It is a function of web strength and drainage as well as well as paper machine design

Other standard attributes mills compare pulps on include tensile strength, freeness, porosity, opacity, wet tensile strength etc.

While the PFI Mill tests serve as good indicators for assessing a pulp's utility, a lot of the influence on the end product property depends on the paper machines used too. There are machines, processes (Through-Air Drying (TAD) technology, Creping etc) which can even convert mediocre pulp into soft napkins

### 3. TEST RUN

"Tons out off the door" is what the production manager is really concerned about. This makes the test run very important. As it results in plant capacity being diverted for a short while, it cannot be done even a few times in a month. The Production Department is concerned about:

- Runnability on the paper machine
- Hour after hour production without need to clean say rubber plates, repair and maintain machines
- Ease of refining

### 4. The Terms of Sale

**Price:** The price of NBSK is the universal benchmark. A consignment model or a non consignment model can be followed. "Consignment" suppliers puts pulp in paper mill's plant who don't pay for it till they use it as opposed to generation of invoice the moment pulp leaves pulp manufacturer for the non consignment model. Because of business climate almost all of top 10 suppliers seem to be going for the consignment model. It is also a common practice to give volume discounts as well as discounts on prompt payment (Say a 1 %discount to pay in 10 days)

**The Credit Period:** Refers to the time period the paper mills have to pay before incurring penalty. In bad times for pulp suppliers, it is about 90 days. In good times, it is usually 30 days

**Inventory Management / Delivery Issues:** The delivery cost to the mill is typically paid by the buyer in Europe, and by the supplier in US. The following issues come up
**The mode of transport.** The industry follows JIT so truck or railroad is preferred for greater reliability. Typically, the production manager looks at his schedules and decides whether he wants a truckload by say the next week.
**Maintain of a local warehouse.** Becomes especially useful when the paper mill suddenly receives an unexpected or big demand. Offshore pulps such as one from Russia are stored in a north eastern warehouse. For railroads, pulps might be deposited in a warehouse local to the paper mill.

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## FACTORS CURRENTLY GIVEN MORE IMPORTANCE WHILE CHOOSING ONE PULP/SUPPLIER OVER THE OTHER

In selecting pulps for a paper's furnish, if it is a fairly uncomplicated grade, importance is laid much more on the following questions:

**PRICE**
What is the pulp cost? (Pulp costs include pulp price, volume discounts as well as discounts on prompt payment)

**CREDIT PERIOD**
Is the payment consignment or non consignment based? If it is not consignment based, how quickly does the supplier have to be paid?

**SUPPLIER RELATIONSHIPS**
Is this a traditional, long-time supplier with whom they have done business for a long time? In other words, is every one in production familiar with this pulp? Is there a good rapport with the salesman?

**INVENTORY MGT/ DELIVERY ISSUES**
Is the supplier's warehouse close to the mill? How much is maintained in inventory? How quickly could the mill get more of this particular pulp? What is the mode of transport (truck, railroad or offshore) used? Market Mediation Costs (Stockout Costs, Markdown costs) are very high in cases of misdelivery and can be an absolute let down especially in a demand driven JIT environment.

*The mills caring predominantly only for Can The Supplier Meet My Schedule? And How much do I have to pay for it? does point to treatment of the market pulps as a commodity. Mills should be asking one more question What value does a superior pulp represent to me? (in terms of increased revenues and decreased operating costs)*

Here's what they should be thinking more about:

1. Has Sales provided us with the customers' requirements, desires and "prime requisites"? (a "prime requisite" is a paper quality that is essential or a "must" for the customer).
2. Have we carefully analyzed this pulp for its (a)benefits (b)outstanding attributes and (c)distinctive qualities? Has our QC dept., R&D etc. determined for what grades this pulp is particularly well suited?

And only then if there are two or three pulps that have the appropriate outstanding attribute should we be asking, is there one that is cheaper than the others or whether the supplier is giving the papermill longer time to pay for it or whether there is an adequate inventory of all qualified pulps.

The next section gives evidence to encourage this kind of “non commodity thinking” by demonstrating the value a superior pulp could bring by increasing revenues/ decreasing costs for a paper mill

# CHAPTER TWO
# MEASURING IMPACT OF SUPERIOR PULP ON COSTS & REVENUES OF PAPER MILL

*Chapter Outline*

- *Increase In Operating Rates (Due To Better Runnability & Due To More Orders)*
- *Increase In Contribution Margin (Due To Higher Quality Product & Lower Production Costs)*

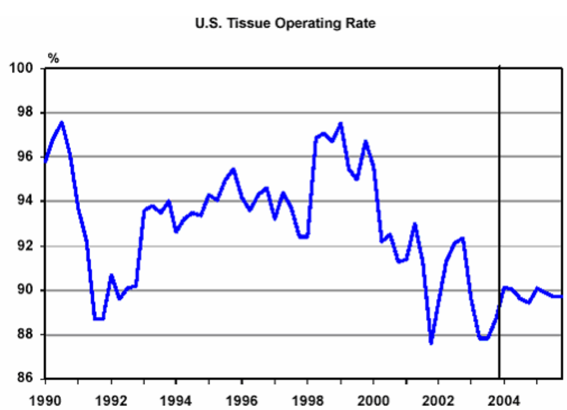
For a paper mill, variable costs (costs which are production related) could be around 50% with fixed costs (time related costs like maintenance materials, personnel and admin.) accounting for 15-25% and capital costs accounting for the reminder 25 – 35 % . [4]

The variable costs are further made up of pulp (typically around 60%) with the remaining being accounted by production related chemicals, energy, operating materials & services.

The Basic Paper Mill Profitability Equation:
Amount Left to cover the Fixed Costs:
Contribution Margin per ton of output * Output (say in monthly tons)

A superior pulp helps to increase profitability by increasing either the contribution margin[5] (amount left to cover fixed costs, got by subtracting variable costs from revenues) or the output. The contribution margin can be increased through decreased variable costs (by requiring lesser energy for drying etc or lesser chemicals) or through increased revenues due to a higher quality of pulp product. A superior pulp can also help increase operating rates and hence output due to more orders or better runnability

## 2.1 INCREASE IN OPERATING RATES (DUE TO BETTER RUNNABILITY & DUE TO MORE ORDERS)




Source: August / September 2003 - US MARKET, Tissue World

[4] Labor is considered as considered as a fixed cost and not a variable one here as time period for consideration is short
[5] Contribution Margin can also be thought as similar to (though not identical to) Gross or Operating Profit

The operating rate can be increased by increasing the output (or production rate) of the mill. Now, (Averaged) Saleable Production Rate = Efficiency * Production Rate

#### HIGHER PRODUCTION RATES

Higher production rates could be achieved with the help of a pulp having better runnability which allows the bottleneck machines (the dryers, wet end part of the machines etc) to operate a higher speed. E.g. for high basis weight substances, drying capacity limits the production rate. And for low basis weight substances, Wet end of the machine limits production rate. Some times for low basis weight substances, runnability limits are even more pronounced.

#### HIGHER EFFICIENCY

Efficiency is contributed by several factors. Some can be significantly improved by pulps having a better runnability. We are talking here about better operating efficiencies (time paper machine is not running due to maintenance work/ felt wire change etc)

A model to estimate the value delivered by a superior pulp (due to more orders or better runnability) by means of increased operating rates or output is documented below.

### MODEL TO ESTIMATE EFFECT OF INCREASED PAPER MILL OUTPUT (IN TERMS OF REQUIRED % INCREASE IN PULP PRICE NEEDED TO NEUTRALIZE THE ADDITIONAL GAIN DUE TO THE SUPERIOR PULP)

The equivalence of any percentage increase in output to percentage increase in pulp price needed to neutralize the additional gain can be found as follows:

The Basic Equation:
Amount Left to cover the Fixed Costs:
Contribution Margin per ton of output * Output (say in monthly tons)

Now, we assume that the superior pulp causes an increase in output by $Y_O$%. This would have to be offset by a $Y_C$% decrease in the contribution margin per ton of output (caused by raising the price of the pulp to its deserved value) so as to neutralize the gain. We thus need to calculate the % increase in pulp price needed to decrease the contribution margin by $Y_C$% to get the true value of the pulp

$$Y_C = Y_O\left(\frac{100}{100+Y_O}\right)$$

Let the ratio of the price deserved by the superior pulp (by paying which, the additional gain is offset) to the existing price of the pulp be: ‘a’
Let the ratio of existing price of pulp used per ton of output to the revenue generated per ton of output be $X_1$.
Let the ratio of the other variable costs incurred (excluding pulp cost) per ton of output to the revenue generated per ton of output be $X_2$.

Now,
$Y_C$ = % Decrease in Contribution Margin =

$$100 * \frac{\left[\begin{array}{l}\left[\text{revenue per ton of output } - (\text{old price of pulp used per ton of output } + \text{other variable costs incurred per ton of output})\right] \\ -\left[\text{revenue per ton of output } - (\text{new price of pulp used per ton of output } + \text{other variable costs incurred per ton of output})\right]\end{array}\right]}{\left[\text{revenue per ton of output } - (\text{old price of pulp used per ton of output } + \text{other variable costs incurred per ton of output})\right]}$$

Solving which we get:
100*(a-1) = percentage increase in pulp price

$$= Yc\left[\frac{\{1-(X_1+X_2)\}}{X_1}\right]$$

$$= Yo\left[\frac{100}{100+Yo}\right]\left[\frac{1-(X_1+X_2)}{X_1}\right]$$

To take an example to illustrate this:
If the operating rate of the plant is currently 85% of the rated capacity. One of the two happens due to a superior pulp used:

- The pulp owing to superior runnability cause this to increase to 90% of rated capacity (by reduced down time, reduced maintenance time, or increased speed of the bottleneck be it the dryers or the wet end part of the paper making process).
- The pulp owing to superior quality cause this to increase to 90% of rated capacity (by generation of more orders for end product

This translates to a (90 -85)/85 * 100 or 5.9% percentage increase in output.

We assume here $X_1$ be .3
We assume here $X_2$ be .2

We could get $X_1$ and $X_2$ by simply dividing the existing pulp price, other variable costs per ton of output to the revenue generated by per ton of output. If this transactional data is not known, a simple model to estimate $X_1$ and $X_2$ by common sense has been shown at the end of this chapter. The values shown above have been approximated using the same model and some assumptions.

Therefore
The justified percentage increase in pulp price = 100*(a-1) =

$$= Yo\left[\frac{100}{100+Yo}\right]\left[\frac{1-(X_1+X_2)}{X_1}\right]$$

$$= 5.9\left[\frac{100}{105.9}\right]\left[\frac{1-(.3+.2)}{.3}\right]$$

= 5.9*.94*1.67* = 9.3 %

Thus, the paper mill owner can pay upto a 9.3 % percentage increase in existing pulp price for the superior pulp. This means if the existing pulp costs $600 per ton, the equivalent price of the superior pulp is really $655.8 per ton. Any price paid by the paper mill less than that amounts to the profit they are making per ton of pulp used. This is a very large figure considering the fact that price flexibility per ton for a particular grade usually lies within $10 - $ 20 in the industry.

## 2.2 INCREASE IN CONTRIBUTION MARGIN (DUE TO HIGHER QUALITY PRODUCT & LOWER PRODUCTION COSTS)

The contribution margin for the paper mill can be increased through decreased variable costs (by requiring lesser energy for drying etc or lesser chemicals) or through increased revenues due to a higher quality of pulp product. A model to estimate the value delivered by a superior pulp by means of increased contribution margin is documented below.

### MODEL TO ESTIMATE EFFECT OF INCREASED CONTRIBUTION MARGIN (IN TERMS OF REQUIRED % INCREASE IN PULP PRICE NEEDED TO OFFSET THE ADDITIONAL GAIN)

The equivalence of any percentage increase in contribution margin (by decreasing the variable costs or increasing the revenues) to percentage increase in pulp price needed to neutralize additional gain can be found as follows:

The Basic Equation:
Amount Left to cover the Fixed Costs:
Contribution Margin per ton of output * Output (say in monthly tons)

An increase in revenue per ton of output of $Y_1$% or a $Y_2$% decrease in other variable costs per ton of output would have to be offset by an A % increase in the pulp price so as to neutralize the gain and keep the contribution margin unchanged. As before,

Let the ratio of the price deserved by the superior pulp (by paying which, the additional gain is offset) to the existing price of the pulp be: ‘a’
Let the ratio of existing price of pulp used per ton of output to the revenue generated per ton of output be $X_1$.
Let the ratio of the other variable costs incurred (excluding pulp cost) per ton of output to the revenue generated per ton of output be $X_2$.

#### FOR THE CASE OF A $Y_2$% DECREASE IN OTHER VARIABLE COSTS PER TON OF OUTPUT

This implies:
Decrease in Other Variable Costs per ton of output = Increase in Variable Costs (due to raised pulp price per ton of output)
Or

$$\left(\frac{Y_2}{100}\right)(X_2)(\text{revenue per ton of output}) = \left(\frac{A}{100}\right)(X_1)(\text{revenue per ton of output})$$

Therefore $A = Y_2\left(\frac{X_2}{X_1}\right)$

To take an example to illustrate this:
If there is a 10% reduction in the other variable costs (which are made up of energy/chemical costs and other operating production related material and services) due to a superior pulp.

We assume here $X_1$ be .3
We assume here $X_2$ be .2

We could get $X_1$ and $X_2$ by simply dividing the existing pulp price, other variable costs per ton of output to the revenue generated by per ton of output. If this transactional data is not known, a simple model to estimate $X_1$ and $X_2$ by common sense has been shown at the end of this chapter. These values of $X_1$ and $X_2$ shown above have been calculated using the model and some assumptions

This implies:

$$A = 10\left(\frac{.2}{.3}\right)$$

= 6.7%

Therefore the paper mill owner can pay upto a 6.7 % increase in existing pulp price for the superior pulp. Thus, if the existing pulp costs $600 per ton, the equivalent price of the superior pulp is really $640.2 per ton. Any price paid by the paper mill less than that amounts to the profit they are making per ton of pulp used. This is a very large figure considering the fact that price flexibility per ton for a particular grade usually lies within $10 - $ 20 in the industry.

**FOR THE CASE OF AN INCREASE IN REVENUE PER TON OF OUTPUT OF $Y_1$%**

An increase in revenue per ton of output of $Y_1$% would have to be offset by an A % increase in the pulp price so as to neutralize the gain. This implies:

Increase in Revenues per ton of output = Increase in Variable Costs (due to raised pulp price per ton of output)

Or

$$\left(\frac{Y_1}{100}\right)(\text{revenue per ton of output}) = \left(\frac{A}{100}\right)(X_1)(\text{revenue per ton of output})$$

Therefore

$$A = \frac{Y_1}{X_1}$$

To take an example to illustrate this:
Let us assume a 5% increase in the price of a superior napkin that is delivered to an end customer.

We assume here $X_1$ be .3

We could get $X_1$ and $X_2$ by simply dividing the existing pulp price, other variable costs per ton of output to the revenue generated by per ton of output. If this transactional data is not known, a simple model to estimate $X_1$ and $X_2$ by common sense has been shown at the end of this chapter. The value of $X_1$ above have been calculated using the model shown and some assumptions)

This implies:

$$A = \frac{5}{.3}$$

= 16.7%

There the paper mill owner can pay upto a 16.7 % percentage increase in existing pulp price for the superior pulp. Thus if the existing pulp costs $600 per ton, the equivalent price of the superior pulp is really $700.2 per ton. Any price paid by the paper mill less than that amounts to the profit they are making per ton of pulp used. This is a very large figure considering the fact that price flexibility per ton for a particular grade usually lies within $10 - $ 20 in the industry.

While decrease in production costs and increase in runnability brought by a superior pulp can be estimated internally, a model is needed to measure the increase in end consumer demand attributable to the use of a superior pulp based product. And thus, the corresponding increase in operating rates as well as contribution margin for the paper mill. This has been discussed in the next chapter.

**Footnote: Model To Estimate $X_1$ And $X_2$**

Where
$X_1$ is the ratio of existing price of pulp used per ton of output to the revenue generated per ton of output
$X_2$ is the ratio of the other variable costs incurred (excluding pulp cost) per ton of output to the revenue generated per ton of output

Let us assume that it takes a mill to run between 25 to 30 days to cover its fixed costs. Let s pick a random number say 26. Let us also assume as the average operating rate is around 90%, i.e. the mills runs for 27 out of 30 days. This would mean

F = Monthly Fixed Costs

$$=\left(\frac{26}{30}\right)(\text{monthly rated capacity in tons})(\text{revenue per ton - variable costs per ton})$$

$$=\left(\frac{26}{30}\right)(\text{monthly rated capacity in tons})\left[\{1-(X_1+X_2)\}\right](\text{revenue per ton})$$

Or $$\frac{F}{\left[\left(\frac{26}{30}\right)(\text{monthly rated capacity in tons})\right]}=\left[\{1-(X_1+X_2)\}\right](\text{revenue per ton})$$

Let Fixed costs per ton produced be $$F_1=\frac{F}{\left[\left(\frac{27}{30}\right)(\text{monthly rated capacity in tons})\right]}$$

Therefore
$$F_1\left(\frac{27}{26}\right)=\left[1-(X_1+X_2)\right](\text{revenue per ton})$$

We know historically let us say over a month, the pulp costs constitutes 30% of the total costs incurred per ton of output. The other variable costs account for 20% and fixed costs the remaining 50% per ton of output.

This implies $F_1$ = Fixed costs per ton produced = Variable costs per ton = 2.5*$X_2$*Revenue per ton, 1.67*$X_1$*Revenue per ton

Putting this in
$$F_1\left(\frac{27}{26}\right)=\left[1-(X_1+X_2)\right](\text{revenue per ton})$$

would mean
$X_1$ is roughly equal to .3
$X_2$ is roughly equal to .2

# CHAPTER THREE
# MEASURING THE INCREASE IN END CONSUMER DEMAND ATTRIBUTABLE TO THE USE OF A SUPERIOR PULP BASED PRODUCT

*Chapter Outline*

- *Market Indicators Of Positive Consumer Demand For Superior Pulp Based Products*
- *A One Step And 2 Step Conjoint Model For Estimating Increase In Consumer Demand Due To The Use Of A Superior Pulp Based Product*

The effect of increased operating rates as well as contribution margin (for a paper mill due to the use of a superior pulp) has been expressed in terms of the required % increase in pulp price needed to neutralize the additional gain in the previous chapter. To carry the argument further, a model is now needed to measure the increase in end consumer demand attributable to the use of a superior pulp based product and thus the subsequent increase in operating rates as well as contribution margin for the paper mill. Such a model has been discussed in this section.

## 3.1 MARKET INDICATORS OF POSITIVE CONSUMER DEMAND FOR SUPERIOR NAPKINS

Unlike the consumer market, commercial tissue producers can't concentrate on mass-producing a single product and selling it as a one-size-fits-all solution to customers' needs. Instead, they must pay attention to the peculiar demands of each customer, whether it's the color of the napkins SCA Tissue makes for Wendy's or the fiber content for Taco Bell or the customized printing for Dairy Queen. Some leading indicators of positive customer demand for superior napkins are:

**CAPITAL INVESTMENTS BY LEADING COMPANIES**

The TAD (Through-Air Drying) Investment: The drive for higher quality is fueling much of the growth. It is obvious that most of the new machines being built to produce tissue are expected to be equipped with TAD technology, the new standard for premium tissue. TAD has played an important role in improving tissue quality for added softness, volume and absorbency. A TAD sheet is stronger than traditional Yankee dried tissue or towel, and can have as much as 50% higher absorbency. TAD machine installations require 30-40% higher capital investment, in addition to higher energy consumption costs. However, some of these increased costs are offset by lower fiber consumption in manufacturing, improved product quality and higher pricing of TAD substrate sheets.

**CHARACTERISTICS OF NEW NAPKIN PRODUCT LAUNCHES**

Georgia-Pacific's Brawny brand is battling out Quilted Northern as the company's premium napkin entry in a move that is backed by the company's first TV support for the category in recent memory. Brawny napkins are heavier and thicker than Quilted Northern, and consumers rate them softer. Ads focused both on strength and softness.

Tork Softline, SCA's latest range of napkins in Europe (launched September 2003), uses an existing technology to address the market's needs in a new way. Softline is a laminated tissue napkin produced with 'pin to pin' technology. It gives a soft and bulky napkin. Laminated napkins are already commonly used in southern European countries, often as an alternative to airlaid varieties

Duni has focused on improving the softness of printed napkins without compromising print quality. The result, known as Softer Tissue, was launched in January 2004. The company is sure it will, Bring added impetus to the tabletop category

Metsä Tissue will be launching its Fasana-branded napkins, including the luxury new DecoSoft range at Hotelympia from 23rd to 27th February, 04 at ExCel London (stand S4061). DecoSoft is a unique new quality napkin manufactured using some of the latest paper technology. The premium linen-feel and high strength napkins are ideal for luxury applications and are very competitively priced against similar premium paper tissue products.

## 3.2 A One Step And 2 Step Conjoint Model For Estimating Increase In Consumer Demand Due To The Use Of A Superior Pulp Based Product

A superior product (here a napkin) delivered by a paper mill could lead to

- A price premium and hence a greater contribution margin
- Or an increase in orders and hence an increase in the output or operating rate for the mill

Which could then be directly translated into the actual value or the justifiable percentage increase in the price paid for a superior pulp

The key thing here is to develop a model which could assess the state of the end consumers (here napkin users) and measure either the price premium or the increase in orders for the mill attributable due to a superior product.

The customers for any paper mill product can be put in one of two categories:

- Primary Users of the Product (This includes the retail or consumer market for the product as well as commercial buyers which buy the product for internal use (like offices, educational institutions etc))
- Non Primary Users of the Product (This includes the component of the commercial market which buys the product to be ultimately be used by its own customers (for whom in turn, the product is a part of an overall purchasing decision) (e.g. the Hotel, Restaurant, Catering segment which buys paper napkins and is visited by customers)

We have developed a 1 step model to measure the increase in revenues, decrease in costs associated with the former category of paper mill customers due to a superior product.

And a 2 step model to measure the increase in revenues, decrease in costs associated with the latter category of paper mill customers due to a superior product.

**1 Step Model**

The model measures the relative value or importance that the primary users attach to the superior quality produced in the product (by a better pulp). Given the competing products, it then converts this to the increased demand from the customers to purchase the product. (which in turn can be translated into increased output as well as price premium for the paper mill. This can then be used to find out the true value of the superior pulp used.)

**2 STEP MODEL**

Step 1: **Gain realized due to favorable purchasing behavior of primary users (i.e. end customers of commercial buyers like restaurants etc):** Step 1 of this model is almost identical to the One Step Model described earlier. The model measures the relative value or importance that the primary users (here the customers of the commercial buyers of the product) attach to the superior quality produced (by a better pulp) in their overall purchasing decision from the commercial buyers. (E.g. the case of Paper Mills & Converters selling napkins to the Restaurant McDonalds etc. Here a softer napkin may translate into greater end customer satisfaction and increased visits by them to the restaurant). Given the competing products (restaurants here), it then converts this to the increased demand from the customers to purchase the overall product. (a restaurant visit here).

The difference here is the need to develop a coefficient to convert the increased demand (say visits to a restaurant here) to the increased orders or price premiums that a paper mill owner could command (say from a restaurant here). This then can then be used to find out the true value of the superior pulp used)

Step 2: **Additional Gain due to the non product price related cost savings directly experienced by the non primary users (i.e. some commercial buyers like restaurants here):** The model measures the cost related savings (besides the price of the product) that directly concern them. (for instance, a bulkier napkin may imply say 1/3 rd lesser napkins consumed by restaurant customers and hence a direct reduction in the costs for the restaurant purchasing napkins) This reduction in the costs can be translated into the price premium justifiable for the paper mill product.

## ILLUSTRATING THE ONE STEP MODEL

We will be illustrating the 1 step model with an example here:

**Consumers who purchase Napkins from retail stores:** These are customers for a paper mill product who are Primary Users of the product. As explained above, we need to find out the relative value or importance that the primary users attach to the superior quality produced in the product (by a better pulp). Given the competing products, we then convert this to the increased demand from the customers to purchase the product

We can do this by directly interviewing end customers and asking them about their increased probability to buy the napkins because of their say superior softness.

Often, it is difficult for customers to accurately answer such a question in isolation. It is highly recommended instead that consumers be instead asked to fill out a conjoint based questionnaire. A conjoint questionnaire estimates an individual's value system, and specifies how much value a consumer puts on each attribute. Rather than forcing consumers to think separately about individual attributes, conjoint asks the customers to make judgments about products overall and then uses mathematical analysis to uncover the value system that must be behind the preference judgments. For instance, it might be difficult for an average consumer to tell a market researcher how much more valuable a napkin which is extra soft is, as compared to a napkin which is of average softness.

The basic output of conjoint analysis is the relative favorable value (utility or part worth) provided to customers by each potential feature of a product (like softness). There are three stages involved in conducting this analysis to measure the increased demand attributable to a superior product.

**Stage 1—Design The Conjoint Study**
**Stage 2—Obtain Data From A Sample Of Respondents**
**Stage 3—Estimate Product Demand**

### STAGE 1—DESIGN THE CONJOINT STUDY

Step 1.1: Select attributes relevant to the product or service category,
Step 1.2: Select levels for each attribute, and
Step 1.3: Develop the product bundles to be evaluated.

E.g. Attributes for a Napkin could be:
Level of softness (3 levels)
Level of absorbability (3 levels)
Level of Printability or Design (3 levels)
Price (3 levels)

(For a pack of 350 napkins)

| Product Bundle Number | Softness | Absorbability | Printability/Design | Price | Overall Resp. Score |
|---|---|---|---|---|---|
| 1 | High | Low | Low | $6.50 | 90 |
| 2 | Average | Average | High | $7.50 | 80 |
| 3 | Low | High | Low | $6.50 | 70 |
| 4 | High | Average | Low | $7.00 | 60 |
| 5 | High | Average | Average | $7.50 | 50 |

(The scores mentioned above are fictitious)

### STAGE 2—OBTAIN DATA FROM A SAMPLE OF RESPONDENTS

Step 2.1: Design a data-collection procedure to collect scores for each set of product bundles from different respondents
Step 2.2: Obtain part-worth functions or relative value of each attribute using any software with a conjoint option like SPSS

Some possible scores by a respondent is shown in the last column above. The part-worth functions or relative value of each attribute can be got by feeding this data into any software with a conjoint option like SPSS.

Example of Computed Part-Worth or Relative Favorable Value for Attributes for a respondent
Softness level High (30)
Softness level Average (15)
Cost Low (40)
Cost Average (25)
Cost High (10)
Etc…..

### STAGE 3—ESTIMATE PRODUCT DEMAND

Step 3.1: Define the Competitive Set
Step 3.2: Select choice rule & estimate demand

Define the competitive set. These are the products from which the target segment makes choices. Say the prominent 4 or 5 brands.

Select Choice rule used to estimate product demand. There are two basic rules which can be used.
Maximum utility rule
Share of preference rule

**Maximum utility rule:** Each consumer will prefer to buy the product (among those available) with the highest total utility points or partworth points for its features. The maximum utility rule is the preferred analysis option, if customers buy products in the product category infrequently and/or are highly involved in the purchase decision

**Share of utility rule:** Under this choice rule, the consumer selects each product with a probability that is proportional to the utility of that product as compared to the total utility derived from all the products in the choice set. This analysis option is most suitable for products that customers buy frequently and/or where the customers are not highly involved in the purchase decision.

To illustrate the use, let us consider there were 4 leading identical napkins in the market. One of the four now got replaced with a product having a superior softness. We can use the share of utility rule to calculate the increased demand for such a napkin.

Let us assume that each of the 4 products previously had a 100 utility points total for all their features as evaluated by respondents. Now due to superior softness, product score for the replaced product raises to 115. (This is so as respondents had earlier been found to giving 30 points to High Softness level and 15 to Average Softness level through the conjoint study)

Therefore its market share by share of utility rule is now (115/415) instead of (100/400). Or 27.7% instead of 25%. This implies a 2.7% increase in demand or orders and hence output for the mill. It may be recalled that in the previous chapter, we had estimated a 5.9% increase in output could after making certain assumptions justify a 9.3% increase in pulp price for the paper mill

The napkin company could also decide to maintain existing market demand or output and instead increase the price to compensate for the increase in utility got by softness. Hence, in this case the cost of the replaced product would also go from Average to High without affecting customer demand. (as the 15 utility points lost by increasing the cost are gained by increasing the softness) This would mean the napkin price could be raised from $7 to $7.5 or by 7.1%. It may be recalled that in the previous chapter, we had estimated a 5% increase in price of napkin could after making certain assumptions justify a 16.7% increase in pulp price for the paper mill

## ILLUSTRATING THE TWO STEP MODEL

Let us examine the case of Paper Mills & Converters selling napkins to the Hotel, Restaurant, Caterer Businesses. (E.g. McDonalds etc).

### STEP 1:

**Gain realized due to favorable purchasing behavior of primary users (i.e. end customers of commercial buyers like restaurants etc):**

For the 2 Step Model, Step 1 is exactly identical only here we would be collecting responses of visitors to restaurants and not the restaurant owners themselves which purchase the napkins. We would thus be calculating the increased number of visits (if any) to a restaurant due to a better dining experience provided by superior say softer napkins. (Pacific Research Group Inc., which runs surveys for Krispy Kreme Doughnuts Inc., among others had said that Napkins can affect 10% to 20% of customer-satisfaction scores)

The difference here is the need to develop a coefficient to convert the increased visits to say a restaurant (got by the conjoint based questionnaire) to increased orders or price premiums that a paper mill owner could command for the napkins supplied. We have shown below steps for development of such a coefficient for this particular example.

1. **Calculate the ratio of new visits/old visits (or new demand/old demand) to a restaurant got by the conjoint based questionnaire administered to restaurant visitors**

2. **Translate that into increased revenue per napkin bought for the restaurant and hence the justifiable price increase or premium for the napkin sold by the paper mill:**
   We can estimate the average contribution margin earned by the restaurant per consumer visit to it. We also know the number of new visits as compared to the old visits to a restaurant. Hence, we know the increase in contribution margin for the restaurant = (new visits-old visits) *contribution margin per customer visit. This divided by total number of napkins used (or napkins consumed per customer visit*new visits) will give the increased revenue per napkin bought.

   Or Increase in revenue (left to cover it's fixed costs) to the restaurant per napkin consumed = [1- (old number of visits/new number of customer visits)] *[(contrib. margin earned per visit)/(napkins consumed per visit)]

This increase in revenue (left to cover its fixed costs) got to the restaurant per napkin consumed is the premium a paper mill could command per superior napkin it sells to the restaurant.

**STEP II**

**Step 2: Additional Gain due to the non product price related cost savings directly experienced by the non primary users (i.e. some commercial buyers like restaurants):**
The model measures the cost related savings (besides the price of the product) that directly concern them. (for instance, a bulkier napkin may imply say 1/3 rd lesser napkins consumed by restaurant customers and hence a direct reduction in the costs for the restaurant purchasing napkins) This reduction in the costs can be translated into the price premium justifiable for the paper mill product.

Let us assume the cost of a napkin is $0.02. Instead of 3 normal napkins being used by a consumer, only 2 bulkier one are used. Hence the price charged by the paper mill to the restaurant for the 2 bulky napkins should be actually equivalent to the price of 3 normal napkins. This means that if the mill was original getting say $X revenues per ton of napkin shipped, it should now get 1.5 times that for the superior napkin Or a 50% increase in price. It may be recalled that in the previous chapter, we had estimated a 5% increase in price of napkin could after making certain assumptions justify a 16.7% increase in pulp price for the paper mill. ( While the gain may not be as much as it seems due to decrease in the volume ordered, it still is significant as a 5.9% decrease in output after making certain assumptions justifies only a 10.5% decrease in pulp price. While a 5% increase in price of napkin could after making certain assumptions justify a 16.7% increase in pulp price for the paper mill)

# PART II
# IMPORTANCE OF PULP PROPERTIES STUDY TO EVALUATE SUPERIOR PULPS (FOR NAPKINS)

(THIS SECTION IS MEANT ONLY TO ILLUSTRATE HOW SIGNIFICANT IMPROVEMENTS IN PRODUCT PERFORMANCE CAN BE GOT BY STUDYING PULP PROPERTIES MORE CLOSELY.

IT IS NOT MEANT TO BE AN AUTHORITATIVE DOCUMENT ON PULP PROPERTY EVALUATION)

# INTRODUCTION TO CURRENT SITUATION IN EVALUATING PULPS TECHNICALLY

Market pulps are classified into various categories based on the type of fiber, pulping process and degree of bleaching. This often leads to pulps in a category (NBSK, for example) being treated as a commodity. On closer examination of market pulps of a certain category – e.g., Canadian NBSK pulps - one finds that there is considerable difference in fiber morphology and performance capabilities

Depending on the particular paper grade and process capabilities, it is possible to make significant improvements in product performance by selecting say the best NBSK from the "commodity" pulps available in the marketplace. Market pulp fiber morphology as well as handsheet information can be used as inputs into optimal pulp selection. The optimal pulp or pulp blend can help provide better formation, smoother surfaces, finer pore structures, and higher opacity as well as a long, strong fiber network to increase wet web strength and runnability on the paper machine, printing and other converting operations.

# BASIC MORPHOLOGICAL & HANDSHEET PROPERTIES OF PULP FIBERS[6]

Pulp Fibers are like drinking straws with length varying from .75 to 6 mm long and length to width ratio between 50 to 140.

Each fiber consists of 4 layers. An outer thin membrane called primary wall, and three layers of the secondary wall (outer S1, middle S2, inner S3). Lumen is the hole through which water is transported. It is the S2 layer which primarily determines cell wall thickness. Cellulose molecule bundles or fibrils make up most of the cell wall. These are held together by weak hydrogen bonds. Separate fibers are bonded together by middle lamella which is mostly made up of lignin. Lignin is responsible for giving structural rigidity to the fiber. We can have thin or thick walled, long or short fibers.

Softwood:
Long fibers (3 - 6 mm)
Length to width ratio of around 100 which is important to flexibility

Hardwood:
Short fibers (around 1.5 mm)
Length to width ratio (around 50)

Paper structure depends on fiber structure and the way it has been manipulated during the paper making process.

#### BONDING

Paper Strength depends on bonding between fibers and the intrinsic fiber strength. Bonding happens when fibers are in close contact with each other so that the weak hydrogen bonds can be formed. The greater the surface area between 2 fibers, the stronger the bond

Greater fiber collapsibility also helps in increasing bonding. Fiber collapse means flattening of fibers or forming ribbon like structures. These have more surface area hence greater contact area between fibers. Also they are also more flexible resulting in more fibers in contact

Fiber collapse depends on 5 factors:

- Thickness of the fiber wall
- Ratio between fiber wall thickness and fiber width
- Amount of lignin left in the fiber wall
- Degree of mechanical action the fiber has been subjected to
- Pressure fibers are subjected to on the paper machine

Softwood fibers have the same wall thickness as hardwood but are wider. They are thus more collapsible. Mechanical damage esp. refining helps to collapse fibers. The longer length of softwood fibers also helps to increase contact surface area and hence results in better bonding. Softwood fibers thus give strength and runnability as they bond well.

[6] Source: Practical papermaking [computer file] / TAPPI. 2001

### FORMATION, PRINTABILITY AND SMOOTHNESS

Hardwood fibers for uniformity, formation, smoothness and printability since they are smaller and fill up the holes and spaces better.

Also, within softwood there exist considerable differences. Northern softwood has a thinner fiber wall, is more flexible so smoother sheets, better sheet surface characteristics. Southern softwood has a longer growing season so thicker fiber walls, so stiffer and poor surface characteristics

**Impact of water:** Excessive water does reduce bonding, but water especially during drainage promotes movement and conformability of fibers. When you dry a fiber, bonds form. Some of them don't break and that does give stiffness and bulk to paper

.

# THE INFLUENCE OF MEASURABLE HANDSHEET AND FIBER PULP PROPERTIES ON EACH OF THE 5 DESIRED PROPERTIES FOR A NAPKIN

Premium tissue grades, particularly those produced by through-air drying, need NBSK to provide low density softness and strength. NBSK provides a long, strong fiber network to increase wet web strength and runnability on the paper machine, printing and other converting operations. Softwood Bleached ChemiThermoMechanical Pulp (BCTMP) is also a popular choice, with its relatively stiff fibers, ensuring high levels of absorbency and softness.

The wood species used in Bleached Hardwood Kraft (BHK) market pulps range from 100 % aspen, maple or birch to mixed Northern or Southern hardwoods and 100 % eucalyptus. BHK pulps are used primarily for their ability to provide better formation, smoother surfaces, finer pore structures and higher opacity. In tissue and napkins, they provide softness and a velvety surface feel.

Pulp properties thus have a significant influence on the properties of the end product and include:

| |
|---|
| **Fiber Morphology** |
| Fiber length (Avg. length-weighted), mm<br>Fiber Coarseness (Avg.), mg / m<br>Fiber Curl Index<br>Fines (< 0.2 mm, Arithmetic), % |
| **Fiber Strength** |
| Zero Span, Wet, km |
| **Handsheet Properties** |
| Bulk, cc/g<br>Tensile, km<br>Stretch, % |
| **Optical Properties** |
| Brightness (ISO), %<br>Scattering Coefficient, cm2/g |
| **Drainage Properties** |
| C.S. Freeness, ml |

The 5 desired properties for a tabletop napkin are softness, absorbability, printability, dust free nature and runnability

### SOFTNESS

**Definition:** Is a general term that descries the presence or absence of the pleasant soft feel against the skin. Bulk softness is defined as the perception of softness obtained when the sheet is crumpled by the hands. Surface softness is defined as the perception of softness obtained when the fingertips are lightly brushed over the surface of a tissue sheet.

**Influence of pulp properties:** Softness generally correlates inversely with sheet strength. The lesser the bonding between fibers, the softer they are. This is so as bonding can increase rigidity of fiber product. Thus Sheet densities play a huge factor. The denser they are the less soft they become. Also, lower the coarseness to length ratio, greater the softness. (Coarseness: is the weight per unit fiber length. There is an inverse relation between coarseness and number of fibers per gram.)
Softness also increases with bulk and decreases with increase in rigidity. Printing inks and the use of additives like starch kill softness

### PRINTABILITY

**Definition:** Refers to the ability of the sheet to absorb ink in a uniform manner without opposite side show-through. Printing dots should be sharp and clear without significant spread. Demands for a smooth surface, high brightness and a porous structure which does not allow the printing ink to penetrate the sheet

**Influence of pulp properties:** Smoothness: is the relative magnitude of irregularities on two surfaces on the paper. It decreases with increase in coarseness. Also, as cell wall thickness prevents fibers from collapsing and hence causes them to protrude, smoothness decreases with increase in cell wall thickness. Thinner fiber walls also imply more flexible so smoother sheets.
Formation: Uniform mass distribution. Quality, uniformity and hence to a certain extent printability goes down as fiber length increases as it promotes fiber aggregation
Printability can also be affected by sheet surface energy, moisture, sheet stability / hygroexpansivity etc

### RUNNABILITY

**Definition:** Ability to get a sheet through the papermachine (presses, dryers) and subsequent converting / printing operations.

**Influence of pulp properties:** Runnability on paper machine is a function of web strength and drainage as well as papermachine design

Web strength: Strength depends on bonding between fibers and intrinsic fiber strength. Bonding happens when fibers are in close contact with each other so that the weak hydrogen bonds can be formed. The greater the surface area between 2 fibers, the stronger the bond. Longer, lesser coarse fiber tends to be stronger. This is so as they are more collapsible, more flexible and also have greater contact surface area. Collapsibility can also be measured as the ratio between fiber wall thickness and fiber width or coarseness to diameter or thickness to diameter. This assumes we can measure fiber width (through say the latest microscopes). Do refer to the section before this for greater details on collapsibility.

Drainage: Wet compactability goes against pulp drainage in the paper machine as do long, slender fibers which tend to form an impervious thin layer, promote aggregation and impede drainage

### DUST FREE

**Definition:** Stickiness and tendency to agglomerate on paper machine. Linting is the phenomenon involving separation of fiber or pigment particles from the surface of the paper and accumulation of these particles on the printing plate and in ink and water systems. Linting is a problem because it requires regular cleaning of the printing press. This results in lost production. Linting also impairs the quality of the printed image.

**Influence of pulp properties:** Very short, low coarseness fibers are loosely held and have a tendency to dust. Strongly bonded fibers don't show a linting tendency.

### BULK/ABSORBABILITY

**Definition:** Bulk is the inverse of density.

**Influence of pulp properties:** Porous and bulky structure is a function of free voids and specific surface area. Ratio of pore volume to total sheet volume is porosity. Thus, the more the pore space, the bulkier they are, the more absorbent they are. Coarser fiber has greater weight per unit length, implies lesser number of fibers per gram and hence more pore space.

Stiffness (maintained by keeping lignin as well as fiber intact during pulping process) also tends to make fibers more rigid when wet and hence more absorbent. Filler content also affects bulk and absorbability

## CASE STUDY OF EVALUATION OF TWO PULPS FOR GENERAL TISSUE APPLICATIONS[7]

For purposes of this exercise, let us assume that the Western Ontario (WO) pulp is the current reference pulp in this pulp users system and the question to be answered is whether the candidate pulp (Eastern Ontario (EO) pulp) would be better.

The first pulp attributes to consider are fiber length and coarseness. Longer fibers make stronger paper. Fiber length has a strong influence on sheet formation and runnability on the paper machine and converting equipment. However, we want these fibers to be slender to provide the best balance possible between softness and strength. Lower coarseness pulps tend to have finer fiber, so we want the lowest coarseness possible. Western Ontario (WO) pulp has the longest fiber, while the Eastern Ontario (EO) pulp has the lowest coarseness. By comparing their fiber length to coarseness values, we can see that these two pulps have similar potential, with EO having a slight edge at 17.0 vs. 16.5 for WO.

Curl Index data indicate that the EO pulp has considerably higher curl levels than the WO pulp. The fiber curl impact is evident in the high stretch levels of EO pulp. This may be beneficial for tissue bulk and stretch if the desired strength levels can be obtained.

The fiber strength data show the WO pulp to have much stronger fibers than EO (13.6 km vs. 11.2 km). This difference is not particularly significant, however, because soft tissue strengths levels are quite low compared to these fiber strength levels.

The major question that needs to be answered at this point is how to deal with the tensile strength differences evident between the EO and WO pulp (2.9 km vs. 5.4 km). Could the EO pulp be refined? This is a situation where more of the beater curve data is needed. Looking at data, the answer is that the EO pulp would have equal tensile strength at 38 kWh/t, a fairly low refining level.

[7] The following case study and analysis has been taken from the paper *"An Efficient, Effective Approach To Pulp Evaluation Using Key Fundamental Properties"* authored by Alan F. Button, Buttonwood Consulting, LLC

Also, at equal tensile breaking length, the EO pulp has higher bulk (1.83 cm3/g vs. 1.73 cm3/g), higher stretch (3.26 % vs. 2.1 %) and higher scattering coefficient (321 cm2/g vs. 315 cm2/g) than the WO pulp. The only negative is the lower freeness for the EO pulp (630 ml vs 697 ml).

To summarize, the EO pulp has better fiber morphology, bulk, stretch and scattering coefficient at equal tensile strength, all important positives for soft tissue. The WO pulp has better fiber strength and freeness, neither of which are likely to be an issue for this application. Assuming that there is willingness and capability to refine the EO pulp, and the supplier can produce a stable product with the sample pulp characteristics, one should choose the EO pulp for the soft tissue application.

## APPENDIX I: FREQUENTLY USED ACRONYMS

NBSK: Northern Bleached Softwood Kraft
TAD: Through-Air Drying
AFH: Away From Home
SCA: Svenska Cellulosa Aktiebolaget
PFI: Process Facilities Inc.,
ATI: American Tissue Inc.
EO: East Ontario
WO: West Ontario
BCTMP: Bleached ChemiThermoMechanical Pulp

## APPENDIX II: UNDERSTANDING CONJOINT ANALYSIS

Conjoint based questionnaires filled in by consumers, allow marketers to evaluate how consumers make tradeoffs between various product attributes (including price) for a particular product concept.

Conjoint asks consumers to rate products (each one consisting of a set of attributes) overall and then uses mathematical analysis to uncover the value system that must be behind the preference judgments.

The basic output of conjoint analysis is the value (also called utility or part worth) attached by customers to each potential attribute (such as say softness for a napkin) of a product.

An example of a conjoint based analysis for determining how consumers evaluate napkins and the math behind it is listed below.

Let the Napkin Attributes and levels be as shown below:

| **Attribute** | **Level** | **Description** |
|---|---|---|
| Napkin Softness | 1 | High |
| | 2 | Low |
| | 3 | Average |
| Printability/Design | 1 | High |
| | 2 | Average |
| | 3 | Low |
| Price | 1 | $6.50 |
| | 2 | $7.00 |
| | 3 | $7.50 |

An example of a Napkin profile could be one with:

| | |
|---|---|
| Softness | High |
| Printability/Design | Low |
| Price | $7.00 |

Now, a hypothetical consumer filled in a conjoint questionnaire asking him to rate nine product profiles as shown below:

**Table 1.1**

| **Profile No.** | **Softness** | **Printability/Design** | **Price** | **Rating** |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | **9** |
| 2 | 1 | 2 | 2 | **7** |
| 3 | 1 | 3 | 3 | **5** |
| 4 | 2 | 1 | 2 | **6** |
| 5 | 2 | 2 | 3 | **5** |
| 6 | 2 | 3 | 1 | **6** |
| 7 | 3 | 1 | 3 | **5** |
| 8 | 3 | 2 | 1 | **7** |
| 9 | 3 | 3 | 2 | **6** |

In order to find out the value attached by the consumer to any particular attribute level (like high softness), we perform here the following analysis:

The simplest estimation procedure, and one which is gaining in popularity, is dummy variable regression. If any particular attribute i, has $k_i$ levels, it is coded in terms of ($k_i - 1$) dummy variables.

This may be represented as:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6$$

where

$X_1$, $X_2$ = dummy variables representing Softness
$X_3$, $X_4$ = dummy variables representing Printability/Design
$X_5$, $X_6$ = dummy variables representing Price

For instance, for Softness attribute, the attribute levels were coded as follows:

| | $X_1$ | $X_2$ |
|---|---|---|
| Level 1 (High) | 1 | 0 |
| Level 2 (Low) | 0 | 1 |
| Level 3 (Average) | 0 | 0 |

Table 1.1 may now be represented as:

| **Preference** | **Attributes** | | | | | |
|---|---|---|---|---|---|---|
| **Ratings** | Softness | | Printability/Design | | Price | |
| Y | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ |
| 9 | 1 | 0 | 1 | 0 | 1 | 0 |
| 7 | 1 | 0 | 0 | 1 | 0 | 1 |
| 5 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 1 | 1 | 0 | 0 | 1 |
| 5 | 0 | 1 | 0 | 1 | 0 | 0 |
| 6 | 0 | 1 | 0 | 0 | 1 | 0 |
| 5 | 0 | 0 | 1 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 1 | 1 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 1 |

The levels of the other attributes were coded similarly. The parameters were estimated as follows by regression:

$b_0$ = 4.222
$b_1$ = 1.000
$b_2$ = -0.333
$b_3$ = 1.000
$b_4$ = 0.667
$b_5$ = 2.333
$b_6$ = 1.333

Now, the product ratings Y could also be represented by the following formula (1):

$$U(X) = \sum_{i=1}^{m} \sum_{j=1}^{k_i} \alpha_{ij} x_{ij}$$

where

| | |
|---|---|
| *U(X)* | = overall utility of an alternative *or product profile* |
| $x_{ij}$ | = 1 if the *j* th level of the *i* th attribute is present *in the product profile* |
| | = 0 otherwise |
| $k_i$ | = number of levels of any particular attribute *i* |
| *m* | = number of attributes |
| $\alpha_{ij}$ | = the part-worth contribution or utility associated with the j th level (j, j = 1, 2, . . . ki) of the i th attribute (i, i = 1, 2, . . . m) |

Comparing Coefficients of
$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6$ with

$$U(X) = \sum_{i=1}^{m} \sum_{j=1}^{k_i} \alpha_{ij} x_{ij}$$

It may be noted that for the sake of comparison that,

$X_{11} = X_1$
$X_{12} = X_2$
$X_{13} = 1 - (X_1+X_2)$

$X_{21} = X_3$
$X_{22} = X_4$ and so on…

We thus get:
$\alpha_{11} - \alpha_{13} = b_1$
$\alpha_{12} - \alpha_{13} = b_2$

and so on…

To solve for the part-worths, an additional constraint is necessary.
$\alpha_{11} + \alpha_{12} + \alpha_{13} = 0$
Thus, equations for the first attribute, Softness, are:
$\alpha_{11} - \alpha_{13} = 1.000$
$\alpha_{12} - \alpha_{13} = -0.333$
$\alpha_{11} + \alpha_{12} + \alpha_{13} = 0$

Solving these equations, we get the following part-worths for the three levels of softness,
$\alpha_{11} = 0.778$ [Part-worth for High Softness]
$\alpha_{12} = -0.556$ [Part-worth for Low Softness]

$\alpha_{13} = -0.222$ [Part-worth for Average Softness]

The part-worths for other attributes reported can be calculated similarly.

The relative importance weights for each attribute were calculated based on the ranges of part-worths they represented, as is shown below:

Sum of ranges of part-worths of each attribute
= (0.778 - (-0.556)) + (0.445-(-0.556)) + (1.111-(-1.222))
= (Softness Part-worth Range) + (Printability/Design Part-worth range) + ((Price Part-worth range)
= 4.668

Thus,
Relative importance of Softness = 1.334/4.668 = 0.286
Relative importance of Printability/Design = 1.001/4.668 = 0.214
Relative importance of Price = 2.333/4.668 = 0.500

Thus, the conjoint based questionnaire gave out the following values attached by the hypothetical consumer to various attribute levels:

| Attribute | Level No. | Description | Utility | Importance |
|---|---|---|---|---|
| Softness | 1 | High | 0.778 | |
| | 2 | Low | -0.556 | |
| | 3 | Average | -0.222 | 0.286 |
| Printability/Design | 1 | High | 0.445 | |
| | 2 | Average | 0.111 | |
| | 3 | Low | -0.556 | 0.214 |
| Price | 1 | $6.50 | 1.111 | |
| | 2 | $7.00 | 0.111 | |
| | 3 | $7.50 | -1.222 | 0.500 |

This information could be very useful in finding answers to questions like is there a market for highly soft napkins and if so how much more will the consumer be willing to pay for a napkin with a superior softness