The goal of the proposed project is to identify economic and regulatory factors that have generated price movements in the pulp & paper industry in order to meet a tactical industry objective of developing improved models for understanding pricing behavior and a strategic industry objective of ensuring the long term economic health of the industry.

The proposed project will employ advanced econometric techniques in order to develop improved paper and pulp pricing models. In particular, regression-based analysis is employed to statistically model those factors that are found to influence prices and to estimate the sensitivity of prices to changes in these determinants. Complementing this, historical time series data will be used to develop pricing behavior models in order to identify the stochastic process that governs price movements. Finally, the project will combine regression analysis with time-series methods to develop more efficient pricing behavior models. In addition to price behavior analysis, this project will also explore the feasibility of implementing a real-time market demand forecast for individual producers. By integrating product demand forecasting tool into production and management processes, producers will be able to adjust production levels in anticipation of market fluctuations, thus avoiding involuntary inventory buildups. This would enable firms to support product prices at a more efficient level.

The proposed project will contribute to research by deepening our understanding of market interactions and price behaviors in the pulp and paper industry. The project will also further the strategic objectives of the paper and pulp industry by providing important insights on those economic determinants that generate price movements and by providing improved pricing models intended to explain price fluctuations with an implication on future price movement. The desired outcomes of the project include a series of research papers and reports on industry structure, pricing behavior, as well as real-time market demand forecasting tools for individual producers.

The proposed project will last for three years. The first year will focus on an industry survey, a case study, an evaluation of existing work on price analyses, and the construction of a preliminary model for the containerboard sector of the industry. The research team includes faculty members from Georgia Tech and the IPST, as well as graduate and undergraduate students. With a broad and in-depth knowledge of econometric and statistical methods, industrial organization, systems engineering, and paper manufacturing technology, the interdisciplinary team possesses the abilities that are necessary for meeting the important research and industry objectives of the proposed project. Our first year budget will be $90,000. The second year has a minimum $80,000 budget and the third year minimum budget is $50,000.
PURPOSE, GOALS & LITERATURE REVIEW

Significant and unpredictable paper and pulp price movements have had a number of serious consequences for the pulp & paper industry, including excess capacity, unintended inventory build-up, and financial losses. And in the long term, unanticipated price behavior will threaten the economic viability of the industry. The primary focus of the proposed project is the pricing behavior of pulp and paper products. Our purpose is to explain price behavior, identify the causative factors, estimate various elasticities, and build statistical pricing behavior models for various segments of the industry. The goal is to advance academic research on pricing using modern econometric methods, and to enhance the industry’s understanding of past and, by extension, future price movements. This project will explore the feasibility of establishing real-time market forecasting models that would enable individual producers to avoid involuntary inventory buildup, which would reduce the pressure on firms to cut prices during a market downturn.

I. Current Forecasting Practices and Existing Studies

Understanding pricing behavior is among the most important issues for the pulp and paper industry. Information on prices are essential for budgeting, project financial assessment, contract negotiations and capacity planning. However, explaining price movements poses a formidable challenge. Fundamentally, market prices are determined in a system of equations that include demand and supply side variables interacting within a specific market structure. Because many variables in this system are endogenous, it is by no means an easy task to accurately model price movements and, therefore, to evaluate where prices may be headed.

In the pulp and paper industry, Resource Information and Systems Inc. (RISI), the Jaakko Pöyry Group, and the Pulp and Paper Forecaster by Miller Freeman Inc. generate a detailed set of forecasts. They publish regular forecasts of demand and prices for almost all pulp and paper products in different regions. While such information has been helpful to the industry, industry experts concur that these forecasts have not been satisfactory. More specifically, the underlying pricing models neither focus on causative factors nor do they provide information on price sensitivities due to changes in the causative factors. In addition, econometric
techniques and methodologies have significantly advanced in recent years, yet many of the existing models of price behavior fail to reflect these advances.

Academic research on pricing in the pulp and paper industry has almost exclusively focused upon the relationship between exchange rates and prices. For example, Alavalapati et al. (1997) uses co-integration analysis to investigate the effects of the Canada-U.S. exchange rate and U.S. pulp price on the price of Canadian pulp. Hanninen and Topinen (1999) estimate the pass-through effects of exchange rate variations on Finnish pulp and paper exports. Uusivuori and Buongiorno (1990) investigate the short-run and long-run effects of changes in exchange rates on U.S. imports of paper from Finland and Sweden. These studies certainly further the understanding of how exchange rates influence price movements, but they do not develop a general framework that focuses on determinants of price behavior and their associated elasticities.

Nebebe and Kira (1992) use Bayesian techniques and least squares approaches (e.g. seemingly unrelated regression methods) to examine the long-term elasticities of demand for pulp and paper products in Canada in selected regions. Singh and Nautiyal (1984) study the factors that affect pulp and paper prices. These studies provide useful estimates of price and income demand elasticities and identify those factors that affect price. For our purposes, Singh and Nautiyal is the most relevant but its focus is on the Canadian pulp and paper industry and on the Canadian market structure in general, and incorporates assumptions that may not carry over to the U.S. pulp and paper industry.

In sum, there are very few studies on prices for the pulp and paper industry in the U.S. The proposed project attempts to fill this gap by developing alternative models of pricing behavior with the aim of understanding the forces that have shaped industry prices in the past and, therefore, will provide insights on future prices for specific pulp and paper products.

II. Understanding Aggregate Price Movements

Regression-based econometric analysis and the Box-Jenkins statistical methods (Box and Jenkins, 1970) will be employed for analyzing prices behavior in the pulp and
paper industry. Econometric models use explanatory variables to analyze price changes and are very useful for identifying the important factors that affect prices and for estimating various elasticities. However, these models are less useful if one is concerned about quantitative estimates of future prices since this requires the analyst to either forecast or assume values for all relevant explanatory variables, complicates the forecast since the uncertainties associated with forecasting explanatory variables are passed onto the price forecasts.

In contrast, Box-Jenkins methods identify the data generation process that governs price movements. The Box-Jenkins approach develops Autoregressive Integrated Moving Average (ARIMA) models that do not typically rely on other explanatory variables for characterizing price behavior. ARIMA models uses information on past prices to identify the data generation process that governs price movements. Such an approach works in two ways. First, intervention analysis focuses upon whether an external event, such as the onset of an energy crisis or passage of more restrictive environmental laws affecting the industry, alters the data generating process. Second, ARIMAX models, which incorporate independent variables, can be estimated, in order to explicitly control for the effects of a limited number of explanatory variables. ARIMA models are useful for identifying the stochastic process and, accordingly, for developing quantitative estimates of future prices without any knowledge of explanatory variables or other technical problems associated with regression models. Although ARIMA models require much less data collection, the approach cannot help explain why prices move in a particular way and what the causative factors are. Nor can it provide information on various elasticities of price responses. Still, intervention analysis and ARIMAX models are useful in exploiting the small data requirements and yet provide some insights on those factors important to price behavior.

Because each approach has its advantages and disadvantages, this project will use regression based and Box-Jenkins based methodologies to study price behavior. Ultimately, these two approaches will be combine to produce a much better understanding of pricing behavior in the industry than would be possible with either technique alone. More specifically, when using regression analysis, the price variation unexplained by the explanatory variables will be left to the error term. Given the time-series nature, these errors are likely to be correlated. Such correlation offers
useful information for the purpose of forecasting because current errors inform us about future errors. By constructing an ARIMA structure for the regression errors, we can obtain more efficient forecasts.

In constructing our regression models for prices, we will include usual demand and supply side variables, such as economic activity and cost variables. More importantly, we will investigate the effect of inventories on prices, which has not been studied in previous work. Clearly, price movements are affected by demand, production, and inventories. Price changes generally start from involuntary inventory building-up or running-down. Therefore, inventory effects have important implications for price movements. Furthermore, we will also control in the price model for the effect of productivity increases caused by technological progress, including the effect of the Internet.

It can be anticipated that a number of technical problems will arise in estimating a price model. In particular, the stationarity of prices should be first examined and tested before running any regressions. Also, a number of variables might be endogenous and thus instrumental variable estimation may need to be applied. Other problems, such as serial correlation and heteroskedasticity, will relatively easy to statistically test and, if necessary, correct. Finally, in an effort to evaluate whether our models have adequately captured pricing behavior in the industry, point and interval forecasts, and their associated confidence intervals, will be generated. A number of criteria will be used to evaluate the models and the forecasts, including ex post forecast and comparison with existing industry forecasts.

III. Firm-Level Market Forecasting Tools

Complementing our analysis of pricing behavior at the industry level, we will also develop market demand forecasting tools at the level of firms to guide an individual firm’s production during a market swings (upturns and downturns). In a downturn, for example, this will help the firm to support its prices and improve efficiency. More specifically, over-capacity and involuntary inventory buildup have been the main pressure for price drops when facing market fluctuations. If each producer can anticipate the market demand and respond prior to the downturn, over-production and excessive inventory can be largely avoided. Therefore, it would be an effective
means to help support price levels if all firms adopt modern market demand forecasting tools and use them in real-time production planning and inventory management. This proposed project will look into the feasibility of providing such real-time, automatic (and even web-driven) market demand forecasting tools tailored to specific firms and products.

In the last several years, two strategies have been proven to be the most effective in supporting price levels, the industry’s restraint on capacity expansion, and the fact that producers are more aggressive in taking down time in response to weakness in demand. Downtime means running machines more slowly, shutting machines temporarily, and shutting machines indefinitely. Based on the “Pulp and Paper Forecaster” (2000), the North American containerboard producers have been leading the strategy of taking downtime and others are following their path. If each firm adopts real-time market demand forecasting in planning its production prior to market changes, the firm can avoid or largely reduce involuntary inventory buildup. Therefore, prices will move in a more natural way.

This proposed project will explore such a possibility by building a demonstration model for selected companies. This kind of firm-level demand forecasting, in general, does not require great accuracy and should be relatively easy to build, e.g., using exponential smoothing. The advantage for such low-cost firm-level market demand models is that they are easy to use and can be web-driven. In each period, market demand forecasts will be updated when new information is available. Moreover, the process can be made to run automatically with an integrated mechanism to track forecasting performance. If systematic errors occur, the process will generate warning signals for human intervention to adjust the forecasting routines.

IV. Summary

The proposed project will be a multi-year project, lasting for at least three years. In order to focus upon substantive issues in the industry and reduce the complexity in econometric model building, in the first year, the project analyses containerboards. Our primary goals are to explain pricing behavior in the industry, identify the major determinants of industry prices, to explore price forecasting implications of the developed models, and to assess the feasibility of incorporating market demand
forecasting tools into production management process to support price levels.

**RESEARCH STRATEGY AND METHODOLOGY**

Given our goals discussed above, we will start from containerboard in the first year. This group of paper products simplifies the analysis for a number of reasons. First, containerboard has a relatively simple grade mix. Also, containerboard is traded relatively less internationally which simplifies the demand-supply structure when modeling price. More importantly, most containerboard producers are integrated in pulp production, which reduces the complexity by avoiding the need to model the price of pulp first.

Because most members in our team are not familiar with the pulp and paper industry, a large part of the effort for the first year will be devoted to acquiring knowledge of the industry structure and institutions in general, and accumulating expertise on pricing in particular. To facilitate an in-depth research on prices for the pulp and paper industry, we will build connections with producers and with forecasting practitioners in the industry. The following steps will be taken for the first year.

1. Industry Case Study - Review all issues related to prices in the American pulp and paper industry in last twenty years. This will include technology advancing in manufacturing, government regulations, market structure and consolidations, environmental issues and the changes associated with globalization, all of which affect prices of pulp and paper products;
2. Industry Self-Assessment – Survey industry leaders on their pricing needs, how knowledge of pricing behavior will benefit them, and on their views on price movements and important factors that affect price behaviors, and their assessment of current knowledge on pricing behavior;
3. Firm Level Case Study-Based on a selected producer, this case study focuses upon current practices that a firm employs in responding to changes in market conditions. In particular, we will investigate price determination and the supply chain process, i.e., market demand change → inventory change → production change → price change, in the firm. Moreover, this case study will assess the feasibility of incorporating real-time market demand forecasting in the producer’s production/inventory management toolkit in order to lessen the incidence of price
reductions caused by involuntary inventory build-up. Such a firm-level case study will also help our team understand company-level operations, and will be helpful in modeling the aggregate price behavior at the industry level;

4. **Assessment of Current Price Analyses** – This includes a thorough evaluation of existing academic and trade literature price behavior and practices in the paper and pulp industry. The assessment is expected to comprise three parts. First, using standard statistical criteria, we will compare existing forecasts from alternative existing sources with the realizations of forecast variables. Second, we will evaluate existing forecasts by comparing them with some naïve forecasts based on much simpler methodologies. Third, to the extent that we have information on forecast methodologies used in the industry (e.g. RISI), we will critically evaluate present forecasting methodologies;

5. **Data collection** – We will leverage all available resources to gather historical data on prices, demand/supply side variables, and any other information that is relevant to price behavior, such as inventory information and data on other products that are substitutes or complements of the selected paper product;

6. **Initial price analysis** – This includes a descriptive analysis that characterizes historical price movements including levels, trends, seasonality, and irregularity. More importantly, we will assess the stationarity of price by examining its autocorrelation, partial autocorrelation, and by using the Dickey-Fuller test (Dickey and Fuller, 1981).

7. **Preliminary Price Model** – This includes constructing and estimating reduced-form regression models and ARIMA models for prices. Technical issues related to estimation, such as endogeneity and serial correlation, will be addressed as they arise using advanced econometric techniques;

8. **Preliminary Price Model Evaluation** – Once appropriate price models are developed and estimated, forecasts from these models will be comparatively analyzed with model results from other studies, and will also be evaluated using ex post forecasts.

The above tasks will be done as a team with specified responsibilities for each PI and Co-PI. Regular project meetings will be held to exchange information and report progress.
DESIRED OUTPUTS & CONTRIBUTIONS TO THEORY & RESEARCH

Analyzing industry markets and price behavior in a global environment that is complex, diverse, and dynamic is a challenging endeavor. At the same time, industry studies significantly contribute to our understanding of the economic, technological, and regulatory forces that have shaped the industry and provide important information on how the industry can ensure its long run sustainability. The reports forthcoming from this project will identify those factors in the paper and pulp industry that are key to explaining price and inventory behavior in paper and pulp products and will shed light on price sensitivity when determining factors change. Similar to existing industry studies in the automobile, telecommunications and electricity industries, a thorough study of price movements and price determinants in the pulp and paper industry will not only generate academic contributions to the literature but, just as importantly, will provide usable outputs to the industry.

For the three-year period, our team will produce about six high quality papers related to pricing behavior for the pulp and paper industry. Since this project requires intensive participation of students, we expect that three to four master theses and a number of undergraduate senior theses will be produced in this area.

The desired outputs of this project for the first year will include the follows.

1. A paper on reviewing changes and trends of the pulp and paper industry that have affected price movements in last twenty years.
2. A paper evaluating the practices and performance of existing pricing models in the pulp and paper industry.
3. A paper on price modeling with implications for future price in the containerboard sector of the industry.
Pricing behavior is among the top priorities for industry leaders. Any advance in understanding price movements will help the industry in many important decisions, including capacity planning, project evaluation, and overall budgeting, and thus will enhance their profitability.

An additional goal is to develop ready-to-use real-time product demand forecasting tools for producers. If each producer were to adopt such a market demand tool to guide its production and blunt market changes through preventive actions, the pressure on firms to cut prices will be significantly reduced. The resulting positive externality will help to support prices at a sustainable level and improve efficiency.

As we progress in the project, we expect to provide the pulp and paper industry with a variety of product-based price models, a list of the most important determinants of prices in the containerboard sector, a matrix of estimated elasticities, and implications for price forecasts. We also expect to provide a demonstrable real-time product demand forecasting model (firm-based and product-specific) that can be tailored and adopted by any producer.

In the first year of the project, the specific industry-focused outputs being sought include the following:

1. A report evaluating the performance of existing pricing behavior models in the pulp and paper industry.
2. A summary of the industry survey on pricing behavior and price forecasting activities.
3. A report on pricing mechanisms at the firm level and on the feasibility of establishing a real-time market demand forecasting tool for producers.
4. A summary of pricing behavior models and estimated elasticities with a detailed discussion of the implications that these results have for the pulp and paper industry.
The project goals will be accomplished in three years. The primary staff will include the following people:

- **GT Faculty:**
  - Haizheng Li (specializes in econometric methods and forecasting)
  - Shomu Banerjee (specializes in industrial organization)
  - Jye-Chyi Lu (specializes in industrial system and statistics)
  - Patrick McCarthy (specializes in econometrics and discrete choice models)

- **IPST Faculty:**
  - Arthur Ragauskas (specializes in paper technology and manufacturing)

- **Graduate Students:**
  - Three Master/Ph.D students (from GT-Economics or GT-ISYE)

- **Undergraduate Students (from GT-Economics)**
Tentative Schedule:

I. Month 1-4:
1. Case study of the pulp and paper industry on issues related to price in the last twenty years (McCarthy, Banerjee, Ragauskas, Li).
2. Survey of the pulp and paper industry needs in pricing models and on other issues related to prices. (Banerjee, Lu, Ragauskas, Li)
3. Survey and evaluation of the practices and performance of the existing pricing models in the pulp and paper industry. (Li, McCarthy, Banerjee, Lu)
4. Select a producer to survey its price determination and its pricing mechanism in responses to market changes, and to assess the feasibility of using real-time market demand forecasting tools to guide the production. (Lu, Ragauskas, Banerjee, Li)
5. Data collection for price behavior modeling. (all members)

II. Month 5-7:
1. Draft the paper and report on industry review related to price in last twenty years. (McCarthy, Banerjee, Ragauskas, Li)
2. Draft the paper and report about the industry survey on pricing issue. (Banerjee, Ragauskas, Lu, Li)
3. Draft the paper and report on the evaluation of the performance of existing pricing behavior models in the industry. (Li, McCarthy, Lu, Li)
4. Draft paper and report of the case study on the producer’s response to market changes and on the assessment of setting up real-time market demand forecasting tools. (Lu, Rasguaskas, Banerjee, Li)
5. Continue data collection. (all members)

III. Month 8-10:
1. Initial price analysis and pricing behavior model construction. (Li, McCarthy, Lu)
2. Initial estimation of regression models on prices. (Li, McCarthy, Banerjee)
3. Initial evaluation and test on pricing models. (Li, McCarthy, Banerjee, Ragauskas)

IV. Month 11-12:
1. Draft paper/report on pricing models. (Li, McCarthy, Banerjee)
2. Final report writing. (all members)
REFERENCES


