

## INDUSTRY 4.0 – PRAGMATIC ALGORITHMS, INFORMATION QUALITY AND RELATIONAL DATABASES

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### **Abstract:**

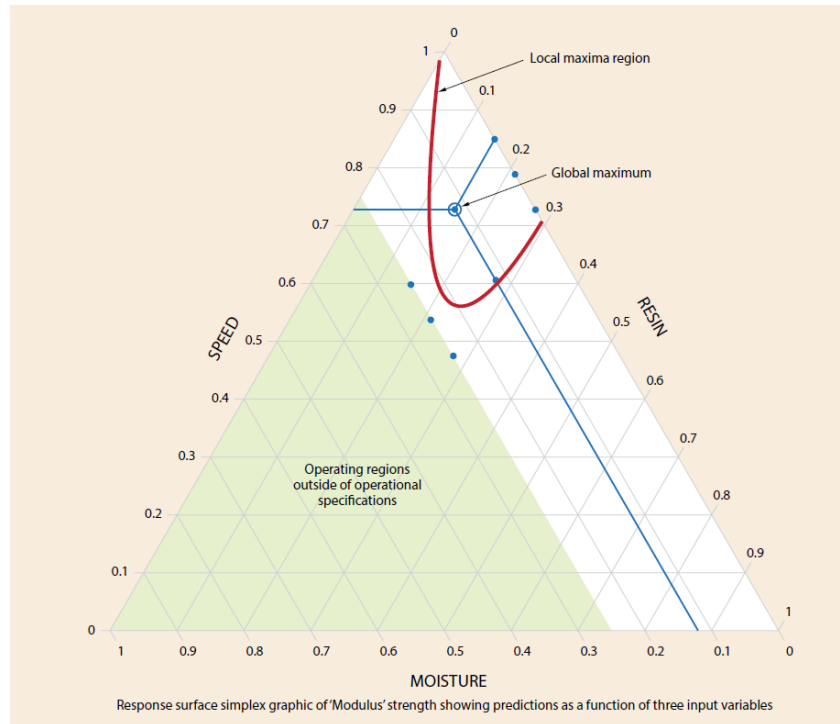
*'Industry 4.0' is the latest term given to the next significant improvement in manufacturing technologies that is supposed to represent the next great revolution in manufacturing. It has also been called the 'smart factory,' in which cyber-physical systems monitor the physical processes of the factory and make decentralized decisions. This includes a system of advanced communication networks of PLCs, robotics, and cyber physical visualization and interaction by operations personnel and machines. This will lead to the optimization of manufacturing systems given the changing dynamics of feedstocks, chemical-additives and machines. The goal in this optimization process is a lower variance of process inputs and product quality attributes; that also lead to lower costs of manufactured product. The literature available related to 'Industry 4.0' addresses the advancements in sensors, robotics, and computational hardware/software systems. However, there is a 'gap' in the literature in the discussion of information quality and advanced database systems that are relational to the sensors and the data from the testing of product attributes. This paper is conceptual and is intended to advance the discussion about the importance of advanced database systems that are relational, and will allow for the development of pragmatic algorithms that are predictive.*

**Key words:** Industry 4.0; pragmatic algorithms; barriers; relational databases.

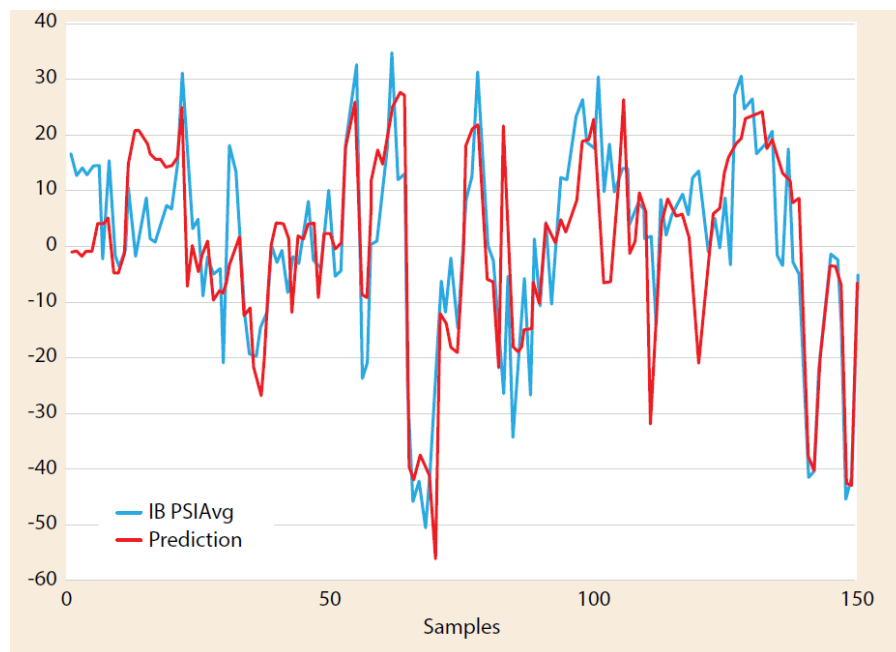
### **INTRODUCTION**

We live in a world where electronic transactions for business are common place and occurring at ever increasing rates. Nearly everyone reading this article has a smart phone and most people conduct some type of business with an 'App' every day – whether it's shopping, searching for information, or summoning a taxi service (Young 2016). Some now define our society as a digital society made of digital citizens. The new generation of people 18 and younger are defined as 'Generation Z' and are classified as never knowing a world without a smart phone in their hands.

'Industry 4.0' is a name for the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things, cloud computing and cognitive computing (Kagermann *et al.* 2013, Heiner 2013). 'Industry 4.0' introduces what has been called the 'smart factory,' in which cyber-physical systems monitor the physical processes of the factory and make decentralized decisions (Fig.1). The physical systems become 'Internet of Things,' communicating and cooperating both with each other and with humans in real time via the wireless web (Marr 2016). The idea builds upon the trend in 'Big Data' and 'Data Mining,' *i.e.*, the storage and synthesis of large quantities of data for the development of decision support systems. The terms are terms often associated with successful companies such as Google, Amazon, FEDEX, Netflix, etc. 'Industry 4.0,' was the talk of LIGNA since 2015 and was also among the major themes for the 2015 Woodworking Machinery & Supply Expo in Toronto. Many highly successful companies collect large amounts of data and use statistical algorithms, or "pragmatic algorithms" to predict the process outcomes and enhance revenues and improve profitability while focusing on lowering costs (Fig. 2), see Young 2015, Kim *et al.* 2012, Young *et al.* 2014. The financial business sector uses financial engineering to conduct automated business transactions at every increasing speeds.



**Fig. 1.**  
**Response surface simplex graphic that illustrates optimization.**



**Fig. 2.**  
**Illustration of real-time predictions of "IB" (internal bond) of wood composites.**

The forest products industries, while using forward-thinking technologies, has lagged behind the successful implementation of 'Industry 4.0.' Many in this industry still drive their processes based on the periodic destructive test (or lab sample). Some say "this is like driving your car looking in the rearview mirror." So what are some of the barriers in implementing 'Industry 4.0' in the forest products industries?

**DISCUSSION**

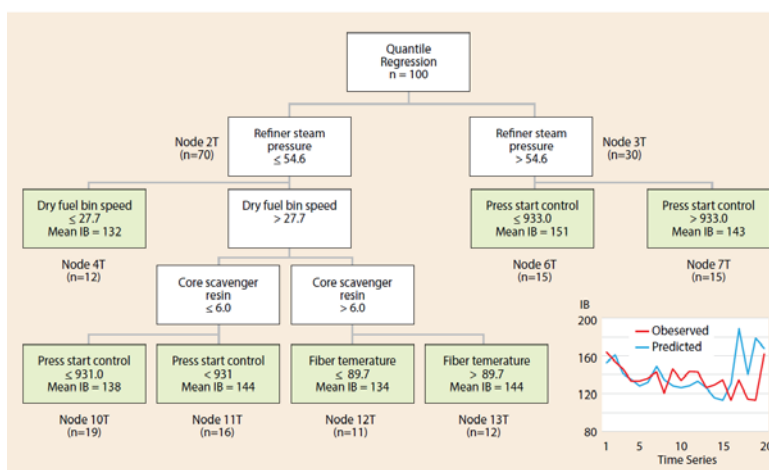
**Pragmatic Algorithms and Information Quality**

For more than two and one-half decades, forest products plants have used real-time data warehousing to monitor processes. Technical labs have software databases documenting the quality of product. The business functions of accounting and marketing have adopted improved software systems for business transactions, e.g., SAP business software, etc. Control rooms in plants have increased their visualization of data by adding larger and more monitors. Some companies have control rooms that have such a large array of monitors that it resembles a stock exchange or space-agency launch control room (Fig. 3). But in what useful format are the data displayed? Even though we have added more hardware monitors, most are filled with simple trend charts.



**Fig. 3.**  
**Illustration of modern operations control room.**

Most companies have built smartphone applications for management that allow them to monitor both business transactions and process performance. However, has the increased visualization of data from online sensors led to more effective decision-making by the operations personnel in the control room? Has improved decision-making by operations kept pace with the large databases and advanced analytics? Perhaps it is time for the forest products industries to transition from simple data reporting and rethink how it uses big data and advanced analytics to continually improve competitiveness and business performance (Fig. 4), see Carty *et al.* 2015, Kim *et al.* 2011.



**Fig. 4.**  
**Regression tree algorithm with predictions.**

**A Barrier for ‘Industry 4.0’ – Absence of a Relational Database**

There are several barriers that exist for many forest products companies that inhibit the use of advanced analytics as an improvement tool to improve product quality and lower costs of manufacturing. A key barrier is the creation of a relational database that fuses the data from the process data warehouse with the data from the testing lab. Unfortunately, a key constraint for creating this relational database is that the process data warehouse exists on the process network, and the testing lab database exists on the business network -- separated by a firewall. Even though the software technology for communicating across these

networks is trivial, the barrier against this merger of networks is sometimes due to protective corporate policies. Companies like Google, Amazon, FEDEX, Apple, Microsoft, and others, have long ago overcome restrictive company policies that hinder improved decision-making.

Another barrier that must be overcome is improper time alignment of the sensor data that are stored in the process data warehouse (Reigler *et al.* 2015). Material flow in the engineered panel manufacturing process from the woodyard to the pressing stage passes across many sensors at different times relative to the time the panel is pressed into a final product. Unfortunately, the process data warehouse sets the time stamp collected from the sensors at periodic intervals (5 minutes) or at delta-change (*i.e.*, only stores data when a value changes). This improper time alignment is a barrier to more advanced analytics and makes it difficult for operations personnel to go beyond basic trend analyses; which are useful, but are subjective and dependent on experience-level. This time alignment problem of sensor data is compounded by the lack of accurate time stamps on panels that are pulled from the production line for testing. Both of these problems are easily overcome by use of software technology that aligns the process data in time as a function of the line speed or pressing cycle. Accurate time stamping of lab test boards can easily be automated at the sampling location on the process line.

A relational database of the process and lab data can result in an immediate and significant improvement in knowledge of sources of variation by highlighting new data patterns and establishing a platform for predictive capabilities through analytics (Zeng *et al.* 2016). Improved knowledge of sources of variation and enhanced predictive capabilities can result in less reject product, a reduction of order rescheduling, lower manufacturing costs, and optimal operations targets for weight, resin, etc.; all of which result in improved business performance.

## CONCLUSIONS

Once a relational database has been created, it offers many potential benefits for the organization. Given the advanced capabilities of analytical software and its relatively low cost, improved knowledge of the process can be gained through data visualization and correlations which may also lead to more advanced predictive statistical models of key process parameters (time to closure, weight variation, etc.) and product quality attributes (CSL, modulus, thickness swell, etc.). This goes far beyond trend analyses, and offers additional "root-cause analysis" benefits to enhance statistical process control analyses. Advanced analytics is a business strategy for successful companies of the future. Many companies outside the engineered wood panel industry now have executive positions within the organization to drive analytics-based decision making throughout the organization.

So why not create a relational database of your process? The cost is relatively low given that once the software code is created; the data fusion process is automated. A relational database of key process parameters and product attributes opens up a panacea of benefits for advanced analytical analysis. Advanced analytics is a gateway for lower costs of manufacturing, improved product value and overall improved business competitiveness.

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