**SOCIETY OF WOOD SCIENCE AND TECHNOLOGY**
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**Delta Québec Hôtel, Room 200B, Québec City, Canada**

# *SWST STUDENT POSTER COMPETITION*

## POSTER 15

### How Porosity Can Explain Wood Desorption at High Humidities

*Giana Almeida*. Ph.D. Candidate, Dept. of Wood & Forest Science, Université Laval, Québec City, QC, Canada

The knowledge of the fluid paths within a material is important to improve its utilization. The efficiency of mercury porosimetry to explain the influence of the wood structure on water movement or sorption behavior was studied for one temperate (*Fagus grandifoli*a) and one tropical hardwood (*Robinia coccinea*). Two experimental techniques were used to perform moisture sorption tests at 25ºC; the first used saturated salt solutions (from 33% to 90% RH) and the second used the pressure membrane method (above 96% RH). Mercury porosimetry and quantitative anatomical analyses were performed to study the porous characteristics of these woods. Double stained anatomical images were treated with tools derived from mathematical morphology in order to make measurements of the different wood tissues. The wood species studied exhibited different anatomical structures, which was reflected on the desorption curves. These differences were more marked at high moisture contents, which are mainly controlled by the capillary forces. The mercury porosimetry allows a good evaluation of the fluid paths and their characteristics within wood, which leads to the prediction of liquid water behavior during longitudinal drainage. The complexity and the heterogeneity of the wood microstructure observed in this work corroborate the analyses done by porosimetry.

The results show a strong radial variation of the wood characteristics from pith to bark, some of them characterizing the juvenile wood - mature wood transition. The results show that most of the significant variation of wood characteristics occurs with sampling height, and these variations are more important in juvenile wood. It is observed that stand density has more impact on growth traits than on wood density traits.

The study of transition age from juvenile wood to mature wood calculated from radial pattern of ring area and maximum ring density, highlights a significant effect of sampling height, the juvenile period being reduced from 17 to 12 years at the top of the tree. Nevertheless, the juvenile wood volume proportion seems to present few variation with sampling height. In contrast, the stand density effect on transition age is not significant but it seems that a high stand density induces a higher proportion of juvenile wood.

The mixed model showed a strong effect of microfibril angle and ring density on the mechanical properties. No significant effect of ring width on the mechanical properties was observed.

## POSTER 17

### A Finite Element Model for the Evaluation of MDF Hot Pressing Process

*Marcia Vidal Bastias*. Ph.D. Candidate, Dept. of Wood and Forest Science, Université Laval, Québec City, QC, Canada

Hot-pressing operation is one of stages of manufacture of wood-composites with a high consumption of energy in a short time. The objective of this study was to demonstrate the potential of finite element method to predict the more important variables during the MDF hot-pressing process in 2-D and 3-D models.

A numerical solution for two- or three-dimensional mathematical model is presented to describe the MDF hot-pressing process. The model is based on the work of García (2002) for OSB panels and Turner and Perré (1995) for wood drying. The coupled and highly non-linear nature of the heat and mass transfer equations that govern the hot-pressing process are solved by the finite element method program called MEF++. This software has been developed by GIREF (Groupe Interdisciplinaire de Recherche en Éléments Finis) at Laval University. This dynamic model predicts the evolution of variables such as total gas pressure, moisture content and temperature during the hot-pressing process. This set formed of three-coupled equations is a more comprehensive physical description for the hot-pressing of a MDF panel at the macroscopic level and randomly formed. Differently to previous model, we have first introduced a new term in the vapor equation and secondly to solve the model we have used Newman non-linear at boundary conditions. We consider that the diffusion term is not negligible in the hot-pressing process and that it is produced simultaneously with the bulk flow. It is recognized that the finite elements method is more versatile and presents advantages when the boundary conditions are irregulars.

**POSTER 18**

**Juvenile Wood Impact on the Kiln Drying Characteristics of Pacific Coast Hemlock Square Timbers**

*Slobodan Bradic*. MS Student, University of British Columbia, Wood Science Dept., Vancouver, BC, Canada

Large volumes of small-diameter logs are generated from sustainable sources such as Pacific Coast hemlock second-growth forests. Percentage of juvenile wood in this kind of material is respectively higher compared with limited old growth wood supplies. This investigation evaluates the drying quality of Pacific Coast hemlock structural timbers as a function of juvenile wood shown with the pith location at their end-surface, cutting season and drying target moisture content.

Timber specimens were classified into four groups depending on the presence and location of the pith. A total of 640 timber pieces were dried in a laboratory conventional (heat-and-vent) kiln to 15% and 20% target moisture content, where in each case, one charge was from the summer and other from the fall cutting season. After the drying, the specimens were planed to the final cross-section of 105x105mm.

The volumetric shrinkage was not influenced by the pith location, but it was higher with a higher range between the initial and final moisture content. Timbers sawn closer to the pith shows higher bow. Twist was attributed by interactions of the pith location and cutting season, and the pith location and target moisture content. There is a lack evidence to claim an effect of the controlled factors on diamonding. Surface checking was higher if the target moisture content was lower and if the pith was closer to the centre of cross-section. Planning significantly reduced diamonding and surface checks. The central pith location class was graded lower then others. The general conclusion is that Pacific Coast hemlock timbers with the central pith location should be avoided in the production of 105x105mm structural products

**POSTER 19**

****Third Place Winner**
**Mechanism to Improve Toughness and Moisture Resistance of a Typical OSB Resin**
*Sudip Chowdhury*. Graduate Research Assistant, WMEL, Washington State University, Pullman, WA

The following study investigates the effect of maleic anhydride polypropylene (MAPP) on the cure kinetics and toughness of phenol formaldehyde (PF) resin. Blends of resin systems were prepared by mixing atomized MAPP in liquid PF resin. The cure kinetics of these resin systems were studied using differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA). Damping property of the cured adhesive formulations, as an indirect measure of toughness, was investigated using DMA. Cure temperature and time were determined by dynamic and isothermal curing of the adhesive systems in DSC. Results indicated that two minutes at 140 $^{o}$C was adequate for complete curing of all the formulations. Dynamic temperature ramp test was done in DMA to examine the changes in the storage modulus (E'), loss modulus (E") and tanδ (E"/E') during cure of the adhesive systems. Addition of MAPP into PF showed improvement in the stiffness of the resin system, however, higher levels of MAPP indicated adverse effects on the stiffness. Shift in the peak value of tanδ during cure indicated higher curing time required for higher amounts of MAPP in the resin system. Dynamic strain sweep test of the cured specimens using DMA was conducted to evaluate damping property of different formulations. Improvement in the damping was observed with the addition of MAPP at the lower strain level. The effect however leveled off for blends with higher MAPP percentage. Fracture cleavage tests, to determine the effect of MAPP on the toughness and moisture resistance, are now ongoing and the results will be presented in the poster. With the outcome of these analytical tests, optimum resin blends will be formulated to fabricate oriented strand composite panels with better moisture durability and enhanced mechanical properties.

**POSTER 20**

**Mortel Intelligence for Latin American ESC-certified Wood Panels in the US and Caribbean Markets**
*Pablo Crespell*. Ph.D. Candidate, Dept. of Wood Science and Engineering, Oregon State University, Corvallis, OR

General Objective: Provide relevant and updated market information to the Latin American FSC certified wood panels producers, particularly to the markets of the U.S and the Caribbean. Specific Objectives • Identify market trends for wood panels, particularly for plywood • Update market trends for certified wood panels • Identify: The markets and final users by type of panel • Price ranges for wholesalers • The general value chain Conclusions: 1. Latin American producers are focused mainly on rotary plywood (BB/CC grade). Their exports account for 50-80% of their production. 2. In 2003, Latin America represented 14% of U.S. imports of tropical plywood (US$ 52 million) 3. After Brazil, other exporters of importance are Ecuador, Colombia and Guyana 5. The U.S. dollar is weak compared to the Brazilian Real driving the cost in Brazil upward. On the other hand, the exchange rate between the Chinese Yuan and the U.S. dollar has remained stable for years meaning an even buying/selling market that favors the competitiveness of Chinese exports. 6. There is no interest in using lesser known species (LKS). Wholesalers don't want to take the risk of not finding customers.

7. For plywood, supply inconsistencies and defaults to the contract are the most common complaints. There are also complaints about quality. 8. Importers prefer agents because they take much of the risk, and provide value through services such as quality control and assistance with the paper work. 10. Fifty-one percent of the 115 identified companies dealing with tropical plywood/veneer are currently environmentally certified

**POSTER 21**

****First Place Winner**
**Moisture Content Determination in Frozen and Unfrozen Lumber using Ultrasound**
*Hermanus van Dyk*. Graduate Research Assistant, Department of Wood and Paper Science, North Carolina State University, *Robert Rice*, Professor, Department of Forest Management, University of Maine.

This study investigated whether ultrasound could be used as an indicator of moisture content in frozen and unfrozen spruce lumber. Initial experimentation indicated that velocity and the attenuation coefficient of ultrasonic waves would be the best methods to determine moisture content. Experiments to determine ultrasonic velocity in the radial direction were conducted at five different moisture content levels and three moisture levels were used for attenuation testing. The results show that a strong inverse relationship exists between ultrasonic velocity and moisture content in both frozen and unfrozen lumber. The wave velocity in frozen wood was consistent and about five percent greater in frozen wood than in unfrozen wood. The relationships existed both above and below fiber saturation and the differences were statistically significant. The attenuation coefficient decreased with a decrease in moisture content in both frozen and unfrozen lumber. Furthermore, no statistically significant difference was fond between the attenuation coefficient in frozen and unfrozen lumber at the three moisture levels. While the main research effort centered on the differences in wave velocity between frozen and unfrozen wood at specific moisture content levels, a study was also done to determine the effect of temperature on ultrasonic velocity. Ultrasonic velocity decreased linearly with an increase in temperature. The findings of this study suggest that both ultrasonic velocity and the attenuation coefficient can be applied as moisture indicators in either frozen or unfrozen lumber.

**POSTER 22**

**Impact of Log Ellipticality on Red Oak (Quercus rubra) Lumber Grade and Volume Recovery for Current Sawing Practices**
*Roncs Ese-Etame*. Graduate Research Assistant, Dept. of Wood Science and Forest Products, VPI & SU, Blacksburg, VA

Red oak is one of the most common species processed by U.S. hardwood sawmills. The volume and value of lumber produced from sawing red oak logs is influenced by log size, grade, and sawing practice. Much work has been done to determine the influence of these factors on round logs. No literature exists describing the impact of red oak log ellipticality on lumber grade and volume recovery for current sawing practices.

The objective of this research was to assess the impact of two degrees of eccentricity of red oak logs on green lumber grade and volume recovery under current sawing practices. Comparisons were made between the lumber grade yield for low and high degrees of ellipticality. It was determined that lumber grade produced was highly correlated to log ellipticality.

**POSTER 23**

**Quantification of CCA in Wood Using Laser-Induced Breakdown Spectroscopy**
*Brad Gething*. Ph.D. Candidate, Dept. of Agricultural Science, Penn State University, University Park, PA

The disposal of CCA-treated lumber is a growing issue for the waste management industry. In response to the concern, research methods such as laser induced breakdown spectroscopy (LIBS) have been explored to identify CCA-treated lumber and separate it from non-treated lumber in the waste stream. The present study analyzes the potential of using laser induced breakdown spectroscopy (LIBS) to quantify the amount of CCA in treated lumber, so that the lumber may not only be separated but also effectively reused in other applications. LIBS has been an accepted form of analysis for two decades however it has only been recently that a commercial system has come to market enabling the development of practical applications such as bulk materials analysis.

LIBS techniques employ a high-intensity laser pulse to produce a high temperature microplasma at the surface of the sample. Using a high-resolution spectrometer, it is possible to identify the atomic emission lines in real-time that correspond to the elemental content of the sample. The magnitude of these emission lines allows for the quantification of desired elements. An Ocean Optics LIBS system was used to measure the amount of copper, chromium, and arsenic on the surface of standardized southern yellow pine specimens treated at levels of 0, 0.13, 0.25, 0.41, and 0.67 pounds per cubic foot of CCA. The results reveal that LIBS is capable of differentiating between definite treat levels of CCA in wood, although additional refinement to the process is necessary to ensure reproducible, substantial conclusions

**POSTER 24**

**The Application of Refrigerated Air and Cryogenic Treatment Reduces Tool Wear When Machining Medium Density Fiberboard**
*Judith Gisip*. Graduate Research Assistant, Dept. of Forestry and Natural Resources, Purdue University, West Lafayette, IN

Cutting tools treated with refrigerated air and cryogenic treatment may result in the reduction of tool wear. By reducing tool wear, tool life is increased and the cost of tool replacement and production downtime is minimized. To reduce tool wear, six double-flute, tungsten carbide tools machined medium density fiberboard (MDF) on a computer numerical control router with a total of 166,000 m in length of cut per flute. Three of the six tools were cryogenically treated to strengthen the metal structure of the tools. Three each of the cryogenic and non-cryogenic tools were used to cut at the temperatures of 20ºF, 40ºF, and 70ºF. A cold gun generated the 40ºF cutting temperature, while the temperature of 20ºF was produced with the addition of ice to the cold gun. Power consumption data were collected to monitor the router bit performance. Surface quality of the MDF from cutting was observed according to an ASTM Standard. Tool wear area was measured with the light microscope with IPLab software. Scanning electron microscope (SEM) photomicrographs were taken at the knife edge at high magnification, allowing for inspection of the tool surface to further determine tool wear. Energy-dispersive spectroscopy analysis using the SEM allowed for characterization and quantification of elements present in the tools. The combination of cryogenic treatment and refrigerated air at a temperature of 20°F reduced tool wear, although 40°F was optimum for the reduction of tool wear.

**POSTER 25**

**Penetration of Polyethylene Glycol in Wood Cell Walls**

*Dragica Jeremic*. Ph.D. Candidate, Faculty of Forestry, University of Toronto, Toronto, Canada

Effective wood chemical treatment is predominantly affected by the ability of the chemical to penetrate and remain in cell wall microvoids. The chemical accessibility to microvoids is dependant, among other factors, on molecular weight (MW) and capability of solute to transfer from solvent to the wood structure. Our research comprises studies of penetration and extractability of polyethylene glycol (PEG) from wood. PEG was chosen as a non-toxic, wide-range molecular weight polymer soluble in both polar and non-polar solvents.

Red pine samples equilibrated to different equilibrium moisture contents (EMC) were treated with 30% PEG-1000 dissolved in polar (water) and non-polar (chloroform) solvents. Ability of PEG-1000 to penetrate cell walls has been confirmed by volumetric swelling of the samples after treatment and Transmission Electron Microscopy – Energy Dispersive X-ray Analysis (TEM-EDXA) of samples treated with brominated PEG. Amount of PEG in cell walls was estimated by sequential extraction from cell lumens and cell walls, and by Raman spectrometry.

PEG-1000 showed inability to penetrate wood cell walls in absence of water. Higher PEG penetration from water than chloroform was noticed for all EMCs. Amount of water in the cell walls appeared to play a significant role in PEG penetration, even for the PEG-in-water solution.

Two distinctive extraction rates characterized PEG extractions with toluene, by both extraction and Raman methods. The higher extraction rate is believed to be due to easily accessible PEG in cell lumens, while the lower one was attributed to much reduced PEG dissolution from the cell walls.

**POSTER 26**

**Droplet Behavior and Shape Analysis of Wood Adhesives on the Wood Surface**

*Sangyeob Lee*. Graduate Research Assistant, School of Renewable Natural Resources, Louisiana State University AgCenter, Baton Rouge, LA

Understanding wetting behavior and surface coverage of an adhesive on a wood surface is important to obtain a satisfactory adhesion and optimize adhesive application for wood composite manufacturing. The objectives of this study were to (1) evaluate droplet behavior and shape of thermoset resins on wood surfaces (Loblolly pine, Tallow tree, Red oak, and Sweetgum) using 3D image analysis and (2) develop predictive models of resin behavior and shape. This study also accessed micro-contacting angels of UF (urea formaldehyde) and PF (phenol formaldehyde) thermoset resins on wood surfaces using atomic force microscopy (AFM). Resin droplets generated with a system of "Air Automation" were on a micro scale (generally from 1 to 100 □m) and showed differing wetting behavior based on droplet size and surface conditions. AFM characterized the interphase of the micro-droplets and the wood surfaces with the various probe materials. Droplet behavior parameters such as volume, angle, height, and radius changed as a function of time were generated with an image analysis system. Rougher wood surfaces prevented micro-droplet spreading irregardless of wood species and resulted in higher contact angles with the exception of loblolly pine. Contact angles parallel to the fiber direction of the hardwood species significantly differed from the angles collected perpendicular to the fiber direction. Sessile droplet models and critical Eotvos numbers ($E_o$) were used to develop the parameters governing the resin change from a spherical droplet to an enclosing hemispherical droplet for each of the four different species. Droplet dispersing areas with sweetgum showed 33 to 38% faster area changes parallel to the fiber surface as compared to perpendicular to the fiber surface.

**POSTER 27**

**Effects of Abrasive Mineral, Grit Size, and Feed Speed on the Quality of Sanded Surfaces of Sugar Maple Wood**

*Luis Fernando de Moura*. Ph.D. Candidate, Dept. of Wood and Forest Science, Université Laval, Québec City, QC, Canada

Sanding is a common practice required in preparing wood surfaces to coating. Little literature is available regarding the effect of sanding parameters on the quality of surfaces. Sugar maple wood surfaces were evaluated in samples that had been sanded using one of two abrasive minerals, three grit sizes and four feed speeds. Roughness, wetting properties and cell damage were used to assess surface quality. For both abrasives, roughness decreased from 100 grit to 120 grit size. No further reduction was obtained by adding a 150-grit stage. Higher feed speeds produced rougher surfaces, due to higher fibrillation. Surfaces produced by silicon carbide were smoother and less damaged than those obtained with aluminium oxide. However, the surfaces sanded with aluminium oxide were more wettable and showed no significant difference in wetting time as a function of grit size. For these surfaces, the wetting time was reduced as feed speed increased. In general, the surface energy increased as the number of sanding stages increased and feed speed decreased. The capillaries produced by silicon carbide appeared to be too narrow to allow a complete wetting by water. In this latter case, the wetting by water was probably more affected by the surface energy than by the capillarity forces.

**POSTER 28**

**Effectiveness of a Nondestructive Evaluation Technique for Assessing Standing Timber Quality**

*Crystal L. Pilon*. M.S. Student, School of Forest Resources and Environmental Science, Michigan Technological University, Houghton, MI, and USDA Forest Service, Forest Products Laboratory, Madison, WI

The primary objective of this study was to determine the usefulness of two stress wave analysis techniques, one which was developed in the laboratory and has proven to be effective in determining standing timber quality; the other a recently-developed commercial tree evaluation tool. The secondary objective of this study was to investigate the quality of plantation-grown red pine (*Pinus resinosa*) and ponderosa pine (*Pinus ponderosa*) trees. Field measurements using both tools were conducted on sixty red pine trees in south-central Wisconsin and 115 ponderosa pine trees in western Idaho. After *in-situ* measurements were taken, thirty tested red pine trees were felled and a 15-foot-long butt log was obtained from each tree, while all tested ponderosa pine trees were felled and an 8½-foot-long butt log was obtained, respectively. The butt logs were sent to the Forest Products Laboratory and nondestructively tested using a resonance stress wave technique. The red pine logs were nondestructively tested using center-point static bending to determine modulus of elasticity. Results of this study indicate that the new instrument gives results comparable to those of the original stress wave method, and that *in-situ* stress wave measurements correlate with wood modulus of elasticity. These results indicate that stress wave testing may be a valuable method for determining standing timber quality..

**POSTER 29**

****Second Place Winner**

**Effect of Solution PH and Ionic Composition on the Solubility of Chromium and Arsenic from CCA-Treated Aspen**

*Suzana Radivojevic*. Ph.D. Candidate, Faculty of Forestry, University of Toronto, Toronto, ON, Canada

Availability of potentially toxic arsenic and chromium and speciation of Cr leached from wood treated with chromated copper arsenate wood preservative (CCA) depends on factors such as pH and ionic composition of the leaching medium. Wood sawdust of trembling aspen treated with CCA-C to 6.4 kg/m$^3$ was completely fixed before extraction with solutions of pH 1 to 10 adjusted with HCl and NaOH and with a range of 1*M* extractants ($NaH_2PO_4$, $NH_4Cl$, $MgCl_2$, $NH_4OAc$, $NH_4HCO_3$, $NaHCO_3$ and $NH_4OH$). Cr and As in extracts were analyzed by ICP-AES and Cr(VI) by Ion Chromatography. Solubility of Cr and As followed similar pattern within investigated pH range. Maximum Cr and As solubility found at pH 1 decreased rapidly to pH 4, and remained low toward pH 10. Extraction yields in 1*M* extractants were significantly higher than expected from their pH values. Anion composition affected the availability of both components in a sequence: $HCO_3^-$ (from $NH_4HCO_3$) > $PO_4^{3-}$ > $OH^-$ > $HCO_3^-$ (from $NaHCO_3$) > $CH_3COO^-$ > $Cl^-$. 1*M* $NH_4HCO_3$ showed remarkable efficiency in extracting both Cr and As. Oxidation of Cr(III) to Cr(VI) was observed in all instances above pH 8. pH of the solution governs availability of Cr and As in absence and at low concentrations of inorganic ions, while at high concentrations ionic composition becomes principal factor. Oxidative transformation of Cr(III) present in treated wood indicates an important route for the generation of highly toxic and soluble Cr(VI) form at alkaline conditions.

**POSTER 30**

**Evaluation and Improvement of Connection Systems for Prefabricated Wall Panels**

*Williams Munoz Toro*. Ph.D. Candidate, Dept. of Wood and Forest Science, Université Laval, Québec City, QC, Canada

The scope of this research is the evaluation and improvement of linear connections of prefabricated shear walls. To evaluate the behaviour of the walls, 18 shear tests (in plane) and 9 bending tests (out of plane) will be done on full-size specimens. The walls will be composed of two parts of 4 by 8 feet connected with three types of linear connections. The shear wall tests will be done monotonically and cyclically according to ASTM standards. Two types of wall-to-foundation connections will be evaluated in the shear wall tests, the first one with hold-down anchors and shear bolts; and the second type is with 16d nails per 16 in. The bending wall tests will be done according to a proposed protocol based on the calculation of the wind pressure related to five hurricane categories from 70 mph to 160 mph. In addition, monotonic and cyclic tests will be conducted on individual connection specimens to input in a finite element model of the walls. This model could allow analysis of the connection and the wall performance in order to improve the behaviour of the wall.

**POSTER 31**

**Water Vapor Sorption in Dried Red Oak Lumber Package Stored in a High Humidity Environment**

*Minghui Zhang*. Ph.D. Candidate, Dept. of Forestry & Natural Resources, Purdue Univ., West Lafayette, IN

Water vapor sorption in a commercial dimensional dried lumber package has never been investigated although sorption equilibra and rate were studied for wood samples. In this research, a wireless probe system is used to monitor moisture content (MC) change for representative thirty nine positions of dried red oak lumber package. End coating was applied to both ends of each board prior to drying to 7% MC, but was removed from one end for this experiment to study the effect of end-coating. The environmental chamber which holds the package was set to temperature 21.1 $^0$C and relative humidity

80%. The distribution of moisture content of the package over 19 weeks was obtained and a mathematic model was developed to predict moisture gain over time. The results show that sorption process is controlled not only by Fick's law, but also by swelling stress relaxation. Stepwise function and fluctuation phenomenon from the experiment results are also explained by a new concept – gas creeping motion.

**POSTER 9**

**Mass Customizing U.S. Furniture--Wooden Furniture Dynamics.**

*Emmanuel T. Kodzi, Jr.*, Ph.D. Student, Wood Products Manufacturing Technology, Purdue University, West Lafayette, Indiana

Mass customization is currently perceived in some circles as a means by which the U.S. furniture industry might compete effectively against offshore manufacturers. Mass customization (MC) has offered significant benefits in other industries that have embraced this business paradigm. They have leveraged their manufacturing capabilities to resolve the trade-off between cost and efficiency on one hand and quality and customization on the other hand. MC must be applied in furniture firms in a way that avoids the pitfalls that earlier customizing organizations encountered.

To what extent might MC concepts be applicable to the U.S. furniture industry? How will MC change the furniture industry dynamics in association with, or as opposed to mass production? What are the critical enablers of MC for wooden furniture manufacturing scenarios? What kind of internal systems and structures are necessary to implement the MC paradigm? How does MC add to firm value?

An in-house pilot study in the Purdue Wood Research Laboratory confirmed some of the major lessons from other industries including the need for a seamless transfer of information between processing centers and for a spontaneous availability of standardized materials.

In the main study I examine the impact of mass customization on the value of the firm and test the hypothesis that mass customization is a feasible option the U.S. furniture industry might adopt to improve its competitiveness. I will adopt a case-study approach focusing on manufacturing system scenarios for wooden furniture. I will use the principles of modularity, agility, quick response and competitive cost as proxies for the industry's readiness to implement mass customization concepts. I will examine the response of firm value to changes in the indicator variables.

The study will extend the knowledge frontier of mass customization as an emerging manufacturing business principle; guide the development of a sustainable framework for a competitive business model for the U.S. furniture industry; and enhance long-term industry survival through the resulting agility to anticipate and respond quickly to marketplace changes.