

# Inquiry: The University of Arkansas Undergraduate Research Journal

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THE UNIVERSITY OF ARKANSAS  
UNDERGRADUATE RESEARCH JOURNAL

# INQUIRY



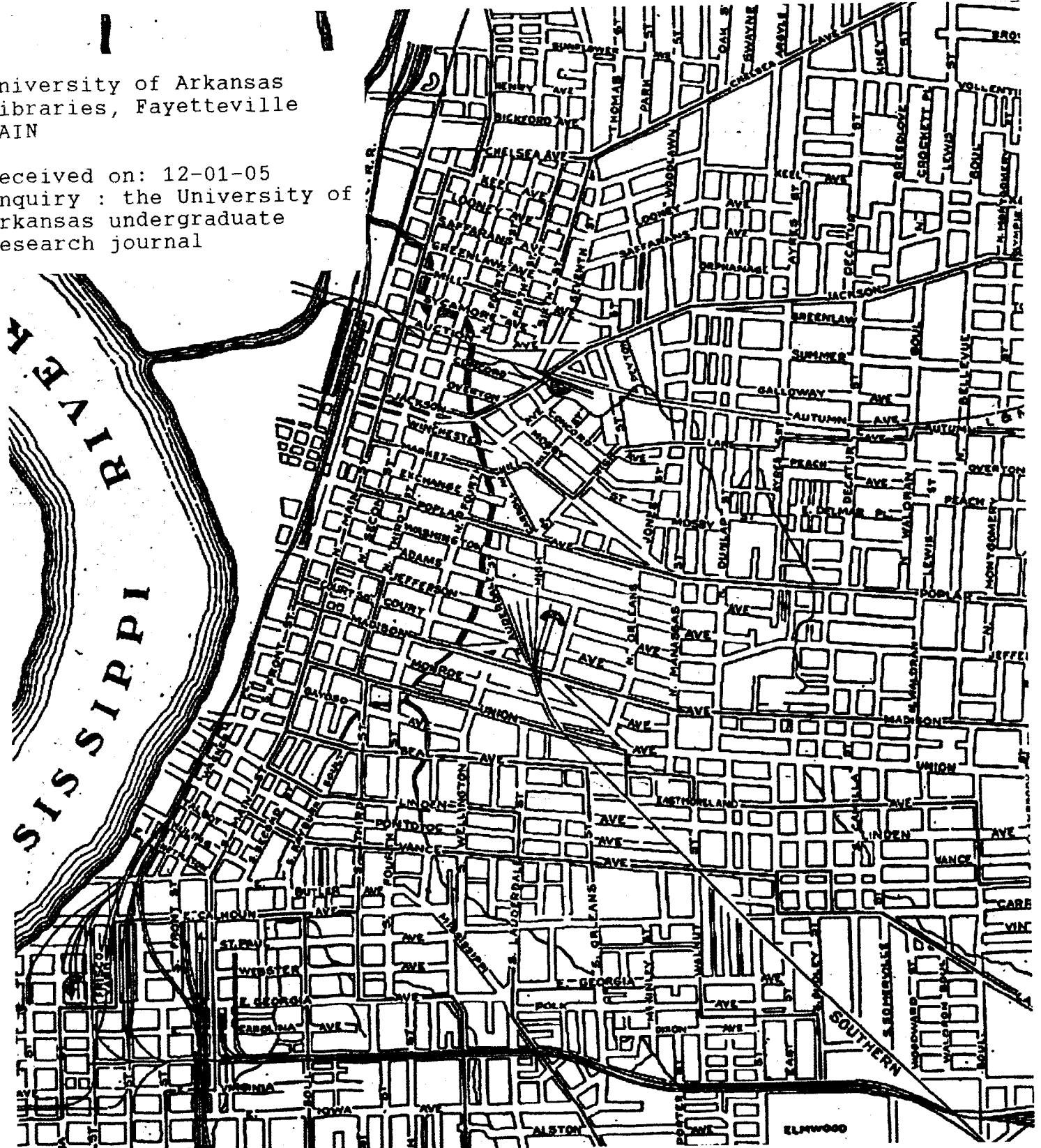
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**INQUIRY: The Undergraduate Research Journal of the UNIVERSITY OF ARKANSAS, FAYETTEVILLE**

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**Foreword:**

This journal, the sixth in an annual series, is a project of the Teaching Academy of the University of Arkansas and is testimony to the Academy's belief that a function of good teaching is to encourage good research and creative thinking on the part of the students.

This issue of *Inquiry* records the individual research exploration of eleven U of A student/faculty mentor pairs during the 2004/2005 academic year. The projects included here are drawn from disciplines from five of the six undergraduate colleges and schools—the Dale Bumpers College of Agricultural, Food and Life Sciences, the School of Architecture, the J. William Fulbright College of Arts and Sciences, the Sam M. Walton College of Business Administration, and the College of Engineering—and are representative of the quality of research done by honor students in the various disciplines represented on campus. The breadth of subject matter included here is testimony to the commitment made throughout the university to honors study and research at the undergraduate as well as the graduate level. These eleven articles were chosen by *Inquiry's* publication board from nearly fifty papers submitted for consideration. (Publication economics controls the size of the journal: most of the papers received were of publishable quality.) The papers chosen vary in subject, in writing style, and in the manner in which they reference their research sources; but they are uniformly excellent in content. In most cases, the paper published herein is a digest of the student's larger research product. However, in some cases, the students' honors theses are published in their entirety. This year for the third time the journal is paired with a website, <http://advancement.uark.edu/pubs/inquiry/>, on which a number of papers appear that were recommended for publication but excluded because of space and cost limitations. We hope interested readers will peruse both the articles in hard copy in the journal and those published on the website as well.

The intent of the journal is to record the depth and breadth of the scholarly activities of the university's best undergraduate students. I believe that it does this.

The editor and publication board of *Inquiry* depend on colleagues throughout the institution to serve as reviewers of material submitted for consideration. The range of disciplines at an institution like ours makes it impossible for the board to be able to evaluate all the papers submitted. We are grateful for the assistance that we receive from reviewers throughout the institution.



Murray Smart, Jr., Editor, University Professor of Architecture, Emeritus

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## **SECTION I: ARTS AND HUMANITIES**

**ARCHITECTURAL HISTORY AND THEORY, MUSIC COMPOSITION, AND  
CLASSICAL STUDIES**

**WILLIAM FAULKNER'S MEMPHIS:  
ARCHITECTURAL IDENTITY, URBAN EDGE CONDITION, AND  
PROSTITUTION IN 1905 MEMPHIS**

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Department of Architecture

Faculty Mentor: Dr. Ethel Goodstein  
Department of Architecture

**Abstract:**

*It has been said by wags that Memphis (Tennessee) is the largest city in Mississippi. Unquestionably, Memphis is the commercial and cultural capital of the Mississippi River delta country north of Vicksburg. As such it figures prominently in the works of southern writers, especially William Faulkner. Faulkner's characters seek out Memphis as a place of excitement and escape. This paper deals with Faulkner's description of Memphis as it existed in the early decades of the twentieth century; the focus is on passages of *The Reivers*, but passages from other works are included as well. Because so many of the events he portrays deal with the exploits of young male characters, the red light district of Memphis (called the Tenderloin) receives particular attention. However, other portions of the city—the downtown area and the cotton offices that filled the buildings on Front Street facing the river are included as well. An interesting picture of the mid-south's major Metropolis as it existed some one hundred years ago emerges.*

For William Faulkner, Mississippi “begins in the lobby of a Memphis, Tennessee hotel” and ends at the Gulf of Mexico.<sup>1</sup> This statement, loaded with meaning, carries great significance when analyzing Faulkner’s treatment of Memphis in his works. It is possible Faulkner “reived” this characterization from the sociologist David L. Cohn. In his 1935 study of the Mississippi Delta, *God Shakes Creation*, Cohn says, “the Mississippi Delta begins in the lobby of the Peabody Hotel and ends on Catfish Row in Vicksburg.”<sup>2</sup> Whether or not Faulkner was familiar with Cohn’s work is inconsequential. What is noteworthy is that they share the awareness of the importance of Memphis on Mississippi. This, in turn, sheds light on Faulkner’s use of Memphis in his Yoknapatawpha works and on the value that his characters place on it. Indeed, the narrator of Faulkner’s *The Reivers* (1962) speaking of Memphis says, “Where else could anyone in north Mississippi want to go.”<sup>3</sup>

In the 1830s, the State of Mississippi contested its state line with Tennessee, saying that it had been drawn too far to the south. Nevertheless, Memphis should have been a part of Mississippi.

This assertion was fallacious and was quickly squelched, but this attempt was not the last of Memphis’s trying to break from Tennessee and unite with north Mississippi. As Memphis historian Gerald M. Capers claims, the people of Memphis wanted to be a part of Mississippi so that its cotton would receive the higher ratings that Mississippi cotton garnered.<sup>4</sup> The people of Memphis also were displeased with their status in Tennessee and their treatment by the Nashville government, a condition that continued in Memphis history. Memphis sought to form a new state, which was to include portions of west Kentucky, west Tennessee, and north Mississippi. It was to be named Jackson, Chickasaw, or Memphis, with Memphis being the favorite choice. The popular Andrew Jackson even supported it.<sup>5</sup> No attempt was made, though, at realizing the goal until the issue was reintroduced in 1841. After much debate the measure was defeated in the Tennessee legislature.<sup>6</sup>

By the turn of the twentieth century, Memphis was being called the capital of north Mississippi because of the great flux of Mississippians who were populating Memphis. In 1900 there were 14,600 Memphis citizens who had been born in Mississippi.<sup>7</sup> Not only was Memphis siphoning population from the Mississippi countryside, it also enticed Mississippi residents to frequent its hotels and numerous saloons. Many farmers from the surrounding countryside took an annual or biannual escapade to Memphis as a celebration, probably corresponding to planting or harvest.<sup>8</sup>

One such excursion is the framework around which William Faulkner’s comedic masterpiece and last novel, the last of his fourteen Yoknapatawpha novels, *The Reivers*, is built. In a May 3, 1940, letter to Robert Haas, Faulkner’s editor since *Light in August* (1932), Faulkner outlined what would become *The Reivers* twenty-two years before its publication:

It is a sort of Huck Finn—a normal boy of about twelve or thirteen [Lucius Priest], a big warmhearted, courageous, honest, utterly unreliable white man with the mentality of a child [Boon Hoggenbeck], an old negro family servant, opinionated, querulous, selfish, fairly unscrupulous, and in his second childhood

[Ned McCaslin], and a prostitute, not very young anymore, and with a great deal of character and generosity and commonsense [Miss Corrie], and a stolen race horse which none of them actually intended to steal.<sup>9</sup>

This original conception developed into the nostalgic retelling of a parentally unapproved childhood trip to Memphis in 1905 and the comedic mania that ensues after the characters, from Faulkner's fictional Jefferson, Mississippi, are stranded in Memphis with a possibly stolen, mediocre racehorse. These characters are stereotypical not only of Faulkner's own work (especially since most had already appeared in other works) but also of Southerners in general. This makes the story and places presented in it representative of the South, so that the view of Memphis it presents is not only a view of a specific place and time, but representative of Southern cities and how they relate to the surrounding (stereo)typically rural South. Both the specific and the symbolic nature of the city and the characters that visit it will be taken into account in this paper.



Figure 1. Bales of cotton being loaded on a riverboat at Memphis's Cotton Row, 1910.

One of the specific qualities of 1905 Memphis is the importance it held for Mississippians, who with Memphians relied on Mississippi lumber and cotton flowing into Memphis, the great distribution center. (Fig. 1) (Mississippi was producing a fourth of US cotton much of which passed through Memphis).<sup>10</sup> Its central location for the rural farmers of the surrounding area provides a context for arriving at an informed understanding of how Memphis functions in William Faulkner's Memphis works. By looking deeper into *The Reivers* (augmented by several of his other works in which Memphis plays a role) we see what Faulkner, through the voice of his character Lucius Priest (the first person narrator), underscores as the notable qualities that constitute the urban fabric of Memphis; a portrait of the Memphis of 1905 emerges. As *The Reivers* was written in 1962 when Faulkner was only eight, it is set in 1905. Its depiction of

Memphis has the potential to be an historically inaccurate portrayal or one that exaggerates certain aspects or phenomena. Whether it is perfectly rendered by accurate historic detail is not as important as the lasting image of Memphis Faulkner provides for the reader, who, probably has never experienced Memphis personally and could never experience the Memphis of 1905—a turning point in the city's development because it was then, despite fires and plagues, that the city's built form began to try to catch up to the growth that had resulted from New South Boosterism and industrialization.

Three pervading characteristics that contribute to 1905 Memphis's urban identity surface in *The Reivers* and other works: the blurred edge condition of south Memphis where the line between the rural and the urban is ambiguous (and is inextricably tied to the differing experiential qualities when entering Memphis by train or by automobile as described in chapter five of *The Reivers*); the implied problem or condition of Memphis's lack of an architectural or symbolic presence that constituted a recognizable identity of place in the built fabric; and the pervasive subject of prostitution and the effect it has on built space, in both the individual house and the tenderloin area, as well as on the perception of place. This paper's exploration of these issues compares the descriptions that Faulkner and his characters from *The Reivers* and other works provide to the historical representation of Memphis—a view legitimized by the lens of history. This is enlightening because it reveals whether Faulkner was exaggerating "reality" to stress an idea or the conditions that make up the urban image of Memphis or whether he was realistically describing Memphis which would imply that he was concerned with an historical recreation that lends a certain reality to his characters and their interactions with the city. Another point of consideration is that Faulkner's portrayal of 1905 Memphis in *The Reivers* is filtered through a view of Memphis as he saw it in 1960, just as other Faulkner works set in the Memphis of the past reflected a bias resulting from his contemporary view of the city.

While examining the specific phenomena of urban form and culture that are addressed in *The Reivers* and other Faulkner works, it is important to evaluate the role Memphis plays for the characters—how it changes or has changed them and how they comprehend the city. Adding this layer to the analysis not only allows the investigation of the salient qualities Faulkner describes, but also provides a contextual treatment of characters' interaction with the city. This undercurrent allows many questions to be raised that would have otherwise remained in the background.

Three of the four main characters are rural inhabitants of Jefferson, Mississippi. Their experience and perception of Memphis is not only affected by their not having a routine acquaintance with the city, but also by their rural and agricultural perspective of space and human interaction—a point that is paramount in a discussion of Faulkner and Southern cities. The three rural characters, Lucius Priest, Boon Hoggenbeck, and Ned

McCaslin, have a change in behavior or engage in activities that they would not have considered in their home town of Jefferson. They visit a trashy and low-class whorehouse in the Memphis Tenderloin district and trade Lucius's grandfather's automobile for a possibly stolen racehorse, and the young boy, Lucius, starts a fight with a fifteen-year-old boy in which he gets cut with a knife.<sup>11</sup> The fourth character, Miss Corrie, the prostitute from Arkansas, lived in Memphis for several years. Her experience of Memphis, as well as how Memphis effects her in the novel, is less important than how it has changed her and how her interactions with these rural characters change her again.

The trip to Memphis that the characters take is preceded by four chapters that build up to their departure. This lengthy prologue provides the background for the trip, including devices of character development as well as the introduction of the infamous Wynton Flyer (Lucius's grandfather's automobile). More importantly, in terms of studying the characters' interactions with Memphis, this introductory section functions to situate the characters in a rural context that contrasts with their experience in Memphis; it also heightens the anticipation, for the characters as well as the reader, of the impending impromptu excursion.

The destination of Boon's and Lucius's scheme (or the look they give each other that instantaneously provides for the two a plan of action) is not initially revealed. Lucius discloses the destination by saying "that's right, Memphis as our destination has never been mentioned, either to you [Lucius is narrating to his grandson] or between Boon and me. Why should it have been? Where else did we have to go?"<sup>12</sup> This speaks to the importance of Memphis to north Mississippians as it is the only large city in the area; it also implies that there is something, some quality or attraction, that Memphis possesses that their town, Jefferson, does not. This implication is seemingly trivial and obvious, but it begins to address the distinction that must be proffered in any urban study between the city and country as to what it means to be a city or urban center in the American South. This question, which is a central issue in this study, logically leads to an analysis of the physical attributes of Faulkner's Memphis in contrast to those of Faulkner's Jefferson for answers to why some of the qualities attributed to Memphis are given such prominence in the narrative.

To begin a comprehensive analysis of the contrasts between Jefferson and Memphis, it is necessary to provide some background by investigating the rural/urban dialectic in the South and the manner in which it is addressed in *The Reivers*. For Faulkner, the cities of the North were "rootless ephemeral cities"<sup>13</sup> that were filled with smoking factories. Perhaps his depiction of Memphis is a critique of what he sees as the invasive modernization of the Southern city. The sprawl of Memphis into the countryside that he describes could be a criticism of the invasive city bleeding into Faulkner's beloved forests of north Mississippi—a condition that he mourned in many of his works. Here is how Lucius describes his experience of nearing Memphis:

The very land itself seemed to have changed. The farms were bigger, more prosperous, with tighter fences and painted houses and even bars; the very air was urban .... The cotton and corn [grew] unvexed now, the mules themselves sabbatical and idle in the pastures, the people still in their Sunday clothes on galleries and in shady yards .... We went on. Civilization was now constant: single country stores and crossroads hamlets, we were barely free of one before here was another; commerce was rife about us, the air was indeed urban, the very dust itself which we raised and moved in had a metropolitan taste to tongue and nostrils ... Then the country itself was gone. There were no longer intervals between the houses and shops and stores; suddenly before us was a wide tree-bordered and ordered boulevard with car-tracks in the middle; and sure enough there was the street car itself ... We were getting close to Main street now—the tall buildings, the stores, the hotels....<sup>14</sup>

This is *less* of a critique of the invasive modern city than simply an accurate portrayal of Memphis in 1905. What is important here, though, is the transition between the rural South and the city. Faulkner describes two emblems of the rural South: the country store and crossroad hamlets. Their increased frequency alone alerts the boy that they were on the edge of the city. In Faulkner's short story, "Two Soldiers," Memphis is described as "set up on one edge of a field."<sup>15</sup> In the description in *The Reivers*, the three visitors pass seamlessly from fields of cotton to crossroads after crossroads to the tall buildings of Memphis. This transition zone is a result of the sprawling tendency of turn-of-the-century Memphis. In the 1890s, members of the upper-middle class began relocating to the eastern edges of Memphis.<sup>16</sup> The annexation of 1899 quadrupled the size of Memphis.<sup>17</sup> It expanded the city limits mostly to the east and the south.<sup>18</sup> The settlers of most of these annexed territories, excluding the more upper-class areas around Annesdale and Overton Parks, were rural immigrants.<sup>19</sup> Historian William D. Miller suggests that at the turn-of-the-century the "bearers and preservers of the city's cultural heritage" were displaced by these rural immigrants resulting in a change in the urban culture of Memphis.<sup>20</sup> If the makeup of the population in 1900 was half rural immigrants,<sup>21</sup> and they were changing the culture of the city to a peculiar blending of rural and urban, (a considerable shift from the relatively cosmopolitan roots of Memphis),<sup>22</sup> then the blending of rural and urban architectural attributes upon entering the city reflects its populace's composition.

Lucius's description of entering the city and its blurred edge condition raises an important issue—the way the introduction of the automobile changed the way the characters experience and perceive the city. Memphis, beginning in the 1850s, was the central terminal of four new railroad lines from the east to the Mississippi River Valley.<sup>23</sup> From the 1850s onward, Memphis increasingly became an important rail hub for the South. Much of its earlier growth was contingent upon the

expansion of the railroads. In several of Faulkner's works, characters visit Memphis, arriving by train. Lucius's description of entering Memphis by car contrasts significantly with the experiences of other characters arriving by train. Though accounts, in Faulkner, of traveling to Memphis by train allude to the blurred edge or sprawling nature of southern Memphis, the speed and isolation of train travel gives the impression that one is traveling through the country and is suddenly thrust into the city. The new experience of entering Memphis by car, allows Lucius to notice the subtle changes between the rural South with which he is familiar and the urban South. He senses this change, not in the built environment, but in an indescribable quality, so intangible that Faulkner reverts to its depiction as a smell. Once in the city, Lucius understands the urban South by the differences between it and his home town Jefferson; however the transition zone, thanks to the greater phenomenological understanding that the automobile affords, is seen as blurred.



Figure 2. Main Street, 1906.

Upon entry into Memphis, Lucius notes, not explicitly but rather by exclusion, the plain, homogenous urban fabric of Memphis—a fabric that lacks a true architectural identity that would give Memphis a distinctive sense of place. (Fig. 2) The lack of an architectural, physical, or visual symbol to which the characters might relate and the mostly banal architectural character of the city is buttressed by nearly every account of Memphis in Faulkner's other works. Paradoxically, the distinguishing condition that emanates from Faulkner's writings of Jefferson or Yoknapatawpha County is a sense of place. The importance of the physical presence and the meaningful semiotic recognition of the square and courthouse of Jefferson provided in Faulkner's Yoknapatawpha oeuvre is in stark contrast with the impression that Memphis is a non-place. This judgement is made not in the sense that Marc Auge suggests<sup>23</sup> but rather in practical terms—an early Modern equivalent—for we must recognize Faulkner's disdain for modernization and homogeneity. He exuded this contempt in works such as *Go Down, Moses* (1942),<sup>24</sup> which

traces, from the time of their virginity to their complete destruction, the history of the destruction of the forests of north Mississippi resulting from the onslaught of modernization in the South. Faulkner argued vehemently against Southern homogenization with what he saw as the increasing lack of diversity in the United States.<sup>25</sup>

In his least appreciated Yoknapatawpha novel, *Requiem for a Nun* (1951), Faulkner devotes the prose portion (the other half is in play form) of his narrative to a description and historical explanation of the town of Jefferson. The town is treated with the same importance that the main characters in the dramatic section in his hybrid novel are given. As in all Faulkner works set in Jefferson, the town square and courthouse comprise the stage upon which many significant events occur. Similarly in the haunting climatic ending of *The Sound and the Fury* (1929), they



Figure 3. The first Lafayette County Courthouse at Oxford, a Civil War bivouac on its grounds.

act as a signifier of place and meaning with which citizens of Jefferson visually associate. Speaking of the significance (which is tied very directly to the architectural pedigree of the building) of the courthouse in Jefferson, Faulkner said, "There was no town until there was a courthouse, and no courthouse until... [it was] transmogrified into a by-neo-Greek-out-of-Georgian-England edifice set in the center of what in time would be the town square."<sup>26</sup> (Fig. 3) He defines the square as the city as well as the county center, describing it as "a Square, the courthouse in its grove the center; quadrangular around it, the stores, two story, the offices of the lawyers and doctors and dentists, the lodge-rooms and auditoriums, above them; school and church and tavern and bank and jail each in its ordered place; the four broad diverging avenues straight as plumb-lines in the four



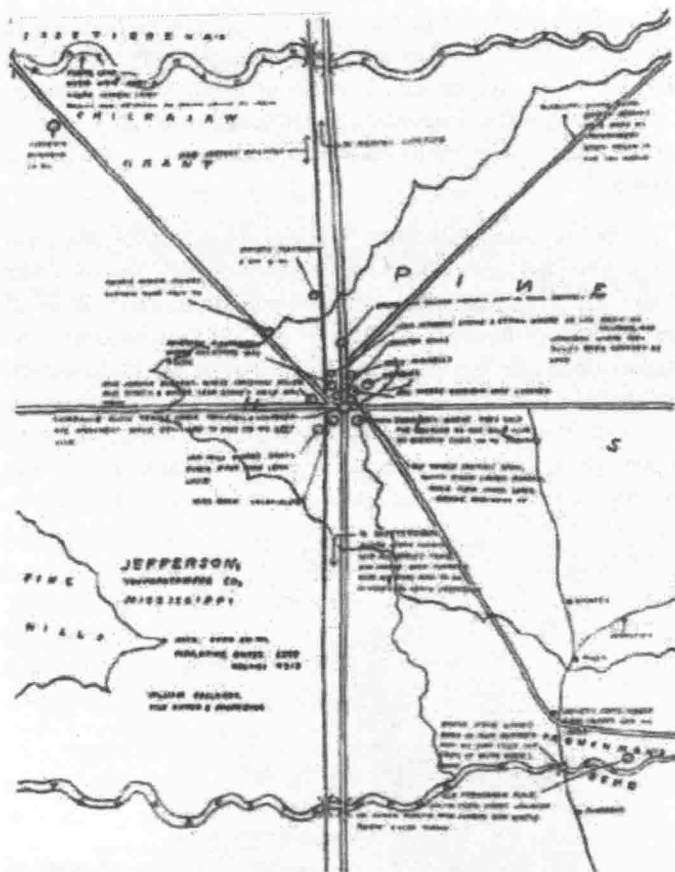


Figure 4. Faulkner's fictional map of Jefferson (modeled after Oxford, MS) showing the location of events from Faulkner's novels and all roads converging on the courthouse at the center of the county.

directions becoming the network of roads and by-roads until the whole county would be covered with it"<sup>27</sup> (Fig. 4) Furthering the image of square and courthouse as center he notes that "above all, the courthouse—the center, the focus, the hub; [sits] looming in the center of the county's circumference, like a single cloud in its ring of horizon, laying its vast shadow to the uttermost rim of horizon."<sup>28</sup> Faulkner's novel *Intruder in the Dust* (1948), closely related in chronology and content to *Requiem*, portrays the square as a stage on which events play out. He even goes so far to compare it to an amphitheatre.<sup>29</sup>

The urban fabric of Memphis, in *The Reivers*, is not described with any one building, or even a square, constituting a city center. No location is imparted with the semiotic or cultural significance of the Square of Jefferson. Memphis side streets, particularly the streets around Gayoso Street, named after Manuel Gayoso, the Spanish founder of a fort near Memphis, and Beale Street, near their intersections with Second and Third Streets<sup>30</sup>, are described as flanked by saloons and composed of "houses that didn't look old or new either."<sup>31</sup> (Fig. 5) In "Two Soldiers," Memphis is presented, through the eyes of a small boy who had never visited it, as only a mass of people and cars with a nondescript architecture.<sup>32</sup> One might assume that a country boy that had never seen skyscrapers would be in awe, but Faulkner



Figure 5. Main Street and Gayoso Street, 1910.

omits all references to tall buildings. The most explicit example of Faulkner's opinion of Memphis comes from his third Yoknapatawpha novel, *Sanctuary* (1931). He describes Memphis as a city of "smoke-grimed frame houses with tiers of wooden galleries, set a little back in grassless plots with now and then a forlorn and hardy tree of some shabby species—gaunt, lopbranched magnolias, a stunted elm or a locust in grayish, cadaverous bloom—interspersed by rear ends of garages" that from the gloom evoked "a sinister and meaningless photograph poorly made"<sup>33</sup> (Fig. 6)

The majority of Faulkner's writings on Memphis involve the red-light district and the poorer southern sections of Memphis. Faulkner description of the depressing state of the Memphis red-light district is similar to the impressions of the business district found in other writings of the time. *The Ladies Home Journal* in 1906 contained an article, "Eyesores that Spoil Memphis," that included many photographs.<sup>34</sup> The business district was especially "drab and depressing [in] appearance."<sup>35</sup> Most of the buildings were four stories tall and were "old, unpainted, unattractive" brick buildings.<sup>36</sup> (Fig. 2) *The Commercial Appeal* even went so far as to say that Main Street was a "horselot" and that Memphis was like a "country town."<sup>37</sup>

Civic leaders, noting the unimpressive and dispersed business district of Memphis, in a frenzy began to improve the downtown area and to consolidate it giving it a central preeminence.<sup>38</sup> In the time period in which *The Reivers* is set, much of the central business district, especially at the center of Main Street and Madison Avenue, was sold to commercial developers. Many of the taller buildings of Memphis were built around this central location in the subsequent years. (Fig. 7) In 1905, however, few large buildings were in existence. The Continental Bank Building (now the D.T. Porter Building), the first steel-framed building, eleven stories tall, was built in 1895<sup>39</sup> and was one of the few tall buildings in Memphis in 1905. (Fig. 8)



Figure 6. An alley off Gayoso Street.



Figure 7. Court Square; in the background are the buildings that surround the intersection of Main Street and Madison Avenue, 1906.

One of the few instances of Faulkner describing the business district occurs in his short story, "Dull Tale." The story is set in the 1920s so it describes the changes made in the business district since its lackluster appearance in 1905: "Where Madison Avenue joins Main Street, where the trolleys swing crashing and groaning



Figure 8. Continental Bank Building on Madison Avenue, built 1885.

down the hill at the clanging of bells which warn and consummate the change of light from red to green, Memphis is almost a city." Continuing to describe the intersection, Faulkner says it was "where four tall buildings quarter their flanks and form an upended tunnel up which the diapason of traffic echoes as at the bottom of a well, there is the restless life and movement of cities; the hurrying purposeful going to-and-for."<sup>40</sup> Faulkner's perception of the Memphis business district as presented here stands in stark contrast to his and to historians' depiction of the Memphis of 1905.

Before the commercial development and definition of city center that the business district underwent in the 1910s, Memphis lacked a central focus. The lack of a fixed center and the reality of a monotonous and dreary urban fabric positioned Memphis as the antithesis of Jefferson. Faulkner, with his cited distaste for the modern, is criticizing the uniformity of the four-story brick buildings of Memphis and even the idea of city itself. Faulkner could be saying that, in the South at least, the city has too many of the qualities of a "country town" or of the rural South that make it de-centered and ugly. In contrast, the traditional smaller town, centralized and looked to by citizens with a pride that translates into architectural elegance, becomes the appropriate means of settlement.

What rises above this banal uniform urban milieu attributed to Memphis, and what emerges as a physical, architectural presence in Faulkner's works, and especially in *The Reivers*, are

the houses of prostitution in Memphis's tenderloin district and the more reputable Memphis hotels. This is a view of Memphis that is not recorded in the city's written history (only incidental references to prostitution are made in the city's histories), nor is it a view that was promoted by civic leaders. Houses of prostitution essentially provide only a mental rather than a physical center to the city (at least for the residence of the hinterlands that indulge in the pleasures provided); they do not give the city a discrete sense of place. These houses, due to the necessity of presenting themselves anonymously, do not provide an architectural signifier of place.

The hotels of Memphis also play a significant role in Faulkner's treatment of the city, as evidenced by Faulkner's characterization that Mississippi begins in the lobby of a Memphis hotel. The dichotomy of houses of prostitution and houses of lodging being the only two signifiers of place to Faulkner and his characters could be a result of their rural point of view and their lack of a daily acquaintance with the city. When one looks at the larger buildings in existence of Memphis in 1905, however, the hotels—the Gayoso, the Peabody, the Chisca, the Arlington, and Gaston's—stand out as making up nearly all of the important buildings. (Fig. 9)



Figure 9. Gayoso House, 1910. One of the numerous large hotels in turn-of-the-century Memphis.

In Faulkner's work, the Southern city—almost exclusively Memphis and New Orleans—is a place of escape and license. Gerald Capers notes what he calls the “antebellum catholicity of taste”<sup>40</sup> that characterized Memphis well into the Progressive Era of the 1910s. He suggests that this led even “good church members” to believe that it was reasonable for male youths to visit houses of prostitution. In Faulkner's works, the red-light district functions as a major draw for the rural poor (as well as some more wealthy characters, though most of the wealthy went to New Orleans). *Sanctuary*, Faulkner's first work to use Memphis as a setting, introduced Miss Reba's house of prostitution as the

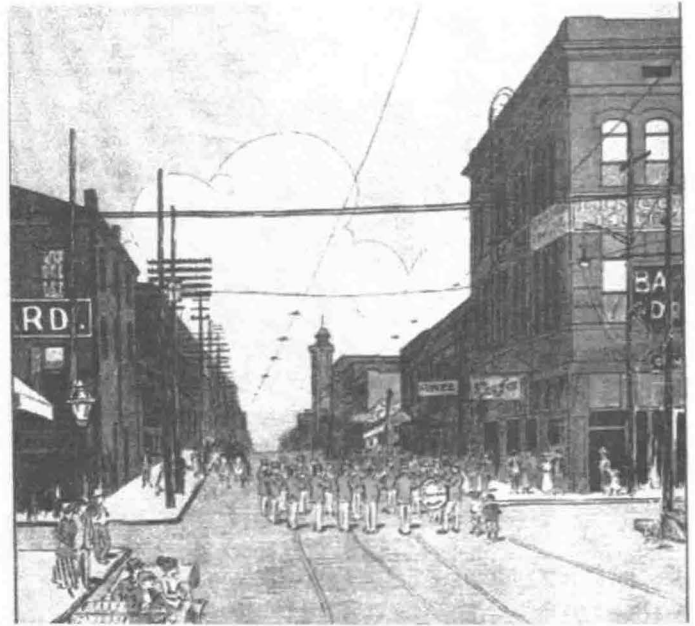


Figure 10. Beale Street. The second sign on the right side of the street is the famous P Wee's Saloon, 1917.



Figure 11. The second Lafayette County Courthouse at Oxford, Mississippi, 2004.

setting for a large portion of the novel. Miss Reba's also plays a role (some more significantly than others) in *Requiem for a Nun*, *The Town*, *The Mansion*, several short stories, and is the central setting in *The Reivers*. Only Miss Reba's bordello is described on the interior in Faulkner's works. In *Sanctuary*, it is described as a “dingy three-story [house], the entrance of which was hidden by a dingy lattice cubicle leaning a little awry.”<sup>42</sup> For Faulkner's characters the Memphis Tenderloin is the center of Memphis. In most trips to Memphis in his novels, the first place that is visited, after arriving at the train or bus depot, is Gayoso Street. It is always the first place that is thought of when characters are planning to go to Memphis. Even the character Mink, in *The Mansion*, though he is on a mission and has only limited means to buy a gun to kill his cousin, is tempted to visit the red-light district; he remembers fondly his last trip to Memphis before he was sent to prison forty-four years prior.



The actual Memphis of 1905 had, as Faulkner depicts, many houses of prostitution as well as an enormous number of saloons. (Fig. 10) The city boasted over 500 saloons in 1903<sup>43</sup> (this number includes grocery stores because most had a barrel of whiskey in the back with cups for sale at ten cents per cup).<sup>43</sup> The situation was seen by some in the religious establishment as being out of control. A very successful evangelist who consistently packed the auditorium on Main and Linden Streets at the turn of the century said of Memphis that "if whiskey ran ankle deep in Memphis, and each front door had a dipper tied to it, you could not get drunk quicker than you can in Memphis now."<sup>43</sup> An editorial in Memphis's mostly widely circulated newspaper, *The Commercial Appeal*, said that "dives have been flourishing as they have never flourished before. Hundreds of lewd women ... have been imported. Street-walkers have been as thick as wasps in summer time."<sup>45</sup> The center of prostitution in Memphis was Gayoso Street.<sup>46</sup> The extent of the Tenderloin was rather small. The area was contained by Main Street on the west, Linden on the north, Mulberry on the east, and Beale on the south.<sup>47</sup> Surrounding this area was the tenement district (eighty-three percent of Memphians rented)<sup>48</sup> that housed many of the rural immigrants.

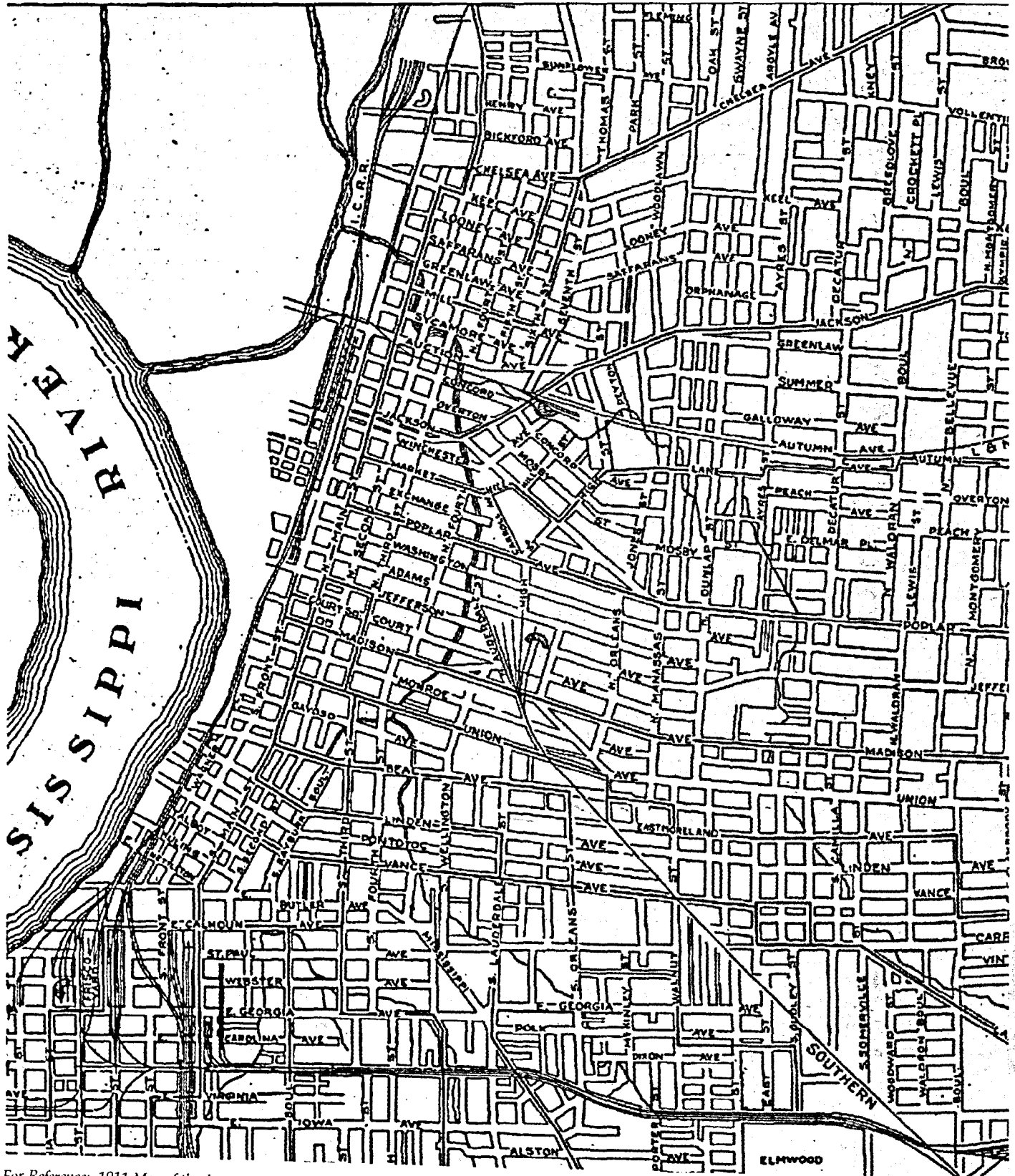
The red-light district, with its close proximity to the tenement district filled with new rural citizens, and the perception for many residents of Yoknapatawpha County of it being the center of Memphis, is in dramatic contrast to Jefferson both in behavior and in architectural form. Rural visitors and new immigrants were free in Memphis to act as they wished. The architecture of the district, as well as the Memphis city plan, aided this freedom. The tight streets, the uniform brick building material, and the scarce windows that are described in most accounts of the district, provide anonymity as well as freedom from the gaze of authority and the community/neighborhood as a whole. Its

uniformity and crowded buildings position this district of Memphis as parallel to the hyper-Modernity of the 1950s. The lack of oversight by an authority figure played a key role in the failure of the Pruitt-Igoe complex in St. Louis, whose destruction heralded the fading of Modernism. This same uniformity and lack of gaze parallels Memphis's pre-Modern urban fabric. (Fig. 5) This contrasts to the square at Jefferson where a structure of power is given architectural expression. This square, being described as stage-like, provides no anonymity, especially since most of the citizens of Jefferson know one another. This controlling gaze intensifies Jason's rage, in *The Sound and the Fury*, that is directed at Luster for taking Benjy to the square. Jason, always concerned with the family name, does not want Jefferson to see his idiot brother bellow.<sup>49</sup> The gaze can, therefore, hinder people's actions. Conversely, the lack of a gaze in Memphis's red-light district frees people to do certain activities that would not even be considered in Jefferson.

In Faulkner's writing, the urban South—Memphis and New Orleans—is defined by what Jefferson is or is not. The uniformity and banality of Memphis's built environment is contrasted to the visually complex and varied and historically rich central district of Jefferson. The freedom the characters exhibit in Memphis is a result of their being out of the controlling gaze of Jefferson's central square. Even the decision or inevitability of Memphis being the destination for the two characters of *The Reivers* is a result of Memphis being what Jefferson is not: a means of momentary escape from the slow rural South. In Faulkner's works, however, Memphis is always and only an escape, an ephemeral place of brothels and streetcars. Jefferson stands, immutable, as the destination of return, the lasting presence in Faulkner's South, with the "clock on the courthouse above the trees around the Square."<sup>50</sup> (Fig. 11)

Figure 12. Beale Street today





For Reference: 1911 Map of the downtown area of Memphis.

**Endnotes:**

- <sup>1</sup> William Faulkner, *Essays, Speeches, and Public Letters* (New York: Random House, 1965), 11.
- <sup>2</sup> David L. Cohn, *God Shakes Creation* (New York: Harper & Brothers, 1935), 17.
- <sup>3</sup> William Faulkner, *Novels 1957-1962, The Town, The Mansion, The Reivers* (New York: Library of America, 1999), 771.
- <sup>4</sup> Gerald M. Capers, *Biography of a River Town; Memphis: Its Heroic Age*, (Chapel Hill, NC: University of North Carolina Press, 1939), 41.
- <sup>5</sup> J. P. Young and A.R. James. *Standard History of Memphis, Tennessee, A Study from the Original Sources*, (Knoxville, TN: H.W. Crew, 1912), 79-80.
- <sup>6</sup> Capers, *River Town*, 41.
- <sup>7</sup> Sigafos, Robert Alan. *Cotton Row to Beale Street: A Business History of Memphis*, (Memphis: Memphis State University Press, 1979), 97.
- <sup>8</sup> Capers, *River Town*, 232.
- <sup>9</sup> Faulkner, *Novels 1957-1962*, 1004.
- <sup>10</sup> Capers, *River Town*, 215.
- <sup>11</sup> Faulkner, *Novels, 1957-62*, 771.
- <sup>12</sup> William Faulkner, *Novels 1942-54, Go Down, Moses, Intruder in the Dust, Requiem for a Nun, A Fable* (New York: Library of America, 1994), 400.
- <sup>13</sup> Faulkner, *Novels 1957-62, 800-801*.
- <sup>14</sup> William Faulkner, *Collected Stories of William Faulkner*, (New York: Vintage International, 1995), 93.
- <sup>15</sup> Sigafos, *Cotton Row*, 103.
- <sup>16</sup> *Ibid.*, 100.
- <sup>17</sup> *Ibid.*, 224.
- <sup>18</sup> Miller, *Memphis During the Progressive Era, 1900-1917*, (Memphis: The Memphis State University Press, 1957), 7.
- <sup>19</sup> *Ibid.*, 8.
- <sup>20</sup> Capers, *River Town*, 226.
- <sup>21</sup> *Ibid.*, 206.
- <sup>22</sup> Kathleen C. Berkeley, *Like a Plague of Locusts: From an Antebellum Town to a New South City, Memphis, Tennessee, 1850-1880*, (New York: Garland Publishing, 1991), 13.
- <sup>23</sup> Marc Auge, *Non-places: Introduction to an Anthropology of Supermodernity*, (New York: Verso, 1995), 77-78.
- <sup>24</sup> William Faulkner, *Novels 1942-1954*, 400.
- <sup>25</sup> *Ibid.*, 616
- <sup>26</sup> *Ibid.*, 499.
- <sup>27</sup> *Ibid.*, 499-500.
- <sup>28</sup> *Ibid.*, 320.
- <sup>29</sup> William Faulkner, *Novels 1957-62*, 839-840.
- <sup>30</sup> *Ibid.*, 802.
- <sup>31</sup> Faulkner, *Collected Stories*, 97.
- <sup>32</sup> William Faulkner, *Sanctuary*, (New York: Modern Library, 1931), 169.
- <sup>33</sup> J. Horace McFarland, "Eyesores that Spoil Memphis," *Ladies Home Journal*, June 1906, 23-29.
- <sup>34</sup> Miller, *Progressive Era*, 15.
- <sup>35</sup> *Ibid.*, 16.
- <sup>36</sup> *Ibid.*, 16. Quoted in the *Commercial Appeal* June 14, 1906.
- <sup>37</sup> Sigafos, *Cotton Row*, 112.
- <sup>38</sup> *Ibid.*, 112.

<sup>39</sup> William Faulkner, *Uncollected Stories of William Faulkner*, (New York, Vintage International, 1997), 529.

<sup>40</sup> Capers, *River Town*, 232.

<sup>41</sup> Faulkner, *Sanctuary*, 170.

<sup>42</sup> Miller, *Progressive Era*, 88.

<sup>43</sup> Helen M. Coppock and Charles W. Crawford., ed. *Paul R. Coppock's Midsouth*, (Memphis: West Tennessee Historical Society, 1985), 80.

<sup>44</sup> Young, *Standard History*, 236.

<sup>45</sup> Miller, *Progressive Era*, 90.

<sup>46</sup> *Ibid.*, 19.

<sup>47</sup> *Ibid.*, 90.

<sup>48</sup> Sigafos, *Cotton Row*, 103.

<sup>49</sup> William Faulkner, *The Sound and the Fury*, (New York: Random House, 1929), 400.

<sup>50</sup> Faulkner, *Novels 1957-1962*, 966. This is part of the long awaited return of the "reivers" home. The account, in full, reads: "About six the next afternoon we came over the last hill, and there was the clock on the courthouse above the trees around the square. Ned said, "Hee hee hee." He was in front with Boon. He said: "Seems like I been gone two years."

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**Editor's comment:**

This paper won the Pella Writing Prize for 2005--a prize awarded for the best undergraduate writing done by an architecture student.

## PROJECTING THE PASSION

### THE INVENTION OF THE 'JUDEO-CHRISTIAN TRADITION' IN THE ROMAN/BIBLICAL GENRE OF POSTWAR AMERICAN FILM

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Figure 1: Charlton Heston, Cecil B. DeMille's favorite actor for Biblical epics.

#### Abstract:

*This paper traces the changes in the American view of the relationship between Jews and Christians from the First World War to the present as reflected in motion pictures from the earliest of the biblical epics to Mel Gibson's *The Passion of the Christ*. It demonstrates that the "Judeo-Christian tradition" as it has developed since the Second World War is a political theme that functioned first as anti-fascist propaganda and then as anti-communist propaganda that portrayed Jews and Christians as good and free in contrast to Nazis and communists; and it shows what an effective medium the movies were in selling this idea.*

#### Projecting the Passion

*Building the Judea-Christian in postwar American film*

In the Lenten months of 2004, a virtual holy war broke out in America over the Ash Wednesday release of Mel Gibson's *The Passion of the Christ*, a bloody 127-minute liturgical depiction of Jesus' scourging and execution. The clash did more than merely reopen the longstanding dispute over the crucifixion. The exposure of a genuine rift between Christians and Jews over just what happened in first-century Judea seemed to cause more

discomfort among religious conservatives than anyone else, for it questioned whether the Gospels should be interpreted as literal, historical fact amid the often contradictory history of Judea and early Christianity. The political instability this threatened among the American Right appears not to have gone unnoticed, as such awkwardness even led conservative Jewish film critic Michael Medved to decry the notion that Christians should be "forced a choice between faithfulness to scripture and amiable relations with Jews."<sup>1</sup> Clearly this does not apply to the majority of (non-literalist) moderate Christians for whom a rigidly literal interpretation of the Gospels is not an issue.

What Gibson's film indeed exposed was how different an American culture greeted *The Passion* than had confronted previous Biblical movies. *New York Times* reviewer A.O. Scott dismissed these earlier films as "palatable (if often extremely long) Sunday school homilies deigned to soothe the audience . . ." <sup>2</sup> Ironically, at the same time in which the ancient Jewish-Christian fissure was being played out awkwardly in conservative newspaper columns, many of the same commentators were invoking the so-called "Judeo-Christian" heritage of the United States to fuel the ongoing culture wars. Cal Thomas, in a column

only a few months before his glowing praise of *The Passion*, sneered at the Council on Arab-Islamic Relations for seeking “the elimination of references to ‘Judeo-Christian’ when describing the heritage of the United States.”<sup>3</sup> As historians from Mark Silk to Deborah Dash Moore have pointed out, the “Judeo-Christian tradition” is really an invention of 20<sup>th</sup> century America. This tradition owes more to World War II solidarity among Jews, Protestants and Catholics and the subsequent Cold War rhetoric that pitted America’s religiosity against godless communism, than to a chain of harmony and cooperation between the two faiths stretching from first-century Judea, through medieval Europe, to revolutionary Philadelphia.<sup>4</sup> Indeed, conservative commentator Dennis Prager, prompted by skepticism over the authenticity of the “Judeo-Christian tradition,” felt compelled in spring 2005 to write a multi-part essay defending the use of the phrase and contrasting this wholly American “tradition” against two models he claims rival it on the world stage: European secularism and Islamic fundamentalism.<sup>5</sup>

But what does Mel Gibson’s *The Passion*, and the furor over it among both Christians and Jews, scholars and clerics, have to do with the so-called “Judeo-Christian tradition”?

There is an accepted mode of film criticism that allows us to see the protagonists and their enemies on movie screens as ideological constructs of the time in which they are made. This could not be truer than with the Roman-biblical epic, whose golden age dawned in the 1950s and ’60s alongside American anti-communist anxieties that in many ways took shape through religious discourse. Both Moore and Silk have noted how the solidarity of Jews, Protestants and Catholics in World War II and the anti-communist movement became devoted to distinguishing America against its godless Russian rival; this in turn led to an appeal to the so-called “Judeo-Christian tradition” of the United States, a tradition that supposedly served as the foundation for Western democracy. As each historian likewise points out, and as Jewish author Arthur Cohen proclaimed in an entire book devoted to “The Myth of the Judeo-Christian Tradition” in 1965, no such “tradition” really exists, but is wholly tied to the initial anti-fascist zeal among Jews and Christians and the subsequent anti-communist movement in the postwar period. The “Judeo-Christian tradition,” often referenced casually and genuinely by those who unaware of its origins, is wholly a product of postwar America. Even as Congress invoked such a tradition in 1954 to add “under God” to the Pledge of Allegiance, explicitly as an anti-Communist device, American moviegoers were seeing the “Judeo-Christian tradition” fabricated in the ancient world, where Jews and Christians weren’t engaged in the fierce polemics that the New Testament, apocryphal writings, and the early church fathers clearly illustrate, but were rather united against another evil empire – Rome: sacrilegiously pagan rather than ardently atheist, cruelly slave-holding instead of collectively communistic, but always depicted in such a way that it could become equated on screen with the irreligious, anti-democratic, anti-individualistic enemy state in American consciousness.

While the emergence of Israel as a modern state in 1948 no doubt added a second political dimension to the Biblical epic, it is the depiction of Rome that best lays bare the anti-communist ideologies at work.

The consequence of this film tradition should be of interest to classical scholars, since the invention of the *Judeo-Christian* in American film claimed as a significant casualty the ancient Romans, who were now associated more with the fascist and communist enemy than with the political model upon which America’s founders based the early republic. This came about in three all-important themes in the Roman-Biblical genre in the postwar period: the crucifixion of Jesus, the persecution of Christians, and the oppression of Jews in the Holy Land, all at the hands of mighty Rome. A thorough examination of these films makes it clear that the Biblical epics of the 1950s and ’60s were hardly the “Sunday school homilies” that Scott proclaimed. Rather, they were decidedly political epics, designed to integrate America’s newfound identity as a “Judeo-Christian” nation against that of an enemy state.

History, it will be shown, was manipulated and sometimes falsified by filmmakers during this time in order to pursue three goals related to the three themes above, and all related to the invention of the *Judeo-Christian*: First, the crucifixion of Jesus was historicized, to make clear who would have been at fault for his execution on a Roman cross; second, the persecution of Christians is fictionalized, utilizing apocryphal tales or history imported from the later Empire into the Julio-Claudian period; and third, the real Jewish-Christian polemic is marginalized, and in its place later films overlapped the Roman subjugation of Judea, as related by Josephus and other historical writers, onto the already-established Christian persecution narrative, and even the crucifixion of Christ. What emerges is a narrative model in which Rome becomes somewhat like the three-headed Cerberus: a persecutor of Christians, oppressor of Jews, and most importantly, crucifier of Christ. Jews and Christians thus become united against Rome in Technicolor just as American leaders were advocating their unity against communism during the Red Scare.

It is the purpose of this article to point out this recurring model that greeted American theatergoers in the postwar period, its contribution to the notion of the “Judeo-Christian,” and the transformation of ancient Rome in the popular consciousness from a Ciceronian pillar of American law and institutions to a Neronian surrogate for communistic enslavement and godlessness.

#### *The Ten Commandments and the quest for Zion*

In March 2005, *New York Times* columnist Frank Rich saw a correlation between the Ten Commandments displays erected by DeMille in the 1950s and the political hand-wringing led by House Majority Leader Tom DeLay over the Terry Schiavo case,



a family dispute over whether a Florida woman in a persistent vegetative state should be allowed to die. In a column titled "The God Racket: From DeMille to DeLay," Rich recounted the "ingenious publicity scheme" that DeMille embarked upon as he readied his 1956 remake "The Ten Commandments" for release to audiences. ". . . He sponsored the construction of several thousand Ten Commandments monuments throughout the country to hype his product. . . . Bizarrely enough, all these years later, it is another of these DeMille-inspired granite monuments, on the grounds of the Texas Capitol in Austin, that is a focus of the Ten Commandments case that the United States Supreme Court heard this month."<sup>6</sup>

To be sure, the Ten Commandments, despite theological nuances among Protestants, Catholics and Jews over their scope and interpretation, are often held up as *the* symbol for the "Judeo-Christian tradition." This correlation did not happen by accident. As Rich points out, DeMille himself made a significant contribution to the Ten Commandments mystique that is now so central to the conservative socio-political agenda. But DeMille accomplished this in more ways than just on stone monuments throughout the country (which, incidentally, still bear the Phoenician-like invented script used on the film's tablets). His 1956 *The Ten Commandments*, as shall be seen, was aligned squarely with the "Judeo-Christian" anti-communist rhetoric of the 1950s, rhetoric that had already become a staple in the Roman-Biblical genre. And yet one only has to compare his Cold War movie with his original 1923 silent by the same name to see how even DeMille himself apparently modified his understanding of the Ten Commandments and their theological importance, and the role of the Jews when it comes to Christianity.

"Our modern world defined religion as a 'religious complex' and laughed at the Ten Commandments as 'OLD FASHIONED,'" the first title screen declares. Then came the horrors of the World War, and people began to look for a "way out." That way out can be found in the commandments, it continues. "They are not laws – they are the LAW."

The beginning of the epic will seem familiar to those who have seen DeMille's 1956 re-make. Many of the set designs showing the enslaved Israelites pulling stones under the whip are virtually identical, as is the montage of slaves. However, there is no backstory to the Moses narrative, and the title merely states that God sent his servant (Theodore Roberts) into Egypt to free his people. When Moses comes down from Mount Sinai and discovers his people in an orgy around the golden calf, he throws the tablets and a disaster ensues, swallowing up the revelers in the earth. "Thou provokest thy God to wrath," Moses says, quoting Deuteronomy. And one Israelite woman, seductively leaning up the Golden Calf, is suddenly stricken with leprosy, leading her fellow people to shout at her: "Unclean! Unclean!"

Amidst the chaos, the camera slowly wipes to a modern-day dinner table, and a melodrama begins about the importance of religion in everyday life. It features a legalistic mother, Martha

McTavish (Edythe Chapman), and her two sons, the good son John (Richard Dix) and his atheistic brother Dan (Rod LaRocque), thus setting up the stock biblical theme redolent of Cain and Abel, Jacob and Esau. The mother reads exclusively from the Old Testament, and her son Dan mocks her. His mother then warns him: "You'll get just what the children of Israel got when they worshipped the golden calf." Dan proceeds to prove her right, becoming a contracting magnate and marrying the female protagonist Mary (Leatrice Joy), and succeeding largely by cutting corners. A church he builds with phony concrete and supplies he smuggled illegally from Asia collapses, killing his mother. Meanwhile, a "Eurasian" stowaway on the smuggling boat, with whom he becomes romantically involved, is revealed to have leprosy, which infects him and later his wife. Amidst all this is Dan McTavish's mock that he will "break all Ten Commandments" and it won't matter, which is of course proven wrong by film's end. In itself, this would appear to be a reinforcement of the later "Judeo-Christian" morality, if it weren't accompanied by the clear "replacement" theology of Christian grace over Jewish law.

While the son Dan is presented as a godless heathen, his mother is often an overly legalistic zealot, and it requires the constant intervention of John, the good son (who also just happens to be a carpenter) to balance the two. So while John admonishes his brother, "You can laugh at the Ten Commandments all you want, but they pack a terrible wallop," he also scolds his mother's strictness with a reference to the previously viewed slave-driving of the Israelites: "You're holding a cross in your hand, mom, but you're holding it like a whip." As she lay dying amidst the rubble of the collapsed church, Martha apologizes to her wayward son Dan, telling him, "I taught you to fear God, not to love him, and love is all that counts." The replacement theology is all but cemented by film's end, as Mary, wracked with leprosy, approaches John the carpenter about her illness. By the time the audience sees another biblical re-enactment, it is of Jesus healing a sick woman as John reads from the New Testament, the "new covenant's" first appearance in the movie. And as if in parallel to the end of the Old Testament account, in which the Israelite woman succumbs to leprosy presumably for her sins against the law, Mary is cured of her leprosy by the love of the New Testament.

This wholly Christianized reading of Jewish scripture was abandoned by DeMille when he remade his epic in 1956, famously starring Charlton Heston in the leading role, and was instead Judeo-Christianized. The modern melodrama was removed entirely (who needed an overtly modern story when Romans and Christians in the first century had been conveying modern ideas for years by then?) and DeMille instead expanded upon the Moses story using yet more religious fiction, namely Dorothy Clarke Wilson's "Prince of Egypt" and J.H. Ingraham's "Pillar of Fire." The Ten Commandments, in this film, are not presented as a Jewish legal document that is nice to follow but secondary to Christian grace – rather, in line with the latest

rhetoric of 1950s America, the Ten Commandments become the Judeo-Christian basis for democracy, and the notion of freedom vs. “the state” again arises in a wholly integrated, Judeo-Christian narrative that makes “The Law” the source of freedom no matter how much Jesus may have monopolized liberty in previous films. We thus have the first movie in the “Judeaizing” of postwar film, which would, ironically, grow strongest in later tales about the Christ.

DeMille makes it clear from the beginning that his is a political epic, stepping out from behind a curtain to unusually introduce the film himself to the audience: “We have an unusual subject: The story of the birth of freedom, the story of Moses. . . . The theme of this picture is whether men ought to be ruled by God’s law, or whether they are to be ruled by the whims of a dictator, like Rameses. Are men the property of the state, or are they free souls under God? This same battle continues throughout the world today.” While *Quo Vadis* had claimed that Jesus died on a cross to “make men free,” DeMille – shedding the post-crucifixion punishment of Jews in *The King of Kings* and the replacement theology of his first *The Ten Commandments* – turned the birth of freedom into something both Christians and (supposedly) Jews could appreciate, under the leadership of their joint prophet. When referring to Philo of Alexandria during his introductory remarks as a historical source for his film, DeMille even refers to Philo’s contemporary as “Jesus of Nazareth,” not the Christ. This was to be a Judeo-Christian film exalting individuals as “free souls under God,” and it was released just two years after Congress added precisely that language to the Pledge of Allegiance.

While *The Ten Commandments* cannot necessarily be classed as a Roman epic given its Egyptian antagonist and setting, it relies heavily on the rhetorical and state model that the Roman movie had by 1956 embedded into popular consciousness. It was no large step, then, for DeMille to put Egyptian headdresses on his characters whilst still showing them in the lap of decadent luxury, living off the fruits of their slaves, the individuals “at the mercy of the state,” as *Quo Vadis* had put it. Throughout, much as Nero had been addressed as “divinity” by his court, Rameses (Yul Brenner) is likewise called “divine one” by his subjects, and the ridicule of pagan gods seems overwhelmingly familiar, most especially when the Pharaoh prays to a statue to heal his son and his wife Nefretiri scoffs, “He’s nothing but a piece of stone with the head of a bird.” However, like the godless Roman state and its actors before, Pharaoh is more atheistic than polytheistic: “What gods?” he asks Moses and the magicians. “You prophets and priests made the gods so that you might pray on the fears of men.”

And most of all, of course, is the recurring theme of freedom vs. slavery and the notion that biblical law is the origin of all freedom, the origin of the Western democratic values of the audience. “It is not treason to want freedom,” Moses tells his “brother,” the future Pharaoh Rameses, before he is outed as a

Hebrew. When he is discovered to be Hebrew, Moses is put in bondage and brought before the Pharaoh with a *tibulum* holding up his arms, very similar to many depictions of Jesus marching to Calvary tied to his crossbeam. When Moses returns a prophet and demands the release of his people, the Pharaoh responds, “Their lives are mine; all that they own is mine.” And Moses makes his governmental model clear: “Man shall be ruled by the law, not by other men.” As the angel of Passover visits the Egyptian households, the anxious Israelites anticipate that “Tomorrow the light of freedom will shine upon us.” And when they err in licentiousness in the wilderness and spark Moses’ and God’s wrath with their appeal to “freedom,” the prophet scolds them, “There is no freedom without the law! . . . If you will not live by the law, you will die by the law.” DeMille’s seemingly favorite motif then ensues again, as hundreds of Israelites are swallowed up into the Earth by the Almighty’s anger. As if to punctuate the importance of Jewish law in Christian tradition, Sefhora (Yvonne De Carlo) tells Moses that he “taught them not to live by bread alone.”<sup>7</sup> Finally, as Moses hands a satchel of scrolls to his brother Aaron and prepares for his walk with God, he parts by instructing them to “Proclaim liberty to all the lands.”

It was a far cry from the vision of Jews that DeMille had provided audiences in *The King of Kings* and his first *Ten Commandments*. Not only would *The Ten Commandments* launch a fully Judeo-Christian understanding of the biblical epic, it would also introduce the character of the fighting Jew, the rebel against tyranny that would, perhaps ironically, retain the gentile, blue-eyed Charlton Heston as its primary actor. Yet the film cannot be said to be Jewish: Rather it is simply an “Old” Testament epic, and the story is told through the typical Sunday-school Christian narrative, aside from its fictional aspects. Later epics that would feature prominent Jews would return to first-century Judea and the cruel Roman state, and would feature the return of Jesus as a central character – Hollywood’s second coming of Christ.

#### *Josephus, Hollywood screenwriter*

“It is written,” intones narrator Orsen Welles in biblical language at the beginning of *King of Kings* (1961), before proceeding to account for the Roman conquest of Judea. Only Welles wasn’t quoting from Scripture, but from history, specifically Flavius Josephus (c. 37-101 CE). More than ever before, the Roman-Biblical films of the 1960s would use generous amounts of Jewish history, and for that filmmakers turned to this first-century author, one of our best sources for Jewish events during the Greco-Roman period. Almost always, the portrayal of the Romans gleaned from Josephus is a notoriously brutal one, and the depiction of the Jews one of freedom fighters or patriots, trying to win their homeland away from the occupier. But it is important to remember that Josephus, while documenting Roman brutality, was not necessarily a Jewish partisan. In his introduction to *The Jewish Wars*, he states:

It is not my intention to counter the champions of the Romans by exaggerating the heroism of my own countrymen. . . . [Judea] was destroyed by internal dissensions, and the Romans who so unwillingly set fire to the Temple were brought in by the Jews' self-appointed rulers, as Titus Caesar, the Temple's destroyer, has testified. For throughout the war he pitied the common people, who were helpless against the partisans; and over and over again he delayed the capture of the city and prolonged the siege in the hope that the ringleaders would submit. If anyone criticizes me for the accusations I bring against the party chiefs and their gangs of bandits, pardon my weakness...<sup>8</sup>

Given Josephus' hostilities to Jewish "revolutionaries," we are faced yet again with a Hollywood that must change or at least manipulate the historical record in order to make its narrative function in line with current ideologies. Nevertheless, Josephus does provide us with a solid history of the Roman-Judean interaction, beginning with Pompey's taking of Jerusalem in 63 BCE. According to his *Jewish Wars*, Pompey and his army assaulted the walls of the city for three months before finally overturning the battlements and storming the temple. "Many of the priests, though they saw the enemy approaching sword in hand, quietly went on with the sacred rites and were cut down as they poured libations and offered incense, putting the service of God before their own preservation."<sup>9</sup> Just as Eusebius' unflattering accounts of his fellow Christians' faith was excised from films about the persecutions, so too Josephus' words indicting some of his fellow Jews in the wars never made the editing cut. "Most who fell were killed by their own country men of the rival faction," he continues. "Others beyond number threw themselves over the precipices; some, maddened by their hopeless position, fired the buildings round the wall and perished in flames."

Despite the calamity, nothing "sent a shudder through he nation as the exposure by aliens of the Holy Place, hitherto screened from all eyes. Pompey and his staff went into the Sanctuary, which no one was permitted to enter except the high priest, and saw what it contained – the lampstand and the lamps, the table, the libations cups and censers, all of solid gold, and a great heap of spices." Though *King of Kings* (1961) will depict this interaction as an oppressive one, Josephus writes that Pompey didn't touch any of the treasures, ordered the Temple purified again the next day, and "proved his worth as a general . . . and by relying on considerateness rather than severity won the goodwill of the citizens."

Nevertheless, Josephus does paint a rather unruly picture of Jerusalem during the time of Jesus of Nazareth. Sometime before the death of Herod the Great in 4 BCE and the placement of Judea under the direction of a Roman governor in 6 CE,<sup>10</sup> two rabbis, Judas and Matthias, on hearing that Herod was dying, caused a popular uprising by urging people to tear down a golden eagle that the king had erected on the gate outside of the Temple. "At mid-day, when masses of people were walking about the Temple

courts, they lowered themselves by stout ropes from the roof and began to cut down the golden eagle with axes."<sup>11</sup> Herod seized the men and the rabbis and had them all burned alive. Of course, the most notorious uprising is the main subject of Josephus' *Jewish Wars*, the siege and razing of the city in 70 CE.<sup>12</sup> It is this oppression – the Roman occupation of Judea and the Jews' resistance – that occupied the attention of moviegoers and filmmakers in the postwar period.

### *A Tale of the Judeo-Christian*

By the time William Wyler wished to produce the 1959 blockbuster *Ben Hur: The Tale of the Christ*, it didn't take much to transform Charlton Heston into the ultimate fighting Jew for the movie-going population. After all, he had been *the* Jewish prophet only a few years before, so his opening lines to the Tribune Messala are meant in all seriousness: "You're a Roman, I'm a Jew." With Heston, Hollywood continued a re-examination of the Jew that it had in earlier films like DeMille's *The Ten Commandments*, which is replete with references to the Hebrew race and the prejudice that had accompanied such identification for centuries. "There is no shame in me," Heston told his adopted mother as Moses in 1956, "how can I feel shame for the woman that bore me or the race that bred me?" Later, before Pharaoh, he lamented "the evil that men should turn their brothers into beasts of burden, to slave and suffer in dumb anguish, to be stripped of spirit and hope and faith, only because they're of another race, another creed. If there is a God, he did not mean this to be so."

Heston would continue playing the part of the prophetic pest to Frank Thring's Herod Antipas in *The Greatest Story Ever Told*. The film turned his portrayal of John the Baptist, perhaps fitting given the film's set location in the American West, into the heroic American outlaw cowboying up to the powers that be, most especially when pumping Herod full of one-liners: "I have orders to bring you to God, heathen!" he yells at an emissary of Herod when asked to come to the Galilean palace. "I won't come with you at all," he adds to the throng of soldiers, who when wading into the Jordan to take the Baptist by force, find themselves repeatedly dunked by Heston. "Repent! Repent!" he yells, as soldier after soldier is submerged. Though Jesus is presented as an otherworldly, anti-materialist sage – one of the most painfully lengthy discourses comes under a bridge as Jesus convinces his disciple that being deprived of his coat was no great loss – the world of the *Greatest Story* is one of upheaval against Rome. At the beginning, before the sea of crucifixions meets the holy family on its return from Egypt, as noted before, a riot breaks out as Israelites tear down a Roman eagle from the Temple gate, a tale ripped straight from the pages of Josephus.<sup>13</sup>

But it is Heston's performance as John the Baptist that no doubt conjured the image of the rebel Jew, especially given his previous performances as Moses and Judah Ben-Hur. "I have no king but God," he defiantly tells Herod at the palace. When



Herod asks where he can meet Heston's king, the Baptist growls, "By standing in the first line you come to this side of Hell!" Herod will find the Christ he is seeking all right, John the Baptist warns: "Your answer is in the fires of Hell, Herod! ... You'll stand in judgment. You'll burn in Hell!" Heston's fiery performance seems to complement the otherwise staid and peaceful portrayal of Max Von Sydow's Jesus. Indeed, as much emphasis is given in *The Greatest Story Ever Told* to John the Baptist's "treasonous" actions and eventual martyrdom as to Jesus himself, as John morphs into the Jewish counterpart to Christianity's Jesus. This is a wholly abiblical portrait of John the Baptist, needless to say, whose imprisonment and martyrdom is attributed only to his rebuking of Herod, not treason against Rome.<sup>14</sup>

It was not the first time. *King of Kings*, the not-so-remade DeMille classic in 1961, also features a rebellious John the Baptist amid a host of other Jewish rebels, led of course by Barabbas. The Jews' continuous fight for the homeland is made a constant backdrop in *King of Kings*, and John the Baptist is at first at the forefront. After Pilate places the standards of Caesar in Jerusalem,<sup>15</sup> John the Baptist stands outside addressing the crowd: "Behold the sign of the pagan," he says. "A day will come when Rome will crumble into dust. . . . The high shall fall and the fallen shall rise." Though Caiphas tells Pilate that "we have found it wiser to ignore the ravings of these false prophets than to persecute them," Pilate thinks there is always a way to get rid of vagabonds, and throws a coin at the Baptist from the window. This John (Robert Ryan), equally as defiant as Heston, throws the coin back at Pilate.

In *King of Kings*, John and his cousin Jesus are put into a rebellious world in which the Jews are fighting for their homeland, including a sympathetic Barabbas, whose throngs of rebels conceal themselves underground in hideouts similar to the catacombs. As if aware of the translation issues surrounding the word *ἠσθητής* in Josephus, Herod asks the eventual convert and Roman centurion Lucius, "What are these men, bandits?" to which Lucius responds, "They call themselves patriots," using the same word Judah Ben-Hur did years earlier to describe his people to Messala. Lucius becomes the lone sympathetic Roman in *King of Kings*, eventually identified with the centurion beneath the cross who confessed Christ's divinity,<sup>16</sup> in an evil empire oppressing the Jews in their homeland and ultimately crucifying Jesus. During the prologue, Orson Welles tells of Herod, the "Arab" and "false and maleficent king of the Jews," causing rebellions to rise up. "Herod, in reply, planted evil seeds, from which forests of Roman crosses grew high on Jerusalem's hills. And Herod made the forest multiply." As Welles drones, the bodies of Jews are seen taken down from crosses, carried to a pit, and thrown among heaps of corpses. It was the postwar film's most explicit Holocaust imagery, and served to render concrete the notion that Rome had been not only the persecutor of Christians and killer of John the Baptist and Jesus, but no better than the Nazis themselves in exterminating a race of people. Of

course, Herod's identification as an Arab is also significant given the strife of the 1960s between Israelis and Arabs, but *King of Kings* makes Herod's service to Rome and Rome's festering presence in Israel paramount to the oppression of the Jews. When Joseph comes to Bethlehem as required by the census, for example, he finds his city "much corrupted by Rome." The entire opening sequence, as referenced before, shows Pompey's legions marching into Rome and "most irreverent Pompey" stepping into the Holy of Holies. No flattering portrait of the general is given here. Pompey has Jewish priests standing firm on the steps of the Temple executed with spears, and as he steps into the inner sanctum, he provides a Roman reversal of the climax to the first *King of Kings*: rather than God rending the Temple veil in anger over the crucifixion, Pompey cuts a long slit in the curtain to enter the chamber.

Even the crucifixion is made to service this image of Roman occupation, as Jesus and the two *ἠσθηταί* next to him are made merely the foreground in a sea of crosses. And when Barabbas is in prison with the two men to be crucified with Jesus, he tells them that he and Jesus seek the same thing: "freedom."

This confusing theme of freedom contrasted over against the Christian spiritual notion of freedom and yet seemingly supported by it at the same time, plays out awkwardly in several films, not the least of which is *Ben-Hur*. The "freedom" of the earlier postwar epics, the freedom sought by Christians under the evil empire to worship as they please, is dovetailed into the freedom of the Jewish people in first century Judea and their quest for Israel, both of which are of course layered on top of the Cold War and Middle-Eastern politics at work in 20<sup>th</sup> century America. After all, only a decade before Israel had declared itself a state upon the lapsing of the British mandate over Palestine, Arab forces invaded and fighting continued until truce agreements are signed in 1949. So it is perhaps unsurprising that Jews were thus encouraged in the Roman movie to take on the godless empire alongside their Christian brethren, for surely Rome (and thus the communist state) was no less hostile to the religious Jewish state antithetical to its irreligiosity. Therefore, despite repeated references to Christ's emphasis on freedom for the soul over freedom won militarily ("I felt his voice take the sword out of my hand," Judah says of the crucified Christ in *Ben-Hur*), filmmakers insist on presenting the latter quest as equally admirable and necessary.

Nowhere does this play out more fully than in *Ben-Hur: A Tale of the Christ*, in which Israel and Christianity converge in the ideal Judeo-Christian alliance. Indeed, Judah Ben-Hur, as his name suggests, becomes a stand-in for Judea, for Israel the state, throughout the film, and as a representative of the Jews his story is made to mirror his contemporary representative of Christianity, with whom he interacts at the beginning and end of the movie. We are told he is a Jewish prince, one of presumed influence given Messala's attempt to recruit him in an effort against the rebels. "They're my people, I'm one of them," Judah protests. If

Messala wants his advice, it is to withdraw the troops and “give us our freedom.” Who are the rebels conspiring against Rome? Messala asks. “They’re patriots,”<sup>17</sup> responds Judah, before emphatically stating his Zionism: “I believe in the past of my people and in their future. ... You may conquer the land, you may slaughter the people, but that is not the end. We will rise again.” This notion of a return to Zion is perhaps unsurprising in the film’s rhetoric, and the equation of Judah with Israel is made explicit when he is captured by Messala after a mishap blamed on the House of Hur and sentenced to the galleys: “I pray that you live till I return.”

In accordance with previous movies in the genre, Romans are of course again depicted as irreligious tyrants. “Rome is an affront to God,” Judah proclaims. “They’re drunk with religion,” complains the outgoing Tribune. “How do you fight an idea, especially a new idea?” How? Messala answers. “With a new idea.”<sup>18</sup> Judah’s galley master and eventually adoptive father Arrius, meanwhile, remarks on “what a strange, stubborn faith you keep, to believe that existence has a purpose.” And the reticence to identify the protagonists, the Jews themselves, as slave holders is likewise played out awkwardly, as Judah’s slave Esther (Haya Harareet) tells him she “never felt like a slave” in his house, and Judah grants her freedom as her wedding gift.

But most pronounced is Judah Ben-Hur’s identification with Jesus throughout the film, as though the fate of the two, Christian and Jew, Christ and Israel, are necessarily entwined against the state. The wise man Bathazar (Finlay Currie) at one point mistakes Judah for Jesus, saying they would be about the same age. Meanwhile, after winning the race with the Star of David around his neck – “to shine out for your people and my people and blind the eyes of Rome,” says the Arab horse trader who gives it to him – Judah is hailed as the “people’s god” and recognized as a threat by Pilate, who orders him banished from his homeland after he renounces his Roman citizenship. While still trying to convince him to accept, the crucifier of Christ entreats him “not to crucify yourself on a shadow such as old resentment or impossible loyalties. Perfect freedom has no existence.” Addressed as Arrius, his adopted Roman name, Heston famously retorts, “I am Judah Ben-Hur.” And while about to face Messala in the arena, Judah makes a Gethsemane prayer to his God: “My path is set. Into your hands I commit my life. Do with me what you will.” The reciprocal images of the enslaved Judah receiving water from the Christ toward the beginning, and the Jew giving water to the condemned Jesus are perhaps so embedded in popular consciousness they need not even be recounted. Suffice it to say, Judah as Jew and Christ as Christian, their parallel struggles against godless Rome and devotion to freedom, constitutes perhaps the most powerful construction of the Judeo-Christian in all of postwar film.

Yet *Ben-Hur* is not a Jewish story, but a wholly Christian one. The two women of the Hur house afflicted with leprosy are cured at the end amid Christ’s crucifixion, and Balthazar succinctly

sums up the general crucifixion theology when asked why Jesus was crucified: for the sins of the world. And yet it should be pointed out that in the 1880 novel by Lew Wallace, Judah is converted explicitly at the end to Christianity, but not so in the movie. It is in fact left intentionally ambiguous to which faith group the Hurs now belong. Instead, the film ends the Friday evening immediately after the crucifixion but before the resurrection – at that small window in time, one might say, when Christians weren’t yet Christians and Jews like the Hurs hadn’t had the chance not to be Christians yet – that one Sabbath in history when all Jews were potential Christians and all Christians still Jews, and Judah himself the ultimate Judeo-Christian.

#### *A new era in film for the Judeo-Christian?*

“Christians and Jews created the United States of America in a revolution against tyranny,” wrote James Atticus Bowden on April 4, 2005, in an “open letter” to the Judeo-Christian Council for Constitutional Restoration and its upcoming conference on *Confronting The Judicial War On Faith*.<sup>19</sup> Continuing with a stark modification of that first moment in recorded Christianity when the Jews supposedly severed themselves from Christians – their John 19:15 scream that “We have no king but Caesar” – Bowden Judeo-Christianizes the story of the American Revolution. “Christian ministers lead [sic] their congregations to fight. Patriots proclaimed, ‘We have no king, but Jesus.’ The tiny Jewish congregations risked everything against the greatest military empire on earth. The fight was about who had the right to tax us. Yet, America became the place where it was safe to be a practicing Christian or Jew.”

There were some Jews in America during the Revolutionary War, and some, like Haym Salomon, played an important part as Patriots. But Bowden’s repeated invocations of the Christian and Jewish patriot are meant to gloss over the very real anti-Semitism that was not absent in America, in an effort to push the “Judeo-Christian” ideological agenda touted at the *Confronting The Judicial War on Faith* conference, including the preservation of the Ten Commandments on public property and the words “Under God” in the Pledge of Allegiance. It is no coincidence that the continuing rhetoric regarding these socially conservative political issues is coated in the “Judeo-Christian” tradition, and that many of the symbols held up by the Right are in fact relics of the Cold War era: DeMille’s Commandments monument; the acknowledgement of God in the Pledge.

The “Judeo-Christian tradition” had several obstacles in its way when anti-communism decided to adopt it as its political model. For one, there was the sheer existence of history to the contrary, history that has shown the enormous influence of Roman law on the founding of the Republic, and not so much an emphasis on Judaic law, let alone “Judeo-Christian” law, a hyphenation that, as Silk has noted, the founders would have scarcely recognized.<sup>20</sup> Secondly, there were 2,000 years of history in which the relations of Christians and Jews were

defined solely by polemic. Not least of which the ancient period, in which even in the gospels we can detect a note of distrust (the Jews still hold “to this day” that the body of Jesus was stolen<sup>21</sup>); the medieval period, when the dreaded Passion play arrived yearly for the Jew; or for that matter the 20<sup>th</sup> century, with its scale-tipping atrocities. But the number one sticking point between Jews and Christians has always been the crucifixion – who did it, and why. For Christian replacement theology, it has long been convenient to see the Jews as rejecting Jesus and thus to see his death as caused by that rejection. As Cohen pointed out, this theological dimension is simply irreconcilable. But historically, the authors of the Judeo-Christian tradition on film attempted to address the crucifixion simply by rewriting the gospel accounts to bring them more in line with what we know of Roman and Jewish history. Thus Rome, not the Jews, became the crucifier of Christ, and the largest obstacle in Christian-Jewish reconciliation was at least superficially removed. Had this happened alone, the reputation of Rome might not have been necessarily as sullied, but it did not happen alone. Christians and Jews needed more camaraderie and a joint enemy as they had been presented with in World War II. They had one: The Union of Soviet Socialist Republics, the communist, Stalinist regime, against which the American Right in the postwar period would constantly strive to define its country. Appealing, perhaps naturally, to religion, the Judeo-Christian tradition was born as we know it today. But as we have seen, this newfound unity was viewed skeptically at best. For the popular American consciousness, however, a relatively new medium proven to spark trends and influence ideologies was put to work to convince the public of the authenticity of the Judeo-Christian. American film perhaps did not conspire with a unified voice and agreed-upon arrangement to create the Judeo-Christian, but the Cold War ideologies at work converged to present a powerful contribution to postwar philosophy, either as its reflection, its refraction, or perhaps most compelling, its stimulus in cementing the Judeo-Christian in the postwar mind. To present the Judeo-Christian in all its authenticity, filmmakers reached back to the origins of rabbinical Judaism and Christianity to the soon-to-vanish Temple Judaism of the first century. And perhaps conveniently, they found a state, sometimes directed by cruelty, sometimes a persecutor of said Christians, on some occasions the conquerors of Israel. They found in common a prevailing enemy state for Jews and Christians to resist together just as the faithful should resist communism. They found Rome.

And so there is Bowden, winding up his tale of how Jews and Christians had fought alongside each other against tyranny throughout American history – in the Civil War, on “both sides” of course, during the world wars, the cold war, and even today. And perhaps not surprisingly, near the rhetorical climax of his rallying cry against “secular humanism” at the hands of the courts, he envisages a leader to direct “America upwards in the way of Christians during Roman Emperor Diocletian’s tyranny. ... When Christians refused the Roman eagle, they were declared ‘enemies of humankind’ and killed horribly. . . . Judges under the

American eagle, demand a greater dishonor of the Judeo-Christian God today.”

For Bowden and others, the decline of Rome in the American mind must assist in yet another dimension: as one of the undisputed pillars of American tradition and law, its despoiled reputation allows for the new, invented model of U.S. governance to exert itself. With our Greco-Roman heritage out of the way, the Judeo-Christian tradition stands at the ready.

Perhaps demonstrating the ongoing mystique of Christian persecution, Mel Gibson went on a publicity campaign in 2004 and claimed the controversy over his film “The Passion of the Christ” owed to his showing a positive movie about Christ. The American Right jumped aboard. But what was really at work? Gibson had failed to follow the rules concerning the Judeo-Christian tradition, blatantly undermining the tenuous crucifixion narrative that had supposedly served so well to reconcile the Judeo with its Christian for the postwar Right. He had spoken the unspeakable, and so a culture-war controversy served as a natural defense mechanism. If such an enormous rift exists between the Christian’s assumption about the Christ and the Jew’s understanding of 2,000 years of religious and racial intolerance, what kind of “Judeo-Christian” tradition is there, anyway? If there is still a question as to how much law Christ “replaced” with his death and crucifixion, how much of Leviticus can be commandeered for the purposes of joint Judeo-Christian morality? Thus we have Medved, a conservative Jew in the social conservative movement, attempting to iron away the rift by urging his fellow Jews to accept Christians’ literalist reading of the gospels, even if those gospels reflect the very ancient polemic against Jews that served as the context for their oppression and suffering for the past two millennia. What the *Passion* controversy was really about was a fissure in the Judeo-Christian tradition. Gibson hadn’t played the script his forebears had provided him in the postwar period, and so on the surface the social conservative model of ideal governance appeared cracking.

Or was it? “Christians and Jews paid the blood tax fighting tyrannical Imperialism, Human Secularist Nazi Totalitarianism, and Human Secularist Communist Totalitarianism in World Wars I, II and III (the Cold War),” Bowden continued in his letter. “Now, we are fighting Islamists, who hate Israel and America in almost equal measure, in a long, long World War IV against Islamist Totalitarianism.”

Gibson’s film was an enormous success among the American Right, but not so the 2003 independent film *The Gospel of John*, a word-for-word retelling of the Gospel that was released just six months before. Why?

Perhaps it isn’t that *Passion* was merely about Christianity or even positive Christianity (no objections were raised to *The Gospel of John*). Perhaps the film conveyed something latent beyond merely its Christian message, something that can explain why it was often reviled by the Left but embraced by the Right,

who watched time and again as American actor James Caviezel as Jesus withstood the cruel thrashings of the Latin-speaking Romans and fundamentalist priests conspiring against him in Aramaic.

While the sadistic and godless soldiers mercilessly beat Christ and ridicule him with their Italic dialect, and the robed and head-dressed middle-easterners speak in a sister language to Arabic, one is tempted to wonder if another version of the Judeo-Christian is working its way onto the screen – Dennis Prager's Judeo-Christian America pitted against European secularism and Islamic fundamentalism<sup>22</sup> – and if it will prove as lasting and indelible as its predecessors.



Figure 2: Caiaphas in *The King of Kings* (1927)



Figure 3: A more Semitic Saint Paul in *Quo Vadis* is made subordinate to the obviously Gentile St. Peter.

## Endnotes:

<sup>1</sup> *The Christian Science Monitor*, Feb. 2, 2004

<sup>2</sup> *The New York Times*, Feb. 25, 2004

<sup>3</sup> Thomas, "The Threat Among Us," May 20, 2003, Tribune Media Services, whose biography on one radio station (WOCA 1370) touts that he "challenges conventional conservative wisdom by invoking a return to biblical morality, and to government based on the truth of the Judeo-Christian moral code."

<sup>4</sup> See Silk, "Notes on the Judeo-Christian Tradition in America," *American Quarterly*, Vol. 36, No. 1 (Spring 1984); and Moore, *GI Jews: How World War II Changed a Generation*, Harvard, 2004.

<sup>5</sup> "Judeo-Christian values are larger than Judaism or Christianity," March 15, 2005, Creators Syndicate Inc.

<sup>6</sup> "The God Racket, from DeMille to DeLay," *The New York Times*, March 25, 2005

<sup>7</sup> Deut 8:3; Luke 4:4

<sup>8</sup> *Jewish Wars*, I.9-12 (Trans. Williamson, Penguin, 1970) – As noted by the Oxford Classical Dictionary, though Josephus was "a zealous defender of Jewish religion and culture, his writing is largely hostile to the various revolutionary groups, whom he regarded as responsible for the fall of the Temple: his theology centers on the idea that God was currently on the Romans' side." (page 798).

<sup>9</sup> *Jewish Wars*, I.150

<sup>10</sup> *Jewish Wars* I.125

<sup>11</sup> *Ibid.*, I.646

<sup>12</sup> *Jewish Wars*, V.279-445

<sup>13</sup> Though Josephus relates this story, he doesn't specify that the eagle was a Roman one, and Williamson notes in his translation that it is difficult to know its origin. In *Greatest Story*, however, the eagle is decidedly Roman, and will appear again behind Jesus as he is sentenced by Pilate.

<sup>14</sup> Mat. 14:1-12, Luke 3:19-20, Mark 6:19-29

<sup>15</sup> Josephus records this tumultuous decision in *Jewish Wars*, II.165.

<sup>16</sup> Mat. 27:54

<sup>17</sup> Cf. page 15

<sup>18</sup> Cold War – n. – a conflict over ideological differences (Merriam-Webster).

<sup>19</sup> As of May 2005, Bowden's letter could be found at <http://www.webcommentary.com/asp/ShowArticle.asp?id=bowdenja&date=050404>, <http://www.renewamerica.us/columns/bowden/050404>, <http://virginianewssource.com/article262.html>, and <http://www.americandaily.com/article/7361>, among others.

<sup>20</sup> Several classicists have treated the issue of Roman influence on America's founding, among them Meyer Reinhold (*Classica Americana*, Wayne State University Press, 1984) and Carl Richard (*The Founders and the Classics*, Harvard, 1994).

<sup>21</sup> Mat. 28:15

<sup>22</sup> Cf. page 2

**Faculty comment:**

Mr. Burrows' faculty mentor, David Fredrick, is extremely complimentary about his student's work. In his letter to the *Inquiry* publication board supporting the publication of Mr. Burrows' article, he said,

I am very pleased to recommend the work of Don Burrows for publication in *Inquiry*. Don is one of my finest Latin students, and his final project for CLST 4003H (Rome on Film, 2003) received the highest score in a class of 20 very talented honors students. He produced a carefully researched and skillfully constructed website analyzing DeMille's *King of Kings* in comparison with the tradition of Passion Plays and Hollywood movies on the crucifixion. This website subsequently formed the kernel of his honors thesis proposal, to examine the transition in post-war films from blaming the Jewish community for Christ's death to blaming specifically the Romans, a movement away from anti-Semitism toward the condemnation of fascism and communism in the aftermath of the Holocaust. Don received a Scholars' Undergraduate Research Fellowship for 2004-05 from the State of Arkansas to support his research.

Over the past year, Don has crafted his thesis into a truly publishable work. I am an associate editor of the journal *Arethusa* (Johns Hopkins), and frequently review manuscripts for Cambridge University and other presses. In the last five years, the representation of Rome on film has become a very hot topic, with several major new books; I may be biased, but if I were to receive his manuscript anonymously, I would regard it as a significant, well researched, and well written contribution to this debate.

Specifically, Don makes a new and persuasive argument that post-World War II Roman movies were an unmatched force for the solidification in popular culture of the newly minted concept of the

"Judeo-Christian." As these films shifted responsibility for the crucifixion of Christ from the Jews to the Romans, the latter were reborn as oppressive stand-ins for fascism and communism. Thus history was rewritten (not so much the irrecoverable history of the crucifixion itself, but American political history) so that Judaism and Christianity could appear as one faith, without conflict, while the formerly positive role of Rome as a major influence on the shaping of American political and legal institutions was eclipsed. Don further exposes the contemporary relevance (and fragility) of the "Judeo-Christian" by parsing the religious Right's awkward response to Mel Gibson's *The Passion of the Christ*. Whether or not it captured what the crucifixion was "really" like, this film threatened to unravel the illusion of a single harmonious tradition by shifting the blame back to the Jews, thus bringing the tradition of Passion plays and widespread Christian anti-Semitism back into the picture. Highly defensive about exposing the "Judeo-Christian" to the grim, undeniable history of Jewish-Christian relations from A.D. 50 - 1950, the Right, Don argues, greatly preferred to frame the debate around the quality and accuracy of Gibson's portrayal of twelve hours in Roman Judea.

Scrupulous in its documentation from the films, the ancient historical tradition, and post-war politics, I regard this manuscript as very nearly ready for submission to a major press. In fact, I have already asked Don to fashion a chapter of it into a contribution for a book I am writing about masculinity in Roman film epics (*Titus Androgynous: Troubled Masculinity in the Roman Movie*). This is the strongest recommendation I can make for the work of an undergraduate, who (just as we all hope) has really emerged as a colleague. This fall, Don will be a graduate student in Classics at the University of Minnesota - I'll certainly miss him as a student, but I can't wait to collaborate with him as a thinker and a writer.

## SONG CYCLE – MEDIEVAL CZECH POETRY

By Haley Britt Beverburg  
Department of Music

Faculty Mentor: Professor James Greeson  
Department of Music

## Editor's Note:

You may listen to the four songs by going to the Inquiry website, <http://advancement.uark.edu/pubs/inquiry/>

## Song Cycle:

The Czech Republic is one of the most beautiful places I have ever visited. My first time to visit was with the Springdale High School choir in 2000. Both Melody Jenkins, the singer for whom I wrote these pieces, and I were on that trip. I have since visited there twice, once on the European Studies Tour in 2002 and again independently in 2003. Since I learned a miniscule amount of Czech while I was there and can pronounce many of

the complicated consonant clusters, I decided to write a song cycle in the language. A big challenge was writing rhythms that fit the long and short vowels while allowing the consonants to be clearly enunciated. Long vowels in Czech are pronounced exactly as the short vowels, only they are held for a longer amount of time. Therefore, the rhythms for the vocal melody had to precisely follow the long and short vowel patterns of the text, or the meanings of the words could be altered. The Czech language is also infamous for consonant clusters of as many as five in a row. Therefore, I had to leave sufficient time between certain words to allow the singer to pronounce these clusters.

The first song, "Svatý Václave," is about Saint Wenceslas, the patron saint of Bohemia in the Czech Republic. The text and translation of the poetry are as follows:

---

"Svatý Václave"  
anonymous Czech poet (ca. 12<sup>th</sup> century)

Svatý Václave,  
vévodo české země,  
kněže náš,  
pros za ny boha,  
svatého ducha!  
Kyrieleison!

Nebesket' jest dvorstvo krásné,  
blazě tomu, ktož tam pójde:  
v život věčný,  
oheň jasný  
svatého ducha!  
Kyrieleison!

Pomoci tvé žádámy,  
smiluj se nad námi,  
utěš smutné,  
otžeň vše zlé,  
svatý Václave!  
Kyrieleison!

"Saint Wenceslas"  
translated by Alfred French

Saint Wenceslas,  
Bohemia's noble lord,  
our prince!  
O pray for us to God  
unto the holy ghost,  
Kyrie eleison!

Glorious is the realm of heaven,  
and blessed he that enters there,  
to reach eternal life;  
the sacred flame  
of the holy ghost,  
Kyrie eleison!

On thee we call for aid,  
have mercy on us, lord!  
raise up the poor in heart,  
from all despite deliver us,  
Saint Wenceslas,  
Kyrie eleison!

This piece (Song 1) features a Gregorian chant-like section on the words “Kyrie eleison” because of the medieval roots of the poem and the liturgical use of these words. The melodies of the rest of the text contain many perfect fifths, and the accompaniment also is filled with perfect fourths and fifths, as well as open chords. There are two reasons for this consistent dominance of perfect intervals. First, sacred medieval music in the Catholic Church allowed for no other intervals besides fourths, fifths, and octaves—the “perfect” intervals. All other intervals were viewed as impure and not for use in God’s house. Second, because this song pays homage to the patron saint of the Bohemians, their hero, I wanted the music to sound heroic. Fifths are traditionally used in heroic music because of the ease with which trumpets, a “heroic” instrument, can play them.

I set the first two stanzas of the poem strophically, using the same basic melody and accompaniment. The music is bold

and optimistic, and both verses end with the chant-like “Kyrie eleison.” The third stanza, which turns from praising Saint Wenceslas and thinking of the glory of heaven to pleading with Saint Wenceslas to pray to God on the people’s behalf, is much less optimistic. The melody begins soft and low in pitch, and gradually and slowly ascends to the highest note in the piece on Saint Wenceslas’ name. Meanwhile, the accompaniment has become at once flowing and melancholy, and the pitches rise along with the singer’s melody. Finally, the piano calms the mood before the entrance of the “Kyrie eleison” chant that ends the piece.

\*\*\*\*\*

The next song, “Otep Myrrhy”, is a love song that was written, like the Wedding Hymn of Solomon, as an allegory of the yearning of the Christian soul for the love of Christ. The text reads:

---

“Otep Myrrhy”  
anonymous Czech poet (ca. 14<sup>th</sup> century)  
Otep myrrhy mněť můj milý,  
milujeť mě z své všie síly,  
a já jeho,  
zmilelého,  
proňžť netbám nic na jiného.  
Můj milý mně biel, červen, krásen,  
jako leteční den jasen.  
To div z díva,  
žeť sem živa,  
proňžť se mé srdečko znímá.  
Vstanúc i pójdu toho dle,  
poptám sobě, proňžť mé srdečko mdlé  
řkúc: Batičku,  
zmileličku,  
zjev mi svú tvář, sokolličku.  
Jehožť má duše miluje,  
viděli ste, zda kde tu je?  
Milost silná,  
žádost pilná,  
k němužť má mysl nemylná.  
Když diech právě o puolnoci,  
stržeť mě jeden z jeho moci  
tak neznámě  
vzezřev na mě  
vecet’: Přenes mě v svém prámě.  
Tehdy já naň vzezřech nice,  
domněch se svého panice.  
Řiech: Kam koho?  
A on: Toho,  
jehož ty hledáš přemnoho.

“A Bundle of Myrrh”  
translated by Alfred French  
As myrrh is my dear love to me,  
he loveth me distractedly;  
and I love him,  
my heart’s desire:  
his spirit rules my heart entire.  
His skin is pale, his color bright;  
as radiant he as summer light.  
The miracle  
my life became,  
has set my longing heart aflame.  
I will arise and go apart,  
to search for him with fainting heart;  
and say: ‘Dear Lord,  
my precious love.  
Reveal to me your face, my dove!’  
O tell me if ye saw him here,  
the one my spirit loveth dear!  
My love is firm;  
my thoughts abide,  
for ever, ever, by his side.  
I, wandering at the midnight hour  
met one whose face recalled his power:  
so strange did he  
look down on me:  
‘Convey me in thy custody!’  
I gazed into the face above me,  
thinking I glimpsed the eyes that love me.  
I said: ‘Where? Whom?’  
‘That one’; said he,  
‘for whom you search so passionately.’

---

The opening passage in the piano, full of grace notes and flourishes, serves as a ritornello, a phrase or section that appears several times in a work of music, throughout the piece. The style of this ritornello is meant to sound Eastern, because the subject of myrrh is reminiscent of the three wise men from the East in the story of Christ's birth.

The melody of the first two verses, the same musical material, is smooth, lyrical, and bittersweet. The accompaniment is calm and full of rich chords. This is when the poet is speaking of her love. The third verse, when she begins to search for him, becomes more urgent and less lyrical. The bass note in the piano is a pedal point on G, with chords above it in G Phrygian mode. Then, the bass note jumps up to E, and the chords are in E Aeolian

mode. When she asks if anyone has seen her love, the accompaniment becomes sparse and the vocals become more speech-like. This resembles recitative in opera. For the rest of that stanza, the music becomes more uplifting, moving to a I bass note pedal with chords taken from the D major scale. The penultimate stanza returns to a slightly varied version of the music from the opening two stanzas. The final stanza is set to a more firm, bold melody and accompaniment, because she has found the thing for which she was searching.

"Ostrovská Píseň" is about the world's Christian history from Eve's sin through the birth and death of Christ. The poet reads:

---

"Ostrovská Píseň"  
anon. Czech poet (12<sup>th</sup>-13<sup>th</sup> century)

Slovo do světa stvoření  
v božství schováno,  
jež pro Evino zhrěšení  
na svět posláno.

Dievcě dřeve porozenie  
jest zvěstováno,  
z Davidova pokolenie  
božsky vzchováno.

Ot něhože naše křšćenie  
jménem nazváno,  
pro drahé naše spasenie  
židóm prodáno.

I pro naše vykúpenie  
na smrt prodáno,  
jehož nám slavné vzkříšenie  
vesele dáno.

"Song of Ostrov"  
Translated by Mac Hammond

*The Logos at world's creation  
In God's head was kept,  
At Eve's sinful transgression  
To the world was sent.*

*To the Virgin the gestation  
Is soon announced,  
From David's long generation  
God's Son descended.*

*The same holy appellation  
For christ'ning was used,  
For our eternal salvation  
To the Jews was sold.*

*For the sake of our redemption  
He to death was sold,  
To us his high resurrection  
With joy is given.*

---

This piece has much rhythmic vitality and is harmonically complex. The opening stanza, which mentions the sin of Eve, sounds determined. The second stanza uses the same music, which sounds more anxious when set to the text about Christ's birth. The third stanza uses an embellished version of the music from the first two stanzas, which heightens the suspense of

awaiting the events of the final stanza. The lines about Christ's death are more subdued, and the vocal melody is very low for the soprano voice and is in recitative style, which is more speech-like. Once Christ is resurrected, the music regains the rhythmic vitality of the beginning, and the harmonies sound more uplifting.



“Hospodine, Pomiluj Ny” is a song pleading for God’s mercy. The words are as follows:

---

“Hospodine, pomiluj ny”  
from prayers of Jan Milič (14<sup>th</sup> century)

Hospodine, pomiluj ny!  
Jezukriste, pomiluj ny!  
Ty, spase všeho mira,  
spasiž ny i uslyšiž,  
hospodine, hlasy našě!  
Daj nám všěm, hospodine,  
žizn a mír v zemi!  
Krlěš! Krlěš! Krlěš!

“Lord Have Mercy Upon Us”  
translated by Alfred French

Lord, have mercy upon us  
Christ, have mercy upon us  
Saviour of all the world  
O save us, and lend ears  
Lord, unto our prayers.  
Grant to us all, O Lord,  
Harvest and peace through the land,  
Kyrie eleison.

---

I used heavy, dissonant chords in the piano and dramatic, chromatic melody lines to convey the sense of urgency in this plea for mercy. Since there is only one stanza, the style is freely composed, with no repeated musical ideas. The first two lines are set to similar music before a dramatic transition in the piano from B major to B minor. The next two lines of text are building up to the fifth line, which is the climax of the piece. At this point, the melody reaches the B an octave and seven notes above middle C, which is the highest note in the entire song cycle. I think this line of text is the most pleading one in this poem, “O save us, and lend ears Lord, unto our prayers.” Finally, when harvest and peace are asked for, the music returns to B major and is placid and calm. The end is a simple B major chord with the soprano singing in her lower register.

Although the Czech text was difficult, I found this song cycle rewarding to compose, and I had the privilege of hearing Melody Jenkins sing three of these pieces in my Senior Honors Composition Recital in March. I tried, to the best of my ability, to capture the moods of these pieces while incorporating medieval elements into these songs, such as perfect intervals and modal harmonies.

#### Faculty comment:

Ms. Beverburg’s mentor, Professor of Music Composition James Greeson had the following to say about his student’s work:

I am very pleased to offer my support for Haley Beverburg’s submission of her Czech Song Cycle for consideration for inclusion in “Inquiry.” Haley composed these songs, as well as other compositions within the past year, as an important component of her Senior Honors Composition Recital on March 3, 2005. I have had the pleasure of serving as Haley’s composition teacher during her years at the University of Arkansas. Despite her self-deprecating manner she is an extremely intelligent and musically talented

young woman. She is majoring in both Music Composition and Physics, and has received exceedingly high grades in all of the classes she has taken. Musically, she has perfect pitch and a very quick mind—two important components of a superior musician.

Her compositions over the years have been somewhat conservative in style as opposed to exploring avant-garde compositional trends as some students are inclined to do. I believe that her compositional approach, which is redolent of music of Samuel Barber and other mid-20th century American composers, is quite appropriate for the medieval poems she set to music. She is the sort of student composer who resists composing music in an idiom that is imposed from outside. I perceive this as a good thing. I feel that these Czech song settings represent some of her best work as a student here and do indeed set the words very appropriately. Much of this is due to her choice of harmonic intervals, being limited to those associated with medieval music, yet combined in decidedly 20th century combinations. She also has a natural affinity to writing music for voice, as she has sung most of her life in various choirs.

### Svatý Václave

Haley Beverburg

Soprano

Piano

S

Sva - tý Vá - cla - ve, vé - vo - do - če - slá - ze - má,

Pno.

S

ri e le i son!

Pno.

S

Ne - bes - ká - jest dvor - svo - krá - sne,

Pno.

S

bla - zé - lo - mu, kvů - tam - pój - de: v ži - vot - vě - ný,

Pno.

S

kně - že - náš, pros - za - ny

Pno.

S

bo - ha, sva - té - ho - du - cha!

Pno.

S

Ky

Pno.

S

oh - eň - já - ný - sva - té - ho

Pno.

S

du - cha!

Pno.

S

Ky ri e le i son!

Pno.

S 52 Po - mo - ci

Pno. 52 *p*

S 62 vše zlé, *ff* sva - řy Vá - cla-ve!

Pno. 62 *ff*

S 56 za - dá - my, smi - luj se nad ná - mi, *mf*

Pno. 56 *mp*

S 66 Ky - ri - e *p*

Pno. 66 *mp*

S 59 u - - - těš smi - né, *f* ot - - - žeň

Pno. 59 *mf*

S 72 le - i soni *pp*

Pno. 72 *pp*

Otep Myrthy

Haley Beverburg

Soprano

Piano *mf*

S 15 zmi - le - lé - ho, proňž net - bám nic na ji - né - ho.

Pno. 15 *p*

S 5 O - tep myr - rhy mně - můj mi - lý, mi - lu - jeť mě *mf*

Pno. 5 *mp*

S 20

Pno. 20 *p*

S 10 z své - sá - e sí - ly, a já - je - ho. *mf*

Pno. 10 *mf*

S 24 Měj - mi - lý mně - bi - el, čer - ven - krá - sen, ja - ko le - teč - *mf*

Pno. 24 *mp*

S 32 *mf*  
ni den ja - sen. To div z div - a.

Pno *mf*

S 44 *f*  
Vsta - núc i pój - du to - ho die. pop - tům so - bě. prožď mé ardeč - ko

Pno *f*

S 34  
zeť sem - ti - va. prožď se mé ardeč - ko zni - má.

Pno

S 46 *ff*  
mlé - kú: Ba - ti - ku, zmi - le - tič - ku, zjev mi svú

Pno *ff*

S 39  
Pno *cresc.*

S 54 *mf*  
tvář, so - ko - lič - ku.

Pno *mf*

S 59 *p*  
Je - hoř má du - še mi - tu - je. vi - dě - li ste.

Pno *p*

S 75  
Pno

S 64 *cresc.*  
zda kde tu je? Mi - lost sii - ná.

Pno *f*

S 79 *mf*  
Když - di - ech přá - vě o pu - cí.

Pno *mf*

S 70  
žá - dost pil - ná. k ně - muž? má - my - si ne - myl - na.

Pno

S 83  
no - cí, stržeť mé je - den z je - ho - mo - cí tak nez -

Pno

101

S

své - ho pa - ni - ce. — ří - ech: Kam — ko - ho? —

Pno.

*dim.* *p*

107

S

ná - mě vzez - tev — na mě ve - cer: Pte - nes mě v - svém prá -

Pno.

106

S

A — on: To - ho, je - hož ty — hle - dás

Pno.

*f*

107

S

mě.

Pno.

111

S

přem - no - ho.

Pno.

*p*

111

S

Teh - dy já nař - vzez - tev — ni - ce, dom - něch se

Pno.

*f*

115

S

Pno.

Ostrovská Píseň

Haley Beverburg

Soprano

*mf* Sto - vo do

Piano

*mf*

5

S

své - ta stvo - ře - ni - e — v - bož - ství — scho - vá

Pno.

5

S 9  
no jež pro E - vi - no zřé - le - ni - e

Pno.

S 16  
*mf* Di - ev - cté - ve po - ro - ze - ni -

Pno.

S 11  
*f* na svtě pos - lá - no

Pno.

S 19  
e jest zvě - sto - vá - no

Pno.

S 21  
*f* z Da - vid - o - va po - ko - le - ni - e bož - - - sky

Pno.

S 30  
e jímé - - - nem naz - vá - - - no

Pno.

S 27  
*decresc.* v zcho - vá - no

Pno.

S 39  
pro dra - hé - ná - že spa - se - ni - e ži - - - dóm

Pno.

S 31  
*f* Ot ně - ho - že ná - že křt - ě - ni -

Pno.

S 43  
pro - dá - no

Pno.

Hospodine, Pomiluj Ny

Haley Beverburg

S 46 *♩ = 85*  
*p* I pro ná - še vy - kú - pe - ni - e... na smrt pro - dá - no...  
Pno. *p*

S 51 *♩ = 110*  
*mf* je - hož nám stav - né vz - kř - c -  
Pno. *mf*

S 54  
*mf* še - ni - e *mp* ve - se - le dá - no.  
Pno. *mf* *mp*

S 9  
Pno. *f*

S 12  
*f* Ty, spa - se vše - ho mi - ra, spa - siť ny i  
Pno. *f*

S 16  
us - ty - biť *ff* Hos - po - di - ne, hie - sy  
Pno. *ff*

Soprano *♩ = 66*  
*p* Hos - po - di - ne, po - mi - luj ny!  
Piano *p*

S 5  
*mf* Je - zu - kri - ste, Po - mi - luj ny!  
Pno. *mp*

S 20  
na - ští! *f* Daj nám všem, hos - po - di - ne, *mf* žizn a  
Pno. *f* *mp*

S 24  
mir v\_ze - mi! *p* Kr - leť! Kr - leť! *pp* Kr -  
Pno. *p*

S 29  
leť!  
Pno. *pp*

## **SECTION II: SOCIAL SCIENCES AND BUSINESS**

**FINANCE, POLITICAL SCIENCE, ACCOUNTING, MARKETING,  
TRANSPORTATION, PSYCHOLOGY, HISTORY, AND ANTHROPOLOGY**



## A STUDY OF THE CIVIL JUSTICE REFORM ACT OF 2003: CAN TORT REFORM BENEFIT ARKANSAS?

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Department of Accounting

### Abstract:

*Without question, reforming America's civil justice system has become a hot button issue in today's political landscape. While most Americans move about their daily lives without giving the subject a second thought, politicians ranging from aspiring state assemblymen to the recently reelected George W. Bush have placed tort reform at the forefront of American political affairs. Although problems plaguing American courts have been discussed for years, criticism of America's current system for adjudicating tort cases has reached a fever pitch. Among the more vocal critics are powerful lobbyist groups, such as the American Medical Association (AMA) and the American Tort Reform Association (ATRA), who believe the current civil justice system is responsible for increases in liability insurance, a decrease in the quality of health care, and an overall increase in the cost of doing business. Opposing groups, such as the Association of Trial Lawyers of America (ATLA), believe it is the right of every American consumer to have their day in court and punish corporations and doctors for committing civil offenses against them. And sandwiched in the middle of this fiasco are the thousands of politicians, businessmen, doctors, and ordinary citizens who are left scratching their heads when they try and figure it all out.*

*This paper attempts to explain the debate surrounding tort reform on both the national and state levels. Further, it summarizes each section of Arkansas Act 649 of 2003, better known as the Civil Justice Reform Act of 2003 (the "Act"), and point to any obvious benefits to the business community as a result of the reforms. A more challenging topic this paper covers is whether or not tort reform, specifically the Act, will provide future economic benefits to the state of Arkansas. This paper attempts to make the direct link between legal reforms and increases in economic output as measured by personal income levels. The model is intended to be very simplistic yet still provide a picture of how tort reform may or may not benefit Arkansas' economy in the future.*

### The Growing Debate:

By now most Americans have at least heard of the McDonald's hot coffee case. The case involved Stella Liebeck of Albuquerque, New Mexico suing her local McDonald's fast food restaurant when she spilled hot coffee on herself after making the purchase at the drive-through window. Liebeck was awarded \$200,000 in compensatory damages and \$2.7 million, two days of McDonald's coffee sales, in punitive damages. The award for punitive damages was later reduced by the trial court judge to \$480,000 (iCan2000, n.d.)<sup>1</sup>. Both sides appealed, but before the appellate court could rule on the matter, the case was settled. This case can serve almost single-handedly as the measuring stick with which to gauge whether or not one is for or against tort reform. Many Americans will see the headlines in the paper, "Woman Awarded \$2.7 Million for Spilling Coffee," and make the judgment that the courts are out of control in awarding millions in what can only be described as frivolous lawsuits. Others will say that Liebeck received adequate compensation from a negligent business that was serving coffee at around 185 degrees with no warning as to how hot the coffee really was. They would also point out that this case shows that the current system provides a mechanism to reduce unusually large jury awards. Thus, in this example, one may begin to see the makings of the current tort reform debate that has grabbed the attention of both the federal and state governments.

On the federal level, the debate has led to many failed attempts by Congress to pass measures involving the limitation of medical liability, class action status, punitive damages, or any other civil justice reform. Although proponents of tort reform have a tremendous amount of support in the Republican Congress, Senate Republicans have yet to garner enough votes to stop the Democrats' filibuster on all things related to reform. Tort reform proponents were able to score a victory earlier this year regarding class action lawsuits, with the passage of the Class Action Fairness Act (CAFA). However, on most of the major reform issues, tort law reformers have failed to win any major battles on Capitol Hill.

Backed by the ATLA, opponents of reform have plenty of firepower to win the support of key congressional leaders and fight off pushes to reform the system. ATLA CEO John Haber states, "I don't agree [that business interests] have traction with Joe Sixpack. Average Americans don't want a system that's tilted so it works for the rich and powerful" (as cited in Dunham, 2005, p. 53). In general, there is a belief among tort reform opponents that ordinary citizens are able to, in effect, police companies and doctors through lawsuits involving torts. When a business places a faulty product on the market that may cause harm, or a doctor commits medical malpractice, reform opponents believe it is the consumer that has a right to go after that business or doctor and prevent such action from occurring again in the future. According to the organization's mission statement, ATLA is in place to "champion the cause of those who deserve redress for injury to person or property," and to "promote the public good through concerted efforts to secure safe products, a safe workplace, a clean environment, and quality health care" (ATLA Mission, 2005).

It is the notion of using the courts as an equalizer that pushes some trial lawyers, such as Senator John Edwards (D-North Carolina), into the consumer protection spotlight. Sen. Edwards made a name for himself by representing clients who were injured by the negligence of corporations and doctors. With the attention turned to Sen. Edwards in the 2004 presidential race, tort reform opponents seized the opportunity to publicly state their opposition to limitations on the consumer's ability to file suit with stories from Sen. Edwards' career as an attorney. One case cited numerous times throughout the campaign involved a five year old child named Valerie Lakey. Valerie, according to Sen. Edwards' book *Four Trials* (2004), was disemboweled by a faulty pool drain cover in 1993. The case made the Senator famous when the jury awarded the Lakey's \$25 million. Cases such as the Lakey's are often cited by tort reform opponents to show how the system successfully acts as the great equalizer between victims of civil offenses and negligent parties.

Opponents of tort reform face an equally powerful group of lobbyists looking to reform America's civil justice system. Organizations such as the AMA, ATRA, and other groups representing insurance companies, pharmaceutical companies, health maintenance organizations, doctors, and hospitals are fighting to win the war on tort reform. These organizations are carved out of the belief that tort litigation has led to an increased cost of doing business and a decrease in the quality of health care. With President Bush back in office and a greater number of Republicans in both the House and the Senate, reform proponents believe they have gained new life in the tort reform debate. President Bush stated in 2000,

From people across America, I am hearing that our legal system needs reform. That our courts aren't serving the people, they are serving the lawyers. That frivolous lawsuits are hurting people. Some think this

special interest group is too powerful to take on. That money determines everything. This is not an argument; it is an excuse. This cause is not hopeless. ("George W. Bush on", 2000).

President Bush again pushed tort reform in the 2004 presidential campaign, and since his reelection has placed reform near the top of his agenda (Dobbs, 2005).

One of the largest organizations fighting for reforming America's civil justice system is the AMA. The organization leads the way in pushing for legislation to limit the number and severity of medical liability lawsuits. The AMA states, "The crisis is threatening access to care for patients in states without liability reforms" (American Medical Association, 2004a). The organization encourages its membership to contact its respective Senators and Representatives to promote passage of a comprehensive liability reform package. To aid in the effort, the AMA has released a "physician action kit"<sup>2</sup> providing information and talking points on the subject of medical liability reform. The organization also releases routinely cited information regarding which states it considers to be crisis states when it comes to medical liability. The current count stands at 20 crisis states and 24 states showing problem signs (American Medical Association, 2004b).

Leading the way for the business community is ATRA. The organization claims to represent "more than 300 businesses, corporations, municipalities, associations, and professional firms," in its quest for a more fair civil justice system (American Tort Reform Association, 2005a). The group cites 3M, Caterpillar, Boeing, and Pfizer among its members. Even with all of this support, ATRA has yet to persuade Congress to pass legislation that would completely overhaul the way tort cases are carried out in this country. Yet, ATRA fights on. President of ATRA Sherman Joyce states,

Some astonishing decisions come out of the courts these days. Hundreds of millions in punitive damages piled on top of relatively minor actual damages. Meritless cases settled because defendants fear the outcome of an emotion-filled jury trial or a lawless court. That's why the American Tort Reform Association (ATRA) leads the fight for a better civil justice system - one that's fair, efficient and predictable (American Tort Reform Association, 2005b).

The AMA and ATRA along with other organizations continue to press Congress to pass comprehensive tort reform. Without it, these organizations believe the American economy will be negatively impacted for years to come.

### Arkansas' Civil Justice Reform Act of 2003:

Arkansas' version of tort reform, the Civil Justice Reform Act of 2003, was signed into law by Governor Mike Huckabee

on March 25, 2003. The Act was passed by the Senate with a vote of 34 to 1, while the House passed the bill 71 to 28.

The Act lays out many changes to the civil justice system in Arkansas. According to an article published in *The Arkansas Lawyer*, some of the more visible reforms include (1) modification of joint and several liability, (2) limits to the amount awarded for punitive damages, and (3) revisions of rules regarding medical injury actions (Leflar, n.d.). While only these three major areas of reform are discussed below, the Act also reforms many other less visible yet still significant areas of Arkansas' tort system. The following attempts to simplify the modifications set forth in the Act. This discussion is designed to follow the organization of the Act as it was passed by the legislature. It does not directly follow the organization of the law as codified in Ark. Code Ann. §§ 16-55-201 to -220, 16-114-206, and 16-114-208 to -212.

### *Joint and Several Liability*

The first section of the Act calls for the modification of joint and several liability. According to this section,

In any action for personal injury, medical injury, property damage, or wrongful death, the liability of each defendant for compensatory or punitive damages shall be several only and shall not be joint. Each defendant shall be liable only for the amount of damages allocated to that defendant in direct proportion to that defendant's percentage of fault, and a separate several judgment shall be rendered against that defendant for that amount (Arkansas General Assembly, 2003, Section 1 (a)).

Prior to the Act, liability for damages in civil cases involving multiple defendants was not divided between each defendant. For example, assume two defendants were found negligent for personal injury in a car accident and were ordered to pay \$1 million in compensatory and punitive damages. Defendant A was responsible for 90 percent of the damages caused by the accident, while Defendant B was responsible for only 10 percent of the damages. If Defendant A was only able to pay \$10,000 due to insufficient funds, then Defendant B, regardless of his percentage of fault, would be required to come up with the remaining balance of \$990,000 if he is solvent. In other words, the amount paid in damages by each defendant is not directly proportional to the percentage of fault.

Section One of the Act attempts to remove the inconsistency that exist between the amount each defendant is ordered to pay and his/her percentage of fault. Using the same example from above, since Defendant A was responsible for 90 percent of the damages, he must pay 90 percent of the award amount, or \$900,000. Defendant B would only be responsible for his percentage of fault. In this example, he would pay 10 percent of the damages, or \$100,000, versus the more than \$900,000 he would pay in the previous example. This example holds true unless one or more of the defendants is insolvent. If that is the

case, the Act calls for a graduated increase in the percentage a defendant must pay as described in Section Three of the Act, discussed later in this paper. As a general overview of the new joint and several liability provisions, however, the simplified example above holds.

Section Two of the Act further details the procedures that are to be used in assessing percentage of fault. Mainly, this section deals with the liability of parties not directly named in the suit. Under the Act, awards must be adjusted based on the percentage of fault of such nonparties. If the defendant can show a nonparty was liable for some of the damages, then the award amount must take into consideration the proportion of damages for which that person is responsible. According to *The Arkansas Lawyer*,

These nonparties to whom fault could be assigned might include out-of-state or foreign firms that cannot be sued for lack of personal jurisdiction; persons or entities protected by sovereign, charitable, or intrafamily immunities; employers whose negligence was one cause of injury to an employee suing a third party such as a product manufacturer; persons or entities without assets "not worth suing"; and persons whose location and perhaps even identity is unknown (Leflar, n.d.).

The Act specifies that fault of a nonparty can be considered either if the plaintiff enters into a settlement with that particular nonparty, or if the defendant can show that the nonparty was either partially or wholly at fault. As laid out in Section Two, the defense must file a pleading with the court stating the identity of the nonparty along with why the defense believes that party to be at fault in the particular matter. The pleadings regarding the percentage of fault of persons not named in the suit must be filed no later than 120 days prior to the date on which the trial is set to begin. Importantly, the Act also states that if the fact finder assesses fault to a nonparty based on a settlement with the plaintiff or a pleading filed by the defense, the findings of fault do not subject the nonparty to any liability with regards to current matter.

Section Three of the Act also relates to joint and several liability reforms. This section calls for graduated increases in the percentage points a defendant is ordered to pay if it is determined that other defendants found liable in the suit are not able to make full payment. In other words, if one defendant is insolvent, the other defendants may have to cover some of the funds that were to be provided by the insolvent defendant. In order to accomplish this, the Act sets up three levels of liability where the defendant determined to be the most responsible for the damages incurs most of the burden, and the defendant that is least responsible for the damages incurs the least amount of the burden. The first level of liability involves those defendants whose percentage of fault is no more than ten percent. If a defendant meets this criterion, then that defendant shall not be subject to any increase in his share of the damages owed. The second level of liability

involves those defendants whose percentage of fault is greater than ten percent but less than 50 percent. Defendants that fall into this category may see their proportion of the damages owed increase by up to ten percentage points if another defendant is unable to make payment. The final level of liability encompasses defendants whose percentage of fault is determined to be 50 percent or greater. Defendants in this grouping may see an increase of as much as twenty percentage points in their amount of damages owed should another defendant become insolvent.

It is easy to see how Arkansas businesses will benefit from reforming the joint and several liability rules that were in place prior to passage of the Act. Under the new provisions, businesses are able to limit their share of liability in certain situations. For example, assume a customer of a small, locally owned retail establishment is injured while taking an item off of a shelf. The customer sues the retail business and is awarded \$100,000 in punitive and compensatory damages. Under the old law, the business must pay the entire \$100,000 in damages. Today, with the new law in place, the business may be able to show that either another named defendant or even a nonparty is partially to blame for the accident. Continuing, assume the trier of fact determines that the defendant was responsible for only 20 percent of the fault while a nonparty was responsible for the other 80 percent, then the business would only have to pay \$20,000, or 20 percent of the damages. As is the case with many small businesses in Arkansas, the difference in paying \$20,000 and paying \$100,000 can be the difference between staying in business and closing the doors for good. Of course, this is only a simplified hypothetical situation, but one can easily see that the changes made to joint and several liability can greatly impact a business's bottom line.

### ***Punitive Damages***

The second major reform imposed by the Civil Justice Reform Act of 2003 pertains to punitive damages. According to *Black's Law Dictionary*, punitive damages are "damages awarded in addition to actual damages when the defendant acted with recklessness, malice, or deceit" (Garner, 2001, p. 171). Section Nine of the Act is the first section to deal with the subject. This section states that if a court is to award punitive damages in a civil case, the plaintiff must first show that the defendant is liable for compensatory damages. Therefore, if a court rules in favor of the defendant and awards no compensatory damages, the plaintiff has no claim with regards to punitive damages. Beyond proving liability for compensatory damages, the plaintiff must also meet either of the following aspects as they relate to a particular case:

(1) That the defendant knew or ought to have known, in light of the surrounding circumstances, that his or her conduct would naturally and probably result in injury or damage and that he or she continued the conduct with malice or in reckless disregard of the consequences from which malice may be inferred (Arkansas General Assembly, 2003, Section 9 (1)).

(2) That the defendant intentionally pursued a course of conduct for the purpose of causing injury or damage (Arkansas General Assembly, 2003, Section 9 (2)).

Providing the plaintiff can show that the defendant's actions meet either one of the above criterion, the plaintiff may then proceed to petition the court to award punitive damages, although the Act states the plaintiff has no right to receive a punitive damages award.

Section 11 of the Act pertains to one of the more controversial and heavily debated reforms put into place by the Act. This section limits the amount of punitive damages that may be awarded in a civil case. According to the Act, punitive damages awarded by a court must not exceed the greater of (1) \$250,000 or (2) three times the amount awarded for compensatory damages not to exceed \$1,000,000. Further, Section 11 requires that every three years beginning January 1, 2006 the limits on punitive damages set forth by the Act are to be adjusted for inflation in accordance with the Consumer Price Index.

To illustrate the punitive damage caps imposed by the Act, suppose, hypothetically, a consumer is severely injured by a razor while shaving. The consumer meets with an attorney and decides to pursue legal action against the maker of that particular razor blade. Upon completion of the trial, the trier of fact determines that the company was indeed liable for the injuries sustained by the plaintiff, the consumer, and awards \$20,000 in compensatory damages to cover medical expenses. Now assume the plaintiff can prove that the defendant knew of the defective razors but chose not to act on this information. In light of this information, the plaintiff may be awarded as much as \$250,000 in punitive damages since, as stated in the Act, this amount is the greater of the two punitive damage caps. If the plaintiff were awarded compensatory damages totaling more than \$83,333, then the plaintiff may be awarded punitive damages in the amount of three times compensatory damages but less than \$1,000,000. Again, this is only a hypothetical example and is oversimplified to communicate the basic aspects of the Act.

Section 11 also allows for exceptional cases in which the plaintiff may recover more than the amount specified by the damage caps. The Act states,

When the fact finder determines by clear and convincing evidence that, at the time of the injury, the defendant intentionally pursued a course of conduct for the purpose of causing injury or damage and determines that the defendant's conduct did, in fact, harm the plaintiff, then (the caps stated previously) shall not apply (Arkansas General Assembly, 2003, Section 11 (b)).

Therefore, continuing with the example regarding razor blades, if the plaintiff can show by "clear and convincing evidence" that the manufacturer of the razor blades intentionally sold defective razors in order to injure its customers, then the

amount awarded to the plaintiff for punitive damages is not subject to the restrictions detailed previously. It is important here to define "clear and convincing evidence." That is, "evidence indicating that the thing to be proved is highly probable or reasonably certain" (Garner, 2001, p. 250). This burden of proof can be described as greater than a "preponderance of the evidence" used in civil cases but less than "beyond a reasonable doubt" used in criminal cases.

Another major reform concerning punitive damages is the establishment of an option to request a bifurcated proceeding. According to Section 14 of the Act, "In any case in which punitive damages are sought, any party may request a bifurcated proceeding at least ten days prior to trial" (Arkansas General Assembly, 2003, Section 14 (a)). In other words, either party may request that the trial be divided into two stages. In the first stage, the trial would take place and the court would decide whether or not compensatory damages are to be awarded. If compensatory damages are awarded, then a second stage commences in which the court rules as to whether or not punitive damages are warranted and in what amount. Section 14 goes on to state that it is only during the second stage of the trial, the stage regarding punitive damages, that the financial condition of the defendant be admissible.

Again, it is simple to see how the reforms regarding punitive damages may positively affect businesses involved in tort litigation. Prior to passage of the Act, a business may have been required to pay thousands or sometimes millions of dollars in punitive damages. Under the reforms laid out in the Act, the amount a business may be required to pay in punitive damages is reduced substantially provided the business did not intentionally cause the injury. If a particular business caused unintentional harm to the plaintiff and lost at trial, the most the defendant would be obligated to pay in punitive damages would total \$1,000,000. Additionally, assuming compensatory damages equaled \$83,333 or less, punitive damages could not exceed \$250,000. Thus the savings to a business' bottom line can be substantial due to the reforms imposed by the Act.

### *Medical Injury Reforms*

Finally, as is the case with many of the tort reforms enacted by states, the Act makes some significant changes to the procedures and rules governing cases involving medical injuries. The first of these reforms appears in Section 15 of the Act. Overturning previous case law, this section eradicates the collateral source rule. As defined in Black's Law Dictionary, the collateral source rule is "the doctrine that if an injured party receives compensation for the injuries from a source independent of the tortfeasor, the payment should not be deducted from the damages that the tortfeasor must pay" (Garner, 2001, p. 109). Although the Act does not limit the amount that may be awarded for compensatory damages, Section 15 does require that any

payments made by an independent source to cover medical expenses be subtracted from the damages awarded. Mainly, Section 15 is designed to account for any money the plaintiff may have received from an insurance provider. If the insurance company already paid for all or part of the medical expenses, that amount is deducted from the compensatory damages award. Under the previous law, a medical care provider may have paid for all of the medical expenses incurred by the plaintiff because of the provider's negligent actions, even if the plaintiff had received reimbursement from an insurance provider. In essence, the complaining party may have collected double the compensation for his/her injuries. This is no longer the case because of the provisions set forth in Section 15 the Act.

Section 18 of the Act establishes new procedures regarding the use of expert witnesses. According to this section, if it is determined that the negligent action for which the defendant is charged is not "within the jury's comprehension as a matter of common knowledge," the plaintiff bears the burden of showing that the injuries caused by the defendant should not have occurred (Arkansas General Assembly, 2003, Sec. 18). This can be accomplished through the testimony of an expert witness. The plaintiff by means of the expert witness, who must be of the same specialty as the defendant, must show that the defendant did not act within what is considered standard practice for that specialty and therefore caused the particular medical injury. The reason for employing such a provision is two fold. First, the use of an expert witness is designed to bridge the gap between what is considered common knowledge and what can be highly technical, medical terminology. Second, it prevents the plaintiff from bringing in a "hired gun" to testify about a specialty in which he/she is not trained (Leflar, n.d.). In this way, Section 18 limits a common measure used by plaintiffs in proving negligence on the part of the defendant.

Section 20 of the Act also contains language pertaining to medical injury cases. Although the reforms made by Section 20 appear subtle upon first glance (only 14 words were added to the existing law), the changes can have a substantial impact on the ability of the defendant to pay, and the plaintiff to receive, any damages awarded by the court. Previously, Arkansas law stated, "If the award for future damages exceeds \$100,000 the court may, at the request of either party, order that the future damages be paid in whole, or in part, by periodic payment" (Arkansas Code, § 16-114-209). The key alteration made by the Act replaces the word "may" with "shall." Although this does not seem significant, the repercussions are noteworthy. In the past, the court had the ultimate say as to whether or not judgments against the defendant were to be paid up front or in periodic payments. Under the Act, the court is obligated to set periodic payments for damage awards at the request of either party. The financial benefit to medical providers is indeed substantial. For example, a judgment against the defendant in the amount of \$500,000 could potentially render the defendant insolvent if a

lump sum payment is required. If the defendant requests periodic payment of the damages, the defendant may allocate future payments into his/her financial situation. Thus, not only is the defendant better able to recover from the loss incurred as a result of the lawsuit, the plaintiff is more likely to receive compensation for his/her injury.

Section 21 of the Act sets new rules regarding what is termed, "False and unreasonable pleadings" in medical injury actions (Arkansas General Assembly, 2003, Section 21). This section, in line with previous law, forces the complaining party to pay for the costs, including attorney's fees, incurred by the defendant as a direct result of the filing of the case. Although previous state law required the same repayment for false and unreasonable pleadings as a means to reduce the number of unfounded claims, the Act goes one step further in allowing the court to place sanctions deemed appropriate on the party or attorney who filed the claim. The Act, however, does not specify what sanctions are considered appropriate.

Section 21 also requires the plaintiff to submit an affidavit signed by an expert showing reasonable cause for filing a particular claim. The affidavit must state,

- (A) The expert's familiarity with the applicable standard of care in issue;
- (B) The expert's qualification;
- (C) The expert's opinion as to how the applicable standard of care has been breached; and
- (D) The expert's opinion as to how the breach of the applicable standard of care resulted in injury or death (Arkansas General Assembly, Section 21 (2)).

This affidavit must be filed within 30 days of the time the complaint was originally filed, or the case will be dismissed by the court before ever going to trial. Again, provisions such as this were put into place to help curb the number of frivolous lawsuits filed against medical care providers in Arkansas.

Section 22 lays out a number of reforms pertaining to medical injury actions. First, this section seeks to limit the liability exposure of medical care facilities (i.e. hospitals, nursing homes, clinics, etc.). The limitation of exposure is accomplished by placing the burden of proof on the complaining party in proving that the medical care provider was indeed an employee of the medical facility named as a codefendant. This provision prevents plaintiffs from attempting to hold a medical facility liable for injuries caused by a non-employee medical care provider at that facility. For example, if a non-employee doctor causes a medical injury while visiting a patient at a hospital, the plaintiff may not bring suit against the hospital since the doctor is not considered an employee of the facility.

Section 22 also provides that surveys and inspections the plaintiff "seeks to use as evidence against a medical care provider must be relevant to the plaintiff's injury to be admissible at trial" (Arkansas General Assembly, 2003, Section 22). For instance, if a plaintiff is suing a hospital in the death of the plaintiff's newborn child, an inspection of the hospital's onsite pharmacy conducted by the State Board of Pharmacy would most likely be inadmissible. This of course assumes the pharmacy was in no way linked to the death of the child. Interestingly, this element of Section 22 applies only to the plaintiff's side of the case. If the defendant wishes to submit surveys or inspection results displaying the overall quality of the medical facility, the evidence would not be deemed inadmissible under Section 22 of the Act.

### The Economics of Tort Reform:

The final piece of this thesis is to measure the impact of the Civil Justice Reform Act of 2003 on Arkansas' economy. With the introduction of this legislation to the state legislature in 2003, many argued that the reform package would bring economic prosperity as insurance premiums went down and industry flooded to the state. Indeed, it is still too soon to know the savings, if any, that the reforms have actually brought to Arkansas' businesses and citizens. However, using data collected from other states that have enacted tort reform bills over the last several decades, it is possible to project the savings to Arkansans within the next few years.

### Methodology

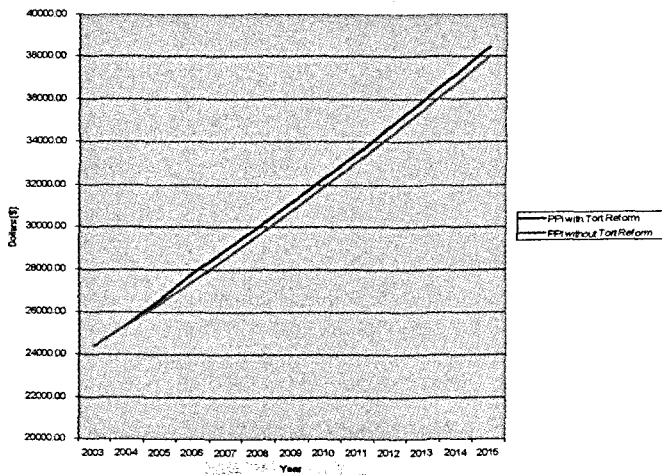
In order to study the impact of tort reform passed in early 2003 on Arkansas' economy, it is first necessary to study the relationship between tort reform enacted in other states and the impact on that state's economy. To accomplish this, I collected data from the Bureau of Economic Analysis regarding each state's per capita personal income (PPI) from 1969 to 2003.<sup>3</sup> I also collected data as to whether or not a state had enacted tort reform and in what year(s) the reforms were passed. This data was collected from the American Tort Reform Association.<sup>4</sup> This study defines tort reform as removal of traditional joint and several liability from a state's civil procedure or as the capping of punitive damages. By doing this, the model employed is able to better compare two of the most basic reforms of the Civil Justice Reform Act (joint and several liability reform and punitive damage caps) to reforms passed in other states. The model developed by the author, Dr. Jeff Collins<sup>5</sup>, and Dr. Cary Deck<sup>6</sup> is as follows:

$$\Delta Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e$$

In this model,  $\Delta Y$  represents the change in personal per capita income (PPI) from year to year.  $\beta_0$  is simply a constant, or intercept term, representing the value of the change in PPI when the X variables are zero. The variable  $X_1$  represents the previous year's PPI, as this is a likely determinant of next year's PPI. The variable  $X_2$  represents whether or not tort reform was

enacted in that particular year. It is a dummy variable that receives a value of zero if no reform occurred in that year and a value of one if reform did occur. In order to account for the likely lag that occurs from the time tort reform was enacted and when its economic impact is measurable, the reform dates are lagged using variables  $X_3$ ,  $X_4$ ,  $X_5$ , and  $X_6$ . These variables represent whether tort reform was enacted the previous year, two years ago, three years ago, or four years ago respectively. The variable  $X_7$  represents whether or not reform was enacted in any year prior to the year attached to this variable. The coefficients of these variables provide for the measure of the impact of tort reform on the change in PPI. The term  $e$  is simply the error term, which in this model is used to account for any other changes within a state's economy that may have led to a change in PPI.

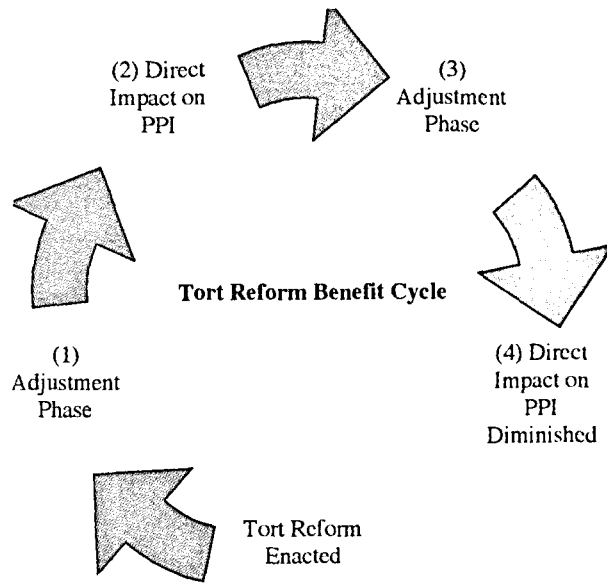
Comparison of PPI



**Findings of the Study**

The chart above summarizes the results obtained by applying the model to the data collected<sup>7</sup>. The results show that tort reform, as defined by this study, does indeed have a slight impact on the change in PPI after the reform is enacted. After running a regression using the model described previously, one observes that the coefficients of the variables representing tort reform on a two and three year lag ( $X_4$  and  $X_5$ ) are both positive and statistically significant using a 95 percent confidence interval (See Appendix 2). The actual coefficient for  $X_4$  is 163.02. This implies that tort reform is responsible for a \$163.02 change in PPI if tort reform was enacted two years prior. The coefficient for  $X_5$  is 204.11. This implies that tort reform is responsible for a \$204.11 change in PPI if tort reform was enacted three years prior. The coefficients for  $X_2$ ,  $X_3$ ,  $X_6$ , and  $X_7$  are all negative, implying a negative impact on the change in PPI for that particular variable. This however is rejected by the author because it does not fall within the 95 percent confidence interval.

The projected benefit to Arkansas from the Civil Justice Reform Act is an increase in the growth of PPI for 2005 and 2006 (two and three years removed from the year the reform was enacted). The model employed in this research shows that there



is a positive change in the growth rate in these years with little or no effect on any prior or future year's PPI. Therefore, one may begin to develop a timeline for when tort reform begins to impact the economy. This timeline is reflected above in the Tort Reform Benefit Cycle. Within the first two years of the reform, businesses, insurers, healthcare providers, and ordinary citizens enter into an adjustment phase (1) in which insurance premiums and the cost of doing business begins to decrease. Eventually, this decrease is passed on to employees in the form of higher wages and to consumers in the form of lower prices (2). This research implies that the passing of the savings occurs in years three and four. After this time, it is reasonable to conclude that the economy adjusts to the original reforms made (3), and the change in PPI is no longer impacted directly by the reforms(4).

By inserting PPI data into the model, one can calculate the per capita dollar impact of tort reform on personal income in Arkansas in the years 2005 and 2006. With the reforms in place, PPI for 2005 should total \$26,577.34. Without the reforms, PPI would total \$26,414.32. The total increase in PPI that can be attributed to the tort reforms passed in 2003 is \$163.02. With the reforms in place, PPI for 2006 should total \$27,833.95. Without the reforms, PPI would total \$27,463.21. The total increase in PPI for 2006 attributable to tort reform is \$370.74. After this time, the model predicts that none of the growth in PPI can be attributed to the tort reforms of 2003. However, although the direct impact on personal income is diminished after 2006, Arkansas' PPI would then grow from a higher level with the tort reform in place versus without. Thus, the actual dollar amount of growth and level of PPI is higher than had reform not been enacted for the foreseeable future.



**Conclusion:**

As one can clearly see, tort reform is a complex and difficult issue. The sheer number of reforms and combinations of reforms possible is, simply put, mind-boggling. One thing is for certain: the debate as to whether or not tort reform provides an overall net positive for society is sure to surge ahead. Some will say that the impact on the economy and improved efficiency in the civil justice system provides enough evidence to conclude that tort reform should be enacted at every level. Others will say that by limiting the amount awarded in damages or eliminating the long standing precedence of things such as joint and several liability or the collateral source rule does nothing but hurt the very people the legal system is designed to protect. Above all else, this study will hopefully prove useful in its summary of the Civil Justice Reform Act of 2003, and its impact on Arkansas' economy

**Endnotes:**

- <sup>1</sup> To read a summary of the entire case, see <http://www.ican2000.com/statements/tort/mcdonalds.html>.
- <sup>2</sup> This publication can be found at <http://www.ama-assn.org/ama/pub/category/14819.html>.
- <sup>3</sup> Data can be obtained from <http://www.bea.gov/bea/regional/spi/#download>.
- <sup>4</sup> Data can be obtained from <http://www.atra.org/states/>.
- <sup>5</sup> Dr. Collins serves as Director for the Center for Business and Economic Research at the University of Arkansas' Sam M. Walton College of Business.
- <sup>6</sup> Dr. Deck is an Assistant Professor of Economics at the University of Arkansas' Sam M. Walton College of Business.
- <sup>7</sup> Results are summarized in Appendix 1.

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**Appendix 1.**

Year	PPI with Tort Reform	PPI without Tort Reform
2003	24384.00	24384.00
2004	25388.07	25388.07
2005	26577.34	26414.32
2006	27833.95	27463.21
2007	28914.19	28535.27
2008	30018.28	29630.99
2009	31146.74	30750.91
2010	32300.12	31895.55
2011	33478.97	33065.46
2012	34683.84	34261.20
2013	35915.31	35483.34
2014	37173.96	36732.46
2015	38460.41	38009.16

**Appendix 2.**

<i>Regression Statistics</i>	
Multiple R	0.41269447
R Square	0.17031673
Adjusted R Square	0.16688423
Standard Error	405.819834
Observations	1700

**ANOVA**

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	7	57202085.54	8171726.51	49.618918	1.9201E-64
Residual	1692	278655035.7	164689.737		
Total	1699	335857121.2			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	465.734185	20.72956871	22.467143	4.816E-98	425.0758937	506.39248	425.075894	506.392477
Last Years PPI	0.02207759	0.001445329	15.2751289	1.903E-49	0.019242767	0.0249124	0.01924277	0.02491241
Tort Reform	-66.171214	68.95168299	-0.9596751	0.3373559	-201.410767	69.06834	-201.41077	69.0683401
Reform (t-1)	-34.590464	69.96783268	-0.4943767	0.6211044	-171.82306	102.64213	-171.82306	102.642133
Reform (t-2)	163.022902	70.09402596	2.32577456	0.0201482	25.54279455	300.50301	25.5427946	300.50301
Reform (t-3)	204.112481	70.28123009	2.90422465	0.0037294	66.26519726	341.95976	66.2651973	341.959764
Reform (t-4)	-74.685266	70.51302106	-1.0591699	0.2896736	-212.987177	63.616645	-212.98718	63.6166445
Prior Reform	-45.996536	30.52463237	-1.5068662	0.1320316	-105.866542	13.87347	-105.86654	13.8734699

**Faculty comment:**

In recommending Mr. Jackson's paper for publication, his mentor, John Norwood, made the following remarks.

I am pleased to support the publication of Scott Jackson's paper in *Inquiry*. Scott's paper deals with the subject of Tort Reform in Arkansas. It is based on the tort reform act passed by the legislature in 2003. In the paper Scott reviews the most common components of tort reform legislation nationwide. He then discusses in details the components of the tort reform law passed by the Arkansas legislature in 2003. It is interesting to see how the Arkansas law is similar to those passed by other states, but is unique in a couple of aspects.

By far the most interesting part of Scott's paper is an economic analysis in which he attempts to answer the question whether or not tort reform is good for

Arkansas. Scott consulted with two economics professors here in the Walton College and with their help developed a model which might provide some insight as to whether tort reform is beneficial. The results of other states are reviewed, and Scott concludes with a prediction of what will be the economic results of tort reform in Arkansas.

In summary, Scott did an outstanding job on this paper, both in terms of background research involving an immense number of hours in the library, and considerable effort in developing an economic model. This was not surprising to me, as I have worked with Scott for many years in my capacity as director of the honors program. Scott is a superior student, and will be graduating next week Summa Cum Laude and as a First Ranked Senior Scholar. After graduation he will continue his studies in law school.

## THE ELECTORAL CONSEQUENCES OF NEOLIBERAL REFORM

### EXPLAINING VOTER TURNOUT IN LATIN AMERICA'S DUAL TRANSITION ERA

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#### Abstract:

*Voter turnout has declined precipitously during Latin America's 25 year experience with representative democracy. This decline has occurred in conjunction with another important trend. Across the region, economic development directed by state leaders and characterized by heavy state intervention has been replaced by a development model, commonly referred to as the Washington Consensus, in which markets are the preferred instrument for growth and the state plays a minimal role. This means that as people were casting off their undemocratic past, their economies were also undergoing fundamental change. This simultaneous turn to democratic governments and market-based economic policy is commonly called Latin America's dual transition. The twin transition gives rise to the basic research question of this work: Is the dramatic decline in democratic participation throughout Latin America somehow linked to the political or economic consequences of market reform?*

#### Turnout Decline & Public Opinion:

In order to proceed with an assessment of the proposed relationship between market reform and declining turnout, we must first establish that turnout is actually declining in the region and demonstrate discontent with the dual transition process.

The raw turnout statistics for both presidential and legislative elections provide compelling evidence that turnout is declining in Latin America. During the democratic period, or the period between a nation's first and last election cycle, average presidential election turnout has declined more than 11 percent while turnout in legislative elections has seen more than a 16 percent decrease. (See Table 1)

The fact that 14 of the 17 countries under consideration have seen turnout declines of 10 percent or more in presidential and/or legislative elections is striking but it is not conclusive. In

**Table 1: Turnout Difference between First and Last Elections 1970-2004**

	Presidential			Legislative		
	First Election (Year)	Last Election (Year)	Difference	First Election (Year)	Last Election (Year)	Difference
Argentina	83.3 (83)	76.1 (03)	-7.2	83.3 (83)	61.7 (03)	-21.6
Bolivia	82 (85)	66.8 (02)	-15.2	82 (85)	66.8 (02)	-15.2
Brazil	88.1 (89)	73.7 (02)	-14.4	84.6 (90)	75.9 (02)	-8.7
Chile	94.7 (89)	87.2 (99)	-7.5	94.7 (89)	75.6 (01)	-19.1
Colombia	58.1 (74)	45.6 (02)	-12.5	57.1 (74)	38.7 (02)	-18.4
Costa Rica	83.3 (70)	67.1 (02)	-16.2	83.3 (70)	66.1 (02)	-17.2
Dominican Rep.	75.7 (74)	79.1 (04)	3.4	69.5 (86)	49.1 (02)	-20.4
Ecuador	80.4 (79)	56 (02)	-24.4	80.3 (79)	56 (02)	-24.3
El Salvador	79 (84)	67.3 (04)	-11.7	67.7 (88)	36.9 (03)	-30.8
Guatemala	65 (85)	52.9 (03)	-12.1	69.3 (85)	50.3 (03)	-19
Honduras	78 (81)	63.2 (01)	-14.8	67.5 (81)	60.4 (01)	-7.1
Nicaragua	86.2 (90)	76 (01)	-10.2	81 (90)	76 (01)	-5
Panama	73.7 (94)	75 (04)	1.3	73.7 (94)	76.9 (03)	3.2
Paraguay	69 (93)	62.3 (03)	-6.7	66.2 (93)	62.3 (03)	-3.9
Peru	81.8 (80)	70.4 (01)	-11.4	80.4 (80)	62.7 (01)	-17.7
Uruguay	85.8 (84)	89.5 (04)	3.7	87.9 (84)	89.5 (04)	1.6
Venezuela	96.5 (73)	56.5 (01)	-40	96.5 (73)	38 (00)	-58.5
Average	80.0	68.5	-11.5	77.9	61.3	-16.6

Data are from the electoral database of Dr. Jeff Ryan.

order to determine whether these drop offs are statistically significant, we need to conduct a difference of means or t-test. The standard cutoff point for t-test significance in social science research is .05 or better. (McClendon, 148) In our case, the null hypothesis, that the observed changes in turnout levels are insignificant in statistical terms, has a significance level of .008 for both legislative and presidential turnout decline. (See Table 2) This indicates a .8 percent chance that the shift in the mean is the result of random variation or, alternatively, it shows a 99.2 percent chance that a nonrandom element or elements are causing the decline in turnout. Thus, the null hypothesis can be rejected with a high level of certainty .

**Table 2: Difference of Means Test for Turnout Change**

Pair	Shift in the Mean	Countries	Significance
Pair 1	-12.825	16	0.008
Pair 2	-8.8975	16	0.008

Data are from the electoral database of Dr. Jeff Ryan.

In order to determine a potential causal element that is driving Latin America's turnout decline, I turn to data from an annual region-wide poll. (Latinobarometro, 2002) The polling data indicates that nearly 70 percent of Latin Americans are neither contented with nor supportive of market reeform. (See Table 3) This means that economic development is moving in a direction that is at odds with the will of the general populous. This is a striking and seemingly counterintuitive phenomenon within a representative democratic context. Given this, it is certainly plausible to suggest that this regional macro-level trend is associated with another, declining electoral participation. We must now conceptualize the link between turnout decline and economic reform.

**Table 3: Attitudes Toward State Intervention in Economy**

Country	Pro-Market	Undecided	Pro-State
Argentina	16.3	1.5	82.3
Bolivia	23.2	3.9	72.9
Brazil	34.4	5.1	60.6
Chile	17.4	2.5	80.1
Colombia	22.2	5.3	72.5
Costa Rica	25.4	4	70.7
Dominican Republic	18.4	1.7	79.8
Ecuador	36.7	2.8	60.6
El Salvador	35.5	4.4	60.1
Guatemala	35.2	6.2	58.6
Honduras	28.4	3.8	67.8
México	25.3	2.3	72.4
Nicaragua	28.2	3.1	68.7
Panamá	29.5	2.7	67.9
Paraguay	29.3	1.9	68.8
Perú	28.2	5.2	66.7
Uruguay	10.8	2.4	86.8
Venezuela	35.9	3.2	60.8
<b>Average</b>	<b>26.7</b>	<b>3.4</b>	<b>69.9</b>

(Latinobarometro, 2002 in United Nations Development Program, 2004) A pro-market attitude indicates that poll respondents approve only of market-based development or have a general pro-market tendency. A pro-state attitude indicates that respondents approve of state-directed development or have a general pro-state tendency.

**Conceptualizing the Relationship Between Market Reform and Turnout Decline:**

There are two general ways of conceptualizing the impact of neoliberal reforms on electoral participation. The first focuses more narrowly on those tangible economic consequences of these reforms which based on existing findings from the voting literature can reasonably be expected to depress turnout. The second looks at the wider impact of the reforms on the very nature of policy decision-making within the region or, put differently, the political consequences of the Washington Consensus. The goal here is to link market reform to changes in the political realm which can plausibly be tied to reduced participation at the polls.

*The Impact of Economic Consequences*

Democracy places certain requirements on its citizenry that other political systems do not. It requires, unlike non-democratic systems, that individuals follow policy issues, track the performance of elected representatives, participate in civil society and perhaps most importantly, vote. The fulfillment of these requirements takes resources such as time and money. Research on voting patterns in the developed world has consistently demonstrated that there is a positive relationship between socioeconomic status and turnout at the individual level. (Powell, 121) The inverse is also well-established in the literature:

People with lower individual means (education, income, experience) have fewer resources to cover the costs of participation (processing the required information, reaching a decision, finding the time to vote). They are also more likely to develop apathetic attitudes towards the political system, and thus are more difficult for parties and institutions to motivate to vote. As a result, they usually vote less. It has been shown that participation increases with age (up until a certain threshold), income and social integration. (Anduiza, 647)

A core reason for this relationship rests in the unique resource requirements of democratic citizenship. Individuals must have the time, means, information, and policy knowledge to engage leaders. They must have the wealth and organizational capacity to engage civil society. Finally, they must have the resources, stability, and information to cast an informed vote. The bulk of the research on the link between socioeconomic status and voting has focused on established industrial countries. Much less attention has been given to this relationship in the study of the developing democracies of Latin America. The exception is a 2003 study by Canton and Jorrot who performed an individual level socioeconomic analysis of voter turnout in Argentine presidential elections from 1983-1999. (Canton & Jorrot, 2003) Their findings confirmed trends found in research on developed democracies: turnout was found to be directly related to a person's economic wellbeing. Unfortunately, individual level data on the scale required to replicate Canton and

Jorrat's study for all of Latin America simply does not exist. We must rely instead on broader measures at the macroeconomic level which can at least give some indication of the relative size of the pools of voters and non-voters based on socioeconomic conditions. In other words, I assume that declines in macroeconomic performance will push greater numbers of people into lower socioeconomic status, making them less likely to vote and thus driving down turnout at the aggregate level. Likewise, positive macroeconomic performance should be linked to increased voter participation.

### *The Impact of Political Consequences*

The political consequences associated with the implementation of the Washington Consensus are many. During the period of statist development, the state controlled most economic activity and had an array of policy options at its disposal. Due to the shift toward market-based economic policy, the state controls little economic activity and has lost its array of policy options. The significance of this in terms of participation is that it has undermined the most historically important mobilizational and representative institutions in the region: organized labor, political parties, and legislatures. At the heart of this impact are the particular disincentives for both individual and collective action that are associated with the neoliberal model. As Kurtz notes,

[Market reforms] raise significant barriers to collective political action and thus induce a decline in the organizational and mobilizational capacity of civil society. [reforms] create collective action problems that inhibit the formation of groups (or for that matter the formation of collective interests) that are essential antecedents of political participation. They can also reduce the scope of political decision making—that is, the set of issues properly thought of as regulated by public policy—which reduces the incentives for individuals to engage in political activity. (Kurtz, 272)

Thus, beyond depressing individual motivation to participate, Kurtz argues that the reforms have seriously undermined those groups or institutions in society which might mobilize otherwise apathetic citizens to go to the polls. In the Latin American context, labor unions and political parties have been the primary agents of mobilization.

### *Unions*

The basis of the collective action problem with regard to unions rests in labor market changes. Reforms have brought a shift in labor market structure, heavily favoring non-union sectors over the unionized sector. The traditional base, the organized and politically active unionized sector, around which mobilization of the working (or even peasant) classes would occur has severely weakened. This fragmentation has made

collective action a logistical impossibility. Additionally, because governments are engaged in a small and rapidly shrinking amount of economic activity, labor mobilization against the state beyond the ballot box (e.g., protests, strikes, etc.) has become a largely useless endeavor. Thus, the Washington Consensus has critically undermined the capacity of one of the most effective vehicles for mobilization, organized labor, to fulfill its historic function.

### *Political Parties*

The impact of market reform on the political parties of Latin America has been equally significant. The implementation of the Washington Consensus has in many ways stripped parties of the two primary mechanisms they have historically utilized to mobilize voters: policy alternatives and tangible benefits. Prior to marketization, parties enticed people to the polls by presenting them with clear choices in the form of programmatic alternatives. Though the cost of such intense ideological competition was frequently polarization and occasionally serious violence, there is no denying that parties in most countries in the region were routinely able to project elections as high-stakes affairs in which voters felt compelled to participate. Not so today, liberalization and globalization have placed ever-increasing pressure on governments, and by extension the parties which hope to control them, to deliver policy options that are consistent with investor expectations. Because of the enormous political and economic risks associated with enacting (or even promising) policies in conflict with the market model, party platforms have become overwhelmingly more responsive to investor expectations than to popular demands.

The second key mobilizational mechanism used by parties was based on their ability to reward their backers in tangible ways. Preceding marketization, the universal characteristic of Latin American party systems was patronage, "which entails an exchange of material benefits for political support." (Roberts, 44) These benefits took the forms of employment, favors, contracts, or subsidies. In the neoliberal context of fiscal prudence and ever-declining state activity, parties are increasingly less able to deliver these material rewards. As a result, the entire logic of the old system has effectively vanished, and with it, much of the mobilizational capacity of parties.

### *Legislatures and Executives*

At the beginning of the dual transition, there was a great deal of concern that the drastic and difficult reforms called for by the Washington Consensus would be virtually impossible to carry out in a context of representative democracy. (Armijo et al., 162-164) Agreement slowly emerged in the region that the only way to overcome this challenge was to somehow insulate economic policymaking from public demands. This ultimately led to the appearance of what Guillermo O'Donnell labeled

“delegative democracy” throughout the hemisphere. (O’Donnell, 1994) This new “species” of democracy differs in fundamental ways from classical representative democracy. In “delegative” systems, presidential candidates feel no compelling need to follow through on their campaign promises once elected to office.

This means that presidents in such systems see themselves not as representatives of the people (and therefore obliged to be responsive to popular demand), but as leaders chosen to do what they think is best for the country, even if it is in conflict with the wishes of voters. In order to carry out this delegated mandate, executives must effectively exclude not just the demands of the public at large, but also of their elected representatives, the legislators. (O’Donnell, 59-61) According to Lasagna and Cardenal, this creates

... a vicious circle with pernicious consequences for democracy. Presidents demand more power to govern on the pretext that parties and legislatures are weak institutions, but this accumulation of power, rather than resolving the problem, further aggravates it, weakening the key instruments society has for enforcing accountability, further distancing citizens from the public interest, and deteriorating democratic life. (Lasagna & Cardenal 132)

As the legislature becomes less and less able to impact public policy, citizens will naturally become less and less concerned with who occupies its seats, and it is reasonable to assume that turnout, especially for legislative elections, will decline.

In sum, the basic assumption underlying the political consequences hypothesis is that if unions are shrinking and becoming marginalized, parties are becoming programmatically indistinguishable and unable to offer material rewards to their backers, legislatures are largely sidestepped when it comes to policymaking, and presidents enact policy based on technocratic criteria rather than in response to popular demands, it is hardly surprising that Latin American voters have concluded that voting is largely a futile endeavor.

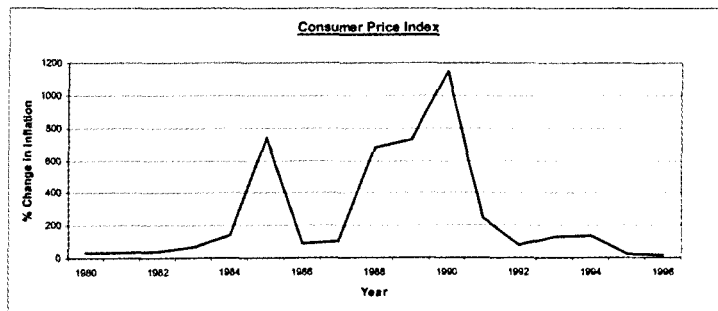
**Overview of Descriptive Evidence:**

Before moving on to a more detailed explanation and test of my main hypotheses, it is appropriate to first take a broad overview of economic and political conditions in Latin America during the post-reform period to see whether there are indications that the sorts of trends we described above are in fact present.

*Economic Performance*

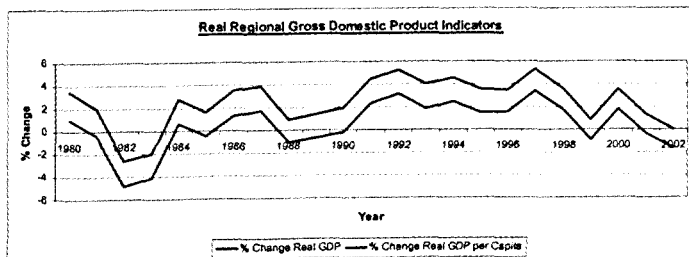
In assessing the record of the Washington Consensus in terms of economic performance to date, the best that can be said is that the results are mixed. The biggest success of reform by far

was the curbing of hyperinflation. Inflation rates dropped from a staggering regional average of 1,152 percent in 1990 to average rates of less than 20 percent by the late 1990s. (World Bank, 2004)



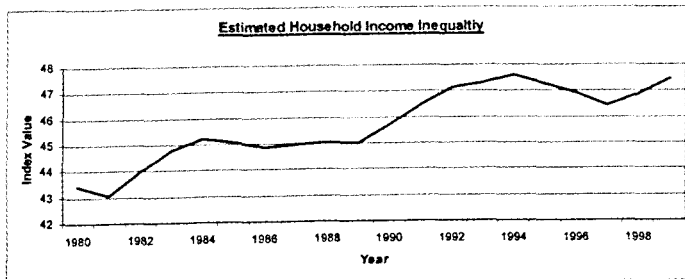
(World Bank, 2004) This graph displays the average regional inflation rate as measured by the change in the consumer price index (CPI) from 1980-1996. CPI reflects price level changes of a basket of consumer goods.

Beyond this very significant triumph, market reforms have generally not lived up to expectations. Real GDP growth has been tepid at best. Despite showing an average growth rate of around 3.9 percent over the 1990-1996 period, growth slowed to an average 2.4 percent over the 1997-2002 period. More significantly, creation of wealth is not keeping pace with the population growth, as GDP per capita growth has lagged behind real GDP growth by around two percent and has actually been negative in three out of the last four years. (World Bank, 2004)



(World Bank, 2004) This graph displays the average regional real gross domestic product and real gross domestic product per capita growth rates from 1980-2002.

Significantly, evidence suggests that this shortfall in growth has been borne largely by the lower income groups. The Estimated Household Income Inequality index (EHII) indicates that inequality has increased more than 10 percent since the onset of the debt crisis, a disturbing trend in a region already plagued by some of the most unequal wealth distribution in the world. (University of Texas Inequality Project, 2004)



(University of Texas, 2004) Increasing regional estimated household income inequality (EHII) indices indicate increasing inequality. A score of 0 indicates perfect equality while a score of 100 indicates perfect inequality. The EHII index is calculated using combined statistics on both wage inequality and economic resource control.

Finally, reforms have failed to create jobs. The regional unemployment rate has risen from 7.3 percent in 1990 to 9.5 percent in 2002, reaching double digits from 1999-2001. (World Bank, 2004)

It seems clear, then, that in most regards the market reforms at the heart of the dual transition have thus far not lived up to expectations. Of course, there are many reasons behind this suboptimal performance, some of which are undoubtedly beyond the control of Latin American policymakers. From a political perspective, though, these reasons may be irrelevant, for as Kurtz notes, "if neoliberal [market] policies are not causally responsible for Latin America's economic problems, the political fact remains that they have become associated with them in the popular mind." (287)

#### *Political Performance*

It is, of course, much more difficult to assess the political impact of the reform era. Nonetheless, there are indications that the sort of damaging consequences of neoliberalism on mobilizational institutions described earlier are indeed present in the region.

In assessing the record of the Washington Consensus in terms of political performance, the results are grim. The dual transition period has witnessed the flexibilization and informalization of the economy. Evidence demonstrates that the unionized, politically-influential formal employment sector is shrinking. During the 1990-2002 period, this focal point of political organization diminished by more than five percent. (See Table 4)

As the size of the formal sector has declined, its mobilizational ability has been undermined. One way to measure union mobilization is in terms of strike and lockout rates, which give some indication of how active the organized labor sector is. The data show that labor action is increasingly less likely. The average yearly regional strike rate has declined from a high of 310 during the 1985-1989 period to 113 during the 2000-2003 period. (See Table 5) The assertion is that the decline in strike rates does not reflect satisfaction (in light of increased unemployment and inequality with lagging GDP per capita growth) with Washington Consensus economic policy, but rather, it reflects an incapacitated organizational ability caused by labor market changes

The impact of neoliberal reform on representative institutions transcends labor unions. Political parties, legislatures, and executives have also lost significant ground in terms of public opinion. Polling data indicates that average regional confidence in these institutions has declined 10, 12, and two percent respectively since 1997. (See Table 6) In a region of ideological uni-polarity, fiscal limitation, technocratic policy-making, and unresponsive leadership, citizens now view those institutions which once represented their interests as no longer effective

The loss of credibility of representative institutions is linked to the perception that these institutions have surrendered their traditional power and policy influence during the reform era, particularly to the private business sector. When asked who wielded the most power in their respective countries, more people identified big business as the most powerful sector than

**Table 4: Formal Sector Employment**

<i>Country</i>	<i>1990-1994</i>	<i>1995-1999</i>	<i>2000-2002</i>
Argentina	48.0	50.7	55.5
Brazil	59.4	54.9	54.0
Chile	62.1	61.2	62.0
Colombia	54.3		44.4
Costa Rica	58.8	56.7	55.0
Ecuador	44.4	36.3	46.7
El Salvador			48.2
Honduras	42.4	41.1	34.9
Nicaragua			45.6
Panama	64.0	62.9	60.1
Paraguay		41.9	39.1
Peru	47.3	44.6	42.3
Uruguay	60.9	58.7	57.8
Venezuela	61.4	55.5	48.5
<b>Regional Average</b>	<b>54.8</b>	<b>51.3</b>	<b>49.6</b>

(International Labor Organization, 2003) Figures indicate the average percentage of the total labor force which is "formal" for the period in question. Formal laborers normally work under contract, enjoy employer benefits, and have a working environment subject to state regulation.



**Table 5: Latin American Strike and Lockout Rates**

<i>Country</i>	<i>1980 - 1984</i>	<i>1985 - 1989</i>	<i>1990 - 1994</i>	<i>1995 - 1999</i>	<i>2000 - 2003</i>
Argentina		431			
Bolivia	273	211	51	81	
Brazil	226	2067	883	800	396
Chile	56	67	213	156	105
Colombia	183	123	320		
Costa Rica	22	15	22	12	
Dominican Republic				2	
Ecuador	91	104	64	11	
El Salvador	22	40	28	155	25
Guatemala	14	18	24	12	
Honduras	38	36	53	58	63
Nicaragua		47	65	8	0
Panama	12	8			
Peru	714	686	293	75	47
Venezuela	113	36	7	18	31
<b>Regional Average</b>	<b>155</b>	<b>310</b>	<b>177</b>	<b>143</b>	<b>113</b>

(International Labor Organization, 2005) A strike or lockout is generally defined as an occurrence that causes the disruption of enterprise activity, though different nations adopt specific variations of this definition.

**Table 6: Confidence in Institutions**

<i>Institution</i>	<i>1997</i>	<i>1998</i>	<i>1999 - 2000</i>	<i>2001</i>	<i>2002</i>	<i>2003</i>	<i>2004</i>	<i>Change</i>
Political Parties	28	21	20	19	14	11	18	-10
Legislatures	36	27	28	24	23	17	24	-12
Presidents	39	38	39	30		31	37	-2

(Latinobarometro, 2004) Figures indicate the percentage of poll respondents who expressed some confidence, confidence, or strong confidence in these institutions.

**Table 7: Power Perceptions in Latin America**

<i>Country</i>	<i>Business</i>	<i>The State</i>	<i>Political Parties</i>
Argentina	70.38	11.66	12.87
Bolivia	34.26	36.93	21.85
Brasil	42.24	24.00	14.22
Chile	68.49	12.50	3.04
Colombia	47.02	13.05	10.95
Costa Rica	38.42	45.17	16.41
Ecuador	46.75	15.67	12.64
El Salvador	47.30	36.05	6.54
Guatemala	29.49	45.92	7.83
Honduras	42.90	34.01	11.24
Nicaragua	36.75	41.76	12.14
Panamá	45.50	19.01	16.38
Paraguay	32.20	35.59	15.68
Perú	33.09	33.50	2.96
Uruguay	42.01	43.01	10.07
Venezuela	28.69	34.33	9.48
<b>Average</b>	<b>42.84</b>	<b>30.14</b>	<b>11.52</b>

(Latinobarometro, 2002 in United Nations Development Program, 2004) The figures represent response to the question, "In your opinion, which of the following has the most power in this country?"

those citing the state and political parties combined. (See Table 7) If, indeed, most citizens feel that their governments and parties are more or less inconsequential relative to private economic interests, then what incentive is there to vote?

**Modeling Voter Turnout in Latin America:**

At this point, I have shown the significance of the turnout decline, reported opinion data on discontent, provided some conceptual justification for my hypothesized link between market reform and that decline, and supplied some preliminary descriptive evidence that indicates the presence of the trends I suggested are at work. I now turn to a more rigorous test of my two hypotheses, which in specific form are the following:

*Hypothesis One: Declines in socioeconomic conditions resulting from the implementation of market reforms will produce declines in electoral turnout.*

*Hypothesis Two: Declines in the strength, effectiveness, and performance of the major mobilizational institutions (i.e., unions, parties and legislatures) resulting from the implementation of market reforms will produce declines in electoral turnout.*

Both of the major hypotheses have a number of sub-hypotheses, which are essentially single indicator linear relationships between various independent variables to our dependent variable, voter turnout. These are:

Table 8: Single Variable Hypotheses		
	Independent Variable	Relationship to Turnout
ECONOMIC	Real GDP per Capita	Positive
	Inflation	Negative
	Inequality	Negative
	Unemployment	Negative
	Privatization	Negative
POLITICAL	Trade Liberalization	Negative
	Labor	Negative
	Financial Liberalization	Negative
	Consumption Taxation	Negative
	Overall Structural Reform	Negative

*Voter Turnout*

The dependent variable in the regression model is voter turnout. The model independently considers turnout in two types of elections: legislative and presidential. The data include results from 17 Latin American nations covering democratic elections from 1980-2003. Turnout has been tabulated for 78 presidential elections and 85 legislative elections. In this analysis, turnout is defined as the percentage of registered voters who cast valid votes. The data are from a compilation of electoral statistics developed by Dr. Jeff Ryan using official government sources. A full listing of the original sources is available in the Turnout Reference Appendix.

*Economic Hypothesis Variables*

Most comparative political research, especially that dealing with the developing world, is limited by the availability and reliability of necessary data. Nonetheless, the economic variables for which I have been able to gather sufficient data should provide a reasonably good test of my hypotheses.

*Percent Change in Real GDP per Capita* measures the ability of an economy to generate wealth in real terms relative to the population size. The coverage of this variable is 1979-2002.

*Inflation* measures the rate at which prices are increasing and is a measure of overall economic stability. The consumer price index (CPI) will be used as the inflation measure in this research. This shows the rate at which prices of basic consumer goods are increasing on an annual basis. The coverage of CPI is from 1979-2002.

*Inequality* is an indicator of the distribution of resources within a nation. The Estimated Household Income Inequality (EHII) index will be used as the measure. This index combines inequality data on wages and pay with that of absolute resource control. (Galbraith & Kum, 2004) This means that it can account for the disparity in earning between low-wage workers and high-income salary employees while simultaneously considering the relative differences in net assets among various holders. A score of zero indicates perfect equality while a score of 100 indicates perfect inequality. The coverage of the EHII index is 1979-1999.

*Rate of Total Unemployment* measures the percentage of the active labor force that is unable to obtain employment. The coverage of unemployment statistics is 1980-2002.

*Political Hypothesis Variables*

The problems of data availability for political variables are even more pronounced than for economic variables. As a result, I was forced instead to rely on an indirect test of this hypothesis using proxy indicators for the relationships I described earlier. Specifically, I will use measures of the reform itself, rather than of the impact of that reform. These variables take the form of a series of indices constructed by Eduardo Lora of the Inter-American Development Bank to measure the extent of reform in each of five particular areas, as well as a composite index measuring overall structural reform. Lora's dataset covers all of the countries in Latin America included in my analysis from 1985-1999.

*Privatization Index* is calculated as the ratio of the cumulative value of privatization to total GDP for the year in question. (Lora, 21) This indicator is not an ideal measure of state industrial involvement, as it penalizes those nations with nothing to privatize or that retain profitable industry

*Trade Reform Index* is the average of the average level and dispersion of tariffs. (Lora, 20) It is reasonable to assert that as tariff levels and dispersion have changed, the level of overall government involvement in regulating trade has changed with it.

*Labor Reform Index* has four components. They are level of flexibility for hiring workers, the cost of layoffs or termination, cost of overtime and holiday employment, and required contributions to benefit plans. (Lora, 21)

*Domestic Financial Reform Index* is the average of three indices. The first measures the level of government control over bank borrowing and lending interest rates. The second is the reserves to demand deposits ratio. The final is the quality of government intervention in the financial system. (Lora, 20)

*Tax Reform Index* is composed of five parts. It combines measures of the highest marginal tax rate for both individuals and corporations, the value added tax (VAT) rate, and the efficiency of VAT and income tax collection. (Lora, 21) The index displays the movement from progressive taxation on income to regressive taxation on consumption. The shift is one of government policy. It does not indicate a withdrawal of the state but a redirection that is a direct consequence of market reform.

*General Structural Reform Index* is the simple average of the previous five indices for the year in question. (Lora, 19) While it is unlikely that each dimension of this index contributes equally to the economic and policy consequences of reform, it is the only aggregate measure available. It can be used to gauge voters' general response to reform rather than to specific policy areas.

### Model Specification

Multiple regression analysis provides the most suitable framework for testing my hypotheses. However, in its basic form, it has a fundamental limitation. It can consider only one cross sectional unit at a time. In the current research, a cross section is a Latin American country. Because we consider multiple countries or cross sections simultaneously, a variation on standard regression analysis is required. The most appropriate technique under these conditions is cross-sectional time series regression, which uses traditional multiple regression to calculate the proper

*B* value for each independent variable in each cross section. It then takes the summation of the calculations in order to determine the proper *B* values when all cross sections are considered simultaneously. (SAS Institute, 2005) Thus, when considering changes in the dependent variable, cross-sectional time series analysis indicates the explanatory capacity of each independent variable considered over all countries.

Two specifications have been made to the basic cross-sectional time series regression model to improve its accuracy

and applicability to modeling voter turnout in Latin America. First, all independent variables have been lagged one year. This is because individuals need time to process and react to economic and political changes. Second, indicator, or dummy, variables have been included. These variables detect the significance of unmeasured qualitative or quantitative effects which cause variation in the dependent variable. They measure the importance of things other than the previously described independent variables. The inclusion of dummy variables has been specified for country specific effects and/or time effects. By lagging the independent variables and including the dummy variables, I hope to produce a more comprehensive and robust picture of electoral turnout.

Using these basic specifications, I then estimated a series of models designed to test a broad array of different combinations of the various hypothesized relationships described above. For each of these combinations, models were estimated separately for presidential and legislative elections. For both of the main hypotheses, I tested each of the specified independent variables (economic and political) alone and in all possible combinations with each other, as well as in combination with the country and time dummy variables. I then estimated a "kitchen sink" model which included both economic and political variables (as well as the dummies.)

## Results and Analysis:

### Presidential Turnout

**Table 9: Presidential Model Results**

Model	Independent Variable	Estimate(B)	Pr	R2	Country*	Time*
E1	GDP	0.5052	0.0837	0.891	X	X
E2	Inflation	0.00199	0.2002	0.888	X	X
E3	GDP	0.816	0.009	0.906	X	X
	Inflation	0.0038	0.019			
E5	Inequality	-0.80972	0.3695	0.915	X	X
E6	Unemployment	1.7382	0.2608	0.968	X	X
P1	Privatization Index	-7.95575	0.1682	0.9	X	
P2	Trade Reform Index	-13.0354	0.009	0.916	X	
P3	Labor Reform Index	-13.1002	0.6605	0.894	X	
P4	Financial Reform Index	-12.5601	0.0207	0.911	X	
P5	Tax Reform Index	-32.5733	0.0195	0.911	X	
P6	General Reform Index	-26.047	0.0058	0.918	X	
KS1	General Reform Index	-31.69	0.005	0.921		X
	GDP	0.1999	0.5143			
	Inflation	-0.00084	0.6612			

Statistical significance is established at a Pr value of .05 or less.

\*Indicates that the dummy variable was included in the model. Results are suppressed.

The model of presidential election voter turnout in Latin America revealed minor support for economic indicator variables in isolation from one another. The test results demonstrate that the interaction between real GDP per capita and inflation has a statistically significant impact on turnout. A one percent decline in real GDP per capita will cause a .82 percent decline in voter turnout. This is the direct relationship anticipated by the economic consequence hypothesis. Inflation also produces a significant result, but in an unexpected direction. A one percent decline in inflation will cause a .004 percent decline in voter turnout. The economic consequence hypothesis expectation was that increases

in inflation would cause decreases in turnout. On the basis of these conflicting results and absent support for other economic variables, the economic consequence hypothesis is rejected for presidential elections.

The voter turnout model revealed robust support for political consequence variables in isolation. When tested independently, the trade, financial, and tax reform indices all achieved high levels of statistical significance and caused voter turnout to change in the direction anticipated by the political consequence hypothesis. As reform increased, turnout declined. When the indices were tested simultaneously, however, they were found to display multicollinearity, meaning they explain the same variation in the dependent variable and share the statistical significance of each independent variable in isolation. (Billingsley, et al., 681) This suggested that the overall reform process may be more important than any single aspect of reform. To explore this possibility, a model using only the aggregate general reform index was estimated. It achieved a high level of statistical significance. An increase of 0.1 in the general reform index was found to cause a 2.6 percent decline in turnout. On the basis of these findings, the political consequence hypothesis is accepted for presidential elections.

The model of voter turnout revealed no support for the importance of the interaction between economic indicator and political indicator variables, or the "kitchen sink" model. This suggests that the previous findings represent the proper explanation of the decline in voter turnout for presidential elections. Turnout is primarily a function of the political consequences of market reform.

### Legislative Turnout

**Table 10: Legislative Model Results**

Model	Independent Variable	Estimate (B)	Pr	R2	Country	Time*
E1	GDP	0.647	0.009	0.93	X	X
E2	Inflation	0.00117	0.5232	0.7022	X	X
E3	Inequality	-1.2319	0.176	0.9422	X	X
E4	Unemployment	-0.2831	0.5267	0.9307	X	X
P1	Privatization Index	-14.6023	0.1103	0.8034	X	
P2	Trade Reform Index	-23.4531	0.0027	0.8377	X	
P3	Labor Reform Index	-44.6943	0.319	0.794	X	
P4	Financial Reform Index	-19.0428	0.0113	0.8248	X	
P5	Tax Reform Index	-59.155	0.001	0.8447	X	
P6	General Reform Index	-47.9488	0.0007	0.8493	X	
KS1	General Reform Index	-58.5895	0.0002	0.8631	X	
	GDP	0.64546	0.0767			

Statistical significance is established at a Pr value of .05 or less.  
 \*Indicates that the dummy variable was included in the model. Results are suppressed.

The model of legislative election voter turnout in Latin America revealed minor support for economic indicator variables in isolation. The test results demonstrate that real GDP per capita has a statistically significant impact on turnout. A one percent decline in real GDP per capita will cause a .65 percent decline in voter turnout. This direct relationship is anticipated by the economic consequence hypothesis. However, the failure of the other economic indicator variables to achieve significance casts doubt on the original economic consequence hypothesis. This

hypothesis can only be accepted in modified form for legislative elections: as real GDP per capita declines, voter turnout will decline.

The voter turnout model revealed considerable support for political indicator variables in isolation. When tested independently, the trade, financial, and tax reform indices were statistically significant and had the inverse relationship to voter turnout anticipated by the political consequence hypothesis. Consistent with the finding for presidential turnout, the individual reform indices were found to display multicollinearity. When the general reform index was tested, it was robustly significant. An increase of .1 in the general reform index was found to cause a 4.7 percent decline in turnout. On the basis of these findings, the political consequence hypothesis is accepted for legislative elections.

The model of voter turnout in Latin America revealed no support for the importance of the interaction between economic indicator and political indicator variables. This suggests that the previous findings represent the proper explanation of voter turnout decline for legislative elections. It is principally a function of the political consequences of market reform but real GDP per capita also has explanatory capacity.

### Discussion of Results:

The previous section analyzed the results of the model of voter turnout in Latin America according to their application to either presidential or legislative elections. This section will merge those findings in order to explore the model results as they apply to each of the hypotheses. By doing this, broad trends in voter turnout can be determined and the applicability, or lack thereof, of each hypothesis can be analyzed. The analysis of each hypothesis will proceed in two steps. First, the independent variables that achieved significance across both presidential and legislative elections will be evaluated. Second, those independent variables that failed to achieve significance will be explored. By merging the results from presidential and legislative elections, a vision of the forces that drive voter turnout in Latin America will emerge.

### Economic Consequence Hypothesis: Economic Deterioration --Turnout Decline

The assertion that economic underperformance is driving the decline in voter turnout in Latin America found little support in either presidential or legislative elections. The only independent variable to achieve statistical significance in each election type was real GDP per capita. In some ways, the fact that this variable was the only one which achieved significance does more to undermine the economic hypothesis than to bolster it. Recall that this hypothesis was derived from the voting literature that linked an individual's socioeconomic status to turnout. My assumption

was that macroeconomic changes in each of the four variables would either expand or shrink the pool of people in the traditional 'non-voting' categories and thus shape overall turnout. Yet among these four variables, GDP per capita is clearly the weakest indicator in this regard, since it tells us very little about who is suffering or prospering during periods of growth or contraction. The strongest indicator, based on the assumptions underlying the economic hypothesis, would clearly be unemployment, followed by the more intermediate strength of inflation and inequality variables.

The failure of unemployment, inflation, and inequality to achieve statistical significance in both election types thus severely weakens the economic consequence hypothesis. It is possible, of course, that my inability to uncover a relationship between economic performance and electoral participation is due to the lack of more appropriate data. Nonetheless, the findings remain puzzling, particularly the lack of significance for unemployment. One would expect that high and chronic unemployment rates would create a substantial pool of poor, marginalized citizens who would withdraw from the political arena. A possible explanation for the weakness of this variable, though by no means a strong one, is that the relationship between unemployment and turnout is non-linear, where initial rises in joblessness actually produce more political activity which then drops off as time goes by and hopelessness sets in.

Something similar may be going on with inflation as well. Following years of hyperinflation, Latin Americans may well have developed a substantially higher tolerance threshold for variations in the consumer price index. The enormous variation in the values of this indicator, which range from roughly -2 percent to nearly 12,000 percent, may also be an important reason for the lack of significant findings. Meanwhile, inequality may have failed to achieve significance due either to a similar regional tolerance for high inequality or because changes in the concentration of wealth are difficult for ordinary people to discern. Taken as a whole, then, the findings call into serious question the importance of economic performance as a driver of voter turnout in Latin America.

#### *Political Consequence Hypothesis: Political Impact of Reform--Turnout Decline*

The hypothesis that the political impact of market reform is driving the decline in voter turnout in Latin America found robust support in both presidential and legislative elections. The trade, financial, tax and general structural reform indices were all significant across both election types. The significance of the tax reform index indicates that as the preferred method of taxation has shifted from income and trade to consumption, turnout has declined. Recall that consumption taxation often assumes a regressive character as lower income groups devote a higher

percentage of their income to consumption than higher income groups.

The findings of significance for both the trade and financial liberalization indices are also consistent with the assumptions underlying the political hypothesis. As the state has surrendered more and more control over the trading and financial sectors to private market forces, it has become less and less relevant in policymaking terms. In sharp contrast to the statist era, the decisions which effect citizens most directly are now more or less made outside the political arena, rendering participation in elections a less meaningful activity. Though these indicators are, as noted earlier, only indirect measures of the political consequences of market reform, it seems more plausible to assume that it is those consequences that people are responding to rather than the reforms themselves. It is difficult to imagine, for example, that Bolivian peasants and Honduran slum-dwellers base their decision to vote on adjustments to the reserves to demand deposits ratio.

Further support is indicated by the significance of the general structural reform index across both presidential and legislative elections. As the reform process has proceeded and the activities of government have declined, turnout has declined with it. Again, it seems very unlikely that any but the most sophisticated citizens are directly linking their turnout decision to the complex array of reform measures captured by the index.

The failure of the privatization and labor reform indices to achieve statistical significance in either presidential or legislative elections would seem, at first glance, to weaken the validity of the political consequence hypothesis. However, the lack of significance is more likely a function of how these indices are calculated by Lora than of a lack of an underlying relationship. Recall that the privatization index reflects the ratio of the cumulative value of privatization to total GDP for the year in question. This method produces some paradoxical and rather contradictory results, particularly from the perspective of this analysis. Specifically, it yields scores which have virtually nothing to do with the percentage of the national economy held directly by the state. A low score could, for example, indicate a state which had divested itself of unprofitable holdings but retained control of valuable assets, or a state which entered into the reform period with very little if anything to privatize in the first place. In other words, economies which were already overwhelmingly private at the onset of the Washington Consensus are effectively lumped in with economies which have failed to follow through on the privatization agenda. If we are to accurately measure the impact of privatization on turnout, it is clear that an alternative measure is needed.

Like the privatization index, the lack of significance of the labor reform index does not necessarily damage the validity of the political consequence hypothesis. The index relies on legal regulations about working conditions, pay, and termination.

There are a number of problems with this approach. One is that it does not consider enforcement of these regulations, which can vary dramatically. Another is that such regulations only relate to the formal sector, which as we have seen, accounts for a shrinking proportion of the overall labor force in many countries. Finally, in statistical terms, this index has shown the least variation (across countries and across time) of any of the reform measures. Because these scores are virtually flat for nearly every country throughout the entire time span, it is next to impossible for them to register significantly in any regression model.

On the basis of this model's explanatory capacity, then, the hypothesis that the political impact of Washington Consensus is driving the observed decline in voter turnout in Latin America is accepted.

### Conclusion:

The political consequences of Latin America's dual transition have clearly been profound. Throughout the region, powerful unions stand crippled, political parties are seemingly adrift, legislatures appear increasingly less able to fulfill their representational function, and executives are growing more unaccountable and insulated.

In the current geopolitical climate, governments in Latin America confront a harsh reality. Even moderate deviations from the reforms embodied in the Washington Consensus are met with serious reactions from the international system. Yet as they conform to the standards of that system, they may be undermining the very foundation of democratic governance. The danger lies in the possibility that traditional forms of political participation, like voting, may give way to more disruptive participatory mechanisms. For while it is obviously possible for elected civilian governments to oversee the painful transition from statist to market economies, it is by no means certain that they can do so without disrupting the very fabric of democratic rule: electoral participation.

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### Turnout Reference Appendix: Voter Turnout

Special thanks must be extended to Dr. Jeff Ryan of the University of Arkansas for access to his database of Latin American voter turnout. The following are the sources used in the construction of his database.

#### Compilation Sources:

Institute for Democracy & Electoral Assistance. *Voter Turnout from 1945 to 1998: A Global Report on Political Participation*. [http://www.idea.int/voter\\_turnout/index.html](http://www.idea.int/voter_turnout/index.html)

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International Foundation for Election Systems (IFES). *Election Guide*. <http://www.ifes.org/eguide/eleguide.htm>.

## Official Government Sources

Argentina	Camara Nacional Electoral	<a href="http://www.pin.gov.ar/cne/">http://www.pin.gov.ar/cne/</a>
Bolivia	Corte Nacional Electoral	<a href="http://www.bolivian.com/cne/">http://www.bolivian.com/cne/</a>
Brazil	Tribunal Superior Eleitoral	<a href="http://www.tse.gov.br/">http://www.tse.gov.br/</a>
Chile	Ministerio del Interior	<a href="http://www.elecciones.gov.cl/">http://www.elecciones.gov.cl/</a>
Columbia	Registraduria Nacional del Estado Civil	<a href="http://www.registraduria.gov.co/">http://www.registraduria.gov.co/</a>
Costa Rica	Tribunal Supremo de Elecciones	<a href="http://www.tse.go.cr/">http://www.tse.go.cr/</a>
Dominican Rep.	Junta Central Electoral	<a href="http://www.jce.do/jce/">http://www.jce.do/jce/</a>
Ecuador	Tribunal Supremo Electoral	<a href="http://tse.satnet.net/tse/">http://tse.satnet.net/tse/</a>
El Salvador	Tribunal Supremo Electoral	<a href="http://www.tse.gob.sv/">http://www.tse.gob.sv/</a>
Guatemala	Tribunal Supremo Electoral	<a href="http://www.tse.org.gt/">http://www.tse.org.gt/</a>
Nicaragua	Consejo Supremo Electoral	<a href="http://www.cse.gob.ni/">http://www.cse.gob.ni/</a>
Panama	Tribunal Electoral de Panama	<a href="http://www.tribunal-electoral.gob.pa/">http://www.tribunal-electoral.gob.pa/</a>
Paraguay	Tribunal Superior de Justicia Electoral	<a href="http://www.tsje.org.py/">http://www.tsje.org.py/</a>
Peru	Oficina Nacional de Procesos Electorales	<a href="http://www.onpe.gob.pe/">http://www.onpe.gob.pe/</a>
Venezuela	Consejo Nacional Electoral	<a href="http://www.cne.gov.ve/">http://www.cne.gov.ve/</a>

### Faculty comment:

In his letter to the Inquiry publication board supporting the publication of Mr. Younger's paper, Professor Jeffrey Ryan made the following remarks:

Ryan's research project, which was funded in part through a SURF grant, is without question one of the most ambitious, well-crafted and innovative that I have supervised during my fifteen years at the university, including the half-dozen Masters theses I have directed. It focuses on a topic that I have been grappling with for a number of years—the relationship between macroeconomic structural reform and democratic participation in Latin America. The question is driven by a puzzling and disturbing observation: the widespread adoption of market reforms has coincided with a dramatic decline in voter turnout in the region.

Despite the obvious importance of this trend for democratic consolidation in the hemisphere, surprisingly little literature exists on the topic. This is, I suspect, due in part to a central challenge confronting researchers trying to assess the relationship. Specifically, how is it possible to disaggregate the economic consequences of market reform from the political consequences of those reforms? Put differently, there are plausible reasons for suspecting that the socioeconomic "pain" caused by structural adjustment (e.g., unemployment, poverty, inequality, etc.) will depress turnout. There are equally persuasive reasons to assume that the political effects of this rapid macroeconomic transition, especially on representative institutions like labor unions and

political parties, may result in a drop in voter participation. Since both occur simultaneously, the daunting task facing researchers is how to determine if one or the other (or neither) is actually related to rising abstentionism.

I must confess that I was both surprised and impressed with the straightforward and even elegant solution that Ryan proposed to a problem that has left researchers (including myself) struggling. He first provided a sound conceptual justification for considering the two types of consequences separately. This justification was rooted squarely in the traditional literature on voting as well as the emerging literature on the political impact of neoliberalism. He then went on to devise an operationalization scheme which would enable him to transform those concepts into measurable variables. The next step was the arduous collection and compilation of the necessary data, which I know from experience, is no small feat when dealing with the developing world. Finally, he consulted a number of faculty on campus as well as the literature to determine the most appropriate statistical methodology for carrying out a rigorous test of his hypotheses. In this endeavor, I must confess, he was largely on his own, as the method he ultimately settled on, cross-sectional time series regression analysis, lies far beyond my zone of competence.

His findings are troubling. His analysis indicates that it is not the economic shortcomings of market reform (which can presumably be corrected) which are driving people from the polls, but the far more pernicious impact those reforms have had on the groups which have historically mobilized citizens to participate.



The implications of these findings are profound not only in a research sense, but also in terms of the quality of democratic life in Latin America and other regions undergoing wholesale reform.

This thesis represents in a very real way the culmination of Ryan's undergraduate experience here at the University of Arkansas. Ryan is one of a handful of students I have had in the course of my fifteen year teaching career who balances all the most desirable traits we hope to see in a young scholar. He is intellectually curious, confident but not cocky, disciplined, responsible and exceptionally intelligent. In and out of class, Ryan has consistently exhibited a genuine interest in learning. This curiosity extends well beyond the "Hill." As you can see from his record, Ryan recently spent an academic semester studying in Cuba. Having spent a short time there, I

can assure you that navigating Cuban society is challenging in nearly every sense, from going about routine daily necessities like eating and getting around to dealing with people whose perceptions of and attitudes towards US citizens are complex, to say the least. That Ryan was not only able to survive, but thrive in these conditions is clear evidence of his ability and eagerness to transform any situation, regardless of how difficult, into a positive learning experience.

My role in Ryan's project has been much more that of sounding board, of co-enthusiast, of listening partner than that of supervisor. This project is, in every sense of the word, a result of his hard work, his insights and his passion for learning. I am just grateful that I was along for the very rewarding ride.

## INTERNET GAMBLING: FAIR GAME IN THE UNITED STATES?

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### Introduction:

Until a few years ago people had to travel, often outside their own state, to a "brick-and-mortar" casino to play slot machines or blackjack. People had to gather a group of friends to play poker, and people had to drive to a convenience store to buy a lottery ticket. All of these things, however, are becoming ways of the past. Yes, people still do all those things, but millions of people have found another way to gamble—on the internet. The internet has altered many aspects of everyday life, and gambling is one activity that has drastically changed. Now, someone who wants to participate in any type of gambling simply has to connect his or her computer to the internet and log onto a website.

Due to accessibility, anonymity, and speed, among other factors, internet gambling is one of the fastest growing forms of entertainment in the United States today. Online gaming brought in an estimated \$8.3 billion of revenue in 2004, with projected revenues reaching \$12.5 billion by 2006 (Catania, 2005). This highly controversial pastime has many opponents as well as participants. Currently, there is no federal law specifically addressing gambling via an internet connection, although several have been proposed. The existing law most often applied to internet gambling is 18 U.S.C. § 1084, also known as the Interstate Wire Act. This law, however, was passed in 1961, predating the existence of the internet, and the application of this law is disputed by many. The Department of Justice has taken the position that this law criminalizes internet gambling and has used the statute in a number of situations and cases. Additionally, several other federal and state statutes apply to this issue. On the international level, the World Trade Organization has recently ruled that the United States' position on internet gambling violates global trade rules. As evidenced by the legal issues mentioned above, there is much uncertainty relating to the legality of internet gambling.

Despite the apparent ambiguity in the law, millions of people, especially Americans, are participating in internet

gambling. The University of Arkansas' school newspaper recently ran a cover story about student gambling and noted that "online poker is another popular option for students" and "is convenient because it can be accessed by a computer" (St. John, 2004). This paper will report the results of a survey that has been taken of students on the University of Arkansas campus in order to determine the extent to which college students are partaking in internet gambling.

Recognizing the problems associated with internet gambling, the federal government and many state governments want to criminalize online gambling in all forms. Several individual states, however, are taking efforts to regulate internet gambling to take advantage of tax revenue opportunities. In 2003, the United States House of Representatives passed the Unlawful Internet Gambling Funding Prohibition Act, making it illegal for banks and other financial institutions to process transactions related to internet gambling. This bill was never approved by the Senate; thus, Congress must begin anew this session, and it remains to be seen what will happen during this session.

Opponents of internet gambling argue that the moral backlash of legalized internet gambling is the main concern. The National Gambling Impact Study Commission reports that internet gambling creates problems by allowing fast, anonymous access for underage gamblers as well as problem gamblers. Additionally, the Commission reported that the "lack of accountability also raises the potential for criminal activities" (NGISC, 1999). Supporters of internet gambling, on the other hand, argue that regulation would benefit all involved parties. Jack Carruthers, CEO of BETonSPORTS, a popular internet gambling company, says, "I believe regulation brings protection, it brings certainty, and it brings quality operators to the game" (Woellert, 2004). Additionally, due to the government's current stance on the practice, no tax revenue is being generated by this lucrative industry. This divisive issue will continue to be debated by both sides until a comprehensive decision is made by federal and state governments.

### Legality of Internet Gambling:

The internet, with its borderless and even wireless capabilities, poses substantial enforcement and regulatory challenges. While the legality of internet gambling is anything but certain, there are arguments to be made on both sides of the issue. There are also several federal and hundreds of state laws that could be applied to internet gambling. Two federal cases have specifically addressed the issue, and the World Trade Organization has taken a stance on online wagering. In the following examination of the legality of internet gambling, the most relevant laws and cases will be reviewed. In addition, the World Trade Organization's ruling will be discussed.

Generally, gambling in the United States is an activity governed by individual states, falling under a state's right of police power. States often use their police power regarding moral issues, under which all forms of gambling can fall. However, gambling on the internet is often conducted across state or international borders, making application of state laws especially complicated. For example, a U.S. citizen can place a bet from a home computer in Arkansas which is then transmitted across state and international borders to a server in the country of Antigua, thereby crossing several jurisdictional borders.

State laws regarding traditional gambling vary immensely in the United States. Utah and Hawaii are the only states that completely ban all forms of gambling (*Economist*, 2004, October 2). Additionally, 39 states have lotteries, and 34 states allow casinos. Each of these states has varying regulations and licensing procedures associated with permitted and prohibited forms of gambling. Arkansas statutes §§ 5-66-101 through 5-66-119 (2005) address gambling within the state of Arkansas. Arkansas is one of the more conservative states regarding gambling and prohibits both casinos and lotteries. The first section of the law states,

"The judges of the several courts in this state shall, in their construction of the statutes prohibiting gaming, construe the same liberally, with a view of preventing persons from evading the penalty of the law by changing of the name or the invention of new names or devices that now are, or may hereafter be, brought into practice, in any and in all kinds of gaming, and all general terms of descriptions shall be so construed as to have effect, and include all such games and devices as are not specially named; and in all cases, when construction is necessary, it shall be in favor of the prohibition and against the offender" (§5-66-101, 2005).

It seems likely that this section could be applied to internet gambling and would prohibit Arkansas residents from participation in gambling on the internet.

Nevada is a state that specifically addresses online gambling. According to Rose (2000), "Nevada was the first state not only

to outlaw, but also to legalize, internet gambling" (p. 4). Nevada Revised Statutes §§ 465.091 through 465.094 (2004) outlaw all forms of making or accepting a wager through any medium of communication other than physical presence. In Nevada Revised Statute § 465.091 (2004), "medium of communication" is defined as including but not limited to "mail, telephone, television, telegraph, facsimile, cable, wire, the Internet or any other similar medium." Interestingly, § 465.094 (2004) makes an exception to this rule when the wager is placed by or received from a person or establishment licensed by the state of Nevada. Nevada is home to the gambling capital of the world, and it appears that the state wants to protect that title, even as it applies to internet gambling. Essentially, the Nevada statute says that internet gambling is completely illegal *unless* the website is licensed by the state. Due to the complexity and a general lack of distinct connection to gambling via the internet that exists among state laws (with the exception of Nevada), this report will focus primarily on federal laws applicable to internet gambling.

Because of geographical/jurisdictional issues, the federal government believes that federal law should be "used to protect the states from having their laws circumvented" (GAO, 2002). Under the Commerce Clause of the United States Constitution, the federal government has the right to regulate interstate commerce, and all indicators are that Congress believes that internet gambling falls under this authority.

#### Most Relevant United States Federal Laws

18 USC § 1084 (Interstate Wire Act of 1961)  
 18 USC § 1952 (Travel Act)  
 18 USC § 1953 (Interstate Transportation of Wagering Paraphernalia Act)  
 28 USC § 3702 (Professional and Amateur Sports Protection Act)  
 18 USC § 1955 (Organized Crime Control Act of 1970)  
 18 USC § 1956 (Money Laundering Statute)  
 18 USC § 2 (Aiding and Abetting Statute)

The most pertinent federal law regarding internet gambling is 18 USC § 1084 (2005), known as the Interstate Wire Act of 1961 and the Wire Wager Act. For purposes of brevity, this is the only federal law that will be reviewed in this paper. This law was originally intended to support state gambling and bookmaking laws, but it is now being touted as the law that makes internet gambling illegal in the United States. Section (a) of USC § 1084 (2005)<sup>1</sup> of the law reads as follows:

"Whoever being engaged in the business of betting or wagering knowingly uses a wire communication facility for the transmission in interstate or foreign commerce of bets or wagers or information assisting in the placing of bets or wagers on any sporting event or contest, or for the transmission of a wire communication which entitles the recipient to receive money or credit as a result of bets or wagers, or for information assisting in the placing of bets or wagers,

shall be fined under this title or imprisoned not more than two years, or both."

On the surface this statute appears to apply conclusively to the use of the internet to place or receive bets, but there are several problems with that assumption. The first problem relates to the wording "wire communication facility" and "transmission of a wire communication." This law, passed in 1961, was clearly intended to prohibit telephonic transmission of gambling-related activities. The internet, however, was not actually conceived until the late 1960's, so the lawmakers could not have even imagined the internet as it exists today. Additionally, new technology may make this statute completely inapplicable. Existing technology such as cell phones and wireless internet capabilities already transmit information wirelessly, bypassing any type of "wire communication facility," and one can only imagine what technological capabilities will exist in the future.

In addition to issues regarding wire transmission, the scope of the Interstate Wire Act brings up another issue. 18 USC § 1084 (2005) specifically mentions wagers regarding "any sporting event or contest," and "legislative history suggests the purpose of this Act was to regulate sports betting and activities related to organized crime" (OGRR 1, 2003). The law seems certainly to apply to sports betting but may not include other forms of gambling, such as casino games, poker, and lotteries. Additionally, the law says that those "being engaged in the business of betting or wagering" are punishable under this act; therefore, internet gambling operators can be held liable, but individual gamblers cannot be held liable under this law. Specific intent is also difficult to determine. In order to convict under this law, the government must prove that a website operator "knowingly" transmits information illegally. Many of the websites operate in jurisdictions in which such activity is legal, and many customers of these sites also engage in the activity legally; therefore, "the government must prove that the gambling operator knew that a particular user or player was logging in from the United States" in order for the activity to be illegal under this statute (OGRR 1, 2003).

Another section of the law potentially relates to telephone service providers. Section (d) of 18 USC § 1084 (2005) reads,

"When any common carrier is notified in writing by a Federal, State, or local law enforcement agency, acting within its jurisdiction, that any facility furnished by it is being used or will be used for the purpose of transmitting or receiving gambling information in interstate or foreign commerce in violation of Federal, State or local law, it shall discontinue or refuse, the leasing, furnishing, or maintaining of such facility but no damages, penalty or forfeiture, civil or criminal, shall be found against any common carrier for any act done in compliance with any notice received from a law enforcement agency . . ."

The above wording implies that the federal government could essentially force telephone companies to discontinue service to parties involved in online wagering. The government has yet to take any action in this direction thus far.

In order to determine whether internet gambling is in fact illegal under the Interstate Wire Act, each of the aforementioned issues will need to be addressed, either by Congress or the courts. The Interstate Wire Act is not the only federal law relevant to the online gaming industry. However, it is the main one being relied on by the federal government to suppress internet gambling. The fact the applicability of this law to internet gambling is questionable demonstrates the difficulty of applying present laws to these kinds of activities.

#### Case Law:

Although each of the laws listed above could potentially apply to internet gambling operators and, in some cases, individual gamblers, there have been only a few cases involving internet gaming in the United States. Additionally, because a number of cases have been settled prior to trial, information is not available on all applicable cases. Prosecution under the many federal statutes is rare because the majority of internet gambling websites are located and operated outside the borders of the United States, and it is difficult for law enforcement to coerce individuals to appear in the U.S. to stand trials (OGRR 2, 2003). In order to avoid prosecution, website operators simply have to stay out of the United States and operate in countries where gambling is legal. Also, it is difficult for the United States to force extradition of website operators from countries where online or even conventional gambling is legal. It is also unlikely that the federal government will decide to prosecute individual gamblers due to the difficulty and contradictory nature of prosecuting an individual for something they do over the internet that may be perfectly legal to do in person, such as buying lottery tickets or playing a casino game.

In order to prosecute a foreign defendant, two conditions must be met—subject matter jurisdiction and personal jurisdiction. Subject matter jurisdiction can first be determined by the "effects test," a two-pronged test which holds that a defendant can be held liable if their actions affect U.S. commerce or their actions result in an effect on the United States (OGRR 3, 2003). Once the effects test has been met, a second test, the true conflicts test, can be applied. The true conflicts test determines whether there is a contradiction between the United States law and the law of the home country of the defendant. In regards to internet gambling, the effects test would most likely be met by offshore gambling website operators, but the true conflicts test would be more difficult to pass since online gambling is legal in several countries and some form of conventional gambling is legal in most countries (OGRR 3, 2003). Personal jurisdiction must also be determined. There is an additional two-pronged test that

determines the minimum contacts that are necessary to establish personal jurisdiction. Websites which require active participation have been upheld as meeting the personal jurisdiction requirement (OGRR 3, 2003).

There are three prominent cases pertaining to internet gambling, *In Re: Mastercard, United States v. Cohen*, and *Casino City, Inc. v. United States Department of Justice*. In the first case, *In Re: Mastercard, Int'l, Inc.*, 313 F.3d 257 (5<sup>th</sup> Cir. 2002), plaintiffs Larry Thompson and Lawrence Bradley argued that the Racketeer Influenced and Corrupt Organizations Act (RICO), 18 USC §§ 1961-1968, should allow them to avoid paying credit card debt they had amassed from online casinos. The plaintiffs argued that the defendants, financial institutions MasterCard, Fleet, Visa, and Travelers Bank colluded with numerous online casinos to create an illegal "worldwide gambling enterprise" (In Re: Mastercard, Int'l, Inc. at 2). They further declared that the financial institutions aided and abetted the illegal conduct of the online gambling websites and that the plaintiffs' debts should be unenforceable since they are illegal. Their case was dismissed in the district court, and the plaintiffs appealed to the U.S. Court of Appeals. The appellate court concluded that the plaintiffs did not "prove a necessary element of a civil RICO claim, namely that the Defendants engaged in a pattern of racketeering activity or the collection of unlawful debt," and the appeal was denied (In Re: Mastercard, Int'l, Inc. at 7). Of particular interest is the court's ruling regarding the allegation that the defendants violated the Wire Act. The court ruled that the defendants did not violate the Wire Act because the Wire Act applies solely to wagering on sports events or contests.

*United States of America v. Jay Cohen*, 260 F.3d 68 (2<sup>nd</sup> Cir. 2001) regards a U.S. citizen, Jay Cohen, who left his job in San Francisco to set up an online bookmaking operation, World Sports Entertainment, in Antigua. His website accepted bets on horse races, and he had thousands of customers from the United States. As a result of an FBI undercover investigation, Cohen was indicted on eight counts of violation of 18 USC § 1084, including the transmission in interstate or foreign commerce of bets and wagers, transmission of a wire communication which entitles the recipient to receive money or credit as a result of bets or wagers, and information assisting in the placement of bets or wagers. Cohen was convicted by a jury and received a twenty-one month prison sentence. He subsequently appealed the court's decision to the United States Court of Appeals for the Second Circuit on a number of different issues, but the Court of Appeals affirmed the district court's ruling. Cohen also appealed to the U.S. Supreme Court but was denied certiorari. Initially this case seems to be a major blow to internet gambling operators, but the facts of this case are complex. Cohen's business accepted wagers over both the telephone and the internet. While the Wire Act's application to the internet is controversial, the Wire Act expressly prohibits making and accepting wagers over the telephone. Therefore, there is little question that Cohen did in

fact violate 18 USC § 1084. It remains to be seen whether a gambling operator that accepts wagers solely through an internet connection would be similarly convicted.

The third case regarding internet gambling is *Casino City, Inc. v. United States Department of Justice*, Civil Action Number 04-557-B-M3 (2005), filed in the U.S. District Court of Middle District of Louisiana. Casino City, Inc. is a website that operates an online casino directory. Casino City, Inc. sued the United States Department of Justice ("DOJ") in response to a letter sent by the DOJ to various media outlets, including Clear Channel Communications, National Association of Broadcasters, Discovery Communications<sup>2</sup>, etc., regarding online gambling advertising. An excerpt of this letter reads,

"The sheer volume of advertisements for offshore sports books and online casinos is troubling because it misleads the public in the United States into believing that such gambling is legal, when in fact it is not. Any person or entity who aids and abets in the commission of offenses is punishable as a principal violator and we reserve the right to prosecute violators of the law" (Catania, 2005).

Several companies received subpoenas from the DOJ following the receipt of the above letter. Casino City, Inc. received neither the letter nor a subpoena, but they argued that the mere threat of a letter and/or subpoena was a violation of their right to free speech under the First Amendment. Upon dismissing the case, the court ruled, "Casino City has failed to show a credible threat of prosecution and plaintiff has failed to establish it has standing to file this suit as a matter of law under the facts of this case" (*Casino City, Inc. v. United States Department of Justice*, 2005). In addition to the lack of a substantial case, the Court also ruled that Casino City cannot claim that its First Amendment rights were violated because the Casino City does not have the right to advertise illegal activity (Vallerius, 2005, February 16). This case was a major setback to other advertisers of online gambling websites that had hoped that the court would rule that the DOJ's campaign was a violation of the First Amendment.

As can be seen from the above cases, the law regarding internet gambling is anything but clear. It will take numerous additional court decisions or a new federal law in order to determine the legality or lack of legality regarding the subject. As mentioned, many website operators are avoiding prosecution of any kind by staying out of the United States. Congress also seems unwilling to make a decision on the matter. Several laws have been introduced in the House and in the Senate, but no law has been signed.

#### International Law:

In addition to federal and case law, the World Trade Organization ("WTO") has weighed in on the issue by examining

a complaint made by the small Caribbean state of Antigua and Barbuda. Several countries, Antigua and Barbuda, Gibraltar, and others, have legalized online gambling and become havens for website operators. Many of the countries that have legalized internet wagering have also set up regulatory bodies to license website operators. As previously discussed, the methods of regulation and licensing vary from country to country. Antigua and Barbuda, however, is a country that takes the online gaming industry seriously. Antigua and Barbuda claim that the industry provides "thousands of jobs and millions of dollars in revenue" for the small country, and they license hundreds of website operators to set up online gaming businesses in their country (Smith & Furlong, 2004, December 3). Their licensing rules are also strict, requiring background checks and other specifications be met prior to receiving an operating license. This country is currently involved in a major dispute with the United States over its stance on internet gambling. As aforementioned, Congress and the Department of Justice have taken the stance that internet gambling violates 18 USC § 1084. Based on this position, Antigua and Barbuda petitioned the World Trade Organization to review applicable trade laws, arguing that "American laws prohibiting gambling over wires that cross state lines violate global trade rules for the services sector" as set forth in the General Agreement on Trade in Services, also known as GATS (*Economist*, 2004, November 20). Both the United States and Antigua and Barbuda have signed the GATS and recognize it as international law.

Antigua and Barbuda's complaint centered on the two following complaints: (1) United States gambling operators are widely authorized in the United States, but there is no avenue for foreign operators to obtain such authorization, and (2) the United States restricts international transfers and payments regarding internet gambling (WTO Request, 2003). Antigua and Barbuda argued that both of these conditions violate the international agreement. The United States, however, believes it is justified in prohibiting internet gambling across international borders. The United States argued that there are substantial differences between online gambling and traditional casino gambling, especially the ability to prevent minors from participating (Miller, 2004). Antigua countered that argument by pointing out various laws that prevent fraud, money laundering, and underage gambling. The United States' main argument encompassed the 1995 WTO decision that allows national governments "to ban trade where it has laws to 'protect public morals'" as well as the controversial placement by the WTO of internet gambling into the protected category of "other recreational services" (*Economist*, 2004, November 20).

This argument is only the fourth official dispute presented to the WTO regarding GATS, and it is the first regarding the definition of a nation's right to protect the "public morals" of its citizens (Smith & Furlong, 2004, December 3). On November 10, 2004 the World Trade Organization ruled in favor

of Antigua and Barbuda, deciding that the United States' prohibition of internet gambling does in fact "violate global trade rules for the services sector" (*Economist*, 2004, November 20). Although the United States appealed the WTO's decision, the WTO has upheld its original decision that the United States' prohibitive stance on internet gambling violates global trade rules. The body recognized the United States' right to protect the public morals of its citizens but held that the United States' policy is discriminatory to foreign countries attempting to provide services offered by domestic countries (Vallerius, 2005, April 7). The law in question is the U.S. Interstate Horseracing Act that allows American wagering companies to take bets via the internet, which the WTO saw as favoring domestic companies. The United States will likely have up to fifteen months to incorporate the WTO's ruling into current policies, and it will remain to be seen what action the United States will take.

### Survey Results:

In order to examine internet gambling activity among college students, a simple survey of 250 students at the University of Arkansas was taken. The complete survey is attached as Appendix 10. The surveys were entirely anonymous and randomly distributed. The survey was conducted in a number of locations, including several classrooms in different colleges and common areas on campus. Valid results were collected from a total of 235 students, with age ranges of eighteen years old to over thirty years old. Of those who chose to reveal their gender, 57 percent of respondents were male and forty-three percent female. The largest age categories were 21-25 years old (55 percent) and 18-20 years old (24 percent), which is expected given that the majority of traditional students are within the age range of 18-23 years.

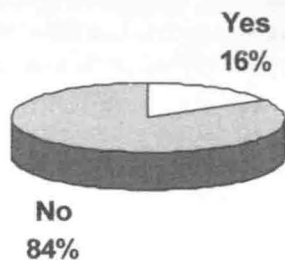
One of the purposes of the survey was to determine whether college students are participating in internet gambling. Based on previous research, millions of people are gambling online. For example, David Carruthers, CEO of BETonSPORTS, PLC, says that his company has "1.2 million registered customers in the United States who make 33 million wagers a year" (Woellert, 2004). This astounding number is from a single online gambling operator, and there are thousands of other such companies. Much of the debate regarding internet gambling is focused on the companies who offer internet gambling, but individual bettors must be taken into consideration as well. As mentioned at the beginning of this paper, individuals cannot depend on gambling websites to give clear answers regarding the legality of gambling online. Most websites state that internet gambling is legal in the operator's jurisdiction and that the individual should follow the laws of local authorities, but it is unlikely that the majority of individuals will take the time to research the laws in his or her area. And, even if individuals were to perform an exhaustive search of relevant laws, they may find,

as this paper has, that laws in the United States are rather unclear and often conflicting on the issue. Due to the large number of individuals who gamble online every day, it appears that most people are either under the impression that gambling online is legal or are not concerned that it may be illegal, a question that was also included in the survey.

As previously discussed, one of the major risks associated with online gaming is underage gambling. In the United States, you must be twenty-one years old to gamble in most casinos and eighteen to buy a lottery ticket. In many countries the legal age is eighteen years old for all forms of gambling, and many internet gambling websites post the required age as eighteen years old regardless of the type of gaming offered. One segment of young people between the ages of eighteen and twenty-three that has particularly high exposure to online gambling is college students. Many students have either a personal computer in their dorm room, apartment, or house or access to a computer on their school campus. Also, some students have a large amount of recreational time because they do not work full time while attending school. Additionally, many college students have access to credit cards, whether it is a personal credit card or a card belonging to their parents. All of these factors contribute to the ability of a college student, some of whom are less than 21 years old, to gamble on the internet.

The first question on the survey was, "Have you ever gambled (with actual money, as opposed to credits or chances to play additional games) using an internet website?" In response to this question, 84 percent (198 people) answered "No," while the remaining 16 percent (37 people) answered "Yes." This shows that while students are certainly gambling on the internet, it does not appear to be a majority of students.

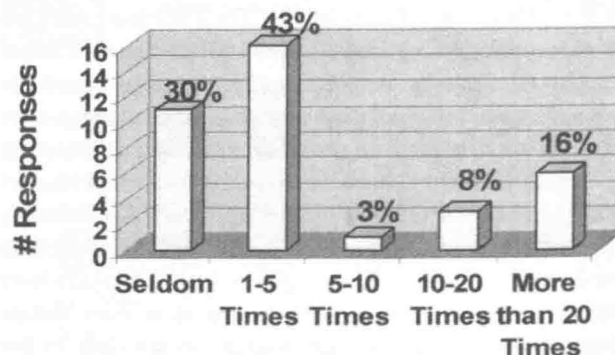
**Have you ever gambled using an internet website?**



The next four questions were specific to students who replied "Yes" to the first question. In regards to the second question, "If you gamble on the internet, how often," 16 of the thirty-seven students, who responded as having gambled on the internet, said they gambled "1-5 times per month." The second most frequent response was "Seldom. No more than 5 times a year." Interestingly, the third most frequent response was "More than 20 times per month." Six students out of 37 are gambling

at least twenty times a week, which is almost daily. It is likely that gambling with such a high frequency interferes with other aspects of the student's life. Perhaps those students are gambling on the internet when they could be sleeping to be more rested for class or work or when they should be focusing on preparing for classes or exams. (Note: The National Council on Problem Gambling reports that frequency does not indicate "whether or not [a gambler] has a gambling problem." Instead, problem gambling is indicated by a "person's inability to control the gambling.")

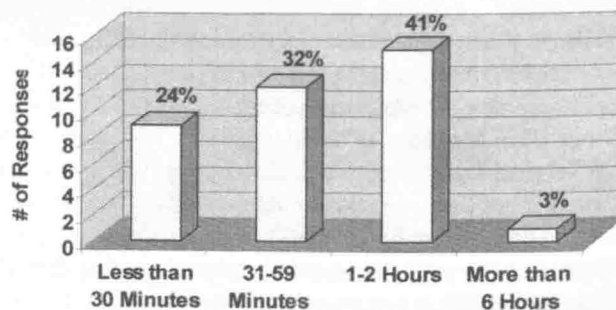
**Frequency of Internet Gambling**



**Episodes Per Month**

The third question on the survey applicable to students who gamble online was, "When you gamble on the internet, how much time do you spend at one session?" Only 3 percent of students replied that they gambled online "More than 6 hours" at a time. The other responses were spread among the remaining options, with a slight majority of students (forty-one percent) saying they gambled "1-2 hours" at a time. As with frequency, the amount of time spent is also not indicative of a problem gambler.

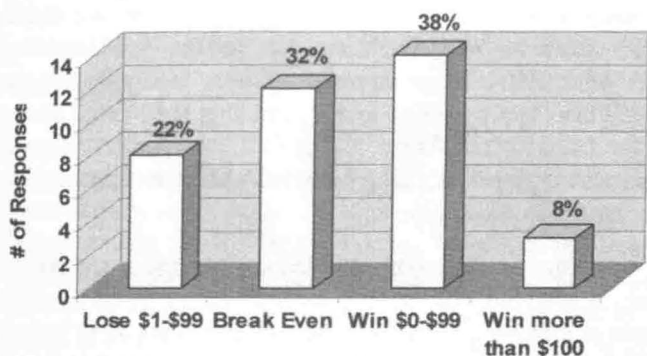
**Time Spent During One Session of Internet Gambling**



The fourth question was, "Each time you gamble on the internet, how much money do you win or lose on average?" While 8 percent of respondents said that they "Win more than \$100" each time they gamble, 22 percent said they "Lose \$1-\$99." The most frequent response was "Win \$0-\$99."

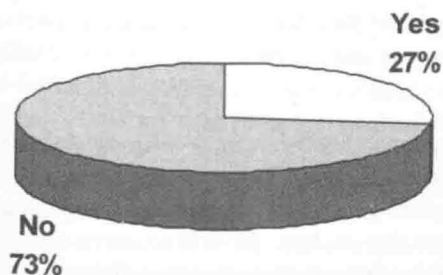


**Average Amount Won or Lost Each Session**



Students were also asked, "When you gamble on the internet, do you ever worry that you will *not* receive your winnings from the website?" to address the question of fraudulent operators. A large majority of students, 73 percent, said that that "No," they did not worry about not receiving winnings from internet gambling websites. Still, more than one in four were concerned about this issue.

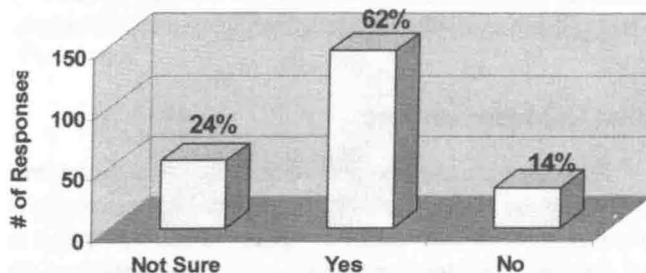
**Do you ever worry that you will not receive your winnings from the website?**



The last question addressed solely to students who gamble online was about the types of gambling students participate in. The optional responses were, "Casino Games (Blackjack, etc.)," "Sports Betting," "Poker," and "Other" or a combination of any of the options. Eight students responded that they solely played poker online, and 7 students said they participated in sports betting only. The other responses primarily included some combination of casino games, poker, and sports betting.

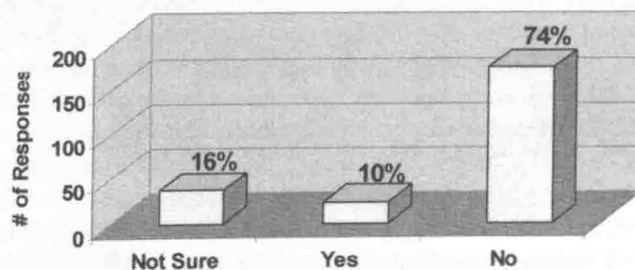
The remaining three questions were to be answered by all survey participants and addressed the legality of internet gambling and traditional gambling. In response to the question, "Do you think it is legal in the United States for a person to gamble on the internet?" 62 percent of all respondents replied "Yes." Twenty-four percent were not sure, and 14 percent said "No." These results are quite interesting, since all of the students surveyed were Arkansas residents, a state which prohibits all forms of gambling.

**Do you think it is legal in the United States for a person to gamble on the internet?**



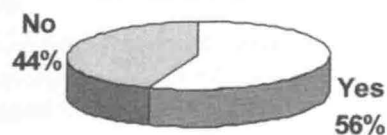
The next question was, "Would you gamble on the internet if you were certain that it was *illegal*?" Out of 235 students, 173 (74 percent) responded "No." Thirty-eight students were not sure, and 24 students said "Yes."

**Would you gamble on the internet if you were certain that it was illegal?**



The final question asked, "Do you gamble using any traditional methods, such as lottery tickets or casinos?" Forty-four percent of students responded that "No" they do not gamble by traditional methods, while 56 percent of students replied "Yes."

**Do you gamble using any traditional methods?**



Overall, the results of the survey were very interesting. While only a small number of total students surveyed responded as having gambled on the internet, their responses to the other questions certainly shed some light on the way they gamble. Additionally, other factors must be taken into consideration when reviewing the results. There is a chance that students may not have accurately complete the survey, possibly not wanting to admit that they have gambled on the internet or even choosing to

overstate or understate the amount of time and money spent on the activity. Overall, the survey demonstrates that some college students do gamble, and those who do are certainly affected by the lack of clear, substantial law and/or regulation in the industry.

### Future Legal Environment:

The decision to either regulate or definitively outlaw internet gambling in the United States is a complicated issue, and it is likely that the issue will continue to be debated. At this point in time, the future of internet gambling is uncertain, and there are several different topics to review regarding the future of this industry.

Attempts at officially prohibiting internet gambling have been made in the past. In the last session of the U.S. Congress several bills circulated regarding internet gambling, and one, the Internet Gambling Funding Prohibition Act, was actually passed by the House of Representatives. This law would have made it illegal for credit card companies to make transactions relating to internet gambling. This bill, however, was never voted on by the Senate. Despite the fact that the bill was never signed into law, several credit card companies have taken action to prevent their cards from being used at internet gambling websites. Bank One has enacted a policy to no longer process transactions from websites that it can identify as internet gambling businesses. J.P. Morgan Chase, Discover, and American Express also attempt to block internet gambling transactions whenever possible (Ahles, 2003). The effectiveness of such attempts vary among companies and internet gambling websites. In 2003, PayPal settled a disagreement with the U.S. Attorney's office regarding assisting in the funding of online gambling activity. The settlement included a \$10 million payment to the federal government but "no admission or finding of criminal activity" (Simonson, 2003). PayPal, which is now owned by Ebay, recently began fining customers who use the payment service for prohibited activities, including online gambling, up to \$500 (*Wall Street Journal*, 2004, September 14). Payment methods are a controversial aspect of the internet gambling industry even though an official law has not been made regarding the issue.

One state, North Dakota, has recently attempted to set forth a law regarding online poker. North Dakota State Representative James Kasper proposed HB 1509, the Internet Poker Bill, which proposed legalizing and regulating online poker in the state of North Dakota. This law would require an annual licensing fee for players and operators and would accept bets from the other 49 states in the U.S., with the exception of states making a legal objection to such activity (Humphrey, 2005). Representative Kasper predicted that this bill would create \$40 million in revenue for the state of North Dakota. Although the bill passed North Dakota's House of Representatives, a letter received from the Department of Justice might have influenced the vote in the Senate. In response to a request for clarification regarding

federal law on the issue, the DOJ sent a letter to North Dakota Attorney General Wayne Stenehjem, stating that the law would in fact violate the Wire Act, Travel Act, and the Anti-Gambling Act (Smith, 2005). Despite several attorneys' testimony that the federal laws apply only to sports gambling, the North Dakota Senate defeated the bill by a vote of 44-3, squashing the chance of establishing legalized online poker in North Dakota (*Interactive Gaming News* 2005).

Georgia, like North Dakota, is debating an internet gambling issue. A 2005 bill, HB 346, was recently passed by the Georgia House of Representatives which would allow the sale of lottery tickets online. In order to participate, a person would go to a Georgia lottery retailer, present a driver license and social security card to prove eligibility to play, and pay a \$3 application processing fee. Once a player is deemed eligible and establishes an account through the website, he or she would be able to participate in the Georgia lottery through a Georgia lottery website, paying with certified funds, a debit card, or other electronic transaction. In an attempt to gain support from existing retailers who feared that access to the lottery through the internet would result in a loss of business, retailers who originally register participants to play online would be compensated "in an amount not less than 1% of the total amount spent online by an individual who initially registered...from that retailer's place of business" (Georgia HB 346, 2005). This bill has been reviewed by the Georgia Senate, and it is currently awaiting a vote by that body.

The international environment is also rapidly changing. While federal, state, and case law seems to be lacking definitive prohibition of online gambling, international laws and laws of other countries are also unclear. Several countries are similarly struggling with the question of whether to regulate or altogether prohibit online gambling. The United Kingdom is currently addressing this issue. The Gambling Bill, which has passed the Parliament and is currently waiting to be signed by the Prime Minister, would create an overhaul of the United Kingdom's existing gambling laws, including laws regarding internet gambling. Currently, residents of the United Kingdom can participate in online gambling but cannot establish internet gambling operations. This proposed law, however, would change existing law by both permitting residents to gamble through "remote technologies" (which include telephone, internet, television, radio, and any other communications technology) and also allowing a Gambling Commission to grant licenses to establish remote gambling operations (Department for Culture, Media and Sport, 2004). As proposed in the bill, the United Kingdom Gambling Commission would be able to grant licenses to remote operators, which would include certain specifications regarding the operator's ability to prevent underage gambling (House of Commons Gambling Bill, 2004). Certainly, this law, if passed, would be a huge victory for internet gambling operators. It will also be interesting to view the reaction by opponents of internet gambling in the United States. If the United Kingdom

is able to effectively regulate online gambling, it is likely that other countries will follow its lead.

**Conclusion:**

There are many laws in the United States which could be interpreted as prohibiting internet gambling, but there has not yet been a definitive court ruling or legislative action supporting that interpretation. Additionally, current events in the internet gambling industry have varying implications for the status of internet gambling in the United States. As indicated by the events in North Dakota and Georgia, this issue will most likely be brought up in other states interested in establishing a presence of some kind in the online gaming industry. It is also clear that laws vary immensely from state to state, so it seems logical that the United States Congress might need to step in at some point to create a definitive law that would prevent confusion and conflict resulting from differing laws across state borders. On the other hand, gambling has traditionally been a state issue, and Congress may continue to allow individual states to determine internet gambling laws as well.

The international arena also poses challenges for the United State's current stance of prohibition. The World Trade Organization's recent ruling upholding its original ruling that the official U.S. opinion on internet gambling violates trade rules is in direct opposition to the United States. Additionally, once the United Kingdom's Gambling Bill is officially signed into law, the United States may be forced to defend its opposition to United States citizens' participation in internet gambling in much the same way it had to in the Antigua and Barbuda disagreement.

This paper has discussed many of the issues surrounding internet gambling, including the influence of United States state, federal, and case laws, as well as international laws, on the industry. A survey of college students was also presented and analyzed and there was a discussion of the benefits and drawbacks of prohibition and regulation of internet gambling. Overall, the industry seems to be "buyer beware" at the moment. A lack of regulation leaves players vulnerable to dishonest operators, and the lack of a definitive law leaves website operators open to prosecution. Despite these risks, adults, including college students, are gambling because website operators are willing to provide that service to players in the United States and around the world.

**Appendix 1: List of Reviewed Internet Gambling Websites**

1. [www.partypoker.com](http://www.partypoker.com)
2. [www.cybersportsbook.com](http://www.cybersportsbook.com)
3. [www.sunvegas.com](http://www.sunvegas.com)
4. [www.wildjack.com](http://www.wildjack.com)
5. [www.888casino.com](http://www.888casino.com)
6. [www.sportingbet.com.au](http://www.sportingbet.com.au)
7. [www.freelots.com](http://www.freelots.com)
8. [www.ultimatebet.com](http://www.ultimatebet.com)

9. [www.jackpotjoy.com](http://www.jackpotjoy.com)
10. [www.bingocabin.com](http://www.bingocabin.com)

**Appendix 2: List of Countries that License Gambling Operators**

1. Kahnawake
2. Tasmania
3. Australia
4. British Channel Islands (Alderny)
5. Hong Kong
6. Vanuatu
7. Antigua & Barbuda
8. Malta
9. Isle of Man
10. Curacao
11. Panama
12. Denmark
13. Estonia
14. Luxemborg
15. Netherlands Antilles

**Appendix 3: Internet Gambling Survey**

Sex: M F

Age: 18-20 21-25 26-29 30+

1. Have you ever gambled (with actual money, as opposed to credits or chances to play additional games) using an internet website?

- Yes
- No

If you have never gambled on an internet site, please skip to question 7.

2. If you gamble on the internet, how often?

- Seldom. No more than 5 times per year.
- 1-5 times per month
- 5-10 times per month
- 10-20 times per month
- More than 20 times per month

3. When you gamble on the internet, how much time do you spend at one session?

- Less than 30 minutes
- 31-59 minutes
- 1-2 hours
- 3-6 hours
- More than 6 hours

4. Each time you gamble on the internet, how much money do you win or lose on average?

- Lose more than \$100
- Lose \$1-\$99
- Break Even (Lose \$0, Win \$0)
- Win \$0-\$99
- Win more than \$100

5. When you gamble on the internet, do you ever worry that you will not receive your winnings from the website?

- Yes
- No

6. When you gamble on the internet, what kinds of gambling do you do?

- Casino Games (Blackjack, etc.)
- Sports Betting
- Poker
- Other ( Specify ) \_\_\_\_\_

7. Do you think it is legal in the United States for a person to gamble on the internet?

- Yes
- No
- Not Sure

8. Would you gamble on the internet if you were certain that it was illegal?

- Yes
- No
- Not Sure

9. Do you gamble using any traditional methods, such as lottery tickets or casinos?

- Yes
- No

#### Endnotes:

<sup>1</sup> See Appendix 3 for complete statute.

<sup>2</sup> Discovery Communications claims that \$3.25 million received from Tropical Paradise, a Costa Rican casino operator, to run advertisements during the Travel Channel's (a division of Discovery Communications) World Poker Tour Channel's was seized by United States marshals. Tropical Paradise is now suing Discovery to recover the money

#### Faculty comment:

Professor John Norwood was extremely complimentary about Ms. Wells' work. He said,

I am pleased to support the submission of the paper "Internet Gambling: Fair Game in the United States," by Brandice Wells, for publication in Inquiry. I worked with Brandy on this project, and observed first hand her diligence, professionalism, and attention to detail. The resulting paper is both original and thorough, and one of the finest undergraduate papers I have ever read.

Brandy's paper is in three parts. In the first part she reviews the many federal and state laws that are

potentially applicable to internet gambling. In her complete thesis she discussed all of the federal laws that might apply, but for purposes of brevity in this version of the paper she discusses only the federal Wire Act. Her conclusion is that no federal law specifically addresses the issue of internet gambling, and although the federal government has taken the position that such activities violate federal law, this is not universally accepted. In the second part of the paper she discusses the few cases which have been decided that involve internet gambling. Once again the legality of such activities is open to debate.

The third part of Brandy's paper is the most interesting. This is where she presents the result of a survey that she took of University of Arkansas students. She surveyed more than 250 students, from undergraduates to law students. Her findings provide some insight as to the number of college students who engage in internet gambling, the kinds of wagers that they make, and the amount of money that they win or lose. So far as I know such a survey has never been conducted on this campus, and the information revealed is both interesting and disturbing.

In summary, this is a truly outstanding project by a superior student. In fact, Brandy was recently named the Outstanding Graduating Senior of this college, and is also graduating Summa Cum Laude and as a First Ranked Senior Scholar. I would say that she is in the top ten of all students I have encountered in my 32 years of college teaching.

## **ECONOMIES OF SCALE IN THE US TRUCKLOAD INDUSTRY**

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### **Introduction :**

The relationship between firm size and the unit cost of production in an industry is important in the development of company growth strategies as well as the formulation of public policy. Three general relationships are acknowledged between unit costs and output: increasing returns to scale (also referred to as economies of scale); constant returns to scale; and decreasing returns to scale (also referred to as decreasing returns to scale). If economies of scale exist in an industry, other things being equal, unit costs would decline as the average firm size in the industry increased. Thus, firms within the industry would find a growth-oriented policy would be desirable. From a public policy perspective, if larger firms are more efficient, then policy makers should encourage growth and mergers. Larger more efficient companies would be able to offer lower cost products or services to the public, increasing the total benefit from trade. If this is the case, government should provide a regulatory environment to monitor the behavior of firms to prevent the loss of competition and possible monopolistic exploitation. There must be protection so that the surviving companies would not exploit the consumer and decrease the total benefit to society. If economies of scale do not exist, it should not matter whether a firm is large or small; small companies should be able to effectively compete with larger ones. Firms should focus on the efficiency of their operations, and government policy should be at a minimum, leaving the industry to the natural forces of competition (Boyer 1998). This issue has been studied extensively in the United States domestic trucking industry, and while the general belief is that there are no returns to scale in the industry, there are inconsistencies in the findings of some studies, which suggest that further analysis is necessary. Furthermore, the majority of studies focus on the less than truckload (LTL) sector (Kling 1990; Corsi, Grimm, and Feitler 1992; Harmatuck 1992), and very little research has focused on the truckload (TL) sector. There have also been many changes in the industry since the most recent studies were published. Anecdotal evidence suggests that the industry is changing. In an era of intense competition, larger firms are growing much faster than smaller ones, and smaller firms are failing at a faster rate than the larger ones,

leading to an increasing gap between the top ten carriers and the rest of the industry. Thus, it is important to re-examine the issue.

The purpose of this paper is to attempt to assess whether or not economies of scale exist in the domestic truckload industry. First, a review of the literature concerning economies of scale in the truckload industry is presented. Then, recent DOT data is analyzed to discover whether or not there is a relationship between size and unit costs, and, finally the implications of the findings are discussed.

### **Past Research:**

Keaton (1978) reviewed the early literature on scale economies in trucking and found conflicting evidence as to their existence. Corsi, Grimm, and Jarrell (1989) also found conflicting evidence in an excellent review provided as part of their study. In their study, they found that economies of scale do not exist in either the LTL or the TL segments both before and after deregulation. They used three output variables; ton miles, average load, and average size. Corsi, Grim, and Jarrell took into account four price variables; fuel, labor, purchased transportation, and capital. They found that higher average loads decreased costs per unit, but this is inherent in the model.

It is relevant to know the priorities of shippers with regards to carrier selection, because it will impact the service variable. A broad study of shippers was conducted by McGinnis (1990), and service was found to be more important than price when it comes to carrier selection. He found that since deregulation, price has become more significant, but that service remains the number one priority. Since the study by McGinnis, a greater emphasis has been placed on controlling inventory levels. Lower inventories would rely on consistent service and lower transit times. This reinforces the importance of service over price, as the higher transportation costs would result in a lower total costs for the company.

Harmatuck (1992) found that the LTL industry had increasing returns to scale since deregulation when controlling

for service. In his study, the cost of service as a percentage was higher than the added revenue large carriers receive for providing higher levels of service, thus making service levels negate economies rather than hide them. According to his study, large LTL companies need to provide a higher level of quality, but they need to make sure they charge for it so that scale economies can be exploited. Harmatuck's article contradicts the general belief that economies of scale do not exist in the LTL industry, however he did not find evidence of a direct negative relationship between size and costs. The study also points to a decrease in elasticity in the truckload industry, thus reinforcing the importance of service to shippers.

Allen and Liu (1994) also considered service in their analysis. They said that to accurately evaluate economies of scale in the LTL industry one must account for costs of service. If the service variable is omitted, the research could hide scale economies of large carriers. If economies of scale exist in the truckload industry, carriers have the option of spending the cost advantage on service to gain a competitive advantage or to offer similar service at a lower cost (Allen and Liu 1994). Given the research by McGinnis, one can assume that large motor carriers would opt for spending their returns to scale on service. Allen and Liu (1994) used annual shipper data to control for service levels. They found that, when service was accounted for, economies of scale were present in the LTL industry.

Xu et al. (1994) also analyzed costs in the LTL industry. They found constant returns to scale if output characteristics were held constant. They say that the advantage that large LTL carriers have is the ability to attract longer hauls and heavier trucks. Therefore, it is not fair to hold output characteristics, average length of haul and average load size, constant as they are the reason for increasing returns to scale (Xu et al. 1994).

Adrangi et al. (1995) tested the issue of economies of scale from a profit function approach. They used data from 1979 and 1984 to conduct a pre and post deregulation study. They found that the industry can be characterized by constant returns to scale, and that no major costs benefit could be obtained through mergers.

Past research on the topic of economies of scale in the motor carrier industry is somewhat inconsistent and remains incomplete, especially with respect to the truckload segment. Many studies have not accounted for safety or administrative overhead. Past research is also dated; more recent data should be analyzed to reassess the issue of scale economies because the industry is changing. Large carriers are growing disproportionately to the industry average. Capacity constraints are indicative of emerging barriers to entry. Entrants into the market are being dissuaded by higher fuel prices, lack of driver availability, higher insurance costs, and more expensive equipment due to recent emission standards (Abt 2004; Long 2004). Growth in the top carriers and the industry since the time of the last analysis is displayed in Table 1.

Table 1: Carrier Growth

Company	Percentage Increase 1989-2002
J. B. Hunt Transport, Inc.	341%
Werner Enterprises, Inc.	433%
Ryder Integrated Logistics, Inc.	452%
Industry Average	46%

Source: Technical Transportation Services, Inc. 1989-2002.

**Methodology:**

The Methodology will be discussed in three parts. First, the model will be explained. Second, variables and hypotheses will be discussed. Third, the data used in the analysis will be described. The statistical technique used was the Linear Regression module in the Statistical Package for the Social Sciences (SPSS).

**The Model:**

The cost per ton-mile is given by the function:

$$\text{Costs/TMI Exp/TM} = f(\text{Ton-Miles, RSP, ALH, ALS, ADE, DRE, INE})$$

Where:

**Exp/TM** = Total Expense per Ton-Mile

**Rev/Ship** = Revenue per Shipment

**Ave LH** = Average Length of Haul

**Ave Load** = Average Load Size

**Admin/Exp** = Administrative compensation as a percentage of total expenses

**Driver/Exp** = Driver Compensation as a percentage of total expenses

**Ins/Exp** = Insurance Expense as a percentage of total expenses

Many of the variables used in this model are repeated in past research; however most models from previous research were under specified. To gain an accurate picture of economies of scale in the truckload industry one must account for safety and administrative overhead. This model will use insurance as a percentage of total expense as a surrogate for safety. The administrative compensation per expense will be a measure of managerial efficiency.

The relationships between the dependent and independent variables are expected to be non-linear. This suggests that the model should be multiplicative and in the form:

$$(1) Y = a X_1^b X_2^c X_3^d \dots X_n^p$$

The multiplicative form reflects curvilinear relationships, but the parameters are linear when in natural logarithmic form. Therefore, converting the data in natural logarithms will permit ordinary least squares estimation of equation (1) by:

$$(2) \ln Y = \ln a + b \ln X_1 + c \ln X_2 + d \ln X_3 + \dots + p \ln X_n$$

The estimated parameters of equation (2) are the exponents of the respective variables. This permits direct interpretation of the relationships between the variables even though the data are in logs (Ozment and Chard 1986).

### Variables and Hypotheses:

The relationship between ton-miles and cost per ton-mile will answer the question as to whether there are economies of scale in the truckload segment of the motor carrier industry. A company with more ton-miles should have a lower cost per ton-mile if everything else is held constant (Corsi, Grimm, and Jarrell 1989; Harmatuck 1992; Allen and Liu 1994; Allen and Liu 1995; Boyer 1998). Other output characteristics include average load size and average length of haul. A higher average load size will decrease the cost per ton-mile as will a higher average length of haul. A high average load size will decrease cost per unit, but will not give us insight into the profitability of a truckload firm. The rate structure is given by shipment instead of by pound. A higher average length of haul could yield a cost advantage due to fuel and time efficiencies. Drivers spend more time on the road rather than at shipper's docks.

To discover whether or not returns to scale exist in the TL industry, we must control for the cost of service. All things held constant, the higher the revenue per shipment the higher the expected level of service. Given McGinnis's study on shipper priorities, larger carriers would spend possible scale economies on service rather than offer a lower price. However, Harmatuck's (1992) study suggests that larger carriers should charge a premium for their increased service rather than keeping the same price as competitors. Using this theory, one would expect that an increase in the revenue per shipment would raise the cost/tonmile.

Insurance should be a significant factor in returns to scale. Larger carriers can pool their risks and are more predictable than smaller carriers when it comes to accidents and damage. Larger companies can afford better safety programs that would help their insurance rates as well. All of these factors could lead insurance companies to lower their insurance rate per ton-mile for larger carriers. This would give larger carriers a cost advantage. Another advantage larger carriers should have with regards to insurance is the administrative cost of the insurer. If insurance rates are held constant, large carriers still have an advantage because it costs less for the insurer to manage one account rather than several hundred. Given these possible advantages, insurance costs should fall per unit as the ton-miles of the carrier increase. Insurance rates will be calculated as a cost per expense.

Driver compensation as a percentage of total expense should provide insight into the effects of driver pay on turnover. Driver turnover has become an increasing problem within the industry. Driver turnover for the industry is currently over 130% (Guido 2005). The costs to hire a driver averages around \$5,000. With average operating ratios hovering around .98, carriers cannot afford the extra expense. In theory, if a carrier raises driver pay more drivers would be attracted to work and stay with that carrier, given they receive a sufficient amount of miles. Using a total cost approach, raising driver pay could lower the costs per ton-mile due to a decrease in driver turnover.

Administrative overhead costs could also be an advantage for larger carriers. Administrative expenses can be minimized by larger carriers because of their ability to allocate the maximum number of people a manager can manage effectively. Smaller carriers will need a manager regardless if they have the optimum number of trucks or not. Larger carriers are also able to streamline their processes by hiring specialized managers in different aspects of the business, where a small carrier manager would have to take on many managerial functions regardless if he is trained or not. This should lead to greater inefficiency.

Refrigerated carriers carry higher costs of maintenance, insurance, and capital equipment. This has the potential to skew the data, therefore a dummy variable for refrigerated carriers must be included in the initial linear regression to test the significance of the variable.

### Data:

The data used in the study was obtained from the Department of Transportation (USDOT) from data submitted by individual carriers. It covers the years 1999-2002 and includes 1,808 observations. The entire data set originally consisted of over 26,000 entries; however, all LTL and House Hold Goods carriers were eliminated, as they are not included in this study. Carriers which only had one or two data entries over the four year period were also eliminated. The next procedure was to remove data that was obviously inaccurate due to faulty reporting or no reporting at all.

The costs per ton-mile were calculated by dividing total expenses by ton-miles. The average load size was calculated by dividing the total number of shipments by total tons. The total number of shipments was obtained by dividing total highway miles by the average length of haul. Average length of haul was calculated by dividing ton-miles by total tons shipped. An alternate average length of haul was obtained by dividing total highway miles by the total number of shipments. Revenue per shipment was calculated using both the reported total number of shipments and the alternate calculation for total number of shipments, with the latter taking precedence. Descriptive statistics of the data sample are shown in Table 2.



Table 2: Descriptive Statistics of the Data

	Gross Rev	Op Ratio	Exp/TM	Ton Miles	Rev/Ship
Min	2,554,708	0.6481	0.0216	3,361,482	100
Max	2,247,885,805	1.2949	1.9677	32,556,083,120	8836
Mean	36,297,852	0.9844	0.1331	396,801,249	869
Median	10,629,118	0.9846	0.0831	119,520,000	688
Std dev	145,146,860	0.0539	0.1710	1,611,667,219	656

	Ave LH	Ave Load	Admin/Exp	Driver/Exp	Ins/Exp
Min	50	1.0	0.0000	0.0000	0.0000
Max	2575	30.0	0.2808	0.5784	0.1371
Mean	588	17.3	0.0589	0.1777	0.0388
Median	455	18.0	0.0550	0.1967	0.0367
Std dev	457	5.6	0.0327	0.1077	0.0174

**Empirical Results and Review of Hypotheses:**

A linear regression was run with the data in natural logarithmic form using SPSS (Statistical Package for the Social Sciences); the model explained over 99% of the data set with a .00000 level of significance. Thus, the model is very accurate in explaining the variation in unit costs from the sample. Given the large sample size and the statistical significance, this model can be seen as a solid picture of the TL segment of the industry. Table 3 displays the significance of the model. The dummy variable for refrigerated carriers was found to be insignificant and was omitted in the final regression.

The coefficients of the model reveal the relationships between the independent variables and unit costs. The measure of size, ton-miles, has a negative relationship with expense per ton-mile. This is indicative of increasing returns to scale, thus supporting the hypothesis. Revenue per shipment is almost a one for one positive relationship with expense per ton-mile, meaning that an increase in revenue from service is almost completely negated by the costs of service. The administrative expense as a percentage of total expense has a weak positive relationship with expense per ton-mile; this signifies that large carriers have

Table 3: Regression Analysis

R	R Square	Adjusted R Square	Std. Error of the Estimate	F	Sig.
0.996	0.991	0.991	0.060	15206	0.0000

Table 4: Coefficients

Independent Variable	Un-standardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	0.1716	0.0295		5.82	0.0000
Ton Miles	-0.0127	0.0015	-0.0232	-8.33	0.0000
Rev/Ship	0.9886	0.0039	0.9509	251.88	0.0000
Ave Haul	-0.9834	0.0033	-1.1882	-294.67	0.0000
Ave Load	-0.9817	0.0037	-0.6867	-267.17	0.0000
Admin/Exp	0.0060	0.0030	0.0048	1.98	0.0474
Driver/Exp	-0.0041	0.0018	-0.0054	-2.24	0.0253
Ins/Exp	0.0054	0.0030	0.0045	1.82	0.0690

no advantage with regards to managerial efficiency, thus rejecting the hypothesis. The driver compensation per expense has a negative relationship with expense per ton-mile. This may contradict the traditional belief that driver pay will not affect the turnover rates for a truckload firm. This finding would only be relevant holding all things constant. If a firm raises pay but does not provide sufficient miles to the drivers, then their turnover rates will not be positively impacted. Table 4 displays the coefficients and significance levels for the independent variables.

**Implications:**

This analysis has serious implications on the truckload industry. Recent sweeping changes have given larger carriers a cost advantage. While the relationship between size and unit cost is statistically significant, the size of the coefficient is relatively small, suggesting that the industry is still going through change. Barriers to entry into the industry are emerging due to the driver shortage, rising insurance costs, fuel prices, and emission standards. If the current trends continue, larger carriers will seize greater shares of the market and perhaps realize even greater increasing returns to scale. The overall affect will be a more efficient market, as long as sufficient competition remains.

The present state of the industry requires no economic regulation from the government. At this point, government should encourage mergers and acquisitions, which should lower the overall costs of truckload transportation. As the larger carriers become dominant, government should focus on facilitating competition so that their power is not abused. As larger companies begin to realize greater returns to scale it will be increasingly hard to maintain a competitive advantage as a smaller carrier. Therefore, corporate strategies should focus on growth and strong mergers.

The study also suggests that the driver turnover problem that currently plagues the industry can be remedied in part by increasing driver wages. The costs of hiring drivers outweigh the savings due to lower wages, holding all else constant. It is important to note that if companies increase driver wages, then they must maintain driver miles. If they fail to give the driver adequate miles, then drivers will not earn more money, and the firm may suffer from the same turnover rates with higher labor expenses, leaving it at a competitive disadvantage.

The relationship between revenue per shipment and expense per ton-mile suggest that minimal gains can be realized if a carrier provides higher service. However, this variable does not take into account the marketing advantage a carrier gains due to service. Superior service makes a carrier very attractive to shippers because of their ability to lower inventory. With the marketing advantage, carriers with high service levels should be able to pick and choose favorable routes that can get their drivers home and provide backhauls.

It was found that larger carriers may not have insurance cost advantage. One explanation may be the potential for harsh punishments resulting from lawsuits. If large carriers suffer from harsher penalties than smaller carriers, insurance companies will charge them higher rates due to an increase in risk.

The data also suggests that larger carriers do not have an advantage with regards to administrative costs. This can be rationalized by the fact that some large carriers invest in management positions that are geared toward providing more favorable routes. Administrative overhead could be a tradeoff for an advantage gained through less driver turnover and more backhauls.

### Potential for Further Research:

Many questions arise after this analysis of economies of scale in the truckload segment of the motor carrier industry. Further research is needed on higher average load size and profitability. The cost structure of the truckload industry is a flat rate per shipment. Therefore, a lower average load size should increase the profitability of the carrier. Empirical evidence is needed to determine if this is an accurate statement. Further research is also needed into the affect of average length of haul on driver turnover. This could yield a hidden advantage to firms with shorter hauls; because it could increase the time drivers get to spend with their families given they are provided backhauls to their home base. A study into the affect of driver pay on turnover is warranted given the results in this analysis. Administrative overhead is an advantage that large carriers are not taking. A study should be conducted on how large carriers can streamline management and what is keeping them from it.

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### Faculty comment:

Dr. John Ozment, Mr. Bradford's mentor, said of his student's work:

Adam Bradford's paper potentially provides a very important contribution to the transportation literature. The issue of whether there are economies of scale in the truckload segment of the trucking industry is very timely and has implication for managers of trucking firms as well as government policy makers. While previous studies did not find evidence of economies of scale, it has been several years since those works were published, and there was reason to believe that results may now be different. His study found that the extremely large truckload carriers apparently have a cost advantage over smaller carriers.

Adam put an unbelievable amount of time and effort into the study. In addition to the amount of reading, which was more than sufficient for an honor's thesis, he had to pour through thousands of the U.S. Department of Transportation's records of trucking companies to develop the data base he used. He also had to reach a level of competence in the use and interpretation of statistical techniques for the analysis that is far beyond the grasp of most undergraduate students.

## **SECTION III: SCIENCE AND ENGINEERING**

**ANIMAL SCIENCE, BIOLOGY, CHEMISTRY, COMPUTER  
SCIENCE AND COMPUTER ENGINEERING, ELECTRICAL  
ENGINEERING, AND HORTICULTURE**

## USE OF CALCIUM HYPOCHLORITE AS A SANITIZER FOR SEEDS USED FOR SPROUTING: TASK # 2

### IMPACT: IMPROVED ALFALFA DECONTAMINATION TECHNOLOGIES

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#### Abstract:

Consumption of raw or lightly cooked alfalfa sprouts has been a concern of the U.S. Food and Drug Administration (FDA) in recent years due to connections between sprouts and food-borne illnesses. Researchers have identified contaminated seeds as the primary source of alfalfa sprouts contamination. Contamination of alfalfa seeds can originate in the field, harvesting, storing, or sprouting. Two pathogens of particular concern on alfalfa seeds are *Escherichia coli* O157:H7 (*E. coli*) and *Salmonella*. These pathogens are capable of producing biofilms that provide protection for individual cells and allow for survival in otherwise hostile environments, including some disinfectant washes. Other factors that contribute to contamination are the crevices of the seed surface, which provide opportunities for the protection of organisms. Various disinfection options have been evaluated and the use of a 20,000 ppm calcium hypochlorite ( $\text{Ca}(\text{OCl})_2$ ) solution is the most effective disinfectant for satisfying the requirements of Task 2.

Continued outbreaks of food poisoning indicate current disinfecting procedures are inadequate. In an effort to improve disinfection procedures, three bench scale apparatuses were constructed and tested to provide options for the commercial range of seed sanitation rates (from about 75 to 600 lb/week). Experiments were conducted to determine the disinfecting effectiveness of the apparatuses, as well as the current sanitization practices in industry. Experiments included dye removal tests where non-uniform dye removal indicated ineffective contacting. Similar experiments were performed using *E. coli* inoculating and post-contacting culturing.

One bench scale apparatus constructed was a model of the rotary drums widely used in industry. After a 30 minute treatment in the rotary drum, the seeds were found to be free of dye, indicating good contacting. The seeds were also sprouted showing sanitation did not damage the seeds. However, due to

the capital expense of \$14,000, the drum is not a viable option for small-scale sprout producers. For sprout growers who currently own rotary drums, drum use is recommended for seed sanitation.

Another bench scale apparatus was designed to improve the current industry practice of hand dunking seed-filled mesh draw-string bags. Through experimentation, it was determined the current hand dunking procedure, with little or no agitation, produces inadequate, non-uniform contact of the seeds and sanitizer. Therefore, the hand dunking procedure was modified to include agitation to effectively suspend the seeds throughout the bag to obtain good contact of the sanitizer solution with the seeds. The agitation-in-bag method is recommended for use in small volume sprout facilities, which currently employ the hand-dunking procedure for sanitizing. A modest investment of \$113 is needed to implement the agitation-in-bag sanitizing method. Since no additional operating costs are accrued in implementation, no incremental costs are required.

Finally, an auger system was designed to sanitize one ton per hour of alfalfa seeds. The one ton per hour rate exceeds the demand of any individual sprout producer. Thus, the auger system is applicable to a partnership of sprout growers. Individual sprout growers within the mung bean industry, with much larger production volumes than the alfalfa industry, could economically use the auger system. However, the auger system can be scaled to sanitize any feed rate. A 1 3/8" diameter, 4' long auger bench scale model was constructed and tested at 4.5 lbs/hr rate with a contact time of 15 minutes. Scale-up of this bench scale sanitizer to a 2000 lb/hr rate requires a 16" diameter by 20' auger. The entire full-scale sanitizing system, which includes a vibrating screen washer, will handle 5,000,000 lb/yr of seeds, operating 8 hr/day, with a capital investment of \$227,000 and an incremental operating cost (primarily labor) of \$214,000/yr.

## Introduction:

Alfalfa seeds are produced primarily in the U.S., Australia, and Canada<sup>1</sup>. In the U.S. alfalfa seed is primarily grown in the northwestern states of California, Idaho, Nevada, Oregon, Washington, and Wyoming<sup>1</sup>. Only a small portion of the seed produced is sprouted; the primary use of seed is to grow forage for the livestock industry. California is a major producer of sprouts in the U.S., accounting for \$6.9 million of revenue to producers in 2000<sup>2</sup>. Current federal regulations for the sprout industry were written in a joint effort by the FDA and the California Department of Health Services (CDHS); therefore, the proposed design is targeted for implementation into a facility in California. Similarly, while sprouts are produced elsewhere in the world, the research presented is based on U.S. sprout growers only.

Most sprout associated illness outbreaks occur because of contaminated seed<sup>11</sup>. Contamination of seeds can occur during growth in the field, harvesting, storing, and sprouting. Sources of contamination have been found to be present in un-sanitized harvest equipment, conditioning equipment, and seed storage areas of the sprouting facility. Additional sources of contamination can also be the product of untreated irrigation water, animal waste, insects and other pests, and worker hygiene<sup>1</sup>. Localized contamination can easily be spread throughout the seed lot. Any damage to the seed coat by processing equipment could make the removal of microorganisms during subsequent steps more difficult.

### Overview of Sprouting Industry

The sprouting industry consists of approximately 300 U.S. sprout growers. The largest scale producers include about 50 companies, which sanitize between 300 to 600 lbs of alfalfa seed per week, producing 3000 to 6000 lbs of sprouts per week<sup>41</sup>. The average sprout grower sanitizes about 75 lbs of alfalfa seed per week, producing 750 lbs of sprouts per week<sup>41</sup>. Given the range of demographics among sprout growers, three separate apparatuses were constructed in order to address the demands of the full range of sprout growers.

### Alfalfa Seed Morphology

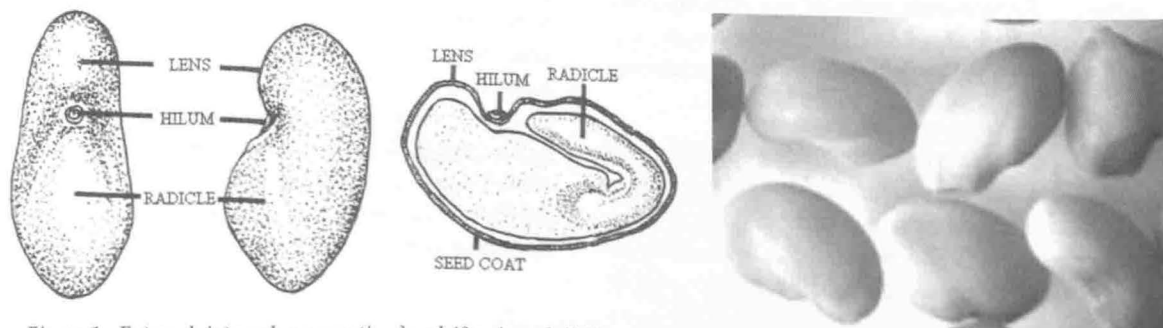


Figure 1. External, internal cross-section<sup>3</sup> and 40x view of alfalfa seed

The morphology of alfalfa seed was studied to determine characteristics that might hinder the sanitization process. Alfalfa seed is yellowish-brown, kidney-shaped, and 1/12" long by 1/24" wide<sup>3</sup>. The alfalfa seed contains a lens, a small bump on the seed coat, which is the weakest point of the palisade layer of the seed and provides an easy entry point for water into the seed during germination<sup>4</sup>. Also, the seed coat of alfalfa seed is rough and creviced in comparison with other sprouted seeds, increasing the potential for contamination<sup>5</sup>. These surface crevices and seed coat imperfections provide sites where pathogens are concealed from the sanitizer solution.

### Foodborne pathogens

Alfalfa seeds are commonly contaminated with *E. coli* and *Salmonella*, thus understanding the characteristics of these bacteria is important to sanitizing the seeds. *E. coli* and *Salmonella* are similar organisms. Both are prokaryotic, rod shaped, gram-negative bacteria with 90% of the same DNA<sup>6</sup>. The bacteria can double in number in as little as half an hour<sup>7</sup>. Optimal growth occurs between 25-40°C and neutral pH which are the conditions used for sanitization. But the bacteria can grow in extremely harsh conditions, including temperatures as low as 4°C and pH as high as 9.0. *Salmonella* is harder to kill than pathogenic strains of *E. coli* and requires a stronger or longer dose of the sanitizer to achieve the same kill level as *E. coli*. The bacteria have the ability to attach to the surface of a host. The surfaces of both alfalfa seeds and bacteria have a negative charge, which repel the attempts of the bacteria to attach to the alfalfa seeds. In order to overcome the negative charge, bacteria use a hydrophobic quality to attach to the hydrophobic seeds and pili to cover the surface of the bacteria<sup>8</sup>. Also, colonies of bacteria form biofilms on the seeds or equipment, which are highly resistant to sanitizers, protect the cells inside and provide nutrients. Given these obstacles, the alfalfa seed is difficult to effectively sanitize.

### Current Sanitizing and Sprouting Facilities

Before improving the current sanitizing practices in industry, the procedures of several sprout growers were investigated to determine whether sources of error or contamination existed.

Before the seeds are sanitized, the seeds are washed to wet the seed coats and to remove any dust<sup>9</sup>. In one sanitization cycle, small volume companies disinfect approximately 12 lbs of seed. The seeds are placed in a mesh bag and soaked in either a stainless steel or plastic tank (varying in size from 20 to 50 gallon) for 15 minutes in a 20,000 ppm Ca(OCl)<sub>2</sub> solution. The seeds are agitated periodically throughout the soaking process by using a paddle or by manually lifting the bag and replacing it in the solution. After sanitation, the seeds are rinsed until the chemical residue disappears and the chemical odor is gone. Some companies will then soak the seeds for two hours to assist germination, while others proceed directly into germination. Forty-eight hours into the sprouting process, companies collect spent irrigation water samples to be tested for the presence of pathogens. With the basis of the current procedures, improvements can be made to avoid contamination of the alfalfa seeds.

#### *Outbreaks resulting from Alfalfa Sprouts*

There has been increasing concern in the past decade regarding the consumption of raw sprouts due to the occurrence of outbreaks in the U.S. Approximately twenty *Salmonella* outbreaks, involving two deaths, and two *E. coli* outbreaks have occurred since 1994<sup>10</sup>. Outbreaks have persisted despite sanitizing recommendations by the FDA and the increased awareness of the potential for contamination of raw sprouts. Several of the outbreaks summarized in Table 1 trace the contamination of alfalfa sprouts to contaminated seeds. The 1999 *S. Mbandaka* outbreak strengthens the argument for the use of chlorine as a

disinfectant. Contaminated sprouts were traced back to a single seed lot that was shipped to sprout growers in California, Washington, and Florida. Out of six sprouting facilities, two did not use any form of disinfectant on the seeds and were linked to the outbreak<sup>10</sup>. However, the effectiveness of chlorine treatments has been questioned, since outbreaks have been linked to seeds that had been disinfected. In 2001, an outbreak of *S. Kottbus* was connected to seed that had been treated with heat and 2,000 ppm of sodium hypochlorite (NaClO)<sup>10</sup>. Also, a *S. Muenchen* outbreak in Wisconsin was linked to seeds that were treated with 20,000 ppm of Ca(OCl)<sub>2</sub>. Knowledge of the outbreaks due to the consumption of alfalfa sprouts establishes the fact that a problem exists with the current sanitizing procedures.

#### **Pathogen Removal and Treatment Techniques:**

Bacteria, whether on sprouts, on equipment, or in the wash water, must be killed or substantially eliminated by effective techniques. While all methods of sanitation of alfalfa seeds were evaluated, the most popular options are summarized in table 2. Ca(OCl)<sub>2</sub> is the most common method of treatment and is recommended by the fda for use on seeds in order to reduce populations of *e. Coli* and *salmonella*<sup>11</sup>. While there is no known seed disinfection treatment eliminating 100% of the pathogens without affecting the seed, using 2,000 to 20,000 ppm of Ca(OCl)<sub>2</sub> effectively reduces the microbial pathogen level<sup>11</sup>. Ca(OCl)<sub>2</sub> kills the bacteria by releasing free chlorine. The chlorine disrupts the cell membrane of the bacteria, disabling its ability to function

**Table 1. Selected Outbreaks Caused by the Consumption of Alfalfa Sprouts**

Year	Pathogen	Location	No. of Cases	Likely Origin	Comments on Treatment Used Prior to Sprouting
1997-1998	<i>S. Senftenberg</i>	CA, NV	60	Sprouter /Seed	Inconsistent Cl <sub>2</sub> treatment (Same sprouter as '98 <i>E. coli</i> outbreak) <sup>11</sup>
1998	<i>E. coli</i> O157:NM	CA, NV	8	Seed	Inconsistent Cl <sub>2</sub> treatment <sup>11</sup>
1998	<i>S. Havana/Cubana</i>	CA, AZ, MD, NM, UT	40	Seed	2,000 ppm Cl <sub>2</sub> for 30 min. then 300 ppm for a few hrs. (Consistency questioned) <sup>11</sup>
1999	<i>S. Mbandaka</i>	OR, CS, ID, WA	87	Seed	No disinfectant used <sup>12</sup>
1999	<i>S. Muenchen</i>	WI, 6 US states	157	Seed	20,000 ppm Ca(OCl) <sub>2</sub> <sup>13</sup>
2001	<i>S. Kottbus</i>	CA, AZ, CO, NM	32	Seed	Heat + 2,000 ppm NaClO <sup>14</sup>
2003	<i>S. Saintpaul</i>	OR, WA	9	Seed	Disinfecting treatment used. All test results for pathogens were negative <sup>15</sup> .

**Table 2. Techniques for the Disinfection of Alfalfa Seeds**

Treatment Method	Advantages	Disadvantages
Calcium Hydroxide <sup>18,19</sup>	<ul style="list-style-type: none"> <li>• 1% Ca(OCl)<sub>2</sub> and 1% Ca(OH)<sub>2</sub> gave similar reductions of <i>Salmonella</i></li> </ul>	<ul style="list-style-type: none"> <li>• Corrosive to skin and eyes</li> <li>• Respirators, protective clothing needed</li> <li>• Slightly higher cost than Ca(OCl)<sub>2</sub></li> </ul>
Ca(OCl) <sub>2</sub> <sup>18,20,21,22</sup>	<ul style="list-style-type: none"> <li>• Significant reductions of populations of <i>E. coli</i> and <i>Salmonella</i></li> <li>• Inexpensive</li> </ul>	<ul style="list-style-type: none"> <li>• Corrosive to equipment, skin and eyes</li> <li>• Respirators, protective clothing needed</li> </ul>
Irradiation <sup>11,22</sup>	<ul style="list-style-type: none"> <li>• <i>Salmonella</i> not found on sprouts treated with 0.5 kGy</li> <li>• Can be used to reduce pathogens on sprouts</li> </ul>	<ul style="list-style-type: none"> <li>• Pathogens detected on treated seeds used to produce sprouts</li> <li>• Dosage to kill pathogens exceeds FDA limits (&gt;5 kGy) and impacts sprouting</li> </ul>
Ozone <sup>22,23,24</sup>	<ul style="list-style-type: none"> <li>• Rapid dissociation to O<sub>2</sub> without by-products</li> <li>• Non-thermal option for sprouts</li> <li>• Kills organisms faster than chlorine</li> </ul>	<ul style="list-style-type: none"> <li>• Treatment of seeds does not significantly reduce populations of <i>E. coli</i></li> <li>• Large capital expense (\$3,500)</li> <li>• Unstable, must generate on-site</li> <li>• Not registered by CDPR for direct contact</li> </ul>

and to reproduce, thus killing the cell. The efficacy of chlorine compounds depends on the amount of hypochlorous acid present, which is dependent on the pH of the solution, the amount of organic material in the water, and the temperature of the water. Thus, it is desirable to maintain a pH of between 6.0 and 7.5 to ensure adequate hypochlorous acid activity to obtain optimum chlorine activity<sup>12</sup>. Ca(OCl)<sub>2</sub> is the preferred disinfectant because few other treatment options produce similar reductions of pathogen levels, and it is inexpensive and easy to handle environmental regulatory analysis.

### Environmental Regulatory Analysis:

#### Regulations and Guidelines

The Environmental Protection Agency (EPA) governs the use of pesticides, such as Ca(OCl)<sub>2</sub>, on raw agricultural commodities while the FDA has the authority over the residue of chemicals remaining on food. Ca(OCl)<sub>2</sub> is labeled as a pesticide since it is intended to be a sanitizer to kill pathogens on alfalfa seeds<sup>13</sup>. While alfalfa sprouts are consumed directly by humans, alfalfa seeds are still classified as food according to the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 321 (f))<sup>14</sup>. Due to this

classification, sprout producers handling both seeds and sprouts are considered food processors and must abide by the FDA's Title 21 of the Federal Code of Regulations. Food facilities are also required by the Act to register under the Public Health Safety and Bioterrorism Preparedness and Response Act in order to protect the public from a terrorist attack on the U.S. food supply<sup>15</sup>.

In California, the CDHS enforces the regulations stated in Title 21. Section 110 of Title 21 outlines proper Good Manufacturing Practices (GMPs) that should be implemented and followed in food manufacturing, packing, and storage by food processors. The GMPs help ensure that the processing facility and equipment are maintained in a manner to prevent food contamination. Contaminated food is deemed adulterated if it contains any poisonous substances that threatens human health when consumed<sup>16</sup>. The CDHS inspects facilities for proper GMP training and implementation on average once per year. The FDA will also inspect food facilities in California about once every five to ten years<sup>17</sup>. The FDA has also recommended Good Agricultural Practices (GAPs) under which the seeds should be grown to minimize contamination<sup>18</sup>.

The FDA also recommends a food safety program called the Hazard Analysis and Critical Control Point (HACCP) system,



which is built on the foundation of successful GMPs. The HACCP focuses on preventing potential hazards for food-borne contamination by applying a scientific method of controls and measurements in all aspects of the food production line. The seven principles of the HACCP call for food facilities to establish necessary operating procedures, sanitation standard operating procedures (SSOP), and recordkeeping methods enabling sprouts to be traced back to the production facility<sup>19</sup>. The FDA recommends that sprouting facilities both sanitize alfalfa seeds before sprouting and test spent rinse water in order to reduce the risk of pathogens on the sprouts. The use of a pesticide for treatment of foods is regulated by both the federal EPA, the California Department of Pesticide Regulation (CDPR) and the California County Agricultural Commissioners (CAC)<sup>30</sup>.

### *Pesticide Registration Process*

All pesticides used in the U.S. must be federally registered with the EPA and with state governments. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) governs the use and sale of pesticides in the U.S. In order for the EPA to register a pesticide, the active ingredient must have a food residue tolerance, an exemption from tolerance, or be on the Generally Recognized as Safe (GRAS) list<sup>20</sup>.  $\text{Ca}(\text{OCl})_2$  is exempt from tolerance on all raw agricultural commodities such as alfalfa seeds, so its use on food is eligible for registration (40 CFR 180.1054).

There are several types of EPA pesticide registrations. A FIFRA, Section 3 registration authorizes full or conditional registration, Section 5 authorizes an experimental use permit, Section 24(c) is used to issue a special local need (SLN) and can be issued in tandem with a state registration, Section 18 authorizes an emergency exemption, and Section 25 is issued by the EPA Administrator to waive registration requirements for a product<sup>25</sup>. These registrations in most cases must not be submitted by the sprout producer but either by a governmental agency or by the company which manufactures  $\text{Ca}(\text{OCl})_2$ .

Currently  $\text{Ca}(\text{OCl})_2$  is a registered pesticide for certain agricultural and commercial uses, under Section 3 by both the EPA and by the CDPR. The chemical is also registered with the EPA for use to sanitize alfalfa seeds. However, there is no registered use on the label of  $\text{Ca}(\text{OCl})_2$  products for sanitizing alfalfa seeds in the state of California. While the current use of  $\text{Ca}(\text{OCl})_2$  in California does occur despite this lack of registration, its use for sanitizing alfalfa seeds is working to prevent contamination, and therefore, no enforcement actions have been taken in recent years<sup>32</sup>. The priority of state enforcement actions depends mostly on environmental impact and available manpower. To apply for an additional use for an existing  $\text{Ca}(\text{OCl})_2$  product, information such as toxicity data, exposure data, and efficacy data must be submitted to the EPA (40 CFR, FIFRA). A new food use registration for a  $\text{Ca}(\text{OCl})_2$  to be used indoors would likely take 24 months to process and cost \$150,000, but if the product can be shown to have a low "reduced risk" to

the public, the process could take 22 months at a cost of \$200,000. Federal maintenance fees must also be paid yearly in the amount approximately \$60,000. Since most sprouting facilities are classified as small businesses under the FIFRA, these fees can be reduced by 50% to 100%<sup>21</sup>.

At the state level, the CDPR believes that data submitted for an EPA registration is not fully sufficient for a California registration. The EPA expects registrants to conduct efficacy studies to support their claims, but waives the actual submission of the information. California asks for this efficacy data to be submitted during the registration process. The state can also request additional data to support Section 24(c) SLN registrations.  $\text{Ca}(\text{OCl})_2$  has been identified as needing no extensive scientific evaluation, so the processing time for a California new use product registration of 120 days may be much shorter<sup>22</sup>.

A public comment period of 30 days follows the processing time before a registration is complete. The proposed registration is posted at CDPR district offices, website, and at CAC offices. If requested by residents or stakeholders, a public hearing may also be held to discuss the impact of the new pesticide on the community. All oral and written comments are published in a report which is reviewed before a final decision is made on the pesticide registration<sup>34,23</sup>.

### *Worker Safety*

The Occupational Health and Safety Administration (OSHA) ensures that each employer provides a place of employment free from recognized hazards likely to cause harm to employees<sup>24</sup>. There are several OSHA standards pertaining to injury reporting and industry safety which govern a sprouting facility. For example, OSHA recommends under ideal conditions, industrial workers be limited to lifting 51 pounds<sup>25</sup>. Workers in an alfalfa sprouting facility will constantly be lifting both dry and wet seed bags weighing nearly 50 pounds. However, the seeds absorb water when soaking, so experiments were performed to determine the additional weight of the absorbed water. The seeds were weighed, soaked in water, drained, and then reweighed. The water retained fraction of washed and drained seeds was determined to be 0.24 grams of water per gram of seed compared to the literature value of 0.22 grams of water per gram of seed<sup>18</sup>.

In addition, the Material Safety Data Sheet (MSDS) for  $\text{Ca}(\text{OCl})_2$ , or any other chemical, should always be followed and kept in the facility. Employees working with the  $\text{Ca}(\text{OCl})_2$  must be trained in the chemical hazards and proper handling and storage procedures in the MSDS.

At the state level, the Cal/OSHA program is responsible for enforcing California laws and regulations covering workplace safety by assisting both workers and employers. The enforcement unit conducts inspections based on worker complaints and reported accidents or illnesses. Workers have the right to file a complaint or request an inspection from the Cal/OSHA office.

The Cal/OSHA officers conduct site inspections at least once a year<sup>26</sup>. Workers can also call the county agricultural commissioner regarding pesticide safety issues. Each pesticide user is issued a permit from the CAC office allowing the calcium hypochlorite treatment. The CAC will conduct inspections at least once a year of each site using the pesticide for agricultural purposes<sup>27</sup>. However, since calcium hypochlorite has several non agricultural uses, anyone can purchase and use the chemical without a CAC permit. A facility without a permit most likely will not be inspected unless a public health incident occurs. The CDPR has many similar responsibilities to the Cal/OSHA program along with a Worker Protection Program, which develops outreach materials such as Pesticide Safety Information Series leaflets<sup>28</sup>.

### Bench Scale Experimentation:

#### Contact Variation Experiments

A common industry procedure to sanitize alfalfa seeds is to fill a mesh bag with seeds and immerse the bag in a solution of  $\text{Ca}(\text{OCl})_2$ . To determine potential problems with this treatment, lab experimentation that simulated current treatment procedures

noticeably darker than other seeds. The seeds in the middle of the bag were slightly darker than those on the bottom and outside edges. Thus, it was concluded that with minimal agitation, the contact of the  $\text{Ca}(\text{OCl})_2$  solution with the alfalfa seeds was not uniform and agitation was necessary to ensure that all seeds were adequately contacted with sanitizing solution. Further experiments were performed involving seeds inoculated with a non-pathogenic strain of *E. coli* (strain VR101) in order to compare contact of seeds in a non-agitated bag (10 lbs loading) with contact in a well-agitated vessel. Results showed that seeds in the agitated vessel were contacted more effectively than seeds in the non-agitated bag. The plate count for the non-agitated seeds was more than twice as large as that for the agitated seeds.

#### Potential Reuse of Sanitizing Solution

Laboratory experiments were performed to determine the ability to recycle the sanitizing solution. After one use, the concentration of the  $\text{Ca}(\text{OCl})_2$  was depleted to approximately 16,000 ppm in 15 minutes, which is in agreement with the literature<sup>21</sup>. Therefore, if an effective free chlorine test method is developed, the sanitizer solution could be recycled with the addition of  $\text{Ca}(\text{OCl})_2$  to bring the solution concentration back to 20,000 ppm. However, since there is not an effective test method

Figure 2. Rotary Drum Bench Scale Photograph



was performed. The goal of the experiment was to determine whether portions of seeds are contacted with sanitizer solution less effectively than others. In order to detect contact variation, alfalfa seeds were dyed with crystal violet dye until the seeds were darkly colored. 2.2 lbs of seeds were placed into a cheesecloth sack and immersed in a 5000 ppm  $\text{Ca}(\text{OCl})_2$  solution for 15 minutes with minimal agitation. The concentration of  $\text{Ca}(\text{OCl})_2$  solution was chosen to ensure removal of some but not all of the dye. The treated seeds were then dried and differences in seed color were noted. It was evident by visual inspection that dye was removed more effectively from seeds on the bottom and outside edges of the bag. Seeds near the top of the bag were

for free chlorine concentration, recycling the sanitizer solution is not currently applicable.

#### Rotary Drum Bench Scale Design

A rotary drum bench scale apparatus was constructed which is shown in Figure 2. The majority of medium to large sprout producers that own a rotating drum use it primarily for germination<sup>29</sup>. The bench scale model was tested for sanitation effectiveness. The purpose was to determine if alfalfa seed can effectively be sanitized in a rotary drum. In experimentation, four pounds of dyed alfalfa seeds were mixed with 0.59 lbs of dry  $\text{Ca}(\text{OCl})_2$  and placed in the rotating drum. 2.4 gallons (6 gal

water per 10 lbs seeds) of water were sprayed into the drum at 15 min intervals for a total of 21 minutes. The drum was rotated, by hand, at approximately 3 rpm to ensure effective contacting between seeds and the  $\text{Ca}(\text{OCl})_2$ . The rotation speed was chosen to ensure sufficient time for contact between the seeds and the  $\text{Ca}(\text{OCl})_2$ . After the cycle, the seeds were found to be free of dye (See middle photograph of Figure 2). Therefore, the rotary drum is recommended, for both sanitation and germination, for current owners of rotary drums or producers able to afford the \$14,000 capital cost<sup>30</sup>. If used for sanitizing, the rotary drum should be constructed of material able to withstand corrosion from exposure to chlorine. Testing of the runoff water 48 hours into the germination process as recommended by the FDA is still required with this design<sup>11</sup>.

#### Agitation-in-Bag Bench Scale Design

The agitation-in-bag bench scale apparatus, shown in Figure 3, which was tested using 10 lbs of seed, was constructed to improve the current repetitive-dunking bag procedure used by some small scale sprout producers. For sprout producers currently processing more than 10 lbs of seed in a cycle, the design could be scaled to address the demand. The equipment consists of (1) a 15 gallon mesh drawstring bag, (2) a four-legged cage within the bag, (3) an agitator support plate, (4) an agitator impeller, (5) an agitator drive motor, (6) a 11" diameter by 20 y" tall [10.5 gallon] sanitizing vessel, (7) a 19 gallon plastic rinsing container, and (8) a 16" by 16" perforated bag support plate for rinsing. The cage keeps the bag from collapsing and provides agitation baffling; it is constructed from y" PVC pipe and pipe fittings. The agitator impeller is a hurricane paint mixer available at most hardware stores. A y" variable-speed drill motor is used as the agitator drive motor. For the experimental unit, the drill support

plate is constructed from æ" plywood; however, a æ" polyethylene sheet is recommended for long-term use to withstand handling and chemical exposure. The drill is held in a 2" diameter hole in the support plate by two vertical all-thread rods, bolted firmly to the support plate. The cost required to implement the apparatus in practice is given in Table 3.

The itemized steps for the sanitizing procedure are the following:

- (1) Put on all personal protective equipment
- (2) Insert the cage into the bag along with 10 pounds of seed.
- (3) To clean seeds, place bag on grate atop the rinsing container.
- (4) Using hose spray seed for about 15 minutes or until runoff water is clear.
- (5) Add 6 gallons of premixed 20,000 ppm of  $\text{Ca}(\text{OCl})_2$  solution to the sanitizing vessel.
- (6) Insert bag with cage and seed into the sanitizing vessel.
- (7) Pull the bag drawstrings tightly over the cage, leaving space for the impeller.
- (8) Insert the impeller [with its shaft firmly in the drill chuck] into the bag.
- (9) Start the drill motor at a predetermined speed of about 400 rpm.
- (10) Agitate the seeds for 15 minutes.

**Table 3. Agitation in Bag Bench Scale Capital Estimate**

<u>Item (quantity)</u>	<u>Cost/Item</u>	<u>Total Cost</u>
½" PVC tees & caps (4each)	\$0.18	\$1.44
½" PVC 45° elbows (8)	\$0.16	\$1.28
½" Sch. 40 10' PVC pipe	\$1.19	\$1.19
½" variable speed drill	\$47.97	\$47.97
1 3/8" all-thread rod	\$0.87	\$0.87
16" x 16" Return Air Grille	\$7.97	\$7.97
40 liter cylindrical trash can	\$6.94	\$6.94
19 gallon plastic tub with rope handles	\$4.94	\$4.94
¾" 2' x 4' polyethylene sheet	\$20.80	\$20.80
Warner 5 gal. hurricane mixer	\$7.92	\$7.92
Miscellaneous (nuts, bolts, etc.)	\$1.00	\$1.00
Tax at 10%		\$10.23
<b>Total</b>		<b>\$112.55</b>

- (11) Stop the agitator and remove the agitation assembly from the sanitizing vessel.
- (12) Place the bag and cage on the grate atop the rinsing container
- (13) Spray water into the seed bed until odor is undetectable and rinse water runs clear.
- (14) Remove the cage and sanitarly transport the seeds to germination.
- (15) Dispose of remaining solution to the sewer and disassemble apparatus for cleaning.

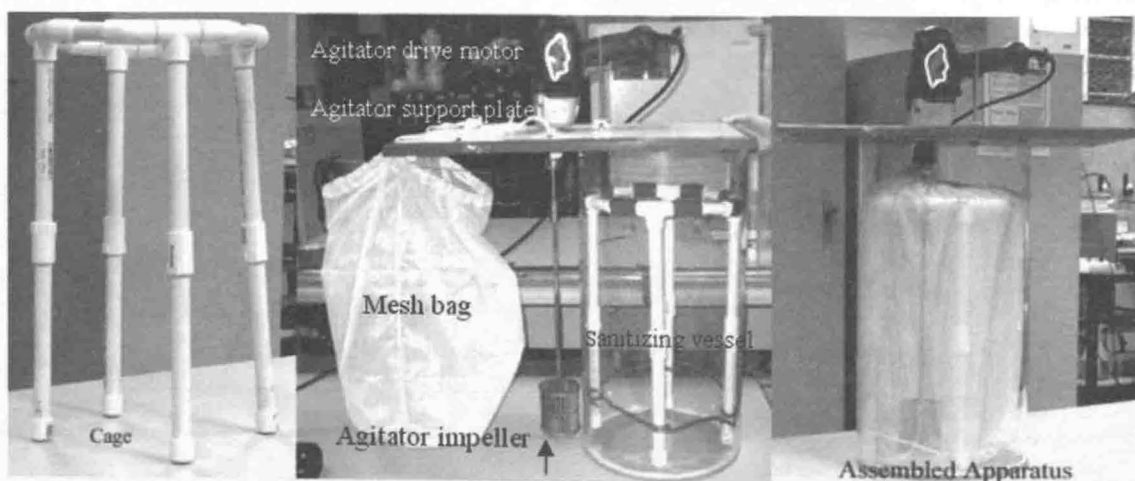
The effectiveness of the agitation in bag system was tested experimentally. Alfalfa seeds were dyed with crystal violet dye. After agitating the seeds at 370 rpm for 15 minutes in a solution of 5000 ppm  $\text{Ca}(\text{OCl})_2$ , visual inspection indicated uniform dye removal. The alfalfa seeds were allowed to sprout. Essentially all the seeds germinated, indicating the agitation did not significantly effect sprouting efficacy.

through the PVC tube. The seed feed rate was 4.5 lbs/hr with a sanitizing solution (20,000 ppm  $\text{Ca}(\text{OCl})_2$ ) feed rate of  $[(6/10)(4.5)/60] = 0.05$  GPM to give a 5:1 ratio of sanitizing solution to seed feed rate. The auger speed required was 3.5 rpm to give a seed residence time of 15 minutes. The PVC tube was elevated at an angle of 15 degrees. The sanitized seeds are conveyed from the upper end of the PVC tube onto the vibrating screen.

The screen is vibrated moving the seeds toward the collection bin. As the seeds are conveyed along the vibrating screen, rinse water is sprayed uniformly along the length of the screen onto the seeds. A rinse water collection bin is placed underneath the screen to collect the rinse water and sanitizing solution. The rinsing headers are two  $\frac{1}{2}$ " ID, 24" long PVC pipes with 3 rinsing nozzles each. The headers are supplied by the rinse water tank and a  $\frac{1}{4}$  HP centrifugal pump. A 5 gallon collection bin is located at the end of the separator to collect the sanitized and rinsed seeds.

Experiments were conducted to determine the effectiveness of the auger system. Dyed seeds were fed at 4.5 lb/hr with 20,000

Figure 3. Agitation in Bag Bench Scale Photograph



#### Auger Bench Scale Design

The auger bench scale experimental apparatus, shown in Figure 4 and Figure 5, was constructed to model the one ton per hour system. Each stream in the figure is numbered corresponding to the stream attributes table, which lists the stream compositions. The apparatus consists of a sanitizing unit and a rinsing unit. The sanitizing unit consists of: (1) a 1.5" ID x 4' long transparent PVC tube, (2) a 1.375" OD x 4' long SS auger, (3) a 5.5" x 6" x 15" tall feed bin, and (4) a 1/8 HP systolic pump. The rinsing unit consists of: (5) a vibrating screen, (6) two rinse water headers, (7) a rinse water pump, (8) a rinse water tank, (9) a seed collection bin, and (10) a rinse water collection bin.

The seed and sanitizing solution are supplied to the feed bin. The auger conveys the seeds and the sanitizing solution

through the auger. The auger was operated at 3.5 rpm for 45 minutes. The dye was effectively removed from the seeds during the sanitation process.

The bench scale washer was a 6" wide by 30" long screen stretched tautly over a wooden frame, which was supported on springs to allow the screen to be vibrated by tapping on the frame by a hammer. Odor tests on the seeds and seed-exit rinse water samples indicated effective  $\text{Ca}(\text{OCl})_2$  removal.

#### Full Scale Design:

The full scale design, shown in Figure 6, was sized based on the bench scale unit. Each stream in the figure is numbered



Figure 4. Auger Bench Scale Photograph

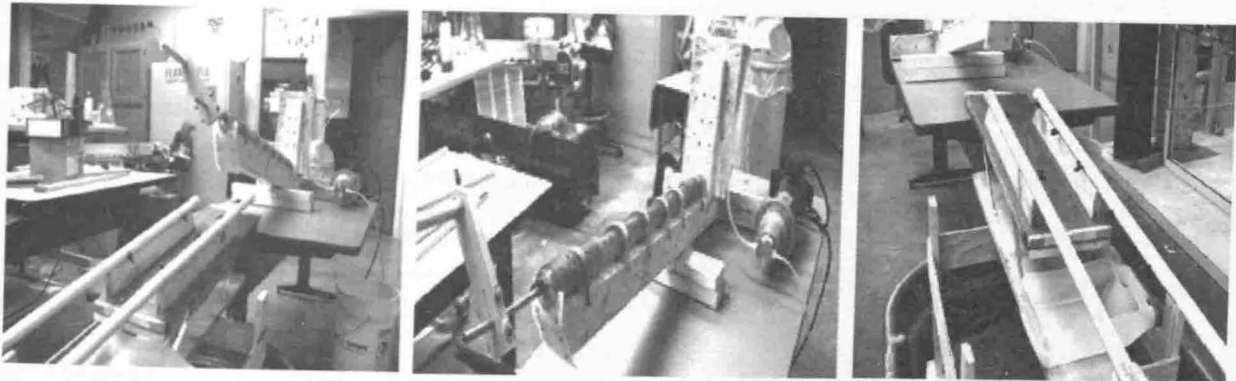
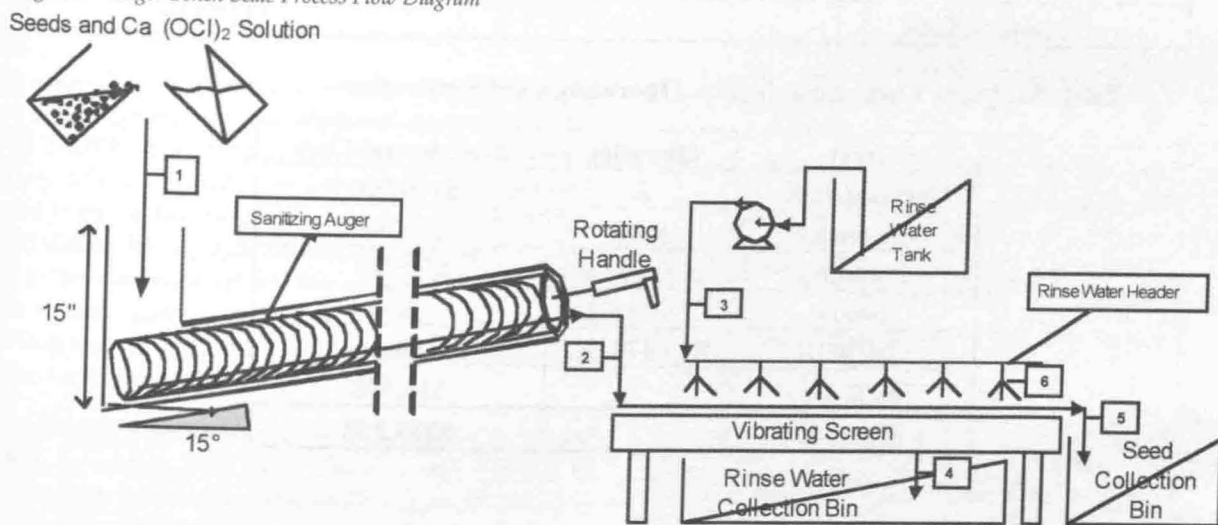


Figure 5. Auger Bench Scale Process Flow Diagram



<b>Bench Scale Stream Attributes</b>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Temperature, °F	75	75	75	75	75	75
Pressure, psig	0	0	0	0	0	0
Alfalfa Seed, lb/hr	4.5	4.5	0	0	4.5	0
Ca(OCl) <sub>2</sub> Solution, gpm	0.045	0.01	0	0.01	0	0
Rinse Water, GPM	0	0	0.9	0.8975	0.0025	0.15
Organic Solids/dirt, lb/ft <sup>3</sup>	trace	trace	0	trace	0	0

corresponding to the stream attributes table, which lists the composition of the streams. Calculations were performed to achieve a seed feed rate of one ton per hour. However, any seed feed rate ranging from 4.5 to 2000 lb/hr can be used for the auger system. The bench scale unit was operated at a seed feed rate of 4.5 lb/hr. The full scale unit requires a feed rate of 2000 lb/hr; thus, the scale-up factor is  $2000/4.5 = 444$ . The bench scale unit had an auger volume of  $0.05 \text{ ft}^3$ ; thus the plant auger must have a volume of  $444(0.05) = 22 \text{ ft}^3$ . With a 16" diameter auger the required auger length is  $[22/(4/p)(16/12)^2] = 18'$ .

The full scale unit capacity is 5.6 million lbs/yr based on one eight hour shift per day, 350 days/yr. The unit has the potential to process 17 million lbs/yr if run 24 hrs/day, 350 days/yr. The capital cost of all equipment is listed in Table 4. Calculations for the operating costs, listed in Table 5, of the auger system were taken on an incremental basis from an existing facility.

The full scale unit operates in four stages: solids loading, sanitizing solution preparation, sanitizing, and rinsing. The

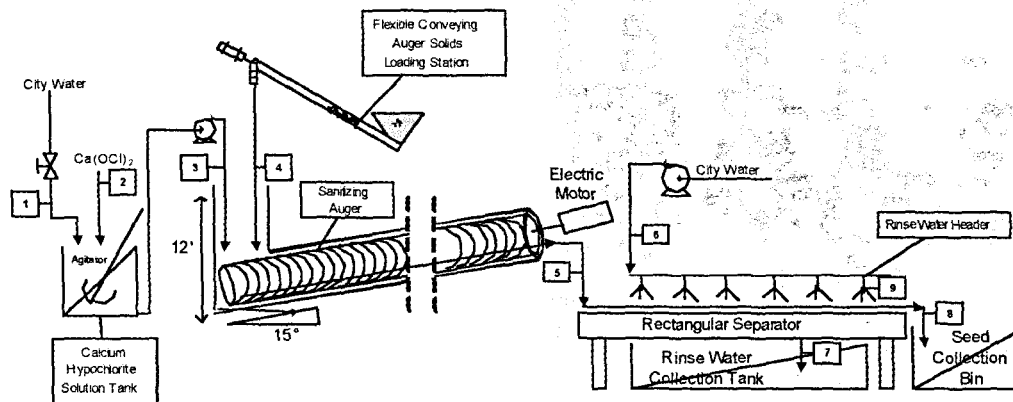
**Table 4. Auger Large Scale Capital Cost Economics<sup>43</sup>**

Equipment(Quantity)	Description	Purchased Cost	Installed Cost
Sanitizer Unit	Feed bin, auger, housing motor	\$18,956	\$31,278
Rectangular Separator	Sprayer, water collection trough	\$51,000	\$84,150
Flexible Auger	0.75 HP, 20' high screw conveyor	\$18,350	\$30,278
Ca(OCl) <sub>2</sub> Tank	16,500 gallon Vertical Poly Tank	\$15,000	\$24,750
Agitator	Turbine Agitator	\$20,000	\$33,000
Solution Pump	Centrifugal Pump, 0.75 HP	\$252	\$416
Seed Collection Tub (8)	100 gallon Polyethylene Tub	\$1,576	\$2,600
<b>Total (14)</b>		<b>\$125,134</b>	<b>\$206,471</b>
<b>Tax at 10%</b>			<b>\$20,647</b>
<b>Total Capital Cost</b>			<b>\$227,119</b>

**Table 5. Auger Large Scale Yearly Operating Cost Economics**

Item	Quantity	Incremental Cost
Operator Salary	3	\$180,000
Electricity	10 kW	\$1,260
Water	8,400,000 gal	\$12,720
Seeds	5,700,000 lbs	\$0
Ca(OCl) <sub>2</sub>	855,470 lbs	\$0
Tax at 10%		\$19,398
<b>Total</b>		<b>\$213,378</b>

Figure 6. Auger Large Scale Process Flow Diagram



Full Scale Stream Attributes									
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>
Temperature, °F	75	75	75	75	75	75	75	75	75
Pressure, psig	40	0	0	0	0	40	0	0	40
Alfalfa Seed, lb/hr	0	0	0	2000	2000	0	0	2000	0
Ca(OCl) <sub>2</sub> , lb/hr	0	300	300	0	60	0	60	0	0
Water, GPM	20	0	20	0	5	10	14	1	0.48
Organic Solids/dirt, lb/ft <sup>3</sup>	0	0	0	trace	trace	0	trace	0	0

solids loading stage consists of (1) a flexible conveying auger solids loading station. The sanitizing solution preparation stage consists of: (2) 16,500 gallon vertical poly sanitizing solution tank, (3) a turbine agitator, and (4) a 30 GPM (20' head) noryl centrifugal pump. The sanitizing stage consists of: (5) an auger tube with a feed bin at the inlet end, (6) a 12" OD x 18' 304SS auger with a Pitch/Diameter of 1/2, and (7) a 1.5 HP 3-5 rpm variable speed drive. The rinsing stage consists of: (8) a universal motion rectangular 3' wide by 15' long vibrating screen separator and (9) a 1.5 HP variable speed (30 rpm max.) motor. The rinse water is sprayed onto the screen by (10) about 21 square pattern spray nozzles attached to PVC headers. The rinsing stage also consists of: a (11) rinse water collection trough underneath the vibrating screen to pump the water to the sewer and (12) sixteen, 100 gallon polyethylene seed collection wheeled tubs.

The solids loading process begins by manually loading seed from 55 lb bags into the feed hopper of the seed conveyor at a rate of 2,000 lb/hr, or roughly one bag every two minutes. One operator will be required to load the seeds. The seeds will be removed from the bag by placing a bag on the feed hopper grating and slitting the bag with a box cutter. Before the seed is conveyed to the sanitizer feed bin, the seeds are washed inside the hopper removing any loose debris. The seeds are elevated from the feed hopper to the sanitizer feed bin by the flexible auger of the feed conveyor.

The sanitizing solution is prepared on a batch basis, for one 8 hour shift, by adding 2400 lb of  $\text{Ca}(\text{OCl})_2$  and 120,000 lb (14,400 gal) of city water to the 15,000 gallon agitated sanitizing solution tank. The sanitizing solution is fed into the sanitizer feed bin by a noryl centrifugal pump at 20 GPM and 30 feet of head. The inclined (15x) sanitizing auger rotates at about a rate of 3-5 rpm. The auger conveys the seeds and the sanitizing solution. The inclination and auger speed were determined to give a residence time of 15 minutes for the seeds in the auger. A 15 minute contact time is recommended by FDA for  $\text{Ca}(\text{OCl})_2$  treatment.

The seeds are discharged from the upper end of the sanitizer, and fall onto the rectangular separator. As the seeds are conveyed and agitated by the separator, rinse water is sprayed through 21 square pattern nozzles at a rate of 20 GPM. The rinse water and chemical residue drains from the seeds through the separator into the rinse water collection tank. The waste water is taken from the rinse water collection tank and disposed of into the sewer. At the end of the separator, the sanitized and rinsed seeds drop into wheeled seed collection bins. At a 500 lb capacity for the bins, a bin will be filled every 15 minutes. The seed collection bins are then transported to the sprouting area, which will require one full time operator. A third full time operator will be required to handle all other aspects of the process except for seed loading and seed transportation from washing to sprouting.

### Business Plan:

The business plan for the IMPACT project involves the possibility of two different processes, one available for the large volume sprout producer and one for the small volume sprout producer. Both processes can be integrated into existing post-harvest operations or into a new post-harvest facility. The process for the large volume sprout producer consists of an auger/vibrating screen system. The project can be completed in about 22 weeks. Six weeks are required for design, 10 weeks for equipment delivery, and 6 weeks for construction and start-up. The operating cost for the auger system capable of processing a ton per hour of seeds is \$214,000. The total installed capital cost of the system is \$227,000.

Alternately, the business plan involves the installation of the agitation-in-bag method for the small scale sprout producer. The project to implement this method can be completed in about one week. All the materials except the polyethylene mounting board can be purchased at local hardware stores. Two days are necessary, however, if special ordering for equipment is needed. All of the equipment can be assembled and installed in about two days with the remainder of the week necessary for startup, testing and training. There are no additional operating costs for the implementation of the design. The total capital cost of the bag agitation system is \$113.

The research work for this investigation showed a substantial improvement in pathogen kill by using the agitation-in-bag method rather than the hand-dunking method. Considering the modest capital investment and no additional operating manpower, the improvement in contacting effectiveness warrants immediate implementation of the agitation-in-bag sanitation procedure.

### Conclusions and Recommendations:

Existing literature and research shows that  $\text{Ca}(\text{OCl})_2$  is an effective treatment for the pathogens found to contaminate alfalfa seeds. Experiments have shown problems exist with current practices concerning contact of sanitizer and seeds. Through experimentation, it was determined the rotary drum can effectively sanitize and germinate alfalfa seeds. Therefore it is recommended for the sprout producers that currently own a rotary drum, to use the drums for both sanitizing and germination. The agitation-in-bag method is a viable and economically attractive option for small volume sprout producers, up to about 80,000 lbs of seeds per year. The cost-effective design improves a current industry practice by minimizing pathogen contamination of seeds by providing very effective contacting of seeds and sanitizing solution.

The auger/vibrating screen system is technically viable for any production rate and could be used by small producers;



however, it is mostly applicable for partnerships of sprout growers with seed requirements greater than 80,000 pounds per year. The auger/vibrating screen system is a relatively modest investment for large producers compared to sanitizing large seed volumes by hand.

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### Faculty Comment:

Roy Penney, in submitting this article for publication consideration, made the following remarks about the work:

The seven authors of this paper are all senior Chemical Engineering students. They participated as a team [the IMPACT (IMProved Alfalfa deContamination Technologies) team] in Task 2 of

the 2005 WERC [Waste-management, Education and Research Consortium, WERC.net] Environmental Design. The IMPACT team started work on Task 2 during Christmas Break in early January 2005 and finished the competition at NEW Mexico State University (NMSU) April 4-7, 2005. The Task 3 problem statement was: "Develop a simple and practical system to use calcium hypochlorite (sanitizer) to treat sprout seeds. The solution must be cost effective and take into account all aspects of chemical treatment (e.g., storage, handling, waste, etc.)". All team members received 3 hours of credit for CHEG 4443, Senior Chemical Engineering Design II.

There have been repeated outbreaks of food poisoning from contaminated alfalfa sprouts, especially in the US Northwest. The USDA believes that the contamination originates from alfalfa seeds contaminated with Salmonella and e-Coli. The IMPACT team did a thorough analysis of the US sprouting industry (which included a thoroughly-documented visit to a Kansas sprout producer) and determined that the most likely cause of seed contamination was inadequate washing of seeds with Calcium Hypochlorite solution by the current hand dunking method. IMPACT developed a simple cost-effective (capital cost •H \$100) mechanical agitation system which effectively treats seeds and remove all pathogens, as demonstrated in laboratory experiments at the University of Arkansas and at NMSU.

The team also developed a cost effective process for treating up to one ton/hour of alfalfa seeds to satisfy a stated task requirement— "address a seed feed rate of one kilogram per hour with a maximum of one ton per hour". Although, no single sprout producer in the US currently processes anywhere near 1 ton/hour of seeds, the SWARE team developed a cost effective process to handle that quantity at that speed. Seed disinfecting with hypochlorite solution was done effectively in a continuous auger unit and the final water washing was accomplished on a vibrating, sprayed screen. The one ton/hour IMPACT process was demonstrated in laboratory experiments at the University of Arkansas and at NMSU.

The IMPACT team performed very well by (1) determining the demographics and operating practices of the US alfalfa sprout industry, (2) developing, and experimentally demonstrating, an economical mechanical-agitation alternative to the current hand dunking method, and (3) developing a cost-effective process for treating up to 1 ton/hour of seeds, which, also was experimentally demonstrated. Their excellent performance was rewarded with a first place award in task and a USDA-CSREES Award of Excellence. The USDA-CSREES award includes a trip to Washington, D.C. for the team and its advisor to present their work to the USDA and other government agencies.



## COMPUTATIONAL STUDY OF A NOVEL DINUCLEAR METAL COMPLEX

By Dragos Seghete

Department of Chemistry and Biochemistry

Faculty Mentors: Dr. Peter Pulay, Dr. David Vicic  
Department of Chemistry and Biochemistry

### Abstract:

The first compound containing an M-H-M was recently reported by Vicic *et al.* With recent availability of large computational resources, molecular modeling has become a reliable tool for confirming experimental results. The novel dinuclear Ni complex  $[(dippm)_2Ni_2Br_2](^o-H)$  was investigated in this work from a theoretical perspective. Full geometry optimization was carried on the dinuclear Ni complex at the DFT/B3LYP with the 6-31G\* basis set. The result verifies the linear Ni-H-Ni bond. Two different starting structures that converged to the same geometry confirm that a global minimum was reached. The computed structure differs from the experimentally determined one by a cis conformation adopted by the bromine atoms relative to the plane of ligands. This difference is believed to be accounted for by the preference of the theoretical model for a pseudo-tetrahedral structure of the Ni atom and by the gas-phase nature of the calculation, which neglects the crystal-packing forces present in the solid state.

### Introduction:

A recent study by Vicic *et al.*<sup>1</sup> synthesized and characterized the dinuclear Ni complex  $[(dippm)_2Ni_2Br_2](^o-H)$  (**1**, dippm = bis(di-isopropylphosphino)methane) which is presented in Figure 1.

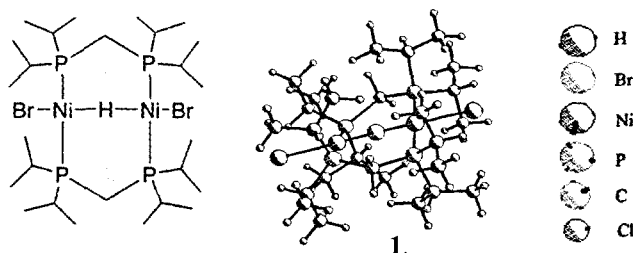


Figure 1.  $[(dippm)_2Ni_2Br_2](^o-H)$  (left) Schematic structure (right) 3-D structure obtained from neutron diffraction data showing the linear Ni-H-Ni bond.

Single-crystal neutron diffraction analysis indicates that the Ni-H-Ni bridge is virtually collinear, with an angle of 177.9°. This was the first study to find a linear M-H-M linkage in a dinuclear metal complex, in contrast with previous research [2,3] that reported only bent geometries. The uniqueness of compound **1** for the existence of a linear M-H-M bond prompted the need for a theoretical inquiry of its existence. Compound **1** is investigated in this work from first principles using computer modeling.

The availability of inexpensive cluster computers and increasingly more accurate modeling software provides nowadays an invaluable tool for many chemists. Computer modeling of chemical reactions is used by organic chemists to predict the desirability of a reaction path at the advantage of saving the expense of unsuccessful experiments. In biochemistry modeling is used in conjunction with physical measurements to determine the complicated structures of proteins. In synthetic projects computational studies are presented as theoretical support for experimental results. In the field of organometallic chemistry papers that include calculations validating the experimental results have also become a routine [4-8]. The main goal of the present work is to employ the theoretical tool of computational chemistry to obtain a molecular model for the dinuclear complex **1**.

My previous work in the Pulay lab studied the behavior of carbon suboxide as a ligand in different organometallic compounds [8]. One example of these metal compounds is the nickel complex with phosphine ligands presented in Figure 2.

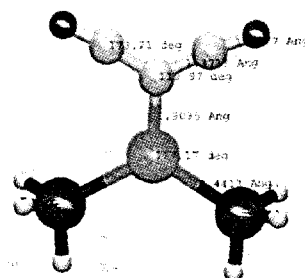


Figure 2.  $NiC_3O_2(PH_3)_2$

This carbon suboxide – nickel complex shares similarities with compound **1**: they both have Ni as the metallic center which is linked to phosphorus containing ligands. The successful implementation of the previous study on smaller but similar compounds led to the belief that the computational methods used are a viable approach to the current problem.

### Theoretical Background:

In this section a few important concepts from quantum chemistry are presented. This summary is considered necessary for understanding the computational methods used in this study.

#### The Schrodinger Equation:

In quantum chemistry a function of the particles' coordinates called the wave function  $Y$  is postulated to exist and contain all the information about the system [10]. The physical meaning of the wave function is that  $|Y(x)|^2$  gives the probability density for finding the particle at a certain location  $x$  in space. The wave function is considered to contain information about all the future states a system can be found in. From a philosophical standpoint, when an experiment is performed, the system has a quantized behavior, in the sense that it can only take one of the states preexistent in the wave function. The non-relativistic Schrödinger equation is used to "extract" information about the energy from the wavefunction:

$$\hat{H}\Psi = E\Psi$$

Here  $E$  is an allowed value for the energy of the molecule,  $Y$  is a function of the nuclei and electrons, namely their position, momenta, and spin.  $H$  is a differential mathematical operator, called the Hamiltonian, constructed from its classical counterpart  $H(p, r) = E$ . The Hamiltonian is obtained by substituting the

classical momentum  $p$  with  $\frac{h}{2\pi i} \frac{\partial}{\partial r}$ . For a system of electrons and nuclei, in vacuum, at 0 K, with no magnetic interaction, the Hamiltonian is given by:

$$\hat{H} = -\sum_i \frac{1}{2} \nabla_i^2 - \sum_K \frac{1}{2 M_K} \nabla_K^2 - \sum_{i,K} \frac{Z_K}{|r_i - R_K|} + \sum_{i>j} \frac{1}{|r_i - r_j|} + \sum_{K,L} \frac{Z_K Z_L}{|R_K - R_L|}$$

In this formula  $i$  and  $j$  are indices for electrons with position  $r$ , while  $K$  and  $L$  are indices for nuclei with positions  $R$ , and charge  $Z$ . The first two terms that contain the Laplacian operator — are the expressions for the kinetic energy of the electrons and nuclei, respectively. The third term is the electron-nucleus coulomb attraction. The last two terms are the electron-electron and nucleus-nucleus coulomb repulsion. In the Born-Oppenheimer approximation the nuclei are considered much heavier than the electrons and thus their position is assumed to be fixed compared to that of the electrons. This is one of the most

important approximations of computational chemistry and it leads to easier calculations in two ways. Firstly, the wavefunction can be written as a product of two independent wave functions, one for the nuclei and one for the electrons. Secondly, some of the terms coupling the nuclei and the electrons can be neglected and the Hamiltonian is simplified to:

$$\hat{H}_{total} \cong \hat{T}_{nuclei}(P, R) + \hat{H}_{electrons}(p, r, R)$$

The Schrodinger equation is then solved for the electrons, keeping the nuclei fixed. However, the computed potential energy of the electrons will depend on the positions  $R$  of these fixed nuclei

$$\hat{H}_{electrons}(p, r, R) \Psi_{electrons}(r, R) = V(R) \Psi_{electrons}(r, R)$$

#### Hartree-Fock

In order to compute  $V(R)$  one must first create an antisymmetric wavefunction  $Y_{electrons}$  that has the property that when two electrons are permuted the sign of the wavefunction is changed. This behavior is imposed by the fact that electrons are Fermions and they are thus subjected to the Pauli Exclusion Principle. A form of the wavefunction that would guarantee that the Pauli principle is satisfied is the "Slater determinant". A "Slater determinant" is the determinant of a matrix which has as its elements the molecular orbital functions  $f_i(x)$ .  $Y_{electrons}$  is then written as a linear combination of such Slater determinants:

$$\Psi_{electrons} = \sum C_i \Phi_{SD_i}$$

Each molecular orbital is in its turn written as a linear combination of atomic orbitals  $c_j$ :

$$\phi_i = \sum D_{ij} \chi_j$$

The atomic orbitals can be represented by any mathematical functions chosen so that they can properly represent the physical properties of the atom. Most used are the Gaussian type functions because they are easy to integrate analytically and therefore economical from a computational standpoint. Conventional sets of such atomic orbitals are called "basis sets" and they will be described later in greater detail.

Another important result in quantum chemistry is the variational theorem. Finding an exact solution to the Schrodinger equation by simply varying the coefficients  $C$  and  $D$  is an impossible task for any molecule bigger than hydrogen. Finding just an approximate solution would be a much easier approach. The variational theorem states that by computing  $E$  for different approximate wave functions  $Y_{electrons}$ , the lowest value of the energy is obtained for the best wave function. The problem is now reduced to minimizing the energy by varying the coefficients  $C$  and  $D$ . Even in this case, for the complete expansion of  $C$  and  $D$  the computation grows fast with the size of the system.

To alleviate this computational difficulty in the Hartree-Fock approximation all but one of the  $C$ 's are assigned a value of zero. After mathematical derivations the Schrodinger equation is reduced to the Roothan-Hall (HF) equations. In this approach the molecular orbitals are therefore taken to be one-electron wave functions and all the electron-electron correlation is eliminated. Instead, each electron interacts with the mean field that arises from the other electrons. Because the mean-field potential changes as the coefficients of the other electrons change, there is no way of finding the solution directly. Instead, the self-consistent-field (SCF) method is used, in which the HF equations are solved iteratively until the wave function is self-consistent, i.e. it does not change within a certain threshold between two consecutive iterations. The general process is known as HF SCF. Although it contains many approximations, this approach is entirely *ab-initio* and provides the best results possible with a minimum amount of computational expense [10].

### **Density Functional Theory:**

In HF SCF the task is to approximate a function of  $3 \times N_{\text{electrons}}$  variables, three spatial variables for each electron. To save computational expense an ingenious solution is to substitute the wave function with a functional of the electron density, in which case the number of variables is reduced to three. A functional is a function that has as variable another function, in this case the electron density. The Hohenberg-Kohn theorem proves the existence of a one-to-one mapping between the electron density functional and the many-electron wavefunction. This existence theorem is important from a theoretical perspective, but it does not provide a method of determining such a mapping and compute the wavefunction from the density. Recent advances in the DFT theory were acknowledged by the 1998 Nobel Prize in chemistry given to Walter Kohn, whose contributions to DFT led to the development of very successful density functionals. Used in this project is the most popular functional commonly known as B3LYP, the Becke-Lee-Yang-Parr hybrid exchange-correlation functional. Because different functionals are optimized to perform better on specific chemical systems, DFT is claimed to be a slightly empirical method. However, results obtained by DFT are comparable to those given by complex wave-function methods at a fraction of the cost, making DFT the only practical approach for very large systems.

### **Basis set:**

We have established that a basis set is a collection of mathematical functions which are combined, in a linear fashion, to form a molecular orbital. The word "basis" has in this setting the same meaning as in the mathematical description of a space. It is intuitive to see that a very large basis set, i.e. one that contains many basis functions, would lead to a good overlap with the real wave function. In fact, an infinite basis set would be able to

describe exactly the wave function. Because such an approach is not computationally feasible more approximations are introduced. The crudest approximation is to include a minimal number of basis functions, enough so that each electron has at least one orbital to be assigned to. In this case there is no room for variation, so the calculations using minimal basis functions cannot provide much insight into the chemistry of a molecule. Because the chemical behavior of a molecule is dictated by the structure of the outer electronic shells the ideas of contracted and split-valence basis sets were introduced [9]. In this approximation, the accurate modeling of the core electrons is given less importance by averaging the primitive basis functions into fewer "contracted" ones, while the valence orbitals are "split" by being represented by more basis functions. In the Pople style notation, one of the most popular basis sets, and also the one used in this study is called 6-31G\*. The dash indicates the separation between the core and valence orbitals. The core orbitals are represented by a function contracted from six primitive Gaussian functions and the valence is split into two orbitals, each represented by three, and one primitive functions respectively. "G" signifies that the basis is formed by Gaussian type functions. The "\*" is equivalent to "(d)" and indicates that a polarization  $d$  function was added to the metal atoms. The split-valence allows for a combination of more of the same type of atomic orbitals, offering the model the ability to change size, but not shape. In order to allow different bonds to form in different directions higher angular momentum functions are added, and these are called polarization functions. Adding a  $d$  polarization function on an atom can be thought of as the  $sp^3d$  hybridization in the Valence Bond Theory. For certain elements that tend to have such hybridized orbitals, like the transition metal Ni used in this work, polarization functions are imperative for modeling the actual chemical behavior of the molecule.

### **Geometry optimization:**

Given the Born-Oppenheimer approximation, performing one complete SCF calculation will give the energy of the molecule only for a given set of nuclei coordinates. As the geometry of a molecule is given by the positions of the nuclei, such a calculation is often called a single point calculation. If interested in predicting the geometry of a molecule, one needs to find the nuclei coordinates that give the lowest total energy. The geometry of a molecule can be defined by different parameters: bond lengths, bond angles, dihedral angles or simply, the absolute position of each atom. Varying one of these parameters and calculating the energy for each point results in obtaining the function  $V(R)$ . To illustrate, if one considers the molecule carbon suboxide  $C_3O_2$  and calculates its single-point energy for different values of the C-C-C angle the following dependence is observed:

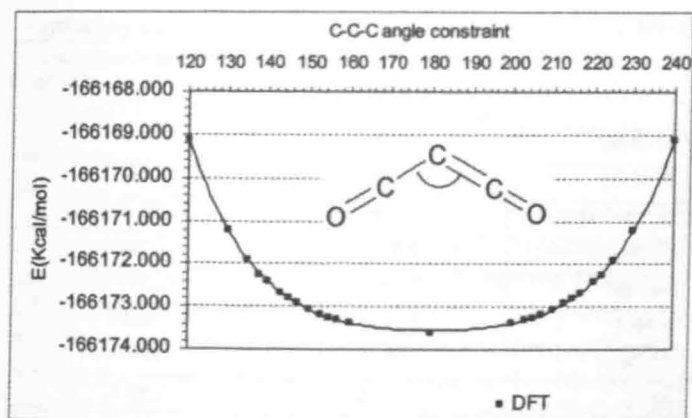


Figure 3. One variable potential energy surface for  $C_3O_2$

If two parameters would be varied, i.e. the angle and a C-C bond, plotting the energy values would produce a three dimensional surface. A non-linear molecule with  $N$  atoms has  $3N-6$  degrees of freedom, or parameters that can be varied. The dependence of energy with these parameters defines the Potential Energy Surface (PES). Finding the most stable geometry of a molecule is equivalent to finding the absolute minimum on a PES. The general mathematical approach for finding minima of functions is to determine the zeros of the first derivative, also known as the gradient, and check for the positive second derivative. Instead of a costly numerical approach to this problem, Pulay showed how to determine the derivatives analytically, providing a cost-effective way of performing geometry optimization calculations [13].

### Methods:

In this study geometry optimizations were performed on compound **1** using the PQS software version 3.1. The calculations were carried in parallel on computer clusters containing 8 or 10 AMD Opteron™ processors. The geometry optimization calculations were performed at the DFT B3LYP level with the 6-31G\* basis set. The unrestricted HF method was used and no constraints were imposed to the molecule. For a faster convergence of the first SCF step a better initial guess of the orbitals was obtained by initially performing a calculation using the smaller basis set 3-21G. A typical PQS input file is given in Appendix 5.

Because of the relative degeneracy introduced by heavy atoms like Ni, the card LVSH was used to force an energy gap between the occupied and virtual orbitals. Otherwise, excited electronic states of the molecule could be obtained, and these are not representative for the present ground state problem.

Particular attention was given to the situations where restarting a calculation was necessary. Although the geometry and orbitals were read from the previous files using the GEOM=READ card, a sequence of SCF and FORCE steps was performed before the geometry optimization. This was needed for the case when the previous calculation would have been

interrupted during the force calculation procedure, thus giving an erroneous gradient as a starting point for the new calculation.

In determining the bond lengths and bond angles an "awk" script was written. Such a script for displaying the Ni-H-Ni angle in degrees is presented in Appendix 6. The script parses through the PQS output file, detects the geometry blocks and computes the bond lengths and angles from the Cartesian coordinates.

### Results and Discussion:

The full geometry optimization of compound **1** was started from the structure obtained experimentally by neutron diffraction [1]. The detailed coordinates of the start and converged geometries are given in appendices 1 and 2, respectively. The calculation converged in 275 geometry optimization cycles, with a total elapsed time of 7 days on an 8 processor cluster. The starting and converged geometries are presented in Figure 4. The most important bond lengths and angles are shown in Table 1.

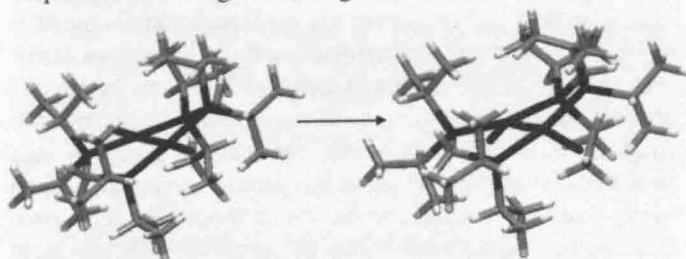


Figure 4. Starting and converged geometry of compound **1** in a DFT/6-31G\* full geometry optimization. The starting geometry corresponds to the experimental structure obtained by neutron diffraction. Black=Br, Ni, Red=P, Grey=C, White=H.

	Starting geometry obtained from neutron diffraction experiment Br-Ni-Ni*-Br* linear	Optimized geometry 275 geometry cycles Total CPU time = 1199 hrs Elapsed / 8 CPU = 7 days
Ni-H-Ni*	177.90 °	175.90 °
Br-Ni-H	177.71 °	154.06 °
Br*-Ni*-H	178.25 °	163.07 °
Ni-Br	2.37 Å	2.53 Å
Ni*-Br*	2.39 Å	2.48 Å
P-Ni-P	177.52 °	166.08 °
P*-Ni*-P*	175.35 °	169.21 °
Ni-H	1.61 Å	1.64 Å
Ni*-H	1.61 Å	1.57 Å
Ni-P	2.18 Å	2.18 Å
$\Delta E = E_t - E_i(\text{lin})$	-60.2 kcal/mol	

Table 1. Molecular parameters for the DFT/6-31G\* full geometry optimization of Compound **1**.

It can be observed that the calculation converges to a Ni-H-Ni angle of 175.90°, very close to linearity. This agrees with the experimental result of Vicic et al., confirming theoretically the existence of such a bond. A general observation is that DFT tends



to overestimate the bond lengths. This can be explained by the non-locality of the functional approach. The calculation does not predict the overall experimental geometry as a minimum. The linearity along the Br-Ni-H-Ni\*-Br\* is not preserved, the bromine atoms preferring a *cis* position relative to the ligand system. Additionally, a slight asymmetry was obtained between equivalent Ni-Br bonds and Br-Ni-H angles. This could be explained by an error during calculation restarts. The combination of a fairly large calculation and an instability of the computer hardware led to several unwanted interruptions of the computation. It is believed that during one of the interruptions an incomplete set of forces was written, which were then read as the starting forces by the new optimization procedure. The unusually high number of optimization cycles is also to indicate that an imbalanced set of forces was introduced in the calculation which led to this asymmetry.

Geometry optimization of large molecules poses increased difficulty because of the increased possibility of converging to a relatively "flat" saddle point or to a local minimum on the PES rather than to a global minimum. Even if the starting geometry is close to the global minimum there is a higher probability of obtaining a path away from the minimum, for many degrees of freedom. From this perspective, the starting geometry was modified and another full optimization was carried in order to verify that the obtained geometry was indeed the minimum. Because the disagreement between the calculation and experiment was in the *cis* position of the bromine atoms, the starting geometry was modified so that the Br-Ni-Ni\*-Br\* bonds were in *trans* to the Ni-H-Ni line, with a relative out of plane angle of 160°. The detailed coordinates of the start and converged geometries are given in appendices 1 and 2, respectively. The calculation converged in 60 geometry optimization cycles, with a total elapsed time of 2 days on a 10 processor cluster. The starting and converged geometries are presented in Figure 5. The most important bond lengths and angles are shown in Table 2.

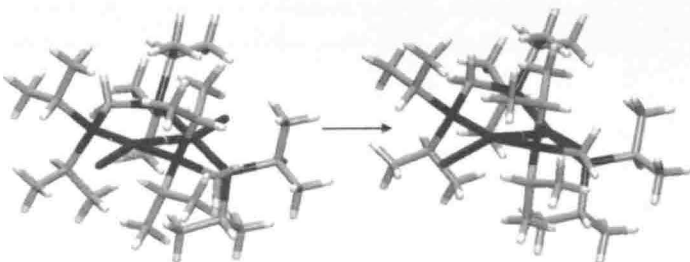


Figure 5. Starting and converged geometry of Compound 1 in a DFT/6-31G\* full geometry optimization. The starting geometry was taken from the experimental structure obtained by neutron diffraction and modified so that the Br-Ni-Ni-Br bonding was *trans*. Black=Br, Red=P, Grey=C, White=H.

As in the previous case, the optimization converged to the structure having the bromine atoms *cis* relative to the ligand plane. This geometry is thus confirmed as a minimum. More importantly, the Ni-H-Ni was again virtually linear with an angle of 177.8°.

	Starting geometry	Optimized geometry
	Modified experimental structure Br-Ni-Ni*-Br* <i>trans</i>	60 geometry cycles Total CPU time = 424 hrs Elapsed / 10 CPU= 2 days
Ni-H-Ni*	177.90 °	177.84 °
Br-Ni-H	160.75 °	156.86 °
Br*-Ni*-H	-161.33 °	157.20 °
Ni-Br	1.89 Å	2.51 Å
Ni*-Br*	2.05 Å	2.51 Å
P-Ni-P	177.52	166.99
P*-Ni*-P*	175.35	166.56
Ni-H	1.61 Å	1.59 Å
Ni*-H	1.61 Å	1.59 Å
Ni-P	2.18 Å	2.22 Å
$\Delta E = E_t - E_t(\text{trans})$		-181.6 kcal/mol
$\Delta E' = E_t - E_t(\text{lin})$		-29.36 kcal/mol

Table 2. Molecular parameters for the DFT/6-31G\* full geometry optimization of Compound 1. Starting geometry was modified to obtain a Br-Ni-Ni\*-Br\* *trans* structure.

The calculated preference for the *cis* position of the bromine atoms can be explained by the Ni atom adopting a configuration in between square planar and tetrahedral. This is also verified by the P-Ni-P which diverges from linearity in the obtained geometry, the atoms P, P, Br, and H forming a flat tetrahedral arrangement around Ni. The preference of the DFT calculation for a pseudo-tetrahedral structure could be correlated with the spin-multiplicity of the complex.

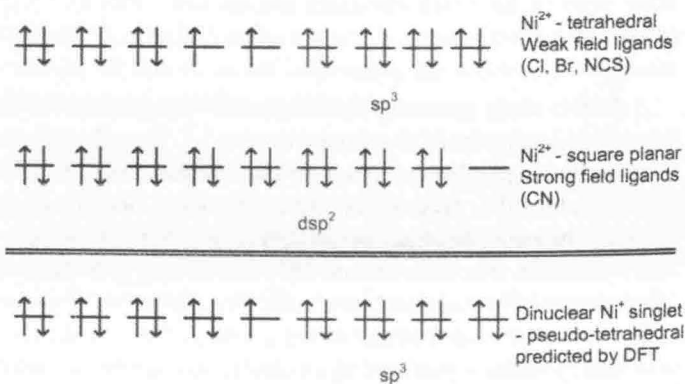


Figure 6. The correlation between spin-multiplicity and geometry of Ni complexes

As schematically indicated in Figure 6, Ni<sup>2+</sup> complexes containing low field ligands adopt a square planar geometry with two unpaired spin electrons, or spin-multiplicity of 3. On the other hand, Ni<sup>2+</sup> complexes containing strong field ligands exist in a tetrahedral geometry with no unpaired spin electrons, or spin-multiplicity of 1. The experiments performed by Vicic et al. on the investigated dinuclear complex formally containing Ni<sup>+</sup> indicate the presence of one unpaired spin electron [1]. The calculations were performed in accordance with the experimental result, hence the presence of the SPIN=2 card in the input file



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(Appendix 5). It can be argued that according to the DFT calculation an intermediate spin state corresponds to an intermediate geometry of the nickel coordination. Further computational study of the complex in different spin states is thus warranted.

Another reason for the slight disagreement between the calculated and experimental geometries can be explained by the ideality of the quantum chemical model. The neutron diffraction experiment was performed on a crystallized sample where the intermolecular forces play a significant role. The energy difference between the experimental structure and the *cis* Br – Ni – Ni – Br structure predicted computationally is 30 kcal/mol. Taking into account the size of the molecule and the fact that the geometry optimization included all the aliphatic groups, the energy difference can be considered small and easily accounted for by crystal packing energies. Minor differences between gas-phase theoretical predictions and experimental results are usually explained by crystal packing forces [5,7].

More detailed insight into the electronic structure of the dinuclear Nickel complex can be obtained by looking at the frontier molecular orbitals. The highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) are presented in Figure 7. The colored wireframes correspond to isoenergetic surfaces for the indicated orbital. The probability of finding the electron inside the colored surfaces is 0.5. In the different spin orbitals which are employed in the open shell UHF calculation (Unrestricted Hartree Fock). The isoenergetic surfaces indicate that the Ni-H-Ni is fairly strong, as the highest electronic density is on the Ni and P atoms. The HOMO and LUMO orbitals show that the most chemically vulnerable bonds of the complex are Ni-P and P-C, which is in agreement with the increased reactivity of the ligand observed experimentally [1]. The low electronic density on the Br atom suggests that direct substitution of the halogen is not favorable.

### Conclusion:

The first reported compound that contains a linear M-H-M bond was investigated computationally. Full geometry optimizations with no bond or symmetry constraints performed at the DFT/B3LYP-6-31G\* confirm the existence of a linear Ni-H-Ni bond. The gas phase computed geometries indicate a

*cis* position of the bromine atoms relative to the Ni-H-Ni line and the ligand plane. Two different starting geometries converging to the same structure demonstrate unequivocally that the obtained geometry is a minimum. The small differences between the experimental and theoretical results can be accounted by the intermolecular forces that exist in the solid state. The HOMO and LUMO orbitals indicate a fairly strong Ni – H bond and an increased reactivity of the phosphine ligand, which is in good agreement with the experiment.

Further improvement of this study could be obtained by using a bigger basis set (6-311G\*\*, or vtz-ahlrichs) and by performing similar calculations on compounds that display a bent M-H-M bond.

This study also demonstrates how the latest advances in computational chemistry and the increased availability of computers recommend molecular modeling as a complementary tool to synthetic chemistry.

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### Faculty Comment:

Mentor Peter Pulay made the following comment about his student's work:

Dragos Seghete has explored the structure of novel organometallic compounds computationally, using methods of modern electronic structure theory. The compounds, containing a new structural motif, a linear Ni-H-Ni bridge, were synthesized in the laboratory of Professor David Vicic, and have been the subject of much interest recently. The calculations confirm the unusual linear structure, and demonstrate that modern electronic structure theory is able to treat these complex molecules. Previously, the high cost of the calculations deterred such investigations. However, improved theoretical methods, together with inexpensive PC-based computers, have changed the situation. Given the almost limitless ways large molecules can be constructed, computer modeling prior to experiment will certainly become an important tool in chemistry, speeding up discovery.

## PREDICTION OF THE TENDERNESS OF COOKED POULTRY *PECTORALIS MAJOR* MUSCLES BY NEAR-INFRARED REFLECTANCE ANALYSIS OF RAW MEAT.

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### Abstract:

*Tenderness in boneless poultry breast meat is of utmost importance to consumers. However, there is currently no non-destructive method to predict poultry breast meat tenderness. Textural properties of poultry breast meat were predicted by near-infrared reflectance (NIR) spectroscopy. Spectra were collected on 390 poultry Pectoralis major muscles from broiler carcasses to examine the correlation between NIR spectroscopy and the Meullenet-Owens Razor Shear (MORS) test. Two instrumental parameters (maximum shear force and total shear energy) were used as estimates of meat tenderness. Calibration ( $R^2_{cal}$ ) and validation ( $r^2_{val}$ ) coefficients of determination were used for predicting instrumental measurements using the reflectance, and its first and second derivatives. The model using second derivative reflectance data yielded the best results for all samples. Regressions performed on these samples produced  $R^2_{cal}$  values ranging from 0.70 to 0.75 and  $r^2_{val}$  values ranging from 0.59 to 0.65 for maximum shear force and total shear energy, demonstrating the potential of NIR to predict poultry breast meat tenderness. These findings could have a practical importance as this method could qualify NIR for an on-line assessment to sort poultry breast meat according to tenderness levels.*

### Introduction:

Many techniques exist for assessing meat tenderness in poultry and other meats. Either instrumental (e.g. Allo-Kramer method and Warner-Bratzler shears) or sensory evaluation tests can provide reliable information (Bouton and Harris, 1972; Huff and Parrish, 1993; Lyon and Lyon, 1990, 1991, 1997; Shackelford et al., 1991; Shackelford, Wheeler and Koohmaraie, 1997; Smith et al., 1988; Yacowitz, Davis, and Jones, 1978) on meat tenderness. However, these techniques are destructive, time consuming, and unsuitable for on-line applications. Developing fast, non-destructive, accurate, and on-line techniques are greatly desired in modern day processing plants. Near-infrared spectroscopy (NIR) can possibly step into this role due to the speed and ease of use.

Near-infrared reflectance is an analytical technique that has been used over the years for quality management of beef, pork, and chicken (Lyon, 2002). Applications have not only included prediction of chemical, textural, and sensory characteristics of meats, but attempts have been made to classify beef according to tenderness levels (Park et al., 1998; Rodbotten et al., 2001). However, the results of these studies were inconsistent at best. Now, using a non-destructive, fiber optic probe, there is a unique opportunity for developing an on-line assessment with the potential of sorting poultry meat by tenderness levels.

The objective of this study was to evaluate the use of NIR to predict poultry *Pectoralis major* muscle texture by assessing the relationship between NIR spectral data and an instrumental razor blade shear test, an instrumental measurement previously found to have a high correlation with the human perception of meat tenderness.

### Materials and methods:

#### *Meat samples*

The birds were obtained from poultry nutrition trials conducted by the University of Arkansas Poultry Research Farm. A total of 195 commercial age broilers were slaughtered at seven weeks of age, and all birds were housed under commercial growing conditions until time of slaughter. Birds were hung on a shackle line and processed commercially in order to obtain the varying range of tenderness in the breast fillets commonly seen in processing applications. Birds were electrically stunned (11 V, 11 mA, 10 s), manually cut (severed left carotid artery and jugular vein), bled out (1.5 min), scalded (55 °C, 2 min) and picked in-line using commercial defeathering equipment.

Following processing, broiler carcasses were chilled using a two-stage chilling system consisting of a 0.25 h pre-chill at 13 °C, followed by an agitated ice-slush chill at 1 °C for 0.75 h. At the time of deboning, both right and left *Pectoralis major* muscles were excised by severing the humeral-scapular joint,

and pulling downward on the wings according to Hamm (1981). Post-mortem deboning time has been shown to be a process parameter influencing the tenderness of *Pectoralis major* muscles (Lyon and Lyon, 1990), therefore it was selected as a process variable. Post-mortem deboning times for the samples (n=390) were 0.25 h (hot-boned), 1.25 h, 2 h, 2.5 h, 3 h, 4 h, 6 h, and 24.0 h post-mortem (PM). The deboning treatments were applied to gain a definite and varying level in meat tenderness. Carcasses for 1.25 h to 24 h PM were aged on ice after the chilling period until deboning. The 0.25 h PM samples were not aged on ice as they were deboned hot.

After aging, the *Pectoralis major* muscles from all carcasses within the deboning treatment were individually placed into coded plastic bags. The bags were then put on ice, and taken directly from the processing plant to the site of the NIR analysis. This was done so as to simulate normal processing practices before NIR assessment of meat tenderness. It was feared that freezing the samples would hinder the potential of NIR spectroscopy and while the results have not been compared (fresh vs. thawed) the samples were not frozen because it is not a common processing practice.

#### NIR spectroscopy

Raw samples were scanned shortly after deboning using a fiber optic probe (NIRSystems 6500) equipped with the software ISIScan. Each breast was placed on a flat surface and scanned twice at the top of the muscle by holding the probe perpendicular to the breast meat. These two measurements were then averaged to obtain the spectra data for the chicken samples. Samples were scanned in reflectance mode from 400 to 2498 nm at 2nm increments. This was done for both breast samples for each bird.

#### Instrumental texture analysis

After NIR analysis, the breast meat was refrigerated at 4°C for approximately 60 h. The meat was held at refrigeration to again simulate common practices by poultry processors. After the period had elapsed, the samples were cooked in coded aluminum lined and covered pans at 176.7°C for 36 minutes or until an internal temperature of 76°C was reached. The internal temperature was measured using a digital thermometer (Model HT1000, Cooper Instruments Industrial Thermometers and Temperature Instrumentation, Ontario, Canada).

Each sample was analyzed for textural characteristics with a TA.XT2Plus texture analyzer (Texture Technologies, Scarsdale, NY, USA). A razor blade shear test (MORS) recently developed in our laboratories and described by Cavitt et al. (2001, 2004) was used. This test consists of shearing the sample perpendicularly to the longitudinal fiber orientation with a 0.5 mm thick, 8.9 mm wide, and 30 mm long straight edge razor blade (#17, Excel, Paterson, NJ, USA). Experiments were conducted to determine

the extent of the blade's sharpness. This was done by monitoring the force necessary to cut a piece of piece of 20lb paper as a function of the number of shear tests performed on *Pectoralis major* muscles. It was determined that a blade could be used for up to 100 shears without seeing an increase greater than 5% in shear force. Conservatively, the blade was replaced after every 50 shears. After proper calibration of the texture analyzer, the cooked sample was manually placed on a flat aluminum plate featuring a 1x50 mm slot (used to prevent the blade from coming into contact with the aluminum plate) and a total of four measurements were made on each of the cooked samples. The crosshead speed was set at 10 mm/s. The sample shear depth was set at 20 mm which had been previously determined as an optimal depth for fully shearing a sample. In addition, to ensure accurate and consistent measurements, each test was started with a contact force of 0.1 N. The instrumental data was collected using Texture Exponent 32 version 1.0.0.92 (Stable Micro Systems, Godalming, Surrey, UK). For each shear, a force-deformation curve (force vs. time) was obtained. Maximum shear force (F, N), and total shear energy (E, N.mm) were calculated using the macro options of Texture Exponent.

#### Data analysis

NIR and texture analyzer data were processed using the multivariate regression software Unscrambler (Version 8.1, Camo, AS, Norway). The mean values for the texture and reflectance data, as well as the spectra's first and second derivative spectrum data were used to develop predictive models using the Partial Least Squares (PLS-I) and Jack-knife optimization options of Unscrambler. The first and second derivative was obtained using the Savitzky Golay algorithm. Jack-knifing is a procedure designed to test the significance of the model and is performed during full-cross validation. Full-cross validation was used to assess the robustness and the discrimination ability of the predictive models. RMSEC (root mean square error of calibration) and RMSEP (root mean square error of prediction) were used to compare the goodness-of-fit of the models. RMSEP is the average difference between predicted and observed response values at the prediction stage, while RMSEC shows differences at the calibration stage. Additionally, the ratio (RMSEP/RMSEC) was used as an indicator of model robustness. The model is said to be robust if values are found to be close to 1.0, but less than 1.2. Also, the relationship between the standard deviation of instrumental parameters ( $S_{tot}$ ) and the RMSEP values were assessed to determine the discrimination ability of the model. Large values (>2) indicate adequate discrimination.

#### Results:

The instrumental texture data indicates that that tenderness improved with increasing deboning time, a similar result to that reported by Cavitt et al. (2004). Values for total energy (TE)

decreased from a maximum at the 0.25hr deboning time of 194.9N.mm to a minimum of 127.3N.mm for the 24hr deboning time. A sharp decrease in TE was observed after 2.5hrs from 190.8 N.mm to 154N.mm at the 4hr deboning time.

For the first derivative of the reflectance spectra, the model statistics were less satisfactory. Calibration and validation coefficients ( $R_{cal} = 0.59$  and  $0.68$   $R_{val} = 0.54$  and  $0.63$ ) were found to be less than those models using the second derivative spectra. However, as seen in Table 1, the use of the reflectance spectrum as a predictor of instrumental texture measurements yielded slightly better calibration coefficients ( $R_{cal} = 0.62$  and  $0.69$ ) than the first derivative spectra curve. Appropriately, validation correlation coefficients were also slightly better ( $R_{val} = 0.55$  and  $0.64$ ) than the first derivative spectra.

The best modeling results were obtained when using the second derivative of the reflectance data. For all samples (all deboning times), the modeling yielded modest results (see Table 1).

	Total Energy to Max Force			Total Shear Energy (Nmm)		
	R <sup>2</sup>	R(1st) <sup>10</sup>	R(2nd) <sup>11</sup>	R	R(1st)	R(2nd)
n <sup>1</sup>	396					
PC <sup>2</sup>	12	4	4	12	4	4
R <sup>2</sup> <sup>3</sup>	0.62	0.59	0.70	0.69	0.68	0.75
r <sup>2</sup> <sub>val</sub> <sup>4</sup>	0.55	0.54	0.59	0.64	0.63	0.65
RMSEP <sup>5</sup>	26.79	25.95	25.10	27.35	26.77	26.35
RMSEC <sup>6</sup>	24.79	24.66	21.81	25.08	25.35	22.75
Robustness <sup>7</sup>	1.08	1.05	1.15	1.09	1.05	1.15
DA <sup>8</sup>	1.24	1.25	1.41	1.37	1.36	1.51
1 - Number of samples				7 - Model robustness = RMSEP/RMSEC		
2 - Optimal Number of Principal Components				8 - Discrimination Ability DA = SD/RMSEP		
3 - Calibration Coefficient of Determination				9 - R = Reflectance Spectra (400-2498nm)		
4 - Validation Coefficient of Determination (full cross-validation)				10 - R(1st) = first derivative of R (1/nm)		
5 - Root Mean Square Error of Prediction (RMSEP) (full cross-validation)				11 - R(2nd) = second derivative of R (1/nm <sup>2</sup> )		
6 - Root Mean Square Error of Calibration (RMSEC)						

Table 1. Model statistics for the prediction of cooked poultry breast meat texture from NIR spectroscopy

	Observed Tender	Observed Tough
Total	239	150
Predicted Tender	229	55
Predicted Tough	10	95
% Correct	95.8	63.3

Table 2. Classification of Pectoralis major muscles by NIR spectroscopy according to tenderness categories.

Calibration and validation coefficients ( $R_{cal}$  and  $R_{val}$ ) were found to be acceptable ( $R_{cal} = 0.70-0.75$   $R_{val} = 0.59-0.65$ ) for total energy (TE) and total energy to max force (TE to MF), and RMSEP as well as RMSEC values were relatively low. Robustness for TE and TE to MF were 1.150 and 1.158, respectively. Thus, the models were said to be robust. Accordingly, the discrimination ability (DA) of the model was found to be slightly low 1.41 (TE to MF) and 1.51 (TE), and the model could not be deemed highly discriminative. This

demonstrates that some model improvements are needed in order to develop a more discriminative model. As seen above, TE and TE to MF, both measured in Nmm, were found to be well predicted. However, max force was found to be unsatisfactorily predicted by NIR spectroscopy. Fortunately, previous research (Cavitt et al., 2004) found TE to be the best predictor of poultry breast meat tenderness and max force to be the least accurate in predicting tenderness.

Weighted regression coefficients helped in identifying the important from the unimportant spectral regions for predicting tenderness by examining the relationship between variables X and Y. Small absolute values (close to 0) are indicative of an unimportant variable, while larger absolute values indicate a variable of large importance. This coefficient value is the average increase in Y when the corresponding X variables are increased by one unit, holding all other variables constant (Camo, 1999). Upon examination of these regression coefficients it was concluded that the spectral regions of 400-600 nm, 950-1,212 nm, and 1,770-1,950 nm were important regions for predicting tenderness in poultry breast meat (See Figure 1). The spectral region of 400-600 nm has been shown in the literature to be highly correlated to myoglobin, whereas the region ranging 1,770 nm to 1,950 nm are closely related to water, proteins, and fats, respectively. These two spectral regions, as seen in figure 1, are positively correlated for tenderness. However, the region from 950 nm to 1,212 nm was shown to be negatively correlated with tenderness. From this model data, average spectra curves for the various debone times were calculated and an average prediction of instrumental force was found and compared to that of the actual averages (See Figure 2). This model yielded excellent results with a R<sup>2</sup> value of 0.97. Razor blade force values were closely, and in some cases exactly, predicted using this model and it seems NIR can be used to accurately predict average razor blade shear force for a deboning time.

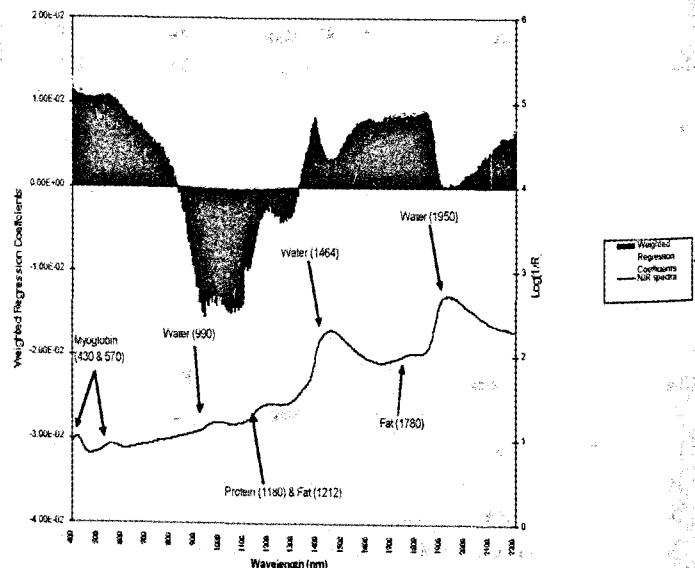


Figure 1. Weighted regression coefficients and corresponding spectra for the model predicting Total Energy from the 2nd derivative of the NIR spectra.

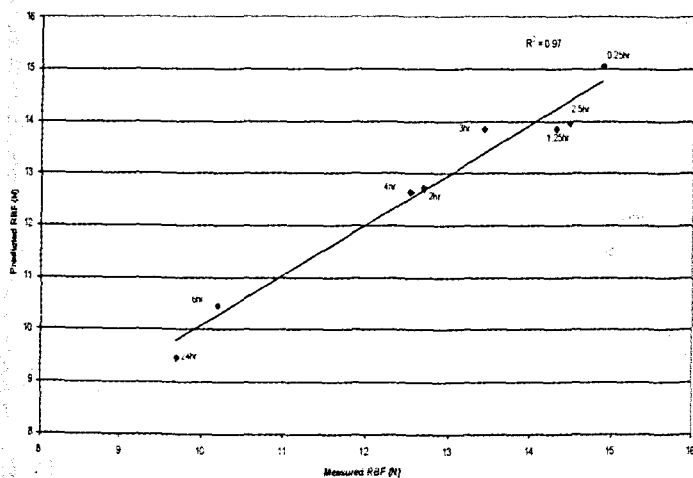


Figure 2. Measured and predicted values from the model for various deboning times.

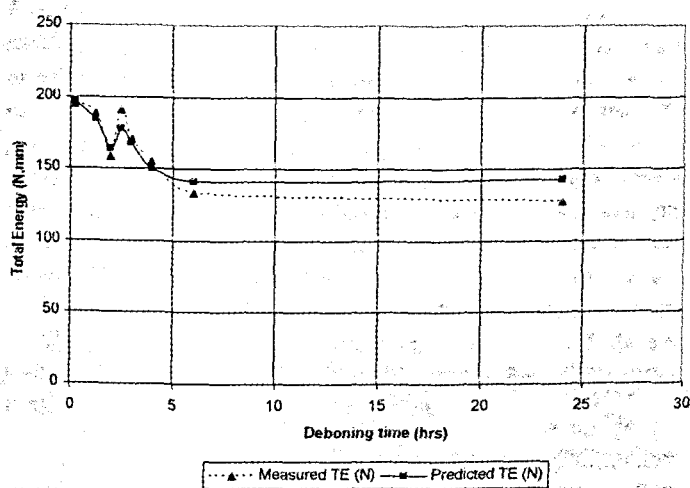


Figure 3. Mean scores for total energy and predicted values from the model using NIR data at various deboning times.

**Discussion:**

The results obtained demonstrate that NIR spectroscopy has great potential for predicting poultry breast meat tenderness. These encouraging results were comparable to prior research conducted by Park et al. (1998) for the prediction of beef muscle tenderness using NIR data. Park, using similar regression techniques, yielded an  $R^2_{cal}$  of 0.82. In this present study, results were slightly less, but still satisfactory with calibration  $R^2$  of 0.70 and 0.75 for TE to MF and TE, respectively.

The second derivative of the reflectance data is recommended for optimizing the correlation between NIR and instrumental measurements for breast meat. The smallest RMSEP's and largest discrimination indices were reported along with the second derivative spectra curve. The mean values for TE at the different deboning times were compared to the mean predicted values using NIR spectroscopy (See Figure 3). Upon examination of these numbers it was concluded that NIR was

very successful in predicting the tenderness of samples at lower deboning times (theoretically, the more tough samples). As seen in figure 3, the 0.25 h and 1.25 h samples predicted means were very close ( $< 4$  Nmm) to the actual means for TE. However, as deboning time increased NIR spectral data had a more difficult time predicting TE. For the 6 h and 24 h samples, actual versus predicted mean score ranges were more varied ( $> 8$  Nmm) than those of the shorter debone times. Thus, NIR spectroscopy is more suitable for the prediction of tougher (3 h PM debone or less) meat than it is for more tender ( $> 3$  h debone) meat.

From the data presented, it seems that NIR could be utilized for on-line assessment of meat tenderness, and certainly the models are acceptable for the possible classification of muscles according to tenderness levels. To verify that statement, muscles were classified into two categories (tender and tough). Values were predicted by cross-validation from NIR data, and the muscles were then classified as tender or tough according to the same value of TE. The value of 177 Nmm was chosen as the cut-off between tender and tough filets based on previous findings in our labs. The percentages of correctly classified samples were then calculated for both the tender and tough categories (see table 2). Results show that out of 239 tender samples NIR was able to predict 95.8%, or 229 samples, accurately. Accordingly, out of 150 tough samples NIR predicted 95, or 63.3%, correctly. It seems that this data, especially for the prediction of tenderness, is acceptable. For instance, before classification only 61.4% of breast filets would have been classified as "tender", while 38.5% would have been classified as "tough". However, after NIR classification, a total of 284 out of 389 filets or 80.6% would be classified as tender, while only 19.4% would qualify as tough. An increase of 20% of tender filets after NIR analysis would certainly justify its use in large poultry processing facilities where marination applications are widely used to achieve a more tender product. Additionally, facilities that run large quantities of breast meat could see efficiency increase and cost decrease as marination may not be needed for as much as 20% of their product.

Further research should concentrate on estimating correlations between sensory measures of tenderness and NIR spectroscopy to confirm the potential of this non-destructive method.

**Conclusion:**

These results demonstrate that NIR spectroscopy has the ability to predict poultry breast meat tenderness; this would qualify NIR as a screening method for sorting breast meat according to tenderness levels. However, more testing must be done to develop robust predictive models and to test the consistency of NIR analysis. In addition, new NIR equipment (more suitable for on-line applications) could be tested as many new NIR spectroscopy applications are now becoming available.

Eventually, on-line NIR non-destructive applications should be tested in a small processing facility to evaluate NIR's performance and durability for large scale processing plant applications.

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## WHERE DOES IT ALL END? BOUNDARIES BEYOND EUCLIDEAN SPACE

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### Preface:

Euclidean space, named for the ancient Greek geometer Euclid, is in some sense the home of mathematics. Mathematicians have been studying the structure and properties of this place for over two thousand years, so they feel at home here. Furthermore, it is a very smooth, homogeneous, friendly place in which to work, where their geometric intuition serves as a dependable guide. If you studied geometry in high school (which would have been Euclidean geometry), then you are familiar with this place. The plane in which you drew your figures is two-dimensional Euclidean space. However, in the early part of the nineteenth century, mathematicians found that Euclidean space has some dark corners that Euclid did not foresee. In fact, there are many subspaces of Euclidean space that bear very little family resemblance.

In these pathological subspaces, they found that their deeply seated intuition was sometimes misleading or even useless. This situation demanded an extension of familiar concepts and definitions, such as what constitutes a boundary point. A large and useful class of spaces they encountered that allowed them to extend the utility of their classical intuition was the class of manifolds. A manifold is a space that can be very unruly on the large scale, but on the small scale resembles Euclidean space. To be a bit more precise, given any point of a manifold, one can enclose it in a sphere (perhaps a very small sphere) inside of which the space is indistinguishable from Euclidean space. Take as an example a basketball and suppose that a recent technological breakthrough has provided us with a shrink ray. It would be possible for us to reduce our size to such a point that, regardless of where we were to stand on the ball, its curvature would be imperceptible to us and so it would appear flat (much as the earth appears flat to us, though we now know it to be a globe). Thus, on the small, local scale the ball resembles two-dimensional Euclidean space at every point making it a two-dimensional manifold, despite the fact that on the large, global scale it is a three-dimensional object.

This local resemblance to Euclidean space allows us to extend fairly easily many of the concepts formerly applied to Euclidean space, such as the idea of a boundary point. Consider

a square cut from the plane, taken to include its edges. There is an intuitively clear difference between a point that is on the edge of the square and a point that is not. To formalize this intuitive difference, we observe that the interior of an arbitrarily small circle centered around a non-edge point resembles all of Euclidean space. The same cannot be said of points on the edge of the square. The interiors of arbitrarily small circles centered about edge points resemble Euclidean "half-space", that is Euclidean space that extends infinitely in all dimensions but one, where it is cropped. Since this observation involves only local properties, it may be applied to manifolds. We can in essence say that a point of a manifold is an edge point if locally it resembles Euclidean half-space, and a non-edge point if locally it resembles whole Euclidean space.

Let us apply this definition to a soup can. If we take any point on the side it should be apparent that, much as with the basketball, we can enclose it in a circle sufficiently small as to make the curvature of the can imperceptible within it. Thus the side of the can be made to resemble the plane. A point taken from the top is only different in that the circle enclosing it can be larger, since the top is already flat. If we take a point on the circle dividing the top from the side, though, we find that this is not the case. Whether we start drawing our circle on the side of the top, we find that even a circle small enough to mask the curvature will hang off the edge of the can and thus resemble Euclidean half-space. Therefore, the can is a two-dimensional manifold with boundary, and the boundary consists of the two circles separating the top and bottom from the side. Although many manifolds have a much more complex structure than our examples of the square in the plane or the cylinder in three-space, the definition of boundary point sketched above continues on where our intuition becomes unclear.

However, there are many interesting spaces that are not manifolds, that is, they do not resemble Euclidean space at all locally (see fig. 2). In many of these examples, we have no intuitive basis for labeling a point boundary or interior, and so must devise formal definitions that both capture and extend our intuitive notions. My thesis explores three proposed solutions for this problem of generalizing the idea of boundary point.



**Introduction:**

Given a topological space, it seems intuitively clear that there is a fundamental difference between boundary points and interior points, but what properties differentiate these two? In the theory of manifolds there is a well-defined notion of which points are boundary points and which are not. We can, in essence, say that a point of an  $n$ -dimensional manifold is a boundary point if it resembles half Euclidean  $n$ -space locally, and a point is not on the boundary if it resembles all of Euclidean  $n$ -space locally. This definition is somewhat restrictive because it requires the space under consideration to be locally like Euclidean space and so does not deal with intrinsic properties of a given point. Furthermore, there are many spaces of interest that do not resemble Euclidean space locally, and so are not subject to the previous definition.

Homotopy affords us a generalization from manifolds to spaces that are locally arcwise connected. In the early nineteen thirties Hopf and Pannwitz advanced the idea of stabil and labil points, here referred to as homotopically stabil and homotopically labil [Hopf]. Roughly speaking, a point is homotopically labil if one can continuously deform the neighborhoods containing the point, while leaving the rest of the space undisturbed, in such a way that the resulting images of the neighborhoods no longer contain the point. This definition replaces the requirement of Euclidean neighborhoods with the requirement of arcwise connected neighborhoods, which is less stringent, and so is in fact an improvement in generality over the manifold definition.

In considering the work of Hopf and Pannwitz, Borsuk and Jaworowski developed a definition of boundary point in the middle of the twentieth century that further relaxed the requirements on the space [Borsuk]. Again speaking roughly, a point is labil if one can find continuous images of the entire space containing the point so that the images do not contain the point and every point of the space is moved "very little." This definition only requires a notion of distance, and so is applicable to any metric space regardless of its connectedness.

In this paper, we first present a brief overview of topology and homotopy to familiarize the reader with the subjects. Next we introduce some preliminary definitions and results in topology to set the stage for a more formal discussion of the boundary definitions. Thirdly, we present the boundary definitions in full formality, and argue that they are indeed successively more general. This is followed by a series of examples further illustrating the interplay between the definitions. Finally, we explore what sorts of processes preserve the properties of homotopic lability and lability, and discuss briefly a cohomological definition of boundary and interior that reflects more recent progress in generality.

**The Definitions:**

Let us begin with our definition of what it is to be on the boundary of such a manifold. In the following definition the set

$$\mathbf{H}^k = \{x \in \mathbf{R}^n \mid x_k \geq 0 \text{ and } x_{k+1} = \dots = x_n = 0\}.$$

**Definition B1:** Given a  $k$ -dimensional manifold  $M$ , the *boundary of  $M$*  is the set of all points  $x$  for which there exists an open set  $U$  containing  $x$ , an open set  $V \subset \mathbf{R}^n$ , and a homeomorphism  $h: U \rightarrow V$  such that  $h(U \cap M) = V \cap (\mathbf{H}^k \times \{0\}) = \{x \in V \mid x_k \geq 0 \text{ and } x_{k+1} = \dots = x_n = 0\}$  and  $h(x) = (x_1, x_2, \dots, x_k, 0)$ . A manifold for which the boundary is nonempty is called a *manifold with boundary* [Spivak 113].

That is, a point of a  $k$ -manifold is on the boundary if it has a neighborhood homeomorphic to half Euclidean  $k$ -space, and the homeomorphism maps it onto a point on the boundary of the half space. Again we observe that this definition is somewhat unsatisfactory in its indirectness and limited applicability. Next we move on to our homotopic definition first given by Hopf and Pannwitz [Hopf].

**Definition B2:** A point  $a$  of a space  $S$  is *homotopically labil* whenever for every neighborhood  $U$  of  $a$  there exists a function  $F: S \times I \rightarrow S$  (where  $I$  is the unit interval  $[0,1]$ ) which is continuous and satisfies the following conditions:

1.  $F(x,0) = x$  for every  $x \in S$
2.  $F(x,t) \in U$  for every  $(x,t) \in (S \setminus U) \times I$
3.  $F(x,t) \in U$  for every  $(x,t) \in U \times I$
4.  $F(x,1) \neq a$  for every  $x \in S$ .

A point that is not homotopically labil is *homotopically stabil*. Note that homotopical lability is a local property, in that if  $a$  is a homotopically labil point of a space  $S$  and  $b$  is a point of a space  $T$  and there exists a homeomorphism  $h$  that takes a neighborhood  $U_0$  of  $a$  onto a neighborhood  $V_0$  of  $b$  such that  $h(a) = b$ , then  $b$  is homotopically labil in  $T$ .

Our final definition was motivated by the observation that, for a metric space, conditions equivalent to 1-4 may be given in terms of the space's metric as follows:

**Definition B2':** A point  $a$  of a metric space  $M$  is *homotopically labil* if for every  $\epsilon > 0$ , there exists a mapping  $g: (M \times I) \rightarrow M$  (where again  $I$  is the unit interval) satisfying the following conditions:

- 1'.  $g(x,0) = x$  for every  $x \in M$
- 2'.  $\delta(x, g(x,t)) < \epsilon$  for every  $(x,t) \in (M \times I)$
- 3'.  $g(x,1) \neq a$  for every  $x \in M$ .

It should be clear that a point  $a \in M$  that is homotopically labil by **B2** is also homotopically labil by **B2'**, but the skeptical reader will require some support for the claim that the converse is true. Suppose then that under **B2'**  $a$  is homotopically labil,  $g(x,t)$  is a mapping satisfying 1'-3' for some  $\epsilon > 0$ , and that  $U$  is a neighborhood of  $a$  such that  $\delta(x,a) < 3\epsilon$  implies  $x \in U$ . Define  $F: (M \times I) \rightarrow M$  thus:

$$F(x,t) = \begin{cases} g(x,t) & \text{for } \delta(x,a) \leq \epsilon, 0 \leq t \leq 1 \\ g[x, t(2 - (\delta(x,a)/\epsilon))] & \text{for } \epsilon \leq \delta(x,a) \leq 2\epsilon, 0 \leq t \leq 1 \\ x & \text{for } \delta(x,a) \geq 2\epsilon, 0 \leq t \leq 1 \text{ [Borsuk].} \end{cases}$$

Having made this realization, Borsuk and Jaworowski saw a way to further generalize this concept of homotopic lability by divorcing it from homotopy. In their paper they introduce the notion of *lability*, and define it thus:

**Definition B3:** A point  $p$  of a metric space  $S$  is *labil* whenever there exists for every  $\epsilon > 0$ , a mapping  $g: S \rightarrow S$  such that

- 1a.  $\delta(x, g(x)) < \epsilon$  for every  $x \in S$
- 2a.  $g(x) \not\downarrow p$  for every  $x \in S$ .

A point that is not labil is *stabil* [Borsuk].

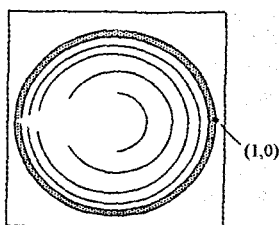
We note here that in contrast to homotopic lability, lability is not a local property. Consider the following sets in the Euclidean plane.

$$S_0 = \{(x,y) \mid x^2 + y^2 = 1\}$$

$$S_n = \{(x,y) \mid x = (1 - 1/n)\cos \theta, y = (1 - 1/n)\sin \theta; |\theta| \leq (\pi - 1/n)\} \text{ for } n \in \mathbb{N}$$

$$S = \bigcup_{n=0}^{\infty} S_n \quad T = S \cap \{(x,y) \mid x \geq 0\} \text{ (see Fig. 1)[Borsuk].}$$

Fig. 1



Obviously,  $S$  and  $T$  are identical about the point  $(1,0)$ , yet this point is *stabil* in  $S$  and *labil* in  $T$ .

**Equivalences and Divergences:**

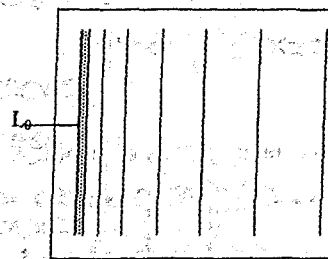
We can show without much work that our manifold definition implies our homotopic definition, which in turn implies our metric definition. For the first implication, assume that an  $n$ -dimensional manifold  $M$  is locally homeomorphic to half of Euclidean  $n$ -space about the point  $p$ . Given some  $\epsilon > 0$  let

$$U_0 = \emptyset, U_t = \{(x,y) \mid \delta(x,p) \leq \epsilon t\}, \text{ and } U = \bigcup_{t \in [0,1]} U_t.$$

For each  $t$ , define  $r(x,t) = r_t(x)$  as the retraction mapping  $r_t: M \rightarrow (MU)$ . It should be clear that  $r(x,t)$  satisfies conditions 1-4 for the neighborhood  $U$  of the point  $p$  in the space  $M$ , and thus  $p$  is homotopically labil. To see that our homotopic definition implies our metric definition, simply observe that if  $g$  is a mapping satisfying conditions 1c-3c for a point  $a$  of a metric space  $L$ , then setting  $f(x) = g(x,1)$  gives a mapping satisfying conditions 1a and 2a for  $a \in L$ .

Obviously the converse is not true in general for the manifold and homotopic definitions, since a point labil in our homotopic sense may not have a single neighborhood homeomorphic to half- or whole Euclidean space. Our next example shows that the converse is also false in general for our homotopic and metric definitions. For the following of example, consider the set given as a subset of the Euclidean plane with the induced topology.

Fig. 2



Let  $N = \{1/n \mid n \in \mathbb{N}\}$ ,  $J = [-1, 1]$ ,  $S = N \times J$ ,  $L_0 = S \setminus (N \times J)$  and  $L_k = \{1/k\} \times J$  (see Fig 2). First observe that any point of  $L_0$  fails to have connected neighborhoods, and so by theorem 4 cannot be homeomorphic to Euclidean space. Thus our manifold definition is of no service to us. We claim that any non-endpoint  $p$  of  $L_0$  is homotopically stabil, but labil. To see that  $p$  is homotopically stabil, assume that there exists a function  $f$  satisfying conditions 1-4 for  $p$  and some neighborhood  $U$  of  $p$ , and consider the images of  $L_0$  under  $f$ . If we assume that  $f$  does not map  $L_0$  onto itself, then  $f$  maps  $L_0$  onto some  $L_k$  and we have a situation depicted in figure 2a. Here we see that the continuous image of  $L_0$ , a connected set, is disconnected, and this contradicts the fact that connectedness is a continuous invariant. Hence, it must be that  $f$  maps  $L_0$  onto itself. However, condition 4 requires that  $p$  not be an element of  $f(U)$ , and so we arrive at the situation depicted in figure 2b. Again we have  $L_0$  mapped into a disconnected set, namely  $L_0 \setminus \{p\}$ , which is another contradiction. Thus we must conclude that no such  $f$  exists and thus  $p$  is homotopically stabil.

Figure 2a.

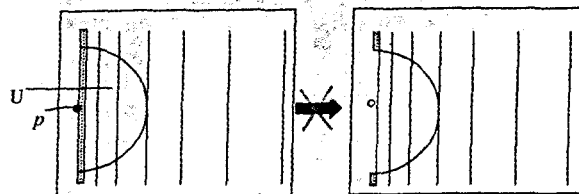
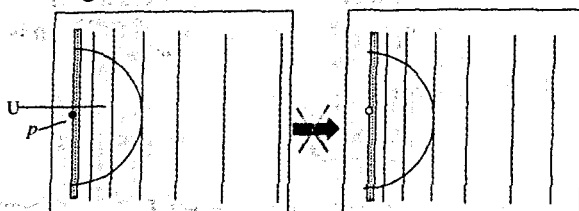


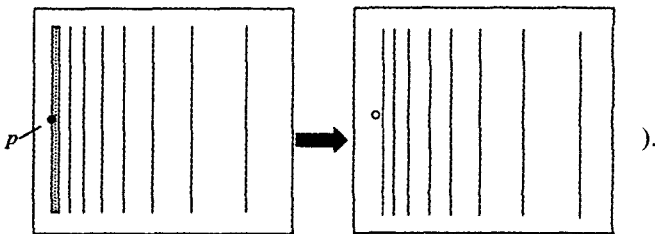
Figure 2b.



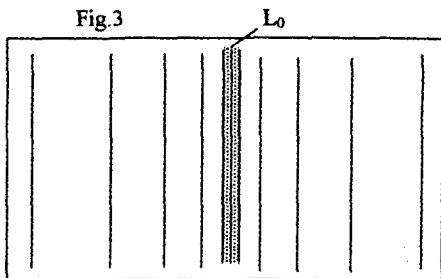
The problem here arises from the fact that, for homotopic lability, the space must remain fixed outside the neighborhood  $U$ . For lability there is no such requirement, so we are free to use a restriction of a projection mapping to map onto some segment  $L_k$ , the segment  $L_0$  and all segments  $L_k$  where  $k > k^*$ , as depicted in figure 2c. More specifically, let  $\epsilon$  be an arbitrary positive real number, choose an  $n \in \mathbb{N}$  such that  $n > 1/\epsilon$ , and define  $f_\epsilon: S \rightarrow S$  as follows:

$$f_\epsilon(0,s) = (1/n,s) \text{ and } f_\epsilon(1/k,s) = \begin{cases} (1/k,s) & \text{for } k \leq n \\ (1/n,s) & \text{for } k > n. \end{cases}$$

This mapping demonstrates the lability of  $p$  (see fig 2c.)



A slight modification of  $S$  indicates that our more general definitions sometimes defy our intuition of what a boundary point is. Let  $N^* = \{1/n | n \in \mathbb{Z}\}$ , and define  $L_0^*$ ,  $S^*$ , and  $L_k^*$  analogously to  $L_0$ ,  $S$ , and  $L_k$  (see Fig. 3). Note that the points of  $L_0^*$  fail to have Euclidean neighborhoods as well. An argument similar to that of our previous example shows that the non-endpoints of  $L_0^*$  are homotopically stabil as might be expected, but a simple modification to  $f_\epsilon$  shows that these points are still labil, despite the fact that any arc drawn from such a point to a simple closed curve enclosing the space intersects the space in at least one other point.



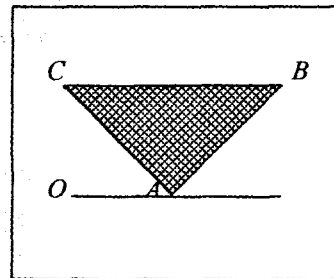
Before we move on to our next topic we note that for a rather large class of examples, the notions of homotopical lability and lability do coincide: when the space under consideration is an absolute neighborhood retract.

**Property Preserving Processes:**

A natural question to ask is 'when are our boundary points preserved?' In the example depicted in figure 2, we see that a

sequence of homotopically labil points (i.e. the endpoints of each  $L_k$ ) converges to a homotopically labil point (i.e. the endpoint of  $L_0$ ). Is the limit of a sequence of labil (or homotopically labil) points labil (or homotopically labil) in general? Consider in the plane the triangle with vertices  $A = (1/2,0)$ ,  $B = (1,1)$ , and  $C = (0,1)$ , and let  $X$  be the union of the set of all points on or contained by the triangle and the segment of the x-axis between 0 and 1 (see Fig 5).

Fig. 5



A sequence of retraction mappings almost identical to the one at the beginning of the previous section shows that any non-endpoint of the line segment  $AB$  is homotopically labil (and thus labil), and the segment contains a sequence of points approaching  $A$ . However, another connectedness argument shows that  $A$  is in fact stabil (and thus homotopically stabil).

Borsuk and Jaworowski prove in their paper on lability that the stability of a point, and also the homotopic stability, are invariant under Cartesian division but leave the question of Cartesian multiplication open. It is fairly easy to see that lability is invariant under this operation, and in fact that a sufficient condition for a point  $(a,b) \in A \times B$  to be labil is for  $a$  to be labil in  $A$  or  $b$  to be labil in  $B$ . For if we have a point  $a \in A$  that is labil in  $A$  and  $f$  is a function satisfying conditions 1a and 2a for  $a$ , then by defining  $g: A \times B \rightarrow A \times B$  as  $g(x,y) = (f(x),y)$  we obtain a function satisfying 1a and 2a for any point in  $A \times B$  of the form  $(a,y)$ . Similarly, we can argue that if  $b \in B$  is labil in  $B$ , then any point in  $A \times B$  of the form  $(x,b)$  is labil.

Soon after the paper of Borsuk and Jaworowski appeared, Noguchi supplied an answer to the question of the invariance of homotopic stability under Cartesian multiplication in two papers published in 1954 and 1955. In the first paper, Noguchi supplied the following homological characterizations of homotopically labil and stabil points.

**Theorem N1:** Let  $A$  be a complex. A point  $a$  of  $A$  is homotopically labil if and only if there exists a contractible neighborhood complex of  $a$  [Noguchi 1954].

**Theorem N2:** Let  $A$  be a complex. A point  $a$  of  $A$  is homotopically stabil if and only if there

exists a neighborhood complex of  $a$  which is not contractible [Noguchi 1954].

In his paper of 1955, Noguchi used these characterizations along with the homological properties of joins to show that in fact homotopic stability is not invariant under Cartesian multiplication, except in the special case of homogeneous complexes [Noguchi 1955].

### A Final Generalization:

Before we conclude we discuss one further generalization of the boundary point concept due to J. Lawson and B. Madison, who published a paper on the subject in 1970. Our homotopic definition replaced the requirement of Euclidean neighborhoods with that of arcwise connected neighborhoods; our metric definition freed us from that restriction by using only a notion of distance; our final definition lacks even that requirement making it the most general to date. Lawson and Madison gave and investigated two definitions in terms of cohomology, which they call peripheral and marginal.

### Conclusion:

We have now presented three successively more general notions of a boundary point. In manifolds, we have identified boundary points as those points having neighborhoods homeomorphic to half-Euclidean space. In locally arcwise connected spaces we have that a point is homotopically labil if we can deform the neighborhoods of the point in the space continuously in such a way that the result does not contain the point, but the complements of the neighborhoods remain unmoved. For any metric space we say that a point is labil if there exist continuous images of the space containing the point that do not contain the point and that do not move any point far.

We then argued that each of these definitions generalizes the one before it. A pair of examples showed that these definitions are not equivalent, and that in at least one instance the more general definitions can have rather counterintuitive consequences. After an investigation into various operations applied to labil and stabil points we learned that Cartesian division preserves both homotopic lability and lability, that Cartesian multiplication preserves lability but not homotopic lability, and that the limit process preserves neither lability nor homotopical lability. Finally, we directed the interested reader to more work in improving the generality of the boundary concept. We hope that our discussion will be as illuminating for others as it has been for us.

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### Faculty comment:

Dr. Bernard Madison made the following remarks about Mr. Thompson's work:

Jonathan's research is in an area that overlaps into point-set topology and algebraic topology. Basically, the goal of work in this area is to determine structures and properties of spaces, e.g. subsets of Euclidean space, using algebraic constructs. The particular problem that Jonathan studied was distinguishing boundary points from interior points in spaces that are different from spaces that are like Euclidean spaces locally. Locally Euclidean spaces such as a circular disk are called manifolds and the notions of boundary and interior are well known and reasonably obvious. This interior versus boundary problem was studied in the 1930's and 1950's by several European mathematicians and resurfaced in the 1960's and 1970's because of relevance to work in topological algebra.

We have no undergraduate course work here in any area of topology so Jonathan had to learn a considerable body of material as background. Jonathan's work centers on two different concepts of boundary points, one defined in terms of metrics and one defined in terms of homotopies. These notions were introduced by H. Hopf and E. Pannwitz (1933) and K. Borsuk and J. Jaworowski (1952). Later, A. D. Wallace, K. H. Hofmann, P. S. Mostert, J. D. Lawson and I expanded these definitions using cohomology structures and applied the results to topological algebra structures. Jonathan's major creative contribution was to describe and analyze several fairly complex subspaces of the plane that provide examples that refine and distinguish between the metric and homotopy definitions of boundary. His apparent understanding of these examples is impressive for an undergraduate, and his exposition of his understanding is extraordinary. Jonathan's introduction to his paper is an excellent effort to convey understanding of his work to non-experts.