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This journal promotes and publishes conceptual papers/models, qualitative research, pedagogical research, practice notes, and case studies in business and applied sciences. Submissions are made through www.baasana.org.

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International Review of Business & Applied Sciences (IRBAS)

Scope and Coverage

The *International Review of Business & Applied Sciences* (*IRBAS*) is a double-blind peer reviewed journal of Business and Applied Sciences Academy of North America (BAASANA) that publishes conceptual papers, Qualitative Research, Case Studies, Pedagogical Research and Interviews involving global or country specific of Business, Social, Behavioral and Applied sciences. The primary focus of the journal is on innovative ideas leading to solutions to problems. Interdisciplinary and or discipline specific descriptive, conceptual ideas, constructs, propositions, models and theories including moral and ethical call for to actions toward solutions of problems across digital divide.

IRBAS publishes review articles, original ideas, and theoretical, conceptual narratives with less discipline specific jargons. Statistical analysis when used, should be explained in plain language for interdisciplinary global readers. Commentaries on articles and reports published in the Journal are welcome and encouraged. Authors will have the opportunity to respond to the commentary on their work and those responses will be published. Special Issues devoted to important global topics, including disruptive innovations, and case studies on UN Sustainable Development Goals (SDG) will be routinely published.

The journal is an invaluable support to academics and researchers, environmental activists, SDG participants, teachers using innovative pedagogical styles, and all those charged with setting policies and strategies for business and social, global and non- profit organizations.

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- Management Issues
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Content

All authors must declare that they have read and agreed to the content of the submitted manuscript.

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Journal Index

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EDITORIAL

Papers included in this issue are five. They are conceptual in nature—clearly fitting into the scope of the journal. All of them relates to issues applied sciences and business. The first paper is authored by Dr. George Tenedios, a medical professional/administrator that deals with the issue of managing health care organizations with an aging workforce in the current context of an expanded cohort of senior citizens with special gerontological medical needs. The health care needs of the retiring baby boomers as well as the concomitant loss of experienced baby boomer employees and professionals from active duty was dealt with from the perspective of strategic human resource management. The author argues that the increased life expectancy of the baby boom generation and consequently greater need of costly care is already beginning to strain the health care services capacity. In addition, with four generations of the workforce with their respective attitudinal differences and individual values working simultaneously in care giving often creating unwelcome interpersonal situations of stress in the work place. Drawing from the best practices of reputable care health care facilities in the region, the author suggested development of strategic human resource management toward resolving the issues he expertly raised in the paper.

The second paper was co-authored by Arian Moghadam and Mohammed Dore. It deals with an applied problem affecting public health. The paper focuses on the issues of comparative cost and, economies of scale in the water treatment plants of Canada. Authors argued financial constraints as well as historical, path dependent practices often are impediments for adoption of new, safer, non-chlorine based water disinfection treatment technology being in Europe (Netherlands in particular). The paper dealt the financial efficacies of the small communities to adopt the newer, safer technologies. Authors developed models to test economies of scale and costs to adopt free chlorine option and concluded that smaller system can achieve economies of scale with a relatively higher fixed cost investment. The findings may be worthwhile for the policy-makers to avert the pernicious impact of chlorine based system (such as myeloid leukemia and colon cancer).

In the third Paper, Joshua Friedman dealt with student scheduling issue for small educational institutions in the United States. He developed a mathematical model accommodating all possible hard and soft constraints for a small College or a High School. He tested the model by applying it at United States Merchant Marine Academy. The objective was to minimize the soft constraints and find optimum solution for varied group and sub groups of students while taking into consideration of the professors' time preferences.

The fourth Paper was written by Dr. Frank Owarish, a strategic research and training specialist, and an international consultant of organizations related to global order and UN interventions. He highlighted the changing dynamics in and perspectives on the international relations. He reviewed the contrasting literature such as the "End of History vs. "the Clash of Civilizations"; reversing the means-ends relationship between international diplomacy vs. international business. Redefinition of "incrementalism" to "pushing down" or "bullying"; the use of social media as instrument of diplomacy; and whole host of other emerging issues such as hacking, cyber security concerns, wiki leaks. He discussed these new dynamics under nine segments that include eLeadership, New globalism, Redefining "win-win" in the U.S.- EU relations; U.S.-China cooperation, competition, and conflict; Russia and its role in the world order; Global Issues of Environment and Climate, and finally, the imperative of Strategic Leadership of Technology. The paper narrates and surveys the

current world issues of conflicts, wars, hunger and poverty, climate change related catastrophe, and the UN Sustainable Development Goals. UN alone cannot mitigate these conflicts and issues. The author urges with general call for action to solve the problems of the world.

The last paper deals with ethics and social responsibility from a comparative perspective. The studies cited in paper are sporadic in nature. That is probably the reason why it has not emerged as a discipline or a track at any serious academic forum. However, this paper recognizes the Small business as main vehicle of economic growth and employment in most countries of the world. Therefore the business ethics which is perceived to be at bay when the small business begins to experience a chronic cash-flow reconciliation issue. Drawing on selected countries of several continents, authors discovered diversity perspectives on ethics, importance given to the subject matter with commonalities of prescriptions provided to resolve ethics challenges. Development of ethical codes, strict implementation, and monitoring of the code enforcement, mandatory ethics training for all employees, offering incentives and rewards were among the many action steps suggested in the current literature. Papers dealing with cases of best practices of small business ethics across the digital divide will be welcome addition to guide for small businesses in the areas of ethics and social responsibility.

This journal makes its journey with this issue. Papers included in this issue are interdisciplinary and have dealt with issues of importance. The readers will find them informative and useful toward professional growth. We will continue to publish qualitative papers, research models, conceptual papers, case studies, professional interviews, reports of disruptive innovation in education and other applied sciences. We welcome authors to spread the word and invite scholars and practitioners to read and also volunteer to write future issues of *IRBAS*.

Sincerely,

M. Ruhul Amin, Ph.D.
Editor-in-Chief

Baby Boomer Employees' Influence upon the Health Care Sector

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Abstract

Strategic human resource managers in the health care sector will have to invest in resources and develop initiatives to serve an expanding group of retired individuals medically, and resource management teams will need to create educational programs on retirement planning and consider work–life balance and compensation packages that will help retain older experienced workers. These programs will help to preserve the older workforce and attract more talented professionals to meet the health care needs of an aging society. The managers of a few strategic human resource departments in the health care organizations have analyzed and developed effective strategies and programs that positively affect older workers. This research report explores and identifies the current impact of the baby boom generation on the workforce in the health care sector. The research report shows which health care organizations are effectively coping with the implications of an aging workforce in the health care sector.

Keywords: aging workforce, health care, geriatrics, strategic human resource management, physicians, nurses, allied health care professionals, older workers, health care organizations.

When baby boomers began turning 65 in 2011, their influence on the characteristics of the workforce in the United States increased. Baby boomers have "challenged standard understandings of modernity" and "helped to humanize capitalism and create social democracy" (Alexander, 2018, pp. 100-101) more than any other generation in history. They were the first generation to revolutionize the view that a woman's place was in the home, and women subsequently "entered the workforce in droves, changing the workplace and the economy forever" (Gibaldi, 2014, p. 52). Since reaching retirement age, baby boomers have challenged another social institution: retirement (Gibaldi, 2014). Unlike previous generations, many baby boomers are "dreading retirement, and fear being disengaged from friends and society" (Gibaldi, 2014, p. 50). Some baby boomers claimed that old age begins at 72, not 65 and that they feel younger than their chronological age (Gibaldi, 2014, p. 50). They have also challenged human resource managers' antiquated strategic programs for early retirement. Baby boomers are not ready to give up the intellectual and social interactions that aging employees discover from active participation and engagement in their place of employment (Gibaldi, 2014).

In the United States, the majority of Americans reaching age 65 who are in relatively good health are likely to live "up to fifteen and twenty years beyond the age of 65" (Bragg & Hansen, 2015, p.

91). The increased rate of survival into older age is a testimony to the technological advancements and medical achievements of industrial societies (Prince et al., 2015). However, the increasing longevity in the United States may place financial burdens on the health care system. As baby boomers age, seven out of 10 are likely to need costly heroic and futile medical care (Bragg & Hansen, 2015, p. 91), and "healthcare services supply capacity will eventually fall significantly short of demand" (Doi, Ide, Takeuchi, Fujita, & Takabayashi, 2017, p. 2). When baby boomers decide to retire from the workforce and start reaching their 70s, 80s, and 90s, the health care and social assistance sector will face an increasing "global burden of disease" (Prince et al., 2015, p. 549).

Older adults require expensive and labor-intensive resources for treating their complex physical, cognitive, social, and psychological symptoms. The leading diseases in the aging population are ischemic heart disease, stroke, chronic obstructive pulmonary disease, diabetes, low back pain, cancer of lungs, visual impairments, hearing loss, dementia, hypertensive heart disease, osteoarthritis, and major depressive disorders (Prince et al., 2015, p. 552). As more workers age, demand will increase for ambulatory care, hospital services, nursing homes services, and home health services. For many high-income countries like the United States, "population aging persists as fertility continues to fall and life expectancy increases slowly" (Prince et al., p. 549). The disparity between population growth and life expectancy has led to an unresponsive health care system that lacks adequate numbers of professional workers to care for aging members in society. The number of health care employees needed will "need to expand from almost 13.6 million jobs in 2002 to almost 22 million jobs in 2022 with an annual growth rate of 2.6% between 2012 and 2022" (SHRM, 2016, p. 3). In the nursing profession, an "estimated 1.13 million new nurses will be needed by 2022 (a 20.2% increase from 2012)" (Denham & Matthews, 2018, p. 32). Many experts worry that a perfect storm looms over the health care arena because "today's skilled and experienced workforce is reaching retirement age faster than new practitioners are being trained to take their place" (Preece, 2018, p. 1). In an expanding aging population, poorly prepared human resource managers in the health care sector will have to employ health care professionals to meet these medical needs. These managers will face many challenges in retaining health care professionals, particularly doctors and nurses, to care for an aging population burdened by chronic diseases.

1. The Effects of a Multigenerational Workforce on the Aging Workforce

The U.S. health care system's workforce has become increasingly diverse in age, gender, race, and culture. There are "47.8 million adults over 65 in the United States, and by 2040 the number is expected to grow to 98 million, or more than one in five Americans" (Fullen, 2018, p. 104). Many millions of Americans continue to work beyond the age of 65 because eligibility for Social Security benefits begins at a later age and because of a lack of retirement savings; other reasons include financial necessity, an interest in staying active, and a need for health care insurance (Senate (Special Committee on) Aging Committee, 2018, p. 20). Four generational groups from the ages of 17 to 70 work in the health care sector: traditionalists, baby boomers, members of Generation X, and millennials. The largest group in the multigenerational workforce is millennials (born between 1977 and 1995), followed by baby boomers (born between 1946 and 1964). Representation in the workforce is as follows: "Traditionalists (1%), Baby Boomers (30%), Generation X (27%), and Millennials (42%)" (Jones, Murray, & Tapp, 2018, p. 91).

Each generational group has its own "collective consciousness molded from commonly shared world events and circumstances in their formative years" (Curry, 2007, p. 1) and brings unique behaviors, expectations, communication styles, personal values, and motivational factors to the health care framework (Curry, 2007, p. 68). Baby boomers "believe in fairness and equal

opportunity," and a "moral belief in having respect for authority" (Benson, Brown, Glennie, O'Donnell, & O'Keefe, 2018, p. 527). They also believe that "working hard" and "being loyal to the organization" (Benson et al., 2018, p. 527) are important for their employability. Based on their past experiences, members of Generation X believe leaders of business organizations "do not value their loyalty" (Benson et al., 2018, p. 527) and feel the future is uncertain because they cannot depend on their employer for lifetime employment. Members of Generation X are also more "individualistic than Baby Boomers" and they "expect to attain and maintain career security and enhance their marketability through challenging jobs in which they are constantly learning" (Benson et al., 2018, p. 528). Millennials are "the first high tech generation" (Becton et al., 2014, p. 177). Their values have been influenced by "globalization of society and the marketplace" and they are the "most racially and ethnically diverse of the four generations" (Becton et al., 2014, p. 177). Like the members of Generation X, millennials do not trust business organizations and thus do not have a strong desire to search out meaningful employment (Becton et al., 2014, pp. 177-178).

These diverse generational views and attitudes can be challenging for human resource managers attempting to promote a constructive and harmonious work environment. The key negative response is that "employees' values and their congruence (or lack thereof) with the organizational values may impact retention and motivation, which in turn affect productivity and overall morale" (Jones et al., 2018, p. 90). To lead the multigenerational workforce effectively, managers must recognize what each generational cohort offers and demands. Each employee in his or her respective generational group has different requests, biases, and work ethics. Because of these distinct differences, major confrontations and misunderstandings "can occur while working together" (Denaro, Giorgi, Sderci, & Fiz-Perez, 2018, p. 145). Most human resource discussions on diversity in the workplace have been about race, ethnicity, gender, sexual orientation, and disability, but another important challenge is age diversity. A crisis is looming in the workforce when population aging "is framed regarding intergenerational conflict as younger members of the population . . . [are] shouldering the old age burden" (Kesby, 2017, p. 375).

Many older workers have experienced age-related discrimination on "job-search websites, human bias in hiring and advancement process, and systemic issues in organizations, where younger people are often favored" (Siegel, Mathews, McCann, & Poerksen, 2017, p. 10). In a study conducted for AARP in 2017 that included 3,900 workers over 45 years of age, Gurchiek (2018) discovered that six out of 10 older workers reported "seeing or experiencing" (p. 1) age discrimination. Discrimination against older workers can be subtle. For example, well-qualified individuals in their 50s can have great difficulty in finding a new position, while less qualified and younger individuals can more easily land the same job. It may be difficult to notice job discrimination in the workplace, but the Equal Employment Opportunity Commission reported that despite the law against employment discrimination of workers over 40 years of age there were 18,376 charges for age discrimination during the fiscal year 2017 (Gurchiek, 2018, p. 1).

Human resource professionals must strategically manage multigenerational employees to conform to organizational processes, but such diversity management can be complicated. Stereotypes about older adulthood are commonly channeled "throughout society and may lead to poor health and well-being of older people" (Fullen, 2018, p. 105). For example, "even after controlling for age, gender, socioeconomic status, loneliness, and functional health, older adults with more positive self-perceptions of aging lived 7.5 years longer than those with less positive self-perceptions of aging" (Levy, Slade, Kunkel, & Karl, as cited in Fullen, 2018, p. 107). Other societal customs against aging are communicated through television shows, movies, advertising, and social media. Messages created by members of social media outlets contribute to the depersonalization, infantilization, and

dehumanization of older adults, which leads to public advocacy toward banning older adults from activities such as driving and shopping (Levy et al., 2014, p. 175). Similar negative attitudes and stereotypes exist in the work environment, including "the notion that older workers have lower ability and motivation, lower productivity, and greater resistance to change" (Fullen, 2018, p. 105). Human resource management departments must communicate and educate their multigenerational workforces that "more positive views toward aging . . . may serve as a buffer against internalized ageism" (Fullen, 2018, p. 105).

Supportive human resource practices regarding older workers' acceptance in the workplace are essential. Generations have more success working together in the workplace and in society if they see eye to eye. One step is to correct inaccurate, negative perceptions that generations have about one another. Mistaken views such as older workers being less productive, less engaged, and unable to learn new technologies are barriers for older workers in training and employment. Research has shown there is no significant difference between the productivity of older and younger workers. Measuring task performance in workers older than 65 and comparing it to data from younger workers revealed the systematic differences in job performance of core tasks are unrelated to chronological age (Ng & Law, 2014, pp. 10-11).

Ng and Feldman (2008) discovered older workers demonstrate "more citizenship behaviors and greater safety-related behavior," and in general "exhibit less workplace aggression, on the job substance abuse, tardiness and voluntary absence" (p. 403). Many other important personality traits for strong work performance improve with age. For example, scientific evidence has shown that an older worker's "conscientiousness, emotional well-being, agreeableness, loyalty, and language complexity" improve with age (Folz, 2017, p. 1). Folz (2017) pointed out that it is an economic fallacy that "by declining to retire, older employees are taking jobs from younger ones" (p. 1). The dynamics of work engagement and meaningful work across generational cohorts are becoming increasingly important for human resource managers to understand ways to develop effective sustainable corporate strategies for their organizations (Hoole & Bonnema, 2015, p. 1).

The positive traits of older workers outweigh the negative stereotypes. Paulin (2018) noted several positive qualities of mature workers: "loyalty, reliability, and dedication, higher levels of engagement, a strong work ethic, job-related skills, including good communication skills, existing network of professional and client contacts, [and] broad work experience" (p. 4).

2. Human Resource Strategies

Human resource managers can take steps to correct inaccurate and negative perceptions that each generation has about other age groups. Human resource personnel must educate themselves and their employees on age-related factors. North (2017) stated, "Generations have more success working together, in the workplace and society, if they can see eye to eye" (p. 8). According to North, "It's not constructive to put generations against one another if we are trying to get them to work better together" (p.9). Human resource managers must understand and help older workers face these stereotypes and barriers. Older workers were historically considered an expendable resource that was not valuable, and therefore subjecting older workers to corporate layoffs was one option to improve the corporate bottom line. In addition to corporate layoff strategies, management often offered early retirement incentives to older long-standing employees. These lean strategic methods created a negative perception that accelerating the exit of older workers from the workforce was in the best interest of the organization's financial success (Calo, 2008, p. 404).

The U.S. health care system has reached a critical point where more talented labor is needed. During the next decade, "the healthcare industry is projected to add more jobs, over 4 million, than any other industry between 2012 and 2011, according to the United States Bureau of Labor Statistics" (Torpey, 2014, p. 28). The health care industry is projected to be among the fastest growing industries in the United States. To keep up with this growth, the leaders of health care organizations must proactively employ highly skilled health care professionals to support an organization's mission. Management must be informed and sensitive to the "various career life stages and phases of its employees" (van Zyl, Mathafena, & Ras, 2017, p. 4). The Human Resource Managers must "acknowledge that there are age-related differences related to differences in individual needs based on their career stage" (van Zyl et al., 2017, p. 4) to decrease the causes and cost of absenteeism in the workplace. There must also be a strong and effective organizational commitment to transferring knowledge from older workers to younger employees, and leaders must be willing to change and develop new approaches that necessitate changing past practices and ingrained attitudes. These are all challenges of having multiple generations in the workplace.

Several strategies can be implemented to create and sustain a vital intergenerational workforce. Gathering information that is necessary for decision making to assess the inventory of the workforce is, therefore, a priority. By evaluating the workforce by "ages, lengths of service, and provisions of the organization's pension plan, it is possible to calculate the number of workers who are eligible to retire now, as well the number who will be available each year until a target planning date, such as the next five years" (Calo, 2008, p. 407). Strategic human resource department personnel must be sensitive to "cultural expectation that employees retire at a certain age, or that provisions of the pension plan encourage or discourage workers from retiring at certain ages" (Calo, 2008, p. 407). Human resource managers who analyze and evaluate the intricacies of their organization's workforce can formulate policy changes, as leadership and human resource professionals must understand what is reasonable to expect from mature workers to avoid unsuitable perceptions and opinions (Anselmo, 2018, p. 114).

The following paragraphs include strategies that human resource managers can change to encourage employee retention. The first strategy is to create opportunities for various cohorts to collaborate on teams and between generations. Human resource managers can develop business hosting in off-site informal events with colleagues so they can interact and learn commonalities about their coworkers. Mature employees may be more engaged with their organization and less likely to leave if their work assignments include "collaboration with bright and experienced people" (Avery, McKay, & Wilson, 2007, p. 1551). In the health care arena, "collaboration with all stakeholders is imperative to successful patient care that integrates clinical expertise and technological support" (Denham & Matthews, 2018, p. 34).

Second, human resource departments with the technical skills of educational leaders can develop training modules for the entire workforce on the distinctions, strengths, and preferences of each generation to overcome and counteract ageism. Human resource departments can provide curriculums that provide opportunities to discuss "shifting population demographics, multigenerational families, and how the aging population will impact" (Fullen, 2018, p. 109) their organization. There is a lack of research on older employees' health in larger research health care centers. Leaders in more proactive health care organizations are developing wellness programs that encourage exercise, self-help, and monitoring of blood chemistries and blood pressure. Given the growing interest in wellness-oriented services for employees, one crucial research initiative is developing wellness programs for older adults that "might mitigate mental health issues and or internalized ageism amongst the workforce" (Fullen, 2018, p. 110).

Third, human resource staff can provide training in conflict negotiation training for managers and staff members to mediate tensions that may arise due to differences among cohorts. Generational knowledge of all employees helps employees to understand and respect the differences in multigenerational workers and promotes collegial and productive interactions. For example, if a younger manager is communicating with a baby boomer employee, the manager should "avoid any mention of growing older" (Fishman, 2016, p. 255). Further, the younger manager should "relate to them by their expertise or experience" (Fishman, 2016, p. 255). For millennials, the communicative approach a younger manager should take will be different from the manager's approach with baby boomers. For example, younger managers who are discussing a strategy with millennial coworkers should include positive feedback (Fishman, 2016, p. 252).

Fourth, the human resource department must encourage cross-mentoring opportunities between staff members of other generations to facilitate knowledge sharing and to build and improve relationships between different age groups. Benefits can arise from older workers collaborating with younger employees. Older workers can serve as "living memories of organizational life" (Avery et al., 2007, p. 113) and possess the knowledge of an organization's "failures and successful ideas, projects, initiatives, and leadership . . . [which can be a] benefit to younger employees in their decision making" (Avery et al., 2007, p. 113). The experiences of older employees can contribute successfully to an organization (Avery et al., 2007, p. 1543). Retention of older workers will become increasingly important to U.S. health care organizations as more workers retire and as their exit from the workforce creates a loss of skills, experience, and knowledge. In the health care sector, it is imperative to retain older workers as long as possible to transfer knowledge experience and to allow younger workers to fill their positions.

Wang and Shultz (2010) described the concept of bridge employment, which "highlights the importance of retirement decision as a major life event" (p. 176). Bridge employment is a process where older workers transition from full-time careers to withdrawal from the labor force. Bridge employees may stay with their existing career and work fewer hours, or they may move into another job or career. For corporations, the benefits of these bridge employment programs are that "more retirees may be hired as contingent workers because organizations will need to maintain flexible access to a skilled and experienced workforce" (Wang & Shultz, 2010, p. 181). Bridge employment provides beneficial outcomes for older workers. These programs provide older workers with economic incentives to delay retirement and therefore ease concerns about health care costs and diminished retirement savings. Bridge employment may help to maintain senior employees' health by providing more time for social contact and leading to fewer disruptions in daily life activities. Older employees who pursue bridge employment are more satisfied with their financial situations because the transition provides them with economic protection to defer retirement (Wang & Shultz, 2010, p. 192).

Some hospital programs offer assistance in retirement planning through seminars about retirement and meetings with retirement counselors. Data have shown that many older workers retire on "the basis of poor planning or misconceptions regarding their financial security" (Adam, Frimpong, & Boadu, 2017, p. 226). Therefore, an opportunity exists to develop seminars in financial planning within the health care industry to support aging workers in their retirement decisions. Another strategy that may delay retirement and keep skilled labor in the workforce is creating flexible work schedules. These programs are attractive to older employees who can adjust their hours to be less demanding if they are experiencing difficulties performing certain types of work.

Illustrations of Effective Strategies Within Health Care Organizations

Older employees will be the largest source of valuable talent in the health care sector in the next few decades (Paulin, 2018, p. 3), and human resource managers need to play a leadership role in developing strategies to encourage retention or in hiring mature workers. Strategic initiatives for employee well-being help to maintain a healthy strategic advantage in the competitive health care market. The health care sector is already experiencing shortages in experienced workers (Harrington & Heidkamp, 2013, p. 2).

This section includes discussions on creative hospital strategies in the U.S. health care marketplace that were purposefully developed to retain older workers to counteract personnel shortages in the health care sector. Hospitals and health care systems can learn from Scripps Health, a not-for-profit integrated health system in San Diego, California. Scripps is a leader in creating unique benefits for its employees. The employees at Scripps have overwhelmingly responded favorably to surveys of the best places to work, and Scripps has been named to Fortune's list of the 100 best companies to work for and was ranked ninth in Fortune's "Best Workplaces in Health Care" list in 2017 (Fortune, 2017). Organizational leaders have developed a strategy that engages in flexible half-retirement by initiating a staged retirement program that allows nurses to reduce their work schedules gradually while keeping the insurance benefits of an active full-time employee. Within this installed phased-retirement program, retirees can work part-time while drawing a portion of their retirement funds. Thus, they still effectively earn a full salary and benefits (Hershfield & North, 2014). Scripps leaders have also developed a formal mentorship program "to draw skills of older workers and retain younger workers who frequently leave health care field early on in their careers" (SHRM, 2016, p. 16).

Mount Sinai Health System recently announced a plan to transform its workforce and reduce employee turnover ("Mount Sinai," 2018, para. 1). A leader at Mount Sinai explained its goal is to leverage advances in science and technology in talent acquisition to transform its workforce and retain its best employees while focusing on diversity and community ("Mount Sinai," 2018). Similar to Mount Sinai's technology innovations, New Jersey's Hunterdon Healthcare System is using technology to "improve workflow, relieve the physically demanding nature of bedside nursing, and address the challenges associated with an aging workforce" (Harrington & Heidkamp, 2013, p. 4). For example, they are providing "smart beds throughout the hospital that collect and submit data automatically that can help in turning patients" (Harrington & Heidkamp, 2013, p. 4). The technology department of Hunterdon is also making it easier for nurses to enter data by installing modified computer keyboards and computer mice.

Other health care organizations also have programs to retain older employees. AltaMed Health Services in California redesigned the job descriptions for older nurses. The organization had problems recruiting nurses so human resource managers "concentrated the most highly skilled portion of work into fewer critical jobs" (Paulin, 2018, p. 24) and devised a program for less critical areas to be managed by experienced older registered nurses who supervised and oversaw licensed vocational nurses and certified nursing assistants. By redesigning the job demands, they addressed the workforce issue "without compromising the quality of patient care" (Paulin, 2018, p. 24). Another example of a creative design of using the experience of older nursing staff is a program at Central Baptist Hospital in Lexington, Kentucky. The program engages nurses with many years of experience to coach younger nurses in developing their careers. The older nurses serve as a resource for younger nurses who have questions about procedures, drug interactions, nursing theory, and future career choices (Paulin, 2018, p. 22).

University of Pittsburgh Medical Center, Geisinger Medical Center, and Evangelical Community Hospital are health care organizations in central Pennsylvania. I spoke with Evangelical's Associate Vice President of Human Resources Ms. Rachel Smith as well as Geisinger's Vice President of Human Resources, Mr. Brion Lieberman.

About one-third of Evangelical's workforce falls in each of the following generations: baby boom, Generation X, and millennial. While the number of employees born before 1945 is decreasing due to retirement at Evangelical, the number of millennial employees born after 1995 is increasing. Both healthcare facilities are aware of the importance of retaining older nursing and medical staff and realize they need to do more outreach with professional nursing and medical personnel to sustain and engage senior professionals. Also, they both offer an excellent curriculum and seminar opportunities for their employees in career development and retirement planning. Ms. Smith reported that during feedback sessions with the chief executive officer, Ms. Kendra Aucker at Evangelical Community Hospital, many employees identified a need for greater understanding and appreciation between the generations in the workforce. The human resource managers in both healthcare facilities determined that employing generational diversity as a strategy could help the hospital be more effective in how employees treat each other and their patients. In 2016, Evangelical engaged the services of a generational expert to train the hospital's leadership team on strategies for bridging the generational gap. Evangelical's training and development team designed its own internal hour-long training curriculum—Creating an Inclusive Culture by Leveraging Generational Diversity—to focus on defining the five generations working side by side at Evangelical and identifying strategies for valuing and leveraging generational differences to maximize team performance. Over 950 employees participated in the training program, in which participants of like generations worked together to share important generational characteristics and worked through various workplace scenarios that people may perceive differently based on generational perspective. Participants identified work style, communication, and technology as the top three generational differences affecting Evangelical's workforce, and 90% of participants indicated they were likely or very likely to apply the learning in their work interactions after the training. Due to critical shortages in key health professions, Evangelical and Geisinger's Human Resource Departments are exploring more flexible work environments that allow employees to continue to work beyond traditional retirement age. Both institutions are committed to structured knowledge transfer practices to ensure critical information and relationships are retained during personnel transitions.

Mr. Lieberman at Geisinger Medical Center indicated the organization was involved in engaging all multigenerational cohorts. He was aware of Scripps' leadership role in engaging and developing programs to retain employees and recognized that Geisinger needs to put more effort into programs for all cohorts. Geisinger leaders are excited about their partnerships with the Bloomsburg School of Nursing and the Commonwealth Medical School to develop and foster medical and nursing education that discusses the multigenerational workforce. The organization is an excellent learning organization for all generations in the health care sector to learn and advance their knowledge to benefit themselves, the community, the organization, and the patients. In September 2018, Geisinger hired 1,800 individuals, 8% of whom were baby boomers. Geisinger's strategic human resource strategy is not to segment any one generation, and leaders encourage collegial interactions among all employees. Benefits and work hours can be flexible, depending on an individual's needs.

Management at the University of Pittsburgh Medical Center has created a professional development workshop called Please Respect My Generation. The workshop presents methods for bridging the gap between generations and shows health care participants methods to avoid conflict and increase productivity in diverse, multigenerational workplaces (Office of Diversity & Inclusion, 2018). The

hospital leaders in central Pennsylvania are aware they need to do more compared to the outstanding representation of Scripps Health and Mount Sinai Health System.

3. Summary

Professionals in the health care sector are uniquely positioned to see the implications of an aging population because the aging population will require more health care services. The aging population will create many challenges for human resource professionals in the health care sector. Although many health care organizations are following Scripps' lead in developing programs to address the multigenerational workforce in the health care industry, many others need to develop and improve strategies in hiring to negotiate increases in employee demands for health care services. Human resource professionals across the health care landscape need to take strategic measures to prepare for these changes and learn about generational demographic transformations. The health care industry will need to embrace flexible work practices to encourage their most productive and valued older workers to remain in the workforce longer. The health care industry must foster respect for the differences of all age groups.

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The Comparative Disinfection Costs of Municipal Drinking Water Plants in Canada

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Abstract

The objective of this study is to investigate the costs and economies of scale for different water disinfection practices using data from public drinking water plants in Canada (the Municipal Water and Wastewater Surveys, Environment Canada 2004 and 2006). The results show that chlorine dioxide and ozone have higher fixed capital costs compared to free chlorine. In addition, only in a high volume of treated water, their economies of scale are comparable to free chlorine. Thus these methods are not suitable for small drinking water systems. In contrast, UV as a primary disinfection method and free chlorine with chloramines as a secondary disinfectant appear to have comparable costs and economies of scale with free chlorine.

Keywords: water systems, water treatment.

1. Introduction

While it is not unheard of that developing countries continue to face major waterborne disease outbreaks and have chronic low quality of water that can even stunt the growth of children (Gadgil, 1998), the record for advanced countries also show disease outbreaks from time to time. [1] A vital part of any public drinking water system is the disinfection of drinking water. This is to not only ensure that drinking water carries no microorganisms that can put human health in danger, but also to prevent the spread of water borne diseases. If public funds were unlimited, with no doubt, many of these problems could be reduced or eliminated. However, each jurisdiction must cover its own

[1]Example of outbreaks in developed countries include: *toxoplasmosis* in Victoria, British Columbia (1995); *E. coli* outbreaks in Cabool, Missouri (1989) and Walkerton, Ontario (2000); *cryptosporidium* outbreaks in Milwaukee, Wisconsin (1993), Kitchener and Waterloo, Ontario (1993), Cranbrook, British Columbia (1996), Kelowna, British Columbia (1996) and North Battleford, Saskatchewan (2001); *Giardiasis* outbreaks in Bradford, Pennsylvania (1979), Pittsfield, Massachusetts (1985) and Picton, British Columbia (1986). More evidence can be found in the annual reports of the Center for Disease Control and Prevention; for example, the state of Pennsylvania alone has more than 120 waterborne disease outbreaks over the last 30 years. Canadian Medical Association Journal (2008) reported more than 1,700 provincial boil water advisories and boil water orders in Canada in 2008, excluding First Nations communities. Among provinces Ontario with 679 listed advisories ranked first followed by British Columbia with 530 advisories and Newfoundland and Labrador with 228 advisories (Canadian Medical Association Journal 2008).

capital and operating costs of drinking water supply. It is often more difficult to raise funds in rural communities since they typically have a smaller population, lower average income per capita, and consequently a lower tax base. The financial constraints as well as other risk factors, some of which were highlighted at a 2004 Montana conference on small drinking water systems (Ford, et al., 2004), make small and rural water systems more susceptible to outbreaks and/or higher incidences of endemic waterborne illnesses.

While the financial constraints are often real, sometimes the adopted water disinfection practices are path dependent, which means historical practices persist regardless of the new available information on what is the most cost-effective practice. The emphasis of public drinking water systems in North America has been on the use of chlorine-based disinfectant treatment technologies. In contrast, many European countries have abandoned or limited the use of chlorine-based disinfectants whenever possible. For example, Smeets et al., (2009) reported that the Netherlands have successfully discontinued the use of chlorine as both a primary and a secondary disinfectant. The shift towards alternative disinfection methods in Europe is mainly due to formation of chlorination disinfection by-products (DBPs) associated with the use of chlorine-based disinfectants. Among the concerns are the reported higher risks of chronic myeloid leukemia (Kasim et al., 2006), bladder cancer (Chevrier et al., 2004; Villanueva et al., 2003), and colon cancer (King et al., 2000) associated with increasing years of exposure to different DBPs.

The objective of this study is to conduct a comparative cost analysis for different water disinfection practices to address whether the newer technologies are too costly for small communities to adopt. In contrast to the studies that use engineering and manufacturing information to conduct a comparative cost analysis (e.g., Wolfe, 1990; the U.S. Environmental Protection Agency, 1996; Parrotta and Bekdash, 1998), this paper presents estimates of costs and economies of scale using data from public drinking water plants in Canada (the Municipal Water and Wastewater Surveys, Environment Canada 2004 and 2006).[2]

2. Data

Data on the public drinking water plants were retrieved from the Municipal Water and Wastewater Surveys (MWWS), carried out by Environment Canada (2004 and 2006). According to Environment Canada (2004 and 2006), "the MWWS is a Canada-wide (excluding federal lands) survey of public-serving community drinking water and/or wastewater utilities serving at least 100 residents or 50 total connections." Canadian regulations require a free chlorine residual of not less than 0.05 mg/L for small drinking water systems if the system provides chlorination but not chloramination, and a combined chlorine residual of not less than 0.25 mg/L if chloramination is used.[3] The objective of regulation is to ensure that the safety of drinking water is not jeopardized within the distribution system. In recent years, however, many water systems have changed their secondary disinfectant to chloramines because chloramines are less reactive with organic material in water; and hence, produce substantially lower concentrations of chlorination disinfection by-products in the

[2] The most recent Municipal Water and Wastewater Surveys were in 2004, 2006, and 2009. Environment Canada has ended the Survey in 2009. The survey in 2009, however, does not include data on disinfection practices, and hence cannot be used. Nonetheless, the adopted technologies in public drinking water plants tend to be in service for many years.

[3] See for example, Health Protection and Promotion Act, Ontario Regulation 319/08: Small Drinking Water Systems, and Safe Drinking Water Act of 2002.

distribution system. In addition, the combined chlorine residual of chloramines are more stable and longer lasting than free chlorine which provides a better protection against bacterial regrowth (the U.S. Environmental Protection Agency 2012). While chlorine-based equipment that is used for primary disinfection is capable of providing free chlorine residuals, non-chlorine-based equipment require additional equipment to provide any required secondary disinfection. Hence, the additional chlorine cost would be common to all systems and is already included.

The Municipal Water and Wastewater Surveys contain information on water systems for 2,402 and 2,410 census subdivisions as defined by Statistic Canada in 2004 and 2006, respectively. The subdivisions are arranged into six groups based on the size of municipal population. These groups are municipalities with a population (1) less than 1,000, (2) from 1,000 to less than 2,000, (3) from 2,000 to less than 5,000, (4) from 5,000 to less than 50,000, (5) from 50,000 to less than 500,000, and (6) 500,000 and more. Water disinfection practices are grouped into six mutually exclusive and collectively exhaustive categories based on the use of primary and secondary disinfection methods as (1) no disinfectant being reported, (2) free chlorine alone, (3) free chlorine with chloramines as the secondary disinfectant (4) chlorine dioxide with a chlorine-based secondary disinfectant, (5) UV with a chlorine-based secondary disinfectant, and (6) ozone with a chlorine-based secondary disinfectant.

Among the public drinking water plants, data on the primary and secondary types of disinfection practices are available for 531 and 593 subdivisions in 2004 and 2006, respectively. However, data on annual expenditures and water flows are only available for 31.5 and 22.8 percent of these public drinking water plants in 2004 and 2006, respectively. The reason for using surveys from 2004 and 2006 is that only a subset of the surveyed jurisdictions provided information on the annual expenditures, water flows, and disinfection practices in each year. This makes it impossible to estimate the economies of scale using one year's survey only. In addition, about 18 percent of the surveyed jurisdictions reported data in both years. For these jurisdictions, if the use of disinfection practices in both years remained the same, the data from 2006 are used; otherwise the data from each survey are considered as a separate entry (i.e., only two jurisdictions). Table 1 presents the number of subdivisions based on the primary disinfection methods in 2004 and 2006.

The use of free chlorine alone is the dominant water disinfection practice in Canadian public drinking water systems (Table 1). Among jurisdictions with reported annual expenditures, water flows, and disinfection practices, 66.5 and 58.5 percent reported the use of chlorine as the only disinfection method in 2004 and 2006, respectively. In comparison, 6.6 and 6.7 percent of the jurisdictions reported the use of free chlorine with chloramines as the secondary disinfection method; 2.4 and 1.5 percent reported the use of chlorine dioxide as the primary disinfection method; 9.6 and 17.8 percent reported the use of UV as the primary disinfection method; and 4.8 and 7.4 percent reported the use of ozone as the primary disinfection method in 2004 and 2006, respectively. Interestingly, 10.2 and 8.1 percent of the surveyed plants reported no disinfection method while they reported annual expenditures and water flow in 2004 and 2006, respectively. These subdivisions were excluded from the analysis.

Table 1: Subdivisions based on population and primary disinfection methods in 2004 and 2006

		The primary disinfection methods (number of subdivisions)					
	Population Groups	None	Free chlorine	Free chlorine & chloramines	Chlorine dioxide & chlorine-based	UV & chlorine-based	Ozone & chlorine-based
2004	[0, 1,000)	0	1	0	0	0	0
	[1,000, 2,000)	4	23	1	1	1	0
	[2,000, 5,000)	3	22	1	0	1	0
	[5,000, 50,000)	5	53	2	2	11	3
	[50,000, 500,000)	4	9	7	1	2	5
	[500,000 & more)	1	3	0	0	1	0
	% of all	10.18	66.47	6.59	2.40	9.58	4.79
2006	[0, 1,000)	0	11	0	0	1	0
	[1,000, 2,000)	2	10	0	2	2	0
	[2,000, 5,000)	3	13	1	0	3	0
	[5,000, 50,000)	6	35	3	0	13	5
	[50,000, 500,000)	0	8	5	0	4	4
	[500,000 & more)	0	2	0	0	1	1
	% of all	8.15 %	58.52%	6.67%	1.48%	17.78%	7.41%

Data on the annual expenditures were retrieved from MWWS (Environment Canada, 2004 and 2006) and were used as a proxy for unobserved annual costs associated with the use of disinfection methods. On average, plants with the same volume of processed water were assumed to have the same proportion of labor, administration, maintenance, and distribution costs; and therefore, any difference in their annual costs can be attributed to the adopted disinfection method. The total annual expenditures include expenditures spent on regular labor, treatment supplies, purchase of bulk water, maintenance, replacement, and expansion and they exclude any expenditures spent on financing. Statistics Canada (2009) reported that drinking water plants in Canada spent a total of $807 million on operation and maintenance expenditures in 2007. The report indicated that the largest component of the expenses was labor costs for a total of $302 million, while materials and energy costs represent $198 and $199 million of these expenses, respectively. On average, treatment plants spent $144 as operation and maintenance expenditures to treat 1,000 cubic meters of water (i.e., 14.4¢ per cubic meter of water) where $54 was attributed to labor costs, $35 to materials, $36 to energy, and the remaining $19 was for other costs (Statistics Canada, 2009). The costs to produce 1,000 cubic meters of treated water were reported to be $124 and $311 for water withdrawn from surface water and ground water, respectively; however Statistics Canada (2009) reported that the difference is mainly due to higher production volumes from surface water that resulted in lower costs per unit of production.

3. Model

The treatment of raw water by disinfection method i is assumed to requires two types of inputs namely capital inputs (k_i) and operating inputs (o_i); capital inputs include all types of capital goods such as equipment, structures, and land; and operating inputs include all types of operating goods and services such as raw materials, water, energy, and labor. The production of treated water is given by:

$$v = V(k_i, o_i) \tag{1}$$

where V represents the production function for treating v cubic meters of water per day for combinations of capital and operating inputs. The objective of a municipality is to minimize the cost of treating the volume of water that is required to meet the demand of the municipality (e.g., v cubic meters of water per day). Assuming that both capital and operating inputs are purchased in competitive markets with the respective prices r and w, this objective function can be written as:

$$\begin{aligned} Cost\ per\ Day &= \min_{k_i, o_i}(rk_i + wo_i) \\ Subject\ to\ V(k_i, o_i) &= v \end{aligned} \tag{2}$$

By solving the above constrained optimization and replacing for optimum values of k_i and o_i, the cost function can be written as:

$$C(v|i) = C(v; w, r) \tag{3}$$

This cost function represents the cost of treating v cubic meters of water per day when capital and operating input prices are r and w, respectively. In the empirical application of the model, the cost function is considered as a Cobb-Douglas cost function:

$$C(v|i) = \alpha_i v^{\beta_i} e^{u} \tag{4}$$

where α_i and β_i are the parameters of the model and u is a vector of random disturbances. The first term, α_i, depends on the factor prices, and the second term, β_i, represents economies of scale where $\beta_i > 1$, < 1, and $= 1$ represent diseconomies, economies, and constant returns to scale, respectively. The parameters of the model can be estimated by transforming the model to a log-linear model and using the expenditures and volumes of treated water from the Municipal Water and Wastewater Surveys (Environment Canada, 2004 and 2006).

$$ln(C) = \alpha_i + \beta_i\, ln(v) + u \tag{5}$$

Theoretically, the model represented by Equation (5) implies persistent economies of scale regardless of how much water is treated. To allow for economies of scale to change with the level of treated water, Equation (5) is adjusted based on the size of municipal population to allow for a piecewise log-linear model. The cost function can be presented as:

$$\begin{aligned} ln(C) = \alpha_0 + \sum_{\text{Province}} \alpha_{\text{Province}} \times \text{Province} + \alpha_{\text{Disinfection}} \times \text{Disinfection} + \alpha_{\text{Treatment}} \\ \times \text{Treatment} + \beta_0 \times ln(v) + \beta_{\text{Disinfection}} \times \text{Disinfection} \times ln(v) \\ + \sum_{i=2}^{6} \beta_i \times d_i \times ln(v) + \delta_i \times d_i \times \text{Disinfection} \times ln(v) + u \end{aligned} \tag{6}$$

where v and C are cubic meters of treated water per day and costs per day in 2006 Canadian dollars, respectively. In addition, the provincial variables are included to control for variation in energy prices, rent, capital and labor costs across provinces with British Columbia as the control group[4]; the disinfection variables are included to control for variation in fixed capital and labor costs across disinfection methods with free chlorine as the control group; and the treatment variable is included to control for the additional costs of a treatment method. While the coefficient of $ln(v)$ estimates economies of scale for free chlorine in small water systems, the coefficients of the product of the disinfection methods and $ln(v)$ allow for economies of scale of the other disinfection methods to deviate from free chlorine. In addition, the products of the indicator variables for the size of municipal population (d_i), disinfection methods, and $ln(v)$ are used to allow for economies of scale to change with the size of municipal population. The indicator variables for the size of municipal population d_i ($i = 1, 2, \dots, 6$) take the value of one if the size of municipal population belongs to the i group from the following list: (1) less than 1,000, (2) from 1,000 to less than 2,000, (3) from 2,000 to less than 5,000, (4) from 5,000 to less than 50,000, (5) from 50,000 to less than 500,000, and (6) 500,000 and more; and zero otherwise. The control group for economies of scale is based on the omitted group(s) for the size of municipal population. In this way, for example, while the coefficient of $ln(v)$ estimates economies of scale for free chlorine in small water systems, the coefficients of $d_i \times \ln(v)$ terms allow for economies of scale for free chlorine to change with the size of municipal population. At the same time, the coefficients of $\text{Disinfection} \times ln(v)$ allow for economies of scale of the other disinfection methods in small water systems to deviate from free chlorine, while the coefficients of $d_i \times \text{Disinfection} \times ln(v)$ terms allow for economies of scale of the other disinfection methods to vary differently with the size of municipal population when they are compared to free chlorine.

4. Results

Table 1 presents the estimates of the cost functions and economies of scale. The second column of Table 1 shows the cost function when free chlorine is used as both primary and secondary disinfectant. In this case, the control group for economies of scale is municipalities with a population of less than 2,000. The third to sixth column of Table 1 present pairwise cost comparisons between free chlorine and the other disinfection methods. These disinfection methods are free chlorine with chloramines as a secondary disinfectant, chlorine dioxide, UV, and ozone with a chlorine-based secondary disinfectant, respectively. Due to the limited number of observations, the control groups for economies of scale differ among the cost-comparison scenarios. While UV has the same control group as free chlorine (i.e., municipalities with a population of less than 2,000), the control group for free chlorine with chloramines as a secondary disinfectant is municipalities with a population of less than 5,000, and the control group for ozone is municipalities with a population of less than 50,000. In addition, it is not possible to estimate economies of scale for chlorine dioxide based on the size of population.

[4] British Columbia is the only province that can be considered a Canadian region (i.e., pacific Canada). At the same time, British Columbia is a good control group because all the primary disinfection methods are used in the province. The included provinces in the regression analysis based on Canadian regions are: New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland and Labrador (Atlantic Canada); Ontario and Quebec (Central Canada); Alberta, Saskatchewan, and Manitoba (Prairies).

Table 2: Estimates of the Cost Functions and Economies of Scale

	Free Chlorine	Free Chlorine & Chloramines	Chlorine Dioxide & Chlorine-based	UV & Chlorine-based	Ozone & Chlorine-based
Constant	2.547***	2.375***	2.590***	2.508***	1.401***
AB	0.010	0.031	-0.025	0.028	0.023
MB	-0.585**	-0.593**	-0.567**	-0.538**	-0.652***
NB	-0.273*	-0.280**	-0.283*	-0.285*	-0.351**
NL	-0.954***	-1.016***	-0.956***	-0.958***	-1.082***
NS	-0.085	-0.066	-0.099	-0.093	-0.031
ON	0.029	-0.022	0.017	-0.001	0.161
PEI	1.379***	1.228***	1.385***	1.056***	1.054***
QC	-0.749***	-0.719***	-0.740***	-0.760***	-0.682***
SK	0.127	0.061	0.112	0.138	0.103
TRT	0.358***	0.356***	0.371***	0.359***	0.407***
Chloramines		-0.937			
Chlorine dioxide			0.871		
UV				-1.48	
Ozone					0.806
Control Groups for Economies of Scale	**Population < 2,000**	**Population < 5,000**	**Population < 2,000**	**Population < 2,000**	**Population < 50,000**
ln(v)	0.545***	0.596***	0.540***	0.551***	0.764***
Chloramines × ln(v)		0.286			
Chlorine dioxide × ln(v)			-0.032		
UV × ln(v)				0.269*	
Ozone × ln(v)					0.038
$d_3 \times ln(v)$	0.048**		0.0485**	0.047*	
$d_4 \times ln(v)$	0.109***	0.080***	0.109***	0.109***	
$d_5 \times ln(v)$	0.145***	0.111***	0.149***	0.143***	0.027
$d_6 \times ln(v)$	0.232***	0.196***	0.234***	0.228***	0.101***
$d_3 \times (1\text{-}Chlorine) \times ln(v)$				-0.041	
$d_4 \times (1\text{-}Chlorine) \times ln(v)$		-0.148*		-0.088	
$d_5 \times (1\text{-}Chlorine) \times ln(v)$		-0.172*		-0.105	-0.096**
$d_6 \times (1\text{-}Chlorine) \times ln(v)$				-0.144	-0.081
F-test $\alpha_{disinfection} = 0$, $\beta_{disinfection} = 0$		F(2, 191) = 7.11 Prob > F = 0.001	F(2, 178) = 5.19 Prob > F = 0.006	F(2, 208) = 1.62 Prob > F = 0.19	F(2, 190) = 18.08 Prob > F = 0.00
N	190	210	196	230	208
R^2	0.86	0.87	0.862	0.869	0.866

AB: Alberta, MB: Manitoba, NB: New Brunswick, NL: Newfoundland and Labrador, NS: Nova Scotia, ON: Ontario, PEI: Prince Edward Island, QC: Quebec, and SK: Saskatchewan. The provincial variables are included to control for variation in energy prices, rent, capital and labor costs across provinces with British Columbia as the control group. TRT takes the value of one if any of coagulation, flocculation, sedimentation, slow-sand, micro-straining, granular, membrane filtration is used. d_3 takes the value of one if the size of municipal population is from 2,000 to less than 5,000; d_4 takes the value of one if the size of municipal population is from 5,000 to less than 50,000; d_5 takes the value of one if the size of municipal population is from 50,000 to less than 500,000; d_6 takes the value of one if the size of municipal population is from 500,000 and more; and zero otherwise

* indicates 10%, ** indicates 5%, *** indicates 1% significance levels.

The coefficients of provincial variables indicate that energy prices, rent, capital and labor costs vary across Canadian provinces. These costs are no different than British Columbia in the provinces of Alberta, Nova Scotia, Ontario, and Saskatchewan, but are lower in Manitoba, New Brunswick, Newfoundland and Labrador, and Quebec; and are higher in Prince Edward Island. The coefficient of treatment variable indicates additional costs when treatments are used.

The second column of Table 1 presents the estimates of the cost function and economies of scale for free chlorine. As mentioned above while the coefficient of $ln(v)$ estimates economies of scale for free chlorine in small water systems, the coefficients of $d_i \times ln(v)$ allows for economies of scale to change with the size of the municipal population. The coefficient of $ln(v)$ suggests economies of scale in small water systems – i.e., municipalities with a population of less than 2,000. While economies of scale decline with an increase in the size of municipal population, the Wald tests with high confidence reject the hypothesis of constant returns to scale for all municipal population groups. These results indicate that despite the fact that free chlorine's economies of scale decline with the size of municipal population, it has economies of scale in all ranges of water treated.

Even though the results of comparative costs for free chlorine with chloramines as a secondary disinfectant (i.e., the third column of Table 1) appear to suggest the same economies of scale as free chlorine in small water systems, the joint significance F-test rejects the hypothesis that the coefficients of Chloramines and $\text{Chloramines} \times ln(v)$ are jointly zero. This result indicates that free chlorine as both primary and secondary disinfectant has better economies of scale in small water systems (i.e., municipalities with population of less than 5,000) compared to free chlorine with chloramines as a secondary disinfectant, while it may require higher fixed capital costs. Nonetheless, economies of scale for free chlorine as primary and secondary disinfectant decrease with the size of population, whereas they increase for free chlorine with chloramines as a secondary disinfectant. The Wald tests indicate that in municipalities with a population of more than 5,000, free chlorine alone and free chlorine with chloramines as a secondary disinfectant have the same economies of scale. The fourth column of Table 1 presents the results of comparative costs for free chlorine and chlorine dioxide. As mentioned above, due to the limited number of observations, it is not possible to estimate economies of scale for chlorine dioxide based on the size of population. The joint significance F-test for Chlorine dioxide and $\text{Chlorine dioxide} \times ln(v)$ rejects the hypothesis that these coefficients are jointly zero. This result indicates that while chlorine dioxide has higher fixed capital costs, it has better economies of scale than free chlorine in large water systems.

The fifth column of Table 1 presents the results of comparative costs for UV. While the coefficient of UV indicates lower fixed capital costs for the use of UV in small water systems, the result is insignificant. In addition, free chlorine appears to have better economies of scale than UV in small water systems – i.e., municipalities with a population less of than 2,000. While the coefficients of economies of scale for UV indicate that economies of scale increase with the size of municipal population, these results are insignificant. Furthermore, the Wald tests reveal that free chlorine and UV have the same economies of scale for municipalities with a population of more than 2,000. This is because free chlorine's economies of scale decline with an increase in the size of population, whereas UV's economies of scale remain unchanged. The last column of Table 1 presents the results of comparative costs for ozone. Due to the limited number of observations, the control group for economies of scale for ozone is municipalities with a population of less than 50,000. While the results appear to suggest that the use of ozone in municipalities with a population of less than 50,000 have the same economies of scale as free chlorine, the joint F-test rejects the hypothesis that the coefficients of Ozone and $\text{Ozone} \times ln(v)$ are jointly zero. This result indicates that in these municipalities, ozone has higher fixed capital costs and lower economies of scale compared to free

chlorine. Nonetheless, free chlorine's economies of scale decrease with the size of municipal population, whereas ozone's economies of scale increase. The Wald tests indicate that free chlorine and ozone have the same economies of scale in municipalities with a population of more than 50,000.

The estimation results for cost functions and economies of scale suggest that compared to free chlorine, chlorine dioxide and ozone have higher fixed capital costs. In addition, only for a high volume of treated water, their economies of scale are comparable to free chlorine which indicates that these methods are not suitable for small water systems. In contrast, the capital costs for free chlorine with chloramines as a secondary disinfectant and UV as a primary disinfection method appear to be lower than or the same as free chlorine, respectively. Furthermore, while these practices appear to have lower economies of scale in small water systems (for systems serving population of less than 5,000 for free chlorine with chloramines as a secondary disinfectant and 2,000 for UV as a primary disinfection method), their economies of scale are comparable with free chlorine for all other municipal population groups. These results suggest that the costs of using free chlorine with chloramines as a secondary disinfectant and UV as a primary disinfection method are comparable to free chlorine in small water systems. The results support the findings of U.S. Environmental Protection Agency (1996), Wolfe (1990), and Parrotta and Bekdash (1998) that in small water systems, the costs of UV disinfection method are comparable to free chlorine. While the cost estimations in the studies mentioned above were based on engineering information and other information submitted by manufacturers, the cost estimations in this study are based on data from public drinking water systems in Canada. These results further suggest that while municipalities' financial constraints are often real, the adopted water disinfection practices are sometimes path dependent which means that historical practices persist regardless of the new available technologies. Canadian municipal water treatment plants will require considerable renovation and transformation in the coming years. The required capital investment to meet water and wastewater infrastructure needs in Canada between 1997 and 2012 was estimated to be in a range from $21 to $90 billion (National Round Table on the Environment and the Economy, 1996; Canadian Water and Wastewater Association, 1998; Mirza, 2007). While Canadian municipalities reported $885 million capital expenditures in 2007 (Statistics Canada, 2009), only a small number of them use UV as the primary disinfection method. This suggests that there is a great potential for improving water quality by adopting newer technologies such as UV while at the same time there is a greater potential for producers of UV technology.

5. Conclusion

The objective of this paper is to conduct a comparative cost analysis for different water disinfection practices to address whether the newer technologies are too costly for small communities to adopt. While the emphasis of public drinking water systems in North America has been on the use of chlorine-based disinfectant treatment technologies, many European countries have abandoned or limited the use of chlorine-based disinfectants whenever possible. The shift towards alternative disinfection methods in Europe is mainly due to formation of chlorination disinfection by-products (DBPs) associated with the use of chlorine-based disinfectants.

In contrast to the studies that use engineering and manufacturing information to conduct a comparative cost analysis, this study presents estimates of costs and economies of scale using data from public drinking water plants in Canada. The results suggest that chlorine dioxide and ozone disinfection methods have higher fixed capital costs compared to free chlorine. In addition, only for a high volume of treated water, their economies of scale are comparable to free chlorine. Thus these

methods are not suitable for small drinking water systems. In contrast, the capital costs for UV as a primary disinfection method and free chlorine with chloramines as a secondary disinfectant appear to be lower than or the same as free chlorine, respectively. Furthermore, while they appear to have slightly lower economies of scale in small water systems (for the systems serving population less than 5,000 for the former and 2,000 for the latter), their economies of scale are comparable with free chlorine for all other municipalities. Therefore, the costs of using free chlorine with chloramines as a secondary disinfectant and UV as primary disinfection method are comparable to free chlorine in small water systems. The results support the findings of previous studies which found that the costs of UV disinfection in small water systems are comparable with free chlorine, but they contradict the finding of the U.S. Environmental Protection Agency (1996) that the costs of ozone in small systems are also comparable with free chlorine.

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Automated Timetabling for Small Colleges and High Schools Using Huge Integer Programs

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Abstract

We formulate an integer program to solve a highly constrained academic timetabling problem at the United States Merchant Marine Academy. The IP instance that results from our real case study has approximately both 170,000 rows and columns and solves to optimality in 4–24 hours using a commercial solver on a portable computer (near optimal feasible solutions were often found in 4–12 hours). Our model is applicable to both high schools and small colleges who wish to deviate from group scheduling. We also solve a necessary preprocessing student subgrouping problem, which breaks up big groups of students into small groups so they can optimally fit into small capacity classes.

1. Introduction

Solving real world academic timetabling problems can quite difficult. Many heuristic approaches have been developed, including graph coloring methods using Kempe ex- changes [16, 17], Max-SAT solvers [2], genetic algorithms [1, 8], ant colony optimization [24] , tabu search [15, 25], and hybrid approaches [18]. See also the surveys [22, 20, 3].

In theory, mixed integer programs can give exact solutions, however in practice they can be so large that they are computationally unsolvable. Nevertheless, for smaller and medium sized instances, integer programming has been used successfully [19, 14, 7, 23, 4, 5, 13].

We solve the academic timetabling problem at the United States Merchant Marine Academy (USMMA). The problem we consider seems to be a more complex, real world, timetabling problem than others that have been solved by integer programming techniques. For most colleges, a curriculum timetabling model is appropriate, where one makes sure that required courses within a curriculum do not clash, while students are free to fill in their schedule with a wide choice of electives. Our situation is much less flexible. Though we are a fully accredited higher education academic institution, our scheduling requirements are more like a high school's, albeit one that offers six majors, has 900 students, roughly 95 percent of all classes are required, and students must graduate in 4 years with approximately 160 credits. In addition, both our students and professors can have very dense schedules. Finally, we must guarantee that all students can enroll in all of their required courses. Our approach is student based, that is, the primary goal is for all students to be able to enroll in all the courses they need.

To very quickly give a sense of our problem, we give a simple example of the type of input our algorithm requires. The following data is overly simplified and not valid.

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* The views expressed in this article are the author's own and not those of the U.S. Merchant Marine Academy, the Maritime Administration, the Department of Transportation, or the United States government.

Table 1: Student Groups

Group Number	Size of Group	1st course needed	2nd course needed	3rd course needed	4th course needed
1	37	CALC1	STAT2	COMP1	PHYS1
2	42	ENGL1	PHYS1	PHYS1LAB	STAT2
3	14	CALC1	PHYS1	PHYS1LAB	ENGL1
4	19	COMP1	PHYS1	PHYS1LAB	STAT2
5	39	CALC1	PHYS1	PHYS1LAB	GEOM1
6	1	ENGL1	CHEM1	CHEM1LAB	COMP1

Second, we have sections (these are the actual classes we schedule), that is multiple copies of the same course offered. Note that the capacity column cannot be exceeded, so the groups above will need to be partitioned into subgroups (see §4) in such a way so all students fit into the classes that they are required to take.[1]

Table 2: Sessions Offered

Professor's Last Name	Course	Periods	Lab	Capacity	Room Type
Gauss	CALC1	3	N	26	CLASSROOM
Gauss	GEOM1	3	N	26	CLASSROOM
Gauss	CALC1	3	N	26	CLASSROOM
Riemann	CALC1	3	N	26	CLASSROOM
Riemann	STAT2	3	N	17	CLASSROOM
Turing	COMP1	4	N	22	CLASSROOM
Turing	COMP1	4	N	22	CLASSROOM
Einstein	PHYS1	3	N	21	CLASSROOM
Einstein	PHYS1LAB	2	Y	21	PHYSLAB
Bohr	PHYS1	3	N	21	CLASSROOM
Pauli	PHYS1LAB	2	Y	21	PHYSLAB
Curie	CHEM1	3	N	25	CLASSROOM
Curie	CHEM1LAB	2	Y	15	CHEMLAB
Austen	ENGL1	3	N	20	LECTUREHALL
Austen	ENGL1	3	N	20	LECTUREHALL

Third, we have a simple database of rooms. Note that the room type column corresponds to the sections, above.

[1]Sections are the events that are scheduled, and there can be multiple sections of each course.

Table 3: Rooms Available

Room	Cap	Room Type
F101	30	CLASSROOM
F102	30	CLASSROOM
F103	30	CLASSROOM
F310	21	PHYSLAB
F339	15	CHEMLAB
B101	30	LECTURE HALL
B102	30	LECTURE HALL

Finally, we have the professor time requests. Note that a zero means the professor prefers not to teach at that time (7 periods per day, 5 days per week).

Table 4: Professor Time Preferences

Prof. Einstein							
	1	2	3	4	5	6	7
M	0	0	0	0	0	0	0
T							
W							
R							
F	0	0	0	0	0	0	0
Prof. Gauss							
	1	2	3	4	5	6	7
M	0						0
T	0						0
W	0						0
R	0						0
F	0						0
Prof. Riemann							
	1	2	3	4	5	6	7
M	0	0				0	0
T	0	0				0	0
W	0	0				0	0
R	0	0				0	0
F	0	0				0	0

The problem we solve is to schedule all sections without any conflicts resulting, so that all students are enrolled in all of their courses, and that we violate as few professor time requests as possible (as well as many other hard and soft constraints).

1.1 Subgroup Problem

In addition to solving the standard assignment problems (assigning classes to rooms, classes to times) we also assign various groups of students to classes, so that they do not exceed the class's capacity. For example, suppose we have three groups of students of size 34, 41, 15 all who need

MATH101, PHYS101, and ENGL101 which have capacity 30,25,15 students, respectively. We will need to offer three sections of MATH101 to handle the 90 students, four sections of PHYS101, and 6 sections of ENGL101. The problem that arises is a hybrid assignment knapsack/bin packing problem. The first problem we must solve, a preprocessing problem, is to break up large groups into smaller groups in such a way that they can packed into the minimal number of courses needed. Though we can break up each group into singleton subgroups, the resulting IP would be computationally unsolvable as it has too many rows and columns.

1.2 Overview of Our Algorithm

We first assume that enough sections are offered to meet demand. In §4 we solve our subgroup problem. The idea is to use an integer program to assign all groups of students to sections of courses that they need. In this initial stage, we will not succeed because the groups are too large. The IP minimizes the overcapacity of the assignment and makes sure that it is possible for groups of students to be enrolled in courses with labs. Then a greedy approach looks for the most over-scheduled section and identifies the biggest group in that section. That group is split into two smaller groups so that one of the new groups will contain only the unscheduled students. Next we re-run the IP with the new, finer, groups, and repeat the process until all students fit into classes. It takes less than 50 iterations to terminate (under 1 minute to complete all iterations).

Once we have subgroups that fit, we run our timetabling integer program (TIP). We do not store the assignment of groups to students from the subgroup problem, even though it would speed up the TIP because it would be suboptimal: a priori, we don't know which groups should be combined to fit into a particular section without considering the global timetabling problem with all of its constraints. Incorporating the subgroup problem into the TIP, would probably not be computationally solvable. Our TIP schedules sections so that professors and rooms do not have conflicts. The groups are assigned sections in such a way that they are enrolled in the courses they need, and so that there are no group time conflicts. Since we actually solve a real problem, there are many constraints we need to deal with: groups who take classes with labs should have the same professor for both, a class and its lab shouldn't be back to back, labs should be scheduled contiguously and in the same room; and many soft constraints: no professor should be assigned to period 1 and period 7 on the same day, each professor should have at least one day off, and most professors should have classes on meeting days.

Our instance[2] has the following key components: 652 students, 334 distinct sections, 126 professors, and 91 classrooms (many of which are specialty labs). The resulting IP is mostly binary, and it is huge. Before pre-solving, it has 178,496 rows, 175,594 columns, and 1,650,967 nonzero entries. Both Gurobi 6.5 and 7.0 were able to solve the instance.[3] Gurobi 7.0 solved our instance in 4–24 hours[4], after tuning. We also attempted to solve our instance with GLPK [10] , SCIP [9], CBC [6], and CPLEX [11], but were unsuccessful. We used the GNU MathProg modeling language that comes with [10] and solved the resulting LP-file with Gurobi. Our hardware was extremely modest: a Macbook Pro laptop computer, with a Core i7 (4 cores, 2 threads/core) 2.5 GHZ CPU and 16 GB RAM. We specified the solver to use seven execution threads.

[2]Term 2 of the 2016-2017 academic year.

[3]Gurobi 7.0 reduced solving times by at least 30 percent over Gurobi 6.5

[4]The variation seems to be due to the random seed parameter that the solver uses. We solved our instance with various seeds.

We also constructed a small artificial instance with 23,294 rows, 28,926 columns and 268,350 non-zeros. It usually solved in 5–20 minutes with Gurobi. However, when we assigned some groups a dense schedule with all 35/35 spots utilized, it took the solver many times longer to find the optimal solution.

Table 5: Typical Schedule of a Freshman (plebe) at USMMA, Group 38; Size = 12

	1	2	3	4	5	6	7
Monday	NAUT130	BUSN110	NASC100	PEA125L	COMMON HOUR	NAUT110	PHYS110
Tuesday	PEA120L	HIST100	NAUT120L	NAUT120L	BUSN110	NAUT120	PHYS110
Wednesday		BUSN101	PEA125L	NASC100	PHSY110L	PHYS110L	HIST100
Thursday	BUSN110			MLOG120		NAUT120	PHYS110
Friday	PEA120L	HIST100			NAUT110	NAUT120L	NAUT120L

We tested our model for the second trimester of the 2016-2017 academic year on real life data and verified correctness with the Registrar. In addition, we have recently tested our model on the third trimester and obtained optimal results in approximately 6–12 hours.

Great advances in mixed integer programming solver technology have occurred relatively[5] recently, and allowed us to solve the problem in this way. In fact as mentioned roughly 7 years ago in [14] ...we report for the first time on solving the four original Udine instances to proven optimality but certainly not only due to the fact that they became rather easy for modern integer programming solvers.

1.3 Applications of Our Method

High schools and small colleges do not have the resources that a large college may have. A small school may only offer two sections of calculus while students from three different majors may need the course. At high schools, students are placed in tracks where only certain combinations of courses may be possible, and thus there is little flexibility for individualized schedules. Small schools are stuck in a group scheduling mode. Our method could allow any high school (or middle school) to have much more flexible student schedules, and allow teachers to have greater control over their schedules. More efficient timetabling could reduce the total number of sections needing to be offered. The big colleges are probably automated, to a certain degree. It is the small schools who are timetabling by hand, who have the most to gain.

[5]"The field of mixed integer programming has witnessed remarkable improvements in recent years in the capabilities of MIP algorithms. Four of the biggest contributors have been presolve, cutting planes, heuristics, and parallelism" (gurobi.com/resources/getting-started/mip-basics).

1.4 Timetabling at USMMA

The United States Merchant Marine Academy is a service academy with approximately 900 midshipmen (students). Scheduling of students, professors, and classrooms is currently being done by hand, and is both quite challenging and time consuming. The midshipmen are all full-time and have a highly constrained schedule. They must be enrolled in all of their required courses, and virtually every course they take is required. There are 35 periods each week (each period is 55 minutes) and it is quite common for large numbers of midshipmen to have 30-33 periods filled with required courses.

Currently students are split into groups, and timetabling is done group-wise (the only way to construct these timetables by hand). However, major problems occur when a student fails a course (or places out of a course) and leaves the common group schedule. Midshipmen attend the Academy for 11 months per year, for 4 years, with three trimesters per year. Each trimester is equivalent to a semester at other colleges. Mid- shipmen spend 3 trimesters on commercial ships, and in the remaining 9 trimesters they must take all the required courses for a B.S. degree, a U.S. Coast Guard license, and a commission in the U.S. Navy. They end up with roughly 160 credit hours.

The midshipmen are partitioned into 48 groups: At any given time half of the sophomores and juniors are out to sea, depending on whether they are A-split or B-split. There are 2 splits, 6 academic majors, and 4 class years. Each semester there are approximately 36 regular groups of midshipmen who are on campus, hence 36 curriculums. In addition there are exceptional groups of midshipmen who fall outside of the common group schedule. Though all members of a particular group need the same courses, they may not have identical timetables (if the group is large, it would be split up).

1.5 Acknowledgment

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2 Definitions

2.1 Rooms

Let R denote the set of rooms, and let **RT** denote the set of *room types*. Each room r is as- signed a room type, **type**(r) ϵ**RT**. Room types, can be, for example, general classrooms in a certain building, laboratories, specialty classrooms, . . . Each room has a capacity cap(r).

2.2 Time and Day

Each day has seven 55 minute periods reserved for classes T = {1, 2, 3, 4, 5, 6, 7} (lunch falls between period 4 and 5) and classes are scheduled five days per week on the days D = {M, T, W, R, F}.

2.3 Professors

Let P denote the set of professors. To each professor p ϵ P we associate a 5 × 7 matrix of availability **avail**(p), where **avail**(p) dt = 1 if professor p can teach on day d and time t; and if professor p cannot teach, then **avail**(p) dt = 0, 1, 2 where 0 denotes they prefer not to teach, 1 it is important that they do not teach, and 2 they absolutely cannot teach, at that time and day.

If professor p is an adjunct, then **adj**(p) = **True**, otherwise **False**. At USMMA, adjuncts get the highest priority for time availability.

2.4 Courses

Let *C* denote the set of courses offered

$$C = \{\textbf{MATH101, MATH120, MATH210, BUSN101, PHYS110, . . . , }\}.$$

Note that multiple copies of each course are generally offered. Each course *c* requires a number of periods which we denote by **periods**(*c*) ϵ 1, 2, 3, 4, 5. For us, a course is just a name with a number of periods. One could also define a course as a set of sections (§2.5). It is the sections that are actually scheduled.

2.5 Sections

Let *S* denote the set of sections being offered. Sections are the objects which are actually scheduled. Each element *s* ϵ S has the following parameters (maps):

1. **prof** $(s) \in P$, the professor teaching section s.
2. $\pi(s) \in C$, the course associated with section s. For example, if s is a section of MATH101, $\pi(s) =$ **MATH101.**
3. **periods**(*s*) ϵ {1, 2, 3, 4, 5}, the number of time slots (number of periods) needed to be scheduled per week. Note that we overload the **periods**(.) function so that **periods**($\pi(s)$) = **periods**(*s*).
4. **lab**$(s) \in$ **{True, False}.** If section s requires all of its scheduled periods to be scheduled consecutively, in the same room, and without lunch interrupting the lab, then **lab**$(s) =$ **True,** otherwise **False.**
5. **cap**(*s*) ϵ N = {1, . . .} ∪ {0} the capacity of *s,* how many students **prof**(*s*) allows in his/her section. If we want to reserve a room for a professor, but not enroll students, we set the capacity to zero.
6. **final**$(s) \in F = \{\emptyset\} \cup C$, the final exam associated to section s.
7. **roomtype**$(s) \in$ **RT**, the subset of rooms that are appropriate for section s. That is, room r is appropriate if **type**$(r) =$ **roomtype**(s).
8. **labtie**$(s) \in \{\emptyset\} \cup \mathbb{N}$. Suppose s_1, s_2 S with **lab**$(s_2) =$ **True,** and **lab**$(s_1) =$ **False.** Then all students enrolled in section s_2 must also be enrolled in s_1 if and only if **labtie**$(s_1) =$ **labtie**(s_2).
9. For $i = 1 \ldots 5$, **mandate**$_i(s) \in (D \times T) \cup (\emptyset, \emptyset)$, requiring that s is scheduled for a day and time. For example, if **mandate**(*s*) = ((*T,* 5), (*W,* 3), (*F,* 5), (Ø, Ø), (Ø, Ø)) then we are insisting that *s* is scheduled Tuesday 5th period, Wednesday 3rd, and Friday 5th.
10. For $i \in \{1, \ldots 6\}$, **coprof**$_i(s)$ $P \cup \{\emptyset\}$, for possible alternate professors who must be available to teach section s.

11. **adjunct**$(s) \in$ **True, False** , if a section is taught by an adjunct professor, they get the highest priority because they often have very limited availability.
12. **link**$(s) \in \{\emptyset\} \cup$ N. Two sections s_1, s_2 must be taught at identical days and times if and only if **link**(s_1) = **link**(s_2).

2.6 Groups

Let G denote the set of groups of students. A group $g \in G$ is a set of students who all need the same exact courses, though not necessarily the same sections. Typically each g represents students who are in the same major and in the same class year. *If a student has an exceptional curriculum, they may be in a group of size one.* Groups can be small to allow for great flexibility. However, the more groups that are present, the longer it will take for an optimal solution to be found.
Each $g \in G$ has a curriculum, that is a set of courses they must take, which we denote by $C_g \subset C$. For each $c \in C_g$ we must find a unique section $s \in S$ with $\pi(s) = c$ to enroll the entire group g.

The size of g is denoted by **size**(g) N.

As mentioned previously, the *Subgroup Problem* needs to be solved (see §4) which will result in slightly smaller groups. This problem is related to the Student Sectioning Problem [21] and [16, p. 16].

3. The Constraints and Objective

The constraints are separated into hard and soft constraints.

3.1 Hard Constraints

1. Each section s must be scheduled for exactly **periods**(s) time slots per week.
2. If two sections s_1, s_2 have **link**(s_1) = **link**(s_2), then they must be taught at identical days and times.
3. For each $d \in D, t \in T, r \in R$ at most one section s can be assigned (one class at a time in each room).
4. Each section that has mandated times must be scheduled accordingly.
5. Each section that is not a lab can meet at most one-time per day.
6. Each section that is a lab must have all its meetings on the same day, in the same room, contiguously scheduled, and without lunch falling within the allotted times.
7. For each $p \in P$ the set of sections s with **prof**$(s) = p$ must be scheduled at disjoint times (no collisions allowed), and they must all be scheduled.
8. For each $s \in S, p \in P$ with **coprof**$_i(s) = p$ for some i, each section s_k with **prof**$(s_k) = p$ must be scheduled so professor p can attend section s. In other words, if p has regular sections, they cannot make it impossible for him/her to attend sections where he/she co-teaches.
9. For each group $g \in G$, and each $c \in C_g$, group g must be scheduled for exactly one section $s \in \pi^{-1}(c)$. Note that we are not preassigning groups to sections.
10. For each $g \in G$, the sections that g is enrolled in must be scheduled at disjoint times (no collisions).

11. If $s_0 \in S$ is a non-lab, and $s_1 \in S$ is a lab, and **labtie**(s_0) = **labtie**(s_1) $\neq \emptyset$, then all groups enrolled in s_1 must also be enrolled in s_0. This constraints keeps labs and lectures together, with the same professor, if requested.
12. For each section s, the number of students enrolled should not exceed **cap**(s). We sometimes make this a soft constraint, but impose a big penalty for over capacity. We make sure that the rooms requested for s have enough capacity, so we do not explicitly check room capacity.
13. If a group g is scheduled for two sections s_1, s_2 with **labtie**(s_0) = **labtie**(s_1), then for each day, at most four hours should be scheduled, combined, for both s_1 and s_2. In other words, we don't want a four hour lab scheduled on the same day as the lecture it is tied to.
14. If a group g is scheduled for two sections s_1, s_2 with **labtie**(s_0) = **labtie**(s_1), then there should be at least a one period break (a lunch break is acceptable) between the two sections. In other words, a lab should not start right before or after lecture if they are tied together.

3.2 Soft Constraints

1. Each section s that is not a lab, with **periods**$(s) = 3$, should not be scheduled in three consecutive days.
2. Each section s that is not a lab, with **periods**$(s) = 2$ should not be scheduled in two consecutive days.
3. Each professor must have at least one day without teaching.
4. On any given day, a professor should not teach both first period and seventh pe- riod.
5. All full-time professors (those teaching 9 or more hours per week) should be as- signed teaching duties on Tuesdays (for weekly department meetings).
6. For each $p \in P$, if **avail**$(p)_{dt} \leq 0$, then do not schedule any section with **prof**$(s) = p$, or **coprof**$_i(s) = p$, at time and day (d, t).

3.3 The Objective

The objective is to minimize the number of soft constraints violated. Each soft constraint has a weight. Violating the time preferences of an adjunct professor has the most penalty, and scheduling a three period class over only three days has the least. More details are in a later section.

4. The Subgroup Problem

Recall §2.6 where we defined the set of groups G, where each $g \in G$ is a set of students, all who need the same set of courses C_g. In this section we solve the Subgroup Problem.
Starting with G we define a refinement $G^{(1)}$ of G.

For any $g \in G$ with **size**(g) >= 2, split g into two subgroups g_1, g_2 so that **size**(g_1) + **size**(g_2) = **size**(g), with both g_1, g_2 of size at least one, and $C_g = C_{g1} = C_{g2}$. Let

$$G^{(1)} = (G \setminus \{g\}) \cup \{g_1, g_2\}.$$

Inductively, we define $G^{(0)} = G$, and $G^{(n+1)}$ is simply a refinement of $G^{(n)}$.

Sections §4.1 and §4.2 comprise the solution to the subgroup problem. It refines the groups G until they are small enough so that they can fit into all the courses without exceeding capacity. It does not give the optimal[6] (least) amount of groups.

For our instance, we have around 650 students who are split into 33 groups, of un- equal size. The groups range in size from 1 to 60 students. Capacities of courses generally range from 8 to 30. After running the Subgroup Algorithm we end up with roughly 40 groups, a great improvement over potentially hundreds of tiny groups (which would make the integer program computationally unsolvable).

The algorithm is a greedy algorithm that calls a simple bin packing integer program called IPA (below). It takes about 50 iterations to solve the subgroup problem completely, and IPA can be solved almost instantly using Gurobi, CBC, or SCIP.

For our instance, IPA has 1289 rows, 2936 columns, and 7472 non-zeros. However, an efficient pre-solver reduces the problem to 24 rows, 136 columns, 264 nonzeros.

4.1 Integer Program A

Consider the integer program (IPA) below. Its inputs include the following sets: S is the set of sections; $G^{(n)}$ a refinement of G for some integer $n \geq 0$; $W^{(n)} = \{(g, s) \in G^{(n)} \times S \mid s \pi^{-1}(C_g)\}$.

We need the following variables: the variables x_{gs}, binary, where $(g, s) \in W^{(n)}$, equal to 1 iff group g is enrolled in section s; t_s, non-negative integer variables, where $s \in S$, represents over-enrollment beyond the capacity of s.

4.1.1 IPA

Objective

$$\min \quad z = \sum_{s \in S} t_s \tag{1}$$

Constraints

$$\sum_{s \in S \,:\, \pi(s) = c} x_{gs} = 1 \qquad \forall g \in G^{(n)},\ \forall c \in C_g \tag{2}$$

$$\sum_{g \in G^{(n)} \,:\, (g,s) \in W^{(n)}} \mathbf{size}(g) x_{gs} \leq \mathbf{cap}(s) + t_s \qquad \forall s \in S. \tag{3}$$

$$\forall\, g \in G^{(n)}, s_0, s_1 \in S \times S :\ (g, s_0), (g, s_1) \in W^{(n)}, \tag{4}$$

$$\mathbf{lab}(s_0) = \mathbf{False},\ \mathbf{lab}(s_1) = \mathbf{True},\ \mathbf{labtie}(s_0) \neq \emptyset, \mathbf{labtie}(s_0) = \mathbf{labtie}(s_1), \tag{5}$$

$$x_{g_{s_0}} \geq x_{g_{s_1}} \tag{6}$$

[6]We wrote an integer program to find the least number of groups needed to solve the subgroup problem, but the IP appears to be computationally unsolvable. Another idea is a quadratically constrained integer program.

Constraints

$$\sum_{s \in S \,:\, \pi(s)=c} x_{gs} = 1 \qquad \forall g \in G^{(n)},\ \forall c \in C_g \tag{2}$$

$$\sum_{g \in G^{(n)} \,:\, (g,s) \in W^{(n)}} \mathbf{size}(g) x_{gs} \leq \mathbf{cap}(s) + t_s \qquad \forall s \in S. \tag{3}$$

$$\forall\, g \in G^{(n)}, s_0, s_1 \in S \times S :\ (g, s_0), (g, s_1) \in W^{(n)}, \tag{4}$$

$$\mathbf{lab}(s_0) = \mathbf{False},\ \mathbf{lab}(s_1) = \mathbf{True},\ \mathbf{labtie}(s_0) \neq \emptyset, \mathbf{labtie}(s_0) = \mathbf{labtie}(s_1), \tag{5}$$

$$x_{g s_0} \geq x_{g s_1} \tag{6}$$

4.2 Algorithm 1: The Subgroup Algorithm

Before this algorithm is run, we assume that enough sections s ∈ S are offered to cover the demand of the groups g ∈ G who request courses.

This algorithm calls the integer program IPA (§4.1)

Data: sets G and S;
variables;

array $t = (t_s)$ with $s \in S$;

$x = x_{gs}$ with $g \in G, s \in S; z \in \mathrm{N}$

Result: a refinement $G^{(n)}$ of G, where n is some integer so that no section $s \in S$ is over capacity when all groups of $G^{(n)}$ are assigned to sections.

$G^{(0)} := G$;

/* Start with the original groups, which are too big to fit into the sections without exceeding capacity

$n := 0$;

Next we call Integer Program A and store the optimal values

$z :=$ optimal objective of IPA($G^{(0)}$);
$t :=$ optimal t_s-values of IPA($G^{(0)}$);
$x :=$ optimal x_{gs}-values of IPA($G^{(0)}$);
/* When $z > 0$ at least one section is over capacity

While $z > 0$ **do**
/* Find the section that is most overbooked

Find r so that $t_r := \max_{s \in S} (t_s)$, ;

/* Find all groups that are enrolled in section r

Find all $g_1, g_2, \ldots, g_k \in G^{(n)}$ with $x_{g\,r} /= 0$
/* Find the biggest group in over capacity section r

choose $g = g_i$ with maximal **size**(g_i) split g into two groups, g^{I}, g^{II} where
size(g^{I}) = **size**(g) − t_r and **size**(g^{II}) = t_r;
/* By optimality of t_r, it follows that **size**(g) − $t_r > 0$

set $G^{(n+1)} = (G^{(n)} \setminus \{g\}) \cup \{g^{\mathrm{I}}, g^{\mathrm{II}}\}$;
/* Run IPA with the refined group $G^{(n+1)}$

z = optimal objective of IPA($G^{(n+1)}$);
t = optimal t_s-values of IPA($G^{(n+1)}$);
x = optimal x_{gs}-values of IPA($G^{(n+1)}$);
$n = n + 1$;
end

5. Formulation of the Timetabling Integer Program

5.1 Sets

$Y = \{s \in S, d \in D, t \in T, r \in R : \mathbf{roomtype}(s) = \mathbf{type}(r), \mathbf{cap}(s) \leq \mathbf{cap}(r)\}$. This reduces the complexity of the search space since only appropriate rooms are considered.

$W = \{(g, s) \in G \times S : s \in \pi^{-1}(C_g)$. Only certain sections are an option for each group.

$A = \{(a, b, c) \in T^3 : a < b < c\ (1, 2, 3), (2, 3, 4), (5, 6, 7)$. These times are not allowed for three period contiguous labs.

$B = \{(a, b) \in T^2 : a < b\} \setminus \{(a, b) \in T^2 : a \neq 4, b = a+1\}$. These times are not allowed for two period labs (recall that lunch falls between periods 4 and 5).

H is the set of professors who are considered full-time,

$$H = \{p \in P : \sum_{s \in S : \mathbf{prof}(s) = p} \mathbf{periods}(s) \geq 9\}.$$

5.2 Variables

All variables are binary unless specified otherwise.

5.2.1 Major Variables

1. For $\{(s, d, t, r) \in Y\}$ define $z_{sdtr} = 1$ if section s is scheduled for day d, time t, and room r, otherwise zero.
2. For $\{(p, d, t) \in P \times D \times T\}$, define $w_{pdt} = 1$ if professor p is scheduled as the primary professor of some section that meets on day d and time t; otherwise zero.

3. For $\{(g, s) \in W\}$, define $x_{gs} = 1$ if group g is scheduled to attend section *s*; otherwise zero.
4. For $\{(g, d, t, s) \in G \times D \times T \times S: (g; s) \in W\}$ define $u_{gdts} = 1$ if group *g* is scheduled to attend section *s* on day *d* at time *t*, otherwise zero.

5.2.2 Auxiliary Variables

All variables are binary, 0-1, unless specified otherwise. Note that the 0-1 variables all give implicit constraints in the formulation of the IP. The auxiliary variables' meaning will be clear from their usage in the constraint section.

1. For $\{(s, d) \in S \times D :$ **lab**$(s) =$ **True**$\}$, y^1_{sd}
2. For $\{(s, d, r) \in S \times D \times R :$ **lab**$(s) =$ **True**, **roomtype**$(s) =$ **type**(r), **cap**$(s) \leq$ **cap**$(r)\}$, y^2_{sdt}
3. For $\{(p, d) \in P \times D\}$, y^3_{pd}
4. For $\{(p, d) \in P \_ D\}$, t^4_{pd}
5. For $\{(p \in P\}$, t^{tue}_p
6. For $\{p \in P\}$, t^5_p
7. For $\{(s, d) \in S \times D :$ **lab**$(s) =$ **False**, $2 \leq$ **periods**$(s) \_ 3\}$, y^{gp1}_{sd}
8. For $\{(s, d) \in S \times \{M, T, W, R\} :$ **lab**$(s) =$ **False**, $2 =$ **periods**$(s)\}$, t^{gp2}_{sd}
9. For $\{(s, d) \in S \times \{M, T, W\}:$ **lab**$(s) =$ **False**, $3 =$ **periods**$(s)\}$, t^{gp3}_{sd}
10. For $\{(p, d, t) \in P \times D \times T :$ **avail**$(p)_{dt} \leq 0\}$, t^0_{pdt}
11. For $\{s \in Sg\}$, $t_s \geq 0$; integer

5.3 Formulation of the Hard Constraints

5.3.1

Each section s must be scheduled for exactly **periods**(s) time slots per week.

$$\forall\, s \in S, \quad \sum_{\substack{(d,t,r) \in D \times T \times R: \\ (s,d,t,r) \in Y}} z_{sdtr} = \textbf{periods}(s) \tag{7}$$

5.3.2

If two sections s_1, s_2 have **link**$(s_1) =$ **link**(s_2), then they must be taught at identical days and times.

$$\forall\, s_1, s_2 \in S, t \in T, d \in D : \textbf{link}(s_1) = \textbf{link}(s_2) \neq 0, \tag{8}$$

$$\sum_{\substack{r \in R: \\ (s_1,d,t,r) \in Y}} z_{s_1 dtr} = \sum_{\substack{r \in R: \\ (s_2,d,t,r) \in Y}} z_{s_2 dtr} \tag{9}$$

5.3.3

For each $d \in$ D, $t \in$ T, $r \in$ R at most one section s can be assigned (one class at a time in each room).

$$\forall\, d \in D, t \in T, r \in R, \tag{10}$$

$$\sum_{\substack{s \in S: \\ (s,d,t,r) \in Y}} z_{sdtr} \leq 1 \tag{11}$$

5.3.4

Each section that has mandated times must be scheduled accordingly. Suppose section s must meet on day d_0, that is $(d_0, \emptyset) \in$ **mandate**(s),

$$\forall\, s \in S, d_0 \in D, i \in \{1 \ldots 6\} : \textbf{mandate}_i(s) = (d_0, \emptyset), \tag{12}$$

$$\sum_{\substack{t \in T, r \in R: \\ (s,d_0,t,r) \in Y}} z_{sd_0tr} \geq 1 \tag{13}$$

The "≥" is necessary because the section could be a multi-period lab. Next, suppose section s must meet on day d_0 and time t_0; that is $(d_0, t_0) \in$ **mandate**(s),

$$\forall\, s \in S, d_0 \in D, t_0 \in T, i \in \{1 \ldots 6\} : \textbf{mandate}_i(s) = (d_0, t_0), \tag{14}$$

$$\sum_{\substack{r \in R: \\ (s,d_0,t_0,r) \in Y}} z_{sd_0t_0r} = 1 \tag{15}$$

5.3.5

Each section that is not a lab can meet at most one-time per day.

$$\forall\, s \in S, d \in D : \textbf{lab}(s) = \textbf{False}, \tag{16}$$

$$\sum_{\substack{t \in T, r \in R: \\ (s,d,t,r) \in Y}} z_{sdtr} \leq 1 \tag{17}$$

5.3.6

Each section that is a lab must have all its meetings on the same day, in the same room, contiguously scheduled, and without lunch falling within the allotted times.
Either all meetings of a lab are on a day, or none are:

$$\forall\, s \in S, d \in D : \textbf{lab}(s) = \textbf{True}, \tag{18}$$

$$\sum_{\substack{t \in T, r \in R: \\ (s,d,t,r) \in Y}} z_{sdtr} \leq \textbf{periods}(s) y^1_{sd} \tag{19}$$

$$\textbf{periods}(s) \leq \textbf{periods}(s)(1 - y^1_{sd}) + \sum_{\substack{t \in T, r \in R: \\ (s,d,t,r) \in Y}} z_{sdtr} \tag{20}$$

Each lab is assigned the same room over multiple periods:

$$\forall\, s \in S, d \in D, r \in R : \mathbf{roomtype}(s) = \mathbf{type}(r), \tag{21}$$

$$\mathbf{cap}(s) \leq \mathbf{cap}(r),\ \mathbf{lab}(s) = \mathbf{True}, \tag{22}$$

$$\sum_{t \in T} z_{sdtr} \leq \mathbf{periods}(s) y^2_{sdr} \tag{23}$$

$$\mathbf{periods}(s) \leq \mathbf{periods}(s)(1 - y^2_{sdr}) + \sum_{t \in T} z_{sdtr} \tag{24}$$

Contiguous periods are required two period labs:

$$\forall\, s \in S, d \in D, r \in R, (t_1, t_2) \in B : \mathbf{roomtype}(s) = \mathbf{type}(r), \tag{25}$$

$$\mathbf{cap}(s) \leq \mathbf{cap}(r), \tag{26}$$

$$\mathbf{lab}(s) = \mathbf{True}, \mathbf{periods}(s) = 2 \tag{27}$$

$$z_{sdt_1r} + z_{sdt_2r} \leq 1 \tag{28}$$

Three period labs:

$$\forall\, s \in S, d \in D, r \in R : \mathbf{roomtype}(s) = \mathbf{type}(r), \mathbf{cap}(s) \leq \mathbf{cap}(r) \tag{29}$$

$$\mathbf{lab}(s) = \mathbf{True}, \mathbf{periods}(s) = 4 \tag{30}$$

$$z_{sd5r} + z_{sd6r} + z_{sd7r} = 0 \tag{31}$$

Four period labs:

$$\forall\, s \in S, d \in D, r \in R : \mathbf{roomtype}(s) = \mathbf{type}(r), \mathbf{cap}(s) \leq \mathbf{cap}(r) \tag{32}$$

$$\mathbf{lab}(s) = \mathbf{True}, \mathbf{periods}(s) = 4 \tag{33}$$

$$z_{sd5r} + z_{sd6r} + z_{sd7r} = 0 \tag{34}$$

5.3.7

For each $p \in$ P the set of sections s with prof(s) = p must be scheduled at disjoint times (no collisions allowed), and they must all be scheduled.

$$\forall\, p \in P, d \in D, t \in T \tag{35}$$

$$\sum_{\substack{(s,r) \in S \times R: \\ (s,d,t,r) \in Y \\ \mathbf{prof}(s) = p}} z_{sdtr} = w_{pdt} \tag{36}$$

Since w_{pdt} is a binary variable, collisions are avoided.

5.3.8

For each $s \in$ S, $p \in$ P with $\mathbf{coprof}_i(s) = p$ for some i, each section s_k with $\mathbf{prof}(s_k) = p$ must be scheduled so professor p can attend section s: In other words, if p has regular sections, they cannot make it impossible for him/her to attend sections where he/she co-teaches.

$$\forall\, p \in P, d \in D, t \in T, s \in S, i \in 1 \ldots 6 : \mathbf{coprof}_i(s) = p \tag{37}$$

$$w_{pdt} \leq 1 - \sum_{\substack{r \in R: \\ (s,d,t,r) \in Y}} z_{sdtr} \tag{38}$$

5.3.9

For each group $g \in$ G; and each $c \in C_g$, group g must be scheduled for exactly one section $s \in \pi^{-1}(c)$. Note that we are not preassigning groups to sections.

$$\forall\, g \in G, c \in C_g, \tag{39}$$

$$\sum_{\substack{s \in S: \\ s \in \pi^{-1}(c)}} x_{gs} = 1 \tag{40}$$

5.3.10

For each $g \in$ G, the set of sections that g is enrolled in, must be scheduled at disjoint times (no collisions). Each section s that g is enrolled in should be in scheduled in the timetable of g for the correct amount of periods that s meets

$$\forall\, (g, s) \in W, \quad \sum_{(d,t) \in D \times T} u_{gdts} = \mathbf{periods}(s) x_{gs} \tag{41}$$

If group g is enrolled in section s then reserve the periods that s meets for the timetable of g.

$$\forall\, (g, d, s, t) \in G \times D \times S \times T : (g, s) \in W, \quad u_{gdts} + (1 - x_{gs}) \geq \sum_{\substack{r \in R: \\ (s,d,t,r) \in Y}} z_{sdtr} \tag{42}$$

Each group should be enrolled the correct total number of periods that the group requires

$$\forall\, g \in G, \quad \sum_{\substack{(d,t,s) \in D \times T \times S: \\ (g,s) \in W}} u_{gdts} = \sum_{c \in C_g} \mathbf{periods}(c) \tag{43}$$

Each group should only have one section at a time[7]

$$\forall\, (g, d, t) \in G \times D \times T, \quad \sum_{\substack{s \in S: \\ (g,s) \in W}} u_{gdts} \leq 1 \tag{44}$$

[7]The above constraint forced us to define the variable u_{gdts} with four subscripts. We spent a lot of time looking for a formulation with only three subscripts, to reduce the complexity of the problem. We did succeed, however, though we had much less variables, we needed many extra constraints, which made the IP computationally infeasible. The necessary constraint of tying the section schedules to the group schedules seems to increase the complexity of this IP.

5.3.11

If $s_0 \in S$ is a non-lab, and $s_1 \in S$ is a lab, and **labtie**(s_0) = **labtie**(s_1) ≠ 0, then all groups enrolled in s_1 must also be enrolled in s_0. These constraints keeps labs and lectures together, with the same professor, if requested.

$$\forall\, g \in G, s_0, s_1 \in S \times S :\ (g, s_0), (g, s_1) \in W, \tag{45}$$

$$\mathbf{lab}(s_0) = \mathbf{False},\ \mathbf{lab}(s_1) = \mathbf{True},\ \mathbf{labtie}(s_0) \neq \emptyset, \mathbf{labtie}(s_0) = \mathbf{labtie}(s_1), \quad x_{g s_0} \geq x_g \tag{46}$$

5.3.12

For each section s, the number of students enrolled should not exceed **cap**(s): We sometimes make this a soft constraint, but impose a big penalty for over-capacity. We make sure that the rooms requested for s have enough capacity, so we do not explicitly check room capacity.

If this is a hard constraint, then

$$\forall\, s \in S, \quad \sum_{\substack{g \in G: \\ (g,s) \in W}} \mathbf{size}(g) x_{gs} \leq \mathbf{cap}(s) \tag{47}$$

If it is a soft constraint,

$$\forall\, s \in S, \quad \sum_{\substack{g \in G: \\ (g,s) \in W}} \mathbf{size}(g) x_{gs} \leq \mathbf{cap}(s) + t_s \tag{48}$$

Here t_s is a non-negative integer variable. The objective would minimize $\Sigma_{s \in S} c^t_s t_s$, where c^t_s is an appropriate weight. For small labs, with zero room for excess capacity, $c^t_s := M$; for some large big M, and for regular classes, a more modest weight would suffice.

5.3.13

If a group g is scheduled for two sections s_0, s_1 with **labtie**(s_0) = **labtie**(s_1), then for each day, at most four hours should be scheduled, combined, for both s_0 and s_1. In other words, we don't want a four hour lab scheduled on the same day as the lecture it is tied to.

$$\forall\, (g, s_0), (g, s_1) \in W, d \in D :\ s_0 \neq s_1, \tag{49}$$

$$\mathbf{labtie}(s_0) \neq \emptyset,\ \mathbf{labtie}(s_0) = \mathbf{labtie}(s_1), \quad \sum_{t \in T} (u_{gdts_0} + u_{gdts_1}) \leq 4 \tag{50}$$

5.3.14

If a group g is scheduled for two sections s_1, s_2 with **labtie**(s_0) = **labtie**(s_1); then there should be at least a one period break (a lunch break is acceptable) between the two sections. In other words, a lab should not start right before or after lecture if they are tied together.

$$\forall\, (g, s_0), (g, s_1) \in W, d \in D, t_0, t_1 \in T :\ t_0 \neq 4, t_1 = t_0 + 1,\ s_0 \neq s_1, \tag{51}$$

$$\mathbf{labtie}(s_0) \neq \emptyset, \mathbf{labtie}(s_0) = \mathbf{labtie}(s_1), \quad u_{gdt_0 s_0} + u_{gdt_1 s_1} \leq 1 \tag{52}$$

5.4 Formulation of the Soft Constraints

5.4.1

Each two or three period section s that is not a lab, should not be scheduled on consecutive days.

$$\forall s \in S, d \in D : \textbf{lab}(s) = \textbf{False},\ 2 \leq \textbf{periods}(s) \leq 3, \tag{53}$$

$$y_{sd}^{\text{gp1}} = \sum_{\substack{(t,r)\in T\times R:\\ (s,d,t,r)\in Y}} z_{sdtr} \tag{54}$$

For $d \in$ {M, T,W, R} define **next**(d) to be the day after day d: When **periods**(s) = 2,

$$\forall s \in S, d_0 = \{M,T,W,R\}, d_1 \in D : d_1 = \textbf{next}(d_0),\ \textbf{lab}(s) = \textbf{False},\ \textbf{periods}(s) = 2, \tag{55}$$

$$y_{sd_0}^{\text{gp1}} + y_{sd_1}^{\text{gp1}} \leq 1 + t_{sd_0}^{\text{gp2}} \tag{56}$$

When **periods**(s) = 3,

$$\forall s \in S, d_0 = \{M,T,W\}, d_1, d_2 \in D : d_1 = \textbf{next}(d_0),\ d_2 = \textbf{next}(d_1), \tag{57}$$

$$\textbf{lab}(s) = \textbf{False},\ \textbf{periods}(s) = 3, \tag{58}$$

$$y_{sd_0}^{\text{gp1}} + y_{sd_1}^{\text{gp1}} + y_{sd_2}^{\text{gp1}} \leq 2 + t_{sd_0}^{\text{gp3}} \tag{59}$$

The sum of the all the variables $t^{\text{gp3}}{}_{\text{sd}}$ and $t^{\text{gp2}}{}_{\text{sd}}$ are minimized in the objective with a small weight. When they are zero, the constraint is fully satisfied. For our real data, a few sections violate these soft constraints.

5.4.2

Each professor must have at least one day without teaching.

$$\forall\, p \in P, d \in D, \quad \sum_{t\in T} w_{pdt} \leq 7y_{pd}^{3} \tag{60}$$

$$\sum_{t\in T} w_{pdt} \geq y_{pd}^{3} \tag{61}$$

$$\forall\, p \in P, \quad \sum_{d\in D} y_{pd}^{3} \leq 4 + t_{p}^{5} \tag{62}$$

The variables $t^{5}{}_{\text{p}}$ are minimized in the objective.

5.4.3

On any given day, a professor should not teach both first period and seventh period.

$$\forall\, p \in P, d \in D,\ t_0, t_1 \in T :\ t_0 = 1,\ t_1 = 7, \quad w_{pdt_0} + w_{pdt_1} \leq 1 + t_{pd}^{4} \tag{63}$$

In the objective the variables t^4_{pd} are minimized.

5.4.4

All full-time professors (those teaching 9 or more hours per week) should be assigned teaching duties on Tuesdays (for weekly department meetings).

$$\forall\, p \in H,\ d \in D:\ d = T\,, \quad y^3_{pd} + t^{\text{tue}}_p \geq\ 1 \tag{64}$$

In the objective, we minimize, with a small weights d^{tue}; the sum

$$d^{\text{tue}} \sum_{p \in H} t^{\text{tue}}_p$$

5.4.5

For each $p \in$ P; if $\mathbf{avail}(p)_{dt} \leq 0$, then do not schedule any section with $\mathbf{prof}(s) = p$, or $\mathbf{coprof}_i(s) = p$; at time and day (d, t). For the main professor of each section

$$p \in P,\ d \in D,\ t \in T : \mathbf{avail}(p)_{dt} \leq 0, \quad w_{pdt} \leq t^0_{pdt} \tag{65}$$

For co-professors[8]

$$\forall\, p \in P, d \in D, t \in T, s \in S, i \in 1 \ldots 6 : \mathbf{coprof}_i(s) = p \tag{66}$$

$$\sum_{\substack{r \in R: \\ (s,d,t,r) \in Y}} z_{sdtr} \leq t^0_{pdt} \tag{67}$$

Let c_0 be a large weight, and let

$$c_p = c_0 10^{-\mathbf{avail}(p)_{dt}}$$

This gives an order of magnitude weight for higher priority professor-time preferences.

5.5 Objective

Minimize z where

$$z = \sum_{\substack{(p,d,t) \in P \times D \times T: \\ \mathbf{avail}(p)_{dt} \leq 0}} c_p t^0_{pdt} + d_4 \sum_{(p,d) \in P \times D} t^4_{pd} + d_{\text{tue}} \sum_{p \in H} t^{\text{tue}}_p$$

$$+ d_{\text{gp2}} \sum_{\substack{(s,d) \in S \times D: \\ d \neq F \\ \mathbf{lab}(s) = \mathbf{False} \\ \mathbf{periods}(s) = 2}} t^{\text{gp2}}_{sd} + d_{\text{gp3}} \sum_{\substack{(s,d) \in S \times D: \\ d \neq F \\ d \neq R \\ \mathbf{lab}(s) = \mathbf{False} \\ \mathbf{periods}(s) = 3}} t^{\text{gp3}}_{sd} + d_5 \sum_{p \in P} t^5_p. \tag{68}$$

[8]Co-professors are allowed to be co-scheduled for more than one section at a time.

Where the constants above are all weights that one chooses to weight which soft constraints should be violated above others.

6. Computational Details

The project started with a small, artificial model of the real timetabling problem. It was modeled with the GNU MathProg language [10] which is integrated with the GLPK MIP solver. When the registrar provided one fourth of the real data, it became apparent that GLPK would not be able to solve the real problem. Since this is an academic project, we tried to solve the problem with other open source solvers. We contacted Yuji Shinano of the SCIP project [9], but he informed us that our problem was "quite huge" and that we would need a cluster of 100 cores and a large amount of time to solve using ParaSCIP or FiberSCIP (parallel solvers, though not the same algorithm as SCIP). We compiled CBC [6] to enable multithread processing, and the result was the same: no open source solver could even find a feasible solution to our IP, even with 24 hours of computational time.

We next tried commercial solvers. IBM's CPLEX [11] was able to find feasible solutions to small versions of our real problem, but didn't succeed in finding optimal solutions, even after 24 hours and running on multiple cores.

We next tried Gurobi 6.5 [12], and the small version of the problem (roughly 1/3 of all students) was solvable in a few hours. The full version of the problem was almost solved by Gurobi 6.5 in about 5–8 hours. Often the solver was very close to the optimal solution (within a few soft constraints) and we accept the very good near optimal solution. When Gurobi 7.0 was released, solving time was cut substantially (by more than 30 percent).

All was going well, we were consistently solving the full problem to near optimality in 4 hours when we discovered that we left out the constraint that forces each classroom to be used by at most one lecture at a time. Coding this constraint brought the solving time to 20-40 hours.

The next step was to tune Gurobi. We modified our small artificial problem so that it was challenging for Gurobi to solve, yet took about 1 hour. Using the automated tuning utility, we found that following parameters reduced the solving time:

Heuristics=0, FlowCoverCuts=1. Other, good, though less ideal parameters were **NormAdjust=1, PreDual=0,** were found by tuning an easier artificial problem. Combining the two sets of parameters offered no improvement.

6.1 Time to Find Solution

One of the drawbacks to using huge integer programs to solve timetabling problems is the variability of the solution time. The solver uses a random seed value to make arbitrary decisions, and this seed can have a big impact on solution times. With a large number of computer cores, one can try out many different seeds simultaneously.

Another aspect that can greatly affect solution time are the weights on the objective. The computer we used was a high performance laptop with an i7 Intel CPU with 4 cores, capable of executing 8 threads per cycle. The memory of the machine was 16GB and when solving with 7 threads, about 3 GB were actually used when the search tree became large. For future work we are hoping for a

machine with many more cores, and an error correcting code memory CPU, such as the Xeon class of processors. We were surprised that such a large IP could be solved on a portable computer.

7. Future Work

There are many directions this work can be extended. USMMA is in the process of transitioning to the TIP solution. We expect many new requests for enhancements over the coming years. The following are some issues on the horizon:

7.1 Decreasing Solving Time

In our model, the TIP assigned actual rooms to sections. We could separate out the room assignment by simply requiring the main TIP not to assign more sections at a certain time, that need a certain room type, than are available in that class of room types.

One could also experiment with pre-assigning students to sections. Then one only needs to assert that the sections do not collide and that the professors have no collisions. This would be a suboptimal approach, so we did not pursue it.

Our subgroup generating algorithm does not find the minimal number of groups needed to pack all groups into classes. We tried solving this subgroup problem with a 0-1 MIP and the computation time exceeded 12 hours. Another approach is a quadratically constrained integer program. We do not know if that would be faster.

7.2 Recalculate Timetables

Suppose the registrar wants to change a few schedules after the term has started. In theory we can solve the problem by modifying our objective and adding penalties for deviations of our binary variables. However, we need to study that type of changes that are requested (in real life) and see how it changes our sets and data, and understand how the TIP changes. A possible solution is to schedule dummy sections and dummy groups which may give flexibility to change our initial TIP without changing too much of the key structures.

7.3 Validity of Data

While it is straightforward to correct simple mistakes in the real data, sometimes one cannot catch a mistake until the solver returns the dreaded *infeasible problem*. Some problems that we discovered were when too many sections requested rooms for a class of room types that was too small; professors were mandating their courses be scheduled at conflicting times; and 3 credit courses were requesting 4 time slots. The infeasibility problem is a serious problem and we had to compute irreducible infeasible sets (IIS) in order to track down subtle errors in the data. We are currently writing traditional computer programs to search for common errors that cause the TIP to be infeasible.

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New Dynamics in International Relations
Working on Solving the Problems of the World: A Call for Action

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Introduction

As we watch the news, we have the feeling that the world is getting more complex day by day with the problems becoming harder to deal with (e.g. wars, vagaries of the weather, culture clashes and religious conflicts, refugees and displaced populations). There are bad news and good news but often we get consumed by the bad news with a feeling of pessimism. However there are good news as well (e.g. better ways of producing and preserving food, better medicine, transportation systems, travel opportunities). We do not quite know whether the glass is half empty or half full; it may depend upon where you are standing. We seem to be more reactive than proactive. Is there also a lack of good will; have we given up trying? This compilation takes stock of what is going on in the world today capturing the 'best of times and the worst of times'. e-Leadership has emerged as a powerful tool fueling countries' advancement (e.g. South Korea, Singapore) as well as companies' transformation (e.g. Apple, Amazon). Nonetheless, is there a transformation problematique albeit a failure in our search for specific improvement methodologies as several sectors face difficulties to adjust with changes? While the private sector seems to be energized by innovation, the public sector is not staying behind either and moving ahead as well, at times overshadowed by political rhetoric and posturing. eGov has come of age and the e-leadership pf the public sector emerged as a decisive factor. Technology is crucial in practically everything we do. When we look at countries, we see that the 'power shift' paradigm of Alvin Toffler has maintained its relevance. While many countries have made the quantum leap forward (e.g. India, South Korea), several are struggling and falling behind beset by many adverse actors. Clean water is an issue in several areas; water processing and desalination technologies are available and could be used more widely. According to the World Bank we are making progress in dealing with poverty in the world; however, there is much more that needs to be done. Not to be overlooked are pockets of poverty in advanced countries with a deepening of the divide between the haves and the have-nots

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Agricultural technologies could be more widely used to resolve poverty and hunger issues. The international community has been looking at global environmental issues for decades; positive steps have been taken but there is a feeling that more could and should have been done. The world got energized by demonstrations in 2014 and 2015 and the leaders were brought in by the UN Secretary General to face the grim situation. As a result, the Paris World Conference on Climate Change made history by the adoption of a treaty engaging all countries in the world, both the public and private sectors, in efforts to make a difference. Implementation is underway and could in some instances face challenges. There is a silver lining however as solutions to the problems open up new opportunities and green business is making significant progress. Why are we not making use of our abilities to foster peace? Why do we have wars which appear to be endless? Is militarism overshadowing diplomacy? The US plays an important role in international affairs; however there are other important players on the world stage such as China, EU, ASEAN; in fact economic groupings are becoming increasingly important. We have gone from a bi-polar to a unipolar and now multipolar world; the way forward is constructive dialogue instead of constant diatribes; it should be recognized that populism is a significant factor both in national and international relations. US-China relation is being redefined and so is US-EU relation. Russia is an important player on the world stage. After the Second World War, ideologies proved to be a dividing factor pitting the east against the west and now as this major divide has been resolved, it looks like the clash of civilizations has become the basis for divisions among countries and groups and at times even triggering wars. The United Nations should be credited to serve its purpose of keeping the world at peace. It plays a crucial role in fostering cooperation among countries. The annual report of the UN Secretary General shows that important efforts are being made by the UN throughout the world to make conditions better for large segments of the under privileged populations. . Should not we be strengthening the United Nations and making it better? Should not we be preventing and resolving wars, avoiding major refugee problems as well as large displacement of populations? Special interest groups often use their power to influence the definition of common good. Globalism catapulted the world forward after World War 2 and free trade was seen as the way forward. Now it seems as if we want to go back to protectionism. We do have the means of resolving trade disputes. Trade agreements can be reviewed and improved. Let us go forward with a spirit of constructiveness. Indeed globalism can be improved.

Chapter 1: Attempt at a Comprehensive Look at the World's Problems and Possible Solutions

Taking a comprehensive look at the world, we find a mixed picture with positives and negatives. Is it the best of times, is it the worst of times? Is the glass half full or half empty? Are we entering a new era in international affairs may be even in national affairs since these two domains interrelate?

In the academic field, International Relations and International Business are two distinct subjects, generally taught in different departments, the first one with a legal twist and the second one with a business twist. In real life, there is a growing intersection between the two subjects albeit an overlap. It is also important to keep in mind that International Relations rests upon diplomacy with elaborate principles, rules and protocol. Common courtesy is a golden rule in diplomacy.

Ignorantia juris non excusat. Business on the other hand often makes use of crude methods and negotiation tactics; the basic idea is to win and keep the upper hand. In an attempt to provide a picture of the real world, we find new ways albeit dynamics as business executives get to occupy key positions in international relations.

Note: the next chapters look into more detail at specific issues and opportunities.

Methodological Considerations

In this day and age, we need to be careful about facts and analyzes; there are biases and more out there. In the academic world we recall Dean Michael Hamlet's principle of 'rigor and quality' both in teaching and research. In *International Relations*, the UN, IMF and World Bank have a vast network of primary and secondary sources and publish several reports, some periodically and some on an ad hoc basis. *The World Factbook* is a valuable source of international information. The *OECD* is a trusted source as well. There are several journals providing helpful information. The foregoing listing is illustrative rather than exhaustive. This chapter makes use of official information sources such as those pointed out above and other credible sources, at times citing in extenso to convey the full messages considered important, with proper attribution.

Conceptual Approach

We start our analysis with conceptual considerations. First, post facto, we can qualify the Cold War Era: as one of confrontation of two major ideologies. There were 'proxy wars' all over the world but we averted a nuclear confrontation between the two super powers.
In the post-cold war era, attention is drawn to two paradigms:

1. *The End of History (*Francis Fukuyama*)*
2. *The Clash of Civilizations (*Sam Huntington*)*

The End of History and the Last Man by Francis Fukuyama is a book published in 1992 (expanding on an essay published in 1989) arguing that the end of the Cold-War marks the endpoint of the development of human history.

Fukuyama draws heavily on the Philosophy of Hegel and its interpretation by Kojeve. Hegel, to summarize, saw history as evolving through conflict between opposing ideas (Hegelian dialectics of thesis, antithesis and synthesis). Kojeve translated this highly influential line of thought into an argument holding that the final condition of humanity's socio-political order is a homogeneous state ruled by a single victorious ideology. This will mark the end of ideology (and therefore of history) since such a society will be, according to Kojeve, a "post-political" society which won't be divided by ideological differences.

In *The End of History and the Last Man*, Fukuyama sees the end of the Cold-War and the fall of the Berlin Wall as marking the end of ideological conflict with the unchallenged establishment of Western liberal democracy as the final ideological stage of human evolution. After the opposition between the liberal West and the communist world was resolved Fukuyama sees no further direction in which history can go. Hence the end of history is not to be understood as no more events happening and no more people born of die, but rather as the final resolution of the tensions which drive history forwards. The end of history for Fukuyama is the end of the making of history and

human progress in its Hegelian understanding (and by that denying Marx's view of history which saw the endpoint of history in a global communist society, see for example *The Communist Manifesto*).

Fukuyama's thesis in *The End of History and the Last Man* was heavily criticized by both other historical thinkers and history itself. Most notable among Fukuyama's critiques is Samuel Huntington in his book *The Clash of Civilizations and the Remaking of World Order* (1996) where he explains that cultural forces will take over ideological forces in shaping global history. Since September 11th 2001 Huntington's critique of Fukuyama's *The End of History* is proved painfully right, history did not come to its end (see End of History vs. Clash of Civilizations debate)
Next we look at a summary of:

***The Clash of Civilizations and the Remaking of World Order* by Samuel P. Huntington**
Summary written by Hollie Hendrikson, Conflict Research Consortium

The Clash of Civilizations and the Remaking of World Order is an expansion of the 1993 *Foreign Affairs* article written by Samuel Huntington that hypothesized a new post-Cold War world order. Prior to the end of the Cold War, societies were divided by ideological differences, such as the struggle between democracy and communism. Huntington's main thesis argues, "The most important distinctions among peoples are [no longer] ideological, political, or economic. They are cultural" (21). New patterns of conflict will occur along the boundaries of different cultures and patterns of cohesion will be found within the cultural boundaries.

Part One: *A World of Civilizations*

To begin his argument, Huntington refutes past paradigms that have been ineffective in explaining or predicting the reality of the global political order. "We need a map," Huntington says, "that both portrays reality and simplifies reality in a way that best serves our purposes" (p. 31). Huntington develops a new "Civilization paradigm" to create a new understanding of the post-Cold War order, and to fill the gaps of the already existing paradigms. To begin with, Huntington divides the world into eight "major" civilizations:

1. *Sinic:* the common culture of China and Chinese communities in Southeast Asia. Includes Vietnam and Korea.
2. *Japanese:* Japanese culture as distinctively different from the rest of Asia.
3. *Hindu:* identified as the core Indian civilization.
4. *Islamic:* Originating on the Arabian Peninsula, spread across North Africa, Iberian Peninsula and Central Asia. Arab, Turkic, Persian and Malay are among the many distinct subdivisions within Islam.
5. *Orthodox:* centered in Russia. Separate from Western Christendom.
6. *Western:* centered in Europe and North America.
7. *Latin American:* Central and South American countries with a past of a corporatist, authoritarian culture. Majority of countries are of a Catholic majority.
8. *Africa:* while the continent lacks a sense of a pan-African identity, Huntington claims that Africans are also increasingly developing a sense of African Identity.

Following the explanations of the separate civilizations in the new paradigm, Huntington describes the relations among civilizations. Before 1500 A.D., civilizations were separated geographically and the spread of ideas and technology took centuries. Huntington argues that research and technology

are the catalyst for civilization creation and development. By 1500 A.D., evolution in ocean navigation by Western cultures led to rapid expansion and eventual domination of ideas, values, and religion.

Twentieth century relations among civilizations have moved beyond the unidirectional influence of the west on the rest. Instead, "multidirectional interactions among all civilization" has been maintained (53). In other words, cultural influence is interdependent; western civilizations influence and are influenced by smaller, less powerful civilizations around the world.

Huntington then refutes the idea of a Western cultural hegemony and the concept of an established universal civilization. He states that "global communications are dominated by the West" and is "a major source of the resentment and hostility of non-Western peoples against the West" (59). The notion of a single, universal culture is not helpful creating an explanation or a description of global political order. However, Huntington also argues that as modernization increases cross-cultural communication, the similarities among cultures also increase. The key to this chapter is Huntington's severance of modernization from Westernization. While the world is becoming more modern, it is simultaneously becoming less Western, an idea he expands upon in part two of the book.

Part Two: *The Shifting Balance of Civilizations*

Huntington starts this section by arguing that Western power and influence is fading. There are contrasting views on the West's hold on power. One side argues that the West still has a monopoly on technological research and development, military strength, and economic consumption. The other side argues that the relative power and influence of Western countries is declining. Huntington adopts the latter view and describes three characteristics of the Western decline:

1. The current Western decline is a very slow process and is not an immediate threat to World powers today.
2. Decline of power does not occur in a straight line; it may reverse, speed up, or pause.
3. The power of a state is controlled and influenced by the behavior and decisions of those holding power.

Also in this section, Huntington asserts the increased role and importance of religion in world politics. Religion is the societal factor that has filled the vacuum created by a loss of political ideology. Major religions around the world "experienced new surges in commitment, relevance and practice by erstwhile casual believers" (96). Huntington goes on to say that replacing politics with religion was also the result of increased communication among societies and cultures. People "need new sources of identity, new forms of stable community, and new sets of moral precepts to provide them with a sense of meaning and purpose" (97). Religion is able to meet these needs.

Chapter five, “Economics, Demography and the Challenger Civilizations,” discusses the relative rise in power and influence of non-Western countries. Huntington specifically focuses on Japan, the Four Tigers (Hong Kong, Taiwan, South Korea, Singapore), and China as countries, which asserted cultural relevance through economic successes. "Asian societies are decreasingly responsive to United States demands and interests and [are] increasingly able to resist pressure from the U.S. or other Western countries" (104). The ability of Asian countries to successfully modernize and develop economically without adopting western values supports Huntington's assertion that the world is becoming more modernized, but less Westernized.

Muslim societies, unlike Asian societies, have asserted cultural identity through the reaffirmation and resurgence of religion. Huntington argues that the resurgence of Islam "embodies the acceptance of modernity, rejection of Western culture, and the recommitment to Islam as the guide to life in the modern world" (110). Religion is the primary factor that distinguishes Muslim politics and society from other countries. Huntington also argues that the failure of state economies, the large young population, and the authoritarian style of governance have all contributed to the resurgence of Islam in society.

Part III: ***The Emerging Order of Civilizations***

During the Cold War, the bipolar world order enabled countries to identify themselves as either aligned or non-aligned. In the post-Cold War world order, countries are no longer able to easily categorize themselves and have entered into an identity crisis. To cope with this crisis, countries started "rallying to those [cultures] with similar ancestry, religion, language, values, and institutions and distance themselves from those with different ones" (126). Regional organizations have formed that reflect political and economic alliances. These include Association of Southeast Asian Nations (ASEAN), the European Union (EU) and the North American Fair Trade Agreement (NAFTA). Huntington also describes the idea of "torn countries," or countries that have yet to entirely claim or create an identity. These countries include Russia, Turkey, Mexico, and Australia.

Huntington discusses the new structure of civilizations as centered around a small number of powerful core states. "Culture commonality legitimates the leadership and order-imposing role of the core states for both member state and core external powers and institutions" (156). Examples of core states are France and Germany for the EU. Their sphere of influence ends where Western Christendom ends. In other words, civilizations are strictly bound to religious affiliation. Huntington argues that the Islamic civilization, which he identified earlier in the book, lacks a core state and is the factor that disallows these societies to successfully develop and modernize. The remainder of this section goes into great detail to explain the different divisions of core states throughout the world.

Part IV: ***Clashes of Civilizations***

Huntington predicts and describes the great clashes that will occur among civilizations. First, he anticipates a coalition or cooperation between Islamic and Sinic cultures to work against a common enemy, the West. Three issues that separate the West from the rest are identified by Huntington as:

1. The West's ability to maintain military superiority through the nonproliferation of emerging powers.
2. The promotion of Western political values such as human rights and democracy.
3. The Restriction of non-Western immigrants and refugees into Western societies.

Non-Western countries see all three aspects as the Western countries attempt to enforce and maintain their status as the cultural hegemony.

In the chapter *The Global Politics of Civilizations*, Huntington predicts the conflict between Islam and the West to be a "small, fault line war," and the conflict between the America and China having the potential to be an "intercivilizational war of core states" (p. 207).

Islam and the West

Huntington goes into a brief historical explanation of the conflictual nature of Islam and Christianity and then lists five factors that have exacerbated conflict between the two religions in the late twentieth century. These factors are:

- the Muslim population growth has generated large numbers of unemployed and dissatisfied youth that become recruits to Islamic causes,
- the recent resurgence of Islam has given Muslims a reaffirmation of the relevance of Islam compared to other religions,
- the West's attempt to universalize values and institutions, and maintain military superiority has generated intense resentment within Muslim communities,
- without the common threat of communism, the West and Islam now perceive each other as enemies, and
- increased communication and interaction between Islam and the West has exaggerated the perceived differences between the two societies (211).

Asia, China, and America

Economic development in Asia and China has resulted in an antagonistic relationship with America. As discussed in previous sections, economic success in Asia and China has created an increased sense of cultural relevancy. Huntington predicts that the combination of economic success of the East Asian countries and the heightened military power of China could result in a major world conflict. This conflict would be intensified even more by alignments between Islamic and Sinic civilizations. The end of chapter nine provides a detailed diagram (*The Global Politics of Civilizations: Emerging Alliances*) which helps explain the complexity of the political relationships in the post-Cold War era (p. 245).

Huntington defines the Soviet-Afghan war and the First Gulf War as the emergence of civilization wars. Huntington interprets the Afghan War as a civilization war because it was seen as the first successful resistance to a foreign power, which boosted the self-confidence, and power of many fighters in the Islamic world. The war also "left behind an uneasy coalition of Islamic organizations intent on promoting Islam against all non-Muslim forces" (247). In other words, the war created a generation of fighters that perceived the West to be a major threat to their way of life.

The First Gulf War was a Muslim conflict in which the West intervened; the war was widely opposed by non-Westerners and widely supported by Westerners. Huntington states that "Islamic fundamentalist groups denounced [the war] as a war against 'Islam and its civilization' by an alliance of 'Crusaders and Zionists' and proclaimed their backing of Iraq in the face of 'military and economic aggression against its people" (p. 249). The war was interpreted as a war of us vs. them; Islam v. Christianity.

To better understand the definition of the fault line between civilizations, Huntington provides a description of characteristics and dynamics of fault line conflicts. They can be described by the following:

- Communal conflicts between states or groups from different civilizations
- Almost always between people of different religions

- Prolonged duration
- Violent in nature
- Identity wars (us vs. them), eventually breaks down to religious identity
- Encouraged and financed by Diaspora communities
- Violence rarely ends permanently
- Propensity for peace is increased with third party intervention

Part V: *The Future of Civilizations*

In the concluding sections of his book, Huntington discusses the challengers of the West, and whether or not external and internal challenges will erode the West's power. External challenges include the emerging cultural identities in the non-Western world. Internal challenges include the erosion of principle values, morals, and beliefs within Western culture. He also contributes to the debate between multiculturalists and monoculturalists and states that, "A multicultural world is unavoidable because global empire is impossible. The preservation of the United States and the West requires the renewal of Western identity" (p. 318). The ability for the West to remain a global political power, it needs to adapt to increasing power and influence of different civilizations. Without adapting, the West is destined to decline in power and influence, or it will clash with other powerful civilizations. According to Huntington, the West clashing with another civilization is "the greatest threat to world peace, and an international order" (p. 321).

Observation:

These two paradigms are used as rationale for policies and actions. Attention has been drawn to their limitations, particularly if followed blindly Economic systems can follow different approaches of public and private sector interaction. Is the approach used by the US necessarily better than the one used by China? What is the definition of democracy in the world today? About the so-called clash of civilizations, should not efforts be made to build bridges among different civilizations albeit cultures, guided by the *UN Declaration on a Culture of Peace*, promoting mutual understanding and respect? Mauritius shows clearly that western and eastern cultures can co-exist peacefully and productively. Many countries in fact consider that cultural diversity is a plus factor. However, right wing leaders recently pointed out that ‘whites’ will soon be a minority both in the US and Europe and that the western culture has to be defended, pointing to the popularity of ‘populist’ right wing movement. We need to take another look at the ‘melting pot’ model and the so-called ‘fruit salad’ model. Theresa May recently pointed out that the different cultures are working along well in the UK.

Dynamics

Dynamics in international affairs can be quite complicated and there are no guiding principles. Case studies help bring some light on the matter. For example, relation between North and South Korea has been rather difficult over many years with no improvement in sight. Then came the 2018 Winter Olympic Games and representatives from the two countries walked together in the opening ceremony of the games. Some sort of agreement must have been reached between the two parties. President Moon from South Korea called for the end to the legacy of th Cold War and both sides agreed to a denuclearization of the peninsula, which still will have to be worked out into a formal document.

The following new factors may be of relevance: in the academic field, International Relations and International Business are two distinct subjects, generally taught in different departments, the first one with a legal twist and the second one with a business twist. In real life, there is a growing intersection between the two subjects albeit an overlap. It is also important to keep in mind that International Relations rests upon diplomacy with elaborate principles, rules and protocol. Common courtesy is a golden rule in diplomacy. Ignorantia juris non excusat. Business on the other hand often makes use of crude methods and negotiation tactics; the basic idea is to win and keep the upper hand. We are finding new ways albeit dynamics as business executives get to occupy key positions in international relations.

Realism is always at play in international affairs perhaps now supplanted or supplemented by constructivism, opportunism, Michaevelism, populism, authoritarianism, 'bullyism' and more.

Now onto a few questions:

What is the relevance of NATO in today's world?

How would one explain what happened at the G-7 meeting in Canada earlier this year?

How would one explain the new dynamics in relation US-China, US-EU, US-Russia?

It is a fact that a new globalism is emerging. Also of relevance is incrementalism compared to rationalism in decision making and the 'science of muddling through' and 'learning curves'. Not to be overlooked, the art of 'pushing the can down the road.' Technology by the way has its own dynamics with many positive aspects characterized by new ways of doing things; there are negative aspects as well relating to cyber security and growing use of hacking.

Tribute to Stephen Hawking

We need human genius like him to give us a sense of direction. We are thankful for his predictions some of which can be said to be 'dire'. Perhaps more importantly in International Relations is his positive thought about 'the power of talking', a self-evident truth which has added meaning when stated by an authoritative source.

Positives

There are many positives out there as well as positive developments. Think of the landmark summit of US and North Korea leaders in Singapore in June this year, definitely a positive development albeit a breakthrough with more work to do to be on solid ground.

Most countries interrelate on a friendly basis; countries cooperate on a bilateral, regional and global basis. Most countries are in a state of peace. Most countries are making progress in socio-economic development, some faster and some slower.

The World Economy is Quite Complex with its Own Short Term and Long Term Cycles

The IMF conveyed a mixed picture in July 2018: 'global growth is projected to reach 3.9 percent in 2018 and 2019, in line with the forecast of the April 2018 *World Economic Outlook* (*WEO*), but the expansion is becoming less even, and risks to the outlook are mounting. The rate of expansion

appears to have peaked in some major economies and growth has become less synchronized. In the United States, near-term momentum is strengthening in line with the April 2018 *WEO* forecast, and the US dollar has appreciated by around 5 percent in recent weeks. Growth projections have been revised down for the euro area, Japan, and the United Kingdom, reflecting negative surprises to activity in early 2018. Among emerging market and developing economies, growth prospects are also becoming more uneven, amid rising oil prices, higher yields in the United States, escalating trade tensions, and market pressures on the currencies of some economies with weaker fundamentals. Growth projections have been revised down for Argentina, Brazil, and India, while the outlook for some oil exporters has strengthened.'

The State of Happiness in the World

According to the *World Happiness Report*, there is a mixed picture out there. The 2017 report states that while Norway can be frigid and the winters bring lots of darkness, it is the happiest nation in the world. Denmark comes in second, followed by Iceland and Switzerland. The second tier of the top ten includes the Netherlands, Canada, New Zealand, Australia and Sweden. Wellbeing is shaped by a range of factors. The report states that all top countries rank highly on all of the main factors found to support happiness: caring, freedom, generosity, honesty, health, income and good governance. According to the report, happiness in the US slipped from 13th in 2015 to 14th in 2017, stating that the reasons are declining social support as well as a decline in trust and an increased sense of corruption. Some of the unhappiest countries in the world are Afghanistan, Chad, the Democratic Republic of Congo and Haiti. Many countries in the low and middle income groups saw gains in happiness. The report points out that there is an alternative to assuming that income is a measure of progress. An important observation is that there are unhappy people even in the 'happy' countries, some of which have a higher suicide rate than that of the unhappy countries.

Survey of Problems

The following findings of a survey of millennials by World Economic Forum 2018 provides a comprehensive picture with ranking of problems by their relative order of importance from the lowest to the highest:

10. Lack of opportunity and unemployment (12.1%)
9. Safety/security; wellbeing (14.1%)
8. Lack of education (15.9%)
7. Food and water security (18.2%)
6. Government accountability and transparency; corruption (22.7%
5. Religious conflicts (23.9%)
4. Poverty (29.2%)
3. Inequality in income; discrimination (30.8%)
2. Large scale conflicts and wars (38.9%)
1. Climate change; destruction of nature (48.8%)

The following two examples provide an indication of a very serious problem:

1) BBC World News reported on April 29, 2018 that a huge glacier, the size of England, broke away and is adrift at sea! Consequent rising sea level
2) The CO2 level is at a record high

Credit has to be given to human ingenuity. Often solutions to problems open up new opportunities, in other words, a negative can be turned into a positive: The WAFUNIF-ASUA Conferences on Climate Change at the UN in 2014 and 2016 showed clearly the path from problems to solutions with opportunities for 'green business' and new ways of dealing with the CO2 problem with the use of artificial trees that absorb the gas. Of course it also makes sense to grow more natural trees and reduce deforestation..

Understanding the Trump Administration: The Complexity of Politics

The US plays a major role in international affairs. The fact is the world has gone from being bi-polar to unipolar and now multi-polar. When we look at politics, we see that populism prevails, such as putting US interest first and make America Great Again, both a slogan and a rallying point. Every new US Administration faces a learning curve and the 'science of muddling through' comes to mind. There are obviously new opportunities. Bringing business leadership to government has its own challenges. When we look at the angles, we find a range of possibilities, from belligerence to outright hegemony, isolationism based upon nationalism. Realism often comes to light. The US has been working on redefining its relationship with the EU, a valuable partner rather than a 'foe'. In today's world, US-China relation is crucial. However the US wishes to also maintain its relation with Taiwan mostly for business purposes.US-Russia relation goes through ups and downs but the reality is that there is a close cooperation between the US and Russia. Regarding developing countries, of what use is it to refer to some of them as s* h* countries. US-relation with the Arab world is rather complex. On the other hand, US-Israel relation is at the closest possible. Now onto the US border situation. There are problems for sure and the US immigration policy is characterized as being 'harsh'; those who try to come in 'illegally' have to be 'punished'. US-relationship with Mexico which had been at an all-time low seems to be quietly improving. US relation to Latin America and Central America seems unchanged. US relation with Canada is tainted by what occurred at the G-7 in Quebec and so with the other five partners; but US-Canada relationship seems to be undergoing improvement. Trade agreements can be reviewed and renegotiated. Imposing tariffs has its own risks. On the whole though, it should be kept in mind that the US has good relations with almost all countries of the world.

North Korea

We have gone from the brink of a nuclear war with escalation of words to a dialogue proving that diplomacy is intricate but does work. There is obviously more to do. President Moon of South Korea refers to the end of the remnant of the Cold War. The turning point was the 2018 Winter Olympic Games in South Korea where the cooperation of North Korea and South Korea started. There was a meeting of leaders of North and South in April 2018 with a pledge to end war and to denuclearize the peninsula. It is obvious that China conducted quiet diplomacy in the back channel. The Minister of Foreign Affairs of North Korea went on a diplomatic trip to several countries. The confidence building efforts seemed to have worked with the release of 3 US prisoners by North Korea ahead of meeting of US and North Korea leaders June 2018 in Singapore which was successful with more work to do. There are more challenges to deal with. Efforts should be made to stay on the positive track, working on resolving the differences.

US-Cuba Relations

Now onto US-Cuba relation which has been tense for decades. The Pope used his 'magic wand' leading to a breakthrough under the Obama Administration with a normalization of diplomatic

relations. It looks like the relationship is “cooler’’ under the Trump Administration; cooperation continues and war is unlikely as Cuba is not perceived as a threat. It should be pointed out that Cuba has ‘normal’ relations with many other countries. It is noteworthy that Cuba recently took the decision to recognize private property.

Iran

The joint Comprehensive Plan of Action was negotiated and entered into by Iran, the United States, France, the UK, Germany, Russia and China in July 2015. The new US Administration pulled out of the agreement earlier this year even after the European countries entreated the US not to do so. The other signatory countries are still in the agreement. The US has imposed sanctions on Iran. China and EU are increasing business with Iran.

Wars

There is no major war in the world. However there are many local wars which appear to be never ending.

Iraq

During the cold war, Iraq was an ally of the US. It is made up of several ethnic groups with conflicts. Sadam Hussein used a strong hand to keep the country together with fair degree of prosperity. In 1990, Sadam Hussein took a gamble by invading Kuwait. The US under Bush Senior Administration took military action and pushed Iraq back. The Bush Junior Administration got involved in further military action leading to the topple of Sadam Hussein. Iraq was perceived as undertaking a plan of weapon of mass destruction with a threat to Israel. More recently the US has pulled out most of its forces which then had to be increased to deal with ISIS/ISIL, perceived as a major problem. The joint effort of Iraq and the US is perceived as having been successful. Iraq held elections and al Sadr promised an ‘all inclusive’ government.

Syria

The situation has been mostly peaceful since independence with some internal conflicts, essentially of an ‘ethnic’ nature. The Assad family, from a minority ‘tribe’ has been in power for years, at times with ‘oppression’ of the majority ‘tribes’. Outright civil war broke in the recent out and is still going on with large segment of the populations being displaced or fleeing overseas to seek asylum. The effort of the UN to bring peace to the country has not succeeded. The US intervened sporadically as well as the UK. Russia and Iran got into the fray. ISIS/ISIL is an actor in the situation. As al-Shām is a region often compared with the Levant or Greater Syria, the group's name has been variously translated as "Islamic State of Iraq and al-Sham", "Islamic State of Iraq and Syria" (both abbreviated as ISIS), or "Islamic State of Iraq and the Levant" (abbreviated as ISIL). There are conspiracy theories to reckon with.

Afghanistan

This country got caught in the Cold War, with a Soviet invasion and occupation. The US helped out by support (both military and financial) to the Mujaheeddin which led to the creation of the Taliban. The Soviet ended its occupation. At the end of the Cold War, the US stopped its help and the groups

concerned got dissatisfied and created the el Quaida which took a clear anti-US stance led by Ossama Ben Ladin and El Waziri. Following 09-11 bombing in the US, an invasion of Afghanistan was undertaken by a group pf western states. The military operation has now been scaled down, however the Taliban has been undertaking war on groups which are pro-US. Negotiation with the Taliban has been on and off with no clear breakthrough. It should be pointed out that despite being land-locked, Afghanistan is in a strategic location.

Refugees and Displaced Populations

As a direct consequence of the wars, large segments of populations were displaced and at times had to flee persecution seeking asylum in other countries with enormous hardships to the people concerned and at times to the host countries. One thought is that had the wars been resolved, this human miseries could have been avoided. The UN had made significant efforts to foster peace but the concerned parties have been rather intransigent. A major international problem is the situation in several Central American countries with populations being forced to seek asylum elsewhere. Mexico has been accommodating to some extent and the US as well. The US has however taken a rather strong stance recently against this movement fearing massive migration. Efforts should be devoted to helping the Central America countries strengthen their law and order system and thus avert the outflow (see section below dealing with migration).

Israel-Palestine Conflict

This is a situation which has been going on for decades, still with no solution in sight. We have to step back and look at history. The League of Nations gave a mandate to the British to oversee the area called Palestine. In this context, attention has to be given to the Balfour Declaration which referred to the creation of a Jewish State. When Palestine was given its independence by the British, the UN drew a partition plan for two states in 1947. In 1948, the Jewish Group went ahead and proclaimed the creation of the State of Israel which secured recognition of the Western powers. War erupted between the Arab-Palestinian Group and the Jewish Group as Arab populations were banished from the State of Israel which aimed at creating a Jewish State. Several neighboring Arab countries joined the war and more grounds were lost to Israel, with consequent ‘occupation’; more wars in the 1960s and 1970s with more ground ‘losses’. The UN took the stance that the pre-1967 borders should be the baseline for negotiation. Israel has taken the strong stance that lands lost by the Palestinian Arabs will not be returned. The Palestinian Group has been rather weak and became divided into two groups with one under leadership of Abass living in the West Bank and the other under Hamas living in Gaza; however because of the stance taken by Hamas against Israel, there is a de facto ‘blockade’ in Gaza. Under the UN Plan, Jerusalem is expected to have an international status. The Palestinians had indicated that it would create the capital of the Palestinian state in East Jerusalem. Past US Administrations had walked on a rather tight rope regarding the situation. President Carter made a major contribution. President Clinton is credited for the creation of a dialogue between the two sides. The Trump Administration seems to be in agreement with the stance of Israel and took the position of moving the US Embassy from Tel Aviv to Jerusalem, unofficially recognizing Jerusalem as the capital of Israel.

The UN General Assembly has taken a resolution recognizing the Palestinian State; however an endorsement of that decision by the UN Security Council needed for full recognition of Palestine has not been forthcoming.

Ethnic Conflicts

There are several ethnic conflicts going on in various parts of the world. There is the thinking that not much is being done to deal with them and it seems that the way out is keep 'pushing the can down the road'.

1. Plight of the Kurds (Iraq, Turkey, Syria)
2. The Rohingya: is ethnic cleansing going on in plain sight?
3. Saudi Arabia and Yemen
4. Saudi Arabia and Iran
5. Jammu Kashmir: with forth and back and no way out as yet after so many years.
6. Minorities in many other countries are apparently been subjected to adverse action.

Extremism

1. Why is it a problem? Leads to violence, senseless acts
2. Multifaceted aspects
3. Desperate people do desperate things
4. Need for safety nets

Extremism - Thoughts by Prof. Vasso Vydelingum

We need to go beyond dictionary definitions of extremism and explore what has been happening to the world in the last two decades and note how people lives have changed. Extremism refers to people or people within organizations holding beliefs that most other people think unreasonable and unacceptable. Extremism also refers to person(s) who favors or resorts to immoderate, uncompromising or fanatical methods or behavior in getting their aims achieved. Extremism can be viewed or studied or observed from different perspectives, namely:

1. Religious Extremism, which can be innocent and peaceful but can also be expressed in violent extremism. Examples are Al Qaeda - Twin Towers, Taliban- anti education of girls and Mallala Yusuf, Boko Haram- anti education of girls and kidnapping of young girls and leading to cruelty and rape etc, So many more examples are there. The sufi/sunni conflicts are also worth considering. Look at the numerous examples of attacks on innocent civilians in Paris, Barcelona, London, Germany etc.

2. Political Extremism - These can be expressed in extreme right or extreme left. The Trump campaign - Making America Great again as a euphemism for making America White Again. America First leading to protectionist measures- banning this Muslims, Mexicans, increasing taxes on foreign goods etc. In the UK, the hate and fear of immigrants leading to a wave of anti-immigrant rhetoric lead to the creation of a new party UKIP which push to a referendum leading to Brexit.. Political extremism can be disguised as nationalist extremism.

3**. Nationalist Extremism** - The latest UN report on what is happening in Mynamar. Ethnic cleansing being carried while the world and the UN are incapable to intervene, This can be viewed also in other forms, such as racist/racial extremism.

4. Racist/Racial Extremism. Such extremism is expressed in the form of irrational hatred of another group purely based on what is referred to as 'race'. Take the case of the KKK and the

hate of black people and extremism expressed in violence and killing of black people purely based on race.

5. **Changes in society** -as a result of extremism. Security at airports, vigilantes groups, CCTV . The role and duty of all responsible leaders or e-leaders in society, including the UN, are about challenging extremism in any form to protect the vulnerable.

The Global Environment: Climate Change

In the interaction of human and nature, problems have emerged such as pollution and degradation of the quality of air and an increase of CO2 level in the atmosphere. Improvement efforts have been going on for decades but it is obvious that not enough has been done to solve the problems. Political and economic interests are at play often with short term gains which hamper serious sustained efforts. The Paris 2015 Conference on Climate Change was a huge success with the adoption of a treaty by 193 countries. Following the needed ratification, the Treaty is now in effect. Implementation of the Treaty is underway with serious efforts being made worldwide not just by central governments but by local authorities as well as business and nongovernmental entities. The Trump Administration took action to pull the US out of the Treaty; however the States, local entities, businesses are adopting and following their own policies taking needed actions. In fact, it is considered that the time is ripe for 'green' businesses.

Poverty in the World

Around the world, 767 million people live in extreme poverty with less than $1.90 per person per day, an amount which is impossible to support a healthy livelihood in any part of the world.
Poverty leads to hunger. One in three children in low- and middle-income countries suffers from chronic undernutrition. Without a sustainable source of income at a sufficient level, young children and their families do not have access to nutritious food, clean water or health care. And the deadly effects of undernutrition cannot be underestimated:

45% of all child deaths worldwide are from causes related to undernutrition, or 3.1 million children a year.

At Action Against Hunger, we believe that no child should die from hunger. We help over 14.9 million people every year gain access to sustainable sources of income, clean water, nutritious food, and health care, but there is still so much to be done.

Global Poverty Facts

Here are some statistics that show the scale of global poverty and its devastating effects.

1. 767 million people, or 10.7 percent of the population, live in extreme poverty with less than $1.90 per day.
2. 2.1 billion people live on less than $3.10 per day.
3. 328 million children are living in extreme poverty.
4. At least 17 million children suffer from severe acute undernutrition around the world. Severe acute malnutrition is the direct cause of death for 1 million children every year.
5. Every single day, 1,000 children under 5 die from illnesses like diarrhea, dysentery, and cholera caused by contaminated water and inadequate sanitation.

Where is Extreme Poverty?

Africa is the continent with the largest number of people living in extreme poverty. See below for a breakdown of where people living with less than $1.90 per day are located.

- •383 Million in Africa
- •327 Million in Asia
- •19 Million in South America
- •13 Million in North America
- •2.5 Million in Oceania
- •0.7 Million in Europe

Some Thoughts

Attention has to be given to poverty in advanced countries where the divide between the 'haves' and the 'have-nots' has grown. Humanism seems to be failing.

Water Situation and Related Issues

844 million people don't have clean water.
2.3 billion people don't have a decent toilet.
31% of schools don't have clean water.

In many countries, there is a need for better conservation and reprocessing. Many countries have used desalination successfully. Many more countries could do so as the costs are not prohibitive.

Sustainable Development

The member states of the United Nations worked together to develop and adopt a comprehensive Plan of Action through 2030 to improve situations in all countries of the world. Implementation requires the efforts of each member states on its own, also working together in joint efforts, with the UN having a key role as well. Progress reports will be prepared annually.

The UNU invites us to EXPLORE THE SUSTAINABLE DEVELOPMENT GOALS (SDGs)

See our growing collection of research, commentary and multimedia related to each SDG.


4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

More on the 17 Sustainable Development Goals (SDGs) to Transform Our World:

GOAL 1: No Poverty
GOAL 2: Zero Hunger
GOAL 3: Good Health and Well-being
GOAL 4: Quality Education
GOAL 5: Gender Equality
GOAL 6: Clean Water and Sanitation
GOAL 7: Affordable and Clean Energy
GOAL 8: Decent Work and Economic Growth
GOAL 9: Industry, Innovation and Infrastructure
GOAL 10: Reduced Inequality
GOAL 11: Sustainable Cities and Communities
GOAL 12: Responsible Consumption and Production
GOAL 13: Climate Action
GOAL 14: Life Below Water
GOAL 15: Life on Land
GOAL 16: Peace and Justice Strong Institutions
GOAL 17: Partnerships to achieve the Goal

Migration

Migration has been going on throughout human history and was an integral part of discovery adventures and resettlement. Examples are people from Europe settling in Africa, Asia, North America and Latin America. The US was a land of considerable attraction by migrants from Europe and also from other areas such as China and Latin America. Migrant workers are to be found in many countries with numerous examples from the Middle East. With wars and violence, many people flee persecution and seek asylum in other primarily but not exclusively neighboring countries. The United Nations has been working on these migration issues for decades. On July13, 2018, 192 member states of the United Nations completed an agreement on improved ways to handle the global flow of migrants. The US stopped its participation in the negotiating group in December 2017. Its handling of migrants, in particular the separation of children from their parents, has attracted international attention, with an attempt to understand the meaning of 'punishment' in context.

United Nations: Organization System, A Closer Look

The United Nations is a conglomerate consisting of the UN Organization headed by the UN Secretary General, specialized agencies each working independently with its own executive head, special programs and various peace keeping entities. Meetings of the conglomerate are held from time to time and are headed by the UN Secretary General, serving as convener and coordinator. The UN Organization is extremely important in that it consists of the UN Security Council working to keep the world at peace all the time (24/7), of the UN General Assembly with representatives of all member states and thus is a de facto world parliament, of the UN Economic and Social Council which deals with issues within its jurisdiction, of the UN Secretariat which is the executive machinery with responsibility to prepare and submit policy proposals to the legislative organs and also to implement policies and programs adopted by the legislative organs being thus the implementation machinery, and of the International Court of Justice (ICJ). When the UN Organizations fails to act, it is less the fault of the implementation machinery as such and more of the policy makers failing to reach agreement.

The annual report of the UN Secretary General outlines major actions being undertaken worldwide to deal with prominent issues. There is a long list of UN quiet accomplishments, often taken for granted. Could the UN do more? More resources may be needed. At times blame is made to the effect that the UN is rather 'bureaucratic'. No doubt the machinery is quite complex. But often political will of the policy makers can be a major factor. Also, implementation can be challenging, there are actions taken by the UN and there are those which require action by the member states. Donors and NGOs play major contributory role, both in terms of added resources and action as such.

UN and Conflict Resolution

The UN was set up to serve as a conflict resolution machinery. Negotiation is at the heart of that function with quiet diplomacy serving a powerful tool for peace making. When a conflict has resulted in open violence and military actions, the other tool used is that of peace keeping such as setting up a buffer zone while negotiation is undertaken to resolve the conflict and make peace. At times, member states and groups take action in their own hand and thus there is little that the UN can do. The UN has set up an agenda for peace which requires more support. It is obvious that the member states and groups may have their own agenda and interest to follow. Conflict resolution is thus rather complicated.

UN and Conflict Prevention

Conflict prevention is more difficult to undertake. It starts with the fact that member states of the UN does not want the organization to be 'spying' on them. However, there are situations where conflicts exist and there is cease fire. Monitoring systems are established to see that the conflict does not further escalate into war and there could be early warning system. The tools in context consist of detailed studies, negotiation, quiet diplomacy, using the so-called 'back channel' and peace building. At times, conflicts are submitted to the UN International Court of Justice for resolution.

International Trade and Investments: Are Trade Wars Necessary?

Globalization which took place at the end of World War 2 has been good for the world at large except for those unable to compete on a world basis. The IMF, World Bank and WTO have been playing crucial role. Negotiation leads to bilateral agreements, regional agreements and global (multilateral) agreements. A new globalism is emerging in light of changes in the world changes. Recently 'trade wars' seem to be looming, with tariffs entering the equation. Some renegotiations are going on. The importance of the WTO is being growingly recognized.

Technological Evolution/Revolution

Technology has been a key factor in human progress. Alvin Toffler refers to the first wave as being one of agricultural revolution, the secnd wave as that of the industrial revolution and the third wave as that of information; each of these revolutions made possible by technologies in the respective wave. We may now be in the fourth and even fifth wave based upon communication and telecommunication technologies. There are countries and companies which in fact create these technologies and they stand to benefit from them. In his book called Power Shift, Toffler refers to the *fasts* and the *slows*; the fasts being those creating the wave and riding it albeit benefiting from the wave and the slows are those left behind. Various entities and program of the UN aim at technology transfer, helping those left behind to benefit from the technologies and there is fair

degree of success in that respect with more to do. There are interesting stories of transformation whereby the slows went through a quantum leap forward, examples are South Korea, India nd China which just a few years back were qualified as developing countries and are now leading countries. The key to the transformation process was education and investment in R&D. With technological progress comes downsides, for instance in the field of cybersecurity, hacking.is seen as being a major problem. A look at the technological leading edge shows robotics as well as automation in general, artificial intelligence, augmented reality, mixed reality and virtual reality, all elements of the next 'big thing.'

New Leadership Albeit eLeadership

Leadership is key to progress in all human undertakings. Over the years, we have learned a lot about leadership in all its forms. In today's fast age of technology, it is often stated that a new leadership is needed, at times called eleadership which is one that relates to leading electronic entities and/or using technologies to lead entities of any nature, front end or traditional.

Human Rights

The baseline is the UN Declaration for Human Rights. The UN has been undertaking standard setting for many years, with fair degree of success such as the adoption of the Covenant on Civil and Political Rights and the Covenant on Economic, Social and Cultural Rights. Member states of the UN undertake serious effort at implementing the norms albeit standards with a system of monitoring and reporting to the Human Rights Council. The US is considered a 'laggard' and more recently pulled out of the Human Rights Council. There are several other bodies albeit NGOs that keep track of the state of human rights in the world, among the best known are The Human Rights Watch; Amnesty International.

State of Corruption in the World

Transparency International undertakes detailed annual analysis of the state of corruption in all contries around the world and publish a report thereon. The 2017 report shows a ranking with New Zealand, Denmark, Finland, Switzerland and Sweden at the top with little to no corruption. Hungary ranks 66, Turkey 81 and Mexico 135.

New Dynamics in International Relations

China is expanding its influence in the world, from Asia to Africa and Latin America. EU is doing more business with China. China is doing more business with Iran. There are some country specific issues to keep in mind; a look at the population structure shows that some countries have an aging population issue such as Japan while many other countries have a large segment of young people that is an asset to be developed, with India providing a fine example. The role and contribution of women should be more clearly recognized; it is noteworthy that Saudi Arabia adopted a policy of allowing women to drive. Women can make important contributions to economic and social development. Women in leadership position have shown that they can do quite well. A look at the relationship of Germany and Russia shows that the former has some degree of dependence on the latter for energy. However, interdependence could be a positive factor as the partnership can be improved. Russia and Iran are significant players on the world stage.

Bullying does not help in international relations which is based on mutually valuable partnerships, both bilateral and multilateral. Incidentally, the EU is bigger than the US. A question can be asked as to the usefulness of NATO in the world of today, keeping in mind that the Warsaw Pact has been dismantled. Are trade wars necessary? Partners in trade agreements could sit down and renegotiate. A good trend seems to be that member countries are rediscovering the usefulness of WTO.

1. A changing world calls for a revisit of well-known theories as to relevance and pertinence: realism, power politics, Machiavellianism, militarism, hegemony, rhetoric, posturing, constructionism
2. Conducting international affairs via tweeting
3. State actors; non-state actors
4. Is there a need for new theories?
5. The UN Charter: it is all there; still relevant; need for re-dedication and commitment; education/re-education may be appropriate

Conclusion 1: Bitter World

If problems are not solved, we are going to get either status quo or they are most likely going to get worse. There are stumbling blocks, often caused by intransigence, intolerance, indifference. Often some key actors take hard line and get into zero sum games. The issue of the 'haves' and 'have nots' cannot be avoided. It may not matter to some leaders if the glasses of the under privileged are 'half empty' or that 'they' do not have a 'glass.'

Conclusion 2: The Best of Times?

What some new writers are saying: Enlightenment now: the case for reason, science, humanism and progress (Steven Pinker). It's better than it looks: reasons for optimism in an age of fear (Gregg Easterbrook)

Conclusion 3: Working to Make the World Better

It takes effort, courage, determination; cooperation as the UN intended; pursuing a Culture of Peace as advocated by UNESCO and promoted by the UN; University for Peace (original); University for Peace in China (in the making); University for Peace in North Korea (under consideration). Minimalist theory; at worse, do the minimum to prevent things from going over the edge; not the best. Humane considerations; humanism should prevail over ruthlessness.

Chapter 2: Leadership, eleadership for the 21st century
https://www.academia.edu/22398546/eLeadership_for_the_21st_Century
https://research.phoenix.edu/donald-hsu/publication/leadership-and-eleadership-analysis-contingency-factors-and-considerations

Chapter 3: eLeadership in the Public Sector; eGov
https://www.g-casa.com/conferences/singapore12/papers/Owarish-1.pdf

Chapter 4: The Emergence of a New Globalism; Role of Economic Groupings
https://www.g-casa.com/conferences/bangkok18/pdf_ppt/Owarish.pdf

Chapter 5: US-EU Relation; Redefining Win-Win
https://www.gasa.com/conferences/berlin17/pdf%20paper/Owarish%20US%20EU20Relation.pdf

Chapter 6: US-China relation: cooperation, competition, conflict
https://www.g-casa.com/conferences/shanghai/paper_pdf/Owarish-US%20China.pdf

Chapter 7: Russia is an Important Player on the World Stage: A Look at the Facts

Russia has been and is an enigma; it may not be an economic super power but it remains a superpower in many ways. Some interesting facts: Russia was part of the Allied Powers during the Second World War, playing a crucial role contributing to victory. In the years after, the West apparently failed to pay attention as Russia then expanded its influence in Eastern and Central Europe and built a formidable empire called the USSR. The Soviet Union, sharing a common ideology with China, then sought to expand its influence in the world. The world then became divided between the East and the West. At times there could have been a third world war, such as during the Cuban missile crisis. Instead we got the Cold War. There were proxy wars all over the world as each of the two sides tried to expand its influence. Then a fact came to light recognized by Michael Gorbachev. The socialist ideology was not working very well dragging the economy of the countries in the Soviet bloc down; on the other hand, those following the western economic ideology fared much better (see Fukuyama, The End of History). Gorbachev and Reagan buried the cold war in the Mediterranean Sea. Relationship improved between the US and Russia and the west and the east. Then came bones of contention with Russia, and the West both the US and EU imposed sanctions on Russia. Crimea was definitely a case in point and relationship between Russia and Ukraine soured. Russia apparently interfered in the election in Ukraine to ensure that whoever gets elected President would be pro-Russia. Nonetheless, there is a significant cooperation between the US and Russia including for the space program, namely, the international space station and the launch of US satellites out of Russia. A growing number of US companies are doing business in Russia. There is a debate about Russia's possible interference in US elections. This is an ongoing debate with no conclusion yet. By the way, when situation improved between the west and the east, Russia was added to the G7 that became the G8. Later as conflicts unfolded, Russia was taken out of the G8 which went back to the G7. The diplomatic game is one of American black jack and Russian roulette; Russia is good at chess games while the US is strong at poker. Worthy of attention: Syria and Iran.

U.S.-Russia Trade Facts
Russia is currently the US 23rd largest goods trading partner with $38.1 billion in total (two way) goods trade during 2013. Goods exports totaled $11.2 billion; Goods imports totaled $27.0 billion. The U.S. goods trade deficit with Russia was $15.8 billion in 2013.

Exports

Russia was the United States 28th largest goods export market in 2013. U.S. goods exports to Russia in 2013 were $11.2 billion, up 4.3% ($465 million) from 2012. The top export categories (2-digit HS) in 2013 were: Machinery ($2.3 billion), Vehicles ($2.0 billion), Aircraft ($2.0 billion), Electrical Machinery ($674 million), and Optic and Medical Instruments ($660 million). U.S. exports of agricultural products to Russia totaled $1.2 billion in 2013. Leading categories include:

poultry meat ($310 million), tree nuts ($172 million), soybeans ($157 million), and live animals ($149 million).

Imports

Russia was the United States 18th largest supplier of goods imports in 2013. U.S. goods imports from Russia totaled $27.0 billion in 2013, a 8.2% decrease ($2.4 billion) from 2012. U.S. imports from Russia accounted for 1.2% of total U.S. imports in 2013.

The five largest import categories in 2013 were: Mineral Fuel (oil) ($19.4 billion), Iron and Steel ($1.6 billion), Inorganic Chemical (enriched uranium) ($1.4 billion), Fertilizers ($815 million), and Precious Stones (platinum) ($813 million). U.S. imports of agricultural products from Russia totaled $40 million in 2013.

Trade Balance

The U.S. goods trade deficit with Russia was $15.8 billion in 2013, a 15.4% decrease ($2.9 billion) over 2012. The U.S. goods deficit with Russia accounted for 2.3% of the overall U.S goods trade deficit in 2013.

Investment

U.S. foreign direct investment (FDI) in Russia (stock) was $14.1 billion in 2012 (latest data available), up 20.7% from 2011. Reported U.S. FDI in Russia is led by the manufacturing, banking, and mining sectors. Russia FDI in the United States (stock) was $6.3 billion in 2012 (latest data available), down 3.0% from 2011. The distribution of Russia FDI in the United States is not available. Note that no services trade data with Russia are available.

Ongoing cooperation between the US and Russia

There is an extensive cooperation going on despite 'bickering' and sanctions:

https://www.washingtonpost.com/world/europe/space-nuclear-security-polar-bears-russia-and-the-us-still-have-some-shared-concerns/2017/08/24/dbae9f6a-86b5-11e7-96a7-d178cf3524eb_story.html?noredirect=on&utm_term=.ee651e0deb0f

https://www.nbcnews.com/news/us-news/space-u-s-russia-friendship-untethered-n806101

World Factbook Russia

https://www.cia.gov/library/publications/the-world-factbook/geos/rs.html

Russia remains concerned about the smuggling of poppy derivatives from Afghanistan through Central Asian countries; China and Russia have demarcated the once disputed islands at the Amur and Ussuri confluence and in the Argun River in accordance with the 2004 Agreement, ending their centuries-long border disputes; the sovereignty dispute over the islands of Etorofu, Kunashiri, Shikotan, and the Habomai group, known in Japan as the "Northern Territories" and in Russia as

the "Southern Kurils," occupied by the Soviet Union in 1945, now administered by Russia, and claimed by Japan, remains the primary sticking point to signing a peace treaty formally ending World War II hostilities; Russia's military support and subsequent recognition of Abkhazia and South Ossetia independence in 2008 continue to sour relations with Georgia; Azerbaijan, Kazakhstan, and Russia ratified Caspian seabed delimitation treaties based on equidistance, while Iran continues to insist on a one-fifth slice of the sea; Norway and Russia signed a comprehensive maritime boundary agreement in 2010; various groups in Finland advocate restoration of Karelia (Kareliya) and other areas ceded to the Soviet Union following World War II but the Finnish Government asserts no territorial demands; Russia and Estonia signed a technical border agreement in May 2005, but Russia recalled its signature in June 2005 after the Estonian parliament added to its domestic ratification act a historical preamble referencing the Soviet occupation and Estonia's pre-war borders under the 1920 Treaty of Tartu; Russia contends that the preamble allows Estonia to make territorial claims on Russia in the future, while Estonian officials deny that the preamble has any legal impact on the treaty text; Russia demands better treatment of the Russian-speaking population in Estonia and Latvia; Russia remains involved in the conflict in eastern Ukraine while also occupying Ukraine's territory of Crimea. Lithuania and Russia committed to demarcating their boundary in 2006 in accordance with the land and maritime treaty ratified by Russia in May 2003 and by Lithuania in 1999; Lithuania operates a simplified transit regime for Russian nationals traveling from the Kaliningrad coastal exclave into Russia, while still conforming, as an EU member state with an EU external border, where strict Schengen border rules apply; preparations for the demarcation delimitation of land boundary with Ukraine have commenced; the dispute over the boundary between Russia and Ukraine through the Kerch Strait and Sea of Azov is suspended due to the occupation of Crimea by Russia; Kazakhstan and Russia boundary delimitation was ratified on November 2005 and field demarcation should commence in 2007; Russian Duma has not yet ratified 1990 Bering Sea Maritime Boundary Agreement with the US; Denmark (Greenland) and Norway have made submissions to the Commission on the Limits of the Continental Shelf (CLCS) and Russia is collecting additional data to augment its 2001 CLCS submission.

Refugees and Internally Displaced Persons

Refugees (country of origin): 427,240 (Ukraine) (2017), IDPs: 19,000 (armed conflict, human rights violations, generalized violence in North Caucasus, particularly Chechnya and North Ossetia) (2017) stateless persons: 82,148 (2017); note - Russia's stateless population consists of Roma, Meskhetian Turks, and ex-Soviet citizens from the former republics; between 2003 and 2010 more than 600,000 stateless people were naturalized; most Meskhetian Turks, followers of Islam with origins in Georgia, fled or were evacuated from Uzbekistan after a 1989 pogrom and have lived in Russia for more than the required five-year residency period; they continue to be denied registration for citizenship and basic rights by local Krasnodar Krai authorities on the grounds that they are temporary illegal migrants.

Trafficking in Persons

Current situation: Russia is a source, transit, and destination country for men, women, and children who are subjected to forced labor and sex trafficking; with millions of foreign workers, forced labor is Russia's predominant human trafficking problem and sometimes involves organized crime syndicates; workers from Russia, other European countries, Central Asia, and East and Southeast Asia, including North Korea and Vietnam, are subjected to forced labor in the construction, manufacturing, agricultural, textile, grocery store, maritime, and domestic service industries, as well as in forced begging, waste sorting, and street sweeping; women and children from Europe,

Southeast Asia, Africa, and Central Asia are subject to sex trafficking in Russia; Russian women and children are victims of sex trafficking domestically and in Northeast Asia, Europe, Central Asia, Africa, the US, and the Middle East. Tier rating: Tier 3 - Russia does not fully comply with the minimum standards for the elimination of trafficking and is not making a significant effort to do so; prosecutions of trafficking offenders remained low in comparison to the scope of Russia's trafficking problem; the government did not develop or employ a formal system for identifying trafficking victims or referring them to protective services, although authorities reportedly assisted a limited number of victims on an ad hoc basis; foreign victims, the largest group in Russia, were not entitled to state-provided rehabilitative services and were routinely detained and deported; the government has not reported investigating reports of slave-like conditions among North Korean workers in Russia; authorities have made no effort to reduce the demand for forced labor or to develop public awareness of forced labor or sex trafficking (2015).

Illicit Drugs

limited cultivation of illicit cannabis and opium poppy and producer of methamphetamine, mostly for domestic consumption; government has active illicit crop eradication program; used as transshipment point for Asian opiates, cannabis, and Latin American cocaine bound for growing domestic markets, to a lesser extent Western and Central Europe, and occasionally to the US; major source of heroin precursor chemicals; corruption and organized crime are key concerns; major consumer of opiates. It is important to note that relationship between two countries entails cooperation, competition and conflict all at the same time on an ongoing basis.

Report on Russia (World Bank Group)

Global growth continued its 2017 momentum and is currently expected to peak at 3.1% in 2018. Recoveries in investment, manufacturing, and trade continue as commodity-exporting developing economies benefit from firming commodity prices.

Oil prices, which firmed up in 2017, are projected to average $65/bbl in 2018 and 2019, and $66/bbl in 2020, but may increase further, especially in the short term.

Supported by deepening macro-economic stability and gradual monetary loosening, Russia's economy continued its recovery in 2017, mainly driven by non-tradable sectors. Growth momentum towards the end of 2017 slowed down, but picked up in the first quarter of 2018.

Russia's balance of payments remained stable. An increase in the trade surplus due to higher energy prices was the key factor behind the strengthening of the current account. Monetary policy remained consistent with the inflation-targeting regime, and is moving from moderately tight to neutral. Annual inflation now stands at a record low-level, below the Central Bank's target of 4%. The poverty rate is expected to decrease slightly due to low inflation and recoveries in private income and consumption, but remains above the pre-crisis level.

The banking sector's fundamentals are largely stable, but the share of state-controlled banking assets grew because of the continuing Central Bank clean-up. The share of state-controlled banks in the combined assets of the Russian banking system increased to nearly 70%.

Russia's growth prospects remain modest, with growth forecast to be between 1.5% and 1.8% in the 2018-20 period. However, in the short-term, these forecasts may change due to changing oil prices.

Relatively high oil prices, continued momentum in the global economic growth and macro stabilization would support growth. Yet, the growth forecast for Russia for 2018 has been slightly decreased to 1.5%.

A strategic focus on digital transformation has enabled Russia to build a national digital infrastructure. However, to gain significant socio-economic benefits from these changes, Russia will need to implement policies that accelerate the digital transformation of the economy's traditional enterprise sector, and promote R&D, innovation and entrepreneurship.

Special Note

Helping with the transformation of the world (personal recollection)
Allow me to share my personal experience with anecdotes. As Director of Training at UNITAR, I co-directed the UN-WB/IMF training programs for UN delegates dealing with economic and social questions. I invited delegates from the Soviet Union and China as well as from several countries that were on the socialist side e.g. Cuba. I thought that it would be a good opportunity for those delegates to learn more about the IMF and WB and the capitalist ideology in the works as such. At one of the dinners with the delegates and senior officials from the IMF and the WB I stuck my neck out and stated that the Soviet Union should be invited to join both the IMF and the WB, Some thoughts that I had gone too far. But my wish became a reality in a short while. I arranged for leaders from the Soviet Union and Japan to meet and discuss possibilities regarding the Kuril Islands. The Baltic States came and sought my help regarding UN membership and here again I briefed them out unofficially. When Romania wanted help to transform its economy, I arranged for leaders of Romania to meet with professors from universities in Georgia and an extensive educational program was arranged and implemented. When Mongolia was interested in parliamentary democracy, I arranged for leaders there to meet with professors also from Georgia universities and a training program was set up and implemented. (Note: there was a close cooperation between UNITAR (where I worked) and universities in Georgia). I arranged for workshops on the ways and means to go through from observer status to full membership both for North Korea and South Korea. I arranged for leaders from these two countries to meet and find common ground for cooperation, with limited breakthrough such as family visits.

Chapter 8: World Environment: Climate Change, the Treaty of Paris, What Next?

https://www.g-casa.com/conferences/shanghai/paper_pdf/Owarish-climate.pdf
https://www.g-casa.com/conferences/singapore16/pdf_ppt/Owarish-Climate%20Change.pdf

Treaty on Climate Change Implementation Efforts

http://www.g-casa.com/conferences/berlin17/ppt%20pdf/Owarish%20Climate%20Change.pdf

US Withdrawal

http://sdg.iisd.org/news/us-withdrawal-from-paris-agreement-mobilizes-governments-stakeholders/

Strategic Automotive Technologies: The Eco Friendly Revolution
https://www.g-casa.com/conferences/prague15/pdf_paper/Owarish.pdf

Chapter 9: Strategic Leadership of Technology
https://www.g-casa.com/conferences/singapore12/papers/Owarish-2.pdf

Chapter 10: A Better Life for the Disadvantaged: The UN Does its Fair Share
https://www.un.org/sg/en/annual_report

Conclusion: Working for a Better World

It is often thought that the main actors are top political leaders; this is true to some extent. As the Treaty of Paris on Climate Change shows, in addition to the state actors, the others who can contribute to make a difference are international organizations, regional organizations, business organizations, non-governmental organizations, sub-national entities such as states and local entities in the US, action groups and individuals. A joint effort is thus possible, in fact needed as the problems become more complex.

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Ethics in Small Businesses: A Review of Comparative Literature

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Abstract

Small businesses are engines of employment and economic growth. However, ethics and social responsibility in small business seems to be neglected for serious research. This is amply demonstrated in the paucity of recent and credible studies. This paper is a review of sporadic papers available via several serial data bases on country-region specific studies of small business ethics. This survey and review demonstrates how countries differ on the perspectives of and treatment of ethics in general and business or small business ethics particular. A corollary of business ethics - social responsibility was also reviewed in the context of small business. While the handling of daily business interactions in a morally correct way, taking a stand for good ethical practices, and modeling ethical behaviors are generally considered important, cases of unethical practices based largely on "greed" seems to be evident in most countries especially when business and personal interests of the owners/managers collide. This paper is an attempt to identify the commonalities and differences of ethical practices within small businesses of the U.S Canada, UK, Spain, Australia, and South Africa. A review of the existing literature demonstrates support for activities addressing ethical challenges, implementing ethical standards, and sanctioning unethical practices will cultivate ethical environments. The authors provide a comparative theoretical narrative of selective countries of North America, Europe, Africa and Australia on ethical challenges and perspectives that could benefit policy makers, owners and managers, and educators of small businesses around the globe. Authors recognize the diversity of practices and perceptions regarding business ethics and social responsibility in Small business operations and therefore concludes that more country specific studies of best practices will benefit all interested in the field.

Introduction

This paper explores ethical dynamics surrounding small businesses from a comparative perspective. A survey of literature is used to establish the commonalties in ethical challenges and perspectives within small business firms. Ethics is the moral understanding of right and wrong; specifically, how one acts during situations, how they evaluate behaviors, and make decisions (Brown, 1985; Lewis, 1985). Making tough decisions are part of the daily interactions in economies where small businesses are the heart and soul of the economic system with 30.2 million small businesses employing 58.9 million people (47.5%) in the United States (U.S.) and accounting for 90% of the enterprises in United Kingdom (U.K.) (Arend, 2013; United States Office of Advocacy, 2018; Vyakarnam, Bailey, Myers, & Burnett, 1997).

Although business both small and large share the common sustainability goal of making a profit but they have distinct differences on how each invests in business ethics (Hill, 2008; Jenkins, 2004; Quinn, 1997; Vitell, Dickerson, & Festervand, 2000).

Small business managers within international markets document that ethical practices aren't considered as a top priority and the government interference contributes to ethical problems that include bribery to enter and conduct business in the global markets (Johnson & Sharma, 2004; Mayo, 1991). The rule of the law that holds the industries accountable for their unethical actions and the written code of conduct of industries that guides personnel to avoid offering or accepting bribes (McKinney & Moore, 2008) vary across countries. Generally, the small business managers that are ethical wouldn't offer bribes or would avoid markets where bribes are prominently accepted as a common business practice (Mayo, 1991). Sustainable business practices require adherence to ethical conduct as such several researchers argued that managers should avoid cases where the media and consumers would horn on negative publicity (Mayo, 1991; Schaefer et al., 2003).

The ability to comprehend and communicate the code of ethics within small businesses is essential to ensure functional and ethical business practices. Within international markets, perceptions of ethics among groups exists with differences in moral reasoning requiring small business owners and top managers to set the tones for ethical practices and bring forth ethical conduct within the entire industry including employees. Understanding ethics within small businesses is crucial as they dominate the majority of the economic systems both in domestic and the international markets. The focus of this literature review, we explore ethics in the small business within North America and international markets that include Europe, Australia, and some countries in Africa.

Business Ethics and International Market

Conducting business around the world has become a common practice with small businesses seeking out global platforms to remain relevant and sustainable in today's competitive markets (Mayo, 1991; Smeltzer & Jennings, 1998). Ethical concerns in the international markets emerge out of the differences in cultural beliefs, business practices, questionable transferring of funds, government involvement in the business, and customs clearance and forwarding and the like (Mayo, 1991; Smeltzer & Jennings, 1998). The unethical practices such as corruption and bribery tend to work against economic development and growth. Inefficiencies brought about by the use of unethical practices such as bribes impacts the progress of the economy and is harmful to the emerging markets because the resources aren't used on crucial elements that include education, human development index, social, healthcare, safety, and environmental protections (McKinney & Moore, 2008; Scholtens & Dam, 2007; Wilhelm, 2002).

Ethical policies vary from one country to another with ethical codes that are continuously tested due to weak societal values, economic pressures, and increased fraudulent activities that occur with the ease in use of technology (Wilhelm, 2002). Lack of ethical practices has been found detrimental to those small businesses that aren't prepared to handle cases of corruption, and lack protocols in place to handle cases such as child labor, bribery, abuse to the environment all of which could impact world economy (Wilhelm, 2002). The involvement of unethical practices by small businesses contributes to a tarnished public image, a boycott by consumers, low sales that would hurt business sustainability within domestic and global platforms (Bhattacharya & Sen, 2003; Mayo 1991). What follows next are description ethical practices in selected countries.

Small Business in the UK and Spain

Communicating ethics is crucial with U.K. and Spain sharing a common practice where the government has a role in formulating the code of conduct that govern ethics within small businesses. For instance, to ensure small businesses act ethically towards the environment; the government sets codes, provides benchmarks, and communicates the environmental values to the small businesses (González & Martinez, 2004; Lepoutre & Heene, 2006). The law plays an important role in influencing ethical behavior. In addition, the employee ethical orientation and the local community values also influence the behavior of small businesses in partaking in ethical and social issues (Spence & Lozano, 2000). Social issues considered essential in communities of the U.K. include care for the environment, ability to support the local community, contributing to charity, and addressing the welfare of employee's health (Perrini, Russo, & Tencati, 2007; Spence & Lozano, 2000). Research confirms that the small business in the U.K and Spain experience the pressure to remain competitive with ethical practices or have grown to become larger businesses where the employees take initiatives in influencing business owners to be socially responsible (Lepoutre & Heene, 2006; Spence & Lozano, 2000).

South Africa's Small Business

South Africa relies heavily on the small business for the betterment of their economy and hence the emphasis on ethical behavior is quite essential because the unethical practices impact the sustainability of the small businesses (Beyer & Nino, 1999; Robinson & Jonker, 2017). The nation faces challenges that include high economic crimes, money laundering, fraud, lack of sufficient strategies in handling, and making ethical decisions within the business (Eweje, 2006; Rossouw, 2005). Small business leaders in South Africa struggle with ethical challenges since a higher ethical risks is correlated with unfair competition, misconduct by customers, theft, product quality, and sales while a lower risks is associated with fraud, accounting, and supply chain processes (Van Zyl, & Mathur-Helm, 2007; Robinson & Jonker, 2017). Maintaining ethical conduct within the South African small businesses requires a formal process that documents the business values and management of ethics that requires the integration of systems that include training and development and use of documented guidelines that would be essential in assisting the owners and managers in handling ethical concerns. (McDade & Spring, 2005; Robinson & Jonker, 2017).

The formulation and implementation ethical principles within small businesses in South Africa is more difficult relative to the UK, Spain and the USA due to informal ethical processes that govern in the country. A large portion of the small business operates under verbally communicated ethical polices by managers or owners. These policies often change from time to time at the discretion of the owner/manager. There is no direct monitoring of policy enforcement, and most importantly the lack formal documentation of the unethical conduct is quite common (Luiz, 2002; Robinson & Jonker, 2017). Many small businesses on the other hand have formal documentation requirement of the ethical processes, but the employees hardly enforce the mechanisms, and are minimally encouraged to do so (Robinson & Jonker, 2017).

Australian Small Business

Ethical conduct is reported to be of great concern within the Australian small businesses because there exist no commonly shared ethical perspectives with personal non-religious beliefs and principles as determinants of business ethics (Dawson, 2001; Phau & Kea, 2007). Research revealed

that Australian small businesses aren't excessively concerned with adherence to ethical practices. Based on the survey, acting fair and being honest in fair pricing, cultivating trust among employees, adherence to the law, and the concern for the environment did not stand out as significantly important and only thirteen percent responses documented adherence to ethics (Dawson, 2001). The spiritual and religious orientation supporting ethical decision making in small business showed very little support. The survey showed higher level of support for ethical attitude among female entrepreneurs (Dawson, 2001; Fernando, & Jackson, 2006). The difference in males and female's attitudes towards ethics is evident in this study (Dawson, 2001; Radtke, 2000).

Small Business in the US and Canada

The definition of small business in the U.S. relative to the rest of the world is broad. The Federal agency-SBA (Small Business Administration) includes businesses that employs 500 or less employees or less than average annual receipt of $ 21 million. In Canada businesses employing less than 100 employees are considered small business. While individualistic orientation of ethics is more pronounced in the U.S., relative to Canada where organizational ethical responsibility is also equally emphasized. Canada may be placed in the middle between Europe and the U.S. with regard to societal/organizational obligations to ethical standards. However, there are certain ethical regulations in both countries that have been legislated into law such as employee discrimination, conflict of interest, bribery. With respect small business, the less formal business structure and weak control systems among small businesses in both the US and Canada could open door to practices that include illegal copying of software due to limited budgets, insider trading, and padding of expenses because there exists a lack of formal monitoring among small and micro businesses owners (Longenecker, McKinney, & Moore, 1989). For a comparative perspective, businesses owned by minority groups in North America such as Asian American, Native American, Hispanic and or Latin American, and African Americans revealed that age had a direct correlation to people's attitudes towards ethics; with the older respondents reacting less ethically than the younger respondents (Ede, Panigrahi, Stuart, & Calcich, 2000; Ford & Richardson, 1994; Rashid & Ho, 2003). The relationship between age and ethics was tied to the race relations in the U.S.; the researchers summarized the exposure to unethical practices and more discrimination as factors contributing to the ability of older responders to be less critical thus adopting some of the unethical practices relative to the younger respondents (Ede et al., 2000; Serwinek, 1992; Vitell, Lumpkin, & Rawwas, 1991).

Ethical Decisions and Social Responsibility

Environmental concerns have become more pronounced in the society these days than before. Environmental sustainability and climate change issue has entered into the main stream political agenda and has become a subject matter for debate in the U.S. political system. The whole world now subscribes to the UN 17 goals of Sustainable Development. Demands from government agencies, consumers, and activists, NGOs and the concerned citizens to protect the ecosystem and to keep it healthy and productive over time are on the rise at the global scale. However, small businesses lack trust among each other to ensure that each carries themselves responsibly without being policed by regulations that sanction them for unethical practices towards the environment (Simpson, Taylor, & Barker, 2004; Tilley, 2000). Evidences of neglect of on this matter are noticeable. These small businesses operate under the assumption that they will not get caught for waste dumping; and those that are caught seems to be okay with paying the fine which is lower than the investment expense of the waste management (Cambra-Fierro, Hart, & Polo-Redondo, 2008).

The issue of engagement of the small business entities with social responsibility movements is rather a complex matter due to limited financial resources and the ability to recognize environmental concerns (Moore & Spence, 2006; Lepoutre & Heene, 2006). To address unethical practices that impact the environment, small business owners may incorporate appropriate values that show sensitivity towards protecting and maintaining healthy environment. It is also imperative for businesses to develop corporate culture within the businesses through the application of cognitive perspectives when making decisions on ethical issues (Fassin, Van Rossem, & Buelens, 2011). Lack of resources to conduct environmental analysis by small business is evident but the use of outside experts before making decisions to support environment is an attainable imperative. This happens when the small business proactively internalizes the urgency of integrating environmental concerns and business ethics toward developing and implementing actionable codes that will shape their business practices to uphold ethical standards to protect the environment (Tilley, 2000).

Conclusion

Theoretical evidence in this study confirms that ethics is a universal issue of concern for both small and large businesses. It doesn't only involve one's ability to comply with regulations or laws but also entails individual who immerses themselves in good moral conduct. In the ethically sound business, the leaders make ethical decisions and surround themselves with ethical personnel as they promote an ethical environment (De George, 1994). Developing ethical conduct within the small businesses can be a formidable challenge with reported cases of unfair pricing, inconsistent quality of the production process that emphasizes availability of cheap resources disregarding how ethically the products were to be sourced. In addition, the culture of low level of trust in sharing business ideas that deters collaboration with other businesses (Lahdesmaki, 2005) is also an impediment. The small business struggles to survive in the cultures of corruption that include majority of the developing countries such as Nigeria, Ghana, Columbia, Angola, Pakistan, and Kenya among others with the government entities as the top culprits (Abdulai, 2009; Uma & Eboh, 2013). Working with the government in the emerging markets to permanently reduce corruption is desperately needed to ensure the success of the small business. Reduction of corruption requires a strong political will geared toward reforming the administrative practices, enacting and implementing legal measures cover both economic and legal systems (Wilhelm, 2002).

The authors recognize that the moral conduct, judgment, and ethical behavior generally differ among individuals especially in the individualism dominant cultures such as USA. In the welfare dominated societies such as Scandinavian countries of Europe much of ethics and social responsibility are socially, culturally shared by the individuals. In the developing countries with weak political and administrative structures competitive race to get ahead economically, socially, politically often compromise individual moral judgments. However, since ethics is linked to moral conduct there should be ethics training and education programs for environmental concerns for all businesses as a post recruitment activity (Solymossy & Masters, 2002; Wilhelm, 2002). Ethics do matter, the owners and leaders should be role models for their employees. Literature confirms that small business managers influence employees and customers when they demonstrate moral obligation to make ethically sound decisions in their daily operations (Spence, 1999). In this respect, the top manager's decision making behavior has to be ethically sound on matters involving employees, customers, and shareholders (Vitell, Dickerson, & Festervand, 2000).

The importance of implementation of an ethics program within the small business cannot be overestimated. It simply may include self-auditing, and unbiased third parties reviews to identify ethics vulnerability so that a code of ethical conduct could be communicated to the employees. The

communication of ethical processes to employees should be formal and the employees should be encouraged to provide feedback for improvement during training and on their routine work with leaders who walk the talk (Miller, 2003; Dixon, 2006). The promotion of ethical conduct within the small business needs to be ongoing and not a one-time deal and it should involve all employees. In addition, businesses may promote ethical actions by offering rewards to employees that conduct themselves ethically (Barrier, 1998; Vyakarnam et al., 1997). A point may be made in this context, which the ethical success among small business lies in the hands of the owners as leaders who strongly embody the values they communicate to their personnel and strongly implement the practices through formal training (Exton, 1982; Seshadri, Raghavan, & Hegde, 2007, Adams, Tashchian, & Shore, 2001; Robinson Jr, & Pearce, 1984; Wilhelm, 2002).

This theoretical study provides evidence that ethics surrounding small businesses varies within countries in North America, Europe, Australia, and Africa. While there were some commonalties in Europe and North America, there are distinct differences in ethical challenges and perspectives among them. Small businesses being the engine of economic growth and employment in all countries of the world, ethics and social responsibility in this sector should receive the attention it deserve both from the scholars and policy-makers. While this study laid a foundation of theoretical review, future studies should be designed towards country specific ethical issues and case studies toward formulating best practices in small business ethics and social responsibility.

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