THE ENVIRONMENTAL FALLOUT OF THE NUCLEAR ERA: WEIGHING THE EFFECTS OF THE MILITARY, CAPITALISM, AND UNEQUAL EXCHANGES

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TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

ABSTRACT

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This research tests multiple theoretical relationships related to the economy, military, nuclear energy, and environment by employing a multivariate linear regression to a data set including 30 nuclear energy producing nations. The theories tested in this model include the treadmill of production, treadmill of destruction, world-systems theory, ecologically unequal exchange, and ecological modernization theory. Results from the cross-national regression model indicate that the treadmill of production increases primary energy consumption, in contradiction with ecological modernization theory. Similarly, the treadmill of destruction demonstrates a positive effect on

primary energy consumption. Strong negative correlations among trade liberalization, and both military participation and GDP per capita, support the arguments of world-systems theory and ecologically unequal exchange. Ultimately these results support previous research that argues political economy frameworks and investigations into consumption-driven environmental impacts should account for the effects of both capitalism and state militarism in a stratified global hierarchy, while vigilantly assessing the roles of mutually interacting power elites.

> "To demand of strength that it should *not* express itself as strength, that it should *not* be a desire to overcome, a desire to throw down, a desire to become master, a thirst for enemies and resistances and triumphs, is just as absurd as to demand of weakness that it should express itself as strength … For just as the popular mind separates the lightning from its flash and takes the latter for an *action*, for the operation of a subject called lightning, so popular morality also separates strength from expressions of strength, as if there were a neutral substratum behind the strong man, which was *free* to express strength or not to do so."
>
> – Friedrich Nietzsche,
> *On the Geneaology of Morals*

Chapter I

INTRODUCTION

The contemporary global economic structure is the result of a historically uneven integration of nation-states into a world system that is stratified economically and militarily (Jorgensen and Clark 2009; Chase-Dunn 1998). The unequal exchange relationship resulting from a stratified global economy has fostered economic and technological exploitation, resource wars, arms races, and disproportionate environmental destruction (Rice 2007; Jorgensen 2006). States consider armed forces necessary for an array of reasons, but their primary role is deterrence and intimidation; as a defense against other nations, and as a threat of attack in support of foreign policy objectives (Westing 1988). Two intricately related yet independent forces in the expansion of state militarism are identified in environmental sociology and political economy perspectives:

1) the pursuit of state geopolitical objectives; and 2) the military-industrial complex (MIC) embedded in a global capitalist economy. Modern armed forces are authorized and sanctioned agents of the state that selectively augment their capacity to wage destruction in order to assert geopolitical dominance, while embedded within the global capitalist growth model and the military-industrial complex (MIC) which demonstrate their own synergistic relationship with military expansion. Analyzing these two separate yet interrelated roots of military expansion, the MIC and state geopolitical militarism, provides insight into the idiosyncratic and synergistic characteristics of state militarism.

Increasingly, the relationships among the economy, military, and environment have drawn attention, due partly to global energy demand, geopolitics, and integrated world-economies. The modern world-system is an increasingly complex global system containing nations engaged in geopolitical contests to secure scarce natural resources within a finite resource base, resulting in exploitation and uneven exchanges of environmental consequences. This exploitation is a consequence of the global division of labor and the dynamics of core-periphery economic relationships, which unevenly benefit production economies over extractive ones. Energy demands, which fuel consumption and production, are steadily increasing worldwide, as "we need ever-larger inputs of high-quality energy to maintain this complexity. In the meantime, internal tectonic stresses- including worsening scarcity of our best source of high-quality energy, conventional oil- are building slowly but steadily" (Homer-Dixon 2009: 3). Technological advances in energy must be analyzed for both their manifest and latent consequences. International political economy perspectives within environmental sociology aim to determine the structural and relational interaction among the interstate

system and socio- environmental outcomes. Previous research (Jorgensen, Clark, and Kentor 2010; Kentor and Kick 2008; York 2008; Hooks and Smith 2005, 2004) identifies the interaction between militarization and negative environmental outcomes; this research aims to identify how different aspects of these theories intersect with nuclear energy and militarization.

Nuclear energy is considered a "cutting edge" technology, so it may function as a marker of both modernizing technological advancement and increased resource consumption. Civilian nuclear energy, 81% of which is produced through pressurized water and boiling water reactors, supplies close to 14% of the world's energy (World Nuclear Association 2010). This does not account for the over 200 nuclear reactors used for propulsion in naval vessels and civilian transport vessels (World Nuclear Association 2010). The purpose of this research is to examine the relationship between militarism and nuclear energy, and test competing theories of military growth. This paper begins with a discussion of the crises facing the global world-system, and then considers the relationship between consumption and militarization in the world-system. World-systems theory (WST), ecologically unequal exchange (EUE), ecological modernization theory (EMT), the treadmill of production (ToP), and the treadmill of destruction (ToD) theories will be employed to analyze the intersection of affluence, militarization, and modernity. Following the literature review I describe data sources, identify quantitative methods, operationalize research variables, test hypotheses, and discuss the results and conclusions.

Chapter II

LITERATURE REVIEW

The major challenges facing humanity involve developmental, environmental, and energy crises. A holistic framework of these crises permits insight into the intersection and potential consequences of these interactions. The developmental crisis, characterized by issues of managing population growth and urbanization, is intricately linked to the need for enhancing sustainable global economic and social development.

Population growth and rapid urbanization are a primary concern of the developmental crisis. Martine et al. (2008) note that between 2000 and 2004, of the 1.76 billion global population increase, 86% is projected to occur in the urban areas of developing countries. Properly managing urbanization, a natural and unavoidable consequence of industrialization and population growth, requires comprehensive consideration of resource and environmental concerns. Complex interdependence produces chains of cause-effect outcomes that cascade throughout the global system (Holling 1973). Heavily polluting industries that primarily rely on environmental resources are concentrated in developing countries (Lechner and Boli 2008: 407), but they are one part of a local, regional, and global system. Urbanization is inevitable, and essential, for enhancing global sustainability and reducing poverty in the developing world (Martine et al. 2008).

The developmental and energy crises challenging the global system accelerate the global environmental crisis. World-systems theory (WST) posits that the distribution of affluence and wealth in the world-system advantageously positions core nations to secure energy and resources (leading to greater levels of consumption), reinforcing economic stratification and power differentials (Gotts 2007; Wallerstein 2004; Chase-Dunn 1995). Ecological unequal exchange (EUE) is recognized as an important component of WST that generates the disproportionate socioeconomic and ecological exchange between core and peripheral states, in function with the global division of labor (Rice 2007). Extractive economic practices and transfers of environmentally destructive processes to the periphery situate peripheral nations disadvantageously in the global hierarchy (Jorgensen 2009, 2006; Jorgensen and Clark 2009; Rice 2007). Ecological modernization theory (EMT) asserts that institutions of modernization will cultivate industrial, ecological, and economic adaptation (Curran 2009; Jokinen 2000).

The treadmill of production (ToP) argues that the paradigm of capitalist expansion and investment bolsters increased consumption and production through the alignment of labor, capital, and actors, intensifying environmental degradation (Gould, Pellow, and Schnaiberg 2008). ToP is consistent with the WST and EUE in the premise of a stratified hierarchal system of global inequality that is maintained primarily through a global division of labor. The treadmill of destruction (ToD) argues that geopolitical strife and arms races expand militarization through technological prowess (Hooks and Smith 2005, 2004). This expansion is unique in that the scope, breadth, and potency of military operations and weapons technology increase, through investments in military research and development, particularly weapons of mass destruction (Hooks and Smith

2011, 2005, 2004). While ToP asserts that militarization increases through capitalist expansion and reinvestment into the treadmill structure, ToD argues that militarization uniquely expands due to geopolitics and arms races. These varying theoretical frameworks provide a range of possible explanations to evaluate within the context of modern influences of nuclear energy and militarization.

It is significant to note the overlaps and contrasts of these theories. WST emphasizes the organization of nation-states in stratified and hierarchal world-system (Gotts 2007; Wallerstein 2004; Chase-Dunn 1998). EUE is a primary component within WST that underlies the disparity of socioeconomic and environmental exchanges (Jorgenson 2009, 2006; Rice 2007; Burns, Kick, and Davis 2003; Chase-Dunn 1998; Bunker 1984). Within the context of a stratified global hierarchy, the ToP expands via the global capitalist economy and the MIC, concurrently exacerbating environmental degradation (Gould, Pellow, and Schnaiberg 2008; Gould 2007; Hooks and Smith 2005). A separate yet interacting treadmill, the ToD, expands militarization through the modernization of military technology, exponentially enhancing its destructive capacity and role in achieving geopolitical agendas. The modernization of the military institution is an important component of the ToD. EMT also emphasizes the importance of modernity, asserting that modernization cultivates industrial, economic, and ecological adaptation. I now present an overview of each of these theories.

World-Systems Theory and Unequal Ecological Exchange

World-systems theory, rooted in Marxist world-historical perspectives, is premised upon the notion that the contemporary world cannot be understood without looking at the system as a whole and understanding its development over extended

periods of time (Gotts 2007; Wallerstein 2004; Chase-Dunn 1998). In the highly structured and interrelated modern world-system, the significant unit of analysis is the entire world-system, comprised of local, regional, societal, and global scales which vary in organization and are an outcome of multiple complex processes (Gotts 2007; Wallerstein 2004; Chase-Dunn 1998).

WST asserts that a market and global division of labor is divided among "core," "peripheral," and "semi-periphery" nations, in which transnational corporations (TNCs) and a transnational corporate class manipulate the global economic structure (Jorgensen 2009, 2006; Gotts 2007; Wallerstein 2004). Core states support the elite's exploitation of labor, resources, and trade in the periphery while the semi-peripheral nations balance both core and peripheral activities, endorsing norms that benefit the core and lessen the divide between core-periphery relations (Wallerstein 2004; Chase-Dunn 1998). Wallerstein (2004) describes the core-periphery relation as the level of production profitability based on the degree of monopolization in production. Peripheral production is in a weak position to compete with the monopolized production found in the core, resulting in unequal exchange (Rice 2007; Jorgensen 2006).

The processes of EUE include the externalization of environmental costs, disproportionate access to and use of bioproductive land and waste sink areas of the global commons, and pervasive underdevelopment in peripheral areas (Jorgensen 2009, 2006; Rice 2007). The dynamics of the global economy allow wealthier nations to secure more propitious trade agreements, which support ecologically unequal exchange. EUE refers to the disproportionate exploitation of nature in a hierarchal world-system, mediated by a global division of labor, which allows TNCs and elites in core nations to

maximize resource extraction and externalize environmental costs through transferences of hazardous products, wastes and processes to the periphery (Jorgensen and Clark 2009; London et al. 2009; Frey 2003). Elites are more likely to maintain and limit environmental damage to their homeland nations, which support the elite structure and propagate the world-system (Rice 2007; Gotts 2007).

Jorgensen's (2009) panel study of lower-income countries demonstrates that the suppression of resource consumption, and increasing use of environmental space in peripheral nations, occur as a result of core cost externalization practices. Rice's (2007) findings demonstrate that the externalization of costs and the disproportionate use of environmental space further contribute to underdevelopment in less developed countries, due to the disparaged value of exported natural resources, which enervate socioeconomic opportunities. Bunker (1984) argues that the extractive economies of peripheral nations develop fewer lateral economic ties, supporting peripheral dependency upon (core) zones of production for exchange value. The accumulation of value occurs in core nations through the undervaluation of imported resources, attenuating their export value and increasing economic instability in the periphery (Bunker 1984). Large export volumes of natural resources result in rapid degradation of local ecosystems, and limit the capacity for economic diversity by fostering economic reliance.

This reliance upon core production has negative implications for peripheral nations, including food dependency, economic insecurity, and stagnant social development. The social and economic development of the extractive economy is guided by extraction needs such as transport and removal infrastructure, and interferes with natural environmental and human settlement patterns (Bunker 1984). Jorgensen et al.

(2005), find that the level of urbanization and international power have the strongest influence upon combined per-capita footprint, while lower-income nations suffer from underdevelopment related to the undervaluation of resources (Rice 2007). Thus, an economic relationship that favors core productive processes over periphery extractive processes is an unequal exchange. EUE aligns with WST in that the movement of surplus value to the core reinforces global economic stratification and power differentials, while the simultaneous transfer of labor and waste to the periphery results in ecological destruction (Jorgensen 2009, 2006; Rice 2007).

WST and EUE support the perspective that nations positioned in the core maintain a dominant position over periphery and semi-periphery nations, through transnational elite movements of labor, capital, resources, and waste. Gartzke and Kroenig (2009) suggest that nuclear weapons status increases state influence in the international context, affecting the resource allocation and bargaining power of proliferating states, thereby improving success in wars and decreasing the intensity of conflicts when they occur. A logical extension of this relationship, particularly in the context of a hierarchal world-system with unequal ecological exchange relationships and geopolitical competition, is that nuclear energy production and the capacity to pursue nuclear weapons programs also affects the resource allocation and bargaining power of nuclear energy nations. This relationship highlights the influence of nuclear energy upon militarization and the achievement of geopolitical agendas (ToD), while such outcomes are embedded within the context of a MIC and capitalist global economy (ToP). WST and EUE provide a framework for analyzing how core-periphery production and consumption processes and material waste transfers may negatively impact marginalized

countries, while supporting the global-economic growth model. Analyzing the global context in which economics, geopolitics, ecology, and technology interact is an important step towards understanding the interaction between militarization, energy consumption, and nuclear energy.

Ecological Modernization Theory

Ecological modernization theory (EMT) analyzes the ways in which environmental concerns are synthesized into everyday life, through social institutions and actors. It is defined as "the social scientific interpretation of environmental reform processes at multiple scales in the contemporary world" (Mol, Spaargaren, and Sonnenfeld 2009). Simplified, EMT is an ecologically oriented theory of the processes of modernization that increase efficiency and reduce environmental destruction. The ways in which EMT aims at integrating environmental policy into an array of policy sectors, particularly the economic sector, is through the use of innovative policy measures (Jokinnen 2000). Market-based environmental policies, implemented through reflexive institutional reorganization around economic and technological markets, environmental protection as a precursor to economic development, and 'internalization' of the 'external' costs of production are primary goals of EMT (Mol, Spaargaren, and Sonnenfeld 2009; Mol and Spaargaren 2000). Important elements of EMT are technology, adaptation and the restructuring dynamic, market economies, the role of the state, and the role of environmental movement organizations (Curran 2011; Mol, Spaargaren, and Sonnenfeld 2009; Mol 1997).

Emphasis on innovation and adaptation within the context of modernity is essential to EMT, but is also a subject of its criticism. Technological innovation is both

unreliable and unpredictable in its influence and significance, and there is lacking evidence for the innovative capacity of the institutions of late modernity to transform, rather than merely respond to ecological imperatives (York 2008; York and Rosa 2003; Rees 1995). De-industrialization and de-modernization are the primary technological challenges to EMT, and recent evidence demonstrating increases in environmental quality associated with de-modernization in the former Soviet Republics fuels the debate over the role of technology and calls into question the efficacy of EMT (York 2008). EMT posits that industrial, social, and economic modernization will function to reduce ecological degradation, but provides minimal evidence in support of this claim (Jorgensen and Clark 2009; York and Rosa 2003). The modernizing role of nuclear energy can be understood through the lens of EMT which posits that institutional, economic, and industrial modernization reduce consumption driven ecological impacts. EMT would argue that the innovative capacity of modernizing nuclear energy enhances the remediation of environmental harms.

The Treadmills of Production and Destruction

The treadmill of production (ToP) asserts that the continuous expansion of capitalist growth and production, implicit in the EMT model, places increasing demands on resources and outputs of waste, creating environmental degradation (Gould, Pellow, and Schnaiberg 2008). Continued expansion and growth, foundations of capitalism, are essential to increase profits that are then reinvested to increase production in order to continually feed the treadmill. Technological innovations reduce the needs for labor, so production is further expanded in order to meet labor demands. The forces of capital, labor, and the state all perceive to benefit from the expansionary dynamic of the

treadmill. Thus, in a finite global system of resources, geopolitical competition results in increasing militarism among nations who vie for power and profit.

The ToP's roots in the Hegelian dialectic are identifiable in many factors (Gould, Pellow, and Schnaiberg 2008). For Hegel, the historical dialectic consisted of a thesis and anti-thesis in contradiction, the conclusion of this contradiction being synthesis. A key example in the ToP involves the dialectic contradiction between stakeholders and shareholders, analogous to Hegel and Marx's proletariat and bourgeoisie (Ritzer 2008). The deteriorating social, economic, and environmental conditions for stakeholders, defined as the laborers and community residents, and the increased political and economic clout of investor and managerial shareholders, was a result of treadmill expansion (Gould, Pellow, and Schnaiberg 2008). Similarly, Marxist environmental literature posits that the natural environment, the welfare of laborers, and the infrastructural and social capital of laborers are fundamental to capitalist expansion, yet the inherent nature of capitalism's productive capacity lies in the exploitation of these pre-conditions, what he terms the second contradiction of capitalism (O'Connor 1998). The second contradiction of capitalism will result in the synthesis of class struggle and ecological struggle (Williams 2010; O'Connor 1998). The ToP takes a similar view of the inherent environmental negligence on the behalf of capitalism as being in direct contradiction with the sources of its production, laying the foundation for capitalism's own collapse (Gould, Pellow, and Schnaiberg 2008).

A growing body of literature addresses the impacts of militarization upon the environment (Kentor and Kick 2008; York 2008) and posits the existence of the ToD

(Jorgensen, Clark, and Kentor 2010; Hooks and Smith 2005, 2004;) nonetheless, given the substantial ecological impact of militarization and the socio-environmental consequences of this relationship, an insufficient amount of attention has been afforded to this issue. Militarization maintains the exclusivity of being the most ecologically destructive human endeavor, according to environmental sociologist Kenneth Gould (2007). The majority of previous research in this area supports the argument that expanding militarization has direct environmental consequences. The changing dynamic of military expansion is an important point of emphasis in analyzing energy consumption. Military technology has evolved from requiring large workforces and quantities of raw materials during the first half of the 20th century into a capital-intensive endeavor that requires specialized materials and skilled laborers (Shaw 1988). Shaw (1988) points out that the advanced technology, low-employment base, specialized labor force, and security necessities of the military virtually mirror the nuclear industry, the difference being the location of the nuclear industry in the civil sector rather than as part of the military-industrial complex.

The modernized warfare of the last half of the 20th century is distinctive from the mass industrial warfare that preceded it, specifically in regards to the lethality of weaponry and the scope of environmental devastation (Hooks and Smith 2011, 2005; Shaw 2002). Socio-economic and geopolitical forces have also influenced the structure of modern militarism and warfare. A political relegitimation of Western militarism and war-making, that justifies war in the West as "humanitarian intervention," has developed with what Shaw (2002) describes as *risk-transfer militarism*. As Shaw (2002: 348-349) points out,

> "… it introduces new contradictions, through the multiple transfers of risk, particularly to civilian populations, which result in the distribution of death (12,000 civilian casualties in Kosovo, and zero Western casualties) … The comprehensive transfer of risks away from Western military personnel appears to be a major aim of the new way of war."

Risk-transfer is implemented in five primary ways: 1) the principal risks are applied to armed enemy combatants, rather than civilians who were historically at greater risk; 2) The risks of ground combat are transferred to local allies in the proximity of the combat zone, while Western forces employ airpower; 3) the systematic and calculated insulation of Western air forces from risk, through the use of less precise high-altitude bombing, which predictably transfers risk to civilians as small 'accidental' massacres; 4) the management of the media, that transfers the risk of delegitimizing war, through the regulation of images portraying direct civilian casualties; 5) indirect civilian casualties exude less culpability and political risk than direct civilian casualties and are therefore regarded acceptable, because of the obscurity caused by other factors, such as drought or sectarian violence (Shaw 2002). This risk-transfer strategy, characteristic of late 20st century warfare, is legitimated through the political refinement of strategy, weaponry and media management (Shaw 2002).

A vital aspect of risk-transfer militarism is the intricate connection between modernized military warfare and the management of media and public opinion, which are contrived to maintain the legitimacy of war in the West (Shaw 2002). Hooks and Smith (2011) extend the risk-transfer militarism argument when they suggest that if the future concentrations of wars occur in the Global South, a "greening" of the advanced military

states will take place, predicated on the transfer of environmental risks to the most perilous areas of the world. As they point out, this risk-transfer to the Global South insulates the Western nations from the environmental hazards, death, and destruction of war. This insularity from the environmental and health hazards associated with warfare functions to benefit the management of media and public opinion that maintain the legitimacy of war. The socio-economic and geopolitical forces that have guided modern Western militarism have distinct individual ambitions and impacts, but are mutually interacting. Mass media and public opinion are managed by elites, and the complex interaction of these elites in the upper tiers of military, industry, and government is crucial to understanding the complex interaction among geopolitical objectives and the MIC.

The role of elites in guiding economic and geopolitical goals is an important point to observe. Elites penetrate the tripartite power structure among military, government, and industry as discussed in C. Wright Mills' (1956) *The Power Elite*. The alignment of these actors in the highest levels of government and industry supports the treadmill structure. The military-industrial complex is an important foundation of the treadmill of production (ToP) theory, in that it guides and influences public policy and agenda. Accelerating environmental destruction, driven by profitability and competition in the market economy, is the result of an expanding military-industrial complex (Gould, Pellow, and Schnaiberg 2008). The treadmill of destruction (ToD), however, is a distinct and unique phenomenon driven by geopolitical strife and arms races. ToD posits that militarization expands through technical and scientific innovation, but that this expansion increases the potency and environmental lethality of military weaponry (Hooks and

Smith 2005, 2004). The ToD phenomenon is distinct in that it is driven by the pursuit of state geopolitical objectives and arms races, rather than the MIC and the global transnational capitalist economy.

In the ToD, the inherent contradiction in the expansionary dynamic of the military is an essential point of departure from the ToP. In the context of geopolitical competition, militarization expands through the research and development of weapons of mass destruction (WMD), which have increasingly destructive environmental capacities (Hooks and Smith 2005). WMD are specifically designed to devastate the environment of enemies and render it uninhabitable, and in this way the risks and lethality of weaponry are qualitatively and quantitatively more dangerous. The expansion of militarism via scientific and technical innovation functions as a geopolitical tool to meet the increasing demands and competition over scarce natural resource treadmill inputs.

Jorgensen and Clark (2009) have identified the profound influence of resource consumption on military expansion, finding that technological innovation facilitates increasing consumption of resources by the military and supporting sectors. Militaries are entrenched in global geopolitics, and accelerating investment in technological advancements, through government contracts, create a positive feedback loop of investment and innovation. Intraspecific competition among nation-states manifests as geopolitical struggles and arms races, simultaneously accelerating environmental destruction. Previous research reveals that “increases in the scale and intensity of national militaries, whether in terms of soldiers or technology, increase their environmental demands and impacts” (Jorgenson, Clark, and Kentor 2010). The pursuit of state geopolitical objectives in the world-systems hierarchy facilitates the development

of increasingly devastating weaponry, while within the global capitalist economy, the MIC reinforces expanding militarization. As Jorgensen and Clark's (2009) findings support, although the economy and military are mutually reinforcing and interacting, they maintain distinct idiosyncrasies in terms of ecological impacts.

From the ToD perspective, geopolitics and military action are used to secure political goals, which often include securing natural resources. Technical sophistication in weaponry provides an extreme military advantage, and this advantage supports increasing investment in weapons technology that has steadily increased in environmentally lethality. ToD theory predicts increases in ecological devastation due to expanding militarization, characterized by shrinking spatial occupancy and growing consumptive and investment practices. Wars and arms races drive the ToD, and a primary motivation for geopolitical and military dominance is natural resource control. The need for control over natural resources is a direct result of the demand for energy security, which characterizes many aspects of the global energy crisis. The capitalist global economy and MIC align with state geopolitical objectives, tantamount to "national security," and independently yet mutually foster the expansion of state militarism to secure access to resources and energy. Most Western capitalist societies are deeply committed to the current global energy infrastructure, and securing access to energy is not only necessary to maintain the current form and functioning of modern society, but also serves as a hedge in the pursuit of future geopolitical objectives.

The struggle for energy is an important catalyst in geopolitical competition and arms races, and understanding the potentials and hazards of technological and political innovation are essential. As the world seeks to fulfill its energy demands, in the wake of

concerns over CO_2 emissions and global climate change, nuclear energy emerges as a promising option. The future role of atomic power in the energy crisis is unclear, but the auspicious potential of this high technology is apparent. The total life-cycle CO_2 emissions per unit of nuclear energy, calculated by the IPCC, are equivalent to and rival that of renewable energy sources (Giddens 2009). Nuclear energy provides an avenue for the analysis of the ToD expansionary dynamic, and as a point of comparison with the ToP assertion that the capitalist global economy and MIC drive military expansion. Analysis of nuclear energy, in regards to its connection with affluence, resource allocation and bargaining power of nuclear energy nations tests WST notions of a global hierarchy. Analyzing nuclear energy production in terms of the propitious trade agreements secured by core countries tests the EUE mechanism of WST. Similarly, the modernizing role of nuclear energy can be analyzed through the lens of EMT, which posits that institutional, economic, and industrial modernization reduce consumption driven ecological impacts. The latent and manifest consequences of investment in this high technology, which is intertwined with military, economic, and geopolitical agendas, must be thoroughly analyzed by social scientists.

Real-Time Cost-Benefit Analysis

In consideration of the risks associated with nuclear energy production, skeptics question the practicality of favoring any alternative other than renewable energy. Data measuring greenhouse gas emissions from nuclear power generation further compound the issue. The ecological footprints of nuclear energy rival current wind and tidal renewable energy sources (World Nuclear Association 2010; Parliamentary Office of Science and Technology 2006), but these advantages are impeded by concerns over

security risks, weapons proliferation, uranium refinement processes, and radioactive waste disposal. These risks translate into the fear that nuclear reactors could become targets of terrorism, or that the potential for nuclear proliferation increases (Parliamentary OST 2006). In addition to these concerns is the high relative cost of constructing and financing nuclear facilities, and the time investment required for construction. According to a recent CitiBank report, "Three of the risks faced by developers — Construction, Power Price, and Operational — are so large and variable that individually they could each bring even the largest utility company to its knees financially" (CitiGroup Global Markets Inc. 2009).

The majority of scholars assert that nuclear weapons tend to spread when states face external threats and perceive a need for the bomb, not merely when they have the industrial and technical capabilities necessary to proliferate (Fuhrmann 2009). Singh and Way (2004) find that countries allied to great military powers are 49% less likely to explore the nuclear weapons option and 54% less likely to attain nuclear arsenals, while countries involved in enduring rivalries, conceptualized through measures of competitiveness, spatial consistency, and time (Diehl 1998), are nearly four times more likely to pursue the nuclear weapons option (382%) and more likely (743%) to acquire these weapons. They also found that the level of economic trade liberalization is significantly associated with a 72% lower hazard rate of exploring nuclear weapons, while pursuance of the nuclear option increased dramatically (563%) with the presence of a minimum industrial threshold (Singh and Way 2004). The industrial threshold is measured using the technologically determinant variables of GDP per capita, energy, electricity and steel production and consumption, and an industrial capacity index, a

dichotomous variable that determines if steel is produced domestically and electricity production exceeds 5000 megawatts.

This research indicates that enduring external threats and economic liberalization are important factors that, although not deterministically linked, do potentiate nuclear proliferation. However, research and case studies of nuclear proliferation in Pakistan, India, and South Africa observe otherwise. Fuhrmann's (2009) time-series cross-sectional analysis found that although the relationship between NCA and nuclear proliferation is non-deterministic, a positive relationship between nuclear weapons proliferation and civilian nuclear cooperation, via civilian nuclear cooperation agreements (NCA). This is attributed to the development of a domestic knowledge of nuclear science, which when created peacefully reduces expected costs of nuclear programs, thereby enhancing the potential for states to pursue the weapons option when threatened (Fuhrmann 2009). Fuhrmann's (2009) case study of South Africa further supports that proliferation was authorized primarily because it was 'technologically feasible.' From these results, it is important to emphasize that nuclear energy procured via civilian NCA was positively associated with an increase in the likelihood of states acquiring nuclear weapons, thus revealing the interaction and overlap of military and civilian nuclear energy. These findings indicate the particular significance of nuclear energy production in the civil sector, and the independent yet interrelated influences of geopolitical and global economic forces upon militarization.

Radioactive waste, security, and proliferation are primary arguments leveled against nuclear energy production, but there are latent consequences to consider. Given the historical influence of national militaries, expanding militarization through

modernizing investments in nuclear energy and technology may enhance ecological destruction. Typical indicators associated with modernization are economy, level of urbanization, industrialization, and international trade (York 2008), and these refer to macro-structural material indicators of modernity, rather than cultural or social ones. Previous research links accelerating environmental destruction with increasing militarization, capitalist expansion, and modernity. The ToD asserts the pursuit of state geopolitical objectives increases militarization through investment in advanced military weaponry, leading to increased resource consumption and broadening the environmental impacts of militarism. This research contributes to the literature by suggesting that within the ToD, as militarization is expanded in the pursuit of geopolitical objectives and modernized arms races, the qualitative increases in the potency, range, and deterrent capacity of weapons actually *reduce* the scale of military participation. This argument is premised on the fact that U.S. armed forces personnel have declined in size from 2.24 million in 1989 to 1.56 million in 2009, while military spending in that same time period has more than doubled (World Bank 2009). The arguments of risk-transfer militarism (Hooks and Smith 2011; Shaw 2002) are further extended in the ToD, in which a shrinking quantitative spatial occupancy seems to be a by-product of geopolitical arms races, which increase the range and lethality of weaponry while reducing military spatial occupancy. The nuclear component of geopolitical arms races has important implications in the context of risk-transfer militarism, particularly in regards to the broad environmental lethality of nuclear weapons, and the small number of military personnel necessary to deploy such devastation.

Three hypotheses flow from this logic.

Hypothesis 1: Nations with greater nuclear energy shares have higher levels of military participation.

Hypothesis 2: Nations with larger nuclear energy shares have higher levels of primary energy consumption.

Hypothesis 3: Nations with greater levels of militarization have higher levels of primary energy consumption.

The theories analyzed in the literature section will be used as a framework for assessing these hypotheses. WST argues that core nations are situated at an advantage in the global hierarchy, and maintain greater access to resources, technology, and political influence, indicated by a strong influence of GDP per capita on consumption. Core hegemony is maintained through military and economic posturing, which is tested by the proposition of hypothesis one, that affluence and modernity are consistent indicators of energy consumption. The additional context of associations among trade liberalization, energy consumption, and GDP per capita address the EUE of this global hierarchy, also providing insight into the first hypothesis. In contrast to the WST and EUE arguments, hypothesis one also tests the EMT assertion that industrial, social, and economic modernization increase efficiency, thereby reducing consumption and environmental degradation.

Hypothesis two tests the ToD assertion that militarization uniquely expands due to geopolitical maneuvering and arms races, driving environmental destruction (Hooks and Smith 2010), by examining whether greater levels of militarization are consistent with higher primary energy consumption. The third hypothetical postulation that high investment in nuclear energy is consistent with higher military participation further

investigates the ToD. This hypothesis concurrently suggests that high investment in devastating weapons technology, specifically technical and sophisticated sectors, is intricately linked with the military such as the civilian nuclear energy sector, indicated by associations among military participation, nuclear energy, and military expenditures. Supporting evidence for the ToD would include a strong influence of military participation upon energy consumption, positive association among nuclear share and military participation, and a positive correlation among military participation and military expenditures.

Although there are intricate overlaps in these theories and the variables measuring these concepts, distinct and specific differences among them provide the opportunity to identify them as individual yet interrelated. The ToP and ToD increase environmental destruction through distinct yet mutually interacting forces of the MIC and capitalist expansion, and geopolitical goals and arms races, respectively. EUE is the driving force that creates inequality and stratification of the global economic hierarchy of WST. The macro-structural elements of WST, EUE, ToP, and ToD fundamentally contrast EMT in terms of the influence of modernity upon environmental outcomes. With the establishment of these theoretical frameworks and their intricate relationships, I now advance to a discussion of empirical methods and data.

Chapter III

EMPIRICAL ANALYSES

Methods and Data

I employ a multivariate linear regression analysis to a cross-national data set to probe the influence of nuclear energy production and military participation on primary energy consumption. All data were collected from 2008 measurements, in order to avoid exclusion of any cases, particularly with a bare minimum threshold of sampling size for multivariate linear regression. Measurements for China do not include Hong Kong SAR, Macao SAR, or Taiwan.

Table 1 ● Countries Included in the Analyses

Argentina	Czech Republic	Republic of Korea	Slovak Republic	Ukraine
Armenia	Finland	Lithuania	Slovenia	USA
Belgium	France	Mexico	South Africa	
Brazil	Germany	Netherlands	Spain	
Bulgaria	Hungary	Pakistan	Sweden	
Canada	India	Romania	Switzerland	
China	Japan	Russian Federation	United Kingdom	

Levels of national energy consumption, nuclear energy production, and militarization are taken from a sample of 30 countries that produce nuclear energy (Table

1). Previous cross-national research has identified the key empirical indicators of modernization to include: GDP per capita, urbanization, and industrialization (Jorgensen, Clark, and Kentor 2010; Jorgensen and Clark 2009; Jorgensen 2009; York 2008; York et al. 2003; Kentor and Kick 2008). Panel data sets from multiple national-scale sources were merged. A panel data with annual nuclear energy output measurements from 1999-2009 are available from the World Nuclear Association (2010). Panel data measuring national military expenditures from 1988-2008 are available from the Stockholm International Peace Research Institute (SIPRI 2009). This figure is chosen from SIPRI rather than the Correlates of War (v4.0) data (Singer 1987) because SIPRI includes all capital military expenditures, such as research and development, standardized to current $US, while the COW data set excludes those essential statistics. The COW data set does, however, provide national measures of primary energy consumption, a comprehensive measure of industrial energy consumption. Panel data measuring level of military participation, GDP per capita, manufacturing as a percentage of GDP, urban population as a percentage of total population, and exports/imports as a percentage of GDP are available from the World Bank (2009).

Dependent Variable

Primary energy consumption is employed as the dependent variable to interpret the influence of nuclear energy consumption, militarization, and nuclear weapons status. As explicated in the National Military Capabilities (NMC) v4.0 codebook, "the greater the energy consumption of a state, the larger the potential manufacturing base of an economy, the larger the potential economy of the state in question, and the more wealth and potential influence that state could or should have (Singer 1987: 49)." This variable

is converted to its natural logarithm (ln), a common practice in linear regression used to minimize the influence of outliers in the sample, and utilized here also to adjust for the small *N*. All independent variables were converted to natural logarithms for the reasons consistent with primary energy consumption, with the exception of nuclear share, urbanization, and manufacturing, which demonstrate normal distributions according to histogram models, as addressed in the discussion of limitations following the operationalization of variables below.

Primary Energy Consumption (ln) encompasses the level of industrial energy consumption, which is identified in a similar vein as an indicator of a state's industrial capacity by Fuhrmann (2009). Primary energy consumption also reflects the consumption and capital-intensity of national militaries and economies. This figure is calculated in the Correlates of War v4.0 (NMC v4.0) as consumption = (production+ imports) – (exports+ Δ in domestic stocks) and converted into 1000 metric coal-ton equivalents. The inclusion of change in domestic stocks accounts for state maintenance of energy commodities in the event of disruptions in export and import flows. Energy sources include coal, natural gas, petroleum, hydroelectric, geothermal, and nuclear. Other sources such as peat, wood, and animal waste are not included because they are used in tiny amounts and do not qualify as industrial energy sources.

Primary Independent Variables

National *nuclear share* figures from 2009 are taken from the World Nuclear Association (WNA 2010) as a measure of nuclear energy production, collected by the WNA and the International Atomic Energy Association (IAEA). These figures measure the ratio of electricity produced by nuclear reactors in Terawatt-hours per year (TWh) to

total energy production. The ToD is applied to assess the influence of nuclear energy shares upon military participation, in line with the premise that geopolitical objectives drive the expansion of militarism and the concurrent environmental degradation through investment in modern technology. In contrast, EMT is used to analyze the assertion that technological innovation functions to reduce ecological destruction via increased efficiency and lower levels of consumption. Negative associations among nuclear share and energy consumption bolster EMT arguments, while positive associations among military participation and nuclear share provide support for ToD.

Military Participation (ln) is the number of active duty military personnel, and paramilitary forces if the training, organization, equipment, and control suggest they may be used to support or replace regular military forces. These figures are taken from the 2008 World Bank WDI. Jorgenson, Clark, and Kentor (2010) use military participation (as a ratio of military personnel per 1000 population) as an indicator of national military's relative labor intensity, and find that military participation has positive effects on both total and per capita carbon dioxide emissions, bolstering the ToD by demonstrating the influences of labor intensive and technologically advanced militaries on resource consumption, and the severity of environmental impacts. In the context of this research, the ToD would assert that military participation has positive associations with both primary energy consumption and nuclear share, supporting the distinct investment in technology and arms races that drive the ToD.

GDP per capita (ln) is used as a control for the level of economic development, technical sophistication, and affluence. GDP per capita is an accurate reflection of economic development, which is most closely associated with the technical, engineering,

and manufacturing knowledge required for the development and construction of nuclear weapons (Singh and Way 2004). Research measuring the per-capita footprints of higher-income and lower-income nations demonstrates that levels of development are the primary impetus of consumption-based environmental impacts (Jorgensen 2009), consistent with WST, EUE, and ToP. WST suggests that core nations monopolize production processes, and given that production needs are driven by energy demands, GDP per capita is a consistent indicator of how core-periphery dynamics influence overall energy consumption. EUE theory asserts that the movement of surplus value to the core reinforces global economic stratification and power differentials, while securing more propitious trade agreements for core nations, which would be indicated by a strong positive effect of GDP per capita on energy consumption, in combination with negative associations with trade liberalization. EMT is used to assess the argument that continuing economic development, in lieu with industrialization and technology, functions to reduce ecological degradation, indicated by lower levels of energy consumption, and is applied to assess whether affluence and modernization of nation-states suppress primary energy consumption. Contrary to EMT, the ToP will assess the positive influence of economic drivers on consumption, via the assertion that the MIC and capitalist expansion drive consumption and the accompanying ecological degradation. Positive associations among GDP per capita and military participation will also provide support for both ToP and ToD. A positive effect of GDP per capita on energy consumption would be consistent among ToP, WST, and EUE in that affluence and consumption driven environmental impacts are primarily concentrated in core nations, and are consistent with capitalist economic growth in a stratified hierarchal world-system.

Additional Independent Variables

Military expenditures as a percentage of GDP (ln), obtained from SIPRI (2009), are a measure of relative national military investments and expenditures, capital intensity, and technological sophistication, and serves as a proxy indicator of modernization. Military expenditures data from SIPRI are derived from the NATO definition, which includes all current and capital expenditures on the armed forces, including peacekeeping forces, defense ministries and other government agencies engaged in defense projects, paramilitary forces, if these are judged to be trained and equipped for military operations, and military space activities. Such expenditures include military and civil personnel, including retirement pensions of military personnel and social services for personnel, operation and maintenance, procurement, military research and development, and military aid (in the military expenditures of the donor country). Excluded are civil defense and current expenditures for previous military activities, such as for veterans' benefits, demobilization, conversion, and destruction of weapons (SIPRI 2009). This measure allows for a more precise interpretation of the effects of military participation, consistent with ToD theory specifically. ToD asserts that geopolitics and arms races drive advanced militaries to increasingly invest in “high technology,” potentially shrinking in spatial occupancy, indicating that militarization increases levels of consumption, and accompanying environmental devastation. This measurement has been employed by Jorgensen, Clark, and Kentor (2010) who found positive associations among military participation and carbon dioxide emissions. Positive associations among military participation and military expenditures per soldier will also function to provide

evidence in support of the independent yet mutually interacting roles of the ToP and ToD, consistent with the results yielded by Jorgensen and Clark (2010, 2009).

Manufacturing as a percentage of GDP is also included to control for the level of which national economies are manufacturing-based. The majority of perspectives within the social sciences assert that national economies with large manufacturing sectors use more resources, thereby increasing environmental degradation through CO2 emissions and other consumption-driven impacts. WST, EUE, and ToP can be applied to assess the impact of manufacturing as a percentage of GDP upon total energy consumption, indicated by strong associations between both variables. WST and EUE argue that core countries maintain more conservative trade liberalization and a large manufacturing base, because of a disproportionate flow of natural resources and waste. ToP asserts that consumption grows as the MIC and economic forces expand, indicated by correlations among consumption, GDP per capita, and manufacturing. A high manufacturing percentage of GDP indicates economic development and potential technological sophistication, which EMT posits will reduce ecological degradation, indicated by lower total energy consumption.

Urban population measured as a percentage of total population is employed as a control for a nation's level of urbanization. The current literature identifies positive associations between environmental outcomes and urbanization. Cross-sectional research of total ecological footprints (York et al. 2003) and per-capita footprints (Jorgensen 2005) shows that consumption-based environmental impacts are greater in more urbanized nations. Other research supports associations between levels of urbanization and consumption based environmental impacts (Jorgensen, Clark, and Kentor 2010,

2009; York, Rosa, and Dietz 2003). This research reflects the need to properly interpret the function of urbanization and affluence as indicators of modernity, which is essential to managing the complex and highly integrated global energy and environmental demands. Urbanization is also perceived to reflect the infrastructure and sophistication necessary for nuclear weapons proliferation. EUE asserts that underdevelopment is propagated by the export of undervalued natural resources, and can be assessed by analyzing the impact of levels of urbanization upon resource consumption (Jorgensen 2005; York et al. 2003), consistent with WST and ToP. The ToD also aligns with these arguments in that modernity is highly associated with urbanization. In contrast, EMT would argue that urbanization, which is highly correlated with manufacturing and GDP per capita, is an indication of modernity, and leads to more efficient consumption.

Trade Liberalization and economic interdependence are measured as exports plus imports as a share of GDP, taken from the World Bank (2010) World Development Indicators. The world-systems literature describes the world-economy as an interconnected system of core-periphery trade relationships. This variable controls for exposure to the global economy, and has been employed in other studies determining nuclear proliferation correlates (Fuhrmann 2009; Singh and Way 2004), and in assessments of EUE relationships (Jorgensen 2010, 2006; Jorgensen and Clark 2009). Jorgensen and Clark's (2009) panel analysis reveals evidence supporting the increasing relationship between position in the international trade structure and unequal ecological exchange. Power differentials and the division of labor in the global economy support a TNC class that manipulates the global economic structure (Gould, Pellow, and Schnaiberg 2008; Wallerstein 2004), and negative association among trade liberalization

and energy consumption will indicate more conservative trade liberalization in affluent nations, consistent with the hierarchal power differentials and disproportionate trading structure argued by WST, EUE, and also garnering evidence of the alignment of key actors in the ToP. As Rice (2007:44) observes, "The trade of natural resources supports the disproportionate per capita material consumption rates typically characteristic of core countries," therefore WST and EUE are applied to understand the influence of trade liberalization and economic interdependence upon resource consumption. Positive association among trade liberalization and nuclear share indicate strong integration into the global economy, which supports the WST argument that semi-periphery nations reinforce core values in the hierarchal global structure, such as modern nuclear energy in this case. Given the sample of nuclear nations, this variable is expected to yield positive associations with nuclear share, as per the high proportion of countries receiving civilian NCAs, and considering that the dissemination of high technology is likely to be accompanied by reciprocal economic liberalization. Negative association among trade liberalization and military participation will garner support for the ToD, as larger military forces in economically conservative nations are indicative of the influence of geopolitical objectives in shaping economic and military policy.

Chapter IV

RESULTS

The purpose of this research is to theoretically and empirically test the ToP, ToD, WST, EUE, and EMT. Prior to discussing linear regression results, I acknowledge limitations and interesting observations in the data, discuss the diagnostic procedures employed, and provide the results of bivariate correlations. Afterwards I present the results of the linear regression, followed by a discussion of bivariate and regression results, their meaning related to the varying theories, and their support or contrast of the three hypotheses.

Limitations

When investigating an esoteric aspect of national energy production such as the nuclear sector, a small *N* is assumed, as there are nuclear energy production measurements for only 30 nations. Given this tiny sample size, both the overt influence of individual cases and multicollinearity are specific concerns. The U.S. and China are responsible for an enormous amount of energy consumption, and relatively low levels of nuclear energy production. The energy consumption of the U.S. alone is nearly double (1.96x) the combined energy consumption of every nation procuring at least 1/3 of their energy from nuclear energy, thus potentially skewing statistical outcomes (U.S. share of nuclear energy is 20%). The significance of the disproportionate energy consumption

and affluence of the U.S. is more staggering considering the respective population distributions of these nations (Figure 1).

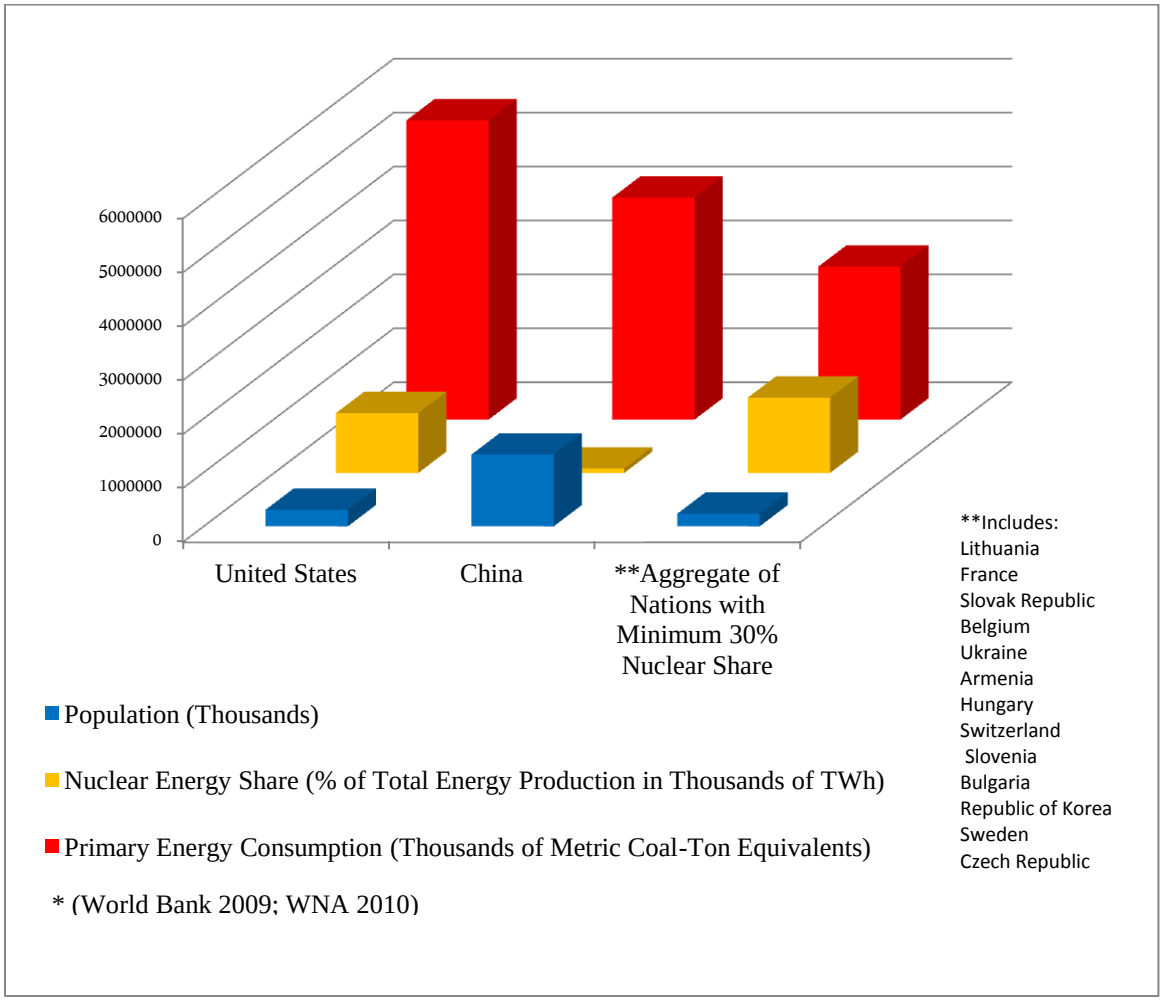

Figure 1: Population, Nuclear Energy, and Primary Energy Consumption (2009*)

Considering the disproportionate ratio of nuclear shares to energy consumption of the United States relative to the other nuclear nations raises issues of validity and reliability. In order to address the overt influence of these cases, two reduced models which individually exclude the U.S., and China, yielded a difference in adjusted r-square of less than .04, and no loss of significance in bivariate associations, supporting the

validity and reliability of the full model. Next I discuss the results of VIFs, histograms, and the removal of potentially over-influential cases, in the context of investigating nuclear energy, support the validity of the regression model.

Diagnostics

To assess multicollinearity, factor analyses, histograms, and variance inflation factors (VIFs) were assessed, and are available upon request. Factor analyses did not reveal a need to collapse independent variables, and the regression histogram revealed a normal distribution. VIFs are assessed for the magnitude of inflation in standard errors associated with multicollinearity, and all are well below the acceptable threshold 4.0 (O'Brien 2007).

Bivariate Correlations

As expected, the percentage of urban population is strongly correlated with GDP per capita, consistent with previous research (Jorgensen, Clark, and Kentor 2010). Urbanization demonstrates a moderate negative association with manufacturing, which I speculate is a result of the cohort of affluent, predominantly post-industrial nuclear energy nations. Consistent with previous research, military expenditures as a percentage of GDP have a significant moderate association with military participation, but correlations with other indicators are non-significant (Jorgensen, Clark, and Kentor 2010). This correlation is expected given the affluence and relative posture of nuclear energy nations in a hierarchal world-system. Descriptive statistics and correlations for all variables are presented in Table 2.

Table 2 ● Univariate Descriptive Statistics and Bivariate Pairwise Correlations for the Sample of Nuclear Energy Nations

	Mean	*Std. Deviation*	*N*
Primary Energy Consumption (ln)	12.379	1.752	30
Share of Nuclear Production (% of total energy production)	27.89	20.739	30
Military Personnel (ln)	11.814	1.597	30
Military Expenditures as % GDP (ln)	.556	.513	30
GDP Per Capita (ln)	9.433	1.169	30
Trade Liberalization (ln)	4.219	.577	30
Manufacturing	17.78	4.911	30
Urbanization	70.072	15.926	30

		1.	*2.*	*3.*	*4.*	*5.*	*6.*	*7.*
Primary Energy Consumption (ln)	*1.*							
Share of Nuclear Production (% of total energy production)	*2.*	-.452*						
Military Personnel (ln)	*3.*	.769**	-.495**					
Military Expenditures as % GDP (ln)	*4.*	.174	.063	.443*				
GDP Per Capita (ln)	*5.*	.201	.242	-.308	-.209			
Trade Liberalization (ln)	*6.*	- .508**	.524**	-.684**	-.206	.168		
Manufacturing	*7.*	-.031	-.060	.082	-.142	-.249	.190	
Urbanization	*8.*	.131	.145	-.209	-.264	.603**	.036	-.367*

*Correlation significant at .05 level (2-tailed). **Correlation significant at .01 level (2-tailed)

Table 3 presents the significant bivariate correlations as relevant to their support or failure to support the research hypotheses. This figure does not present all significant correlations, only those particularly related to the hypotheses; significant correlations for the various theories are assessed in the discussion following the presentation of the linear regression results.

Table 3: Bivariate Correlations Significant to Hypotheses

	Correlations	*Theories*	*Support/Fail*
Hypothesis 1	Military Participation x Nuclear Share (-.494)	ToD	Fail to Support

The strong negative correlation between trade liberalization and energy consumption supports the argument that a disproportionate trading structure within a hierarchal global power structure favors core nations, consistent with both WST and EUE, and also provides evidence of the alignment of key actors in the ToP, which Mills (1956) described as power elite.

The strong negative correlation among trade liberalization and military participation supports the assertion that the pursuit of geopolitical objectives expands militarization and supports the assertion that the presence of nuclear energy may function to increase a state's bargaining power and allocation of resources, consistent with the geopolitical posturing of the ToD, and the concentration of power in a stratified global hierarchy, aligned with WST. Positive association among trade liberalization and nuclear shares also indicate the strong integration of nuclear nations in the global economy, which supports the WST argument that semi-peripheral nations reinforce core values (nuclear modernity) in the hierarchal global structure, and is also consistent with argument that economic liberalization accompanies civilian NCAs.

The moderate positive correlation among military participation and military expenditures supports the ToD in that larger modern armies have high investment in military spending, and consistent with the ToP argument that the MIC expands as it exacerbates consumption and environmental destruction. The influence of GDP per capita also provides evidence in support of WST, which argues that disproportionate per capita material consumption rates are typically characteristic of core countries (Rice 2007). In this context, the strong negative correlations between trade liberalization and both energy consumption and military participation provide supporting evidence for the hierarchal power differentials and disproportionate trading structure argued by WST and EUE. A moderate negative association among nuclear share and energy consumption supports the EMT argument that modernizing influences reduce consumption-driven environmental impacts.

Linear Regression

The results of the regression analysis of the nuclear energy producing nations are presented in Table 5. The unstandardized coefficients, absolute values of t-statistics, standardized coefficients, adjusted R-square, F-statistic, and sample size are provided. The predictors for the regression model consist of shares of nuclear energy production and military participation, and controls include military expenditures as a percent of GDP, GDP per capita, trade liberalization, manufacturing as a percentage of GDP, and urban population as a percentage of total population. As indicated in Table 5, military participation and GDP per capita positively affect primary energy consumption, with military participation demonstrating a strong influence. The influence of GDP per capita on energy consumption specifically supports the ToP argument that economic expansion

drives consumption-based environmental impacts, (Gould, Pellow, and Schnaiberg 2008). In an independent yet mutually interacting process, the influence of military participation on energy consumption provides support for the ToD. Thus, it seems more affluent nations and those with larger militaries consume larger quantities of energy.

Table 4: Regression Outcomes Significant to Hypotheses

	Correlations	*Theories*	*Support/Fail*
Hypothesis 2	Energy Consumption x Nuclear Share (-.444)	WST/EUE	Fail to Support
		EMT	Support
Hypothesis 3	Energy Consumption x Military Participation (.769)	ToD	Support

Given the cohort of primarily affluent nuclear energy nations in the sample, and the affects of military participation and GDP per capita on energy consumption, these results are not surprising, and are consistent with previous research in environmental sociology and political economy perspectives (Jorgensen, Clark, and Kentor 2010; Rice 2007; Gould, Pellow, and Schnaiberg 2008; Dietz, Rosa, and York 2007, 2003). Large military participation and affluence are consistent with high levels of energy consumption.

Table 5 ● Coefficients for the Regression of Primary Energy Consumption in Nuclear Energy Nations: Linear Regression Model

	Primary Energy Consumption (ln)
Share of Nuclear Production (% of total energy production)	-.011 (-1.236) [-.136]
Military Personnel (ln)	1.141*** (7.153) [1.04]
Military Expenditures as % GDP (ln)	-.497 (1.323) [-.146]
GDP Per Capita (ln)	.700*** (4.27) [.468]
Trade Liberalization (ln)	.531 (1.332) [.175]
Manufacturing	-.019 (-.526) [-.054]
Urbanization	.002 (.19) [.022]
Constant	-9.185* (-2.760)
Adjusted R-Square	.794
F-statistic	16.95
P-value for Overall Model	.000***
N	30

Notes: *p<.05 **p<.01 ***p<.001 (two-tailed tests); unstandardized coefficients flagged for significance; absolute value of t statistics in parentheses; standardized coefficients in brackets; p value for Constant is .011; Variance inflation factors (VIFs) and partial correlations available upon request.

The bivariate correlations, in the context of the linear regression model, provide interesting insights into the research hypotheses. Hypothesis 2 suggests that nations with large nuclear energy shares have elevated levels of energy consumption, yet bivariate correlations among nuclear shares and energy consumption suggest the opposite, and the regression outcomes provide no supporting evidence for this assertion. The correlations provide menial support for EMT, but the context of military participation and GDP per capita's strong influence on energy consumption largely detracts from the EMT argument; therefore the null hypothesis cannot be rejected.

Hypothesis 3 asserts that nations exhibiting greater levels of militarization have higher levels of energy consumption. The regression outcome supports this argument, as both military participation and GDP per capita exert a strong influence on energy consumption. This primarily supports the ToD, in that geopolitical objectives drive expanding militarization, increasing energy consumption. The strong negative bivariate correlations among trade liberalization and both military participation and energy consumption demonstrate partial support for the ToD in that larger military forces in economically conservative nations are indicative of the influence of geopolitical objectives in shaping economic and military policy, yet the multiple regression results do not. The influence of GDP per capita upon energy consumption supports the ToP in that capitalist expansion and the growth of the MIC increase consumption driven impacts. The strong correlation among military participation and military expenditures also provides insight into interplay among the treadmills, and their independent, yet mutually interacting influence in driving consumption and environmental devastation.

In consideration of the first hypothetical assertion that nations with large nuclear energy shares have elevated levels of military participation, the strong influences of affluence and militarization upon energy consumption yielded in the regression, while controlling for nuclear energy among other variables, provides support for the ToD. The strong negative association among military participation and trade liberalization in the context of the regression model is interpreted to support the ToD assertions that the geopolitical posturing of affluent states drives military expansion through investments in nuclear energy and qualitatively more destructive weapons (Hooks and Smith 2011, 2005, 2004). This argument also supports the extension of Gartzke and Kroenig's (2009) assertion that nuclear weapons status increases state influence in the international context, by suggesting that nuclear energy bolsters the bargaining power and resource allocation of states, through the securing of more propitious trade agreements.

In highly consumptive affluent societies, military participation is high, but greater investments in nuclear energy production and conservative trade liberalization are associated with lower military participation. This supports the ToD, which asserts that geopolitical objectives drive advanced militaries to commit larger qualitative investment in R & D and technology, while shrinking in quantitative spatial occupancy. Furthermore, the moderate negative trade liberalization associations with energy consumption and military participation provide insight into the unequal core-periphery economic exchanges within the world-system. Military participation yields a strong positive association with primary energy consumption, supporting both the ToD and ToP, while additional correlations suggest distinct differences between the two. A strong negative association among military participation and nuclear share reveals evidence of

the distinct investment in technology and arms races of the ToD, and provides support for the assertion that risk-transfer militarism attenuates the quantitative spatial occupancy of modernized militaries. This association also supports the assertion that nuclear energy may function to increase a state's bargaining power and allocation of resources, consistent with the geopolitical posturing of the ToD, and the concentration of power in a stratified global hierarchy, aligned with WST.

Chapter V

DISCUSSION AND CONCLUSION

This research sought to examine the relationship between nuclear energy and militarization in order to test competing theories of military growth and the influence of modern technology. The results of the regression analysis reveal that national military participation and GDP per capita exert strong influences on primary energy consumption, supporting both the ToD and the ToP. The bivariate results provide partial support for the regression outcome, and provide insight into independent yet mutually interacting roles of the ToP and ToD. Significant bivariate predictors, which lose significance in the regression model, indicate the interacting influence of the regression predictors. GDP per capita had no bivariate significance yet is significant in the regression, and two variables which were significant and negative in bivariate correlations - nuclear share and trade liberalization - are non-significant in the regression model. Military expenditures are positive and significant in the bivariate tests but non-significant in the regression model. These results suggest that nuclear share and trade liberalization are likely made significant through either military participation or GDP per capita. The non-significance of nuclear share in the regression, and significant bivariate correlations, indicate the potential influence of military participation.

Expanding militarization through investment in nuclear energy and technology has been predicated to enhance ecological destruction. Mutually, yet independently, the MIC and capitalist expansion exacerbate the ecological destruction, in stratified global hierarchy of nation-states that perpetuate environmental inequality through ecologically unequal exchange. The results presented here support the tenets of the treadmill of production, treadmill of destruction, world-systems theory, and unequal ecological exchange, while garnering minimal evidence in support of ecological modernization theory. The fundamental arguments of EMT run counter to the other theories presented, further weakening the position that the modernization of social, industrial, and economic institutions will function to reduce ecological degradation.

Emphasis is again placed on the fact that such an esoteric investigation has obvious limits due to sample size, being that only thirty nations have established and confirmed nuclear share figures. The overwhelming disparity in affluence and consumption of the United States is a vital element to acknowledge, in terms of its limitations to the results, but more substantively as an insight into global inequality and hegemony. Given the small *N* and the disparity in non-nuclear energy consumption by two of the largest global consumers (U.S. and China), this data sample and empirical method seem to render hypothesis 2 as an objectively inappropriate question. A more appropriate test for the hypothesis that nations producing larger nuclear energy shares consume larger amounts of energy would compare differences in energy consumption in both nuclear and non-nuclear nations. Another way to test this hypothesis is an analysis of the longitudinal patterns of energy consumption, prior to and after the onset of nuclear energy production. Additional quantitative research in this area should focus on

identifying the specific contours of geopolitics, arms races, and risk-transfer militarism in the stratified global hierarchy. Another interesting investigation might include a longitudinal analysis of state resource allocation and bargaining power, prior to and after the onset of nuclear energy production, providing greater insight into the interaction of geopolitics and nuclear energy, in the context of expanding militarism and environmental destruction. Subsequent analysis into the independent yet mutually interacting treadmills would benefit from an examination of the connections between geopolitical posturing, the MIC, and the power elite.

The MIC and economic expansion of capitalism in the ToP drive energy consumption, enhancing environmental destruction, and simultaneously, the ToD expands through geopolitical maneuvering and arms races. A primary point of analysis in the intricate connections among these two processes must include the role of Mills' (1956) power elite and the TNCs identified by WST and EUE (Jorgensen and Clark 2009; London et al. 2009; Frey 2003). It is useful to contemplate how the symmetrical achievement of geopolitical and economic objectives, expanded through both the MIC and hegemonic arms races, benefits twofold the goals of capital expansion, and commanding elites. The achievement of geopolitical objectives through arms races secures access to scarce natural resources which expand the treadmill, while arms races necessarily facilitate the growth of the MIC in order to maintain hegemonic dominance through modern warfare, all of which severely enhances environmental destruction. Simultaneously, the ecologically unequal exchange in the world-economy benefits treadmill elites in core nations, who maximize resource extraction and externalize

environmental costs through transferences of hazardous products, wastes and processes to the periphery (Jorgensen and Clark 2009; London et al. 2009; Frey 2003).

Through modern risk-transfer militarism, mass media and public opinion, controlled by elites, are manipulated in order to legitimate war in the West (Shaw 2002). Elites who direct TNCs are more likely to maintain and limit environmental damage to their homeland nations, which support the elite structure and propagate the world-system (Rice 2007; Gotts 2007). This is a double transfer of risk via elites, who manage public opinion of the legitimacy of war while externalizing hazardous environmental wastes to the periphery, conceivably in or near the zones of conflict. This highlights the vital role elites play in both the ToP and ToD. It is logical to conclude that both of these processes are driven at least in part by the power elite and TNC class.

The role of power elites and TNCs in propagating the global capitalist economy and the new Western way of war is particularly important when considering their insularity from institutional constraints, and the legitimized displacement of responsibility concomitant with the maximization of corporate profit. The institutional contradiction of corporations in the U.S., for example, binds corporations in a legal obligation to shareholders, which is to act in the interest of the corporation, specifically by making profits (Hinkley 2002). This in combination with the likelihood of elites to maintain and limit environmental damage to their homeland nations (Rice 2007; Gotts 2007) results in devastating outcomes for the periphery. Risk-transfer militarism and the ToD define the new Western way of war, and the institutional contradictions of corporations and the role of elites shape the global capitalist economy.

The construction, power price, and operational risks of nuclear energy (CitiGroup Global Markets 2009) are manifest financial risks of global nuclear energy development. The manifest security risks of nuclear energy production are an explicit concern, but the latent outcomes of expanding militarization and arms races, although perhaps more subtle, are qualitatively more dangerous for global security and stability. Comprehensively, there is no substantive evidence of a benefit from the global spread of nuclear energy, and significant evidence of negative consequences, both environmental and social. Even peaceful civilian NCAs, which must be heavily subsidized by governments because of financial precariousness, pose a substantial threat of nuclear proliferation (Fuhrmann 2009). As the global hegemon, the West, and specifically the United States, has a major role in shaping the global polity, and both the manifest and latent risks of nuclear energy must be weighed against the benefits of nuclear energy production.

Since the 2011 failure of the Fukishima reactor in Japan, several nations including Germany, Switzerland, and most recently Belgium have chosen to opt out of nuclear energy entirely (Levitan 2011). This choice has interesting implications for analysis through both the ToD and EMT. Would a reduction of investment in nuclear energy production influence militarization and consumption? Does EMT consider this move de-modernization, or an alternative modernization, and will it function to reduce consumption-based environmental impacts? More significantly, how will these choices influence the global perspective on nuclear energy production as a viable alternative to fossil fuels? The nuclear fallout occurring in Japan has been measured all over the world in samples from areas as far as California, Alaska, Hawaii, New York, and Canada

(MacKenzie 2011), indicating the global risk of a single reactor failure. Will the choice of these Western nations to opt out of nuclear energy create a global disjuncture between nuclear and non-nuclear energy producers?

A recently proposed collaboration between the U.S. and the Russian Federation, the construction of a nuclear powered space ship, has interesting implications for the future collusion of militarism and nuclear energy (BNO News 2011). What is the specific relationship between nuclear energy, modernization, and militarization? Does militarization in atomic nations increase at a different rate than in non-atomic nations, and is it distinctly qualitative military growth? Given the historical negligence of military institutions regarding environmental safety, and the intricate connection between atomic energy programs and military institutions, this research has sought to uncover insight into a vital socio-environmental issue. Atomic energy production provides a vital point of intersection for and analysis of consumption, modernity, militarization, and socio-environmental outcomes. A sound case for promoting atomic energy, as even a supplementary energy source, is precarious. Given the modernizing function of both militarization and nuclear energy, and the inherent relationship between them, there arise distinct ecological threats that have an immensely destructive capacity.

It is evident that the environment is tertiary to national military objectives, yet the interrelationship between the environment and militarization is distinct. The auspices of the Department of Defense can be interpreted from their annually intensified attempts at gaining broad environmental law exemptions, demonstrated in the U.S. Government Accountability Office's (2008) report to Congressional Committees: "DOD has not presented a sound business case demonstrating a need for the proposed exemptions from

the Clean Air Act, RCRA, and CERCLA to help achieve its training readiness and requirements." Ultimately Nietzsche's introductory quote imbues a very important maxim: Does the global order conceive nuclear power and mastery over nature as expressions of strength, and do those symbols translate to modernity? Has the popular morality separated strength from the expressions of strength?

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