THREE ESSAYS ON REGIONAL POLICY ANALYSIS AT DIFFERENT REGIONAL SCALES WITH VARIOUS METHODOLOGICAL APPROACHES

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Three Essays on Regional Policy Analysis at Different Regional Scales with Various Methodological Approaches

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Regional policy analysis requires an appropriate method that is tailored to a specific region because of differences in demographics, policy purpose, and the direction of policy. Each policy can be analyzed through different methods or viewpoints on how to approach the problem. This dissertation attempts to narrow the literature gap by developing computational tools to analyze regional policy at different regional scales. This dissertation includes three essays on different policy issues, each of which is analyzed using a different method.

In the first chapter, for which the regional scope is the county, I investigate the impact of tax incentive policy using an agent-based modeling (ABM) approach. In 2013, Governor Cuomo introduced the policy START-UP NY (New York), designed to create more jobs by helping people start or move their qualified business into tax-free zones. Measuring the impact of START-UP NY, however, is difficult because the data are not yet available for causal inference purposes. The agent-based model developed for this chapter is designed to simulate the impact of START-UP NY on the local economy of Tompkins County. The simulation results show that ensuring a stable demand for firms' output is more critical for firms to survive than the kind of tax exemptions offered by START-UP NY.

The second chapter expands the regional size to the national level and analyzes the impact of reducing military expenditures using a computable general equilibrium (CGE) model. Military spending is an essential budget item because it is directly related to national security. Unlike the literature, this thesis does not analyze the relationship between defense expenditures and economic development. Instead, I develop a CGE model to analyze how various industries are affected by defense expenditures, and to identify industries for which increased government expenditures would improve household wellbeing when defense expenditures are reduced.

The final chapter analyzes international regional policy to explore the relationship between peace and trade using a structural equation modeling (SEM) approach. In this paper, I explore the impact of peace on trade and vice versa using a SEM approach. I conduct a SEM analysis using the Militarized Interstate Dispute dataset. I propose two latent variables—peace and trade—to investigate the relationship between the latent variables and the indicators. I found that there is a reciprocal effect between peace and trade. In addition to analyzing the relationship between trade and peace, I extend the dataset to include observations up to 2010, which has not been done before. I show using the new dataset that the relationship between trade and peace has remained stable in the decades between 1990 and 2010.

BIOGRAPHICAL SKETCH

Woosung Kim was born in Seoul, South Korea. He received his Bachelor’s degree from the University of California, Irvine, in 2009. Subsequently, he was awarded a Master of Arts in Regional Science from Cornell University, Ithaca, New York, in 2012. His master’s thesis was titled “Economic impact of multifunctional administrative city construction: Interregional social accounting matrix approach.” He began his doctoral studies in Regional Science at Cornell University in the fall of 2012, and will receive his Ph.D. degree in August 2020. He is married to Song Yi Jeong, and has two children: Aiden Jiyul Kim and Kylie Ayul Kim.

Dedicated to:

My love, Song Yi Jeong; my precious children, Aiden and Kylie;

and to my parents and parents-in-law, Jae Soon Kim, Young Jung Kim, and Sook Keun Oh

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CHAPTER 1

DOES START-UP NY PROMOTE FIRM FORMATION?

1.1 Introduction

The formation of new firms is a preponderant factor contributing to economic growth and development. Just like a drop of water rippling widely, a new firm contributes to economic development by creating new jobs. Various policies have been introduced to promote startup businesses that the government expects to promote economic development goals. Four local economic development strategies have been discussed widely: 1) reindustrialization to stimulate economic growth through government aid to revitalize and modernize aging industries and to encourage the growth of new ones; 2) tax incentives to help industries through tax exemptions; 3) free market policy that promotes the open market; and 4) industrial policy that regulates businesses based public safety and the protection of industry (Leigh & Blakely, 2013). Among the four strategies, a tax incentive policy is specifically designed to promote local economic development through the formation of new firms, which, in turn, motivated New York's 56th Governor, Andrew Cuomo, to introduce START-UP NY in 2013, to help start, expand, or relocate qualified businesses to a tax-free zone.

START-UP NY is an economic development program of the Empire State Development (ESD) Corporation, which is New York State's organization for economic development and urban development. The policy provides participating firms with various tax exemptions from, for example, property taxes, income taxes, sales taxes, or business taxes for ten years, which support entrepreneurship and innovations (Haufler, Norbäck, and Persson, 2014).

The intent of START-UP NY, is to stimulate the local economy through economic development zones, which ESD anticipated would create more jobs and revitalize communities through the formation of new firms (Birch, 1979).

Nationally, Stangler and Kedrosky (2010) show that the rate of new firm formation is essentially constant in the United States. That is, the number of firm formations has been stable over time notwithstanding the changing economic environment. The following figure was adopted from Stangler and Kedrosky (2010) and represents the very stable level of firm formation from 1977 to 2005 in the United States.

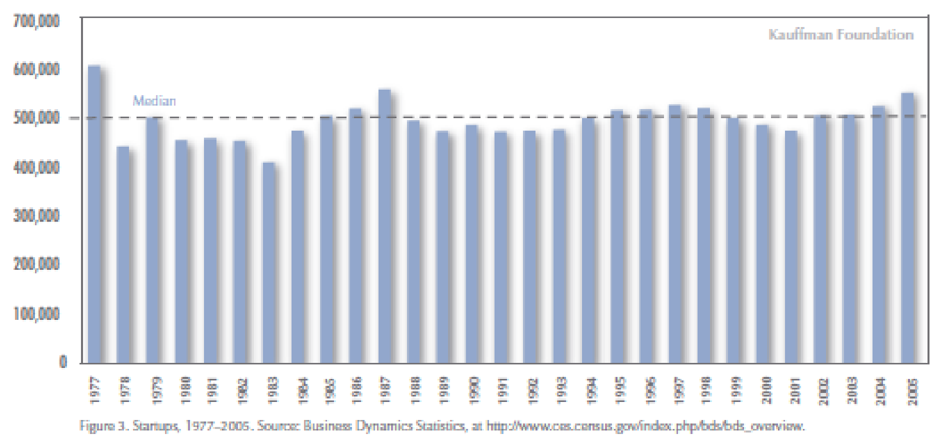


Figure 1.1 Formation of New Firms in the United States (Adapted from Stangler and Kedrosky [2010])

In Figure 1.1, we observe that the level of firm creation is stable across time at the level of 500,000 new firms annually.

Smith (1776) observed that entrepreneurship influences economic development and sustains economic growth. More recently, Berry (1989) argues that a high rate of firm formation is essential for economic development. According to Berry (1989), anything that adversely affects firm formation also adversely affects economic development. However, Berry (1989) along with many other scholars, also noted that firm birth and death are necessary conditions for innovation and the growth of new markets. While interest in creating new companies may increase because of the opportunity to make money, there is always the risk of losing money.

Local economic development is an essential policy for all types of municipalities, including cities, towns, and counties, with diverse size and goals (Friedman, 2005). Therefore, each local government has a different set of policies depending on their goals. Thus, scholars and policymakers have suggested various perspectives and approaches for local economic development. START-UP NY is expected not only to create more jobs and benefit other industries but also to generate the revenues needed for infrastructure improvement projects.

In this thesis, I develop an agent-based model (ABM) to investigate the impact of START-UP NY on new firm formation in Tompkins County, New York. The ABM has been used to explore and understand the properties of complex social systems through computer simulations. ABM combines induction and deduction, starting with a set of assumptions, then generating data to be analyzed using standard methods of causal inference. The ABM is not a deductive method of theorem proving, but instead generates data from a specified set of rules (Axelrod, 1984).

In his book “Methods of Interregional and Regional Analysis,” Isard (2017) discusses several channels of syntheses made possible by regional science methods.

Specifically, the combination of the social accounting matrix (SAM)[1] and econometric methods, as well as other fusion methods. In this thesis, I utilize data from the Impact Analysis for Planning (IMPLAN[2]) database for Tompkins County to generate ABM simulations. I will show ABM simulation results depicting the formation and performance of startup businesses and incumbent firms for different combinations of demand and entry levels. In doing so, I demonstrate the efficacy of START-UP NY in promoting new firm formations.

1.2 Literature Review

There are three stages of local economic development: business attraction, business retention, and broader community economic development. The first stage focused on the attraction of mobile manufacturing investment—hard infrastructure investment—which in the United States was executed from the 1960s to the early 1980s with notable success. The second stage focused on the retention and growth of local businesses between the 1980s and the 1990s. Some results were achieved. These early stages, while focusing on inward investment attraction, did not target specific sectors or designated areas.

The third stage focuses more on establishing the industry complex to create synergy in the business environment than operating firms individually. Its focus is on

[1] Social accounting matrix (SAM) is a model to analyze national income and product accounts, which recognizes the interdependence among producers, markets, households, and other economic actors (Isard et al. 1998). A SAM has three main parts: production activities, institutions, and factors of production. Production activities produce commodities using raw materials, intermediate goods, and factor services. Commodities are supplied from domestic producers and imports and are then shipped to customers, including for export. Institutions comprise households, companies, and the government. Factors of production include labor, land and other natural resources, and capital.

[2] IMPLAN (Impact Analysis for Planning) is software for economic impact assessments developed and maintained by the Minnesota IMPLAN Group (MIG). (https://www.implan.com)

soft infrastructure investment, public/private partnerships, networking, and competitive advantage of local areas.

START-UP NY focused on the first two stages because tax incentive policy was dealt with in the first stage while encouraging the establishment and extension of the company, such as the extension of a product, customer franchise, company expertise, and brand distinction, which are part of the retention and growth strategy of the second stage.

1.2.1 Local Economic Development Strategy

The most common strategies for local economic development, according to Bartik (2003), are tax incentives (citywide or in designated zones); job training programs; customization based on the needs of individual firms of industries; community development corporation; and microenterprise programs.

Kemp (1987) notes that local governments offers many types of incentives to achieve successful and stable operation of businesses without increasing taxes. START-UP NY is related to enterprise zone programs (EZPs) and small business development. In particular, EZP makes use of tax incentives to target small, new, and existing companies for expansion and relocation.

1.2.2 Firm Survival Research

Lee, Lim, and Suh (2014) researched the survival strategy for establishing startups through 200 sample surveys of young entrepreneurs using regression analysis. They categorized the success factors affecting survival according to psychology, background, and strategy. Motivation and desire for accomplishment belong to the psychological factor; experience and capital belong to the background category; and managing ability and a better revenue model are strategic factors. Lee et al. (2014) use factor analysis with the following identified factors: social network, business performance, founder competency, sufficient cash flow, and innovative business model. They recommend that young startups and founders focus on fulfilling customer needs and developing a social network to share information in the short term.

Lim, Ribeiro, and Lee (2008) explore factors affecting a business's performance in order to establish a tool to evaluate firm performance. To do this, they categorized factors into six groups: the idea of business; the influence of the firm's department; the area of production and technology; human resources; strategy; and capital. They introduced an objective method to evaluate the performance of a business. Finally, they noted that a larger sample size has a limitation; thus, they suggest using more quantitative data to create a better objective tool to evaluate firm's performance.

Giardino, Wang, and Abrahamsson (2014) discuss similar factors affecting firm operation but investigate reasons for the failure of startups through their case study and mention that startups must practice before establishing their businesses to avoid failure because one failed project means closing the company. Additionally, they argue that most startups fail because of self-demolition instead of competition with other firms. Incumbent firms have fewer considerations for networks, production, and customers because they already experienced the challenges startups are facing

(Giardino et al., 2014). Moreover, Blank (2013) analyzes that startups fail because of a lack of experience and technology rather than a failure to secure customers.

Human capital investment improves employees' performance and improves a firm's performance. Arthur, 1994; Bishop, 1994; Blanch-flower & Osward, 1998; Brudell & Preisen-dorfer, 1998; Boselie, Paauwe, & Jansen, 2001; Van Praag, 2002). Bosma, Van Praag, Thurik, and De Wit (2013) emphasize the importance of investment in human and social capital, hypothesizing that higher levels of human social capital are a driver for improved performance, and conclude that levels of human and social capital are associated with better individual and firm performance.

Since research on firm formation is of global interest, similar studies have been conducted in many countries. Shin, Park, Choi, and Choy (2017) investigated factors that drive the survival of small- and medium-sized enterprises, especially biotechnology firms in South Korea. They sort factors into two types: internal and external. The origin of a firm and the business sub-sector are internal factors; while external factors include government R&D funding and strategic alliances. To be more specific, the origin of a firm represents work experience, and the business sub-sector represents two types of business: platform-based firms and product-based firms. For external factors, government R&D funding and strategic alliances are related to outside factors that affect firms. Shin et al. (2017) hypothesize that both internal and external factors lower hazard rates for the firm's survival. Their analysis is from 2005 to 2012; and they use the Cox proportional hazards model for survival analysis. For the biotechnology sector they found that internal factors are positively related to hazard rates for the firm's survival, but only government R&D funding in external factors is negatively related to a firm's hazardous survival rates.

In Taiwan, Wang (2006) investigated factors affecting new firm formation through cross-sectional and time-series data for the period 1986–2001. He used a fixed effects regression model with the following equation:

$$NF_{it} = \alpha + \beta_1 D_{it} + \beta_2 W_{it} + \beta_3 E_{it} + \beta_4 R_t + \beta_5 U_t + \beta_6 G_t$$

where NF_{it} is the number of new firms created; D_{it} is real GDP as a proxy of the level of demand; W_{it} is the average of employees' salary; E_{it} is the number of persons employed; R_t is the real interest rate; U_t is the unemployment rate; and G_t is the economic growth rate to represent the health of the economy. Wang concludes that new firm formation positively contributes to lower unemployment rates by creating more jobs and to higher economic growth rates by promoting economic production. However, he could not obtain statistically significant evidence for other factors at the confidence level of 90%.

The literature has investigated factors affecting firm survival; i.e., more networks, technology, human resources, strategies, and capital positively affect formation. Additionally, the policy to stimulate entrepreneurship is of global interest. Although scholars have discussed policies to evaluate, this paper anticipates policy using ABM, which will use the aforementioned factors as simulation variables.

1.2.3 Tax Incentives

Tax incentives are commonly used as an economic development strategy in the United States. Eberts (2005) overviews economic development policy for USA local and state governments. A tax incentive is economic development policy, and Eberts argues that promoting business climate is most efficacious to achieve economic development, suggesting that it could improve local economic development by analyzing such US development policies.

Elvery (2009) studies the impact of tax incentives offered in California and Florida by examining enterprise zone programs (EZPs), especially the effects on employment. To ascertain the effects of EZPs, Elvery uses estimation steps. Unlike traditional methods that have find the effect of EZPs by estimating relationships between the wage as a dependent variable and individual-level data (e.g., school years, skills) as a treatment variable, Elvery uses an independent variable at the neighborhood level to explore the effects of EZPs. For the EZPs of California and Florida, Elvery finds no evidence of the effects of EZPs on resident employment.

Bondonio and Greenbaum (2007) investigate the relationship between tax incentives and economic growth. They use an econometric method to analyze the data from the District of Columbia and 10 states (CA, CT, FL, IN, KY, MD, NJ, NY, PA, and VA). They observe that EZP influenced economic development, especially by increasing the number of employees and sales, and that EZP affects incumbent firms more than newly established ones. Bondonio and Engberg (2000) used two different econometric methods to evaluate EZP and investigate their impact on employment.

An EZP is a geographically targeted policies, and an EZP is a location where government authorizes a tax reduction or regulatory exemptions. Their econometric methods include collected panel data from diverse sources related to an EZP, and the Census Bureau and the Department of Housing and Development of five states: California, Kentucky, New York, Pennsylvania, and Virginia. They compare zones with EZPs and zones without EZPs. Notably, zones with or without EZPs are distinguished by zip code levels to evaluate the impact of EZPs. Bondonio and Engberg (2000) use a random growth rate approach and a propensity score approach. The former addresses the non-random assignment of zone status and estimates job growth rate for two types of sample selection. The following equation is used:

$$\Delta LnY_{ii} = \alpha_i + \beta_i t + \varphi_t + \delta EZ_{it} + \lambda EZ_{it}^{*} pol_{it} + \varepsilon_{it}$$

The second approach manages the selection bias problem. They found that results differ across the states, so that whether EZPs affect local employment remains unclear. Additionally, they find that the estimated random growth rate increased only once between 1981 and 1984. Moreover, the results from the propensity score approach show that the employment growth rate in zones with EZP is lower than the annual employment rate. Thus, they conclude that no evidence indicates that EZPs affected local employment.

Neumark and Kolko (2010) explore the impact of EZPs in California on job creation. Unlike the previous studies, they use a geographic mapping method, and draw precise EZP boundaries by using a geographic information system software instead of zip codes and census tracts, and then estimate employment rates and established numbers of businesses. Neumark and Kolko find no evidence that EZPs increase employment. In their paper, they discuss that it is difficult to derived the results. This is the reason why I chose to use ABM in this thesis to explain how tax incentives improve economic development and what tax incentives can affect.

Ham, Swenson, İmrohoroğlu, and Song (2011) also investigate the impact of an EZP and use the estimation approach to evaluate the impact of State Enterprise Zones (ENTZs), Federal Empowerment Zones (EMPZs), and the Federal Enterprise Community (ENTC). They investigate seven US states: California, Florida, Massachusetts, New York, Ohio, and Oregon. Ham et al. (2011) used disaggregated market data to estimate the labor market impact of EZPs, especially in the 1990s, on the unemployment rate, the poverty rate, the fraction of households with wage and salary income, average wage and salary income, and employment. To obtain more significant results, they use the average national effects as an instrumental variable. Unlike Newmark and Kolko (2010), Ham et al. (2011) found all three programs significantly and positively affect local labor markets.

Phillips and Goss (1995) investigate the effects of tax incentives on economic development using meta-regression analysis, an improved version of meta-analysis to summarize results from multiple empirical studies on a particular topic, namely, tax elasticity. Their objective was to explore the size of the effect of tax policy. Due to the shortcomings of meta-analysis, i.e., only summarizing the method of empirical data, the authors use a meta-regression analysis to provide more precise estimates of the impacts. Phillips and Goss reexamine Bartik's results (1991), which asserts that a tax reduction strategy affects the increase of business activities despite its enormous costs; finding effects of tax incentives on economic development. They also found evidence that tax policy affects economic development, although they could not determine the size of the tax policy effect. By estimating tax elasticity, they found that tax policy has a greater effect within a metro area and a lesser effect across interstate and inter-metro areas.

Braunerhjelm and Eklund (2014) investigate the relationship between regulations and firm formation. They found that while regulations lower new firm formation, networks positively affect new firm formation. They argue that reduction in the tax administrative burden decreases market entry. That is, a lower tax rate promotes the opening of more businesses. They used the following equation to estimate the relationship between market entry and tax:

$$\ln\left(Entry_{jt}\right) = \alpha + \beta_1\left(\ln(Tax\ adm.burden)_{jt}\right) + \beta_2\left(\ln(Tax\ rate)_{jt}\right) + \beta_3 X_{jt} + \varepsilon_{jt}$$

where X_{jt} is a vector of country j's control variables: growth, GDP per capita, and entry costs. They conclude that tax administrative burden lowers the intention of opening a business.

Most research on tax incentives has used econometric methods and evaluated previous outcomes. However, this paper utilizes ABM to capture firm behavior firms and potential entrepreneurs. Through using ABM, we can estimate not only the relationship between tax policy and firm formation but also the size of the effect of tax policy. Therefore, ABM can help to anticipate the impact of tax policy; thus, ABM is a superior methodology.

1.3 Methodological Approach

1.3.1 Model Setup

I develop a model to investigate the impact of START-UP NY on new firm formations using ABM simulations. In an ABM, agents represent various decision-making units, specifically investors, startups, and incumbents, which interact as autonomous entities given certain conditions. Firm agents, in particular, survive or die (i.e., go out of business) based on their performance.

1.3.2 Initial Setup

The model has two different types of agents, namely, circles that represent incumbent firms and people that represent individuals preparing to open a business, at the initial setup. Reflecting the real world, incumbent firms represent firms, while people represent investors whose ultimate goal is maximize profit. However, the individuals' first goal is to open a new business. Firms maximize profits by selling their product, and individual agents likewise open a new business under favorable conditions. Firm output of produced goods is described by the Cobb–Douglas function in equation (1.1):

$$Y_{i,t} = L_{i,t-1}^{\alpha} K_{i,t-1}^{1-\alpha} \; for \; \alpha > 0 \tag{1.1}$$

where $Y_{i,t}$ is the output of each firm i at time t; L_i is the total amount of labor of firm i at $t-1$; and K_i represents the capital input of firm i to produce at $t-1$. In Equation 1.1, the total output of the firm at time t, is selected as the amount of input of labor and capital at $t-1$. The amount of labor and capital for each firm, and people, are assigned randomly at the initialization level. The minimum number of workers of an incumbent firm is 5, and the maximum number is 25. The capital is assigned between 100 and 300. Therefore, each firm has a different capacity to produce products. Moreover, people in the system have similar static state variables: labor, asset, education, experience, and links (networks) with other agents. The number of workers implies potential employees after opening a business and is assigned a number from 1 to 10. The minimum amount of an asset of each startup is 10, and the maximum is 50. People also have different education and experience levels. These variables determine the probability of opening a business, explained by Equation (1.2):

$$Pr_{i,t} = \frac{1}{2}\left(\frac{Exp_{i,t-1}}{MaxExp_{i,t-1}} + \frac{Edu_{i,t-1}}{MaxEdu_{i,t-1}}\right) \quad (1.2)$$

Equation (1.2) implies that an agent with more experience and education has a higher probability of opening a business. The range of education of each agent is 12 to 24 years; i.e., at least a high school education and at most a doctoral degree, and the range of experience is 0 to 20 years. Networks are be used when people open a business. A person with more links with high-tech companies tends to open a high-tech startup; otherwise, people tend to open a business of other industries besides a high-tech startup.

Firms must sell their products to maximize their profits, and each firm's profit is based on the following rule. Based on the assigned variables, namely, the number of labor, amount of capital, and the Cobb–Douglas function, firms produce output and must sell their products. Equation (1.3) explains profit (π), calculated as the difference between total revenue (TR) and total cost (TC), which includes a lump-sum tax (Tax):

$$\pi_{i,t} = TR_{i,t-1} - TC_{i,t-1} - Tax_{i,t} \quad (1.3)$$

where $TR_{i,t} = Y_{i,t-1}P_{t-1}$ and $TC_{i,t} = W_{i,t-1} + C_{i,t-1}$

In Equation (1.3), TR is a product of total output (Y) from Equation (1.1) and price (P); and total cost is assigned between 0 and 20% of the asset. It includes rent and miscellaneous costs. Moreover, demand and price are necessary to profit; thus, they are set at the different assigned range. Because every firm has a different level of demand, this factor is assigned based on initially, incumbent firms with demand between 70% and 160% of their outputs (Equation 1.4):

$$0.7Y_{i,t-1} < D_{i,t} < 1.6Y_{i,t-1} \tag{1.4}$$

Equation (1.5) represents the demand level of an incumbent firm when it survives after 5 years, that is, it has a more stable level of demand:

$$0.6Y_{i,t-1} < D_{i,t} < 1.5Y_{i,t-1} \tag{1.5}$$

Because startups have more risk and higher returns compared with incumbents, the former's range of demand is wider:

$$0.6Y_{i,t-1} < D_{i,t} < 1.9Y_{i,t-1} \tag{1.6}$$

The demand level changes after 60 periods as well for startups to express, that is, startups overcome an early stage's risk and then have stable operations by attracting customers.

$$0.6Y_{i,t-1} < D_{i,t} < 1.5Y_{i,t-1} \tag{1.7}$$

To set up agents' thresholds to open their business, I simulate the system at different levels of probability to open a business (Equation 1.2). Initially, the system sets the minimum threshold probability at 0.7; therefore, a person with a higher probability calculated by education and experience levels than 0.7 can open and operate a business in simulation.

Figure 1.2 is a captured screen of the initial setup in the NetLogo system, i.e., software that provides an environment for modeling of multiagent programming.

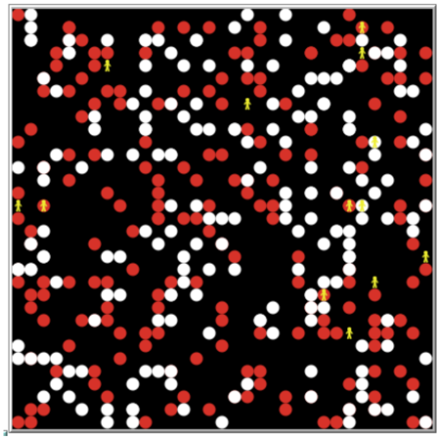


Figure 1.2 Initial Setup of the System

Red-colored dots represent existing high-tech firms, and white-colored dots represent other industries. Yellow-colored, human-shaped agents are potential entrepreneurs. When the setup button is clicked, the system initially creates three types of the agent. The ratios of high-tech and other firms are from the IMPLAN data for 2012 Tompkins County, based on 2012 data of IMPLAN, the total number of companies in Tomkins County is 9063, and the total number of employment is 63,232. I use the North American Industry Classification System to collect, and analyze statistical data related to the U.S. business economy. Table 1.1 summarizes industry details of Tompkins County at the two-digit level.

Description	Employment	Output
Total	63,232.08	8,278,229,953.06
11 Ag, Forestry, Fish & Hunting	1,192.43	91,104,741.70

21 Mining	675.69	130,893,651.01
22 Utilities	180.30	156,915,121.56
23 Construction	1,754.97	262,097,431.66
31–33 Manufacturing	3,320.47	1,467,306,785.15
42 Wholesale Trade	702.27	147,263,061.52
44–45 Retail trade	5,757.26	393,821,020.13
48–49 Transportation & Warehousing	887.81	93,176,409.90
51 Information	506.16	175,730,124.62
52 Finance & insurance	1,323.80	530,785,121.20
53 Real Estate & Rental	1,096.16	712,776,704.86
54 Professional: Scientific & Tech Services	5,490.67	591,082,897.19
55 Management of Companies	74.15	12,507,251.74
56 Administrative & Waste Services	953.41	71,901,079.89
61 Educational Services	15,843.06	1,712,609,664.92
62 Health & Social Services	7,005.93	544,979,658.13
71 Arts: Entertainment & Recreation	875.49	50,074,177.22
72 Accommodation & Food Services	5,798.55	471,705,371.86
81 Other Services	2,931.01	181,708,546.40
92 Government & non NAICs	6,862.50	479,791,132.41

Table 1.1 Industries Detail for Tomkins County (Adopted from IMPLAN 2012)

From Table 1.1, manufacturing and professional (scientific and tech services) sectors appear to benefit from START-UP NY because the policy has been designed to help high-tech industries to relocate or expand their businesses. Professional (scientific and tech services) sector represents industries such as architectural, engineering, computer systems design, scientific research, and development; additionally, manufacturing sectors in Ithaca produce several products related to high-tech products. Therefore, I aggregated the original 20 sectors into three sectors; high tech, others, and government. Table 1.2 contains the combined data. The high-tech sector comprises the manufacturing and professional-scientific & tech service sectors, while others represents the remaining sectors. In Table 1.2, the percentage of employees in the high-tech industry is 14%, accounting for one quarter of output of Tompkins County. Thus, high-tech industries are a major sector in Tompkins County.

Description	**Employment**	**Output**
Total	63,232.08	8,278,229,953.06
High Tech	8,811.13	2,058,389,682.34
Others	54,420.95	6,219,840,270.72
High Tech/Total (%)	0.14	0.25

Table 1.2 Summary of two sectors of Tompkins County

1.4 Algorithm Implementation

To describe the ABM, I use the ODD (overview, design concept, and details) protocol of Railsback and Grimm (2011). ODD overviews the model and how it is designed by explaining its purpose, agent characteristics, the process, scheduling, design concepts, initialization, input data, and the detailed sub-models. In the following sections I discuss three elements: (i) purpose; (ii) entities, state variables, and scales; and (iii) process overview and scheduling.

1.4.1 Purpose

The model's purpose is to assess how tax incentive policy affects startups and the total number of firms in the regional economy. I focus on the effect of different entry levels for startups, different demand levels, and the tax waivers program.

1.4.2 Entities, state variables, and scales

The model has two types of entities: individual agents and their network connections.

1.4.3 Process overview and scheduling

The model has three processes: (1) the creation of a new firm and the linking of people and startups to incumbent firms; (2) the formation of startups; and (3) the operation of companies. For the first process, in each period a newcomer enters the system and is assigned a random static state variable with a specific probability to open a new business based on the newcomer's background [see Equation (1.2)]. At the same time, incumbent firms and individuals who are potential business owners are assigned static state variables for the number of employees, the amount of assets, and the cost of capital needed to generate total output and profit.

In the second process, newcomers enter the system and attempt to open a business based on the probabilities expressed in Equation (1.2). Here, a person with insufficient experience, education level, and number of connections, cannot open a business and must wait until they achieve the minimum qualification. Once an individual meets the threshold, the person is transformed to a startup agent. Based on the number of links to incumbent firms, a startup then decides whether to become a high-tech startup. Specifically, an agent with more links to high-tech companies has a higher probability to establish a high-tech startup.

In the third process, firms and startups attempt to maximize profits using the assigned input variables [see Equations (1.1) and (1.3)] based on of the level of demand for their output [Equations (1.4)–(1.7)]. A period ends when all the aforementioned processes have been completed for all agents (Figure 1.3). Before advancing to the next period, firms with negative assets in three consecutive periods die (i.e., go out of business), implying that firms can only survive up to a maximum of three months without earning a profit.

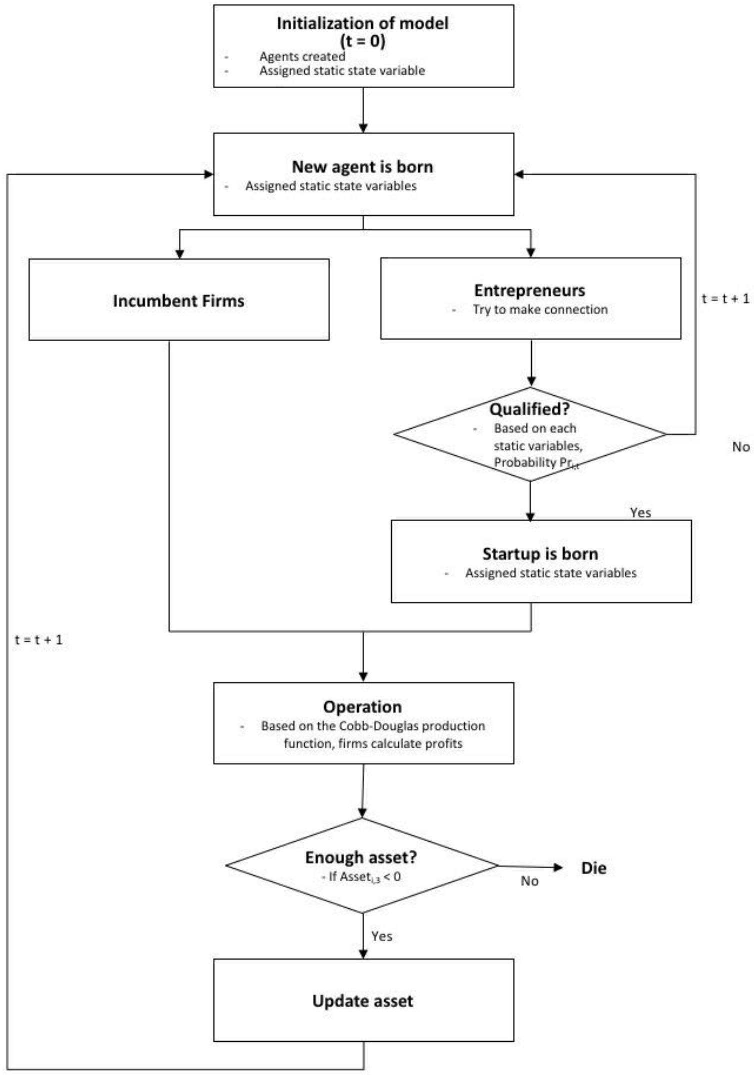


Figure 1.3 ABM flow chart

1.4.4 Simulation

Figure 1.3 above describes the first behavior of the system after one tick, which is the terminology used in the NetLogo program to represent one unit of simulation time. Surviving entrepreneurs create more connections to others; in other words, they attempt to have more relationships with others to expand their network. An explanation is that more connected individuals have a higher probability to open a new business. By contrast, a firm goes out of business if it fails to make a profit within three ticks, while a potential entrepreneur leaves the system when she/he does not have sufficient network connectivity.

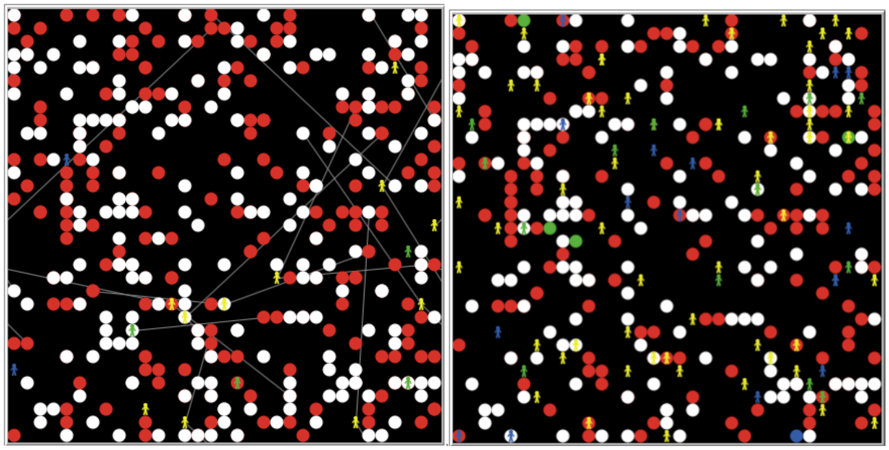


Figure 1.4 Simulated Screen

The left panel of Figure 1.4 represents the simulation result after one time period, while the right panel represents the result after a number of periods have elapsed. Shown are green-colored circles (representing high-tech companies that grew from startups) and one blue-colored circle (a low-tech firm from a startup) are observed.

The model allows for two possibilities to generate new agents: high-tech startups and other startups. High-tech startups receive a tax incentive benefit in the system tantamount to participating in the START-UP NY program.

At the beginning of the simulation, each agent is given a different set of attributes for education, work experience, and network connections. Additionally, demand for each firm is generated randomly between 60% and 140% of total output to mimic the different economic environments in which different firms operate. Each firm also is endowed with different amounts of labor, assets, and capital costs to produce output. Potential entrepreneurs have varying levels of education, years of work experience, assets, and network connectivity.

In each period, firms seek to maximize profits, while potential entrepreneurs attempt to connect to other agents in order to earn work experience. Potential entrepreneurs with more connections to the high-tech field have a higher likelihood of starting a new high-tech company.

1.5 Results

To compare and analyze the behaviors of agents in the system, I conducted simulations for different values of the model parameters: open chance, tax incentives, and degree of demand. I expect a lower level of market entry to adversely affect the number of firm formations, while tax exemption may help create new firms.

1.5.1 Tax Incentives

Because this thesis' main goal is to explore the impact of tax incentives, I compare the results between simulations in different conditions with different combinations of parameters which provide tax exemption or not to high-tech startups. Therefore, I first conduct an experiment to explore the impact of tax incentives, and then simulate a system with the level of open chance set at 0.7 while the parameter of the minimum demand of startups is set at 0.6. Thus, the range of demand for startups ranges between 60% and 190% of output because the default level of open chance is 0.7, which means investors in the system have to be educated and have the experience described in Equation (1.2).

Moreover, I simulate the system with different conditions with changing parameters: the parameter of the demand of startups 0.3 to 0.5, and the open chance is 0.3 to 0.7. The lower demand of startups implies the difficulty in starting a new business, while high demand of startups means having enough customers. Additionally, the lower level of open chance is a lower barrier to open a business in the system even though investors have a lower level of education and less experience, and the higher level of open chance implies a higher qualification to open a business. That is, I assume that the lower open chance reflects the situation of more investors opening their business, because START-UP NY may motivate more people to participate and open more businesses. Simultaneously, I also want to capture the impact of the change in demand for firms because startups must secure their sales to customers to operate a business. I conduct eight different experiments, and report figures below that contains the simulations results.

In my experiments, I vary the values of the minimum demand for startups, minimum demand for incumbent firms, and the probability of starting a business. I simulate the system with different combinations of variable values. Each parameter value is increased in increments of 0.1, while each simulation is repeated 200 times, each with a different random seed number. In particular, the range of the minimum demand of firms is between 0.5 and 0.7; the range of the minimum demand of startups is between 0.3 and 0.5, and the probability of open chance is between 0.3 and 0.7. The total number of possibilities is therefore 45 $(3 \times 3 \times 5)$. The reason for 200 receptions for each simulation is to have enough samples for the experiment. Thus, the total number of simulations run is 9000 (45×200). This is only for one scenario, whether a tax incentive is present, or not. Therefore, the grand total number of experiments is 18000 (9000×2). Each experiment generates 56 values for the total number of firms, total output, total demand, total assets, total revenue, total labor, total wages, total tax of firms, other startups, high-tech startups, other firms, high-tech firms, dead startups, and dead firms.

I explore four scenarios in these experiments. First, I assess the impact of a tax incentive on firm formation. Here, I expect that a tax incentive may increase the number. Second, the impact of the open chance is be explored. I expect that the lower open chance may increase the number of firm formations and may increase the firms. Third, I assess the impact of a changing demand for the output of startups and incumbent firms. I anticipate that higher demand contributes to an increase in the number of firm formations by having a stable income for firms. Finally, I explore the factors affecting the number of firms that exit the system (i.e., go out of business). I construct three hypotheses:

Hypothesis 1: Tax incentives will increase the number of new firms.

Hypothesis 2: Lower open chance will increase the number of new firms.

Hypothesis 3: Higher demand will increase the number of new firms.

First, I set the baseline model as follows: the minimum demand of incumbents is set to 0.6; the minimum demand for startup output is 0.4, and the open chance is 0.5. The range for the incumbent's minimum demand is between 0.5 and 0.7, in increments of 0.1. Thus, the three cases. Similarly, the minimum demand for startups is between

0.3 and 0.5, while the open chance parameter ranges between 0.3 and 0.7. I assume that the tax policy lowers the entry of opening a new business, that is, the open chance parameter in the system is lower. Therefore, I must set the baseline of simulations; thus, I use the mid-point of the range of the parameters mentioned above. Figure 1.5 shows the result of the simulation of two different scenarios, without a tax incentive and with a tax intensive, and describes the number of startups without a tax incentive or with a tax incentive.

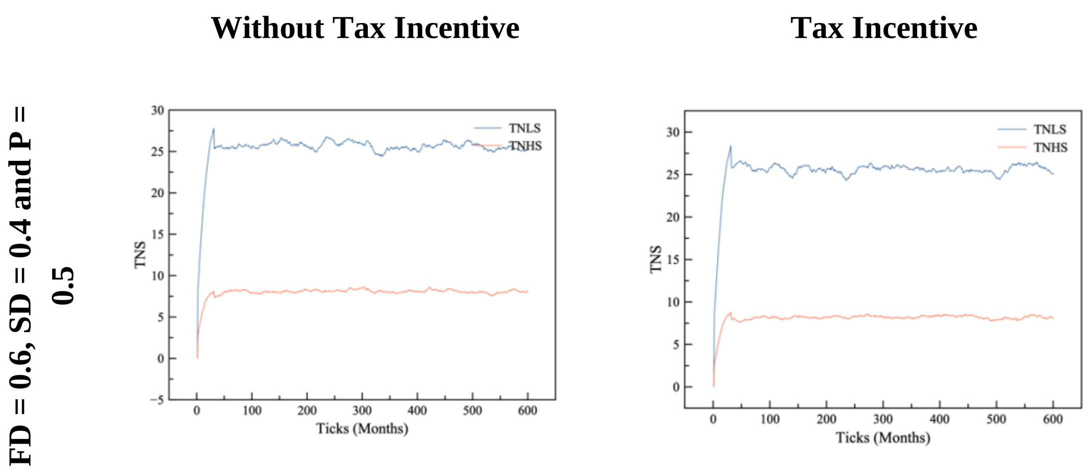


Figure 1.5 Total Number of Startups (FD = 0.6, SD = 0.4, and P = 0.5)

Upon comparing Figures 1.5 and 1.6, I observed that the level of creation of startups and firms is higher when the demand for startups increases by 8% (Figure 1.6). The number of startup creations in Figure 1.5 are about 25 (other industries) and 7.5 (high tech) and the number of startup creations in Figure 1.5 are about 30 (other industries) and 10 (high tech), shown by the top two graphs in Figure 1.5. The levels of creation firms from startups are 15 (other industries) and 5 (high tech) and the levels of firm creations from startups are 25 (other industries) and 7.5 (high tech). In other words, firm survival rate from startups is higher when they have stable demand.

Figure 1.5 depicts two simulations: the left graph indicates no tax incentive is in the system; the right graph demonstrates that high-tech startups receive a tax incentive for 20 years. In Figure 1.5, all plots taper off at some points. TNS in the y-axis represents the total number of startups, while the x-axis represents a unit of simulation time. Based on the results, I cannot say whether the tax incentive policy had an impact, because the patterns are similar. The red-colored line (Figure 1.5), which is the TNHS, represents the total number of high-tech startups, and the blue-colored line, which is the TNLS, represents the total number of low-tech startups. Although high-tech startups receive tax incentive in the simulation, a similar number of low-tech startups is created. Thus, I explore next the number of new firms transformed from startups. Figure 1.6 contains the number of new firms transformed from startups.

Without Tax Incentive **Tax Incentive**

FD = 0.6, SD = 0.4 and P = 0.5

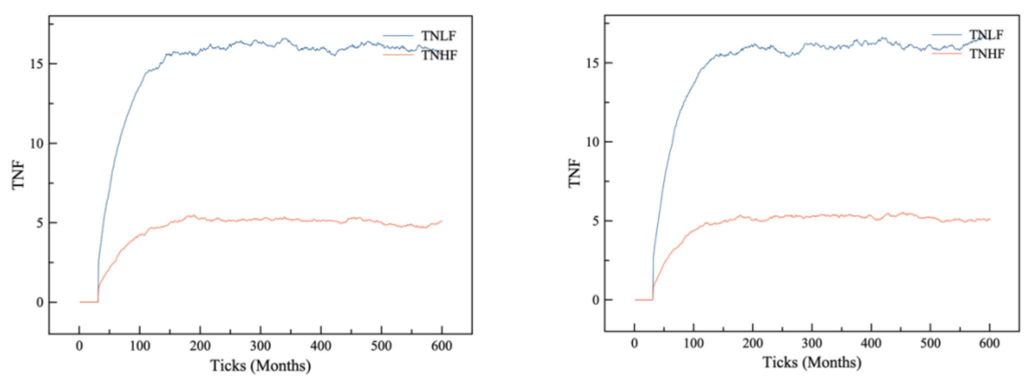


Figure 1.6 Number of New Firms from Startups (FD = 0.6, SD = 0.4, and P = 0.5)

In Figure 1.6, the y-axis represents the total number of new firms, and the x-axis represents the period (months). Red-colored lines (located below) on both sides (TNHF), the left and the right, represent the total number of new high-tech firms.

Figure 1.6 also indicates a “flattening off” in the number of new businesses. I have difficulty asserting that more high-tech firms are created under the tax incentive policy because the total number of firm formations with and without tax exemptions is flattening off at a similar level (Figure 1.6). Because I cannot find the reason why the level of firm formation is similar to the previous simulation (Figure 1.6), I explore the different results of the simulation, namely, the number of dead firms. Exploration of the impact of a tax incentive on the same parameter combination is also difficult. Thus, I posit that the lowering open chance or higher open chance can explain the psychological impact of tax policy because more people attempt to get into the market after a new tax incentive policy is introduced. Therefore, I compare the results under different values of the open chance parameter. I expect this experiment to capture the psychological impact of the policy, that is, the psychology of expectations.

To simulate the impact of the psychology of expectations, first, a new simulation includes a lower open chance, implying that more investors attempt to start a new business driven by the psychology of expectations. Investors may expect a more successful story after receiving information on the tax incentive policy. I expect more startups and firms will be established. Figure 1.7 contains two graphs that illustrate the number of new startups.

Without Tax Incentive **Tax Incentive**

FD = 0.6, SD = 0.4 and P = 0.4

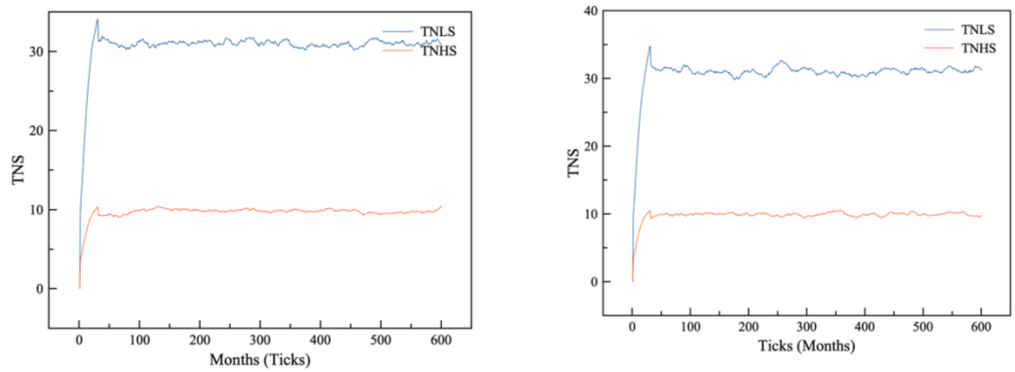


Figure 1.7 Number of Startups (FD = 0.6, SD = 0.4, and P = 0.4)

In the two graphs in Figure 1.7, more startups appeared in the system compared with Figure 1.5. By comparing Figure 1.5 and Figure 1.7, I observe that the number of low-tech startups are more created about 30 from 25, which means 20% more startups are created by decreasing 10% of open chance. Does this affect the number of new firms created? Figure 1.8 illustrates the number of new firm formations.

Without Tax Incentive **Tax Incentive**

FD = 0.6, SD = 0.4 and P = 0.4

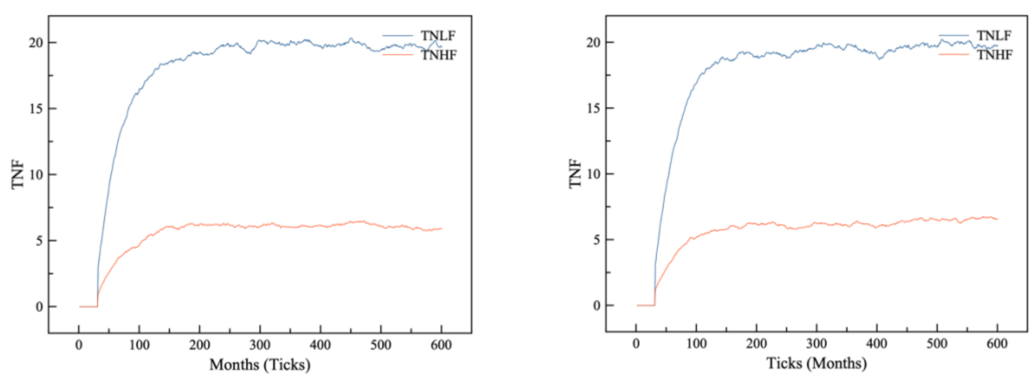


Figure 1.8 Number of New Firms from Startups (FD = 0.6, SD = 0.4, and P = 0.4)

In Figure 1.8, compared with Figure 1.6, on average, five more new firms are created when the open chance decreases by 10%; thus, entry to the market is lower.

Without Tax Incentive **Tax Incentive**

FD = 0.6, SD = 0.4 and P = 0.5

FD = 0.6, SD = 0.4 and P = 0.4

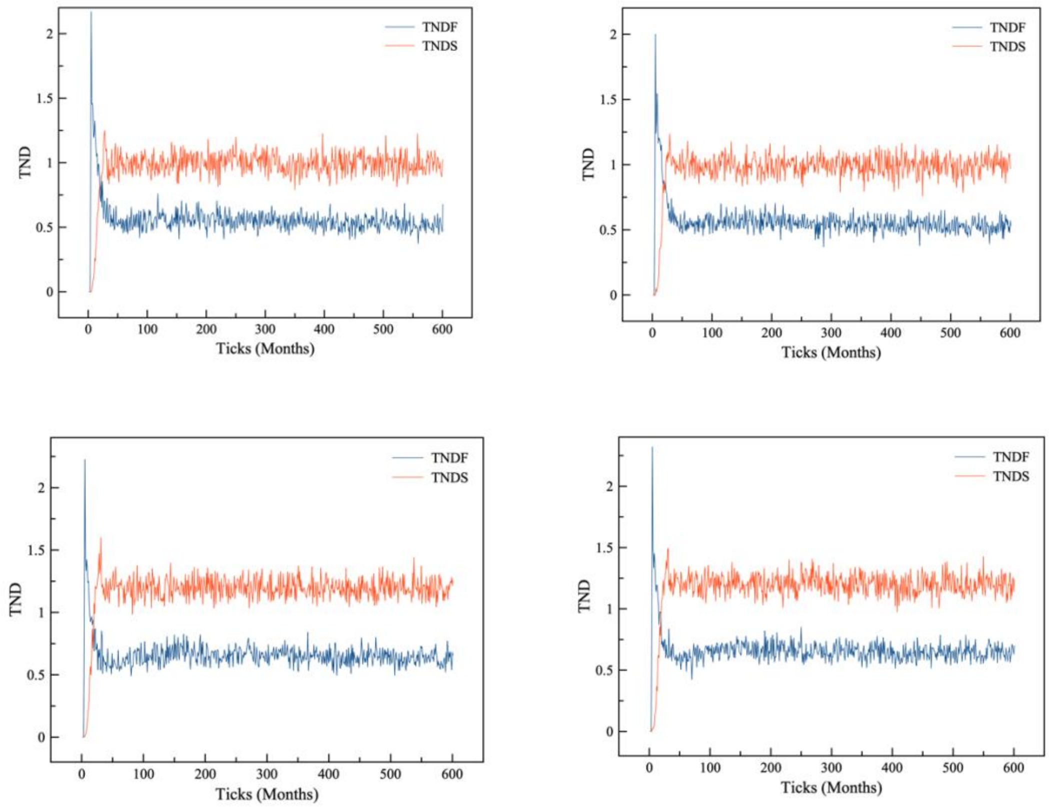


Figure 1.9 Number of Died Startups and Firms given Different Conditions

Figure 1.9 demonstrates the number of startups and firms that exit the system (i.e., went out of business). In Figure 1.9, the y-axis (TND) represents the total number of dead agents each month, and the x-axis represents the period. The two graphs in the first row are the results from the parameter combination with the minimum demand of firms at 0.6, the minimum demand of startup at 0.4, and the open chance at 0.5. The graphs on the second row in Figure 1.9 result from the same parameter combination with lower open-chance at 0.4. The TNDF, blue-colored and located below each graph, represent the number of dead firms each month, and the TNDS, red-colored and located above each graph, represents the number of dead startups each month. Comparing the two different simulations with different parameter combinations indicates more startups failed when the chance to get into the market was higher. As more investors enter the market, more investors lose their money because of their failures. Additionally, the levels of dead firms are similar compared with the top and bottom rows in Figure 1.9. Based on these simulations, I assert that agents in the system are able to operate their company after transferring to a firm because of stable demand. To explore the impact of lowering the open chance, I simulate another experiment by changing the open chance to 0.3, that is, lowering the entry level more.

Without Tax Incentive **Tax Incentive**

FD = 0.6, SD = 0.4 and P = 0.3

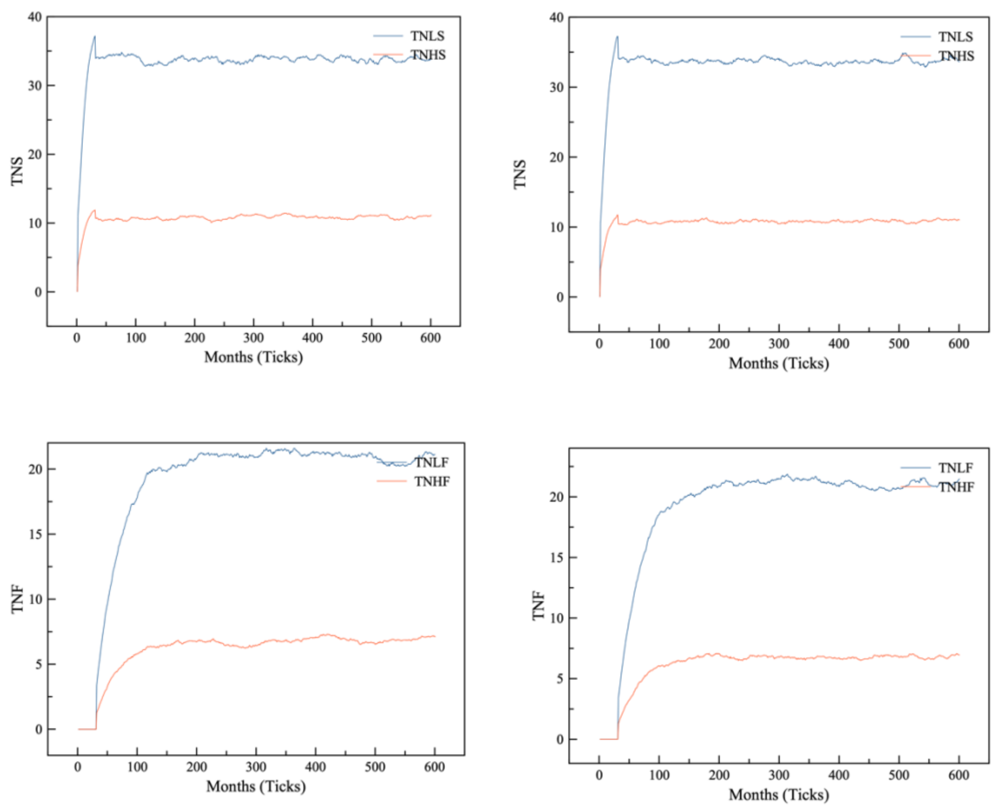


Figure 1.10 Number of Startups (FD = 0.6, SD = 0.4, and P = 0.3)

In Figure 1.10, the lowered open-chance increases the number of startups compared with previous simulations but does not affect the number of new firm formations as much as it affects startups in the graphs in the second row. I could assert that more investors can open more businesses, but survival and maturation of firms would be difficult. Figure 1.19 shows the results increasing the open chance to 0.6. As the entry to market increases (i.e., the requirement to open a business is increasingly higher in the system) fewer investors open their startups. This implies that investment sentiment is shrinking. Next, an experiment is simulated with a higher value of the open chance parameter of 0.6.

Without Tax Incentive **Tax Incentive**

FD = 0.6, SD = 0.4 and P = 0.6

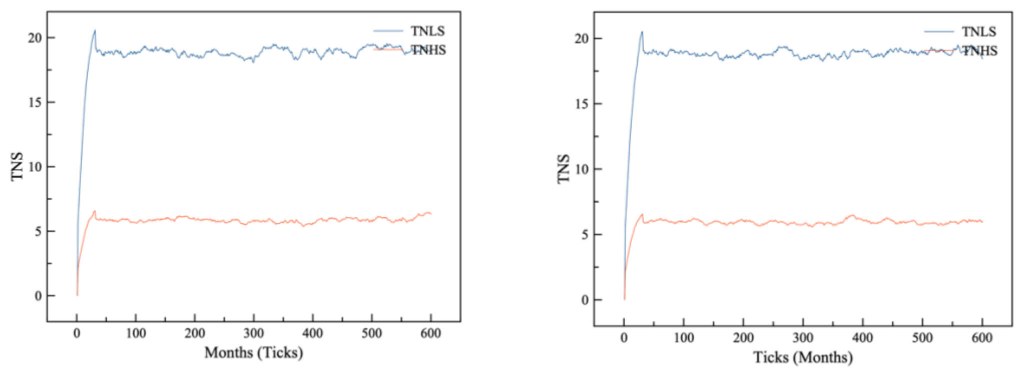


Figure 1.11 Number of Startups (FD = 0.6, SD = 0.4, and P = 0.6)

Figure 1.11 demonstrates that the number of startups decreases compared with Figure 1.10. Twenty low-tech startups are created in this experiment, and six high-tech startups are established.

Without Tax Incentive | **Tax Incentive**

FD = 0.6, SD = 0.4 and P = 0.6

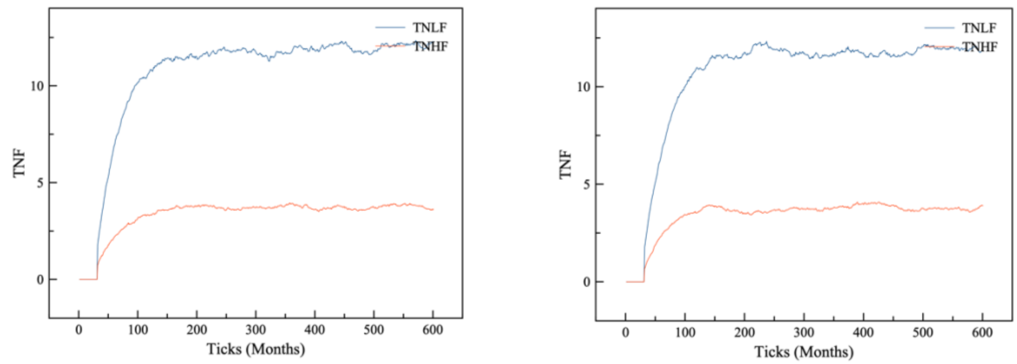
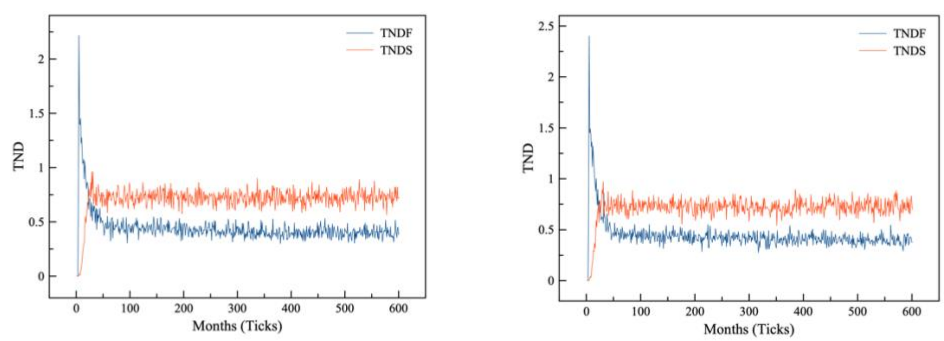


Figure 1.12 Number of New Firms from Startups (FD = 0.6, SD = 0.4, and P = 0.6)

Figure 1.12 also depicts that fewer number of firms are created than in the previous scenario, as demonstrated in Figure 1.10. One explanation is that fewer firms are established because fewer startups are created due to fewer investors entering the market. Figure 1.13 contains the number of dead agents.

Without Tax Incentive | **Tax Incentive**

FD = 0.6, SD = 0.4 and P = 0.6



FD = 0 .6, SD = 0.4 and P = 0.3

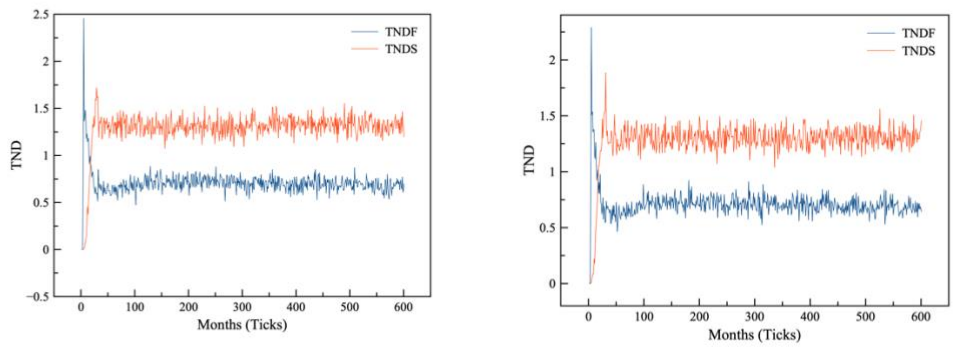


Figure 1.13 Number of Dead Startups and Firms on Different Conditions

In Figure 1.13, the number of dead agents increases when the open chance is lower than the higher entry of market when compared the upper row and the lower row in Figure 1.13. All the aforementioned results suggest that the shape of every graph is similar and flattens off. Why? Because the death of agents (i.e., the exit of businesses) inevitably occurs in the system. To investigate this reason, I analyze factors affecting the death of agents in the system. The following conditions are specified in which each agent dies: (1) Investors will die when they cannot fulfill the requirement to establish a startup; (2) Startups and firms will die when they have negative profits for three consecutive periods. Therefore, I explore next the profit situation for dead agents to find the factors affecting firm death. Figure 1.14 contains the factors composing profit. To operate firms and startups, they have to sell when they produce to make a profit. Therefore, I compare the level of demand and output of dead agents.

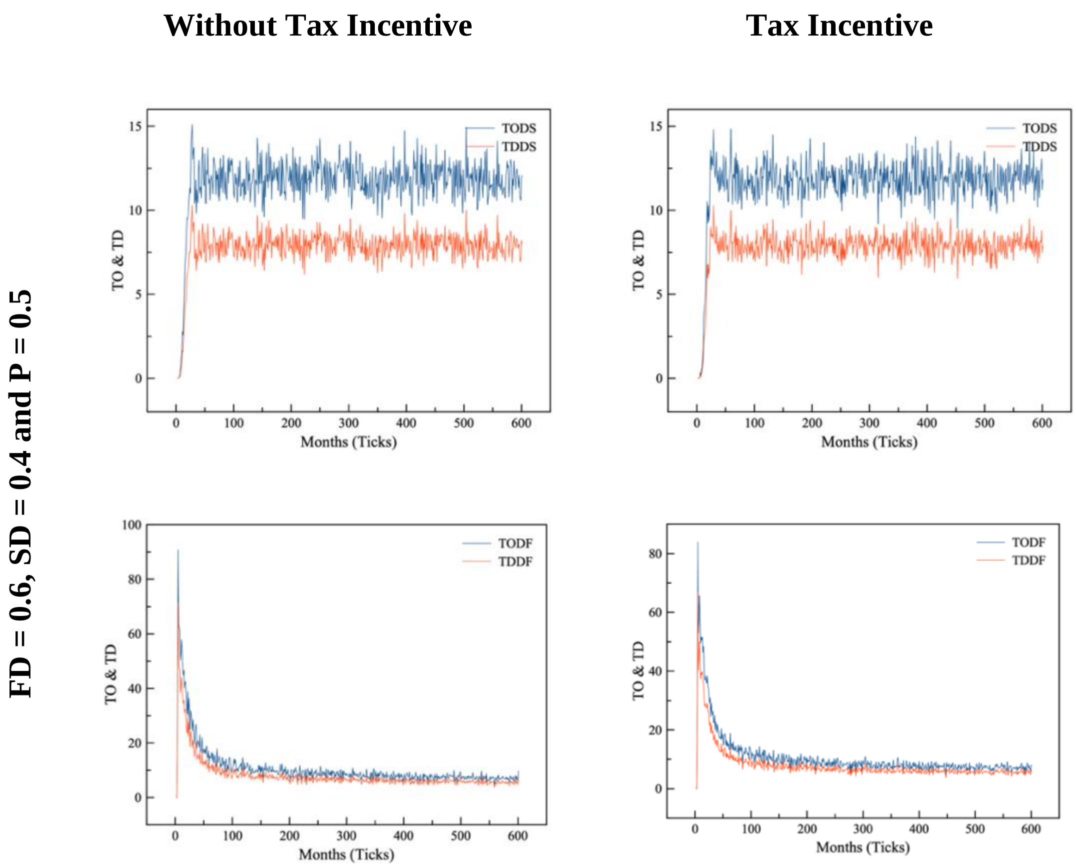


Figure 1.14 Demand and Output of Dead Startups and Firms (FD = 0.6, SD = 0.4, and P = 0.5)

In Figure 1.14, the line above between the two lines of each graph represents the total output of startups and firms, that is, the amount of total produce startups and firms can produce, and lines located below represent the total demand of dead startups and firms. That is, startups and firms close because they cannot sell what they produce in order to make a profit. I also explore the impact of the change of the level of demand of startups. I expect more startups and firms will be established as the stability of demand increases.

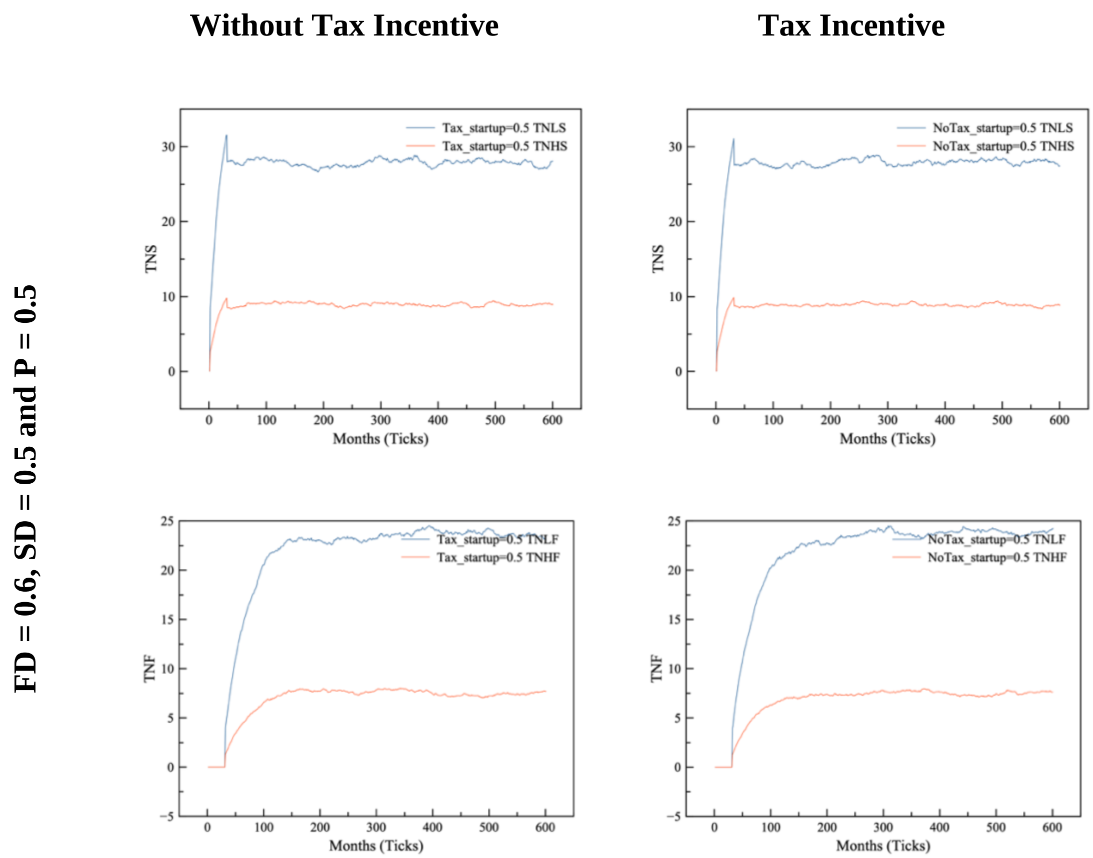


Figure 1.15 Number of Startups and Firms (FD = 0.6, SD = 0.5, and P = 0.5)

Comparing Figures 1.5 and 1.6 to Figure 1.15, we observe that the number of startups and new firms created is higher when the demand for startups increased by 8% (Figure 1.15). The number of startups created in Figure 1.5 is about 25 (other industries) and 7.5 (high tech) and the numbers of startup created in Figure 1.15 is about 30 (other industries) and 10 (high tech) as shown in the top two graphs in Figure 1.15. The firms created from startups is 15 (other industries) and 5 (high tech) and the firms created from startups is 25 (other industries) and 7.5 (high tech). That is, firm survival rate from startups is higher when they have a stable demand.

Comparing Figures 1.5 and 1.6 to Figure 1.15, the level of creation of startups and firms is higher when the demand for startups increased by 10% (Figure 1.15).

Without Tax Incentive **Tax Incentive**

FD = 0.6, SD = 0.5 and P = 0.5

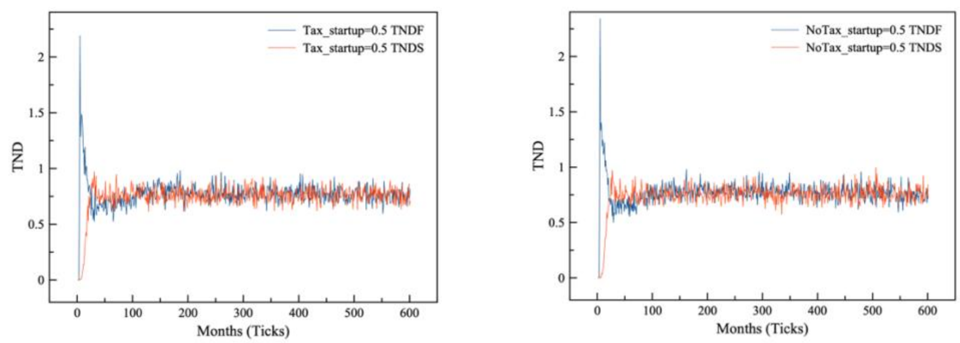


Figure 1.16 Number of Dead Startups and Firms (FD = 0.6, SD = 0.5, and P = 0.5)

Comparing Figure 1.9 with Figure 1.16, the number of dead startups decreases from the lower demand of startups. This finding implies that having more demand is a better means to stimulate the establishment of more firms because fewer investors' businesses fail.

The simulation results comport with Stangler and Kedrosky (2010) in Figure 1.5. Both graphs have similar shapes. Stangler's graph indicates the stable number of firm formation, and the simulation results from ABM also demonstrates that startups are continuously formed. In the complex system, the number of firms is stable (Figure 1.5) and similar to the result of Stangler and Kedrosky (2010).

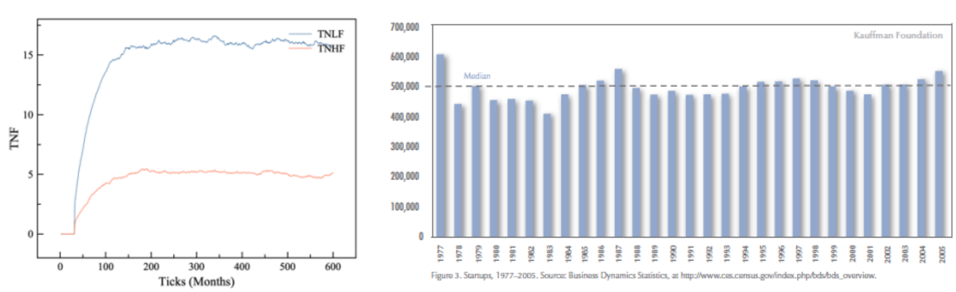


Figure 1.17 Number of Firms

Moreover, new firms that have survived from startups are continuously established (Figures 1.6, 1.8, 1.12, and 1.15). However, surviving to become a firm from a startup is difficult if there is insufficient demand. The results indicate the "flattening off" in the number of startup businesses (defined as a firm younger than 10 years old, or 120-months old, since one tick = 1 month). The results are remarkable given that they resemble the empirical evidence, without the need for any complicated mechanism. This is because there are limited resources (demand) to sell their products.

However, it is hard to say that the stable number implies a stable economic condition, because the stable number of firms is the result of emergence[3] pattern in the system even though agents are stimulated by tax incentives. Tax incentive policy influences creating more startups, but startups without a stable demand cannot survive even though they receive a tax exemption. Based on Governor Cuomo's expectation, the number of firms must increase, but more established startups also close because they do not have the ability to survive. Moreover, the reason why a certain level of firm formation is observed for each simulation is that, in the aforementioned experiments, there are agents that always fail and agent that succeed.

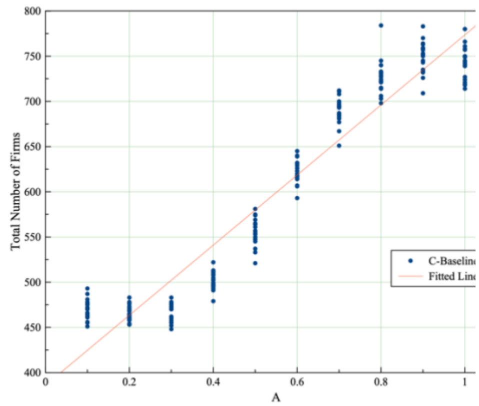
In addition to the results above, I plotted the results in terms of the changing parameter values representing the minimum demand of startups, and the probability of opening a business. The minimum demand of startups is set between 10% of their output and 100% of their output, which implies they can sell all their produced

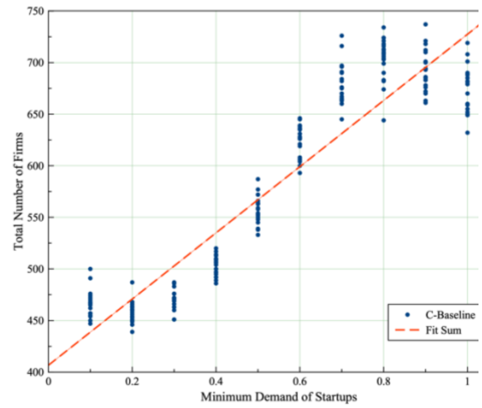
[3] Emergence is defined as the act or an instance of emerging, any of various superficial outgrowths of plant tissue usually formed from both epidermis and immediately underlying tissues (Merriam-Webster). Emergence in a complex system is explained as unexpected collective behaviors in a long-run iteration. For example, Shelling (1971) illustrated how individual incentives and perceptions of difference could lead collectively to segregation. In his model, each agent belongs to one of two groups and aims to reside within a neighborhood where the fraction of 'friends' is sufficiently high. Therefore, the spread agents are finally segregated after the long run iteration. Moreover, the iterated prisoners' dilemma of Axelrod (1984) also exemplifies emergence.

products. The open chance is set between 0.1 and 1. Moreover, the minimum demand of incumbent firms is fixed at 60%. The simulation results for these conditions are:

The minimum Demand of Incumbent Firms = 0.6

Without Tax Incentive	**Tax Incentive**



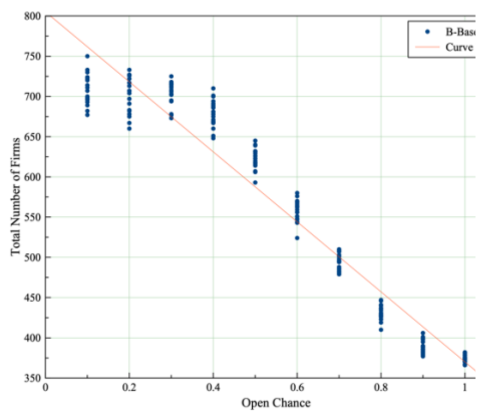


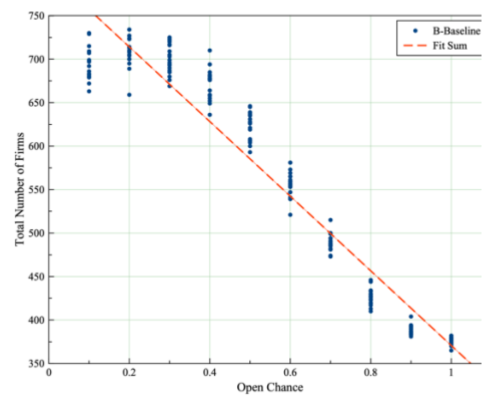
$y = 387.76x + 385.91$

$R^2 = 0.9231$

$y = 320.73x + 406.68$

$R^2 = 0.866$





$y = -435.02x + 805.15$

$R^2 = 0.9351$

$y = -429.35x + 799.98$

$R^2 = 0.9266$

Figure 1.18 Total Number of Firms by Changing Demand and Open Chance

As shown in Figure 1.18, the level of demand is positively related to the rate of new firm formation, but open chance is negatively related to firm formation. Comparing the left to right panel, we can see that tax incentives are positively related to the number of new firms. Moreover, the slopes of the fitted lines indicate that having a tax incentive leads to an outcome that is less sensitive to change as indicated by the slopes in the right panel which are less steep than the slopes in the left panel.

1.6 Conclusion

Given that new firm formation is a preponderant factor contributing to local economic development through the creation of new jobs. New York State introduced START-UP NY to promote new businesses, and helps people start, expand, or relocate their business with a ten-year tax exemption.

In my ABM simulations, I first explored the impact of tax policy on the economy of Tompkins County, and I found that the number of startups and firms are stable over time as the results have shown in this paper. I then examined the impact of the psychology of expectations to simulate the scenario whereby more people invest in new businesses after the introduction of a tax intensive policy. I found that more firms are created when the value of the open chance parameter is lower. And, I also found that more firms die as more new firms are established; and that a more stable demand can increase the number of new firms without increasing the death rate. Tax incentive policy provided by START-UP NY up may influence the rate of new firm formation, but my ABM simulations suggest that more firms might eventually exit the economy because of insufficient demand.

The most important finding of this study is the importance of a stable demand for new firms to survive. The ABM results suggest that a higher demand for startup output has a larger influence on firm formation than a tax exemption. Thus, while

START-UP NY may increase number of new firms, these firms may not survive in the absence of stable demand, which is the most important factor in securing the long-run financial viability of firms. START-UP NY may create jobs and revitalize the local economy in the short term, but is not able by itself to sustain stable economic development. I conclude that policymakers should focus on ensuring a stable environment for firms instead of on new firm formation.

REFERENCES

Ardagna, S., & Lusardi, A. (2010). Heterogeneity in the effect of regulation on entrepreneurship and entry size. *Journal of the European Economic Association*, *8*(2-3), 594-605.

Audretsch, D. B., & Acs, Z. J. (1994). New-firm startups, technology, and macroeconomic fluctuations. *Small Business Economics*, *6*(6), 439-449.

Axelrod, R., & Axelrod, R. M. (1984). *The evolution of cooperation*. Basic Books (AZ).

Bartik, T. (1991). *The Effects of Property Taxes and Other Local Policies on the Intrametropolitan Pattern of Business Location* (pp. 57-80). Kalamazoo, MI: W. E. Upjohn Institute for Employment Research.

Bartik, T. J. (2003). *Local economic development policies*. Kalamazoo, MI: W. E. Upjohn Institute for Employment Research.

Berry, B. J. (1989). *Venturing to Develop: Forces that Promote Economic Transformation at the Leading Edge and on the Far Periphery*. Institute of Government and Public Affairs, University of Illinois.

Birch, D. L. (1979). *The job generation process: MIT program on neighborhood and regional change*. Cambridge, MA: Cambridge Press.

Blank, S. (2013). *The four steps to the epiphany: successful strategies for products that win*. BookBaby.

Bondonio, D., & Engberg, J. (2000). Enterprise zones and local employment: evidence from the states' programs. *Regional Science and Urban Economics*, *30*(5), 519-549

Bondonio, D., & Greenbaum, R. T. (2007). Do local tax incentives affect economic growth? What mean impacts miss in the analysis of enterprise zone policies. *Regional Science and Urban Economics*, *37*(1), 121-136.

Bosma, N., Van Praag, M., Thurik, R., & De Wit, G. (2004). The value of human and social capital investments for the business performance of startups. *Small Business Economics*, *23*(3), 227-236.

Braunerhjelm, P., & Eklund, J. E. (2014). Taxes, tax administrative burdens and new firm formation. *Kyklos*, *67*(1), 1-11.

Ciccone, A., & Papaioannou, E. (2007). Red tape and delayed entry. *Journal of the European Economic Association*, *5*(2-3), 444-458.

Cullen, J. B., & Gordon, R. H. (2007). Taxes and entrepreneurial risk-taking: Theory and evidence for the US. *Journal of Public Economics*, *91*(7-8), 1479-1505.

Eberts, R. W. (2005). Overview of state and local economic development policies and practice in the United States. In Giguere, S., Higuchi, Y., & Japan Institute for Labour Policy and Training (Ed.), *Local Governance for Promoting Employment: Comparing the Performance of Japan and Seven Countries* (pp.87-102). Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

Elvery, J. A. (2009). The impact of enterprise zones on resident employment: An evaluation of the enterprise zone programs of California and Florida. *Economic Development Quarterly*, *23*(1), 44-59.

Emergence. 2016. In Merriam-Webster.com. Retrieved Nov 21, 2016, from https://www.merriam-webster.com/dictionary/emergence

Friedman, T. L. (2005). *The world is flat: A brief history of the twenty-first century*. Macmillan.

Giardino, C., Wang, X., & Abrahamsson, P. (2014, June). Why early-stage software startups fail: a behavioral framework. In *International Conference of Software Business* (pp. 27-41). Switzerland: Springer.

Ham, J. C., Swenson, C., İmrohoroğlu, A., & Song, H. (2011). Government programs can improve local labor markets: Evidence from state enterprise zones, federal empowerment zones and federal enterprise community. *Journal of Public Economics*, *95*(7), 779-797.

Haufler, A., Norbäck, P. J., & Persson, L. (2014). Entrepreneurial innovations and taxation. *Journal of Public Economics*, *113*, 13-31.

Isard, W., Azis, I. J., Drennan, M. P., Miller, R. E., Saltzman, S., & Thorbecke, E. (2017). *Methods of interregional and regional analysis*. Taylor & Francis.

Kemp, R. L. (1987). Raising revenues without increasing taxes through cooperation between local bodies and private sector: A note. *Pakistan Economic and Social Review, 25*(2), 109-114.

Klapper, L., & Love, I. (2010). *The impact of business environment reforms on new firm registration*. World Bank Policy Research Working Paper No. 5493.

Klapper, L., Laeven, L., & Rajan, R. (2006). Entry regulation as a barrier to entrepreneurship. *Journal of Financial Economics*, *82*(3), 591-629.

Lee, S. C., Lim, W. H., & Suh, E. K. (2014). Youth startup firms: A case study on the survival strategy for creating business performance. *Journal of Distribution Science*, *12*(6), 81-88.

Leigh, N. G., & Blakely, E. J. (2013). *Planning local economic development: Theory and practice*. Thousand Oaks, CA: SAGE Publications.

Lim, S., Ribeiro, D., & Lee, S. M. (2008). Factors affecting the performance of entrepreneurial service firms. *The Service Industries Journal*, *28*(7), 1003-1013.

Morse, S. C., & Allen, E. J. (2016). Innovation and taxation at start-up firms. *Tax Law Review, 69*(3), 357-388. Retrieved from https://search-proquest-com.proxy.library.cornell.edu/docview/1845772222?accountid=10267

Neumark, D., & Kolko, J. (2010). Do enterprise zones create jobs? Evidence from California's enterprise zone program. *Journal of Urban Economics*, *68*(1), 1-19.

Phillips, J. M., & Goss, E. P. (1995). The effect of state and local taxes on economic development: A meta-analysis. *Southern Economic Journal*, 320-333.

Railsback, S. F., & Grimm, V. (2011). *Agent-based and individual-based modeling: A practical introduction*. Princeton, NJ: Princeton University Press.

Reindustrialization. In Merriam-Webster.com. Retrieved June 16, 2016, from https://www.merriam-webster.com/dictionary/reindustrialization

Schelling, T. C. (1971). Dynamic models of segregation. *Journal of Mathematical Sociology*, *1*(2), 143-186.

Shin, K., Park, G., Choi, J., & Choy, M. (2017). Factors affecting the survival of SMEs: A study of biotechnology firms in South Korea. *Sustainability*, *9*(1), 108.

Smith, A. (1937). *The wealth of nations* [1776]. New York, NY: Random House, Inc.

Stangler, D., & Kedrosky, P. (2010). Exploring firm formation: Why is the number of new firms constant? *SSRN Electronic Journal.* http://dx.doi.org/10.2139/ssrn.1585380

START-UP NY Program. (2016, August 18). Retrieved September 03, 2017, from https://esd.ny.gov/startup-NY-program.

Wang, S. W. (2006). Determinants of new firm formation in Taiwan. *Small Business Economics*, *27*(4-5), 313-321.

CHAPTER 2

THE IMPACT OF REDUCING MILITARY EXPENDITURES IN SOUTH KOREA USING A CGE MODEL

2.1 Introduction

2.1.1 Military Expenditure

Military expenditure, also known as a defense or military budget, refers to the budget provided to the military for weapons, equipment, and soldiers by the government. As military expenditure is directly related to national security, it is a vital spending to protect a state. Historically, the amount of the global defense budget has increased over the last five decades. Stalenheim et al. (2007) indicate that world military spending increased by 45% over ten terms from 1998.

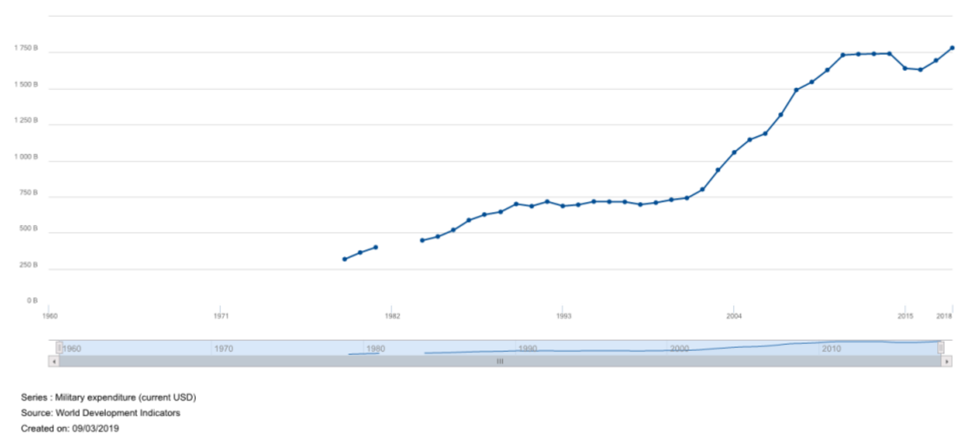


Figure 2.1 The Amount of World Military Expenditures (source: The World Bank, https://databank.worldbank.org/reports.aspx?source=2&series=MS.MIL.XPND.CD&country=)

As shown in the graph above, global military expenditures have increased rapidly. One reason is that governments have implemented more money to protect their properties.

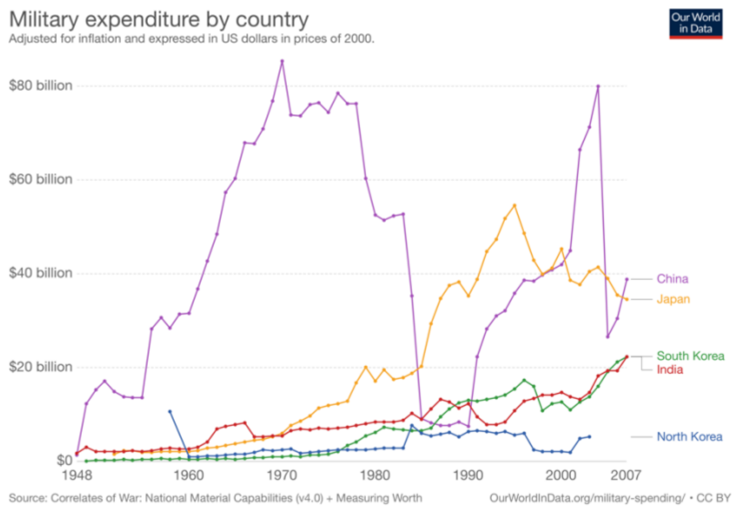


Figure 2.2 The Amount of Military Expenditures of Four Major Asia Countries and North Korea (Source from Our World in Data https://ourworldindata.org/military-spending)

As shown in Figure 2.2, most countries, except China, have recently increased military expenditures. South Korea, one of four significant spenders in Asia, which includes China, India, Japan, and South Korea, also has been increasing its military budget, as shown in Figure 2.2. Asian defense spending has increased by 53% during 1998–2008 (Stalenheim et al. 2007). The military budget is crucial in South Korea to protect from neighboring countries because South Korea has historically been invaded by neighbors. Also, South Korea regards military expenditures as an essential budget expenditure because of the Military Demarcation Line dividing North and South Korea. Korea, located in East Asia between Japan and China, is the only divided country in the world. The approximate coordinates are 37° North and 127° 30´ East

(Figure 3). North and South Korea were formed after the Korean War in 1953. Since then, the two Koreas, divided into two different regimes, have kept each other in check while developing their defense powers. As soldiers from each country guard their respective country at the center of the ceasefire line, defense spending is considered an essential budget by the South Korean government and its citizens. The relationship between North and South Korea has changed. However, The South Korean government has helped North Korea. Specifically, from 1998 to 2008, the South Korean government executed the Sunshine Policy soften North Korea's attitudes towards the South by encouraging interaction and economic assistance. From 1998, North and South agreed to establish a special administrative region at Mount Kumkang in North Korea. South Korean and other tourists were permitted to visit Mount Kumkang.

However, the South Korean government ceased the Sunshine policy after 2008. Moreover, tourism at Mount Kumkang has been closed. North Korea keeps threatening launching missiles and inventing nuclear weapons. Thus, plans for spending on defense and policies toward North Korea also serve as a key factor in determining the presidential election. Traditionally, the left-side presidential candidates emphasized a policy that favored North Korea, while the right-sided advocated a tougher policy, attracting voters (Kim, 2007; Bae, 2018).

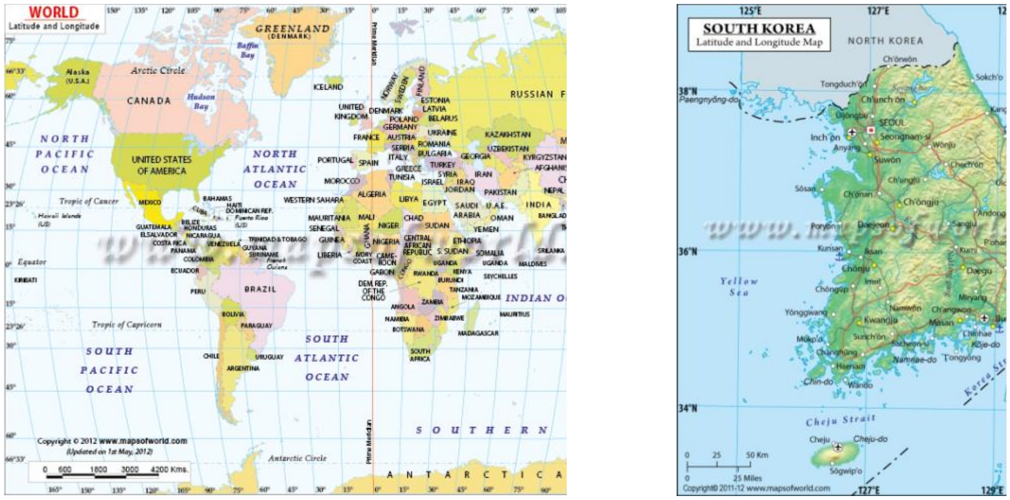


Figure 2.3 South Korea on the World Map and Map of South Korea (source: Maps of World)

After the Korean War, two different countries have developed differently, with South Korea achieving rapid economic development. North Korea has not economically economic developed, focusing on improving the military due to its isolation. South Korean government has implemented additional military spending as it develops. Still, North Korea keeps increasing its military budget even though it has developed much since the end of the Korean War (see Figure 2.3).

Can the South Korean government reduce military expenditures? It is hard to say since each government has different perspectives for using the national budget. Historically, South Korea has been strategically surrounded by the sea on three sides and has been viewed as a hub of trade and war. South Korea has a history of being invaded by neighboring nations.

However, military spending can be reduced if the National Security Department is wasting its budget by corruption. Articles on corruption in South Korea

Defense Department are continuously published. The following paragraph reports cases of corruption in the military.

Na (2015) reported on corruption in various defense industries. Based on his article, the Army, Navy, and Air Force seemed to be corrupt, with most related to substandard goods or confidential military leaks. The amount of each corruption is 3.75 million USD by the Army, 7 billion USD by the Navy, and 1.5 million USD by the Air Force. The article pointed out the closeness of defense projects as a structural cause of defense corruption. As the projects are military secrets, it is difficult to access and monitor. Yoon (2017) reported on perforated body armors. She described a case of bribery in exchange for a contract to deliver a body armor that could not stop bullets. Lim (2019) wrote that someone cheated on the cost price and stole 1.75 million USD. He submitted the copied document after changing the cost price when he proposed the import declaration certificate to the military defense industry. Ahn (2019) reported a case of corruption related to bribes. A brigadier general was reportedly bribed in exchange for signing an export contract for the K2 tank technology.

As indicated, South Korea's military expenditure has not been used correctly due to corruption; thus military spending can be potentially reduced. This thesis will explore the impact of cutting South Korea's defense spending by using the computable general equilibrium (CGE) model, which uses actual economic data to estimate how an economy might react to changes in policy, technology, or other external factors.

2.2 Literature Review

Scholars have studied military expenditures, researching trends, its effects, and the relationship between military expenditure and conflict.

Isard (1979) defined the field of peace science as the study of conflict theory and analysis, conflict management, and conflict resolution; including efforts to deal with conflict and to establish world order or order within societies. Isard contributed to peace science by researching arms reduction, international security, and modeling for scientific peace. Based on Isard's concern for peace, I will analyze the articles exploring the decline of defense expenses.

2.2.1 Studies of Military Expenditures

There is copious research on the relationship between military expenditures and economic growth in various regions utilizing different methods.

Benoit (1973) argued that defense helps development in less developed countries, finding a positive correlation between the economic growth rate and defense expenditures as a proportion of national income.

Deger (1986) analyzed the interrelationship between defense burden, savings, and economic growth. Deger (1986) partially agreed to Benoit's opinion, but that the empirical evidence did not support it. Accordingly, the defense burden would raise the growth rate of developing countries only if a partial picture of the complex process is taken. Defense expenditures allocates scarce resources away from civilian investment and fails to mobilize or create any additional savings. It significantly depresses the savings/income ratio, which harms growth and development. Deger found a positive relationship until some point, but after that, a negative relationship. In Deger's opinion, this change occurs because of the change in economic structure that is brought about by modernization.

Mintz and Huang (1990) estimated the relationship between military expenditures and economic development. They assumed that economic outputs are composed of three sectors: military, non-military, and private. They estimated differences in externality effects, and found that reducing military expenditures, in the long run, would stimulate investment; therefore, it promotes economic growth.

Russet (1982) tested the effects of changes in military spending on federal expenditures for health and education between 1941 and 1979. The author's starting point was the proverbial guns and butter trade-off. The author found no significant depressing effect on health and education expenditures from his research. The author analyzed changes in federal spending on education because of changes in military spending and other variables. Russet's basic hypothesis of a trade-off between education and military spending is explained by the following equation:

$$\frac{E_t - E_{t-1}}{E_{t-1}} = a - b\frac{M_t - M_{t-1}}{M_{t-1} + e}$$

E represents education spending and *M* military spending. With this simple method, the author added like health, housing, and productivity.

Bohmelt and Bove (2014) explored the determinants to predict or decide the level of military expenditure because global military spending 2.5% of the world's GDP in 2012, equal to Canada's GDP, the world's 11th largest. In their model military expenditures is the dependent variable, with independent variables including , peace years, democracy, trade percent to GDP, and GDP. They found that the previous level of military spending and economic characteristics improves the estimation of military expenditures.

Churchill and Yew (2016) investigated the impact of military spending on economic development by using a meta-analysis. (A meta-analysis is a method to analyze combined results from the same question to derive a better estimation.) They uses 272 estimations from 48 research papers, finding positive effects of military expenditure on economic growth in most developed countries rather than in less developed countries.

Saba and Ngepah (2019) explored the relationship between defense spending, state fragility, and economic growth of African countries using panel data. They used a generalized method of moments because it provides more relevant results by using time-series variation, reducing finite sample biases, and controlling for endogeneity. The authors found that state fragility causes negative effects of military expenditure on economic growth because public sector resources are reduced when defense spending suppress conflicts or riots to achieve peaceful security.

2.2.2 Military Expenditure Research for South Korea

Heo (1997) studied the impact of military expenditures on economic growth in South Korea from 1954 to 1988. He used ordinary least squares with financial data from the International Comparisons Project. The author found no direct connection between military expenditures and economic growth, but non-military government expenditures positively affect economic growth. He concludes that defense spending does not help economic growth in South Korea.

Kim (2004) investigated the determinants of South Korea military spending, noting that Korean governments have mostly focused on strengthening defense since the end of the Korean War. The author used a generalized least squares to estimate the military spending demand function. He found that incrementalism, the unemployment rate, and presidential priorities positively affect the military budget, but there is no welfare evidence. Moreover, he found no evidence that the government sector affects economic growth positively.

However, I argue that it cannot be said that there is no direct effect of military spending on economic growth because military spending is related to all other industries in a complex economy.

2.2.3 Motivation

Of course, reducing any level of government expenditures will negatively affect economic development because it reduces that amount of money somewhere. Previous research has investigated the impact of reducing military expenditure or the relationship between lowering defense expenditure and economic development. Some scholars only mentioned the relation between military spending and economic growth. They did not discuss related sectors with military costs or suggested sectors to invest if military spending tends to move in the same direction s economic growth. However, this paper explores the impact of reducing military expenditure on industrial performance. And then, simulates the redistribution of a reduced amount of military budget to other sectors to investigate potential improvements in industrial performance. I will construct a CGE model, to enable a comprehensive analytical tool in which the equilibrium outcomes of endogenous variables are determined simultaneously from the economy’s many interrelated markets. The benefit of using the CGE model is that there is an interconnection between all industries in the economy. (Haddad, 2009)

This thesis does not analyze whether defense expenditures are related to economic development, but rather to analyze via the CGE model how various industries are affected by defense expenditures and to identify industries in which increased government expenditures would improve household wellbeing when defense expenditures are reduced.

2.3 Data

According to Table 2.1, national defense expenditures have been increasing. Moreover, the South Korean government has spent about 15% of the national budget for the national defense. I assume that South Korea reduces 10% of the national defense budget, which is approximately 3.25 billion USD.

Year	National Defense Expenditures (in billion USD)	Rate per GDP (%)	Rate per National Budget (%)	Increased Rate (%)
2005	19.184	2.44	15.6	11.4
2006	20.466	2.48	15.3	6.7
2007	22.270	2.51	15.7	8.8
2008	24.226	2.60	14.8	8.8
2009	26.345	2.72	14.2	8.7
2010	26.875	2.52	14.7	2.0
2011	28.548	2.54	15.0	6.2
2012	29.961	2.52	14.8	5.0
2013	31.360	2.45	14.3	4.7
2014	32.459	2.53	14.4	3.5

Table 2.1 Population in the SNCA (Unit: 1,000 persons, %) Source: Korean Statistical Information Service database

As shown in Table 2.1, South Korea increased national defense expenditures from 2005 to 2014. The defense spending to GDP ratio has been set at about 2.5%, and the ratio of military expenditure to national budget is about 15%.

In this paper, Korea SAM explores the impact of reducing military expenditures, and to find sectors to redistribute a reduced amount of spending to achieve economic development. South Korea's economy comprises 34 industries, two factors of production, two institutions, one investment, and the rest of the world. Thus, the size of SAM 2003 is a 40 x 40 matrix.

South Korea SAM		Firms (A)	Factors		Institution		Capital Account(C)	Rest of World
			Labor(L)	Capital(K)	Household (HH)	Government		
Firms (A)		(1)			(9)	(13)	(17)	(18)
F	Labor (L)	(2)						(19)
	Capital (K)	(3)						
I	Household (HH)	(4)	(7)	(8)		(14)		(20)
	Government (G)	(5)			(10)			(21)
Capital Account (I)					(11)	(15)		(22)
Rest of World (F)		(6)			(12)	(16)		

Table 2.2 The Structure of SAM Korea 2003

Descriptions:

(1) : Intermediate input from sectors to sectors

(2) : Endowments for the h_{th} factor for the household factor demand in labor

(3) : Factor demand in capital

(4) : Business Consumption (hospitality fees, meeting fees, refreshments)

(5) : Direct tax of firms

(6) : Imports

(7) : Income distribution

(8) : Surplus

(9) : Household consumption

(10) : Direct tax of households

(11) : Private saving

(12) : Transfer from households to rest of world

(13) : Government consumption

(14) : Transfer from government to household (Social Security Benefits)

(15) : Government saving

(16) : Transfer from government to rest of world

(17) : Investment

(18) : Export

(19) : Household Endowment from the rest of world

(20) : Transfer from rest of world to households

(21) : Transfer from rest of world to government

(22) : Foreign savings

2.4 Methodology

The simplest way to analyze an economy using a SAM model is to create a SAM multiplier, albeit with constricting assumptions: constant prices, demand driven, excess capacity. Therefore, it is necessary to build a CGE model that will give us a comprehensive analytical tool in which the equilibrium outcomes of endogenous variables are determined simultaneously. The model incorporates the behavior of each agent and its relation to the agents such that all agents behave optimally in the economy.

2.4.1 Precursor: The Input–Output Approach

In the 1930s, the economist and Nobel Prize winner Wassily Leontief developed Input–Output (I–O) analysis to analyze the interdependence of an economy's industries. An (I–O) model contains a system of linear equations that show the distribution of an industry's product throughout the economy. Using the model, we can track the flows of products from each industrial sector and the activity of a group of industries that both produce goods and consumed goods from other inputs.

An essential component of an (I–O) dataset is the monetary values of the transactions between every pair of sectors (between sector i and sector j), designated as x_{ij}. An I–O framework is composed of rows and columns. The rows represent producers' output while the columns describe the inputs required to produce goods for each industry.

Figure 2.4 depicts the structure of (I–O) data. I–O analysis investigates the flows of products from each industrial sector, considered as a producer, to each of the sectors, itself, and others, considered as consumers. From Figure 2.4, x_{ij} is the value of input i used in the production of a dollar's worth of output j. As shown in Figure 2.4, I–O maintains the balance between rows and columns. The sum columns represent total input expenditures (X_j), which is composed of intermediate inputs and value-added. The sum rows list the total sales values of total output (X_i), which consists of intermediate demand and final demand.

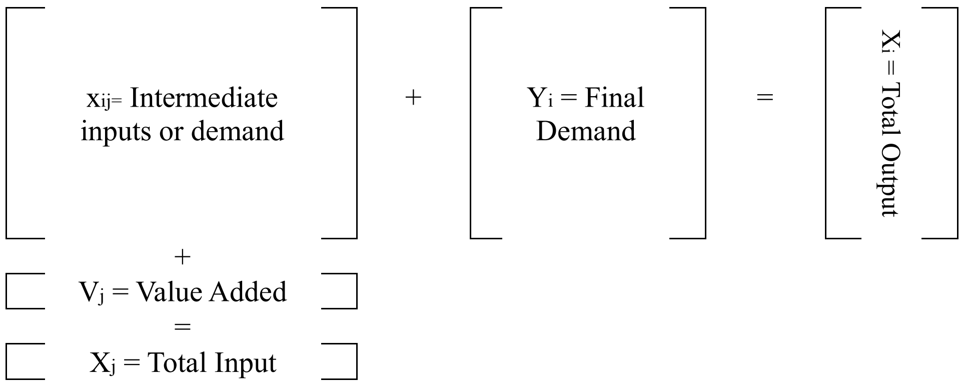


Figure 2.4 Structure of Input–Output Model

Mathematically, the rows are defined as:

$$X_i = x_{i1} + x_{12} + \cdots + x_{ij} + \cdots + x_{in} + f_i = \sum_{j=1}^{n} x_{ij} + f_i \tag{2.1}$$

$$\begin{aligned} X_1 &= x_{11} + \cdots + x_{1j} + \cdots + x_{1n} + f_1 \\ &\vdots \\ X_n &= x_{n1} + \cdots + x_{nj} + \cdots + x_{nn} + f_n \end{aligned} \tag{2.2}$$

These equations can be arranged in terms of vectors and matrices as in (2.3):

$$= \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}, X = \begin{bmatrix} x_{11} & \cdots & x_{in} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nn} \end{bmatrix} \; and \; f = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix} \tag{2.3}$$

Note: the matrix *X* in (2.3) is composed of total output without final demand and the vector *f* is the vector of final demand.

Columns also can be defined mathematically as:

$$x_j = x_{ij} + x_{2j} + \cdots + x_{nj} + va_j + m_j$$

To compute the I–O multipliers, we have to calculate the coefficient first, i.e., a_{ij}. From Figure 2.4, we can compute the coefficients using the following equation:

$$a_{ij} = \frac{x_{ij}}{x_j} = \frac{value\ of\ good\ i\ bought\ by\ sector\ j}{total\ value\ of\ production\ in\ sector\ j} \tag{2.4}$$

For example, if a_{ij} is 0.5, it means that 50 cents worth of input from sector i is needed to produce one dollar's worth of output in sector j. We can rewrite x_{ij} with a_{ij} and x_j as:

$$x_{ij} = a_{ij} \times x_j \tag{2.5}$$

We can then rewrite (2.1) as follows:

$$X_i = a_{i1}x_j + a_{12}x_2 + \cdots + a_{ij}x_j + \cdots + a_{in}x_n + f_i$$
$$= \sum_{j=1}^{n} x_{ij} + f_i \tag{2.6}$$

(2.6) can be expressed in a matrix form:

$$\mathrm{X} = \mathrm{AX} + \mathrm{f} \tag{2.7}$$

Since the coefficients and final demands are known, we can solve the vector of endogenous output X in (2.7) as:

$$\mathrm{X} = (I - A)^{-1} f \tag{2.8}$$

Note: $(I - A)^{-1}$ is the matrix of I–O multipliers. Equation (2.8) allows us to compute changes in the output vector X as a function of changes in final demand Y. The following equation expresses the impact in terms of changes in demand:

$$\Delta\mathrm{X} = (I - A)^{-1} \cdot \Delta f \tag{2.9}$$

2.4.2 Social Accounting Matrix

In 1962, economist and Nobel laureate Richard Stone developed the Social Accounting Matrix (SAM) to analyze national income and product accounts. A SAM recognizes the interdependence between producers, markets, households, and other economic actors (Isard et al., 1998). A SAM is divided into three main parts: production activities, institutions, and factors of production. Production activities produce commodities using raw materials, intermediate goods, and factor services.

Commodities receive supply from domestic producers and imports, and then sell them to customers, including for export. Institutions are composed of households, companies, and the government. Factors of production include labor, land and other natural resources, and capital. Figures 2.5 and 2.6 illustrate the structure of a typical SAM and the flow of money.

<table>
<tr><td colspan="4" rowspan="4"></td><td colspan="5">Expenditures</td></tr>
<tr><td colspan="3">Endogenous Accounts</td><td>Exogenous Accounts</td><td rowspan="2">Total</td></tr>
<tr><td>Production Activities</td><td>Factors</td><td>Institutions</td><td></td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td rowspan="5">Receipts</td><td rowspan="3">Endogenous Accounts</td><td>Production Activities</td><td>1</td><td>T_{11}</td><td>0</td><td>T_{13}</td><td>f_1</td><td>y_1</td></tr>
<tr><td>Factors</td><td>2</td><td>T_{21}</td><td>0</td><td>0</td><td>f_2</td><td>y_2</td></tr>
<tr><td>Institutions</td><td>3</td><td>0</td><td>T_{32}</td><td>T_{33}</td><td>f_3</td><td>y_3</td></tr>
<tr><td>Exogenous Accounts</td><td>Sum of Other Accounts</td><td>4</td><td>l_1</td><td>l_2</td><td>l_3</td><td>t</td><td>y_x</td></tr>
<tr><td colspan="2">Total</td><td>5</td><td>y_1</td><td>y_2</td><td>y_3</td><td>y_x</td><td></td></tr>
</table>

Figure 2.5 Social Accounting Matrix (Source: Isard et al., 1998)

Each element of the table in Figure 2.5 is sub-matrix of a generic SAM, which are defined as:

T_{11} = the intermediate input requirement among production activities.

T_{13} = households' consumption of the produced goods from each industry.

T_{21} = factor requirements of each production activity.

T_{23} = the distribution of factor income to household groups.

T_{33} = the income transfer between household groups.

f_1 = final demand of goods and services from rest of the world (exports)

f_2 = household income generated overseas such as foreign remittance and government transfers.

l_1 = import payments

l_2 = private savings and direct taxes

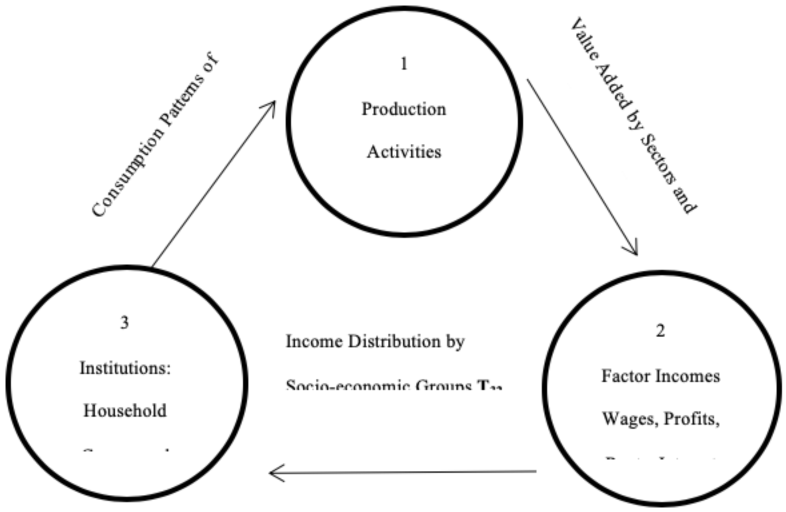


Figure 2.6 Interrelationship among Endogenous SAM Accounts (Source: Isard et al., 1998)

A SAM-based economic impact analysis also uses the multiplier approach. Indeed there are both similarities and differences between (I–O) and SAM. Similarities are that SAM is also based on double-entry bookkeeping: rows represent revenues and columns represent costs. Also, SAM possesses I–O's limitations, such as constant prices, static framework, fixed-proportion production function, purely demand-driven, ignoring supply constraints, and aggregate forms into broad sectors.

Unlike I–O, SAM focuses on income distribution among households differentiated by jobs, income levels, gender, and ethnicity. In fact, SAM contains more complete information than the I–O model: SAM combines I–O with income distribution, consumption patterns, investment and savings, and balance of. Therefore, SAM is capable of determining the effect on household and government sectors endogenously.

To determine this effect, I used the multiplier framework ($\Delta X = (I-A)_{-1}\Delta Y$). Multiplier analysis is a useful tool for estimating the impact of an exogenous shock on the income of endogenous accounts. Theoretically, we could endogenize any of the institutions (households, state and local government, federal government, or capital). As we endogenize an institution, we build into the SAM multipliers activities of that institution as well as any inter-institution transfers. The multiplier refers to every dollar collected locally by an institution that will be re-spent for that local institution's operations. Therefore, the multiplier captures the direct effect (produced by a change introduced by the user), and the indirect effects (the additional economic activity from industries buying from other local industries), plus the induced effect.

Figure 2.7 describes the structure of CGE model and the detailed explanation of the model will be in model part 2.4.3.

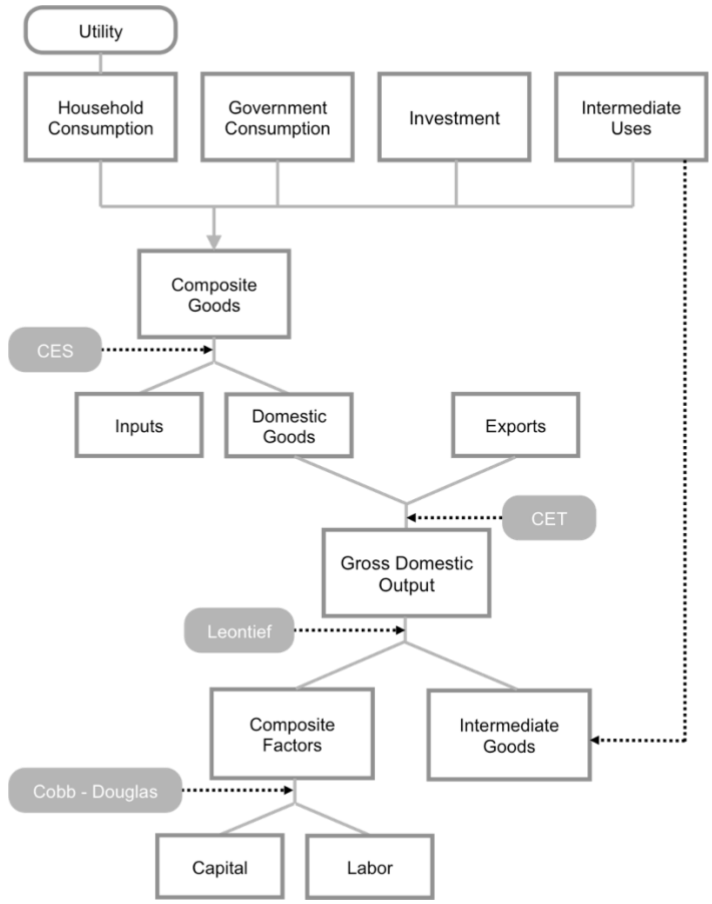


Figure 2.7 The Overview of Standard CGE Model

2.4.3 CGE Model

In the CGE model, we assume perfect competition with constant returns to scale and firms use intermediate inputs for the production process divided into two stages. In the first stage, firms maximize their profits π_j^y by choosing their composite factor Y_j and the h$_{th}$ factor used by the j$_{th}$ firm based on its relative prices, composite price P_j^y, and factor price P_h^f. In this stage, we assume a Cobb–Douglas production function. In the second stage, we assume a Leontief production function. In the first stage, each firm chooses input factor $F_{h,j}$ with price P_h^f to produce the composite factor. They maximizing profit subject to constant elasticity of substitution technology. The profit maximization problems for the j th firm is as follows:

$$\max \pi_j^y = P_j^y Y_j - \sum_h P_h^f F_{h,j} \tag{2.10}$$

subject to

$$Y_j = b_j \prod_h F_{h,j}^{\beta_{h,j}} \tag{2.11}$$

where b_j is a scaling coefficient in the composite factor production function

$F_{h,j}$ is the factor used by the j th firm in the first stage

$\beta_{h,j}$ is the share coefficient in the composite factor production function

For the second stage, we find the maximized profit π_j^z of gross domestic output of firms Z_j with price of the i th composite goods and intermediate input of the i-th good used by the j th firm. The profit maximization problem is as follows:

$$\max_{Z_i Y_j X_{i,j}} \pi_j^z = p_j^z Z_j - \left(p_j^y Y_j + \sum_i p_i^q X_{i,j} \right) \tag{2.12}$$

subject to

$$Z_j = \min\left(\frac{X_{i,j}}{ax_{i,j}}, \frac{Y_j}{ay_j} \right) \tag{2.13}$$

Note: $ax_{i,j}$ is the input requirement coefficient of the i th intermediate input for a unit output of the j th good; ay_j is input requirement coefficient of the j th composite good for a unit output of the j th good. By solving these two problems, we obtain:

$$Y_j = b_j \prod_h F_{h,j}^{\beta_{h,j}} \quad \forall j \tag{2.14}$$

$$F_{h,j} = \frac{\beta_{h,j} P_j^y}{P_h^f} Y_j \quad \forall h, j \tag{2.15}$$

$$X_{i,j} = ax_{i,j} Z_j \quad \forall i, j \tag{2.16}$$

$$Y_j = ay_j Z_j \quad \forall j \tag{2.17}$$

$$Z_j = \min\left(\frac{X_{i,j}}{ax_{i,j}}, \frac{Y_j}{ay_j}\right) \quad \forall j \tag{2.18}$$

Replace (2.18) with a zero-profit condition, which should always hold, as follows:

$$\pi_j^z = P_j^z Z_j - \left(P_j^y Y_j - \sum_i P_i^q X_{i,j}\right) = 0 \quad \forall j \tag{2.19}$$

Note: Y_j is a composite factor

b_j is a scale parameter in the production function

$F_{h,j}$ is the hth factor used by the jth firm in the first stage

$\beta_{h,j}$ is the share coefficient in the composite factor production function

P_j^y is the price of the jth composite factor

P_h^f is price of the hth factor

$X_{i,j}$ is intermediate input of the ith good used by the jth firm

$ax_{i,j}$ is the input requirement coefficient of the ith intermediate input for a unit output of the jth good

ay_j is the input requirement coefficient of the jth composite good for a unit output of the jth good

Z_j is the gross domestic output of the jth firm

P_i^q is price of the ith composite good

Using (2.16) and (2.17), we can eliminate $X_{i,j}$ and Y_j to obtain the following equation:

$$P_j^z Z_j - \left(ay_i P_j^y Z_j - \sum_i ax_{i,j} P_i^q Z_j \right) = 0 \quad \forall j \tag{2.20}$$

Then, we obtain the unit cost function by eliminating Z_j:

$$P_j^z = ay_j P_j^y + \sum_i ax_{i,j} P_i^q \quad \forall j \tag{2.21}$$

2.4.3.1 Government

In the CGE model, the government collects taxes and consumes goods; households pay a direct tax for income and firms pay a production tax, and the government consumes all tax revenues. The following equations embody these assumptions:

$$T^d = \tau^d \sum_h P_h^f FF_h \tag{2.22}$$

$$T_j^z = \tau_j^z P_j^z Z_j \quad \forall j \tag{2.23}$$

$$X_i^g = govfac_i \frac{\mu_i}{P_i^q} \left(T^d + \sum_j T_j^z - S_g - \sum_{in} Trans_{in,govt} \right) \quad \forall i \tag{2.24}$$

Note: T^d is the direct tax

τ^d is the direct tax rate

P_h^f is price of the hth factor

FF_h is the household endowment of the hth factor

T_j^z is the production tax on the jth good

τ_j^z is the production tax rate on the jth good

P_j^z is price of the jth gross domestic output

Z_j is the gross domestic output of the jth firm

X_i^g is government consumption

$govfac_i$ is the government factor multiplier

μ_i is the share of the ith good in government expenditures ($0 \leq \mu_i \leq 1, \sum_i \mu_i = 1$)

P_i^q is the price of the ith composite good

S_g is government savings

$Trans_{in,govt}$ is the transfer between institutions and government

2.4.3.2 Investment and saving

In the CGE model, it is assumed that the investment agent collects funds from the households, the government, and the external sector; and spends the collected funds to buy investment goods. We depict this with the investment demand function (2.25):

$$X_i^v = \frac{\lambda_i}{P_i^q}(S^p + S^g + \varepsilon S^f) \quad \forall i \tag{2.25}$$

Note: X_i^v is investment demand

λ_i is the expenditure share of the ith good in total investment

$(0 \leq \lambda_i \leq 1, \sum_i \lambda_i = 1)$

P_i^q is the price of the ith composite good

S^p is private savings

S^g is government savings

εS^f is foreign savings

Equation (2.25) means that total savings in an economy always equals total investment:

$$S^p = ss^p \sum_h P_h^f FF_h \tag{2.26}$$

$$S^g = ss^g \left(T^d + \sum_j T_j^z \right) \tag{2.27}$$

Note ss^p is the average household propensity for savings by the household; ss^g is the average propensity for savings by the government.

2.4.3.3 Household behavior

The households in the CGE model always seek to maximize their utility given their budget constraint, and with savings and direct tax payments:

$$\max_{X_i^p} UU = \prod_i {X_i^p}^{\alpha_i} \tag{2.28}$$

subject to

$$\sum_i P_i^q X_i^p = \sum_h P_h^f FF_h - S^p - T^d \tag{2.29}$$

Note: UU is utility

X_i^p is the household consumption of the ith good

P_i^q is the price of the ith composite good

α_i is the share parameter in the utility function ($0 \leq \alpha_i \leq 1, \sum_i \alpha_i$)

P_h^f is the price of the hth factor

FF_h is the household's endowment of the hth factor

S^p is household savings

T^d is the direct tax

By solving the household problem, we can obtain the household demand function for the ith good as:

$$X_i^p = \frac{\alpha_i}{P_i^q}\left(\sum_h P_h^f FF_h + \sum_{in} Trans_{hhs,in} + \sum_j Busicon_{hhs,j} - S^p \right. \\ \left. - T^d - Trans_{ROW,hhs}\right) \forall i \tag{2.30}$$

Note: X_i^p is the household consumption of the ith good

P_i^q is the price of the ith composite good

P_h^f is the price of the hth factor

FF_h is the household endowment of the hth factor

$Trans_{hhs,in}$ is the transfer between the institution and household

$Busicon_{hhs,j}$ is the business consumption by the jth firm to households (rebate)

S^p is household savings

T^d is the direct tax

$Trans_{ROW,hhs}$ is the transfer between households and the rest of world

2.4.3.4 International trade

There are two types of price variables for international trade in the CGE model: prices in terms of the domestic currency ($P_i^{w_e}$and P_i^m); and prices in terms of the foreign currency (P_i^e and $P_i^{w_m}$). The CGE model assumes that the economy has balance of payments constraints:

$$P_i^e = \varepsilon P_i^{w_e} \; \forall i \tag{2.31}$$

$$P_i^m = \varepsilon P_i^{w_m} \; \forall i \tag{2.32}$$

$$\sum_i P_i^{w_e} \varepsilon E_i + S^f + Forwage + Trans_{hhs,row} + Trans_{govt,row}$$
$$= \sum_i P_i^{w_m} \varepsilon M_i + Trans_{row,hhs} + Trans_{row,govt} + ForInv \qquad (2.33)$$

where P_i^e is the export price in terms of the foreign currency (exogeneous)

$P_i^{w_e}$ is the export price in terms of the domestic currency

ε is the foreign exchange rate (domestic currency/foreign currency)

P_i^m is the import price in terms of the domestic price

$P_i^{w_m}$ is the import price in terms of the foreign currency (exogeneous)

E_i is the export of the ith good

S^f is the current account deficit in terms of the foreign currency

$Forwage$ is the foreign wage

$Trans_{hhs,row}$ is the transfer between households and the rest of world

$Trans_{govt,row}$ is the transfer between the government and the rest of world

M_i is imports of the ith good

$Trans_{row,hhs}$ is the transfer between households and the rest of world

$Trans_{row,govt}$ is the transfer between the government and the rest of world

$ForInv$ is foreign investment

2.4.3.5 Armington's assumption

Armington's assumption is imperfect substitution exists between imports and domestic goods, that is, domestic goods are similar but slightly different from imported goods. Domestic and import goods are not directly consumed by households, firms, and government, but they are combined into Armington composite goods. The firms consume a suitable combination of domestic and imported goods to maximize profits. The degree between domestic and imported goods can be measured by the elasticity of substitution in constant elasticity of substitution.

2.4.3.6 Substitution between imports and domestic goods

The optimization problem for the ith Armington-composite-good-producing firm is as follows:

$$\max_{Q_i, M_i, D_i} \pi_i^q = P_i^q Q_i - \left[P_i^m M_i + P_i^d D_i\right] \tag{2.34}$$

subject to

$$Q_i = \gamma_i \left(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i}\right)^{\frac{1}{\eta_i}} \tag{2.35}$$

$$M_i = \left[\frac{\gamma_i^{\eta_i} \delta m_i P_i^q}{P_i^m}\right]^{\frac{1}{1-\eta_i}} Q_i \quad \forall i \tag{2.36}$$

$$D_i = \left[\frac{\gamma_i^{\eta_i} \delta d_i P_i^q}{P_i^d}\right]^{\frac{1}{1-\eta_i}} Q_i \quad \forall i \tag{2.37}$$

Note: π_i^q is the profit of the firm producing the ith Armington composite good

P_i^q is price of the ith Armington composite good

Q_i is the ith Armington composite good

δm_i, δd_i are the input share coefficients in the Armington composite good production function ($0 \leq \delta m_i \leq 1, 0 \leq \delta d_i \leq 1, \delta m_i + \delta d_i = 1$)

M_i is the ith imported good

η_i is the parameter defined by the elasticity of substitution ($\eta_i = (\sigma_i - 1)/\sigma_i, \eta_i \leq 1$)

D_i is the ith domestic good

γ_i is the scaling coefficient in the Armington composite good production function

P_i^m is the price of the ith imported good in terms of domestic currency

P_i^d is price of the ith domestic good

2.4.3.7 Transformation between exports and domestic goods

$$\max_{Z_i, E_i, D_i} \pi_i = \left(P_i^e E_i + P_i^d D_i\right) - (1 + \tau_i^z) P_i^z Z_i \tag{2.38}$$

subject to

$$Z_i = \theta_i \left(\xi e_i E_i^{\phi_i} + \xi d_i D_i^{\phi_i}\right)^{\frac{1}{\phi_i}} \tag{2.39}$$

Note: π_i is the profit of the firm engaged on the ith transformation

P_i^e is the price of the ith export good in terms of gomestic currency

E_i is exports of the ith good

P_i^d is the price of domestic good

D_i is the supply of the ith domestic good

τ_i^z is the production tax on the ith gross domestic output

P_i^z is the price of the ith gross domestic output

Z_i is the gross domestic output of the ith good

θ_i is the scaling coefficient of the ith transformation

ξe_i, ξd_i are share coefficients for the ith good transformation

$$(0 \leq \xi e_i \leq 1, 0 \leq \xi d_i \leq 1, \xi e_i \quad + \xi d_i \quad = 1)$$

ϕ_i is the parameter defined by the elasticity of transformation

$$(\phi_i = (\psi_i + 1)/\psi_i, \psi_i \geq 1)$$

ψ_i is the elasticity of transformation of the ith good transformation

$$(\psi_i = \frac{d(E_i/D_i)}{E_i/D_i} / \frac{d(P_i^e/P_i^d)}{P_i^e/P_i^d})$$

$$E_i = \left[\frac{\theta_i^{\phi_i} \xi e_i (1 + \tau_i^z) P_i^z}{P_i^e}\right]^{\frac{1}{1-\phi_i}} Z_i \tag{2.40}$$

$$D_i = \left[\frac{\theta_i^{\phi_i} \xi d_i (1 + \tau_i^z) P_i^z}{P_i^d}\right]^{\frac{1}{1-\phi_i}} Z_i \tag{2.41}$$

2.4.3.8 Market Clearing

The CGE model assumes the market-clearing condition, i.e., demand meets supply in all markets:

$$Q_i = X_i^p + X_i^g + X_i^v + \sum_j X_{i,j} - R_i^b \tag{2.42}$$

$$\sum_j F_{hc,j} = FF_{hc} \tag{2.43}$$

where R_i^b is reimbursement, i.e., money from firms to households

2.4.3.9 Gross Domestic Product (GDP) and Consumer Price Index (CPI)

GDP

$$GDP_i = X_i^p + X_i^g + X_i^v + E_i - M_i \tag{2.44}$$

CPI

$$CPI = \sum_i cwts_i \, p_i^q \tag{2.45}$$

where $cwts_i$ is the consumption bundle weight

$$cwts_i = \frac{Xp0_i}{\sum_j Xp0_j} \tag{2.46}$$

2.5 Scenarios and Results

This section will discuss an experiment using the CGE model for reducing South Korea’s military expenditures, and then exploring efficacious policies to enable policymakers to achieve their objectives. Here, we focus on the affected sectors by reducing the military budget, and how to invest a reduced budget in other sectors.

The current military budget allocation has been recently increasing and it is difficult to reduce military expenditures when influential people are interested in security and protection. Some scholars warn that reducing military expenditures will threaten national security when every other state keeps increasing it. That is, reducing military expenditure will cause neighboring countries to threaten South Korea. However, as corruption in the defense industry in South Korea continues, I intend to explore and present the results through experiments informed by different opinions about reducing defense costs.

Under the assumption that policymakers can reduce military expenditures, at first, they need to explore the impact of reducing military spending. Table 2.3 below presents the results of reducing the military budget. The first scenario is reducing the defense budget by 10%; and the others in which the budget is increased by 10%. In other words, the second scenario is 20%, and the third scenario is the result of reducing the defense cost by 30%.

Variable	Baseline 1	Baseline 2	Baseline 3
GDP	−0.6557	−1.3127	−1.97095
Inflation	4.66294E-13	−6.5503E-13	−6.6613E-13
Consumption	−3.8858E-13	6.66134E-13	6.88338E-13
Investment	0.0087	0.0174	0.0262
Fiscal Spending	−6.7990	−13.6107	−20.4354
Imports	0.0842	0.1685	0.2529
Exports	0.0632	0.1266	0.1900
Private Savings	4.44089E-14		
Government Savings	0.0457	0.0916	0.1375
Exchange Rate	3.24185E-12	4.75175E-12	6.21725E-12

Table 2.3 The Results of Reducing Military Budgets (Shown in %)

The impact of military expenditure decline is reflected in Baselines 1, 2, and 3. As Table 2.3 indicates, the reduction in defense costs harms the economy: most of the economy gets negative impacts besides government saving and the trade. From the baseline 1, GDP decreases by 0.6557% from the baseline because of the high backward and forward linkage of national security sector with other sectors. It does not affect inflation significantly. Imports and exports increase by 0.84% and 0.63%, respectively. The most significantly affected variable is fiscal spending; that is, the government loses tax revenue. The national security sector is highly related to government taxes. Moreover, government saving increases by 0.04% when the military expenditure decreases by 10%.

To discuss the effects reported above, we must explore the impacts by each sector because the purpose of these simulations is to find how to reinvest the reduced ME to other industries to foster economic development. The CGE model can examine in detail through optimization analysis using sector interconnectivity. Table 2.4 contains the most affected ten sectors by reduced military expenditures in terms of GDP.

Sectors	**GDP (%)**
Public Service and National Security	−9.8273234
Building Maintenance	−0.3822754
General Machinery	−0.1703832
Transportation and Storage	−0.1230631
Precision Machinery	−0.0764664
Primary Metals	−0.0533557
Power	−0.033259
Textiles	−0.0314678
Electrical and Electronic	−0.0096705
Agriculture	−0.0012287

Table 2.4 The Sectoral GDP Results of Reducing Military Budgets by 10% (Shown in %)

The national security sector was the most affected. Table 2.5 displays the ten most affected sectors in terms of output production. The difference between GDP and output is that GDP is the market value of all *final* goods and services produced within the domestic boundaries; whereas the value of output includes *intermediate* goods

Sectors	Output (%)
Public Service and National Security	−10.482374
Construction Non-residential	−4.920436
General Machinery	−0.5291595
Building Maintenance	−0.3822754
Waterworks	−0.3498826
Transportation Equipment	−0.2444847
Print, Publishing	−0.2437438
Precision Machinery	−0.2072218
Textiles	−0.0694923
Communication and Broadcasting	−0.0687189

Table 2.5 The Total Result of the Baseline 1 (Shown in %)

As shown, the non-residential construction industry is most affected after the national security sector with a decrease of about 5%. Moreover, the general machinery industry is also affected. Based on these results, the industries in Table 2.5 have a higher interconnection with defense expenditures.

Next, I simulate non-housing construction and general machinery directly by as much as 10% of the national security sector; each sector gets half of 10% of national security. Table 2.6 displays the results:

Variable	Baseline	Scenario 1
GDP	−0.6557	−0.1298646
Inflation	4.66294E-13	4.44E-14
Consumption	−3.8858E-13	5.33E-13
Investment	0.0087	−0.1054838
Fiscal Spending	−6.7990	−1.0635327
Imports	0.0842	−0.152759
Exports	0.0632	−0.1147628
Private Savings	4.44089E-14	6.22E-13
Government Savings	0.0457	−0.5540196
Exchange Rate	3.24185E-12	3.60E-12

Table 2.6 The Total Results of Reducing Military Budgets (Shown in %)

GDP decreases by 0.12%, and imports and exports are negatively affected. Other sectors have not been significantly affected. To explore the results in detail, Table 2.7 contains the sectoral effects:

Sectors	GDP (%)
Public Service and National Security	−10.930318
Paper/wood	−5.3378138
Gas	−0.9963353
Chemistry	−0.9724982
Furniture and Manufacturing	−0.960881
Coal and Petroleum	0.92232988
Primary Metals	0.94581385
Construction,_non-residential	6.12583981
General Machinery	13.5589977
Non-metallic	14.5756956

Table 2.7 The Sectoral GDP Results of Scenario 1 (Shown in %)

The top five rows are sectors negatively affected, and the bottom five industries were positively affected. Besides national security, paper/wood was most affected. Also, gas, chemistry, and furniture manufacturing were negatively affected. On the other hand, non-metallic production, general machinery, non-residential construction, primary metal, and the petroleum industry are positively affected.

Sectors	Output (%)
Construction, residential	−53.977428
Public Service and National Security	−11.658854
Furniture and Manufacturing	−4.1841452
Paper/wood	−4.000287
Chemistry	−1.7498892
General Machinery	6.19017132
Construction, non-residential	7.91243413
Non-metallic	7.91439677
Mining	10.4173152

Construction, transportation	72.0300056

Table 2.8 The Sectoral Output Results of Scenario 1 (Shown in %)

For output production, house-construction, furniture and manufacturing, paper, and chemistry decrease their output. Still, construction for transportation, mining, non-metallic production, non-residential construction, and general machinery increased their production.

The next scenario is to invest the reduced defense spending in educational facilities. This is because education plays an important role in determining the value of people's moving, investment, or real estate in Korea.

Variable	Baseline	Scenario 1	Scenario 2
GDP	−0.6557	−0.1298646	−0.0291006
Inflation	4.66294E-13	4.44E-14	−1.02E-12
Consumption	−3.8858E-13	5.33E-13	7.06E-12
Investment	0.0087	−0.1054838	−0.0236373
Fiscal Spending	−6.7990	−1.0635327	−0.2383212
Imports	0.0842	−0.152759	−0.185311
Exports	0.0632	−0.1147628	−0.139218
Private Savings	4.44089E-14	6.22E-13	6.59E-12
Government Savings	0.0457	−0.5540196	−0.1241474
Exchange Rate	3.24185E-12	3.60E-12	2.58E-11

Table 2.9 The Total Results of the Scenario 2 (Shown in %)

Compared to scenario 1, GDP has increased by 0.1%, and imports and exports have decreased by 0.02%. Table 2.10 displays the sectoral results:

Sector	GDP (%)
Public Service and National Security	−10.139758
Non-metallic	−6.02726
Paper/Wood	−4.6819538
Furniture and Manufacturing	−0.8756369
Building Maintenance	−0.5983131

Communication and Broadcasting	0.01097452
Precision Machinery	0.17016726
Electrical and Electronic	0.17673136
Power	0.207393
Education	5.93797154

Table 2.10 The Sectoral GDP Results of Scenario 2 (Shown in %)

Sectoral effects also differ from the results of Scenario 1. Specifically, the non-metallic industry is negatively affected even though it receives a positive effect from Scenario 1. This is because it is related to the general machinery industry. On the other hand, the education sector positively influences power, electrical and electronic, precision machinery, and communication and broadcasting industries in terms of GDP.

Sector	Output (%)
Construction, residential	−59.910739
Public Service and National Security	−10.815696
Furniture and Manufacturing	−3.8972984
Paper/wood	−3.5172709
Non−metallic	−3.2737412
Waterworks	0.32345098
Precision Machinery	0.46557832
Education	5.11175044
Construction, transportation	6.65536609
Construction, non-residential	75.6665825

Table 2.11 The Sectoral Output Results of Scenario 2 (Shown in %)

Residential construction decreases approximately 50%, and furniture and manufacturing also receives a negative effect by stimulating the education sector. While transportation and non-residential construction obtain positive results by investing reduced military costs into the education sector.

In terms of increasing GDP, the non-residential and residential construction sectors are selected to invest. These two construction sectors get 50% for the reduced military expenditures. Table 2.12 compares the baseline results to each scenario:

Variable	Baseline	Scenario 1	Scenario 2	Scenario 3
GDP	−0.6557	−0.1298646	−0.0291006	0.05499283
Inflation	4.66294E-13	4.44E-14	−1.02E-12	1.78E-13
Consumption	−3.8858E-13	5.33E-13	7.06E-12	6.66E-14
Investment	0.0087	−0.1054838	−0.0236373	0.04466843
Fiscal Spending	−6.7990	−1.0635327	−0.2383212	0.45036673
Imports	0.0842	−0.152759	−0.185311	0.39960669
Exports	0.0632	−0.1147628	−0.139218	0.30021133
Private Savings	4.44089E-14	6.22E-13	6.59E-12	2.22E-13
Government Savings	0.0457	−0.5540196	−0.1241474	0.23460653
Exchange Rate	3.24185E-12	3.60E-12	2.58E-11	3.75E-12

Table 2.12 The Total Results of Scenario 3 (Shown in %)

Table 2.12 indicates that only Scenario 3 achieves a positive GDP, investment, fiscal spending, and government savings, even though the government sector reduces its budget. Comparing each scenario shows that the investment in the construction sectors can foster national development, as indicated by increased GDP. Table 2.13 includes the sectoral results:

Sectors	GDP (%)
Public Service and National Security	−9.4799924
Construction repairing	−0.2632903
Transportation Equipment	−0.1217029
Power	−0.1087989
Primary Metal	−0.0472816
Metallic Production	0.75929955
Paper/wood	2.0346929
Non-metallic	3.24979688
Construction, non-residential	6.27593959
Construction, residential	7.27071276

Table 2.13 The Sectoral GDP Results of the Scenario 3 (Shown in %)

As shown in Table 2.13, the national security sector was the most negatively affected by directly reducing the military budget, followed by construction repairing.

Sector	Output (%)
Public Service and National Security	−10.111908
Construction Transportation	−5.8195962
Construction non−residential	−5.7122225
Watering	−0.2893131
Construction repairing	−0.2632903
Metallic Production	1.30518778
Primary Metals	1.33554501
Paper/wood	1.5242978
Non-metallic	1.76563211
Construction, residential	17.7623053

Table 2.14 The Sectoral Output Results of the Scenario 2 (Shown in %)

As shown the construction sectors (transportation and non-residential) had negative effects, while residential construction was most affected. Non-residential construction industry is highly related to the public service and national security sector. The non-residential construction sector's output is negatively affected even though stimulated directly by 50% of the reduced amount from the national security. That is, non-residential construction highly relies on the national security sector's business.

2.6 Conclusion

In simulation experiments with a CGE model in which military expenditures are reduced and expenditure reductions are invested in other sectors, results differ depending on the sectors in which defense expenditure cuts are invested. Military spending is important for fiscal stimulus in each nation, so it is hard to decide to reduce it. However, if defense costs are leaking somewhere due to corruption, I think there is plenty of room to share opinions on how to reduce defense costs.

This paper explored the impact of reducing military expenditures and suggests how to use the reduced amount of military spending. Simulations show results differ by which sector policymakers focus on investing. Moreover, simulations produce different results according to industry interconnectivity. In my opinion, focusing on the education sector may help reduce increasing real estate prices However, it is important to state that while industries are developed with investment, industries are also decreasing. This paper ascertains which industries are interrelated with each other so that policymakers can consider developing.

REFERENCES

Bae, J. S. (2018). Generation and ideology factors of evaluation on North Korea and security policy. *Korea and World Politics, 34*(2), 100-134.

Barbieri, K. (1996). Economic interdependence: A path to peace or a source of *interstate* conflict? *Journal of Peace Research*, *33*(1), 29-49.

Benoit, E. (1973). *Defense and economic growth in developing countries* (pp.17-19). Lexington, MA: Lexington Books.

Coghlan, D. (2008). *Prospects from Korean Reunification*. Strategic Studies Institute.

Eberstadt, N. (1997). Hastening Korean Reunification. *Foreign Affairs,* 77-92.

Deger, S. (1986). Economic development and defense expenditure. *Economic Development and Cultural Change*, *35*(1), 179-96.

Haddad, E. (2009). Interregional computable general equilibrium models. In *Tool Kits in Regional Science* (pp.199-154). Berlin: Springer.

Heo, U. (1996). The political economy of defense spending in South Korea. *Journal of Peace Research*, *33*(4), 483-490.

Huang, C., & Mintz, A. (1991). Defense expenditures and economic growth: the externality effect. *Defense and Peace Economics*, *3*(1), 35-40.

Isard, W. (1979). A Definition of Peace Science, the Queen of the Social Sciences: Part I. *Conflict Management and Peace Science*, *4*(1), 1-47.

Isard, W. (1980). A Definition of Peace Science, the Queen of the Social Sciences, Part II. *Journal of Peace Science*, *4*(2).

Isard, W., Azis, I. J., Drennan, M. P., Miller, R. E., Saltzman, S., & Thorbecke, E. (1998). *Methods of interregional and regional analysis*. Aldershot, England: Ashgate.

Integrated System for Separated Families. Retrieved April 06, 2014, from https://reunion.unikorea.go.kr/reunion/jsp/user/un/unm0201L?currentSN=11&q_section=EVENT& (in Korean).

Joh, J. J., Kim, Y., & Koh, Y. (2010). "Territorial development policy, Chapter 5." In SaKong, I., & Koh, Y. (Eds.), *The Korean economy, six decades of growth and development* (pp. 179-226). Seoul: The Committee for the Sixty-Year History of the Korean Economy.

Kim, H. J. (2007). The 16th Korean Presidential Election and the North Korea Variable. *The Journal of Political Science & Communication, 10*(2), 47-64.

Korean Statistical Information Service. (n.d.). *Census 1960 to 2008*. Available from KOSIS Data database.

Korean Statistical Information Service. (2010). Retrieved June 15, 2012, from http://kosis.kr/wnsearch/totalSearch.jsp (in Korean).

Miller, R. E., & Blair, P. D. (2009). *Input-output analysis foundations and extensions*. Cambridge: Cambridge University Press.

Mt Kumgang Tour. Retrieved April 11, 2014, from http://www.mtkumgang.com (in Korean).

Na, S. (2015). *혈세 빼돌리기 3 軍 따로 없어... '별' 22 개 떨어졌다* [All Three of Army, Navy, and Air Forces took their taxes away…22 'Stars' fell]. *KMIB News*. Retrieved from http://news.kmib.co.kr/article/view.asp?arcid=0923162369&code=11122100&cp=nv

Russett, B. (1982). Defense expenditures and national well-being. *The American Political Science Review, 76*(4), 767-777.

South Korea Latitude and Longitude Map. *Maps of World*. Retrieved June 14, 2012 from http://www.mapsofworld.com/lat_long/south-korea-lat-long.html

Stalenheim, P. (2007). Perdomo, Catalina. "Military expenditure". *SIPRI-Stockholm International Peace Research Institute*, 267-297.

The World Bank (n.d.). *Census 2003 to 2012.* Available from The World Bank Data database.

The World Bank (n.d.). *Gross Domestic Product 2003 to 2012.* Available from The World Bank Data database.

World Map Latitude and Longitude Map. *Maps of World*. Retrieved June 14, 2012 from http://www.mapsofworld.com/world-maps/world-map-with-latitude-and-longitude.html

Yoon, S. (2017). '*뚫리는 방탄복' 비리연루 예비역 장성 항소심도 집유* [Collected the depth of appeal of the General of the Reserve, who is involved in 'Body armor']. News1. Retrieved from http://news1.kr/articles/?3168588

APPENDIX

SAM Components

No.	Abbreviation	Category	Description
1	Agri	Production Sector	Agriculture
2	Mine	Production Sector	Mining
3	Food	Production Sector	Food and Drink
4	Text	Production Sector	Textile and Leather
5	Pape	Production Sector	Paper and Wood
6	Prin	Production Sector	Printing and Publishing
7	Petr	Production Sector	Coal and Petroleum
8	Chem	Production Sector	Chemistry
9	Nmet	Production Sector	Non-metallic
10	Mnan	Production Sector	Primary-metal
11	Fpro	Production Sector	Metallic Production
12	Gmac	Production Sector	General Machinery
13	Eleq	Production Sector	Electtrical and Electronic
14	Pins	Production Sector	Precision instruments
15	Tran	Production Sector	Transportation equipment
16	Furn	Production Sector	Furniture and other manufacturing industries
17	Elec	Production Sector	Power
18	Gas	Production Sector	City gas and heat supply business
19	Wate	Production Sector	Watering
20	Chos	Production Sector	Housing Construction
21	Cnho	Production Sector	Non-housing Construction
22	Crep	Production Sector	Construction repair
23	Ctra	Production Sector	Transportation facility construction
24	Coth	Production Sector	Other Civil Construction
25	Whol	Production Sector	Wholesale and retail
26	Acco	Production Sector	Accommodations and Restaurants
27	Ware	Production Sector	Transportation and Storage
28	Tele	Production Sector	Communication and broadcasting
29	Fina	Production Sector	Finance and insurance
30	Rest	Production Sector	Real Estate and Business Service
31	Nsec	Production Sector	Public Administration and Defense
32	Educ	Production Sector	Education and health
33	Sass	Production Sector	Social Assistance and other services
34	Othe	Production Sector	Others
35	Labo	Factor of Production	Labor
36	Capi	Factor of Production	Capital
37	hhs	Institution	Households

No.	Abbreviation	Category	Description
38	govt	Institution	Government
39	KA	Capital Account	Households Capital Account
40	ROW	Capital Account	Foreign institution Capital Account

CHAPTER 3
DOES PEACE PROMOTE TRADE?

3.1 Introduction

Which came first, the chicken or the egg? This question reflects an ancient dilemma related to cause-and-effect relationships and is applicable to the relationship between peace and trade. Does peace promote trade, or does increased trade lead to more stable international relationships? Generally speaking, it is difficult to establish which one is the cause because it is hard to establish whether war or trade existed first in history. Therefore, this is a controversial issue among; some scholars say fewer conflicts between states leads to more trade, while others insist that more trade leads to a more peaceful relationship between nations.

A more peaceful relationship tends to promote conversation between states, which, in turn, increases the likelihood for interstate alliances to form. In turn, the formation of alliances will promote even more subsequent trade, repeating itself and becoming a virtuous circle. However, a conflict can arise between states over the opportunity cost of trade gain because states would want to have more profit through trade. (Martin, Mayer, & Thoenig, 2008). As a result, states would have a bad relationship and trade would decrease. In my opinion, the phenomenon described above is like the Mobius strip; it is difficult to distinguish between beginning and end. Even though it is hard to conclude whether it was peace or trade that came first, we can still discuss their mutual contribution.

The ambiguous relationship between trade and conflict has been studied by many scholars. Researchers have investigated the relationship between trade and peace via causal factors, such as physical distance between states, political orientation, and each state's alliances. However, few studies on trade and peace were conducted before 1945; it is hard to find references about the relationship between conflict and trade before that time (Coulomb, 1998). It can be explained by the fact that the amount of international trade was relatively stable before 1945, but since then international trade has accelerated. Figure 3.1 plots the level of international trade over the last five decades.

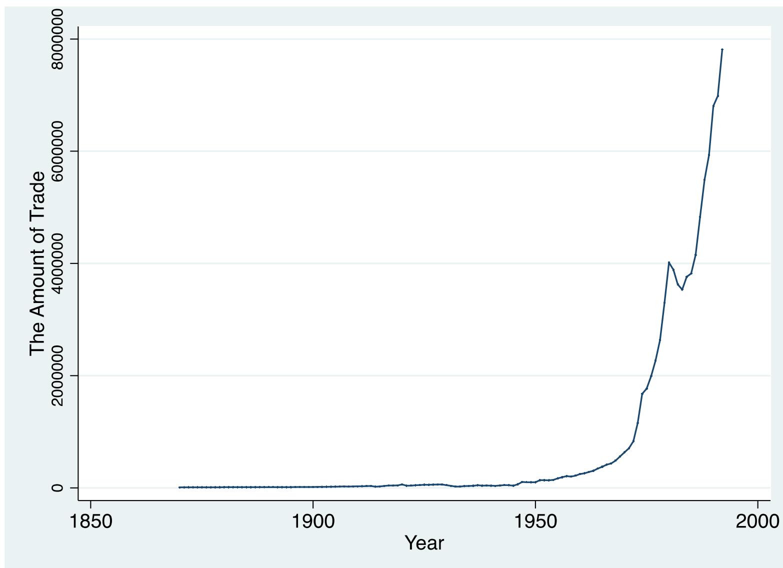


Figure 3.1 Total Amount of International Trade in Millions of Current USD (source: Barbieri's https://people.cas.sc.edu/barbierk/databases.html)

Figure 3.1 shows that international trade dramatically increased after the 1950s. As a consequence of globalization, Stiglitz (2002) argued that many countries have benefited from international trade through its positive effects on economic development. Singer (2004) wrote that we are living in one world; Friedman (2005) says that the world is now flat, which suggests there is no limit to the exchange of goods, thoughts, or even cultures. Hummels (2007) states that changes in international transportation by technological innovation in the globalization era, especially decreasing shipping costs, increases international trade.

Has the number of conflicts decreased or increased? I use the Militarized Interstate Disputes (MIDs) dataset, which is obtained from the Correlates of War project originally maintained by the University of Michigan (https://www.icpsr.umich.edu/icpsrweb/ICPSR/series/00232) but now housed at Penn State University (http://www.correlatesofwar.org). The following graph demonstrates the frequency of militarized conflicts:

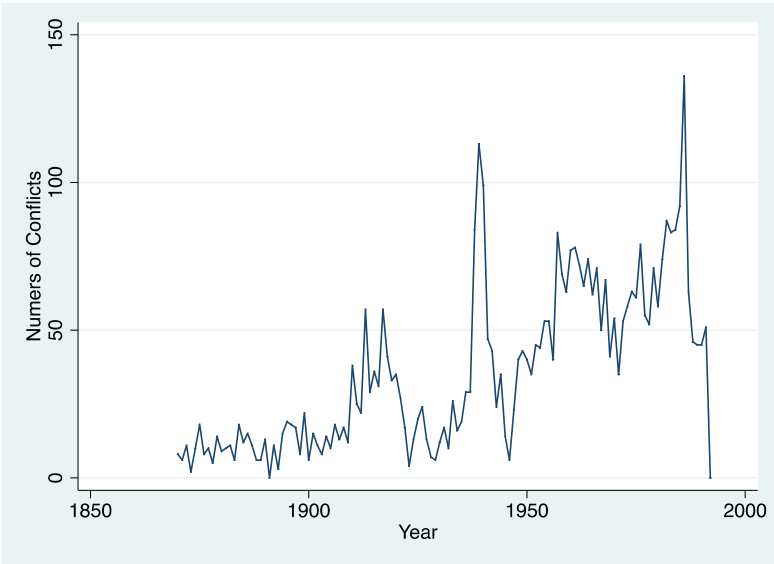


Figure 3.2 Total Number of Annual Militarized Conflicts (source: Barbieri's https://people.cas.sc.edu/barbierk/databases.html)

Figure 3.2 shows that the number of global militarized conflicts indeed fluctuates. In an upward-trending graph, it can be said that conflicts are constantly occurring throughout history, though the frequency diminishes in some periods. Since this graph only shows an overall trend, it does not show whether a pattern of relationship exists between peace and trade. Therefore, it is necessary to empirically investigate the trade and dispute history of each country.

How has each nation benefited from globalization? People have many opportunities to choose goods with more competitive prices, and companies can have more opportunities to expand markets to sell their products. As a result, the amount of international trade has increased. Did the end of World War II (WWII) affect trade? It might have. It could be that people have gained more knowledge and understanding of other nations through cultural exchanges. García-Pérez, Boguñá, Allard, and Serrano (2016) mention that trade networks have become more complex and larger since World War I; it can be said that the amount of trade increased after World War I.

However, the trend of international trade does not reflect all nations. North Korea has not received any globalization benefits, given its increased isolation (Oh & Hassig, 2004). Nevertheless, many countries and organizations have tried to open the door to North Korea. For example, South Korea has made efforts to have a better relationship with North Korea. In the six decades following the Korean War (1950–1953), the relationship between North and South Korea has changed; the relationship is amicable in some periods but contentious in others. During the amicable period, families separated by the Korean War had 18 opportunities from 2000 to 2014 to reunite. From 2002 to 2008, South Koreans were allowed to visit some parts of North Korea through a guided tour, called the Mount Kumgang Tour (Integrated Information System for Separated Families and Mt Kumgang Tour). However, North Korea eventually stopped South Korean tourism, and the South Korean government stopped giving aid under its Sunshine Policy. In addition, South Korea has helped North Korea by giving aid. Even though the amount of aid is different from government to government, South Korea continues to help North Korea. Moreover, in 2018, the North Korea–United States summit was held in Singapore, and Donald Trump, the 45th president of the United States and Kim Jong-un, Supreme Leader of North Korea, met and discussed building a lasting and stable peace regime on the Korean Peninsula. If peace is maintained as a result of the summit meeting, can this help trade in goods?

In this paper, will establish the mutual impact between trade and peace because most scholars have only studied the one-way impact of trade on peace, or vice versa. However, peace and trade do not simply affect each other in one direction, but mutually and interdependently. In order to reveal this interdependency, I constructed a SEM analysis that allows for a latent variable to be represented by multiple indicators, enabling me to determine which indicators are more influential in terms of capturing the variation in peace or trade. By using the MIDs dataset, I generate two latent variables for SEM with indicators that are selected based on their ability to explain the variation in each latent variable. Moreover, I explore the relationship between peace and trade after WWII given that because international trade has increased rapidly since then.

I apply the results of the SEM analysis to the relationship in the Korean Peninsula. Therefore, this paper will help policymakers in South Korea improve their relationship with North Korea from a multifaceted perspective, rather than focusing solely on aid. I hope this paper will become a roadmap to help improve inter-Korean relations.

3.2 Literature Review

I will summarize two types of studies: studies that examine the effect of trade on peace, and studies that examine the effect of peace on trade. I will begin with the first part. Many scholars have explored the relationship between trade and peace, and there are different ways to research this topic.

3.2.1 The Effect of Trade on Peace

Many scholars of peace-related studies have studied the relationship of peace with trade. In order to explore the impact of trade on peace, many scholars use peace as a dependent variable. Among the works on trade and peace, I do not attempt to provide comprehensive reviews but start by reviewing Barbieri's work.

In "*The Liberal Illusion*," Barbieri (2002) explored the relationship between peace and trade based on different approaches and methods. The author, at first, modifies and generates variables from the MIDs dataset to explore the relationship between peace and trade, especially the impact of trade on peace. Furthermore, the author is interested in the relationship between interdependency and peace because she investigates the impact of economic links on conflicts. The author found that a lower possibility of conflict with a lower degree of interdependency; a higher likelihood of conflict when states have a higher level of interdependency of trade.

Polachek (1980) utilized a dyadic dataset from the Conflict and Peace Data Bank from 1958 to 1967 covering 30 countries. An expected utility model describes a relationship between international trade and conflict. At first, the author assumes that more conflicts reduce the amount of trade and measures the relationship between trade and conflict by conducting a bivariate regression analysis. Moreover, the author uses export and import quantities. The following equations are used:

$$NETF_{ij} = \alpha_o + \alpha_1 x_{ij} + \varepsilon$$

$$NETF_{ij} = \beta_0 + \beta_1 m_{ij} + \varepsilon$$

$NETF_{ij}$ represents the net conflict and is calculated as the difference between the frequency of conflicts (9–15) and the frequency of cooperation (1–7) from country *i* to country *j*; x_{ij} is the exports from country *i* to *j*. The variable m_{ij} is the imports from country i to country j; and ε is a random error term that assumed normal distribution with a mean of zero. The author expands these equations to multiple regression by including population density, school enrolment, defense expenditures, and others because he assumes that country size is related to the relationship between peace and trade. Then, he finds that higher economic trade decreases belligerence.

Martin et al. (2008) explored the relationship between trade and conflict by analyzing empirical correlates of war (COW) and MIDs datasets with a gravity equation. They analyzed the impact of conflicts on trade. They found evidence that trade does not promote peace; that is, both bilateral and multilateral trade increase the probability of wars.

Parlow and Chakrabati (2009) investigated the relationship between trade and conflict and found no relationship. They analyzed empirical studies using a simple regression method, comparing each study because each one uses different regression methods. Then, they used a vector autoregression model (VAR) to analyze a bivariate model. As it is well known, a simple regression model is expressed with the following equations:

$$conflict_{ij} = \beta_0 + \beta_1 trade_{ij} + \beta_2 attributes_i + \varepsilon_i$$

or

$$trade_{ij} = \beta_0 + \beta_1 conflict_{ij} + \beta_2 attributes_i + \varepsilon_i$$

Compared to a single regression method, they find that each study has different results according to the different approaches and methods used. In a VAR model, variables are dependent on their own lagged variables; that is, the actions or outcomes that have been done affect the present. This can be expressed by the following equations for two variables:

$$trade_t = \beta_0 + \beta_{11} trade_{t-1} + \beta_{12} trade_{t-2} + \beta_{13} conflict_{t-1} + \beta_{14} conflict_{t-2} + \varepsilon_{1t}$$

$$conflict_t = \beta_0 + \beta_{11} conflict_{t-1} + \beta_{12} conflict_{t-2} + \beta_{13} trade_{t-1} + \beta_{14} trade_{t-2} + \varepsilon_{2t}$$

Accordingly, each dependent variable is affected by the outcomes of one year and two years ago. Parlow and Chakrabati (2009) conclude that empirical research, (including their study) may not be trusted because each study uses a different regression method and has different results; thus, the results are likely to be biased.

Later, Parlow (2011) investigated the impact of trade on peace by applying a gravity model, which was introduced by Isard and is a useful framework for bilateral flow data. Isard's model is $F_{ij} = G\,\frac{M_i * M_j}{D_{ij}}$ where F_{ij} is the trade quantity from state i to state j; M_i and M_j is the GDP of country i and j; and D_{ij} is the distance between country i and j. This model also can be expressed as $F_{ij} = G\,\frac{M_i^{\beta_1} M_j^{\beta_2}}{D_{ij}^{\beta_3}}\eta_{ij}$ for econometric estimation. By taking logs of both sides, we obtain the following equation:

$$\ln F_{ij} = \beta_0 + \beta_1 \ln(M_i) + \beta_2 \ln(M_j) - \beta_3 \ln(D_{ij}) + \varepsilon_{ij}$$

Parlow uses the MID's dataset for conflicts; the United Nations Statistics Division database for GDP; the World Trade Organization database for regional trade agreements (RTA), and the polity score from the COW project. Parlow constructed a model by adding the following independent variables: alliances, languages, military expenditures, development, and democracy score. Parlow conducted a gravity model analysis to explore the relationship between trade and peace, and uses instrumental variables to attenuate endogeneity. Parlow's baseline of estimation is to have GDP, per capita income, and distances between nations, then controls for RTA and common language. Parlow found that the democracy score affects both trade and peace, development only affects trade, and military expenditures positively affect the probability of war. However, he concludes that there is no relationship between trade and conflict, and that conflicts are caused by other factors.

3.2.2 The Effect of Free Trade on Peace

In addition to the previous research regarding the relationship between trade and peace, McDonald (2004) concentrates on the impact of free trade on peace. He assumes that free trade is negatively related to peace; that is, free trade may increase conflicts between states. To test his hypothesis, he uses the MIDs dataset for conflicts and free trade, expressed by market protection or openness:

$$Conflict_{ij} = \beta_0 + \beta_1 Protect_H + \beta_2 Depend_L + \beta_3 Democracy_L + \beta_4 Ally + \beta_5 Contig + \beta_6 CarRatio + \beta_7 Growth_L + \beta_8 Interests + \beta_9 GDP_H + \beta_{10} Distance + \beta_{11} GreatPower + \varepsilon_{ij}$$

Note: $Protect_H$ represents a measure of market protection by using import duties. $Depend_L$ is trade dependency, calculated by total trade divided by GDP. He also includes the democracy score ($Democracy_L$), the number of alliances (*Ally*), the number of borders (*Contig*), the national power (*CarRatio*), economic development (*Growth*), and *Interests*. He found that a higher level of free trade reduces the number of interstate conflicts.

3.2.3 The Effect of Interdependence on Peace

Focusing on the relationship between interdependency and peace, Oneal and Russett (1999) replicate Barbieri's (2001) work to evaluate liberal peace with different approaches for their research because some of the variables that Barbieri uses are not useful. Especially, trade shares have multicollinearity risk. They use a logistic regression analysis and focus on estimating the effect of interdependence on the likelihood of conflict for contiguous states, major power pairs, and all other dyads separately. they found that unbalanced trade does not increase conflict. In other words, trade which is economically important promotes peace.

Neo-Marxists believe that trade has an insignificant or counterbalancing effect on conflict. Copeland (1996) provides evidence on whether economic interdependence increases or decreases interstate conflicts. His thesis focuses on the impact of economic interdependence on conflicts with historical evidence providing a new theory for building liberal and realist approaches to economic interdependence and war. Copeland (1996) focuses on expectations of future trade: If expectations are positive, political leaders have less reason to make war because they expect to benefit from trade.

3.2.4 The Effect of Trade Integration on Peace

Lee and Pyun (2016) investigated the impact of trade integration on disputes between states. The reason they emphasize trade integration is because globalization influences the emergence of markets and the integration of developing countries into the international trading system. In order to ascertain the effect of trade integration on disputes, they use the data from the COW project and the MIDs dataset, and the expected utility model to calculate the probability of conflict, expressed as the following equation:

$$MID_{ijt} = \alpha + \beta_i Bilateral\ trade\ openess_{ijt} + \beta_2 Global\ trade\ Openess_{ijy} + \gamma X_{ijt} + \delta Year_i + u_{ijt}$$

The equation states that militarized interstate disputes are affected by trade interdependency between bilateral states, trade interdependency toward other states except for the dyadic states, and other determinants. All variables are dyadic between states *i* and *j*, and they are assigned at time $t-2$, and MIDs are assigned at time *t*. Their independent variables included: national power, alliances, contiguity, oil exporter dummy, common language, and religious similarity. They conclude that interstate military conflict decreases when bilateral trade interdependence and trade openness levels are higher.

3.2.5 The Effect of International Cooperation on Peace

Grieco (1990) investigated trade's effect on peace and found that international cooperation increases conflict. In his book, he argued that concerns over relative benefits might override the short-term gains of cooperation in the long term. States avoid long-term agreements that benefit another state disproportionally because states expect the externality from cooperation. Therefore, he concludes that trade results in more disputes.

3.2.6 The Effect of National Power on Peace

Rahman (2010) explored the relationship between national power, especially naval power, and international trade by analyzing relations between wars, alliances, naval power, and trade. He used the standard gravity model:

$$Trade_{ij} = C\left(\frac{Y_i Y_j}{Dist_{ij}}\right)$$

where $Trade_{ij}$ represents the trade between nations *i* and *j*; *C* is a constant; *Y* represents the GDP of each nation; and $Dist_{ij}$ is the physical distance between nations *i* and *j*.

Then he modifies the basic model by adding measures of the naval power of the "Protagonistic" and "Antagonistic" fleets:

$$Trade_{ij} = C\left(\frac{Y_i Y_j}{Dist_{ij}}\right)\left(\frac{e^{ProtagFleet_{ij}}}{e^{AntagFleet_{ij}}}\right)$$

Rahman found that naval conflicts reduce the amount of international trade, but allied countries have more trade between themselves. In other words, it can be said that the countries involved in a war reduce the volume of trade and that the countries with an agreement increase the volume of trade.

In this paper, unlike the literature, I will explore the bidirectional relationship between peace and trade using the structural equation modeling (SEM) approach, which allows estimating in one unified framework. the impact of peace on trade and, conversely, the impact of trade on peace. Using the SEM, I will produce evidence of a changing relationship between trade and peace before and after WWII.

3.3 Methodology

I use the SEM approach to describe relationships among latent and observed variables (Lomax and Sachumacker, 2004). SEM has two parts: structural and measurement. The former describes relations between latent variables. Latent variables represent theoretical concepts that are not directly observed but can be inferred from other variables that are designed to measure the unobserved concept. The later part thus aims to measure latent variables using observable variables available from the data (indicators). SEM is a multivariate statistical technique and is widely used in social science research, psychological research, behavioral sciences, and medical experiments. SEM is a mixture of multiple regression and explanatory factor analysis (Bagozzi & Yi, 2011; Hox & Bechger, 1998; Ullman & Bentler, 2003). SEM implies a structure of the covariance matrix of the measures; hence its alternative name “analysis of covariance structures”). Once the model’s parameters have been estimated, the resulting model-implied covariance matrix can then be compared to an empirical or data-based covariance matrix. If the two matrices are consistent, then the structural equation model can be considered a plausible explanation for relations between the measures (Nelson & Olsen, 1978).

Acock (2013) introduced four types of SEMs: confirmatory factor analysis (CFA), path analysis, latent variable structural model, and latent growth curve model. CFA is a multivariate statistical technique and it can estimate how the observed variables explain latent variables. Unlike explanatory factor analysis, CFA can selectively estimate the observed variables for latent variables, while all measured variables are related to latent variables in exploratory factor analysis. SEM also has the capability to do path analysis, which is regarded as a causal model. This means that we can establish the causal effects of the independent variables on the dependent variable through path analysis, rather than simply estimating the correlations. In this paper, I will use SEM with latent variables to establish the bidirectional causality between trade and peace. In particular, I will use path analysis to establish the causal effect of trade on peace and the effect of peace on trade.

A basic structure of the SEM matrix is as follows:

$$\begin{bmatrix} y_1 \\ y_2 \\ \cdots \\ y_n \end{bmatrix} = \begin{bmatrix} 0 & \beta_{12} & \cdots & \beta_{1n} \\ \beta_{21} & 0 & \cdots & \beta_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \beta_{n1} & \beta_{n2} & \cdots & 0 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ \cdots \\ y_n \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \cdots & \gamma_{1n} \\ \gamma_{21} & \gamma_{22} & \cdots & \gamma_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \gamma_{n1} & \gamma_{21} & \cdots & \gamma_{nm} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \cdots \\ x_m \end{bmatrix} + \begin{bmatrix} \varsigma_1 \\ \varsigma_2 \\ \cdots \\ \varsigma_n \end{bmatrix}$$

$$y = By + \Gamma \mathrm{x} + \varsigma$$

Based on the matrix structure above, there are n simultaneous equations. The Y variables are the endogenous outcome variables; the X variables are the exogenous explanatory variables; the βs are the parameters of the structural part of the SEM analysis; γ are causal parameters of the measurement part; and the ςs are the error terms.

Standard assumptions are that the errors terms are not correlated with exogenous variables, and the $|I - B|$ matrix is invertible. Formally,

$$Cov(x, \varsigma) = 0$$

$$|I - B| \neq 0$$

Variances and covariances of the exogenous variables are stable, and the error terms have homoscedastic variance.

$$V(x) = E\left(xx^{'}\right) = \Phi \text{ and}$$

$$V(\varsigma) = \mathrm{E}\left(\varsigma\varsigma^{'}\right) = \Psi$$

Figure 3.3 exemplifies a simple SEM structure. We wish to estimate the variances and covariances of the latent variables and the residual error variances of the indicator variables. The ovals represent the unobserved latent variable; rectangles represent the observed indicator variables, and circles represent the latent error terms.

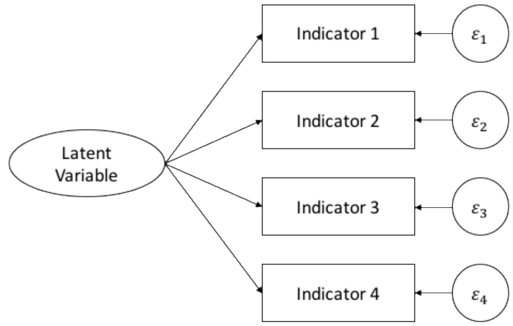


Figure 3.3 Measurement Model for a Latent Variable

The regression equations for this measurement model are:

$$I_1 = \alpha_1 + L\beta_{11} + e.I_1$$

$$I_2 = \alpha_2 + L\beta_{21} + e.I_2$$

$$I_3 = \alpha_3 + L\beta_{31} + e.I_3$$

$$I_4 = \alpha_4 + L\beta_{41} + e.I_4$$

where *L* represents the latent variable, and *I* represents the indicator variables. A standard assumption is $(\mathrm{L}, I_1, I_2, I_3, I_4, e.I_1, e.I_2, e.I_3, e.I_4) \sim$i.i.d. with mean vector μ and covariance matrix Σ where i.i.d. means that observations are independent and identically distributed.

Indicator variables are measures of the latent concept. The model's objective is to extract the latent variable as a common factor that explains the variation in the indicator variables. The idea here is that the indicators are reflective, which means a change in the value of the underlying concept (i.e., the latent variable) is reflected by a change in the indicator variables. For example, in this article, a change in the latent variable, peace, should be reflected in changes in the various indicators for peace, such as the number of militarized interstate conflicts, alliances exist, or if the country is at war.

SEM can estimate the relations among observed variables and the latent variables, and it can help find evidence of the reciprocal relationship between trade and peace. Also, SEM provides estimates of complex models through large numbers of equations (Tomarken & Waller, 2005).

In the structural part of the model, we connect multiple latent variables through hypothesized causal relationships. For example, in the model where two latent variables affect each other mutually, the relationship can be described as follows:

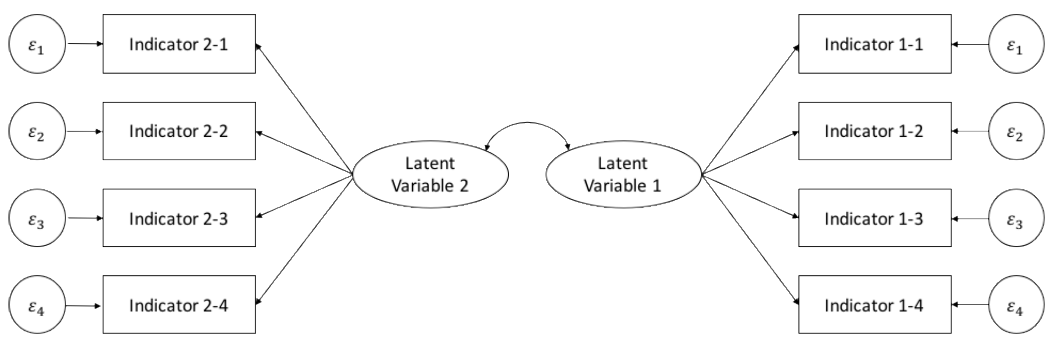


Figure 3.4 A Two-Factor Model

As it is a two-factor model in Figure 3.4, one factor is an unobserved variable (called a latent variable), so a two-factor model explores the relationship between two latent variables with indicators for each. As shown above, SEM's advantage is the ability to integrate latent and observed variables into one framework. SEM also deals with measurement error, which is a major issue in many disciplines, by explicitly including an error term for every measurement model. That is, measurement error and statistical analysis are treated separately (Schumacker & Lomax, 2012). Bagozzi and Yi (2012) summarized SEM's benefits, which includes the ability to provide integrative functions and to obtain more precise estimates through the inclusion of multiple indicators for each latent variable.

3.4 Data Descriptions and Model Structures

To construct a SEM for peace and trade, I use the MIDs data set (see the introduction section). MIDs is defined as a case of conflict in which the threat, display or use of military force (but short of war) by one state is explicitly directed toward the government, official representative, official forces, property, or territory of another state (Jones, Bremer, & Singer, 1996: 163).

Each case of MIDs is a dyadic variable that represents a conflict between two states. In order to establish the causal relationship between peace and trade, peace is defined to be the absence of militarized disputes (Barbieri, 2002).

In Barbieri (1996), peace is the dependent variable, and trade is the key independent variable. The control variables included are contiguity, regime type, numbers of alliances, and the Composite Index of National Capability (CINC) score. Contiguity is the number of shared borders between the two countries. For the regime type, she uses the polity III (https://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/6695) democracy levels, which range from 10 to −10 to express democracy and autocracy levels, based on an evaluation of a state’s openness, competitiveness of elections, and political participation. For example, military dictatorships in North Korea and Saudi Arabia were assigned −10 in the polity III score in 2018, while Australia and Austria were assigned 10. For my study, South Korea was assigned 9 in the Polity III score for

2018. Alliance is a binary variable equal to 1 when an alliance exists between the states, and 0 otherwise. CINC is calculated from the COW project to measure national power. National power is an average of population, natural resources, and military status. CINC is calculated as follows:

$$\frac{(TPR + UPR + ISPR + ECR + MER + MPR)}{6}$$

where TPR is the total population of country ratio; UPR is the urban population of country ratio; $ISPR$ is the iron and steel production of country ratio; ECR is the primary energy consumption ratio; MER is military expenditures, and MPR is the military personnel ratio, where $ratio = \frac{Country}{World}$.

In my initial analysis, I use Barbieri's dataset available from her website (https://people.cas.sc.edu/barbierk/databases.html) which contains information from 1870 to 1992. Barbieri has modified several variables from dyadic to non-dyadic. The following table contains Barbieri's variables:

Variable	Details
Lyr_{t-1}	Years
stnum_{t-1}	COW State Code
Nmids	Number of Militarized Interstate Disputes
totimp_{t-1}	Imports in Millions of Current USD
totexp_{t-1}	Exports in Millions of Current USD
tottrade_{t-1}	Total Trade in Millions of Current USD
pi_{t-1}	US Consumer Price Index
allied_{t-1}	Number of Alliances

$contig_{t-1}$	Number of Shared Borders
$cinc_{t-1}$	COW CINC Score
dem_{t-1}	Polity III Democracy Score
aut_{t-1}	Polity III Autocracy Score
$poly_{t-1}$	Democracy Score ((dem−aut)+10)
$Rimp_{t-1}$	Imports/PI
$Rexp_{t-1}$	Exports/PI
$rttrade_{t-1}$	Total Trade/PI
gdp_{t-1}	GDP in Millions of Current USD
$rgdp_{t-1}$	GDP/PI
$rbot_{t-1}$	Balance of Trade
$tdep_{t-1}$	Tottrade/gdp
$Devel_{t-1}$	$(GDP_t - GDP_{t-1})/GDP_{t-1}$

Table 3.1 Variables in the Dataset

In the order listed, Lyr represents a year for the data. The nmids is the number of militarized interstate disputes for each nation. Totimp and totexp are the levels of imports and exports in millions of current USD. Tottrade is the total trade, which is the sum of total imports and total exports. Pi is the US consumer price index. ALLIED is the number of alliances of each state. Barbieri (1996) generated the joint democracy score to measure the degree of democracy, calculated by subtraction from the democracy score to autocracy score, and added 10. Therefore, the range of joint democracy is from 0 to 20. For example, the joint democracy score between Australia and Austria (having the highest democracy score) is $(10 - 0) + 10 = 20$, and the joint democracy score between North Korea and Saudi Arabia (having the highest autocracy score) is 0, $(0 - 10) + 10 = 0$.

Rimp, rexp, and rttrade are real imports, exports, and total trade divided by the US consumer price index, as indicators for estimating the real values of imports, exports, and total trade adjusted by price change. GDP is measured in millions of current US dollars. RGDP is also calculated by dividing PI to measure changes in the real output level of an economy. RBOT is a balance of trade. TDEP is trade dependency in which total trade is divided by GDP for each state. Development is newly generated in this paper, which is the growth of GDP from the previous year. $(Development_t = \frac{GDP_t - GDP_{t-1}}{GDP_t})$.

As listed in Table 3.1, most of the variables, except the number of militarized interstate disputes (NMIDS), were assigned at the time period *t−1*, because Barbieri assumed that the amount of trade at the previous year at *t−1* affected peaceful status at year *t*. However, I created a lagged-year NMIDS in order to adjust the time period at the same time in order to use SEM for a two-factor model. Among the variables in Table 3.1, I chose the variables as indicators for each latent variable—peace and trade.

One of the most challenging aspects of a SEM is to find the appropriate indicators for a latent variable. For example, it is complicated to choose indicators for peace or trade from data. Some scholars argue that contiguity is related to peace, and others categorize contiguity as a variable that influences trade. In this paper, I will use contiguity as a factor for peace because the distance between states is no longer as important as it once was because transportation and globalization. Moreover, I choose the number of militarized interstate disputes (NMIDS) as an indicator of peace because I think, no matter what, the conflict would be more closed to peace rather than trade. Figure 3.5 describes the structures of SEM for the latent concepts of peace and trade:

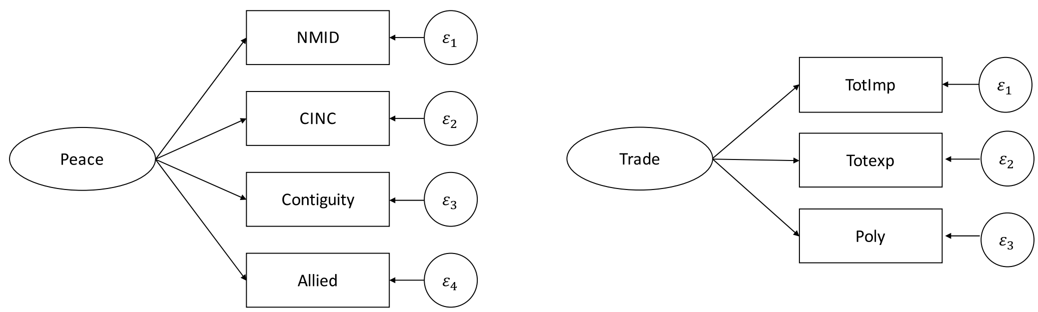


Figure 3.5 SEM for Peace and Trade

Figure 3.5 can be expressed by the following equations:

$$nmid_i = \alpha_1 + Peace\beta_1 + e.nmid_i$$

$$CINCi = \alpha_2 + Peace\beta_2 + e.CINC_i$$

$$Contig_i = \alpha_3 + Peace\beta_3 + e.Contig_i$$

$$Allied_i = \alpha_4 + Peace\beta_4 + e.Allied_i$$

$$totimp_1 = \alpha_1 + Trade\beta_1 + e.totimp_1$$

$$totexp_2 = \alpha_2 + Trade\beta_2 + e.totexp_2$$

$$Poly_3 = \alpha_3 + Trade\beta_3 + e.Poly_3$$

To use SEM to analyze trade as a latent variable, I choose indicators as well. As shown in Figure 3.5, I selected the amount of exports and imports as indicators of trade. Total trade represents the total amount of trade of each state in millions of current USD. Furthermore, I used the democracy level (poly) as an indicator of trade, because it is also used for analyzing the relationship between North Korea and South Korea, which have different political regimes.

Decker and Lim (2009) argue that democracies promote trade more; and Mitra Thomakos, and Ulubaşoğlu (2002) argues that a higher level of democracy positively links with trade. Also, two nations might have extremely different economic structures. For example, the North Korean economy is very closed, while, the South Korean economy is a free market economy.

As is mentioned in the introduction, the relationship between North and South Korea has been dependent on the amicability of the South Korean government. When the South Korean government was friendly, North Korea had less intention to make threats. The meaning of "amicable" here is more supports or aid from South Korea to North Korea. Therefore, the democracy level is more likely related to the use of trade as an indicator rather than the use of peace. That is, trade is a formative action influencing peace according to the relationship between the two Koreas.

SEM can explore reciprocal relationships. To do this, after estimating two latent variables, I connect two models for building a two-factor model, which is depicted as follows:

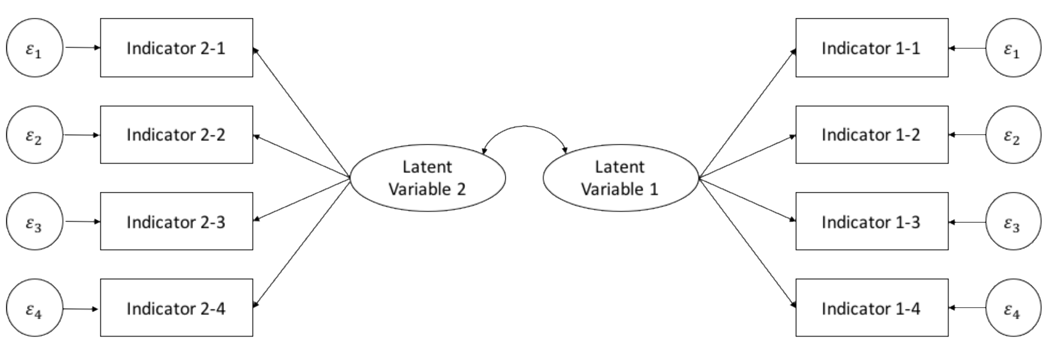


Figure 3.6 A Two-Factor Model

Figure 3.6 demonstrates a structure of two latent variables with four indicators for each. By means of this model, we can observe the relationship between two unobserved latent variables from the dataset. I will explain more details about a two-factor model for this paper in a later part in results part.

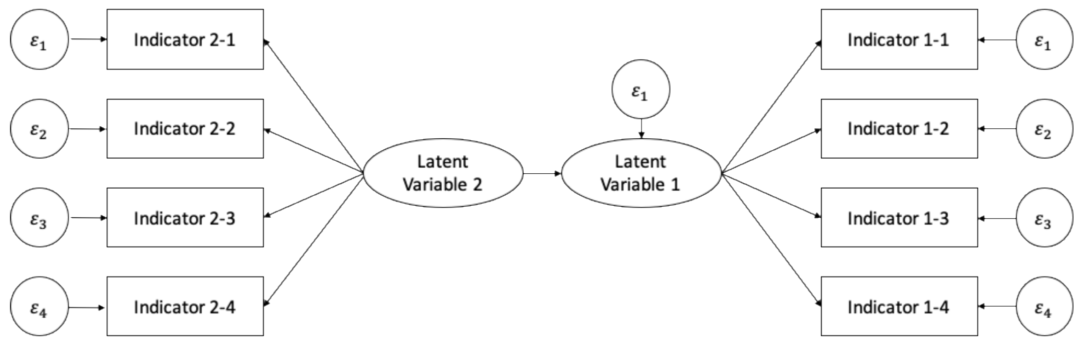


Figure 3.7 Path Analysis Model

3.5 Results

In order to explore the reciprocal relationship between trade and peace after the end of WWII, especially since the 1950s, i.e., the beginning of globalization (James & Steger, 2014), I conducted a SEM for peace and trade. The first task in using SEM is to select the indicators for the latent variables: trade and peace. Therefore, I conducted a two-latent SEM model.

I also estimated a two-factor model in order to explore the reciprocal relationship between peace and trade; thus, connecting the two SEMs together. Figure 3.8 illustrates the structure of a two-factor model and describes a basic model of SEM between peace and trade:

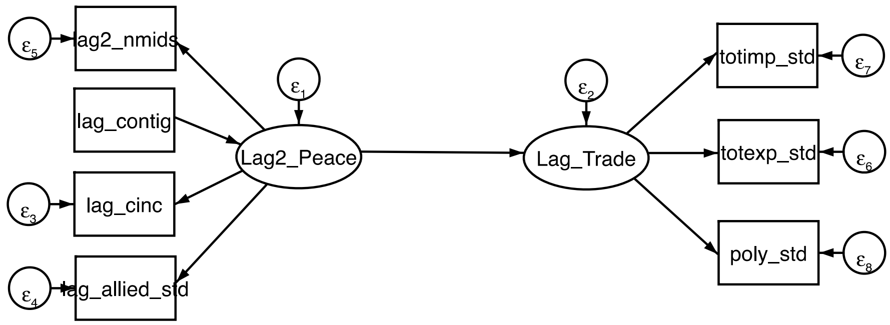


Figure 3.8 Two-Factor SEM for Peace and Trade

As illustrated, peace is explained by three indicators: the number of conflicts (NMIDS), national power (CINC), and the number of alliances (ALLIED); while trade is measured by three indicators: imports (TOTIMP), exports (TOTEXP), and the joint democracy score (POLY). Moreover, contiguity affects peace directly because the contiguity between states does not change as much as other indicators.

Table 3.2 and Figure 3.9 contain the SEM analysis results between peace and trade. Indicators for peace are assigned at the time $t-1$, and indicators for trade are assigned at time t. To do this, I generated lagged observed variables for peace because the original data contained two different time periods in which the NMIDS are assigned at t and other variables are assigned at $t-1$. The purpose is to establish the causal effects of peace (at time $t-1$) on trade (at time t). Therefore, I generated a two-year lag variable for the number of conflicts, and one-year lag variables for the other indicators for peace (contiguity, national power, and alliances), while I use same time period for imports, exports, and democracy score, the indicators of trade. Moreover, I change the contiguity to an endogenous variable for peace because contiguity does not have physical changes as time passes, so it has a direct effect on peace for the structural part.

Structural equation model   Number of obs = 8,060
Estimation method = ml
Log likelihood = −286029.89

(1) [lag_cinc]Lag2_Peace = 1
(2) [totexp]Lag_Trade = 1

	Coef	OIM Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Structural						
Lag2_Peace <-						
lag_contig	.3287466	.0127057	25.87	0.000	.3038438	.3536494
Lag_Trade <-						
Lag2_Peace	3086.047	171.9238	17.96	0.000	2749.082	3423.011
Measurement						
lag_cinc <-						
Lag2_Peace	1	(constrained)				
_cons	−.1481845	.0761255	−1.95	0.052	−.2973876	.0010187
lag_allied <-						
Lag2_Peace	.4623618	.0811304	5.70	0.000	.3033491	.6213745
_cons	7.703122	.1836988	41.93	0.000	7.343079	8.063165
lag2_nmids <-						
Lag2_Peace	.295169	.0119693	24.66	0.000	.2717096	.3186284
_cons	−.0038861	.0215956	−0.18	0.857	−.0462127	.0384404
totexp <-						
lag_Trade	1	(constrained)				
_cons	131.418	390.0384	0.34	0.736	−633.0432	895.8792
totimp <-						
lag_Trade	1.112135	.010901	101.02	0.000	1.09077	1.133501

_cons	−225.4114	424.121	−0.53	0.059	−1056.673	605.8505
poly <-						
lag_Trade	.0000679	3.68e−06	18.44	0.000	.0000607	.0000751
_cons	9.096146	.086075	105.68	0.000	8.927442	9.26485
var(e.lag_cinc)	10.69994	.2633189			10.19404	11.23095
var(e.lag_allied)	125.9451	1.998296			122.0888	129.9232
var(e.lag2_nmids)	.7641152	.0211853			.7237008	.8067864
var(e.totexp)	2.90e+07	4475294			2.14e+07	3.92e+07
var(e.totimp)	3729733	5505993			206584.1	6.73e+07
var(e.poly)	51.41587	.8105201			49.85157	53.02926
var(e.Lag2_Peace)	3.847807	.2303756			3.421765	4.326895
var(e.lag_Trade)	4.29e+08	8608985			4.13e+08	4.46e+08

Note: The LR test of model vs. saturated is not reported because the fitted model is not full rank.

Table 3.2 Unstandardized Result of Two-Factor SEM for Peace and Trade

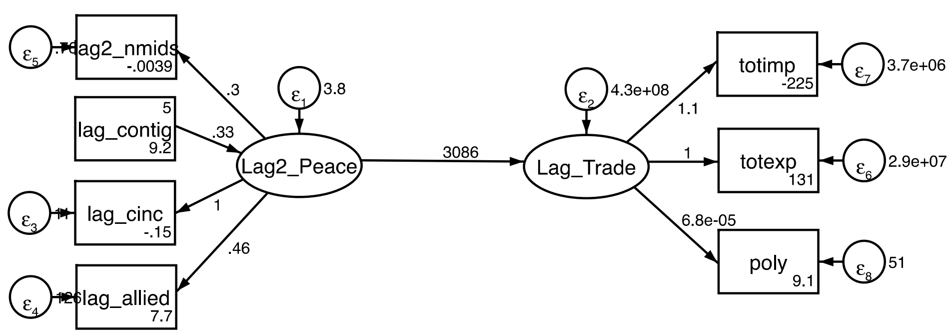


Figure 3.9 Result of Two-Factor SEM for Peace and Trade

As shown, all indicators are significant. However, the table contains the unstandardized result, so the reason the coefficient of the lagged national power (lag_cinc) is 1 is that lag_cinc is used as a reference for other variables; moreover, that the coefficient of total imports is 1 means that it is used as a reference for other variables. That is, an unstandardized parameter retains the original scale of the associated variable. Therefore, I focus on standardized solutions. Standardized parameter estimates are transformations of unstandardized estimates that remove scaling and can be used for informal comparisons of parameters through the model. Standardized estimates correspond to effect-size estimates. Output and standardizations are both observed, and latent variables have a variance of 1.0. That is, we do not need a reference indicator because a standardized result provides comparability between variables. Table 3.3 and Figure 3.10 report the standardized solutions:

Standardized	Coef	OIM Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Structural						
Lag2_Peace <-						
lag_contig	.453206	.0138903	32.63	0.000	.4259816	.4804305
Lag_Trade <-						
Lag2_Peace	.3115381	.0142649	21.84	0.000	.2835795	.3394967
Measurement						
lag_cinc <-						
Lag2_Peace	.558178	.0140104	39.84	0.000	.5307181	.5856379
_cons	−.0375876	.0192178	−1.96	0.050	−.0752539	.0000787
lag_allied <-						
Lag2_Peace	.0902911	.0151906	5.94	0.000	.0605181	.1200641
_cons	.6835946	.0174956	39.07	0.000	.6493038	.7178854
lag2_nmids <-						
Lag2_Peace	.5964277	.0142468	41.86	0.000	.5685046	.6243508
_cons	−.0035684	.0198208	−0.18	0.857	−.0424164	.0352796
totexp <-						
lag_Trade	.9708419	.0045929	211.38	0.000	.9798438	.9798438

_cons	.005853	.0173806	0.34	0.736	−.0282123	.0399184
totimp <-						
lag_Trade	.9968419	.0046698	213.47	0.000	.9876893	1.005994
_cons	−.0092688	.0174248	−0.53	0.595	−.0434208	.0248831
poly <-						
lag_Trade	.2020635	.0107796	18.74	0.000	.1809359	.2231911
_cons	1.242386	.0157597	78.83	0.000	1.211498	1.273275
var(e.lag_cinc)	.6884373	.0156406			.6584548	.7197851
var(e.lag_allied)	.9918475	.0027431			.9864856	.9972386
var(e.lag2_nmids)	.644274	.0169943			.6118121	.6784583
var(e.totexp)	.057466	.0089179			.0423952	.0778942
var(e.totimp)	.0063062	.0093101			.0003492	.1138732
var(e.poly)	.9591704	.0043563			.95067	.9677467
var(e.Lag2_Peace)	.7946043	.0125903			.7703069	.819668
var(e.lag_Trade)	.902944	.0088881			.8856906	.9205335

Note: The LR test of model vs. saturated is not reported because the fitted model is not full rank.

Table 3.3 Standardized Result of the Baseline of the Estimates

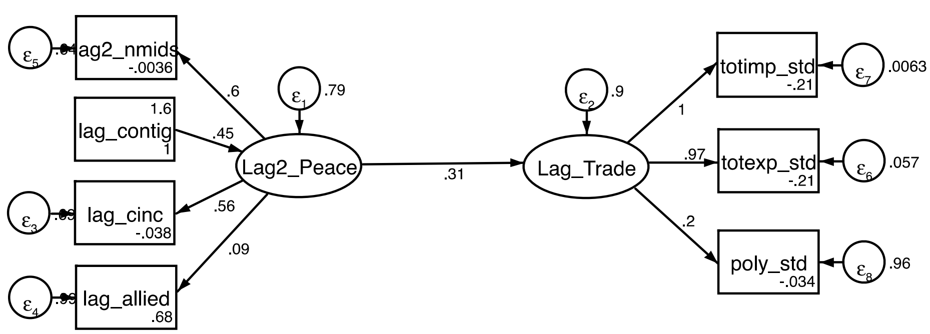


Figure 3.10 Standardized Result of the Baseline of the Estimates

Table 3.3 and Figure 3.10 show the standardized result that explains that peace, as explained by conflicts, national powers, and alliances, is positively related to trade.

The result is not much different from the previous result before modifying the variables, but Table 3.4 provides a better fit by using the results from a chi-squared test.

Based on results, a one standard-deviation increase in peace is estimated to lead to an increase of 0.31 standard deviations in trade. Contiguity is positively related to peace by a 0.45 standard deviation increase in peace; and peace is associated with conflicts, national power, and alliances by a 0.6, 0.56, and 0.09 standard deviation increase, respectively. Moreover, trade affects total imports, total exports, and political regime scores positively. However, the estimated model is not a full ranked model; that is, each of the rows of the matrix is not linearly independent and full column rank when each of the columns of the matrix is not linearly independent. So, I handle some variables after checking means and standard deviations. Table 3.4 summarizes the variables' statistics:

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
lag2_nmids	9,048	.4689434	1.084435	0	26
lag_contig	9,243	4.785351	3.036711	0	20
lag_cinc	9,013	1.412199	3.833212	.0001876	38.02125
lag_allied	9,243	7.758845	11.0049	0	42
totimp	9,166	4971.806	24255.6	.0304082	552610
totexp	9,165	4791.306	22842.41	.0194525	447400
poly	8,481	9.344535	7.283699	0	20

Table 3.4 Summary: Statistics of the Variables

To obtain a better fit of the model, I standardized four variables from Table 3.4: lag_allied, totimp, totexp, and poly. Table 3.5 contains the result with standardized variables:

Structural equation model   Number of obs = 8,060
Estimation method = ml
Log likelihood = 88402.588

(1) [lag_cinc]Lag2_Peace = 1
(2) [totexp]Lag_Trade = 1

Standardized	Coef	OIM Std. Err.	z	P>|z|	[95% Conf. Interval]	
Structural						
Lag2_Peace <-						
lag_contig	.4532091	.0138903	32.63	0.000	.4259845	.4804337
Lag_Trade <-						
Lag2_Peace	.3115405	.0142649	21.84	0.000	.2835818	.3394992
Measurement						
lag_cinc <-						
Lag2_Peace	.5581725	.0140106	39.84	0.000	.5307123	.5856327
_cons	−.0375859	.0192179	−1.96	0.050	−.0752522	.0000805
lag_allied_std <-						
Lag2_Peace	.0902944	.0151906	5.94	0.000	.0605213	.1200675
_cons	−.008177	.016298	−0.50	0.616	−.0401204	.0237664
lag2_nmids <-						
Lag2_Peace	.5964264	.0142467	41.86	0.000	.5685033	.6243495
_cons	−.0035717	.0198207	−0.18	0.857	−.0424196	.0352762
totexp_std <-						
Lag_Trade	.9708424	.0045928	211.38	0.000	.9618406	.9798442
_cons	−.2075427	.0171198	−12.12	0.000	−.2410968	−.1739886
totimp_std <-						
lag_Trade	.9968414	.0046697	213.47	0.000	.9876889	1.005994
_cons	−.2137089	.0171751	−12.44	0.000	−.2473715	−.1800463
poly_std <-						
lag_Trade	.0107796	.0107796	18.75	0.000	.1809361	.2231913
_cons	−.0339265	.0117428	−2.89	0.004	−.0569419	−.010911

var(e.lag_cinc)	.6884434	.0156406			.6584609	.7197912
var(e.lag_allied)	.9918469	.0027433			.9864848	.9972382
var(e.lag2_nmids)	.6442755	.0169943			.6118137	.6784597
var(e.totexp)	.057465	.0089179			.0423943	.0778932
var(e.totimp)	.0063072	.00931			.0003494	.1138386
var(e.poly)	.9591703	.0043563			.9506699	.9677466
var(e.Lag2_Peace)	.7946015	.0125905			.7703039	.8196655
var(e.lag_Trade)	.9029425	.0088882			.885689	.9205322

Note: LR test of model vs. saturated: chi2(13) = 936.16, Prob > chi2 = 0.0000

Table 3.5 A Better Fit Model Between Peace and Trade

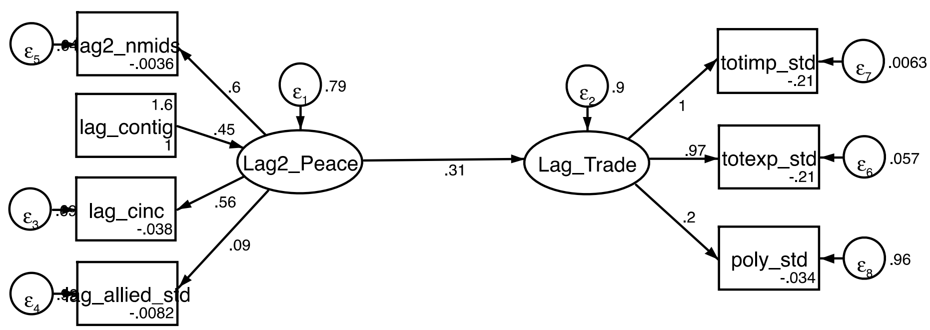


Figure 3.11 The Results with Standardized Variables

From the better fit model, peace is explained by conflict, national power, and alliances, and are positively related to trade, as shown in Table 3.6 below. The result is not much different from the previous result before modifying the variables, but a chi-squared test reveals that the model estimated with standardized variables provides a better fit to the data. Based on the results, peace is associated with an increase of 0.31 units in trade. Contiguity is positively related to peace, increasing by 0.45 units; and that peace is associated with conflict, national power, and alliances by an increase of 0.6, 0.56, and 0.09 units, respectively. Moreover, trade is positively associated with total imports, total exports, and the political regime. That is, countries having more trade and democratic political regimes have higher trade volumes in general.

Next, I check the model's reliability by checking all fit statistics, with the results:

Fit Statistic	Values	Description
Likelihood ratio		
chi2_ms(13)	936.164	Model vs. saturated
p > chi2	0.000	
chi2_bs(21)	25807.462	Baseline vs. saturated
p > chi2	0.000	
Population error		
RMSEA	0.094	Root mean square error of approximation
90% CI, lower bound	0.089	
upper bound	0.099	
pclose	0.000	Probability RMSEA <= 0.05
Information criteria		
AIC	176845.176	Akaike's information criterion
BIC	176985.069	Bayesian information criterion
Baseline comparison		
CFI	0.964	Comparative fit index
TLI	0.942	Tucker–Lewis index
Size of residuals		
SRMR	0.049	Standardized root mean squared residual
CD	0.205	Coefficient of determination

Table 3.6 Fit Statistics of Variables

The comparative fit index (CFI) is 0.964, which is bigger than 0.90, meaning that the index value is reliable (Acock, 2013). Transforming variables to standardized values improves the model's fit. Acock (2013) suggests that the standardized root mean square residual (SRMR) expresses how well the model fits the data; and since it is 0.049, which is less than the critical value of 0.08, we may infer that the model fits the data well. This result means that each correlation is reproducing within 0.049 on average among the six indicators.

Next, I estimated the impact of trade on peace and the impact of peace on trade simultaneously. The idea is that peace affects trade, and, in turn, trade also affects peace. That is, this model can capture the reciprocal effects between trade and peace because the model is established by time series: peace at time $t-2$ affects trade at $t-1$, while trade at $t-1$ affects peace at time t. Table 3.7 and Figure 3.12 describe the route from peace to trade to peace, and contains the estimated results:

Structural equation model Number of obs = 7,890
Estimation method = ml
Log likelihood = −119870.83

(1) [lag_cinc]Lag2_Peace = 1
(2) [totexp]Lag_Trade = 1
(3) [nmids]Peace = 1

Standardized	Coef	OIM Std. Err.	z	P>|z|	[95% Conf. Interval]	
Structural						
Lag2_Peace <-						
lag_contig	.4536345	.0138727	32.70	0.000	.4264444	.4808246
Lag_Trade <-						
Lag2_Peace	.3138025	.0144249	21.75	0.000	.2855302	.3420748
Peace <-						
Lag_Trade	.2701416	.0152113	17.76	0.000	.240328	.2999552
Measurement						
lag2_nmids <-						

Lag2_Peace	.6060285	.0143396	42.26	0.000	.5779233	.6341337
_cons	−.0105118	.019967	−0.53	0.599	−.0496464	.0286228
lag_cinc <-						
Lag2_Peace	.555533	.0139777	39.74	0.000	.5281377	.5829292
_cons	−.033891	.0193644	−1.75	0.080	−.0718445	.0040625
lag_allied_std <-						
Lag2_Peace	.091265	.0152605	5.98	0.000	.0613554	.1211755
_cons	−.0143245	.0164089	−0.87	0.383	−.0464854	.0178364
totexp_std <-						
Lag_Trade	.9723796	.0031436	309.32	0.000	.9662181	.978541
_cons	−.2242557	.0172621	−12.99	0.000	−.2580889	−.1904226
totimp_std <-						
lag_Trade	.9943667	.003167	313.98	0.000	.9881595	1.000574
_cons	−.2286605	.0173345	−13.19	0.000	−.2626356	−.1946855
poly_std <-						
lag_Trade	.2006863	.0108802	18.45	0.000	.1793614	.2220112
_cons	−.0373625	.0118635	−3.15	0.002	−.0606144	−.0141105
nmids <-						
Peace	.5516652	.0243454	22.66	0.000	.5039492	.5993812
_cons	.4052217	.0123449	32.82	0.000	.381026	.4294173
f_cinc_std <-						
Peace	.6579445	.0284979	23.09	0.000	.6020896	.7137994
_cons	−.0122089	.0118097	−1.03	0.310	−.0353555	.0109377
f_allied_std <-						
Peace	−.009651	.0159669	−0.60	0.546	−.0409456	.0216436
_cons	.0723327	.0113165	6.39	0.000	.0501527	.0945127
var(e.lag2_nmids)	.6327295	.0173805			.5995651	.6677283
var(e.lag_cinc)	.6913826	.0155301			.6616044	.7225011
var(e.lag_allied_std)	.9916706	.0027855			.9862261	.9971452
var(e.totexp_std)	.0544779	.0061136			.0437217	.0678804
var(e.totimp_std)	.0112348	.0062983			.0037443	.0337099

var(e.poly_std)	.959725	.004367			.9512039	.9683225
var(e.nmids)	.6956655	.026861			.6449618	.7503554
var(e.f_cinc_std)	.567109	.0375001			.4981737	.6455833
var(e.f_allied_std)	.9999069	.0003082			.999303	1.000511
var(e.Lag2_Peace)	.7942157	.0125863			.7699262	.8192716
var(e.lag_Trade)	.90152	.0090531			.8839576	.9194476
var(e.Peace)	.9270235	.0082184			.9110549	.9432721

LR test of model vs. saturated: chi2(13) = 53974.96, Prob > chi2 = 0.0000

Table 3.7 The Standardized Result with Three Latent Variables

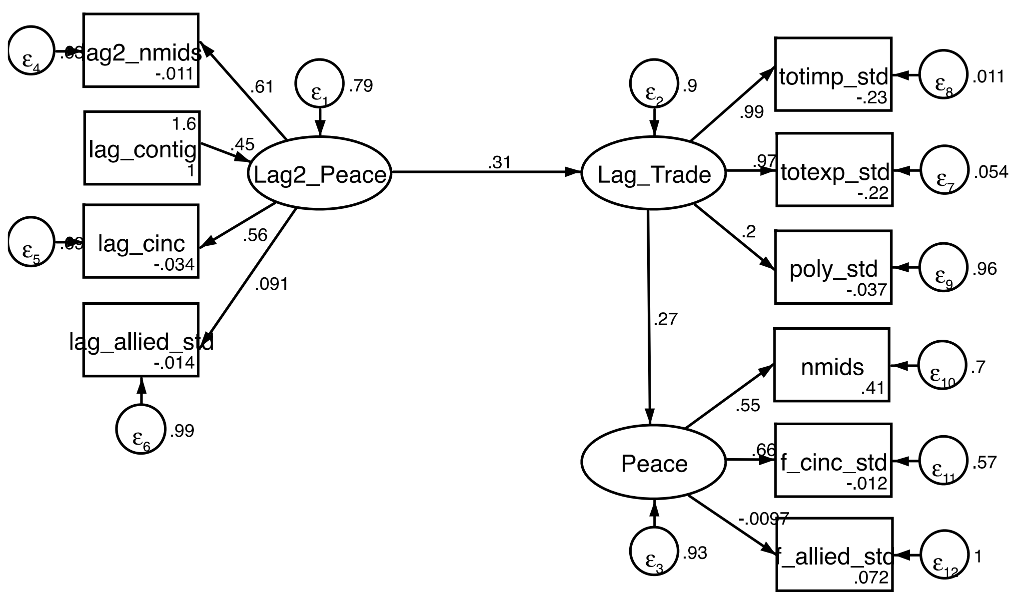


Figure 3.12 The Impact of Peace to Peace Through Trade

By establishing one more latent variable, SEM can also capture the impact of trade on peace, which means that a SEM approach to estimation may be employed to answer Barbieri's research question, and mine. The effect of peace on trade is the same with the two-factor SEM analysis, and the coefficient of trade on peace is 0.27, as shown in Figure 3.12, which is a little smaller than the opposite effect, from peace to trade. Moreover, it also can estimate the indirect effect of peace_{t-2} on peace_t by the product between the coefficients of peace on trade and trade on peace, 0.0837 (0.31×0.27). In addition, the direct and indirect effects of contiguity are estimated. Contiguity can affect not only peace but also trade, so the direct effect of contiguity on peace is 0.45 and the indirect effect of contiguity on trade is 0.1395 (0.45×0.31). Based on these results, that trade is more associated with an increase of units of conflict because trade is associated with an increase of 0.31 units in conflict and peace is associated with an increase of 0.27 units of trade.

Fit Statistic	Values	Description
Likelihood ratio		
chi2_ms(13)	53974.959	Model vs. saturated
p > chi2	0.000	
chi2_bs(21)	79584.286	Baseline vs. saturated
p > chi2	0.000	
Population error		
RMSEA	0.455	Root mean square error of approximation
90% CI, lower bound	0.000	
upper bound	.	
pclose	0.000	Probability RMSEA <= 0.05
Information criteria		
AIC	298826.494	Akaike's information criterion
BIC	299035.695	Bayesian information criterion
Baseline comparison		
CFI	0.322	Comparative fit index
TLI	0.075	Tucker–Lewis index
Size of residuals		
SRMR	0.199	Standardized root mean square residual
CD	0.206	Coefficient of determination

Table 3.8 Fit Statistics of Model with Three Latent Variables

By checking the fit statistics, however, the CFI of this model is 0.319, so I need to improve this model by establishing the relationship between variables. In order to have a better fit model, I indicate the relationship between alliances within a period of two years. Generally, it can be explained that alliances between two different time periods are correlated because the number of alliances cannot be changed in two years.

Structural equation model Number of obs = 7,890
Estimation method = ml
Log likelihood = −109761.6

(1) [lag_cinc]Lag2_Peace = 1
(2) [totexp]Lag_Trade = 1
(3) [nmids]Peace = 1

Standardized	Coef	OIM Std. Err.	z	P>|z|	[95% Conf. Interval]	
Structural						
lag_allied_std <-						
Lag2_Peace	.0912705	.0152604	5.98	0.00	.0613606	.1211803
_cons	−.0143262	.0164086	−0.87	0.383	−.0464866	.0178341
f_allied_std <-						
lag_allied_std	.9607092	.0008685	1106.21	0.000	.9590071	.9624114
Peace	−.0068235	.0041827	−1.63	0.103	−.0150214	.0013745
_cons	.0208347	.0031504	6.61	0.000	.01466	.0270093
Lag2_Peace <-						
lag_contig	.4536211	.0138724	32.70	0.000	.4264316	.4808105
Lag_Trade <-						
Lag2_Peace	.3137891	.0144254	21.75	0.000	.2855159	.3420623
Peace <-						
Lag_Trade	.2718203	.0149465	18.19	0.000	.2425258	.3011149
Measurement						
lag2_nmids <-						
Lag2_Peace	.6060488	.0143395	42.26	0.000	.5779233	.6341337

_cons	−.0105136	.0199669	−0.53	0.599	−.0496464	.0286228
lag_cinc <-						
Lag2_Peace	.5555243	.0139775	39.74	0.000	.5281288	.5829198
_cons	−.0338726	.0193644	−1.75	0.080	−.0718261	.0040809
totexp_std <-						
Lag_Trade	.9723371	.0031382	309.84	0.000	.9661864	.9784878
_cons	−.2286543	.0172616	−12.99	0.000	−.2580619	−.1903976
totimp_std <-						
lag_Trade	.9944103	.0031614	314.55	0.000	.9882141	1.000607
_cons	−.2286543	.0173346	−13.19	0.000	−.2626294	−.1946792
poly_std <-						
lag_Trade	.2006737	.01088	18.44	0.000	.1793493	.22219981
_cons	−.0373563	.0118634	−3.15	0.002	−.060608	−.0141045
nmids <-						
Peace	.5555823	.0230464	24.11	0.000	.5104122	.6007524
_cons	.4047604	.0123209	32.85	0.000	.3806118	.428909
f_cinc_std <-						
Peace	.652632	.0262908	24.82	0.000	.601103	.7041609
_cons	−.0121269	.0118076	−1.03	0.304	−.0352693	.0110156
var(e.lag2_nmids)	.6327048	.0173809			.5995397	.6677045
var(e.lag_cinc)	.6913928	.0155297			.6616153	.7225104
var(e.lag_allied_std)	.9916697	.0027856			.9862249	.9971445
var(e.totexp_std)	.0545606	.0061027			.0438198	.0679342
var(e.totimp_std)	.0111481	.0062875			.0036909	.0336724
var(e.poly_std)	.9597301	.0043667			.9512096	.9683268
var(e.nmids)	.6913283	.0256083			.6429156	.7433866
var(e.f_cinc_std)	.5740715	.0343164			.5106033	.6454289
var(e.f_allied_std)	.0770933	.0016679			.0738926	.0804326
var(e.Lag2_Peace)	.7942279	.0125857			.7699396	.8192824
var(e.Lag_Trade)	.9015364	.009053			.8839962	.9194558

var(e.Peace)	.9261137	.0081225			.9103242	.9421771

LR test of model vs. saturated: chi2(32) = 33756.50, Prob > chi2 = 0.0000

Table 3.9 Results Conducting Correlation Between Alliances

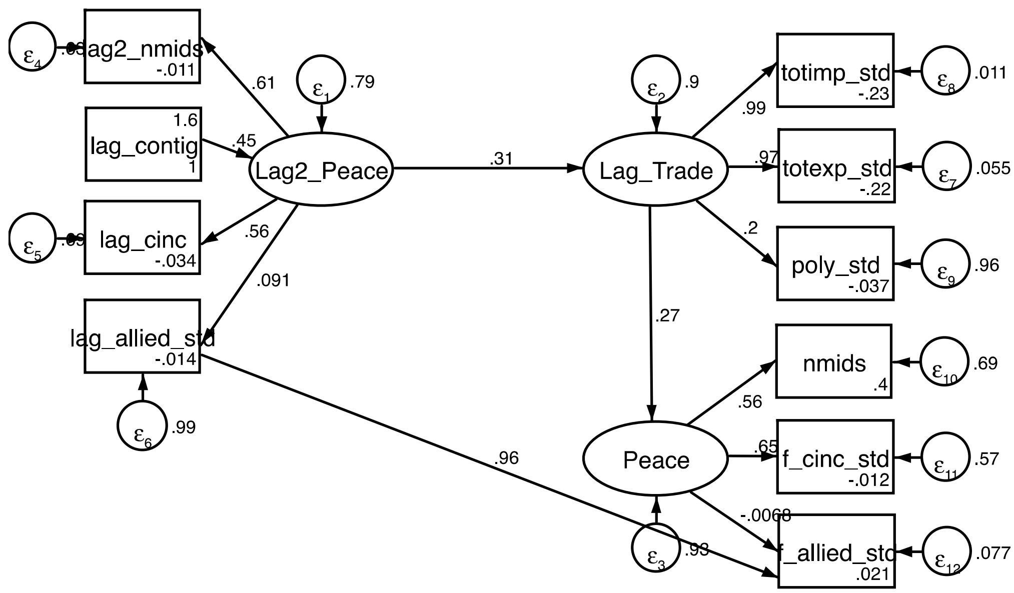


Figure 3.13 Adding the Correlation Between Alliances

Fit Statistic	Values	Description
Likelihood ratio		
chi2_ms(32)	33756.504	Model vs. saturated
p > chi2	0.000	
chi2_bs(45)	79584.286	Baseline vs. saturated
p > chi2	0.000	
Population error		
RMSEA	0.365	Root mean square error of approximation
90% CI, lower bound	0.000	
upper bound	.	
pclose	0.000	Probability RMSEA <= 0.05
Information criteria		

AIC	219585.198	Akaike's information criterion
BIC	219801.372	Bayesian information criterion
Baseline comparison		
CFI	0.576	Comparative fit index
TLI	0.404	Tucker–Lewis index
Size of residuals		
SRMR	0.159	Standardized root mean square residual
CD	0.206	Coefficient of determination

Table 3.10 Fit Statistics Assigning the Correlation Between Alliances

By indicating the correlation between alliances, the model fit explained by CFI is improving from 0.322 to 0.576. It means that alliance does not change dramatically over time.

Next, I estimated one more model by adding economic development. Economic development is calculated using the amount of change of RGDP from the last year. Figure 3.14 shows the results as follows:

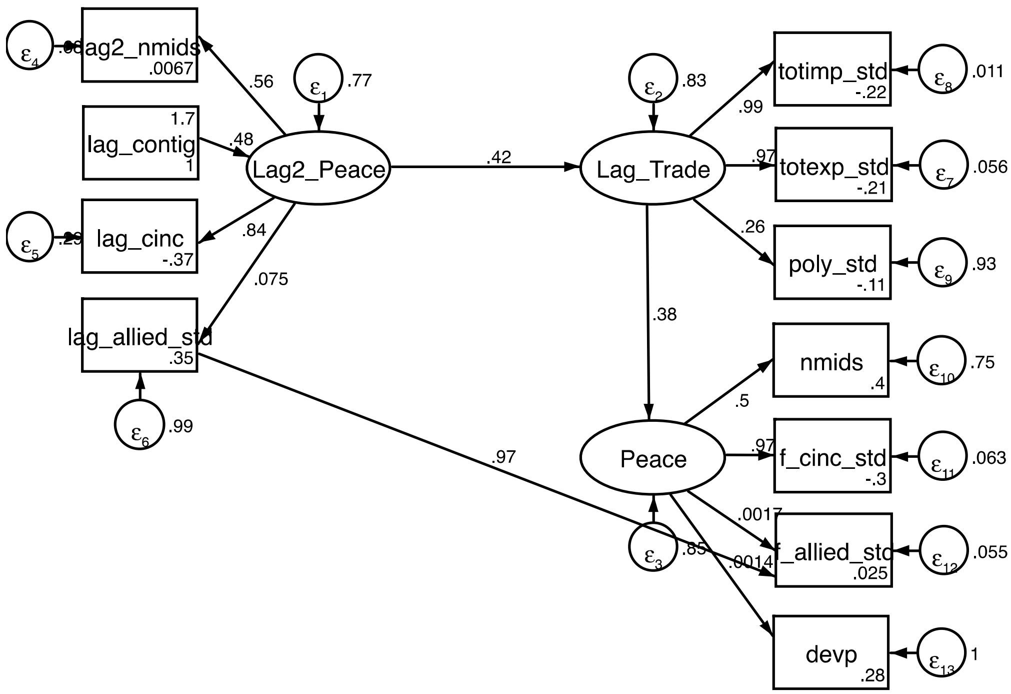


Figure 3.14 Full Model with All Variables

Accordingly, the coefficients are changed by adding, development. The coefficients between peace and trade increased when we consider economic development as well.

I also estimated the impact between peace and trade after the 1950s. Figure 3.15 illustrates the results:

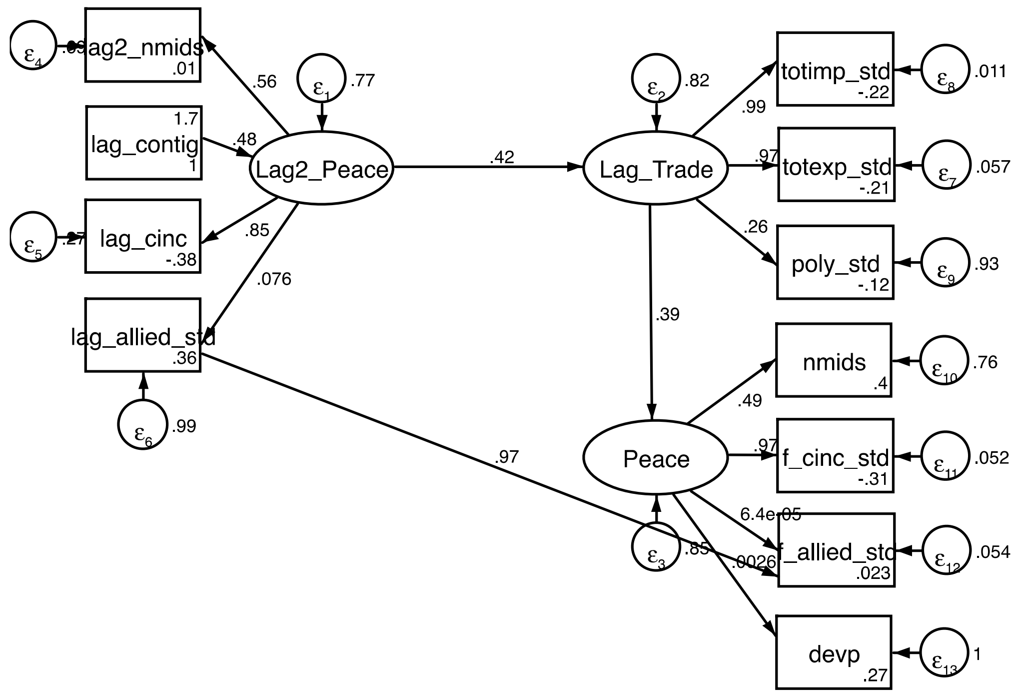


Figure 3.15 Result post-1950s

By comparing Figures 3.14 and 3.15, we can see that there was only a slight change. The impact from trade to peace shows a slight increase; however, it has not dramatically changed. It can be explained that conflict and trade affect each other positively; that is, conflicts increase trade and trade increases the number of conflicts.

3.5.1 Extension

This paper also presents a dyadic data which Barbieri uses in Chapter 4 of her book. The range of Barbieri's data is between 1870 and 1991, but this paper will use an extended dataset between 1870 and 2010, which no one has used yet.

To extend Barbieri's data from Chapter 4 in her book, I use six datasets to merge into one dataset. First, I merge MIDA 4.3, Militarized Interstate Data version 4.3, and MIDB 4.3 (from https://correlatesofwar.org/data-sets/MIDs). MIDA has

2,315 observations and MIDB has 5,558 observations. By combining the data, I obtain a monadic data set containing dispute numbers, country code, year, outcome type, settlement type, battle fatalities, the highest act of force in dispute, and the hostility level. By merging the two data sets, 2,820 observations are matched. Next, I add the polity score (from http://www.systemicpeace.org/inscrdata.html), which represents the level of democracy or autocracy. The Polity IV score is a monadic dataset with 17,562 observations. After merging the polity score, 2,607 observations are matched. Then, it is necessary to reshape the merged data from monadic to dyadic. By so doing, observation numbers change to 5,795.

The next step is to merge contiguity data. I use contiguity data (from https://correlatesofwar.org/data-sets/direct-contiguity), which is dyadic and represents whether or not states are contiguous. I coded this data with the value of 1 if a state has any borders or 0 if there is no border. Then, I merge the trade dataset from the Correlates of Wars project (from https://correlatesofwar.org/data-sets/bilateral-trade). To do this, I need to reshape the trade data from monadic to dyadic. As a result, the data set contains dyadic variables for each state. Finally, I merge alliance data. There are four types of an alliance in the original data, which I code with dummy variables. The logic to modify the data is to capture the existence of an alliance between states. To do this, I coded with a value of one the end year of an alliance being less than or equal to the current year, for example, if the end year is 1990 at 1989, there would be an alliance, but if the end year is 1979 at 1980, it means that there is no alliance between the states. Every variable is assigned to the lagged year at $t-1$ except the Militarized Interstate Dispute at time t.

After merging all data, I investigate the relationship between trade and peace, and the resulting structural relationship is as depicted in Figure 3.16.

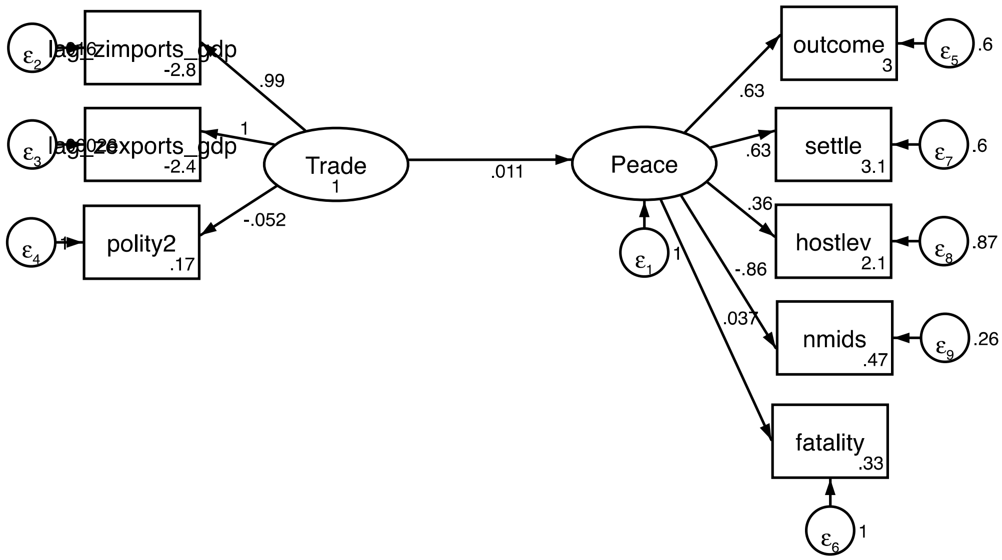


Figure 3.16 The Results with Data Extended until 2010

Figure 3.16 shows that the latent variable for trade explained by the standardized value of imports per GDP and exports per GDP, and polity score, is positively related to peace, which is explained by battle outcome, settlement, hostility level, and the number of disputes, and battle fatalities. Thus, the relationship between trade and peace until 2010 is still similar to the previous trend.

3.6 Conclusion

Although peace and trade are not difficult variables to define, their causal relationship is difficult to estimate statistically because neither can be explained using a single-equation approach. More specifically, peace (defined here as a lack of conflict) and trade affect each other and are also interrelated through other regional, relational, and political variables, creating a simultaneity bias problem for single-equation estimation.

In this paper, I conducted SEM to explore the reciprocal relationship between peace and trade. First, I selected indicators for peace and trade from the COW dataset. Then, I selected the number of militarized conflicts between states, the number of contiguities, the national power of states, the number of alliances as indicators for peace, the amount of imports and exports, and the joint democracy as indicators of trade. Moreover, I compared the results with SEM after WWII, the period of rapidly increasing international trade. Furthermore, I conducted two-factor SEM analysis to explore the reciprocal impact between peace and trade. I assigned variables to different time periods to estimate the impact of trade or peace on the future.

The global trend of peace and trade is very similar after WWII compared with the previous era. More trade causes more conflict and more conflict promote more trade, like a virtuous circle.

3.6.1 Implications

Throughout this research, I estimated the reciprocal relationship between peace and trade, finding evidence that peace and trade affect each other positively. Trade increases conflict and conflict promotes trade. In other words, the relationship between trade and peace can be expressed with the causality dilemma; it is hard to determine which one comes first. In fact, it is hard to say which is more important for mending the relationship between North and South Korea, being peaceful or promoting trade; in fact, both are equally important. With this result, I also want to offer a suggestion regarding the relationship between North and South Korea because the South Korean government has decided to pursue a peaceful relationship with, and provide economic support to, North Korea. Since the Korean War, the South Korean government has been concerned about whether the main priority should be to maintain good relations with North Korea, or to provide aid to North Korea's economic development. Based on the results from my research, the South Korean government should consider complex policies toward North Korea because the relationship between trade and peace is an infinite regress; I think the South Korean government should consider strategies to help North Korea develop economically and conclude agreements with other countries, rather than focusing on a single policy, i.e., aid, as with the Sunshine Policy. In my opinion, economic aid is not the best instrument to promote interstate cooperation. I believe that it is better for both the Koreas to engage in more dialog and decide upon the direction in which North Korea should go forward.

REFERENCES

Acock, A. C. (2013). *Discovering structural equation modeling using Stata: Revised edition*. Stata Press books.

Anderton, C. (2003). Economic theorizing of conflict: Historical contributions, future possibilities. *Defence and Peace Economics*, *14*(3), 209-222.

Barbieri, K. (2002). *The liberal illusion: Does trade promote peace?.* Ann Arbor, MI: University of Michigan Press.

Bagozzi, R. P., & Yi, Y. (2012). Specification, evaluation, and interpretation of structural equation models. *Journal of the Academy of Marketing Science*, *40*(1), 8-34.

Copeland, D. C. (1996). Economic interdependence and war: A theory of trade expectations. *International Security*, *20*(4), 5-41.

Coulomb, F. (1998). Adam Smith: A defence economist. *Defence and Peace Economics*, *9*(3), 299-316.

Decker, J. H., & Lim, J. J. (2009). Democracy and trade: an empirical study. *Economics of Governance*, *10*(2), 165-186.

Dollar, D., & Kraay, A. (2004). Trade, growth, and poverty. *The Economic Journal*, *114*(493), F22-F49.

Friedman, T. L. (2005). *The world is flat: A brief history of the twenty-first century*. New York, NY: Farrar, Straus and Giroux.

García-Pérez, G., Boguñá, M., Allard, A., & Serrano, M. Á. (2016). The hidden hyperbolic geometry of international trade: World Trade Atlas 1870–2013. *Scientific Reports*, *6*, 33441.

Ghosn, F., & Bennett, S. (2003). Codebook for the Dyadic militarized interstate dispute data, Version 3.10. *Correlates of War Project. The Pennsylvania State University*.

Gowa, J., & Mansfield, E. D. (1993). Power politics and international trade. *American Political Science Review*, *87*(02), 408-420.

Grieco, J. M. (1990). *Cooperation among nations: Europe, America, and non-tariff barriers to trade*. Ithaca, NY: Cornell University Press.

Hox, J. J., & Bechger, T. M. (1998). An introduction to structural equation modeling. *Family Science Review, 11*, 354-373.

Hummels, D. (2007). Transportation costs and international trade in the second era of globalization. *Journal of Economic Perspectives*, *21*(3), 131-154.

James, P., & Steger, M. B. (2014). A Genealogy of “Globalization”: The Career of a Concept. *Globalizations*, *11*(4), 417–434. https://doi-org.proxy.library.cornell.edu/10.1080/14747731.2014.951186

Jones, D. M., Bremer, S. A., & Singer, J. D. (1996). Militarized interstate disputes, 1816–1992: Rationale, coding rules, and empirical patterns. *Conflict Management and Peace Science*, *15*(2), 163-213.

Lee, J., & Pyun J. H. (2016). Does trade integration contribute to peace? *Review of Development Economics*, *20*(1), 327-344.

Lomax, R. G., & Schumacker, R. E. (2004). *A beginner’s guide to structural equation modeling*. New Jersey: Lawrence Erlbaum Associates.

Malul, M., Mansury, Y., Hara, T., & Saltzman, S. (2008). An economic development road map for promoting Israeli-Palestinian cooperation. *Peace Economics, Peace Science and Public Policy*, *14*(1), 1-22.

Marshall, M. G., Jaggers, K., & Gurr, T. R. (2002). *Polity IV project*. Center for International Development and Conflict Management at the University of Maryland, College Park.

Martin, P., Mayer, T., & Thoenig, M. (2008). Make trade not war? *The Review of Economic Studies*, *75*(3), 865-900.

McDonald, P. J. (2004). Peace through trade or free trade? *Journal of Conflict Resolution*, *48*(4), 547-572.

Mitra, D., Thomakos, D. D., & Ulubaşoğlu, M. A. (2002). “Protection for sale” in a developing country: democracy vs. dictatorship. *Review of Economics and Statistics, 84*(3), 497-508.

Mt Kumgang Tour. Retrieved April 11, 2014, from http://www.mtkumgang.com (in Korean).

Oh, K., & Hassig, R. C. (2004). *North Korea through the looking glass*. Brookings Institution Press.

Oneal, J. R., & Russett, B. (1999). Assessing the liberal peace with alternative specifications: Trade still reduces conflict. *Journal of Peace Research*, *36*(4), 423-442.

Parlow, A. (2010). *Does trade promote peace? a panel data approach within a gravity-model framework* (pp. 1-24). Working Paper, Department of Economics, the University of Wisconsin, Milwaukee (UWM).

Parlow, A., & Chakrabati, A. (2009). *Does trade promote peace? A new window in economics*. Working Paper, Department of Economics, the University of Wisconsin, Milwaukee (UWM).

Peace [Def. 4]. (n.d.). *Merriam-Webster Online.* In Merriam-Webster. Retrieved May 2, 2015, from https://www.merriam-webster.com/dictionary/peace

Polachek, S. W. (1980). Conflict and trade. *Journal of Conflict Resolution*, *24*(1), 55-78.

Rahman, A. S. (2010). Fighting the forces of gravity–Seapower and maritime trade between the 18th and 20th centuries. *Explorations in Economic History*, *47*(1), 28-48.

Singer, P. (2004). *One world: The ethics of globalization*. New Haven, CT: Yale University Press.

StataCorp. 2013. *Stata 13 Base Reference Manual*. College Station, TX: Stata Press.

Stiglitz, J. E. (2002). *Globalization and its discontents*. New York, NY: W. W. Norton.

Suhr, D. (2006). The basics of structural equation modeling. Presented: *Irvine, CA, SAS User Group of the Western Region of the United States (WUSS)*.

Tomarken, A. J., & Waller, N. G. (2005). Structural equation modeling: Strengths, limitations, and misconceptions. *The Annual Review of Clinical Psychology, 1*, 31-65.

Ullman, J. B., & Bentler, P. M. (2003). Structural Equation Modeling. *Handbook of Psychology*, pp.607-634.