GLOBAL VALUE CHAINS AND PRODUCTION NETWORKS: STATE-BUSINESS RELATIONS AND COMPLEXITY IN ECONOMIC CRISES

Zhengqi Pan

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Approved by:

Thomas Oatley

Timothy McKeown

Justin Gross

Todd BenDor

Gary Gereffi

ABSTRACT

ZHENGQI PAN: Global Value Chains and Production Networks: State-Business Relations and Complexity in Economic Crises
(Under the direction of Thomas Oatley)

The proliferation of global value chains and production networks (GVCs/GPNs) has significantly altered the complexion and complexity of international trade. Much research fervor has been generated to examine the economic organization and spatial dispersion of transnational production, with particular emphasis on firms. However, politics and the role of the state in GVCs/GPNs are often neglected. This dissertation thus advances existing research by exploring the political economy of GVCs/GPNs with states as the focal point. In addition, I base my work largely on the regions of Northeast and Southeast Asia, given the regions' strategic state-led developmentalism and meteoric rise as a global manufacturing hub. I first examine the Asian developmental state model and the evolution of state-business relations within these states as they move up the value chain using large-n statistical analysis. I then investigate the dynamics of state-business partnerships through a comparative case study analysis of eight Asian countries. Finally, I explore the propagation of shocks in production networks and the role of Asian developmental states during a global economic crisis, using network analysis and agent-based modeling. Overall, I find that Asian developmental states moving up the GVC tend to develop tighter linkages with businesses through strategic and aggressive industrial policies and innovation partnerships. Moreover, in times of crisis, Asian developmental states help to mitigate the impact of economic shocks through economic policies, strategy and political will. Consequently, rather than being static, Asian developmental states have been adaptive to changing global circumstances, tailoring policies to suit their local conditions.

To Ah Gong, Ah Po, Ah Neh, Ba and Ma.

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1 INTRODUCTION

International trade today is primarily characterized by the fragmentation of production processes and the dispersion of these processes around the world. With improvements in information and communications technology (ICT), logistics and services, as well as increased liberalization of cross border transactions since the 1990s and especially in the 2000s, firms are incentivized to relocate production processes to different countries (UNCTAD (2013)). Given that labor and capital costs are unevenly distributed across the world, firms also find it profitable and advantageous to participate in fragmented and dispersed production or supply chains. Previous economic development models that entail deep and vertical industrialization within the country to spur economic growth are increasingly abandoned in both developed and developing countries. In other words, countries today seek to join supply chains[1] and no longer aspire to develop their own industries from scratch.

With the emergence and proliferation of global supply chains or GVCs/GPNs, economies are not merely connected via trade in final products – they are also increasingly connected through trade in intermediate goods and services required to produce the final product. In fact, statistics from the OECD in 2013 show that over 50% of the world's manufacturing imports are intermediate goods and more than 70% of the world's services imports are intermediate services.[2] Countries are thus increasingly exporting goods that contain value-added[3] imported from abroad. Global supply chains has thus radically altered the dynamics of international trade, increasing the economic complexity and interdependence among different economies.

The dynamics of GVCs/GPNs are most evident in the Northeast and Southeast Asian economies, which have adopted a strategic state-led developmental model and are highly successful in global supply chain participation and integration (Ferrarini and Hummels (2014)). As Choi and Rhee (2014) note, the world has witnessed the meteoric rise of *Factory Asia*, or Asia's critical role as a

[1] In general, scholars use the terms global supply chains, global value chains (GVCs), and global production networks (GPNs) quite interchangeably. But as a guide, this dissertation uses the GVC/GPN framework. An overview of the GVC/GPN approach is discussed in the next section.

[2] See OECD (2013*b*).

[3] Value-added refers to the contribution to a semi-finished product.

global manufacturing hub. *Factory Asia* depicts a set of production networks that connect "factories in different Asian economies; producing parts and components that are then assembled, with the final product shipped mainly to advanced economies" (ibid, p.5). Indeed, *Factory Asia* signify the phenomenon of "supply in the East, consume in the West" (Ferrarini and Hummels (2014)). A study of the Asian economies would no doubt increase our understanding of global supply chains.

This three-essays dissertation focuses on two important aspects of GVC/GPN dynamics: (1) state-business relations in the context of Asian developmental states, and (2) shock propagation via production networks following an economic crisis. The first and second papers discuss how state-business relations evolve as Asian developmental states move up the GVC. Notably, paper 1 focuses on changes in state-business industrial policies, while paper 2 examines the evolution of state-business partnerships. I provide a counterintuitive finding: instead of converging towards the neoliberal market model, Asian developmental states moving up the GVC will embark on more strategic and aggressive industrial policies in order to counter the vagaries of market forces and facilitate the entry of fledging domestic firms into the global economy. Moreover, the developmental state will engage in more intensive partnerships with businesses as it moves up the GVC in order to spur innovation. While both papers 1 and 2 focus on domestic dynamics as a consequence of global economic forces, paper 3 takes on a more macro-level approach and examines complex global network dynamics as a whole during an economic crisis. I investigate how complex interdependencies and the bullwhip effect exacerbate the spread of economic crisis in GVCs. Importantly, I look at how the developmental state can serve as a shock absorber in times of crisis, pointing to the significance of politics in mitigating economic crises.

This dissertation thus makes two major contributions to current research on GVCs by (1) developing further insights on Asia's supply chain governance and institutional structure, and (2) examining the mechanisms of shock propagation within GVCs during an economic crisis. Importantly, I emphasize the role of politics and the state in the institutional governance of GVCs, and examine the complex interplay of domestic and global forces. Methodologically, I use both quantitative and qualitative research to complement existing studies. Moreover, the use of simulation-based approach and statistical network analysis in the third paper of my dissertation contributes to the methodological

innovations in current research by taking into account complex interactions and interdependencies within GVCs, as well as complements the large existing qualitative literature on GVCs/GPNs.

1.1 Overview of Global Value Chains and Global Production Networks

Two dominant analytical frameworks exist to conceptualize global supply chains: (1) Global Value Chains (GVCs), and (2) Global Production Networks (GPNs). The value chain concept was first used in Porter (1985) and is highly popular in the management science community. But the most rigorous theorization of GVCs is found in the works of Gary Gereffi, whose GVC framework has a specific intellectual lineage tied to the world-systems theory developed by Immanuel Wallerstein.[4] Broadly, Gereffi defined the value chain as "the full range of activities that firms and workers perform to bring a product from its conception to end use and beyond" (Gereffi (2014), p.4). Gereffi (1995) uses four fundamental dimensions to understanding GVCs: (1) an input-output structure, which describes the process of transforming raw materials into final products, (2) a geographical consideration, which maps the spatial shifts in global production and industries, (3) a governance structure, which explains how the value chain is controlled and managed by firms[5], and (4) an institutional context in which the industry value chain is embedded, which describes how local, national and international conditions and policies shape each stage of the value chain. In addition, subsequent work by Gereffi and his colleagues explored the concept of upgrading, which is the "dynamic movement within the value chain by examining how producers shift between different stages of the chain" (Gereffi and Fernandez-Stark (2011), p.4).

Gereffi's work focuses on the linear nature of cross border supply chains, noting the value creation and capture across each progressive stage of the supply chain. Importantly, Gereffi notes the differential power of firms and their value extraction at various points in the chain (see Gereffi, Humphrey and Sturgeon (2005)): governance is largely exercised by lead firms in global industries, constituting power asymmetries between powerful (western) firms and firms in developing countries. Nonetheless, firms in developing countries still have opportunities for industrial upgrading through different methods of organization and by moving up the value chain. As such, Gereffi's GVC concept

[4]See for instance Gereffi (1994*b*,*a*, 1995, 1999*b*,*a*, 2003, 2005, 2014) among others.

[5]Gereffi, Humphrey and Sturgeon (2005) further conceptualized GVC governance into five typologies: (1) market, (2) modular, (3) relational, (4) captive, and (5) hierarchy, to illustrate the different processes of firm-based GVC framework.

extends beyond Wallerstein's static core and periphery world-systems theory to a more dynamic framework.

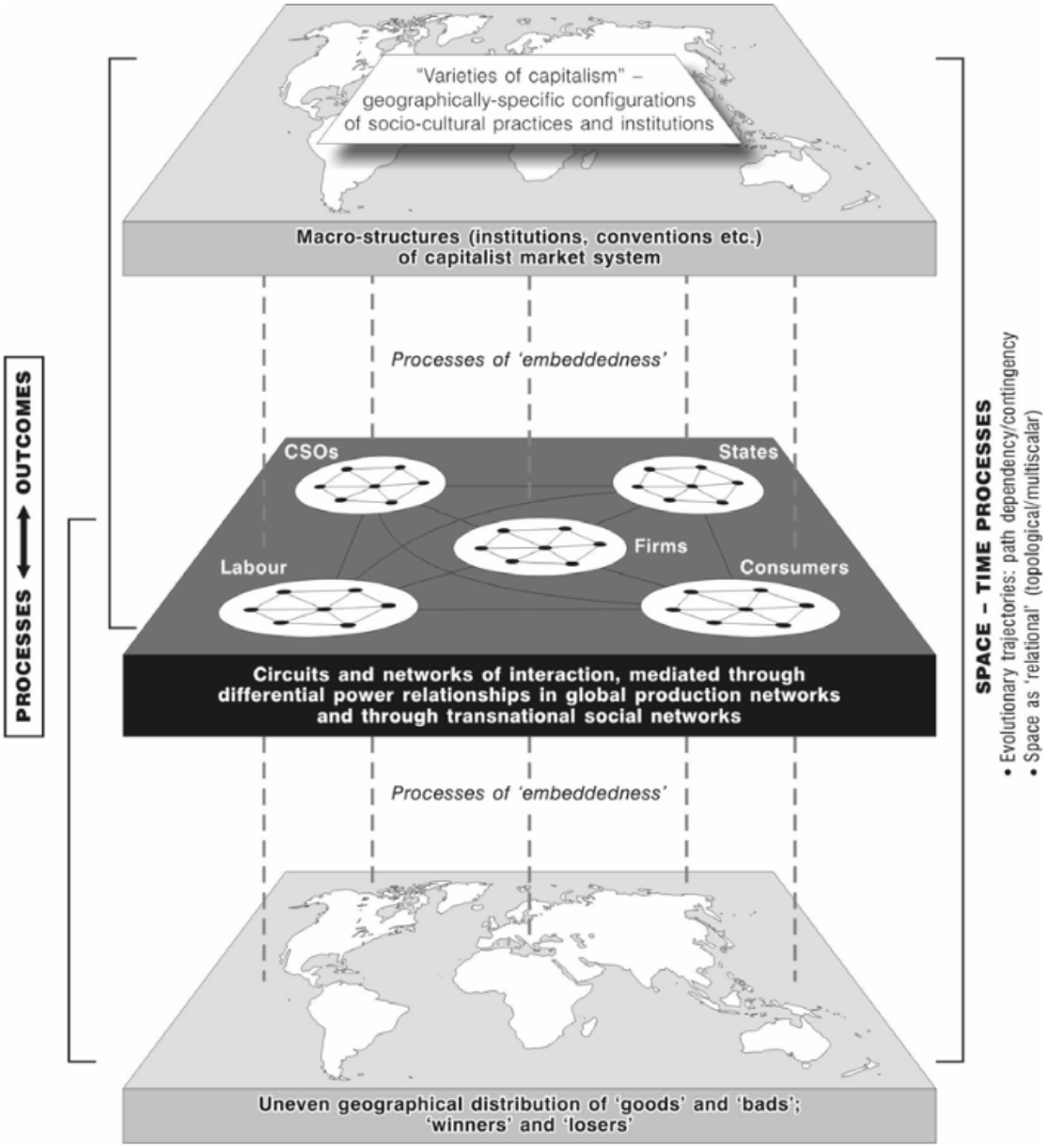
Building on the GVC concept, Dickens and his colleagues extended the theorization of global supply chains to include more actors and placed more emphasis on geospatial network relations (see Dicken and Malmberg (2001); Dicken, Kelly, Olds and Yeung (2001) and Henderson, Dicken, Hess, Coe and Yeung (2002)). Their notion of the Global Production Networks or GPNs thus includes actors beyond the firm such as states, regional and intergovernmental organizations (IGOs), as well as nongovernmental organizations (NGOs) and individuals, and allows scholars to explore more closely the various institutional contexts in which the value chain is embedded in.[6] Moreover, as its name suggests, the GPN framework hinges on the concept of the network, which reflects the complex and dynamic interconnectedness and *power relations* between the diverse set of actors in the global economy. Importantly, actors in GPNs are embedded in a complex nexus of relations, within global and local contexts.

Figure 1.1 below shows a heuristic framework to analyze the global economy. Apart from the diverse network of actors, Figure 1.1 also shows a "complex intermingling of *different geographical scales* (global, regional, national and local) in network formation and network processes" (Dicken et al. (2001), p.95). Indeed, "it becomes meaningless to talk of local versus global processes as in much of the global-local literature. Instead, we should think in terms of network agents (such as individuals, firms or states) acting across various distances and through diverse intermediaries" (ibid). It might thus be useful to think of actors in the global economy as interacting in complex patterns in a multiscalar and multidimensional latent space.[7] While the processes and interactions transcend boundaries, actors themselves are nonetheless shaped by the geographical territory or institutions that they are in. Moreover, "actors involved in most commodity chains are typically dissimilar because they are the products of different institutional environments...even firms operating in highly internationalized sectors still tend to retain distinct organizational forms and practices that largely

[6]Depending on the discipline, both GVC and GPN approaches are used quite interchangeably by scholars. I provide an overview of the GVC and GPN approaches for greater intellectual clarity and to introduce the main works of prominent scholars.

[7]This idea is reinforced by Dicken et al. (2001): "we believe that the global economy is constituted by 'spaces of network relations' (p.97).

Figure 1.1: GPN Framework (adopted from Dicken (2004))



reflect the regulatory environment of their home country".[8] As such, even though actors may be transnational, they still carry an 'institutional baggage' with them, reflecting a certain path-dependent developmental trajectory.

[8] See Whitley (1996) and Dicken et al. (2001) p.96-97

The discussion on the institutional baggages of firms and path dependency is particularly salient, and directly points to the significance of national political and economic institutions in shaping production processes. The various national institutional environments shape how states and firms interact in a dynamic process, and ultimately constitute and reconstruct the "position of firms, labor and capital in global production networks, including policies for national economic competitiveness" (Smith (2014), p.2).

2 STATE-BUSINESS RELATIONS IN ASIAN DEVELOPMENTAL STATES

2.1 Introduction

While scholars have recognized the importance of domestic political and economic institutions in global value chains (GVCs), research on supply chains remains largely firm-centric. The role of the state and its institutional environment are often overlooked. As such, while the economics of supply chains receive widespread discussion from management science to urban planning to business communities, the *politics* of supply chains are very rarely discussed by scholars.[1]

Bridging the gap between the discussion on GVCs and the state, this paper uses the developmental state theory to examine Asian state-business relations within global supply chains. The developmental state model is a form of hybrid capitalism model that combines both neoliberal economic characteristics with state-led intervention and industrial policy.[2] Following Schmidt (2009), this paper attempts to put "the 'political' back into political economy by bringing the state back in yet again" (p.516).

Importantly, the increasing complexity of globalization has led some scholars question the relevance of the developmental state.[3] In particular, with the emergence of global supply chains and lead firms that guide global production, has the developmental state model become redundant? Is the world witnessing a convergence towards the neoliberal or free market model? Are local firms in developmental states detaching themselves from the state and gaining more autonomy?

I argue that claims about the demise of the developmental state are unfounded. As Weiss (1999) notes, the neoliberal claims about the redundancy of the developmental state due to globalization ignore the adaptability of these states. Rather than a convergence to the neoliberal model, the developmental state has adapted and evolved according to changing global circumstances, while still maintaining its grip on the economy. This paper discusses the role of Asian developmental states in

[1] See Smith (2014), MacDonald (2014), Bair (2005, 2009), Smith, Rainnie, Dunford, Hardy, Hudson and Sadler (2002), and Leslie and Reimer (1999).

[2] See Johnson (1982) and Woo-Cumings (1999). I will provide a more thorough review of the developmental state model in the subsequent section.

[3] See Beeson (2004), Low (2004), Sato (2013), Pirie (2013) among others.

global production networks and explores the specific state-business relations in these countries. I posit that in the face of greater uncertainty and foreign competition following participation in GVCs, Asian developmental states continue to maintain tight control of trade and investment policies. As such, far from being autonomous, local firms are still very much tied to the state.

2.2 The Primacy of Politics in Asian Developmental States

First theorized by Chalmers Johnson in his seminal work on Japan's industrial policy, the developmental state model or developmental capitalism is a Weberian ideal type of state-led interventionist economic model that has both neoliberal and socialist elements.[4] Compared to the neoliberal and social-market models, developmental capitalism is much more state-centric and involves the active role of the state in industrial policy and economic strategy. As such, rather than viewing the state as a problem, as portrayed in the neoliberal paradigm, the developmental state model emphasizes the significant role of the state in spearheading economic growth and poverty reduction in society. As Evans (2013) notes, the model provides a counter framework to the dominant neoliberal narrative that emphasizes the market as the most important institution that drives economic growth and welfare. Notable examples of developmental states include Japan, South Korea, Singapore and Taiwan, which are often considered as archetypes of the developmental state, as well as Malaysia, Indonesia, Thailand, Philippines, Vietnam and (most recently) China.[5] Recent literature has also explored the developmental state beyond the Asian context, looking at African economies such as Botswana.[6]

The dominant force driving development in these states is politics. Indeed, developmental states are interested in shoring up economic growth and reducing poverty *because* political stability rests on these achievements. Moreover, the political stability of developmental states rests on significant improvements (or perceived improvements) in the standards of living across a broad segment of society so as to avoid social unrest and for the ruling elites to stay in power. As Doner, Ritchie and Slater (2005) note, many developmental states came to being because they faced the threat of

[4]See Johnson (1982). Also see Wade (1990), Amsden (1989), and Woo-Cumings (1999) for an extensive discussion on the developmental state.

[5]See Johnson (1982), Amsden (1989), Wade (1990), Woo-Cumings (1999), Chang (2006), Doner, Ritchie and Slater (2005), Hayashi (2010), Howell (2006), and Jian-xing and De-jin (2010).

[6]Botswana is often held up as an example of a developmental state in Africa. Some scholars and policymakers have been increasing interested in looking at the applicability of the developmental state model in other parts of Africa such as Ethiopia and South Africa. For a more thorough discussion on African developmental states, see Sandbrook, Edelman, Heller and Teichman (2007), Kellsal and Booth (2010), Meyns and Musamba (2010), and Edigheji (2011).

internal unrest, and thus, one of the key aims of the developmental state was to develop a workable strategy that involves economic growth in order to quell domestic unrest. In addition, the authors posit a set of factors for the developmental state to emerge, namely, (1) a credible internal threat, (2) geopolitical insecurities, and (3) scarcity of natural resources. Indeed, the developmental state focuses on broad-based economic development and growth due to political and economic exigencies. A pragmatic view of political stability is the prime motivation of economic development in the developmental state.

Given the primacy of politics in the developmental state literature, Vu (2007) notes two key aspects of developmental states that go hand in hand: (1) state capacity, and (2) political will[7]. Indeed, a state that possesses strong institutional capacity may still not be classified as 'developmental' if it lacks the leadership or political will to carry out developmental goals, which refer to the attainment of high economic growth rates, widespread increases in standard of living and broad-based legitimacy (Routley (2012), p.7). Conversely, a state that possesses the political will to carry out developmental reforms but lacks the capacity to do so will also not become a developmental state. To further operationalize the concept of the developmental state, I draw from Routley (2012) and a variety of the readings in the developmental state literature. The attributes of the developmental state can be summarized as having: (1) a political leadership that is oriented towards the economic development of the country[8], (2) a meritocratic and autonomous[9] bureaucracy that is connected to or embedded in business communities[10], and (3) active policy interventions to help promote and sustain economic growth[11]. Consequently, developmental states are commonly characterized by the

[7]Political will in this case is narrowly defined as the determination of political leaders to carry out developmental goals. Some countries lack the political will to carry out developmental policies and prey on society through rent-seeking operations. Notable examples include Zaire under Mobutu and Cameroon under Biya. For a more thorough discussion, see Evans (1995).

[8]See for instance Fritz and Menocal (2007), Vu (2007), and Musamba (2010).

[9]Generally free from political influence in the country. Even in authoritarian regimes, the bureaucracy is able to exercise considerable autonomy in economic policies. In Johnson's words, "politicians reign and the state bureaucrats rule" in developmental states (Johnson (1981)).

[10]Evans (1995).

[11]See Johnson (1982), Wade (1990), Amsden (1989), and Woo-Cumings (1999). Notably even with active industrial policy, developmental states may not experience high growth rates in the event of a global or regional economic crisis such as the Asian Financial Crisis of 1998. Nonetheless, a key characteristic of the development state is the deliberate and active intervention of states in the economy regardless of whether or not an economic crisis exists. This is in stark contrast with the neoliberal model.

deliberate, close, and often mutually beneficial symbiotic relationship between state agencies and business communities.

2.3 The Developmental State Model: Redundancy or Reconfiguration?

For much of the past three decades, economic globalization has progressed hand-in-hand with the dominant theory of neoliberalism, which advocates unfettered markets and the minimal role of the state (Hayek (1973), and Rothbard (2004)).[12] To proponents of neoliberal economics, free markets and free trade will unleash the creative and entrepreneurial spirit of individuals, leading to individual liberty and well-being, as well as the efficient allocation of scarce resources. The state, on the other hand, does not possess sufficient information to "second-guess market signals (prices)" and is prone to be captured by particularistic interests that will "inevitably distort and bias state interventions" (Harvey (2005), p.2). Neoliberal economists thus view states with skepticism and they view state intervention in the economy via active industrial policy with disdain. Consequently, the developmental state model is often seen as incompatible with the competitive pressures of economic globalization (Baker, Epstein and Pollin (1998), Kozul-Wright and Rowthorn (1998)). As Weiss (2003) notes, states seem to be increasingly threatened by capital mobility from below and intergovernmental organizations such as the World Trade Organization (WTO) from above, and their "traditional hold over economic actors has diminished, their control of the domestic economy has eroded, and their room for maneuver in the policy arena has been reduced to the margins" (p.245). In addition, some critics argue that the Asian financial crisis in 1997 was "the result of the malfunctioning of the Asian developmental states in the age of globalization" (Frankel (2000) and Yellen (1998)).[13]

With increasing fragmentation of world trade and global production, the dominance of the developmental state over the economy seems to be even more bleak. Yeung (2014) asserts that as local firms in developmental states become more embedded in global production networks, these firms will be increasingly tied to global lead firms and gradually detach themselves from the state.

[12] For more discussion see Harvey (2005), and Friedman (1980). In particular, Harvey (2005) attempts to provide a comprehensive definition of neoliberalism by defining it as, "a theory of political economic practices that proposes that human well-being can best be advanced by liberating individual entrepreneurial freedoms with skills within an institutional framework characterized by strong private property rights, free markets and free trade. The role of the state is to create and preserve an institutional framework appropriate to such practices...Furthermore, if markets do not exist (in areas such as land, water, education, health care, social security- or environmental pollution) then they must be created, by state action if necessary. But beyond these tasks the state should not venture" (p.2).

[13] Also see Shin (2005) for a discussion on the role of the state in the age of globalization.

Yeung develops the concept of 'strategic coupling' to advance a firm-centric model of economic transformation and industrialization in East Asian economies. For Yeung, the notion of 'strategic coupling' involves the "dynamic processes through which national firms decouple partially or completely from their domestic political-economic structures – developmental states or otherwise – over time *and* re-couple with lead firms in global production networks" (p.3). Importantly, he posits that the developmental state's ability to manage industrial transformation through direct industrial policy will become increasingly "difficult and problematic" due to deepening linkages between local firms and global lead firms that drive global production networks (Yeung (2014), p.4). For Yeung, inter-firm dynamics play an increasingly critical role in driving GPNs.

Quite similarly, Wong (2011*a*) notes that state-led development in advanced Asian economies such as South Korea, Taiwan and Singapore is no longer tenable in the phase of science-based high-tech industrialization. He posits that these hi-tech industries pose great uncertainty in terms of (1) technological research, which does not always yield the expected results, (2) economic returns, which may not be profitable after all due to uncertainty in the economic valuation of new science applications, and (3) the length of time taken to achieve performance and results (Wong (2011*a*)). Indeed, as advanced developmental states move into the hi-tech value chain, they will face multiple challenges in managing their industries and achieving phenomenal growth rates. Wong's central argument is that developmental states that are engaged in innovation processes can no longer micro-manage and intervene directly in the economy due to the lack of information and high degree of uncertainty, and must thus (inevitably) cede control to firms and let market mechanisms play out efficiently. Indeed, systemic factors such as the nature of the hi-tech global value chain and transnational inter-firm dynamics may force the state to take a secondary role in the industrialization process.

While the developmental state model seems in danger of becoming obsolete, scholars such as Linda Weiss and Christopher Dent argue that critics have overlooked the adaptability of developmental states to new global circumstances. Proponents of the developmental state model assert that rather than being static and rigid, the developmental state is constantly learning and adapting to the external and internal environment, such that its management strategies change and evolve over time. Drawing insights from two in-depth case studies on South Korea and Taiwan, Weiss (2003) notes that the "increased exposure to global markets makes the state's infrastructural and coordinating role more,

not less, important" (p.267). For instance, the South Korean government created new initiatives to finance high-tech start-ups and created a new state-backed software retail market to support the Korean software industry in the late 1990s and early 2000s. According to Weiss, local producers in the software industry also welcomed close collaboration with the Korean government as piracy was rife and firms needed the state to regulate the consumer market. Local firms also benefitted from close private-public partnerships when the state organized a consortium of thirty-seven companies, the Software Infra Network of Korea (SOFRANO), to enable firms establish close contacts with other firms and engage in synergistic development (Weiss (2003), p.258). Moreover, when local firms face fierce competition from abroad, they may "end up inviting, rather than rejecting, state involvement in a shared transformative project" (ibid). Indeed, the developmental intent behind Taiwan's Financial Merger and Acquisition law was to "promote national firms capable of withstanding competition from foreign firms in banking, insurance, and securities" (Weiss (2003), p.266). For Weiss, the state is in a process of *adaptive* rather than transformative institutional change. Local firms are not given free reign in their business networks, but rather, are being encouraged and facilitated by the developmental state.

Dent (2007) argues that developmental states have not become extinct, but rather have evolved within the complexity of the global economy. He notes that "while the policy tools and means may have changed, developmental states still preside over various adaptive-cum-transformative economic projects that increasingly involve a partnering with transnationalized capital" (p. 227). Importantly, he asserts that developmental states are highly adaptive because of their inherent characteristics, such as having strong technocratic capabilities for strategic planning and market intelligence, as well as having close and established networks with domestic and foreign businesses (ibid). His case analysis of Singapore, South Korea and Taiwan shows that the workings of developmental states are still very much evident in these countries. The author notes that even in the case of South Korea, where attempts have been made to decouple the state-*chaebol*[14] nexus, the path dependent interlocking nature of both the state and the *chaebols* made decoupling very difficult. Dent (2007) remarked that the developmental state's "embeddedness within the domestic political economy is not so easily eradicated" (p.239).

[14] *Chaebols* refer to domestic big business groups in South Korea.

In another more recent paper, Lee, Heo and Kim (2014) note that the South Korean government was instrumental in the creation of newly-emerging high-tech clusters, giving birth to Korea's successful liquid crystal display (LCD) industry. Moreover, the state was a critical player in the coupling process between local firms and global lead firms, acting as the role of coordinator and mediator of conflicts. Consequently, strategic coupling cannot occur without the auspices of the state, and the developmental state with its institutional capacity and political will is aptly positioned to facilitate such a process.

Perhaps the more interesting question is not whether Asian developmental states still exist (or if they are still important), but rather, *how* and *why* they have changed with time. Importantly, Asian economies have neither converged to the neoliberal model nor have they remained the same as before (Yeung (2007), and Kyung-Sup, Fine and Weiss (2012)). Even scholars who emphasize a firm-centric argument still recognize some core characteristics of the developmental state in Asia (Yeung (2014), and Wong (2011*a*)). For instance, Yeung (2014) wrote that his argument for the evolution of East Asian state-firm relationships "does not imply a zero-sum relationship in which state power declines *because* of the rise of national-firms", but rather, the state is no longer the dominant player in complex production networks (p.5).

2.3.1 Evolution of Developmental States Following Participation in GVCs

While studies have tried to explain the adaptability of developmental states and how these states influence businesses, the evolution process itself has not been adequately accounted for.[15] Most of these processes seem to be influenced by the abstract and complex forces of 'globalization'. I argue that in order to better understand the evolution of state-business relations, we need to examine changes in the country's *position* along the global value chain.[16] I assess state-business relations by looking at: (1) the degree of intrusiveness of the state on businesses through economic policy, such as price controls and investment restrictions[17], and (2) the number of state-business partnerships.

A country's position in the global value chain determines its state-business relations. Wong (2011*a*) argues that as developmental states climb higher up the value chain and venture into

[15] See for instance Weiss (1999, 2003, 2012), Weiss and Hobson (2000) and Dent (2005, 2007). Also see the collection of articles in Fine, Saraswati and Travasci (2013), and Kyung-Sup, Fine and Weiss (2012).

[16] Notably, some countries may switch value chains (e.g. from medium to high tech chains) but the analysis is similar to that of moving up the value chain.

[17] A more elaborate operationalization will be provided in the data section below.

innovation processes, they are less likely to micro-manage the economy and restrict businesses due to great difficulties in doing so arising from technical and information uncertainty. However, this argument underestimates the political will of developmental states to conduct active industrial policies and overlooks the possibility that developmental states may still be eager to manage the economy even in the face of great uncertainty and difficulties. Indeed, increasing challenges do not necessarily deter developmental states from active industrial policies. After all, the primary objective of the developmental state is to maintain political and social order through economic growth and prosperity. Taking a hands-off approach after decades of developmentalism may create unnecessary shocks in the economy, thereby hurting domestic producers. This may in turn upset the political stability within the country and undermine the state's power. Moreover, even though the prospect of gradual reforms may be tempting, developmental states may not be willing to liberalize much given that economic growth is so critical to regime stability. Since participation in GVCs entail exposing the country to greater market forces and uncertainty, the state may choose to further tighten the management of its economy, rather than subject the economy to the vagaries of the market. As such, rather than neoliberal reforms, the developmental state may adopt more aggressive industrial policies as it moves up the value chain in order to overcome new challenges and maintain economic and political stability.

In addition, as states move into research and innovative processes, high barriers to entry make it difficult for fledging domestic firms to enter the global market. Consequently, the developmental state needs to step in to support and protect local firms. Local firms can then better survive through incentives and help from the state. Thus, state support is critical to ensure that local firms have a chance to enter the market in the first place. Notably, state support for local firms occur at every stage of the value chain, but this support may be more critical and substantial as the state moves higher up the chain due to increasingly high barriers to entry.

Importantly, due to their focus on nurturing niche or champion industries, developmental states are likely to impose restrictions on capital flows and foreign ownership of companies. Investments are likely to be channeled to particular 'niche' sectors to drive growth in those industries. Moreover, as the developmental state moves up the value chain, the choices of champion industries are likely to shrink due to high technical barriers to entry. Consequently, developmental states high on the value

chain may impose more restrictive investment policies that reflect the states' priority of cultivating champion industries. I thus develop the following hypothesis:

Hypothesis 1: The higher the developmental state is on the GVC, the more intrusive its economic policies will be.

Besides economic restrictions, developmental states also rely on positive inducements such collaborative partnerships with MNCs to drive and sustain growth. Following participation in GVCs, developmental states need to leverage the technical expertise and reputation of global lead firms to advance their domestic industries. As such, developmental states often form partnerships with global MNCs for technical diffusion to occur.[18] Industrial parks catered to particular sectors may be set up to induce MNCs to invest in the country. The industrial parks provide opportunities for local firms and global MNCs to interact and exchange information, linking local firms with prestigious multinational brands. Indeed, local-global business partnerships allow for synergistic development and enable local firms to leapfrog into the global market. Notably, as developmental states move higher up the GVC, they will require more partnerships with MNCs due to the need for greater technical and knowledge diffusion.

Hypothesis 2: The higher the developmental state is on the GVC, the more partnerships it will forge with global MNCs.

From the discussion above, local firms are still very much tied to the state. While local firms may have increased their linkages with global MNCs, they are still highly bounded by local state policies. Moreover, as Lee, Heo and Kim (2014) note, strategic coupling between local and global firms cannot occur without the auspices of the state. Importantly, the state is also a critical player in conflict resolution and mediation between local and global firms. Thus, one can view Asia's state-business relation as 'tripartite' in nature, as an 'iron triangle' constituting local firms, MNCs, and developmental states in production networks.

2.4 Data and Methods

My dependent variables are (1) intrusiveness of state-business policy, and (2) number of collaborative state-business partnerships. The data cover the years 2000 to 2011 and include 94 countries worldwide for each year. Countries beyond Asia are included in the full dataset to ensure greater

[18] See for example Dent (2007) and Weiss (2003).

generalizability and validity of results. Data used to measure the intrusiveness of state-business policy are drawn from the 2012 Economic Freedom of the World (EFW) Data by the Fraser Institute. This dataset represents a credible source of economic freedom data, and is used widely in peer-reviewed academic journals such as *Academy of Management Journal*, *World Development*, *Kyklos*, and *Public Choice*, to name a few.[19] By having several disaggregated indicators, the EFW dataset provides a nuanced way of measuring economic freedom. In particular, I will pay attention to the following indicators, which are directly relevant to this paper: (1) transfers and subsidies, (2) tariffs and non-tariff barriers, (3) foreign ownership investment and restrictions, (4) capital controls, (5) licensing restrictions, and (6) government enterprise and investment. The data is based on a 10-point scale (interval variables) and I have transformed the data by multiplying it by -1, such that the higher the score of a particular component, say transfers and subsidies, the worse a country has fared in terms of economic freedom.[20] Six separate regressions are thus run to assess the importance of developmental states in affecting each of these indicators. Lastly, data for state-business partnerships are obtained from the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Institute for Statistics, which shows the percentage of manufacturing firms that cooperated with the government and public research institutes.

My main independent variable is the interaction term *Developmental State x Position on the GVC*, which comprise the variables *Developmental State* and *Position on the GVC*. *Developmental State* is a binary variable with '0' representing countries that are not developmental states, '1' representing the developmental states of Northeast and Southeast Asia, such as Japan, South Korea, Singapore, Taiwan, Malaysia, Indonesia, Thailand, Vietnam and the Philippines. *Position on the GVC* is calculated using a country's domestic value-added exports divided by its gross exports. Thus, a country with high domestic value-add as a percentage of gross exports is said to be positioned high up on the chain or is primarily engaged in a high-tech value chain for exports. Data to measure

[19]For a full list of peer-reviewed journals published using the EFW dataset since 1994, see `http://www.freetheworld.com/papers.html` (Last assessed: 22 April 2015).

[20]Originally, the reverse is true: a score of 10 represents the maximum freedom rating for a component, while a 1 represents the worst freedom rating. I transformed the data to make the results more intuitive for interpretation in my regression analysis.

domestic value-add as a percentage of gross exports are obtained from United Nations Conference on Trade and Development (UNCTAD) GVC-EORA database.[21]

My control variables include (1) *Bribes, Payments, and Favoritism*, which represents corruption, (2) *Polity*, which is the democracy score of a country, (3)*FDI as a percentage of GDP*, which measures the stakes and extent of foreign MNC involvement in the country, (4)*Centralized Collective Bargaining*, which measures the power of labor unions in the country, (5)*Percentage of R&D Financed by the Government*, which represents the gross domestic expenditure on research and development financed by the government, and (6)*Tertiary Education Expenditure by the Government*, which is the tertiary education expenditure as a percentage of total government education expenditure.[22] Data for *Polity* are obtained from the Polity IV project, and data for *FDI as a percentage of GDP* are obtained from UNCTAD. Data for *Percentage of R&D Financed by the Government*, and *Tertiary Education Expenditure by the Government* are both obtained from UNESCO's Institute of Statistics. The rest of the data are obtained from the EFW dataset. In addition, the variables *FDI as a percentage of GDP*, *Percentage of R&D Financed by the Government*, and *Tertiary Education Expenditure by the Government*, have continuous values greater than 0 but less than 100, while *Polity* is an ordinal variable ranging from -10 to 10. *Bribes, Payments, and Favoritism* and *Centralized Collective Bargaining* are interval variables on a 10-point scale.

2.4.1 Multiple Imputation

Like the vast majority of statistical analyses, the dataset for this paper contains missing values. Most statistical software only considers complete cases in their statistical analysis, and casually deletes the missing rows from the data in a process known as casewise deletion. Casewise deletion omits cases that might yield important results and are likely to bias our statistical analysis. Another method that is increasingly popular and more accurate is known as multiple imputation, which is a procedure to fill in a set of plausible values that reflect the uncertainty about the correct value for each of the missing case. The set of imputed datasets are subsequently analyzed using standard statistical techniques and the results are combined using strategies described in Rubin (1987). Multiple imputation is desirable because it helps to reduce bias and obtain fairly accurate estimates of the

[21] I would like to specially thank Mr Masataka Fujita, Head of Investment Trend and Issues Branch, UNCTAD for kindly sharing the UNCTAD dataset with me.

[22] Controls 5 and 6 are catered to hypothesis 2 of the paper.

standard errors and t-scores. Moreover, multiple imputation is robust to departures from normality assumptions and provides adequate results in the presence of low sample size or high rates of missing data. For my dataset on the intrusiveness of business policy, I have approximately 21.54% missingness, which is considered a moderate level of missingness. On the other hand, my dataset on state-business partnerships has very high degree of missingness, with the year 2010 containing the least missingness (at 65.96% missingness) and some years containing complete missingness for the variable on state-business partnerships. Rather than deleting all the missing cases, I impute the datasets and conduct my regression analysis for the pooled datasets and also specifically for the year 2010 as a further robustness check.[23]

The main assumption is that the missing data are Missing at Random (MAR), which is the case when missingness of one variable can be related to other variables. This is in contrast with data that are Missing Completely at Random (MCAR) or Non-Ignorable (NI). As noted by Gelman and Hill (2007), MCAR is very rare in social phenomena because it assumes that no underlying association process exists to cause the absence of the data. NI occurs when missingness is related to unknown and unobserved parameters, and is not likely in my data as all the missing values contain at least one neighborhood observation. In addition, given that the missing data are mainly related to sensitive issues such as government economic policies and state-business partnership information, companies and the government may be reluctant to provide such information in surveys. In the case of state-business partnerships, businesses may be more comfortable with providing just their research and development expenditure data rather precise data on state-business cooperation. The inclusion of more predictors in the model can thus mitigate the censoring mechanisms and bring the data closer to what is described as MAR (Gelman and Hill (2007)). As such, the assumption of MAR fits my dataset the best.

2.4.2 Fixed Time Effects (Least Squares Dummy Variable Approach)

Many studies in political science ignore heterogeneity across time by running a straightforward ordinary least squares (OLS) or logistic regression on time-series cross-sectional (TSCS) data, which are data that consist of "repeated observations on a series of fixed units" (Beck (2001)). This crude

[23]Time-series multiple imputation is conducted using the Amelia II package in R (see Honaker and King (2010)). I have used m=10 imputations, which is considered to be robust by common standards. Applications with very high degrees of missing data require just 5 to 10 imputations to achieve high reliability (see Rubin (1987)).

aggregation will lead to bias estimates and inaccurate analysis. Recognizing time heterogeneity, I will use the Fixed Time Effects model with Least Squares Dummy Variable (LSDV) approach in my paper, which controls for time effects but considers unit heterogeneity in the model. This model is well-suited for my research, given that my main aim is to explore the effects of various developmental states on government economic policies and collaboration. Mathematically, the fixed time effects with LSDV has the same mechanism as the general OLS, except that it controls variation across time by incorporating time dummy variables[24]. The equation below presents the general form of the fixed time effects with LSDV:

$$Y_i = \theta + \sum_{t=2001}^{2011} \alpha_t \tau_t + \beta_1 X_i + \mu_i, \tag{2.1}$$

where:

- Y_i is the dependent variable
- θ is the base year intercept of the model, which is year 2000 in this case
- α_t is a coefficient estimate for each time dummy variable apart from the base year
- τ_t is a time dummy variable
- X_i is an independent variable
- β_1 is the coefficient estimate of X_i
- μ_i is the error term

To ensure greater robustness of the results, I implement panel-corrected standard errors (PCSE) in my models. As noted in the seminar paper by Beck and Katz (1995), TSCS data are often plagued with non-spherical errors due to unit level heteroskedasity and contemporaneous correlation across units. Cross-sectional heteroskedasity will yield inconsistent OLS standard errors, and contemporaneous correlation of errors across units will result in inefficient coefficient estimates and

[24] An alternative (but almost identical) way is to model it using fixed effects with the within-time approach. However, this modeling technique suppresses the intercept and time-invariant variables (such as the developmental state variable in this paper), resulting in inaccurate R^2 and adjusted R^2 statistics. I thus use the least squares dummy variable approach instead, which yields similar results for the coefficient estimates but has more accurate test statistics.

biased standard errors. As such, in order to correct these issues and to allow better inference of my models, I use panel-corrected standard errors.

2.5 Results and Analysis

The results in tables 3.1 and 2.2 (see below) point to the statistical significance of the main predictor: *Developmental State x GVC Position*. Overall, the results support hypothesis 1 of this paper by showing that the higher a developmental state is on the global value chain, the more intrusive its industrial policies. The coefficient estimate of the main predictor is positive and statistically robust at the 0.05 level in four of the six models with the following dependent variables: (1) Transfers and subsidies, (2) Tariff and non-tariff barriers, (3) Foreign ownership and investment restrictions, and (4) Capital controls.[25] The other two models with dependent variables *Licensing Restrictions* and *Government Enterprise and Investment* do not show statistical significance of the main predictor. None of the models has a negative and statistically significant interaction term, meaning that no results were found to be in conflict with hypothesis 1. Notably, the interpretation of just the individual terms in the interaction may be incomplete or misleading as one term is conditioned upon the other.

In addition, the predicted and marginal effects plots (with 95% confidence bands) provide a greater robustness check and shows how the interaction term is empirically salient (see figures 3.1-2.4). From the plots, we see that the predicted effects of GVC position on various industrial policies[26] for developmental states are all positive and much more impactful compared to non-developmental states, as characterized by larger slopes of the developmental state. In fact, for figure 3.1, non-developmental states have an inverse relationship between GVC position and predicted values of transfers and subsidies, while developmental states exhibit a positive relationship in lieu with hypothesis 1. The positive relationship also holds true for all the marginal effects plots that show the marginal effect of the developmental state on various industrial policies across the range of possible GVC positions. Consequently, developmental states encourage greater use of industrial policies as these states move higher up the value chain.[27]

[25] These variables are also the most commonly cited within the developmental state literature.

[26] These are the dependent variables as mentioned above. The plots show in greater detail the relationship between the significant interaction terms and their respective dependent variables. To be clear, the dotted line represents developmental states, while the solid line represents non-developmental states.

[27] A straightforward substantive interpretation of the coefficient estimates is not possible given the various mathematical transformations involved in the calculation of the dependent variable indices, which are based on the Economic Freedom of the World (EFW) scores on a 10-point scale. In addition, given that the main predictor is the interaction term which is

For the control variables, corruption (*Bribes, Payments and Favoritism*) is statistically significant and positive for all but one of the models in tables 1 and 2.[28], which means that the higher the level of corruption, the more intrusive the business policies (except transfers and subsidies) of a country. A possible explanation for the anomaly in the transfers and subsidies model is that official government transfers and subsidies have manifested in the form of illegal and underhand monetary transfers, bribes and payments, thereby decreasing the need for outright monetary transfers. For the case of *Centralized Collective Bargaining*, it is positively correlated with intrusiveness business policies and is statistically significant for five of the six models, indicating that the more powerful the labor unions, the more restrictive the economy will be as governments seek to protect the local workforce from foreign competitors. *Centralized Collective Bargaining* is not statistically significant for model 3 ("Foreign Ownership Investment and Restrictions"). For *FDI as a Percentage of GDP*, the results are only statistically significant and negative for three of the six models[29], showing that as MNC investment in the domestic economy increases, the government will be less willing to implement intrusive business policies as these policies may hinder investors and hurt the economy. *Polity* is a proxy for democracy and has a negative and statistically significant coefficient for five of the six models. Interestingly, *Polity* is positive and statistically significant for the transfer and subsidies model, implying that as a country becomes more democratic, it is likely to increase transfers and subsidies in the economy. Examples can be seen in the US and the European Union, where agricultural subsidies are rife. In addition, given that mature democracies are usually affluent societies, transfers and subsidies may also be used in high-tech industries such as Boeing and Dow Chemical in the US to moderate costs and encourage innovation under high degrees of technological uncertainty. For other intrusive business policies *Polity* has a dampening effect, meaning that democracies are more likely to demolish trade barriers and engage in free trade in general. For *Position on GVC*, it is a statistical control used to create the interaction term in question.[30]

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conditioned by both *Position on GVC* and *Developmental State*, interaction term plots present more nuanced relationships on predicted values and marginal effects, and are thus more effective than the direct interpretation of the coefficient estimates.

[28]Results for hypothesis 2 will be discussed later in this section.

[29]These are models 2 ("Tariff and Non-Tariff Barriers"), 3 ("Foreign Ownership Investment and Restrictions") and 4 ("Capital Controls"). The rest of the models are not statistically significant.

[30]Note that the intercept, which represents the base year dummy variable (year 2000), as well as the other year dummy variables are not of interest in this paper as they act as controls for the time dynamic in the dataset.

Table 2.1: Fixed Time Effects Regression Results

	Dependent variables:		
	(1) Transfers & Subsidies	(2) Tariff & Non-Tariff Barriers	(3) Foreign Ownership & Investment Restrictions
Developmental State	-9.436*	-1.809*	-1.217*
	(0.486)	(0.342)	(0.283)
Position on GVC	-5.951*	3.179*	1.264*
	(0.291)	(0.341)	(0.303)
Developmental State x Position on GVC	11.838*	3.038*	1.899*
	(0.654)	(0.481)	(0.491)
Centralized Collective Bargaining	0.174*	0.146*	0.012
	(0.030)	(0.029)	(0.033)
Bribes, Payments and Favoritism	-0.360*	0.683*	0.316*
	(0.022)	(0.075)	(0.025)
Polity	0.038*	-0.073*	-0.035*
	(0.011)	(0.011)	(0.011)
FDI as Percentage of GDP	-0.002	-0.027*	-0.013*
	(0.005)	(0.007)	(0.005)
Intercept (Base Year=2000)	-3.957*	-10.359*	-6.507*
	(0.448)	(0.626)	(0.389)
Year 2001	0.031	-0.072	-0.010
	(0.031)	(0.046)	(0.035)
Year 2002	-0.013	-0.078	1.101*
	(0.029)	(0.050)	(0.048)
Year 2003	-0.038	0.101	1.162*
	(0.026)	(0.058)	(0.044)
Year 2004	-0.033	-0.114	1.029*
	(0.027)	(0.071)	(0.038)
Year 2005	-0.242*	0.430*	1.172*
	(0.033)	(0.069)	(0.048)
Year 2006	-0.133*	0.282*	1.066*
	(0.0370)	(0.073)	(0.050)
Year 2007	-0.084	-0.078	0.964*
	(0.044)	(0.096)	(0.064)
Year 2008	0.137*	-0.009	1.506*
	(0.043)	(0.099)	(0.053)
Year 2009	0.392*	-0.231*	1.638*
	(0.053)	(0.096)	(0.062)
Year 2010	0.359*	-0.277*	1.514*
	(0.056)	(0.116)	(0.060)
Year 2011	0.273*	0.034	1.564*
	(0.055)	(0.113)	(0.058)
Observations	1128	1128	1128
R^2	0.500	0.532	0.492
Adjusted R^2	0.493	0.525	0.483
p-value of F Statistic	$<$ 2.2e-16*	$<$ 2.2e-16*	$<$ 2.2e-16*

Note: Panel Corrected Standard Errors *p<0.05

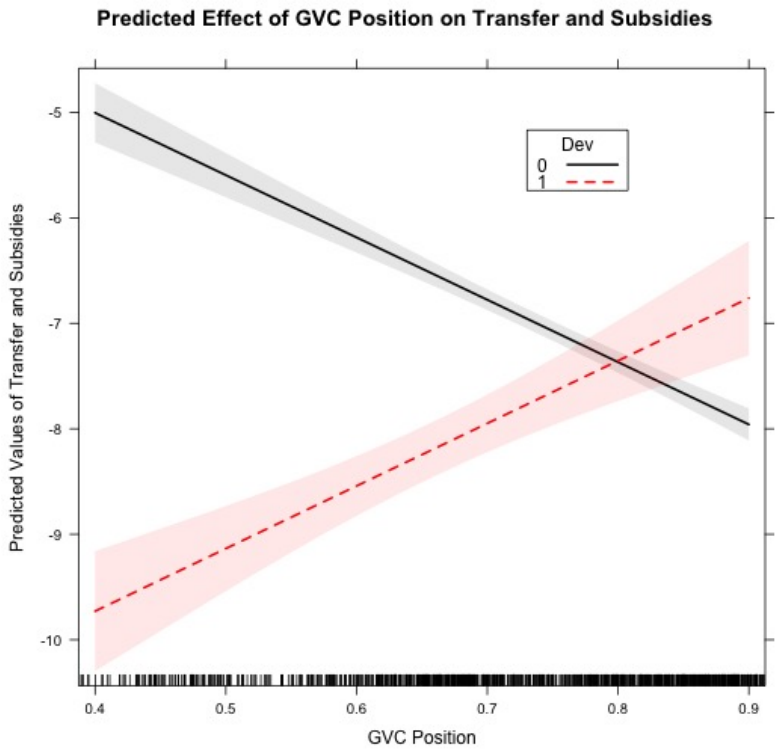
Table 2.2: Fixed Time Effects Regression Results (Continued)

	Dependent variables:		
	(4) Capital Controls	(5) Licensing Restrictions	(6) Government Enterprise
Developmental State	-0.533	-2.026*	1.079
	(0.833)	(0.736)	(0.566)
Position on GVC	1.370*	-0.074	2.443*
	(0.444)	(0.450)	(0.774)
Developmental State x Position on GVC	2.931*	2.354	-0.370
	(1.155)	(1.307)	(0.783)
Centralized Collective Bargaining	0.220*	0.101*	0.218*
	(0.054)	(0.031)	(0.043)
Bribes, Payments and Favoritism	0.470*	0.535*	0.501*
	(0.045)	(0.071)	(0.054)
Polity	-0.167*	-0.041*	-0.084*
	(0.012)	(0.019)	(0.015)
FDI as Percentage of GDP	-0.032*	0.000	0.004
	(0.012)	(0.007)	(0.011)
Intercept (Base Year=2000)	0.144	-1.723*	-2.452*
	(0.496)	(0.741)	(0.837)
Year 2001	-0.221*	-0.214*	-0.240*
	(0.049)	(0.072)	(0.081)
Year 2002	-0.367*	-0.384*	-0.214*
	(0.056)	(0.093)	(0.074)
Year 2003	-0.474*	-0.421*	-1.082*
	(0.046)	(0.086)	(0.069)
Year 2004	-0.456*	-0.911*	-1.152*
	(0.082)	(0.147)	(0.075)
Year 2005	0.205*	-0.782*	-1.384*
	(0.077)	(0.119)	(0.119)
Year 2006	0.148*	-0.941*	-1.531*
	(0.073)	(0.140)	(0.114)
Year 2007	0.018	-1.260*	-1.438*
	(0.090)	(0.147)	(0.120)
Year 2008	-0.021	-1.50*	-1.372*
	(0.104)	(0.163)	(0.128)
Year 2009	0.191	-1.547*	-1.011*
	(0.114)	(0.157)	(0.118)
Year 2010	0.128	-2.092*	-1.188*
	(0.120)	(0.167)	(0.143)
Year 2011	0.152	-2.23*	-1.357*
	(0.119)	(0.170)	(0.143)
Observations	1128	1128	1128
R^2	0.316	0.307	0.221
Adjusted R^2	0.305	0.295	0.209
p-value of F Statistic	$<$ 2.2e-16*	$<$ 2.2e-16*	$<$ 2.2e-16*

Note: Panel Corrected Standard Errors *p<0.05

Figure 2.1: Predicted and Marginal Effects Plots (Transfer and Subsidies)

(a)



(b)

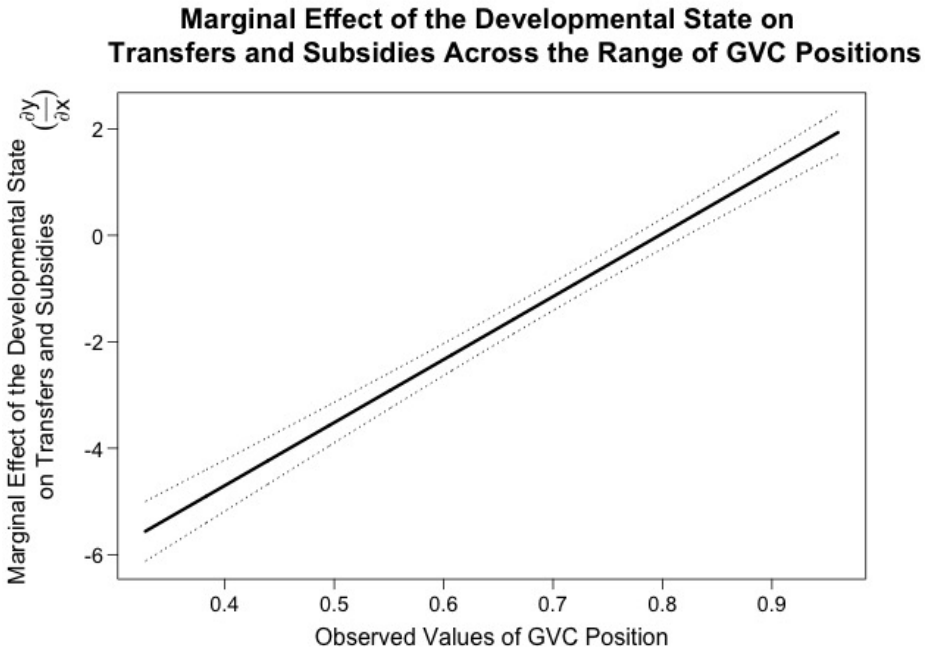
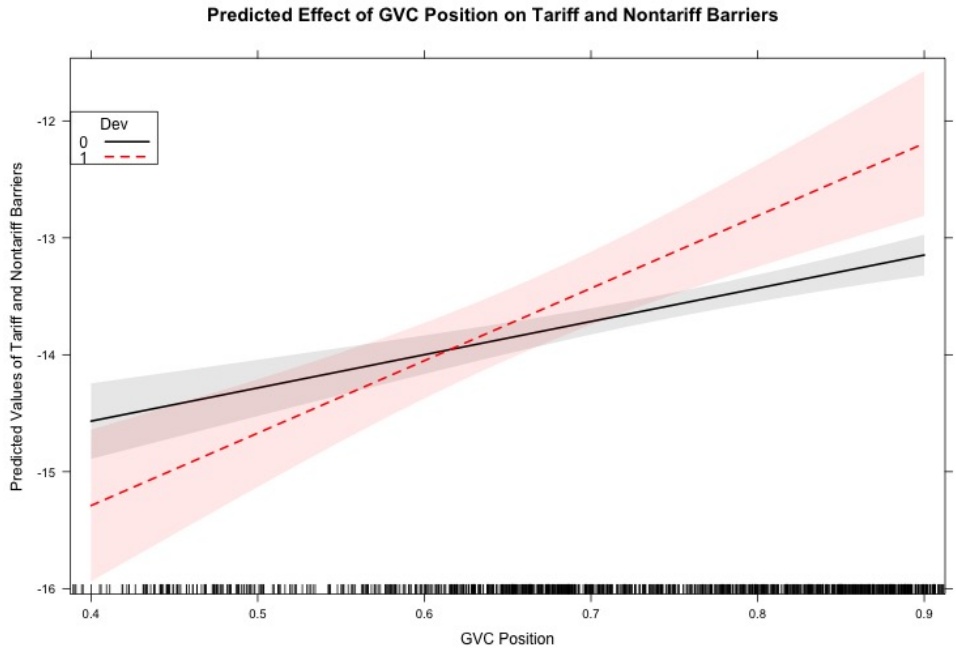


Figure 2.2: Predicted and Marginal Effects Plots (Tariff & Non-Tariff Barriers)

(a)



(b)

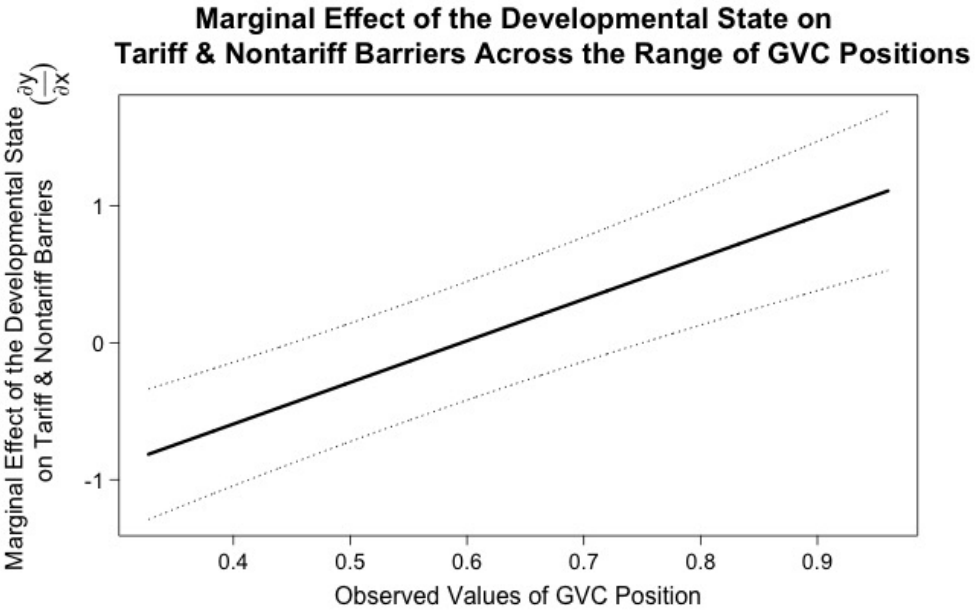
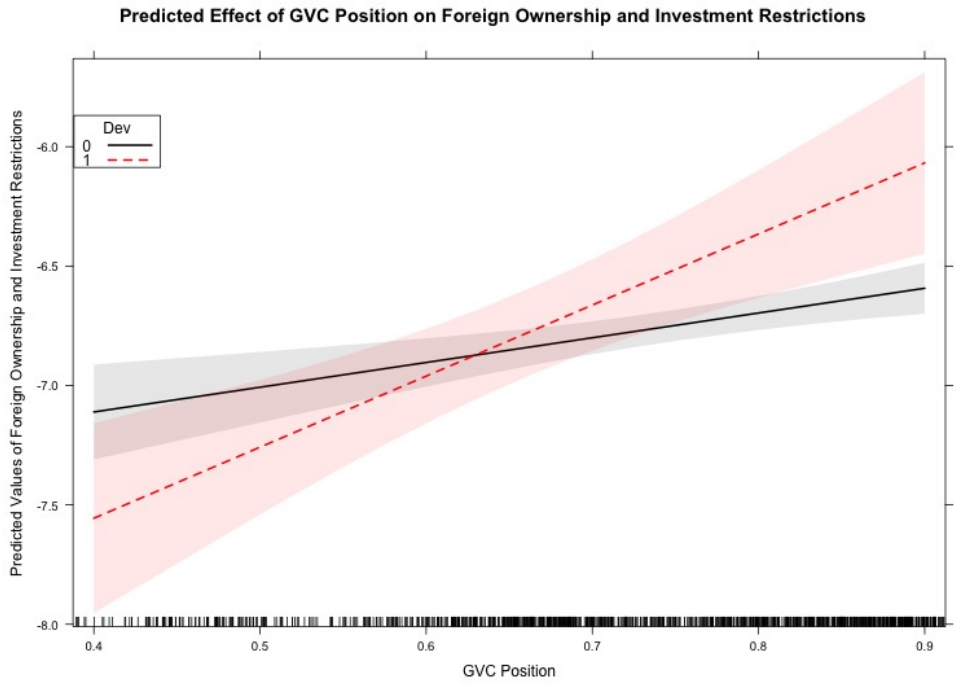


Figure 2.3: Predicted and Marginal Effects Plots (Foreign Ownership Investment & Restrictions)

(a)



(b)

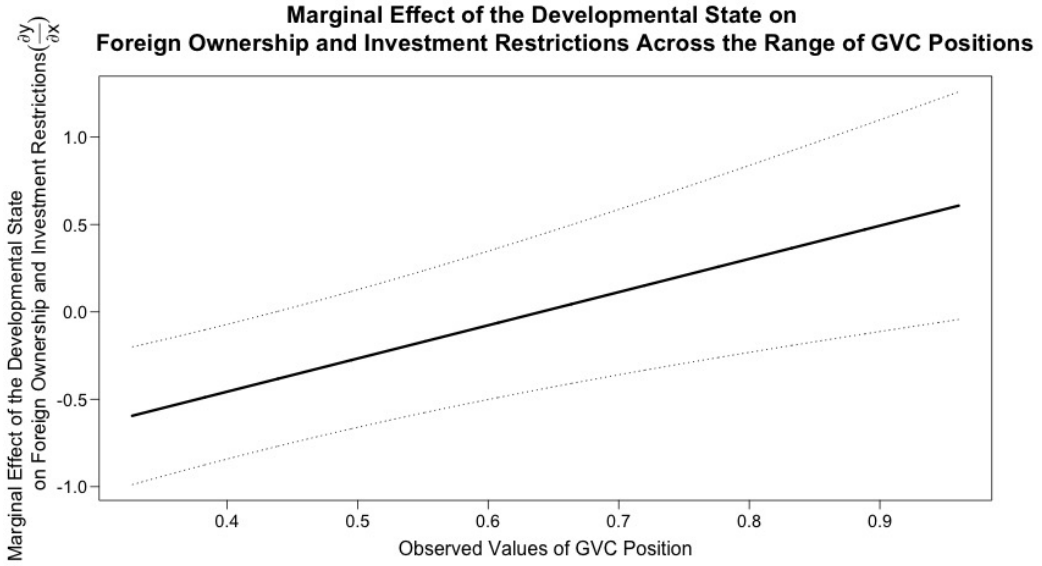
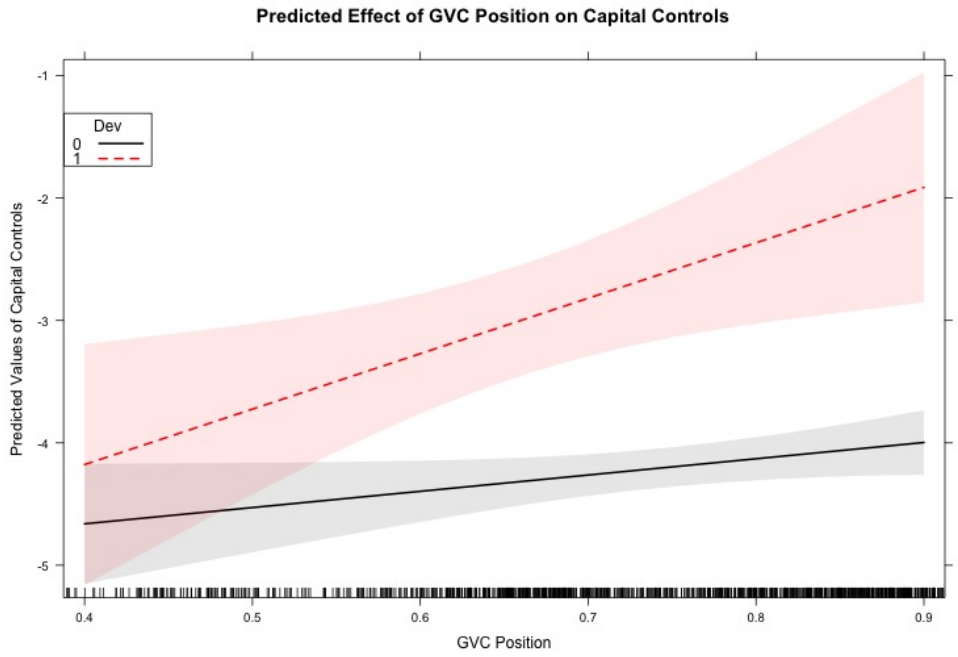


Figure 2.4: Predicted and Marginal Effects Plots (Capital Controls)

(a)



(b)

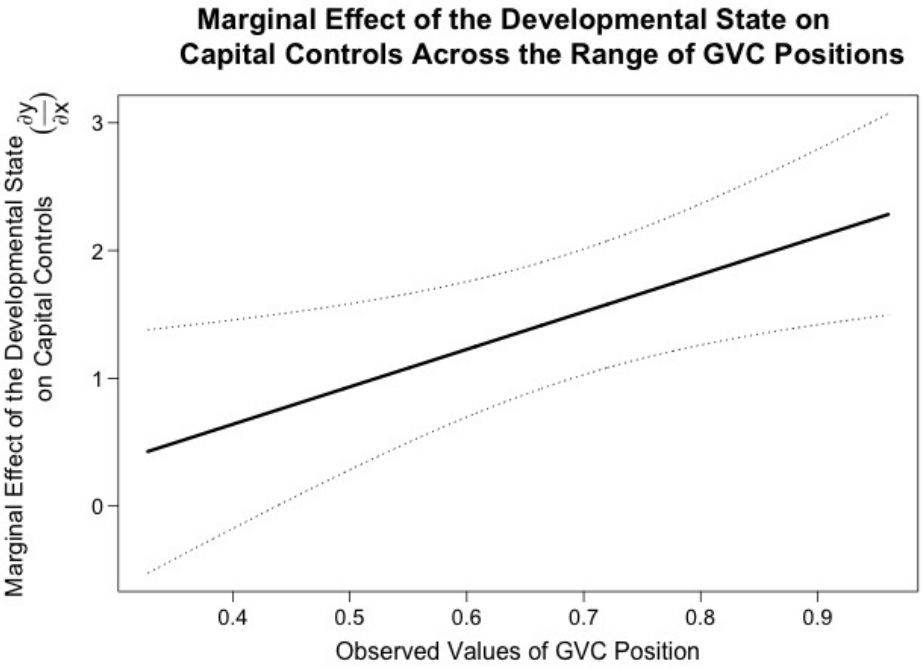


Table 2.3: Fixed Time Effects and Ordinary Least Squares (OLS) Regression Results

	Dependent variable:	
	(7) State-Business	(8) Cooperation
Developmental State	9.897	14.616
	(6.951)	(12.256)
Position on GVC	2.372	8.128
	(1.731)	(5.332)
Developmental State x Position on GVC	-10.938	-16.122
	(9.163)	(18.797)
Percentage of R&D financed by Government	-0.034	-0.044
	(0.036)	(0.057)
Tertiary Education Expenditure by Government (As Percentage of Total Government Education Expenditure)	-0.004	-0.016
	(0.014)	(0.047)
Centralized Collective Bargaining	0.283	0.712
	(0.184)	(0.479)
Bribes, Payments and Favoritism	0.274	0.085
	(0.367)	(0.380)
Polity	0.037	0.041
	(0.044)	(0.129)
FDI as Percentage of GDP	0.023	0.088
	(0.043)	(0.117)
Intercept (Base Year=2000)	15.025*	10.822
	(6.031)	(6.523)
Year 2001	-0.080	
	(0.173)	
Year 2002	0.461	
	(0.504)	
Year 2003	-0.214	
	(0.336)	
Year 2004	-1.380	
	(1.152)	
Year 2005	-1.073	
	(1.152)	
Year 2006	-0.921	
	(1.022)	
Year 2007	-0.802	
	(0.996)	
Year 2008	-0.443	
	(0.725)	
Year 2009	-1.233	
	(1.293)	
Year 2010	-1.841	
	(1.447)	
Year 2011	-1.510	
	(1.369)	
Observations	1128	94
R^2	0.175	0.402
Adjusted R^2	0.160	0.338
p-value of F Statistic	4.081e-13*	0.032*

Note: Panel Corrected Standard Errors for model 7 *p<0.05
OLS results are for the year 2010

In addition, models 7 and 8 above are run to examine the effect of developmental states on state-business partnerships: (1) a pooled model containing all years from 2000 to 2011, and (2) a single-year model based on observations in year 2010. As discussed earlier in the section on multiple imputation, data on state-business partnerships are mired with high degree of missingness, which inevitably make the imputation process less accurate. Data for year 2010 contain the least number of missing values and are thus run as a single-year model as an added robustness check to the statistical analysis. From table 2.3, however, both models do not provide conclusive statistical evidence to the hypothesis that as a developmental state moves up the value chain, it will increase the number of state-business partnerships. Importantly, the results may be inconclusive due to the heterogenous nature of state-business partnerships across space and time: state-business partnerships may be manifested in different forms for different countries and at different time periods, making statistical comparisons difficult. For instance, state-business partnerships in South Korea may be represented by the creation of hi-tech consortiums while partnerships in Indonesia may be more concentrated around specific private-public infrastructure development. Moreover, due to the limitations of hi-tech industries, the number of partnerships in South Korea may be less than that of Indonesia's. Thus, merely judging the *number* of state-business partnerships is insufficient – we should also pay attention to the type and intensity of state-business partnerships. Case study analysis may be better suited to investigate this hypothesis at a deeper level.[31]

2.6 Conclusion

This paper brings our attention to the importance of politics in GVCs/GPNs. Notably, the developmental state is primarily driven by politics, not economics. Critics to the developmental state argue that it will converge towards the neoliberal model in the era of dense economic globalization. However, the neoliberal convergence argument proved to be too simplistic and underestimates the resilience of politics in developmental states. Indeed, the empirical results of this paper show the prevalence of the state in Asian economic affairs. Consequently, instead of being decoupled from the state, local firms are still highly dependent on their governments.

[31] A more extensive research on state-business partnerships involving Japan and three of the tiger economies (Singapore, South Korea, and Taiwan), as well as the tiger cub economies of Malaysia, Indonesia, Thailand and the Philippines, is found in paper 2 of this dissertation.

One could understand the actions of the developmental state through its goals. As discussed earlier in the paper, the developmental state's goal is to shore up economic growth *in order to* preserve social order. In other words, politics not economics is what primarily motivates developmental states. Consequently, while developmental states may find it more difficult to implement strict industrial policies as they move higher up the value chain due to high degrees of technological uncertainty and the lack of information, they will nonetheless find ways to do so (and indeed find ingenious methods to tap the hi-tech markets) in the hopes of providing more incentives for local businesses to participate and thrive in the value chain, as well as to reduce the probability of failed investments that can result in domestic unhappiness and backlash. In addition, given that developmental states are prone to nurture national champions and cultivate niche industries, the state's reputation as a credible leader in guiding the economic progress for the country is also at stake. The developmental state thus finds it necessary to maintain a degree of oversight and control on the nation's economy.

Overall, while the global production network certainly plays an important role in shaping the developmental state's economic options and trajectory, it does not guarantee a simple linear path of neoliberal convergence. In fact, while developmental states may at first find it easy to participate in value chains as they do not have to build up their own industries from scratch, they will be faced with a competitive and uncertain environment once they are plugged into the GPN. Domestic backlash resulting from global competition as well as the eagerness to help local firms to excel can lead developmental states toward more aggressive industrial policies. Indeed, the global economy is tightly intertwined with the domestic politics of different countries, and states do not always gravitate toward the neoliberal model. Several forces are at work and developmental states orientate themselves to suit first and foremost their political objectives.

3 DEVELOPMENTAL STATES AND PARTNERSHIPS FOR INNOVATION

3.1 Introduction

Asia's emerging economies have long enjoyed prosperity due to their comparative advantage in low-cost labor. However, with the acceleration of technology and the resulting mechanization of global manufacturing, Asian economies aspiring to sustain high growth rates and achieve strong economic performance cannot merely depend on exporting labor-intensive goods. Economic restructuring and moving up the value chain will be imperative for these economies to maintain their competitiveness. In other words, innovation is key for Asian economies to continue to grow and thrive.

In an era of rapid technological advances, the most competitive economies are knowledge-based economies (KBE). A central feature of KBEs is that these economies harness the resources of multiple actors, from the government to the industry to universities, forging a trilateral synergistic relationship between the actors and sustaining a virtuous cycle of economic innovation[1]. According to the World Bank and OECD, a knowledge-based economy is one that has (1) an institutional regime that "stimulates the acquisition, creation, dissemination, and use of knowledge and information to improve its growth and welfare", (2) an educated and skilled workforce to create, use and share knowledge, (3) a technological adaption system made up of multiple actors ranging from firms to research institutes to the government that will tap and assimilate the immense stock of global knowledge and adapt it to local needs, and (4) an information and communications technology-enabled (ICT-enabled) environment to facilitate the creation, processing and flow of information (WB (2012*b*) and ADB (2014)).

Consequently, Asian economies aspiring to move up the global value chain (GVC) will need both an enabling institutional regime to spur research and development, education and innovation, as well as strong partnerships between the various stakeholders of innovation. Moreover, given the pressing concern that some of the emerging Asian economies such as Malaysia and Thailand are

[1]This is known as the triple helix model of innovation. More will be explained in the later sections.

stuck in a middle-income trap, which refers to the predicament that middle-income countries face due to their lack of competitiveness in high-tech products on one hand and cheap low-end products on the other making them a sandwiched class of economies, these economies have no choice but to move up the value chain and plug themselves into the knowledge-based economy (ADB (2014)). Indeed, moving towards a knowledge-based economy will no doubt help Asian economies to achieve much more in economic productivity and output. The transformation towards a knowledge-based economy will also ensure that countries stay adaptive and viable in the face of fierce global economic competition and technological change.

Given the huge degree of information uncertainty and resource constraints in innovation, the state needs to step in to not only provide an institutional framework conducive for innovation to occur through policies and incentives, but also identify potential sources of high-technology to invest in. The Asian developmental state, a state-led interventionist economic model consisting of neoliberal and socialist elements, thus plays a critical role. Even for the case of high-income Asian economies such as Japan, South Korea, Singapore and Taiwan, the developmental state is still important in sustaining innovation and finding new areas of growth. Moreover, as Lee, Heo and Kim (2014) note, strong partnerships between multiple stakeholders of innovation are most likely to be formed with the support of the government.

This paper discusses the importance of the developmental state in helping Asian economies engage in innovation, focusing on the role of the state in establishing partnerships with the industry and universities. Importantly, how and under what conditions do state-business partnerships evolve when a developmental state moves up the value chain? I argue that Asian developmental states that are high up on the value chain will move away from a simple bilateral state-industry relation to a more complex trilateral state-business-university relation under the auspices of the government, leveraging the talent in universities to further drive innovation processes. This paper uses both the developmental state model and the triple helix model to examine innovation partnerships in Asian economies.

3.2 Developmental States and Innovation Partnerships

As discussed in paper 1 of this dissertation, the developmental state is an interventionist state that actively promotes industrial policies and economic strategy to achieve growth. The high degree of state intervention sets the developmental model apart from the neoliberal model, which advocates for

the minimal role of the state. Moreover, industrial policies include not only protectionist trade policies to shield infant industries from global competition, as characterized by Alice Amsden's notion of "getting the prices wrong" (Amsden (1989)), but also policies to forge strong economic partnerships with targeted industries to ensure smooth state-business dynamics that runs in congruence with the state's economic goals. In other words, developmental states are highly active in establishing linkages with the respective industries so that the state and industry are embedded in a strategic collaboration. As Evans (1995) notes, one of the core elements of the developmental state is strategic embeddedness within productive sectors of the economy, an alliance that facilitates the implementation of industrial policies. Notable examples include the cooperation between the Korean state and the large *chaebols*, the partnership between the Japanese government and the dominant *keiretsu*, as well as direct government-linked corporations (GLCs) in Singapore.[2]

As Asian developmental states move up the value chain, they will face high degrees of uncertainty inherent within innovation processes and in a global knowledge-based economy. Strategic partnerships between the state and the industry, as well as between the state, the industry, and universities help to ameliorate the uncertainties involved. Notably, the principal challenge in innovation is to first identify which science-based techniques and applications actually work to avoid resource and time wastage. For instance, Wong (2011*a*) notes that even after several decades of basic research in the biotech industry, scientists are still unclear "if, how, and which biotechnological techniques and applications can work to improve human health" (p.7). Developmental states fill this gap of uncertainty by actively identifying niche areas of research to focus on, and forging links between public and private sectors, thereby creating a collaborative environment for actors to pool and share information. Consequently, developmental states provide national innovation frameworks and strategies for firms and universities to focus on, with partnerships that further inform and advance the direction of innovation. Through cooperative networks made up of innovation actors, the uncertainty of identifying which areas to research and innovate can be greatly reduced.

In addition, under the coordinative leadership of developmental states, local entrepreneurs are encouraged to invest in particular high-tech sectors with the costs and risks of industrial upgrading

[2]The Korean chaebols are large conglomerates of family-owned firms that have close links with the Korean government. Some examples include the Samsung group, LG, and Hyundai. The Japanese keiretsu is a loose grouping of dominant companies in Japan such as Mitsubishi (includes Mitsubishi Electronic, Mitsubishi Chemical, and Nikon, to name a few), Tokai (includes Toyota and Suzuki motors), and Sumitomo (includes Asahi Breweries, Mazda and NEC).

offset by the state.[3] For example, Singapore's Economic Development Board (EDB) and Standards, Productivity and Innovation Board (SPRING) have forged strong links with the biotech industry as well as local public universities, providing funding and opportunities for productivity training for local start-ups, and helping to link these start-ups to multinational corporations (MNCs) (Wong (2011*a*)). Partnerships coordinated by the state can thus help to jump-start local innovation. Moreover, the institutional environment setup by the state helps to facilitate technological diffusion from MNCs to local firms. The South Korean liquid panel display industry provides a good example of the crucial role the government plays in establishing linkages between local firms and MNCs to spur technological diffusion and development (Lee, Heo and Kim (2014)).

The developmental state can also be seen as a mediator of conflicts in innovation partnerships. Conflicts that arise between actors can be arbitrated by the state given its authority to enact laws and policies. For instance, the state acts as a container of laws and practices within a country and sets the various regional innovation frameworks that guide industrial development.[4] Conflicts between the various actors can be mediated within existing regulatory frameworks and through the various government agencies in-charge. For instance, the Fourth Science and Technology Basic Plan of Japan (2011-2015) not only outlines strategies to promote collaboration between the state, industry and academy, but also highlights innovation regulations as well as institutions for intellectual property rights protection (METI (2012)).

Some scholars have even gone to the extent to argue that the institutional arrangements for innovation are unlikely to be created in the absence of the state (see Chang (1999)). Citing the Austrian-American economist Joseph Schumpeter, Ha-Joon Chang argued that the process of innovation often requires "complex institutional arrangements that cannot be provided by arm's-length market relationships and maximum price competition, which the neoliberals aim to attain through liberalization" (ibid). Wong (2011*a*) has also noted that "all states – even the leanest of the liberal market economies" have engaged in intervention in new industry development (p.40). Regardless of the extent of importance of state intervention in innovation, the developmental state model is likely to remain prominent in Asia as countries move up the value chain. Moreover, as Onis (1991) notes, the

[3]For more information, see Wong (2011*a*) p.22, and Cheng (1990).

[4]Also see Lee, Heo and Kim (2014) for a discussion on how the South Korean government acts as a mediator of conflicts between firms in the Korean LCD industry.

fact that private businesses have been "nurtured by the state in the first place has, in turn, rendered them extraordinarily dependent on the state for their future survival" (p.116). Indeed, state-business partnerships are also likely to persist in the innovation phase of industrialization even in mature Asian economies due to path dependency. Lastly, in order to increase economic productivity and growth, developmental states also have the incentive to create robust partnerships between the various actors of innovation.

3.3 Innovation Partnerships and the Triple Helix Model

A related question is how innovation partnerships *evolve* over time. Moreover, under what conditions do these partnerships evolve? To further understand innovation partnerships in developmental states, as well as the complex changes in partnership linkages, I use a model of innovation called the "Triple Helix Model" (Etzkowitz (1995), Etzkowitz and Leydesdorff (2000), and Lowe (1992)). The Triple Helix Model involves the shift from a dyadic collaboration between the state and the industry to a triadic one between the state, the industry, and the academy, so as to increase overall innovation performance via network synergies. Applying the triple helix model to Asian economies, the main actor driving the establishment of the trilateral relationship is the state.

The government and industry have long dominated patterns of industrialization. More recently, since the rapid acceleration of ICT and resulting ongoing information explosion, the university has emerged as a critical actor that has a competitive advantage over government laboratories and research institutes within firms to synthesize and produce knowledge (ibid). Indeed, universities, with their constant replenishment of students, are a highly productive wellspring of new ideas and knowledge. Triadic partnerships are thus formed between the government, the industry, and the academy. In addition, drawing from social network analysis theory, triadic partnerships are more likely to result in innovation synergy compared to bilateral ones due to increased information flow among the actors (resulting in reduced information uncertainty), and the greater pooling or sharing of knowledge within the triad. As Cranmer, Desmarais and Menninga (2012) note, a synergy effect means that the utility of collaborative ties between three actors in a triadic closure will be greater than the sum of their dyadic level ties.[5] Furthermore, the synergistic effects may lead to a self-sustaining

[5]Note that a triadic closure depicts a closed triangle in social network analysis and is the same as the triadic partnership between the state, industry and academy that we have here.

"virtuous cycle", in which the actors reap exponentially greater benefits from the triadic partnership, ultimately leading to innovation breakthroughs.

In addition, as states move from an industrial economy to a knowledge-based one, both the government and the industry take on additional roles: (1) the government might act as a public venture capitalist while retaining its role as an industrial regulator, and (2) firms may develop more learning and research centers that resemble the university (Etzkowitz (2008)). Correspondingly, universities may develop roles of the industry by "stimulating the development of new firms from research, introducing the 'capitalization of knowledge' as an academic goal" (ibid p.1). The complex interaction between the three key actors of innovation thus constitutes the triple helix model. Notably, as Dzisah, Ranga and Zhou (2007) note, the *ideal* triple helix model consists of three core elements: (1) the inclusion of the university as a core actor in national and regional innovation, (2) a movement towards partnerships between the three major actors (government, industry and academy) in which innovation is a result of the interactions between these actors rather than being wholly dictated by any one particular actor, and (3) each actor "takes the role of the other", thereby developing new synergies in interaction and increasing the complexity of the innovation process. The positive feedback or virtuous cycle resulting from innovation synergy will inform policies of the state and the industry. Thus, even in the case of the developmental state, where the state takes the dominant role, its innovation strategies will be increasingly informed by both the industry and the academy, and are not formulated solely by the state itself.

3.3.1 Configurations of the Triple Helix Model

Etzkowitz (2008) notes two distinct configurations of triadic partnerships: (1) a statist model, which focuses on the role of the state, and (2) a laissez faire model, which emphasizes the industry. To elaborate, the statist model focuses on the role of the government in establishing triadic linkages between the state, industry and academy. The government constitutes the dominant institutional sphere, and the industry and academy are subsumed under the state (ibid). In addition, the government is expected to initiate new developmental projects with the help of specialized agencies within the government bureaucracy. As such, innovation cannot occur without the auspices of the state. Although other actors of innovation can inform state policy, the system of policy making is concentrated at the top of the bureaucracy, making bottom-up approaches difficult and ineffective

(ibid). A movement towards greater decentralization might occur as the country embeds itself in a knowledge-based economy but the state retains the most power in innovation policy making.

On the other hand, a laissez faire model focuses on the driving force of the industry to spur the creation of the trilateral relationship. The government, however, is expected to play only a minimal role in regulation. In addition, the university is expected to provide only basic research and train scientific talents required for innovation. Industry dynamics are key in driving the direction of innovation and economic development. Importantly, several firms, as in a perfectly competitive market, characterize the industry (ibid). Thus, as opposed to the statist model, the laissez faire model places the industry at the top, while the government and universities act as secondary institutions of innovation.

An interesting point to note is that countries sometimes alternate from one model to the other. For instance, even in laissez faire archetypes such as the US, the role of the government might increase at times of crisis or national emergencies, thus resembling the statist model (ibid). During World War II, universities and industry were subsumed under the state, with many projects initiated by the government. For example, the Manhattan Project to develop the atomic bomb targeted particular key industries and personnel from universities, under the control of the US military. In addition, with the threat of the Soviet Union after the war, the US space program in the 1960s depended heavily on the government, which helped to establish ties between the industry and universities (Ward (2012)). Nonetheless, short of a crisis or major economic restructuring, a country's innovation model is unlikely to swing from a laissez faire to statist model or vice versa.

Regardless of whether a country is statist or laissez faire, triple helix scholars assert that in today's knowledge-based economy, both types of regimes will ultimately trend towards a *balanced* model, which places the university on par with the government and industry, with all three actors on equal footing. Importantly, due to the demands of a knowledge-based economy, universities can no longer be seen as secondary to the industry and the government. Thus, the statist and laissez faire models might evolve to the ideal (balanced) model of the triple helix as countries get increasingly plugged into the global knowledge-based economy.

3.3.2 The Developmental State and the Triple Helix Model

As should be apparent, given the dominant role of the government, the statist model best characterizes the workings of the developmental state. Importantly, the statist model may not

represent the reality of innovation partnerships for *all* Asian developmental states. In fact, the triple helix model of trilateral relationships may only be applicable to the advanced Asian economies that have successfully plugged into the knowledge-based society. Other developmental states in emerging Asia might still be struggling with their bilateral relations between the state and the industry. Linkages with universities may thus be weak or non-existent. In general, I argue that as Asian economies move up the GVC, they will forge stronger partnerships with businesses in order to spur innovation.[6] Moreover, Asian economies that are high up on the GVC will progress towards the (statist) triple helix model of innovation, with strong trilateral relationships between the government, industry and academy.[7] I present a more nuanced set of configurations that cater specifically to the different types of innovation partnerships in Asia (see below).

Figure 3.1 presents a template for the various stages of evolution in innovation partnerships for Asian developmental states from a weak triadic configuration to a strong one. Correspondingly, four successive phases of economic development eventually give rise to the triple helix ideal type: (1) low-tech industrialization, (2) industrial transitional phase, (3) high-tech industrialization, and (4) innovation take-off.

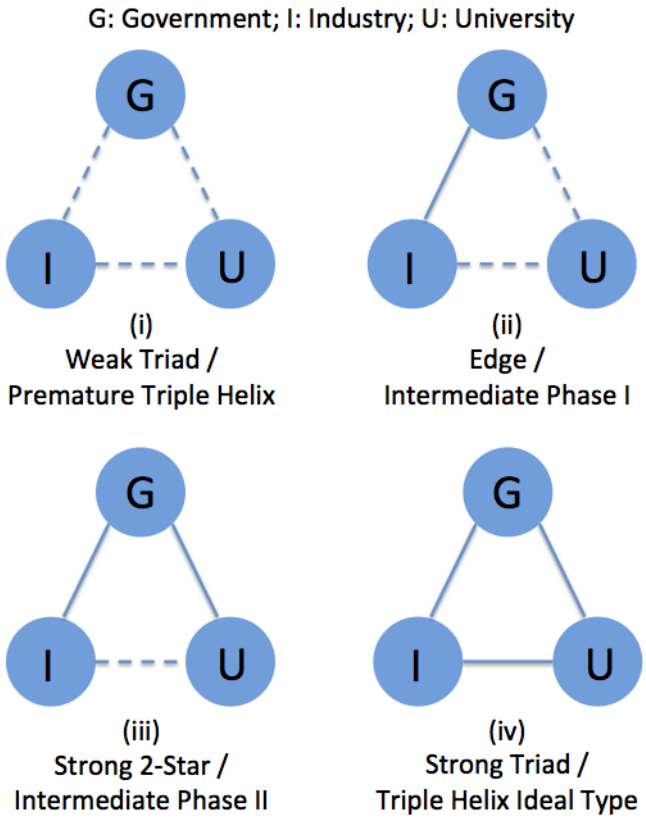
Stage 1: Low-tech industrialization (low GVC position) and premature triple helix: During the initial stages of a country's industrial development, collaboration between the government and the industry is tenuous as the government is still trying to garner resources to create industrial parks and regulatory frameworks to strengthen government-industry relations. University relations with the government are also weak as the government channels the bulk of economic resources to the industry, neglecting the university, as demand for highly educated talent is low. In addition, the government does not actively encourage ties between the industry and university, as there is no demand for such ties to be formed yet. This is characterized by figure 3.1(i). I would expect this form of triadic dynamics for the low and lower-middle income Asian economies such as Philippines, Indonesia and Thailand.[8]

[6] As seen from earlier discussions.

[7] Note that I do not present my assertions in the standard (linear) 'hypothesis form' that is found in many quantitative papers as it would undermine the complexity involved in the triple helix evolution.

[8] Although Thailand is considered to be upper-middle income status by the World Bank from 2010 onwards, it has been for the most part (from 2000-2011, the time period used for this study) a lower-middle income country.

Figure 3.1: Triple Helix Topologies



Stage 2: Industrial transitional phase (middle GVC position) and edge configuration: As the country develops, linkages between the government and the industry will become stronger. Government expenditure to universities is expected to increase during this phase, as the industry demands more talent and expertise. However, relations between the university and the other two actors will be in the nascent stages and are likely to remain weak, as characterized by figure 3.1(ii). The 'edge configuration' in figure 3.1(ii) thus only depicts the significant bilateral relationship between the government and the industry.[9] I would expect the upper-middle income economies such as Malaysia to adopt this form of configuration.

Stage 3: High-tech industrialization (high GVC position) and strong 2-star configuration: Following further advancement of the economy and as the country focuses on high-tech manufacturing, strong links would continue to be expected for government-industry relations. Moreover, strong

[9]In network theory, an edge is a connection between two actors in the network. Although all three actors are connected in this case, I only consider significant connections. Weak connections are just for illustrative purposes to show how the triple helix actually evolves.

government-university relations would be developed at this stage, due to the high demand for skilled workers. The resulting network configuration is the 2-star, which depicts the two sets of strong bilateral relations between the government and the industry, as well as between the government and the university.[10] However, ties between the industry and university might still be developing, as the country might not be fully plugged in to the knowledge-based economy. Nonetheless, demand for industry-university collaboration is expected to steadily increase during this phase of industrialization. A country at this phase of industrialization would be engaged in high-tech manufacturing, but has yet to become a full-fledged creative economy. Figure 3.1(iii) illustrates this type of triadic relationship.

Stage 4: Innovation take-off (GVC apex) and the triple helix ideal type: Lastly, when a country has moved into a predominantly high-tech and knowledge-based phase of economic development, government-industry-university relations will cement to form the triple helix model – a closed triad of tightly connected actors. Importantly, the triple helix model represents an ideal type, and in reality, even highly developed economies might have yet to reach this stage. Thus, I posit that mature Asian economies of Japan, South Korea, Taiwan and Singapore are likely to be in *transition* from the strong 2-star configuration of figure 1(iv) to the ideal type configuration seen in figure 1(iv).

3.4 Case Study Analysis of Asian Developmental States

I provide a comparative case study analysis of eight Asian countries – Japan, South Korea, Singapore, Taiwan, Indonesia, Philippines, Thailand and Malaysia – to evaluate the evolution of government-industry-university partnerships in Asia. The juxtaposition between the developed and emerging economies of Asia[11] serve to highlight the differences in trilateral partnership configurations posited in the previous section. Moreover, in order to make my empirical analysis manageable, I restrict the time period to 2000-2011, to control for marked changes in a country's pattern of industrialization.[12] Data and information on the cases are drawn from inter-governmental organization reports (OECD, World Bank, Asian Development Bank, UNESCO to name a few), journal articles and books, as well as official ministry reports found in the various government websites.

[10] In network theory, a strong 2-star configuration depicts an actor that is tightly connected to two other actors.

[11] The four developed economies are Japan, South Korea, Singapore and Taiwan, while the emerging economies are Indonesia, Philippines, Thailand and Malaysia. More will be explained in the later sections.

[12] This time period is also chosen because it corresponds to that in paper 1. As this paper is an extension to paper 1, I have decided to use the same time period.

The following subsections present the case studies beginning with the emerging Asian economies, which are positioned low on the value chain, to show the nascent triadic relationship. As theorized, even within emerging Asia, heterogeneity exists, with Indonesia, Philippines and Thailand belonging to lower-middle income economies, and Malaysia at the higher end of the middle income spectrum. Indeed, the triadic configuration of Malaysia may be different from the lower-middle income economies. Subsequent subsections will move on to illustrate the mature Asian economies of Taiwan, South Korea, Singapore and Japan. As discussed, these economies are likely to show a much stronger triadic relationship. A comparative case analysis thus helps to elucidate more precisely the complex triple helix dynamics in Asia.

3.4.1 Emerging Asia: Indonesia

Despite being listed as one of the most prominent emerging markets in Southeast Asia by the World Bank, with GDP growing at an average of 5.31% from 2000 to 2011 (WB (2015)), Indonesia still remains at stage 1 of industrial development and consequently has extremely tenuous triadic relationship between the government, the industry and the university. Most of Indonesia's exports rest on natural resources such as petroleum and coal. In terms of domestic value-added, Indonesia focuses on simple manufacturing and low technology, with mining, quarrying and petroleum as its dominant industry.[13] In addition, gross exports of high- and medium-high tech goods only make up around 20% of total exports on average from 2000 to 2010 (OECD (2013*a*)). Moreover, bearing in mind that these high and medium-tech goods may contain high foreign content imported from abroad in the first place as part of the supply chain, the domestic value-added or local contribution ultimately made to these goods often merely involve simple assembly and other low-skilled processes. OECD notes that since 2000, "Indonesia has increased its propensity to import high-technology manufactured goods from 5% [in 2000] to 14% in 2010" (ibid). Besides continued dependence on foreign technology and its overall low-tech domestic production structure, Indonesia faces a lack of skilled labor, political corruption, small English-speaking population and poor physical infrastructure that all impede industrial upgrading. Indeed, Indonesia remains at the nascent stages of industrial development, with multiple challenges for the government to tackle.

[13] Information and data obtained from UNCTAD-EORA GVC database for the time period 2000-11.

Joint collaborations in research and development between the government and the industry are extremely weak. Government-industry cooperation is often hindered by the lack of robust institutional frameworks. For instance, the lack of adequate private property protection, weak implementation of tax regulations, and the lack of transparency deter businesses from even starting. Intellectual property rights are also rarely enforced due to political corruption (ibid). Nonetheless, a few ambitious government initiatives designed to transform the Indonesian economy from a natural resource-driven to an investment and innovation-driven one have sprung up since 2010 (with the establishment of the National Innovation Committee (KIN)), but Indonesia still lacks the capacity and political will for robust innovation to take place. Moreover, even with recent initiatives, research and development is still concentrated within government research institutes, with very little cooperative projects with the industry or the university (ibid).

Funding for research in Indonesian universities comes primarily from the government. However, the government only allocates a very modest share of research expenditure to universities (ibid). Consequently, the publication performance in international refereed journals and patent activity are rare (see UNESCO (2010)). Moreover, very few research connections exist between government research institutes and the universities. In addition, as Lakitan, Hidayat and Herlinda (2012) note, although "R&D collaboration has been encouraged at least for two decades...scientific productivity of public R&D and higher education institutes has not increased as expected" (p.228).

Only a few initiatives have been made by the government to encourage university-industry linkages, all with little success (see OECD (2013*a*)). This is due to the budget constraints imposed on government-sponsored schemes. For instance, unspent allocations need to be returned to the government every financial year and "all income generated from industry projects has to be transferred to the Ministry of Finance" (ibid, p.172). Consequently, the high disincentives to participate in government schemes, political corruption and bureaucratic red tape make university-industry relations tenuous. Overall, Indonesia characterizes the premature triple helix configuration, with a very weak triadic connection among innovation actors.

3.4.2 Philippines

Philippines sets itself apart from the the other emerging economies in Asia in that it is focused on services, in particular the information-technology business process outsourcing (IT-BPO) service industry, as its main engine for growth. However, it is at best still in the process of transitioning from

stage 1 to 2, with a production structure still largely low-tech, and with weak triadic connections among innovation actors overall (ADB (2013)). To add, although the government has drawn out strategic plans for industrial upgrading by encouraging the expansion of IT software and services, as well knowledge-process outsourcing that includes medical transcription, web design and animation, the bulk of Philippines' IT-BPO industry rests on low value-add call centers (ibid). Moreover, a key component of Philippines economy, constituting 9%-10% of GDP from 2000 to 2011, are remittances from over 4 million Filipinos working overseas thereby making Philippines one of the most remittance-dependent countries in the world (ibid). Consequently, Philippines is still very much a developing economy that is positioned fairly low on the GVC.[14]

Collaboration between the government and the industry is slightly more visible in Philippines than in Indonesia, but linkages remain weak. Since the mid-2000s, the Philippine government has instituted innovation initiatives such as the Philippine Cyber Corridor and Next Wave Cities Initiative as special efforts to promote and expand the IT-BPO industry into higher value-added activities and to further develop ties with private IT-BPO firms to fine-tune policies (BPAP (2007)) Moreover, consultations with private IT-BPO firms helped the Philippine government to rapidly expand the IT industrial parks in the country and develop more technical-related training programs for its workforce (Keitel and Ledesma (2013)). However, these innovation strategies and partnerships are all fairly recent and are still in their embryonic stage (ADB (2013)). Joint R&D projects between the government and the IT-BPO industry remain rare and non-existent. In addition, public sector weakness such as bureaucratic red tape and corruption are still rife. The enforcement of government policies, laws and regulations also remain weak for both the central and local governments, hampering ambitious initiatives and partnerships (ibid).

Government funding for universities in Philippines remains very low compared to other emerging Asian economies discussed in this paper. Comparing data from the UNESCO Institute of Statistics, government expenditure in tertiary institutes as a percentage of GDP for Philippines is only a mere 0.35% on average from 2000 to 2011, compared to 0.41% in Indonesia, 0.69% in Thailand and 1.86% in Malaysia. Correspondingly, government funding for university research in Philippines can be seen to be very lacking. Moreover, given that regulatory frameworks take a long time to implement due to

[14]For more information on each country's position on the value chain, see table 3.1.

the lack of coordination among ministries and government agencies, robust innovation partnerships are unlikely to be formed with universities.

While universities have increasingly linked up with the industry for joint research, "collaborative and published works are still very modest in scale" (Vea (2013), p.13). As Vea (2013) further notes, government efforts have also been lackluster in bringing the industry and university together for joint R&D. In addition, from the governments strategic initiatives and roadmaps, the emphasis seems to be highly focused on establishing strong inter-firm linkages (between local and foreign enterprises) for technological diffusion to occur, than forging robust university-industry relations (ADB (2013)).

Overall, Philippines can be seen as having a triple helix that is transitioning from a premature one to one that has a strong bilateral government-industry relation, as characterized by stage 2 of industrial development, but much remains to be done. The current triadic framework for the Philippines is still very much a stage 1 configuration, and unless robust policies are implemented to strengthen the institutional framework for cooperation to occur, ambitious initiatives in themselves will not bring about a successful transition. Nonetheless, as compared to Indonesia, Philippines still remains slightly ahead in its innovation progress.

3.4.3 Thailand

Similar to Philippines, Thailand can be seen as being in transition from stage 1 to 2 of economic development. Since the early 2000s, the electronics and global automotive sectors have been increasing in prominence (OECD (2013*a*)). Moreover in 2006, Thailand's exports of hard disk drives constitute 48% of the global market (ibid). Notably, Japanese firms such as Sony, Toshiba, Hitachi and Mitsubishi (to name a few) comprise the bulk of MNCs in Thailand. That being said however, despite the focus on high-tech industries and the presence of global lead firms, productivity has grown slowly and technological diffusion from MNCs has been limited (WB (2012*a*)). The domestic value added for the electronics and automotive industries remains low as most local producers are involved in the assembly of parts and components and other labor-intensive activities (see OECD (2013*a*), AIT (2003) ,and Bonaglia (2006)). Moreover, due to weak supporting domestic industries, Thailands high-tech manufacturing depends largely on imported parts and raw material (Bonaglia (2006)). As a result, Thailand is at best slowly transitioning from a low-tech to a medium-tech industrial base, and is still positioned fairly low on the GVC.

Product R&D and innovation partnerships in Thailand are severely lacking. Small-medium enterprises (SMEs) which constitute 78% of Thai employment are not linked to MNCs, thus greatly hampering the innovation progress within the country (OECD (2013*a*)). Moreover, only 6% of local firms invest in R&D, with the main aim of enhancing production processes rather than product innovation (ibid). In addition, due to the long-standing dependency on cheap labor, only a paucity of firms will be motivated to invest in innovation and move up the value chain. Thus, despite the government's strategic initiatives to encourage innovation, the inherent weakness of Thailand's innovative capacity impedes the implementation and actualization of the government's master plans. Furthermore, because of the lack of transparency and accountability, public research institutes are not highly viewed as credible sources of knowledge, and few collaborative ties exist with private firms (Schiller (2006) and Intarakumnerd (2010)). Moreover, although the Thai government has established several high-tech industrial clusters, cluster policies remain weak and fragmented (Arnold, Bell, Bessant and Brimble (2000)). Consequently, government-industry cooperation is tenuous.

Government funding and R&D activities within universities remain low (OECD (2013*a*)). As noted earlier, the Thai government's expenditure in tertiary institutes as a percentage of GDP is 0.69% on average from 2000 to 2011, a figure that is higher than both Indonesia and the Philippines but still lags considerably behind Malaysia. Moreover, outdated curricula and university programs further obstruct innovation partnerships (ibid). The persistent weakness in the quality and funding of university education in Thailand shows to a large extent the negligence of the Thai government in channeling resources and revising policies for Thai tertiary education.

Due to the low quality of university education, university-industry linkages have also been highly limited. Similar to the case of public research institutes, firms generally do not regard universities as wellsprings of knowledge. Moreover, even when research collaboration exists, the ties are formed based on personal contacts without an elaborate institutional framework (ibid). More recently, the Thai government has outlined a 15-year Tertiary Education Framework (2008-22) that is geared towards university-industry collaboration, but the impact remains to be seen. Overall, even with strategic initiatives for innovation partnerships, Thailand's triple helix is only slowly developing out of its fledging phase and is far from evident.

3.4.4 Malaysia

Malaysia is positioned at stage 2 of industrial development and consequently has strong bilateral government-industry relations. Malaysia is classified by the World Bank as an upper-middle income country and has an average GDP per capita[15] of US$16432.30 (2000-11), which is much higher than other economies in emerging Asia, although it still lacks quite considerably behind the mature Asian economies.[16] Malaysia's major export sectors are the electronics and automotive industries, with semi-conductors making up 40% of total exports (OECD (2013*a*)). In addition, among ASEAN economies[17] Malaysia ranks after Singapore in terms of economic competitiveness, leading Thailand, Indonesia and the Philippines by a fairly wide margin (WEF (2011)).[18] Although high-tech exports in Malaysia account for approximately 59.85% of all manufactured exports on average from 2000 to 2011, the corresponding percentage of domestic value-added is only about 24.38 % (Thiruchelvam, Chandran and Ng (2011)).[19] Malaysia, like Thailand, mainly exports technology-based products that have high foreign import content, and that production is structured mostly around the assembly of manufactured goods and other labor-intensive operations (Rasiah (2009)). Nonetheless, in comparison with Indonesia, Philippines and Thailand, Malaysia has a much stronger institutional framework with strong government-led industrial clusters in the electronics sector that help to spur innovation. Moreover, the electronics clusters have had increasing success in creating local firms with international reputation and high innovative capacity such as Engtek Group, Globetronics Technology and Vitrox Corporation (OECD (2013*a*)). In addition, Malaysia has also channeled considerable resources in developing its own auto industry, with Proton and Perodua as the prime examples. Consequently, although Malaysia still lags behind the mature Asian economies, it is situated higher up the value chain compared to Indonesia, Philippines and Thailand.

[15] GDP per capita, PPP, current US$

[16] As a comparison, the average GDP per capita for Indonesia, Philippines and Thailand are US$6150.15, US$4449.43, and US$9966.63 respectively over the same time period. Data obtained from the World Bank Development Indicators.

[17] ASEAN economies refer to the ten Southeast Asian economies of Malaysia, Singapore, Thailand, Indonesia, the Philippines, Laos, Vietnam, Brunei, Cambodia, and Mynamar.

[18] According to the *Global Competitiveness Report* by the World Economic Forum (2011), Singapore overall ranking in global competitiveness is 3 while Malaysia ranks 16, followed by Thailand (38), Indonesia (44), and the Philippines (85).

[19] Although data is not available from 2000-04 and 2011, the composition of exports, especially domestic value-added, is likely to be largely the same as 2005-10.

Under the political leadership of Badawi, who served as Malaysia's Prime Minister between 2003 and 2009, the developmentalist agenda of collaborating with selected industries was strongly promoted (Gomez (2012)). Government-linked corporations, which are the dominant firms in Malaysia, were tied up with MNCs and SMEs such that local firms can gain access to foreign markets and innovation (ibid). Strong industrial cluster policies that encouraged strategic alliances among firms were instituted, especially in the electronics and automotive sectors. The rise of Engtek and Globetronics was in large part due to their connections with MNCs in the Penang electronic cluster (ibid). In addition, public research institutes such as the Malaysian Palm Oil Board (MPOB) and the Malaysian Rubber Board (MRB) in the agricultural sciences work closely with the agriculture and forestry industry for research and development (Chandran, Farha and Veera (2008)). Thus, government-industry linkages are strong and much more pronounced compared to those in Indonesia, Philippines and Thailand.

Government funding for universities in Malaysia leads the other emerging Asian economies.[20] Since 2007, the Malaysian government has reformed and instituted a rating system for higher education institutes (SETARA) to promote best practices and upgrade the quality of education in public universities (OECD (2013*a*)). Moreover, the government created grants that promoted R&D, patenting and the commercialization of research. However, even with the massive government funding and well-intentioned initiatives, research output has remained low due to the lack of technical expertise and the heavy teaching load in universities (ibid). In addition, although the government has created several plans for research within universities, it has not supported the collaboration between public research institutes and universities. Overall, government-university partnerships are still seen to be fairly tenuous.

University-industry linkages are highly limited in Malaysia due to the lack of industrial relevance in university research (OECD (2013*a*)). Moreover, the lack of intermediary agencies that help to link the universities and industry together also make it difficult for both actors to collaborate. Despite the proliferation of high-tech industrial clusters that benefited from strong government support, the university's involvement in these clusters remains non-existent (ibid). As such, although the bilateral tie between the government and the industry is evident, government-university and especially

[20] As shown earlier in the statistics drawn from UNESCO.

industry-university ties are still weak. The lack of partnerships and innovation synergy may partly explain why Malaysia is caught in the middle-income trap, which is a situation where the domestic economy is unable to evolve and develop new market technologies.

Overall, as seen from above cases, Indonesia is worst at producing innovation partnerships, followed by Philippines and Thailand. Indonesia is situated at the lowest stage of industrial development, while Philippines and Thailand can be seen as transiting from stage 1 to 2, though the triple helix of all three countries are in general premature and very weak. Malaysia exhibits the strongest triple helix configuration among the emerging economies, but most of the strength is concentrated in the bilateral tie between the government and the industry. The next section discusses the advanced Asian economies of Taiwan, South Korea, Singapore and Japan, and provides a useful comparison to the emerging economies of Asia. In terms of the triple helix topology, I expect a marked contrast between the emerging and advanced Asian economies, with the advanced Asian economies likely to be in stage 3 or 4 of development and thus forging a much stronger trilateral connection.

3.4.5 Advanced Asian Economies: Taiwan

Since the 2000s, Taiwan is positioned at stage 4 of economic development, which yields a strong trilateral relationship. The high-tech electronics sector constitutes Taiwan's core manufacturing strength, with local firms such as TSMC, UMC, ACER, Compal Electronics and Hon Hai Precision Industries (Foxconn) attaining international brand recognition. The domestic value-added of Taiwan's electronics sector makes up the bulk of electronics gross exports, averaging 59.44% from 2000 to 2011, a stark contrast from the emerging economies discussed earlier.[21] Notably, SMEs dominate the Taiwan economy, with the majority of the workforce employed in SMEs (Chen, Lin and Chu (2013)). Interestingly, given that SMEs generally lack resources for R&D and incentives to innovate, how did Taiwan transform itself from an industrial to an innovation economy? The key to this puzzle is Taiwans longstanding practice of the developmental state model, in which the government actively promotes competitive manufacturing, exports and innovation through partnerships and nimble policies. Consequently, as Dent (2007) notes, Taiwan's SME sector is highly global, with successful shifts from original equipment manufacture (OEM) subservience to original design

[21] Data obtained and analyzed from the UNCTAD-EORA GVC database.

manufacture (ODM), and more recently to original design logistics (ODL) and global logistics (GL) in international supply chains.

Central to Taiwan's economic success is the government's efforts to generously create and support non-profit R&D organizations that act as inclusive hubs for innovation partnerships (Jan and Chen (2006)). The prime example is the Industrial Technology Research Institute (ITRI), which is "most visible and dynamic" amongst the organizations (Chen, Lin and Chu (2013), p.405). Founded in 1973 by Taiwan's Ministry of Economic Affairs (MOEA), the ITRI serves both as a public policy arm that promotes innovation, and as a R&D hub that has over the years successfully forged strong ties with the industry and universities, creating an extensive and complex network of technological partnerships (ibid). The ITRI has seen considerable results since the 1980s, with local spin-offs of the Taiwan Semiconductor Manufacturing Company (TSMC) and the United Microelectronics Corporation (UMC), which are both amongst the top three semiconductor foundries in the world. To note, the ITRI and other semi-government research institutions also create a conducive environment for SMEs to conduct research, by providing the infrastructure, direction and funding for R&D to thrive in local firms. As Hsu and Chiang (2001) and Chen, Lin and Chu (2013) note, ITRI has also collaborated and transferred technology know-how to SMEs, creating new business and upgrading opportunities. Moreover, through its training programs, ITRI is the main supplier of industrial leaders in Taiwan (Chen, Lin and Chu (2013)). In addition, ITRI has also engaged with universities for joint R&D collaboration (ibid). For example, one of Taiwan's most prestigious research universities, the National Tsing Hua University (NTHU) has a joint research center with ITRI focusing on nano-electronics and digital imaging. Moreover, as a technological research hub, ITRI acts as an intermediary and provides opportunities for both businesses and universities to work together (Chang and Shih (2004)). Overall, after more than four decades of experience, the ITRI is the governments main vehicle for innovation policy and has an extensive network of partnerships that is still expanding.

In conjunction with government-sponsored research institutes, strategic industrial clusters also provide a platform for innovation partnerships. Taiwan's high-tech clusters have been gaining momentum since the establishment of the highly successful Hsinchu Science-based Industrial Park (HSIP), home to Taiwan's largest firms such as ACER, TSMC and UMC. MNCs such as Logitech and Philips are also located in the park. Notably, Taiwan's industrial clusters welcome not only

businesses, but also research universities that value-add to overall cluster synergy (Chen, Lin and Chu (2013)). For example, Taiwan's prestigious National Chiao Tung University and National Tsing Hua University, both technical powerhouses, are all located within the HSIP. These two universities provide HSIP with talent for basic research, high quality human resource for information exchange on product innovation and diffusion of knowledge on recent scientific breakthroughs in the academic realm (ibid). In addition, specialized research institutes such as the National Synchrotron Radiation Research Center (NSSRC) and the National Center for High Performance Computing (NCHC) can also be found in the cluster. As Chen, Lin and Chu (2013) note, the resulting industrial cluster effect of HSIP helps to (1) generate rapid knowledge and technological diffusion, (2) provide greater attraction for foreign MNC investment due to talent agglomeration, (3) reduce cost due to the integration of upstream and downstream industries, and (4) facilitates the networking of personnel within the cluster, resulting in tighter connections between the government, industry and academy. Indeed, the resulting economic impact of a successful industrial cluster like the HSIP will be greater than the sum of its parts. Strong trilateral partnerships create a virtuous cycle that will further enhance innovation development.

The triple helix model is highly robust and evident in Taiwan's case. Under the direction of the Taiwan government, innovation frameworks geared towards forging strong trilateral relationships between the government, the industry and the academy have been developed and refined since the 1980s. As Taiwan continues on its high-tech knowledge-based economy, the triple helix framework is likely to evolve in complexity and intensity.

3.4.6 South Korea

As one of the most high-tech economies in the world, South Korea (henceforth known as "Korea") is not only engaged in intensive high-tech manufacturing, but also in product innovation (OECD (2009)). Korea thus has a stage 4 knowledge-based economy with a strong triple helix. Since the late 1990s and early 2000s, Korea has produced a number of prominent global lead firms such as Samsung, LG, SK, POSCO and Hyundai. Perhaps the most well-known is Samsung (Electronics), which is the world's largest electronics company.[22] In contrast to Taiwan, Korea's economy is dominated by large, highly diversified, family-owned companies called *chaebols*. Chaebols remain shielded

[22]Samsung is a large conglomerate consisting of several affiliate companies. The most notable one is Samsung electronics, followed by Samsung Heavy Industries, which is one of the world's largest shipbuilders.

by the government through subsidies and tax incentives, especially during Korea's industrialization phase in the 1980s and 90s, and arguably have the most resources for innovation development.[23] Nonetheless, SME innovation has gradually risen in importance, especially after the Asian Financial Crisis in 1997.[24] Regardless of whether it is the chaebols or SMEs, the Korean government, under its developmental state paradigm, plays a highly directive and important role to the country's innovation pathways.

State-business partnerships in innovation are well established in Korea. States often develop strong ties with the chaebol via public research institutes (PRIs). For instance, PRIs (along with universities and SMEs) are important innovation collaborators with Samsung (OECD (2009)). Moreover, R&D consortia organized by the government often consist of PRIs and private firms (ibid). Fruitful innovation outcomes have been achieved from these consortia. For example, the Electronics and Telecommunications Research Institute (ETRI)[25] has helped to develop state-of-the-art digital and semiconductor technologies, such as Mini-Super Computer (TiCOM) and High Density Semiconductor Microchips (DRAM), with private firms. In addition, government funded programs are usually cooperative in nature, requiring state-business or business-university partnerships (ibid). Moreover, free economic zones (FEZs) such as the Incheon and Daegu-Gyeongbuk FEZs consisting of private firms, PRIs and university research centers have also been set up to spur innovation partnerships (Dent (2007)).

The government has also actively encouraged research in universities through talent enhancement policies and PRI engagements. For example, Korea's Ministry of Education, Science and Technology (MEST) rolled out a plan[26] that invested over USD$750 million from 2008-13 to attract top science and technology overseas researchers to engage in scientific collaboration with Korean professors (OECD (2009)). PRIs and universities have also linked up to train graduate students. For instance, the Korean Institute of Science and Technology (KIST), a government research institute, has set up graduate programs with nine Korean universities, requiring participating students to be involved

[23]The Korean government has somewhat relaxed protectionist policies for chaebols, but is nonetheless still deeply intertwined with these corporations. For more information, see Dent (2007).

[24]The crisis exposed the bureaucratic weakness and inefficiencies of some of the chaebols, prompting a gradual shift away from chaebol reliance. However, this shift is largely ineffective due to enduring over dependency on chaebols as the main driver of the Korean economy.

[25]ETRI is a prominent government research institute in Korea.

[26]This plan is known as the World Class University program.

in KIST research projects as part of their curriculum (ibid). In addition, to further encourage collaborative research, the government created the University of Science and Technology (UST) that runs only as a graduate school, and is affiliated with 22 PRIs (ibid).

R&D collaboration between firms and universities are also significant. Business-financed R&D in Korean higher education institutes are amongst the highest in the OECD area, pointing to the strong industry-university innovation linkages (ibid). Moreover, since the early 1990s, the government has administered an array of measures to encourage industry-university collaboration. One notable policy is the Law on Fostering Industrial Education and Industry-University Cooperation that was implemented in 2003. By 2005, over 300 partnership offices have been established in the universities (ibid). In addition, the government has enacted a law that allows professors and researchers to run their own venture businesses in their university laboratories (under certain conditions), in order to promote greater spin-offs from universities and research institutes.

Overall, the government is the main actor in spearheading R&D in Korea. Similar to Taiwan, the triple helix model in Korea is strong and steadily improving. No doubt, the triple helix is critical to Koreas innovation economy, and the government is likely to continue channeling significant resources to improve this trilateral relationship.

3.4.7 Singapore

Since the late 1990s and early 2000s, Singapore has shifted its reliance away from MNC-led innovation to indigenous technology development, successfully transiting from a stage 3 high-tech manufacturing economy to a stage 4 creative economy that focused on research and development (Wong (2005)). With the establishment of the National Science and Technology Board (NSTB) and the implementation of two five-year National Technology Plans, the scope of public R&D, local high technology entrepreneurship, and basic research in the sciences were intensified (ibid). Technology development starting in 2000 emphasized biomedical sciences and stem cells research, shifting Singapore to the frontiers of innovation research.[27] Recent achievements in Singapore's biomedical sciences industry include a H1N1 flu vaccine (phase I clinical trial[28]), SARS easy detection kit,

[27]The strategic shift towards biomedical sciences also acts as a diversification of risks for the Singapore economy, away from its traditional reliance on the IT and electronics sector, which faces increasingly stiff competition from powerhouses such as Korea and Taiwan, as well as rising regional powers such as Malaysia and China.

[28]This phase includes testing to a small group of people to gauge the best dose required.

and multiple advances in regenerative medicine.[29] Behind the complex dynamics of the Singapore economy is the government, which is instrumental in identifying niche markets to focus on, as well as formulating strategic industrial policies. Notably, despite the top-down approach of policy formulation, a flexible and pragmatic approach guides the actual implementation of policies, in which earlier strategic plans can be replaced with new ones if opportunities and threats have changed drastically (OECD (2013*a*)). The triple helix model is highly developed in Singapore, with the government as the prime actor who actively creates linkages between the participants of innovation.

Government-industry linkages are strong in Singapore. The two key government agencies that chart the course of Singapore's economic development and are responsible for spurring entrepreneurship are the Economic Development Board (EDB) and the Standards, Productivity and Innovation Board (SPRING). For instance, in order to encourage high-tech entrepreneurship, EDB introduced a public co-investment scheme in 2001 to stimulate early-stage business angel investment (OECD (2013*a*)). In addition, a mega business park called One-North was created in the late 2000s[30], which is an innovation city within Singapore consisting of public research institutes, higher education centers, MNCs[31], local tech startups, intellectual property law firms as well as hotels, convention halls, and living quarters for research scientists (Wong (2011*b*)). Notably, the One-North park is composed of two highly specialized science hubs: (1) Biopolis, which houses biomedical-related institutes, and (2) Fusionopolis, which is an ICT hub that focuses on engineering.[32] To increase bureaucratic coordination and efficiency, government agencies such as EDB, SPRING, and the Media Development Authority (MDA) have also been relocated to One-North. Moreover, to further enhance research partnerships and knowledge sharing, the Agency for Science, Technology and Research (A*STAR)[33] has established a number of consortia such as the Singapore Bioimaging Consortium and the Singapore Stem Cell Consortium within One-North. Indeed, the government has invested considerable resources to foster cluster synergies among innovation actors.

[29]Due to the complex scientific names and processes, I have omitted the specificities. For additional writeup and information, see http://www.nrf.gov.sg/scientific-advances

[30]The first phase has been completed with additional phases under construction.

[31]Some notable examples include GlaxoSmithKline (GSK), Novartis, Abbott, Takeda and Lucasfilm.

[32]An upcoming media hub known as Mediapolis, which specializes in high-tech interactive media research, is currently under construction.

[33]Formerly National Science and Technology Board (NSTB).

Besides the involvement in research consortia and science parks, PRIs have also established themselves within universities for greater research collaboration. Supported by the National Research Foundation (NRF) and the Ministry of Education (MOE), PRIs such as the Cancer Science Institute of Singapore and the Center for Quantum Technologies are housed within the National University of Singapore (NUS), Singapores oldest and most prestigious research university. Other PRIs such as the Energy Research Institute and the Singapore Membrane Technology Center are located within the Nanyang Technological University (NTU).[34] Together, these PRIs leverage the talent pool within universities to conduct cutting-edge scientific research that can translate into industrial outcomes. The frequent networking between PRIs and universities also create more opportunities for knowledge diffusion and exchange of ideas across organizations, critical for high-tech research breakthroughs to occur.

Since 2000, Singaporean universities have increasingly emphasized the commercialization of technologies and collective R&D with private enterprises (OECD (2013*a*)). Wong, Ho and Singh (2007) also found that the most common partners of innovating firms in Singapore are universities and PRIs, which have become more important than other firms within the same industry as well as research-consulting firms. Furthermore, Singapore also ranks sixth on university-industry R&D collaboration in the 2010-11 Global Competitiveness Report (WEF (2011)). More specifically, in 2001, NUS has setup a new division called NUS Enterprise, which is the chief coordinating agency within the university to manage activities related to the commercialization of technologies and entrepreneurship. Active industrial partnerships and intellectual property advising are also supported via the division. Through NUS Enterprise and its Entrepreneurship Center, networks of entrepreneurs comprising researchers, students, venture capitalists and angel investors have been formed to provide spin-offs (Wong, Ho and Singh (2007)). Indeed, Wong, Ho and Singh (2007) note that NUS has shifted from the traditional university model to what Etzkowitz, Webster, Gebhardt and Terra (2000) termed as an "Entrepreneurship" university, which is critical in developing triple helix synergies.

Despite Singapore's fairly recent developments in high-tech entrepreneurship and basic research, it has managed to create a vibrant and dynamic knowledge-based society. The government's

[34]NTU is another research university in Singapore. Due to the small geographical size of Singapore, only NUS and NTU are research intensive and highly comprehensive universities. Other universities such as the Singapore Management University (SMU), Singapore University of Technology and Design (SUTD) and Singapore Institute of Technology (SIT) are all fairly young universities that are established post 2000.

aggressive and targeted policies to forge robust links between innovation actors, coupled with an influx of global talent, have resulted in a virtuous cycle within the triple helix that continues to perpetuate innovation and research advancement. Indeed, Singapore presents a highly successful case of multifaceted interactions between innovation actors.

3.4.8 Japan

Japan is the archetype of the developmental state and is the world's third largest economy that has a high-tech industrial and research base. Indeed, Japan is undoubtedly in stage 4 of economic development. Although Japan faced an agonizing lost decade[35], its high-tech development has remained at the frontiers of science. Japan is also among the leading OECD countries on R&D intensity (2.49% of GDP in 2010) and business R&D (77% of GERD[36]) (OECD (2008)). With regards to economic competitiveness, Japan ranks sixth in 2011, second only to Singapore in the Asian region (WEF (2011)). Similar to many Asian economies, Japan has traditionally focused on the electronics and automotive industries as strategic sectors of development, giving rise to several prominent MNCs such as Sony, Mitsubishi, Olympus, Toyota, Honda and Nissan, to name a few. The great success of Japanese firms have led other developing Asian economies to rely on Japanese MNCs for technological learning and diffusion.[37] Since 2001, under the Second Science and Technology Basic Plan (2001-2005)[38], the Japanese government has encouraged the rapid advancement of new areas of technology, such as environmental sciences, life sciences, IT, and nanotechnology (Eddington (2008)). Importantly, while innovation has been largely confined to the large Japanese conglomerates known as the *keiretsu* companies, more collaborative triple helix type of research partnerships have been created since the 2000s (Hosono and Nakayama (2012) and Eddington (2008)). Similar to the other advanced developmental states, Japan's innovation policies are still largely top-down in nature, with government agencies playing the most assertive role in forging strong trilateral partnerships.

Industrial clusters form the backbone of Japan's triple helix model. Cluster initiatives are usually top-down, highly institutionalized, and launched by the Ministry of Economy, Trade and Industry

[35] Some scholars have argued that Japan faced two lost decades from 1990-2000, and 2000-10.

[36] Gross domestic expenditure on R&D. Figure is based on OECD report for 2010.

[37] This is seen earlier on in the case of Thailand's automotive sector, but other countries such as Indonesia and Malaysia also rely on Japanese firms. Even the current developed economies of South Korea, Taiwan and Singapore have depended on Japanese technological diffusion.

[38] The Third Science and Technology Basic Plan (2006-2010) also focuses on high-tech innovation in the same sectors.

(METI), and the Ministry of Education, Culture, Sports and Science and Technology (Eddington (2008)). As discussed, industrial clusters provide a conducive environment and platform for private firms, research institutes and universities to pool resources and share information. Beginning in 2001, METI launched a comprehensive Industrial Clusters Program designed to upgrade existing clusters and help local SMEs to gain more product development support and intellectual property protection via networks of collaboration (ibid). One prominent offshoot is the Hokkaido Super Cluster Promotion Project, which began in 2001. By 2005, Hokkaido had a massive collaborative network comprising 96 companies, 21 universities and public research institutes, 2 local government organizations, and 82 financial institutions.[39] Indeed, multiple actors spanning government agencies, universities and firms collaborate in the ambitious super-cluster project, unprecedented in the rest of Asia.

In addition, while METI focused on the industry and downstream commercialization, MEXT emphasized on universities, public research institutes, and upstream R&D (ibid). Under the Knowledge Cluster Initiative, MEXT encouraged tighter industry-university-government linkages and also pushed for the joint development of new technologies (ibid). Under the directions of MEXT, over 16 knowledge clusters were formed all over Japan, specializing in high-tech industries in-lieu with the governments Second and Third Science and Technology Basic Plan (ibid). Indeed, Japan's industrial cluster planning showed the government's high degree of organization, experience and discipline in forging government-industry-university relations.

Besides industrial clusters, government law reforms also helped to spur innovation partnerships between the university and the industry. For example, the Japanese Technology Licensing Organization (TLO) Act in 1998 promoted technology transfers from universities to private firms via TLOs, which obtains patents for university research and licenses out to private firms, acting as intermediary between the academy and the industry. In addition, the Japanese Bayh-Dole Act (inspired by the American model) helped to entrust patent rights from public research funds to trustees (Hosono and Nakayama (2012)). The corporatization of Japanese national universities in 2004 also facilitated university-industry technology transfers when these universities started to run

[39] Sub-networks of similar and specialized groups of actors are likely to be found. For more information on the Hokkaido Super Cluster Promotion Project, see METI's website: http://www.hkd.meti.go.jp/hokii/s_cluster_e/

their own TLOs (ibid). Thus, entrepreneurship-oriented reforms beginning in the late 1990s have paved way for the deepening of relations in the Japanese triple helix.

Like the other advanced Asian economies, Japan not only has a high-tech manufacturing base, but also strong triple helix connections. The highly institutionalized and elaborate triple helix programs point to the resolve of the Japanese government in sustaining and nurturing an innovation economy for the future. Given the scope and depth of the Japanese government's industrial cluster policies and national science and technology five-year plans, Japan's triple helix programs are undoubtedly the most comprehensive among all the Asian developmental states.

3.5 Analysis and Discussion

Table 3.1 below summarizes the findings for the case studies. In general, the case studies provide support for my assertion that as Asian developmental states move higher up the value chain, they will engage in more intensive partnerships with businesses in order to spur innovation. In addition, states that are very high up the GVC will move away from a simple bilateral government-industry relationship to a complex triple helix connection involving the government, the industry and the academy. Overall, while the case studies do not provide a perfect fit to my theory on GVC position and corresponding triple helix configuration, no stark anomalies exist either.

Table 3.1: Summary of Findings from Case Studies

Country	Stage of Economic Development	GVC Position (Independent Variable)	Triple Helix Configuration (Dependent Variable)
Indonesia	1	Low	Weak Triad
Philippines	Transitioning from 1 to 2	Lower-Middle	Weak Triad
Thailand	Transitioning from 1 to 2	Lower-Middle	Weak Triad
Malaysia	2	Middle	Edge (bilateral G-I)*
Taiwan	4	Very High	Strong Triad
South Korea	4	Very High	Strong Triad
Singapore	4	Very High	Strong Triad
Japan	4	Very High	Strong Triad

**G-I* refers to strong partnerships between the government and the industry. See Figure 3.1(ii).

Confirming my earlier expectations, Indonesia, Philippines and Thailand all have weak trilateral linkages, though Philippines and Thailand are positioned slightly higher than Indonesia on the GVC. From table 3.1, Thailand and Philippines are already transitioning from low-tech manufacturing to medium-tech manufacturing, resulting in a 'lower-middle' position in the GVC, but due to their embryonic institutional frameworks and the lack of innovation demand, both bilateral and trilateral relationships remain weak. Moreover, given widespread corruption and the lack of institutional transparency, these states face considerable hurdles in establishing innovation partnerships.

Malaysia performed the best among the emerging Asian economies and serves as the intermediate case in my analysis. To add, Malaysia is in an industrial transitional phase (stage 2) of medium-tech manufacturing, which often requires collaboration between MNCs and local firms for some technological diffusion to occur. As such, the Malaysian government establishes industrial clusters and forge strong ties between government-linked corporations, local firms and MNCs. A robust bilateral government-industry relationship is thus formed. However, given that the economy is still medium-tech and the demand of skilled labor is not high (albeit increasing), the government may not have the sense of urgency to establish strong relations with the university. Most resources are still targeted at government-industry relations. Indeed, even though government-university relations may improve, the relationship is likely to be in the nascent stages and remain weak. Similarly, due to the lack of demand for skilled labor, the government is less inclined to tie the industry together with universities. Consequently, as supported by the case of Malaysia, countries in stage 2 of economic development will only have strong state-business relations.

The advanced Asian economies of Japan, South Korea, Singapore and Taiwan, which are positioned very high up on the GVC all exhibit robust trilateral relations. This is consistent with what was theorized earlier. Indeed, countries that have very high GVC positions are advanced economies (stage 4) with both high-tech manufacturing and strong research and development demands. These countries require constant product and process innovation in order to stay ahead of the curve. In other words, countries at the apex of GVCs cannot merely be followers of technology – they must innovate aggressively to continue growing and thriving. In addition, these countries face stiff global competition from other advanced economies that may have a broader talent pool and more established infrastructure. Moreover, as Wong (2011*a*) notes, countries which engage in high-end innovation research such as biotechnology, nanotechnology, and robotics will need to manage high degrees of

information uncertainty that may lead to innovation failure. Consequently, bilateral government-industry and government-university innovation partnerships are not sufficient. The government needs to step in to forge strong trilateral partnerships in order to reap greater synergistic effects that drive knowledge and technological diffusion that in turn also helps to minimize uncertainty. A robust triple helix would no doubt be required to sustain economic development for advanced Asian economies. The high demand for innovation will drive these developmental states to forge or maintain a strong trilateral relationship.

While the advanced Asian economies showed similar results, the emerging markets had greater heterogeneity in their triple helix configurations. The case study analysis has managed to reveal substantively why and how each case is the same or different from another, providing a richer context to innovation partnership formation in Asian developmental states. Importantly, while I have shown how innovation partnerships have evolved when a state moves up the GVC, I have yet to fully explore evolutions beyond the strong triple helix model. That is, would a statist triple helix model that is controlled by the government evolve to become a balanced model with all three actors on equal footing? Would that be possible for the case of the Asian developmental state? My empirics do not suggest this, but the time frame is too short to tell. An important implication is that if the ultimate configuration is the balanced model, then would structural conditions finally render the developmental state redundant past a certain stage of innovation? While this question is related to my study of developmental states within the triple helix framework, it is beyond the scope of this paper.

3.6 Conclusion

This paper analyzes the evolution of state-business-university partnerships in Asian developmental states and provides some insights on what needs to be done in order for innovation to progress. Indeed, the process of innovation is not confined within the industry. The government and the academy also play critical roles. While a dynamic private sector alone may spur innovation, having a robust trilateral government-industry-university relation is likely to result in virtuous cycles and greater synergies. Developing economies that reach middle-income status may want to invest more in their universities and encourage entrepreneurship among researchers under the auspices of the government. Only through a persistent and sustained joint effort among the actors involved can the economy realize its full potential.

Future research may wish to investigate the evolution of the triple helix via social network analysis (SNA). The triple helix presents a challenging but interesting model for SNA research: (1) current SNA methods, especially statistical SNA such as the exponential random graph model and the latent space model have not been calibrated to compute complex tripartite networks, and (2) data for tripartite networks is severely lacking due to the complexity of relations both within a single slice of network and between interlocking slices of networks. However, to fully understand the dynamics of the triple helix and the critical factors that sustain it, we will ultimately need to unpack and investigate the multidimensional relations between actors and between sets of actors that constitute the triple helix.

4 THE GREAT TRADE COLLAPSE: SHOCK AMPLIFIERS AND ABSORBERS

4.1 Introduction

Trade volumes all over the world experienced an unprecedented, sudden and synchronized drop immediately following the global financial crisis of 2008. The drop in world trade was so severe that it was faster than that observed during the Great Depression (Eichengreen and O'Rourke (2009)). Moreover, the World Trade Organization (WTO) reported that the majority of countries in the world experienced a drop in their exports and imports during the second half of 2008 (Baldwin (2009)). Scholars have posited a number of factors attributing to the world trade collapse, from the global credit crunch to fear and panic to trade protectionism, but perhaps the most significant factor that is increasingly gaining attention is the emergence of global supply chains. As Barry Eichengreen notes, "the most important factor [of the world trade collapse] is probably the growth of global supply chains, which has magnified the impact of declining final demand on trade" (International-Economy (2009)). In addition, Bems, Johnson and Yi (2009) assert that the "international supply chains are a leading contender for explaining why the great collapse was so great". Global supply chains matter due to their complex production structures, with linkages that extend worldwide, making countries much more interdependent than before.

Global production has undergone a radical evolution during the past few decades. Advances in information and communications technology (ICT) coupled with WTO's push for low trade barriers have contributed to the emergence of fragmented production processes (or value chains) in world trade, where production is no longer concentrated in one country but broken up and dispersed globally. Moreover, the reorganization and dispersion of production processes imply that each production task is now situated in the location with the highest comparative advantage (OECD (2013*b*)).

With production processes sub-divided into several stages across the world, many countries became involved in production networks that each uses several intermediate inputs to produce a final good to consumers. Moreover, Pitigala (2009) notes that emerging economies benefit considerably from the development of GVCs, since these economies can participate in them easily and reap the

gains of world trade. However, joining GVCs also expose these emerging economies to the risks of economic shocks as economies (both emerging and advanced) become highly interdependent.

This study seeks to understand the mechanism of shock propagation through global production networks. In particular, I examine the TV and communication equipment value chain (from 1996 to 2013), which is highly fragmented and dispersed internationally. I explore how shock propagation is uneven throughout the value chain and discuss the implications. I argue that while the bullwhip effect and complex network interdependencies magnify economic shocks throughout the supply chain, with trade in intermediate goods being hurt more than trade in final goods, domestic political forces and strong state capacity help to mitigate these shocks. In particular, the developmental state, a highly interventionist state that actively promotes industrial policies and economic strategy, is significant in countering the effects of an economic crisis. This paper investigates the effects of economic shock propagation from both economic and political viewpoints. Moreover, I further extend my earlier discussion on the developmental state to explore how these states are important in times of economic crisis.

4.2 Economic Shock Amplifiers: Complex Interdependencies and the Bullwhip

International trade, which is the exchange of goods and services across borders, necessarily entails connecting different countries in the world together in a complex network of economic relations[1]. With increased liberalization of cross border transactions and the proliferation of supply chains since the 1990s, countries are rapidly being embedded in global production networks. As such, trade can no longer be viewed as merely bilateral, that is, trade between two countries is also affected by other countries in the region and beyond. For instance, bilateral trade of TV and communication goods between the US and China is likely to be dependent on bilateral trade between China and Japan, as all three countries are involved in the same supply chain, albeit in different stages. The US is likely to be the consumer country in this case[2], while China is the country that assembles the final good with intermediate products imported from Japan. Consequently, due to interdependencies inherent in the world trade network, the transmission paths and feedback effects of an economic

[1]Of course, social (e.g. cultural exchanges) and political relations (e.g. diplomatic ties) may also result from trade connections. But we focus on economic relations to make the analysis manageable.

[2]Or it could also be an innovator, depending on which specific product we are looking at within the TV and communication industry.

crisis are often complex. Understanding the types of network connections and the topology of the world trade network may shed more light on the propagation of economic crises.

The study of contagion effects via complex interdependencies is most prominent in the public health scholarship, where researchers investigate the origins, patterns and consequences of disease spread using social network analysis. Lessons drawn from the public health literature can sometimes be applicable to our study of crisis propagation in economic networks. For instance, the heterogeneity of degree distributions, which refer to the varying strength of connectedness among actors in the network, as well as cluster coefficients, which measure the degree to which actors in the network tend to cluster together, often point to the extent in which a disease can spread within the health-related network, and can be applicable to economic networks as well.[3] Indeed, a trade network that has many tightly connected actors, as characterized by multiple or dense trade links among countries, is likely to transmit economic shocks very quickly. Moreover, with the rise of tight regional production networks that are linked to global ones, a crisis that occurs in the region might spread more quickly within the cluster before spreading to other parts of the global network. In some cases, however, depending on the patterns of connections and network topology, a crisis that occurs in a cluster might not even spillover to become a global crisis (Oatley, Winecoff, Pennock and Danzman (2013)). For instance, while the Asian Financial Crisis of 1997-98 had devastating impact on Southeast Asia, and to some extent Northeast Asia, financial contagion was largely limited to the Asian countries as strong clustering exists among them but they remain as semi-peripheral countries in the international financial system (ibid). On the other hand, the US subprime crisis of 2007-08 had a devastating effect on the vast majority of countries in the world, given that the US is the global finance hub.

How then might the world trade network perform differently from the global financial network? A stark distinction is the presence of tight linkages that bind different regional clusters in the world together due to the rise of global supply chains. In other words, a tightly clustered region (for example, the phenomenon of 'factory Asia'[4]) is also likely to be strongly connected to other regions in the world. Consequently, shocks that occur in one regional cluster is likely to propagate throughout the network, though the strength of shock propagation is uneven. Importantly, uneven shock propagation does not mean that the economic shock will attenuate as it gets further from the center of the crisis –

[3] See May and Lloyd (2001), Moreno, Pastor-Satorras and Vespignani (2002), and Watts and Strogatz (1998)

[4] 'Factory Asia' is a name given to describe the complex web of regional supply chains in Southeast and Northeast Asia.

much depends on the country's position in the supply chain.[5] Moreover, due to the tightly connected nature of clusters and complex interdependencies, a country that is recovering from an economic crisis might still be highly susceptible due to contagion from its neighbors in the network.

Overall, the world trade network is likely to be densely connected and contain multiple connected clusters that are highly susceptible to crisis contagion. In social network theory, graph density, which is the ratio of the number of connections in the network to the maximum number of possible connections, serves as a good predictor for shock propagation. Moreover, networks with multiple tightly clustered or triadic relationships are likely to have economic shocks being circulated within the cluster, making recovery from a crisis more difficult.[6] I thus develop the following hypothesis:

Hypothesis 1: The denser and more clustered[7] the trade network, the greater the likelihood of crisis contagion.[8]

4.2.1 The Bullwhip Effect: A Complexity Analysis of Economic Shock Propagation

While complex interdependencies in supply chains help to explain the spread of economic shocks, the concept of interdependence alone does not fully explain the complex and unpredictable impact of these shocks across the whole supply chain. Notably, as Zavacka (2012) notes, exporters of intermediate goods were hurt much more than exporters of final goods during the recent trade collapse, independent of network ties. Why is this so? Apart from network connections, what accounts for uneven shock propagation in the supply chain? Studies have often failed to differentiate the types of goods involved in international trade and assumes all trade is trade in final products for consumption in the recipient country (ibid). However, with greater fragmentation of world trade, this assumption is increasingly erroneous as the intermediate trade network performs very differently from the trade network in final products during an economic crisis.

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[5] In some cases, shocks can even get magnified further away from the crisis epicenter. This phenomenon relates to the bullwhip effect, which will be described in the next section.

[6] Other types of configurations such as *k*-cycles can also serve as a proxy to model network clusters, but in general, a triad serves as the simplest form of cluster relations in the network and can be used to generalize other types of clusters. Notably, a 3-cycle is a triad. The closed triad is often used in the calculation of clustering coefficients (see Lusher, Koskinen and Robins (2014)).

[7] Network density and clustering are somewhat related. A very dense network is likely to have many clusters. However, a sparse network is less dense, but multiple local clusters may still exist. In general, density relates more to network connections, while clusters (or clustering triads) reflect more of network topology. This hypothesis is thus contingent on 2 conditions (1) density and (2) clustering of a network. Twining these two conditions together will allow more feasible testing of this hypothesis as the actual networks that are dense are also highly clustered, while sparser networks are less clustered, according to my data on TV and communication GVC. More will be explained in the later sections.

[8] Trade network here refers to either trade in intermediate or final goods. This paper will explore both types of goods.

One major mechanism that is useful in analyzing shock propagation is the 'bullwhip effect' (Altomonte, Di Mauro, Ottaviano, Rungi and Vicard (2012), and Zavacka (2012)).[9] The bullwhip effect refers to "the magnification of the initial (negative) demand shock along the supply chain due to an adjustment of production and stocks [or inventories] to the new expected levels of output" (Altomonte et al. (2012)). In the case of the recent financial crisis, the negative demand shock is the result of the credit crunch and low business (and consumer) sentiments. Consequently, firms needed to tone down their output as well as clear their existing inventories. Moreover, the clearing of existing inventories by firms downstream (final goods) caused firms upstream (intermediate goods) to face an even larger reduction in demand. As such, demand distortions ripple and amplify throughout the supply chain, hitting producers that are further upstream the hardest.

In addition, due to the high degree of uncertainty in an economic crisis and the lack of communication between upstream and downstream suppliers, upstream suppliers often need to cut their production more rapidly than if they had more information, in order to protect themselves from excess capacity. As a result, trade in intermediate goods will fall more rapidly than trade in final products. As Cachon and Terwiesch (2011) note, the bullwhip effect increases volatility in supply chains and may lead to product shortages, low utilization of capacity, and/or poor quality of goods as a result of hasty production when the upstream producer discovers that demand is not actually that low. To make things worse, the bullwhip effect creates a vicious feedback cycle that indirectly affects downstream producers as well, which must "cope with less reliable replenishments from upstream stages" (ibid). Consequently, the bullwhip effect explains the complex dynamics between the intermediate and final trade networks during an economic crisis.

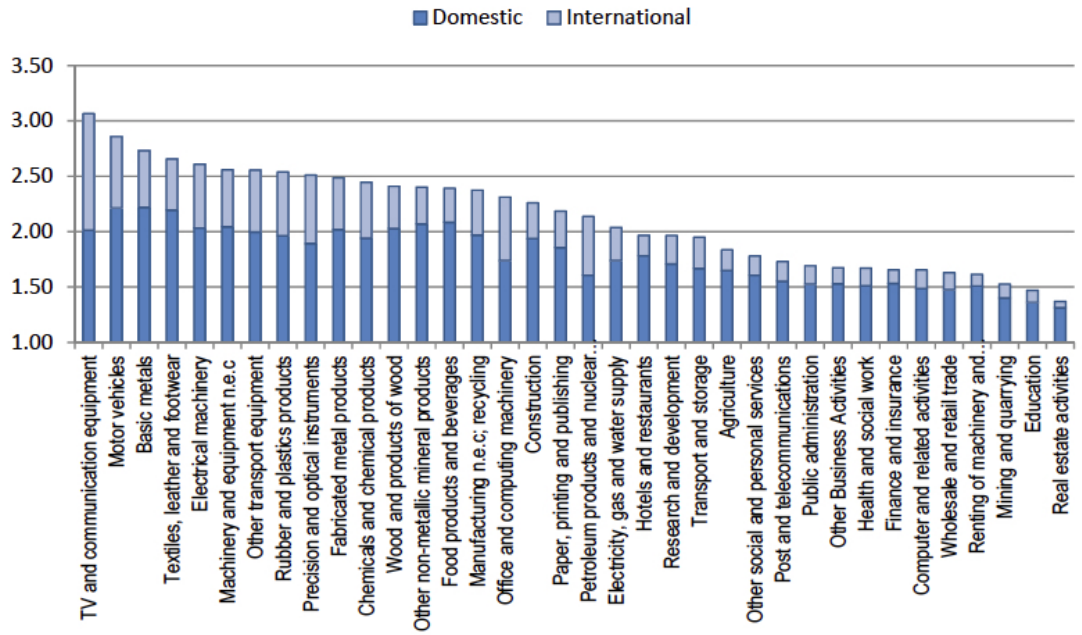
4.2.2 Variations in the Length of GVCs

Not all production networks are fragmented and dispersed in the same way. For instance, an agricultural GVC is likely to be concentrated domestically while an electronics GVC would be more dispersed internationally due to the many product parts involved. Consequently, the length of GVCs may determine the amount of shock amplification in the supply chain due to the bullwhip effect: longer GVCs should be more susceptible to the harmful effects of the bullwhip as more stages and actors are involved. Indeed, the existing literature reveals strong bullwhip effects in the automobile

[9] Also see Escaith and Gonguet (2009), Escaith, Lindenburg and Miroudot (2010), Ma and Van Assche (2011), Lee, Padmanabhan and Wang (1997), and Cachon, Randall and Schmidt (2007).

and retail industries, which have long chains (Chen and Lee (2012)). Figure 4.1 below shows the length of GVCs for various industries in 2008.

Figure 4.1: GVC Length Variation in 2008 (adopted from OECD (2012))



From the graph, we see that the TV and communication equipment industry has the longest GVC length. In addition, this industry is also the most dispersed internationally. In general, the manufacturing industries have longer value chains compared to the service industries (for example, education, health and social, and finance and social insurance industries). Moreover, service industries are also more concentrated domestically. Indeed, the service industry serves to provide support for consumers (for example after-sales service and healthcare service) and thus needs to be predominantly domestic and less fragmented to ensure smooth support functions.

In order to more fully investigate the bullwhip effect, I base this paper on the TV and communication equipment industry as it has the most fragmented and dispersed value chain. Indeed, substantial sectoral and regional variation exist in GVCs. Not controlling for these variations may lead to erroneous findings. I thus develop my second hypothesis:

Hypothesis 2: Following an economic crisis, exports in intermediate goods (upstream) will decrease more than exports in final goods (downstream) in the TV and communication equipment

industry. In other words, an economic shock will have more impact on intermediate goods than final goods.

The above hypothesis has serious implications for economic development in emerging economies that are engaged in the TV and communication equipment industry. Emerging economies join GVCs because they are easy to join, but when crisis strikes, emerging economies will also be hard hit due to the bullwhip effect. Indeed, Inomata (2011) notes that emerging Asian countries that engage heavily in the production of intermediate electronics goods were severely affected when American and European consumers cut down on demand during the recent financial crisis.

4.3 Shock Absorbers: State Capacity and the Developmental State

The global financial crisis of 2007-08 has led some scholars to question the taboo of state intervention in economics, and to argue that the state is actually a prominent actor in mitigating crises.[10] In addition, even the OECD, a pro-market intergovernmental organization, has published a report urging governments to take a more active role in industrial restructuring and policy making after the crisis (OECD (2009)). Indeed, when severe market distortions exist and the invisible hand fails to deliver, the state must step in to reduce the risks of market collapse in their respective economies. States can thus act as shock absorbers that mitigate the risks of a crisis through an array of policy measures. In general, while particular policy instruments differ from state to state, governments that are transparent and bureaucratically efficient are likely to perform better during a crisis as urgent policies would not be hindered too much by organizational and political forces. The ability of governments to respond quickly to devise and implement both short and long term policies is critical to manage crises as they unfold (UNDP (2011)). Three general state capacity variables are discussed: (1) government effectiveness in the civil service, (2) regulatory regime, and (3) transparency and accountability.[11]

A country's civil service is perhaps the most important institution that is mobilized during a crisis (ibid). In times of crisis, the civil service helps to set up task forces that engage in monitoring and evaluation to inform policy making and economic strategy. Moreover, the effectiveness of a country's policy coordination, public finance management. budget planning and execution as well as the delivery of public goods all depend on its civil service (ibid). When resources dwindle during

[10] See for instance Cimoli, Dosi and Stiglitz (2009).

[11] I will extend and carry on this discussion to talk about the developmental states in the section below.

an economic crisis, the effectiveness of policy management and coordination becomes even more salient. Indeed, a strong and robust civil service is critical to not only prevent wastage of a country's economic resources, but also ensures that a country recovers as quickly as possible from a crisis. Citing examples of Mauritius and United Republic of Tanzania, a report from the UNDP notes that countries that have well institutionalized mechanisms for policy development are able to cope better during the recent economic crisis (ibid). On the other hand, the lack of a coherent, predictable and functioning bureaucracy will be detrimental to a country's ability to respond to crises (Evans (2010)).

Besides bureaucratic effectiveness, a country's regulatory regime is also important to dampen the effects of external economic shocks. Negative demand shocks and the bullwhip effect during a crisis might dampen business sentiments and industrial production. However, robust regulatory regimes that are active in promoting private sector development can help to increase business activity, offsetting to a certain extent the effects of an economic crisis. Furthermore, highly institutionalized regulatory frameworks help to instill a sense of confidence in the country's economy, which may in turn attract investors that are pulling out of other countries.

Transparency and accountability may also help to mitigate a crisis. Both of these factors help to heighten a sense of public confidence (which may be low during a crisis) in the government's management of the country. Businesses operating under transparent and accountable countries may have higher business sentiment and greater trust in the system. Conversely, corrupt regimes often perform poorly during a crisis as the government's coffer dries up. With the discussion on state capacity, I thus develop the following hypotheses:

Hypotheses 3a-c: The greater the (a) government's effectiveness in its civil service, (b) institutionalization of regulatory regime, or (c) transparency within the government, the stronger the mitigation of economic shocks during an economic crisis.

4.3.1 The Developmental State and Crisis Mitigation

Extending the discussion above, developmental states are a unique breed of countries that have high state capacity. More precisely, developmental states are highly interventionist states that engage in industrial policy for economic growth. As Evans (1995) notes, developmental states have both strong state capacity and the political will to carry out reforms. Consequently, during an economic crisis, developmental states not only have the institutional framework and capacity to counteract the pressures of economic shocks, but also the political will to carry out painful reforms if necessary.

Meyns and Musamba (2010) identify three defining features of the developmental state that are critical to economic crisis management: (1) an autonomous and effective bureaucracy, (2) competitive and production-oriented private sector, and (3) development-oriented political leadership. As discussed above, an effective and efficient bureaucracy is important to help the country tide over a crisis. Developmental states boasts outstanding bureaucracies, with rigorous standards of civil service entry that select some of the best talent available in the country (Onis (1991)). Moreover, developmental states exhibit a rare form of administrative management that is highly focused on economic growth. Bureaucrats not only create highly institutionalized economic frameworks and regulatory regimes, they are also active in forging state-business partnerships. As Meyns and Musamba (2010) note, "decision-makers and technocrats were able to effectively formulate economic policy, forge business alliances and direct state interventions in the economy" (p.23, also see Nissanke and Aryeetey (2003) and Pempel (1999)). Moreover, in times of crisis, state-business partnerships may help to provide bureaucrats with necessary information in the private sector, making economic reforms and restructuring more relevant, and increasing the chances of crisis recovery.

Although the private sector is closely tied to the bureaucracy, businesses are frequently held up to stringent performance standards. For instance, Wade (1990) and Amsden (1989) note that the state was "not only able to secure the survival and ability of the private sector to compete at any level, but, more crucially, was able to "create" and "reward" in addition to "picking" good performers, as well as "punishing" bad ones".[12] Firms within developmental states need to perform well or they risk having their subsidies or other incentives revoked by the government. The exposure to tough standards and the global market forces firms to develop highly organized and systematic structures that may help to counter economic crises.

Apart from having a robust state capacity, developmental states have a political leadership that is heavily focused on economic growth. Indeed, the political will of developmental states should make crisis management more efficient, all other things held constant. The willingness to reform and restructure the economy for developmental outcomes or long term stability will make the country more resilient to economic crises. Moreover, having a strong political will to carry out painful but necessary reforms may help a country recover from a crisis more quickly.

[12]Cited in Meyns and Musamba (2010)

Hypothesis 4: A developmental state is more likely to mitigate the effects of an economic crisis compared to a non-developmental one, all other things held constant.

4.4 Data

As discussed in earlier sections, I will conduct my empirical analysis on the TV and communication equipment GVC from 1996 to 2013, considering exports of both intermediate and final goods. Data is drawn from the OECD Structural Analysis (STAN) Bilateral Trade Database (ISIC Rev. 3). In addition, the three state capacity variables[13] (1) government effectiveness in civil service, (2) regulatory quality, and (3) transparency are obtained from the World Bank's World Governance Indicators. The developmental state binary variable is constructed similar to paper 1, with '1' signifying that the exporter is a developmental state and '0' otherwise.[14] In addition, I explore three economic crises in my dataset: (1) Asian Financial Crisis 1997, (2) Dotcom bubble 2000, and (3) US subprime crisis 2007-08. The crisis variable is constructed as a binary variable with '1' indicating a crisis occurred during that year and '0' otherwise. Altogether, the dataset contains 59,508 observations.[15]

Two main statistical network models[16] are run to assess the importance of economic crises on exports in intermediate and final goods respectively.[17] State capacity and developmental state variables will be also interacted with the crisis variable to test whether or not (and to what extent) these variables mitigate an economic crisis. The main dependent variables are (1) intermediate trade exports, and (2) final trade exports, while the main independent variables are *Crisis*, (*Gov*[18] *x Crisis*), (*Regulatory Quality x Crisis*), (*Transparency x Crisis*), and (*Developmental State x Crisis*).

Control variables used in this study include *GDP*, *Trade openness*, *Democracy Dyad* and *Lagged Export*. *GDP* measures the market size of a country, and data are obtained from the World Bank. *Trade openness* is measured as a country's total gross trade divided by its GDP and the data is also

[13] As a note, the state capacity variables are in the range -2.5 to 2.5, with 2.5 indicating the highest level of state capacity. For the purposes of network analysis and tie connection, I add each of the state capacity variable to the absolute of the minimum value of each variable, making the minimum value non-negative across the variables.

[14] Consistent with paper 1, the developmental states are Japan, South Korea, Singapore, Taiwan, Malaysia, Thailand, Philippines, Vietnam and Indonesia.

[15] This is across 18 years (1996 to 2013) for 58 countries.

[16] More will be explained in the methods section below. Also, note that the networks are directed as the main dependent variables are exports.

[17] This is to gauge for the bullwhip effect. That is, I expect to see the crisis variable to be more salient in the intermediate goods model compared to the final goods model.

[18] Refers to government effectiveness in civil service.

from the World Bank. *Democracy Dyad* is the polity IV score of the dyad. *Lagged Export* is the export (intermediate or final export, depending on the model) lagged by one year.

4.5 Methods

Due to the computational complexity in this paper, I use two types of quantitative methods to assess my claims: (1) Agent-based Model (ABM), and (2) Temporal Exponential Random Graph Model (TERGM). These two models represent the most current technology in assessing complex network effects and dynamics. Below I give a brief description of each model:

4.5.1 Agent-based Model

Agent-based modeling is a class of computational modeling method that can simulate complex interactions and network effects described in hypothesis 1. Importantly, ABM can account for feedback effects that are not captured in statistical analysis. In addition, ABM allows agents to interact in non-linear ways and is useful to explore emergent behaviors, which are properties of the system that can only be understood by viewing the system as a whole and cannot be gleaned just by looking at individual components or parts. Overall, ABM provides a dynamic modeling platform for my exploration of trade network complexity. I use the Netlogo program, developed by Uri Wilensky, for my ABM simulations. Results are reported and discussed in the later sections.

4.5.2 Temporal Exponential Random Graph Model

The TERGM is the temporal extension of the Exponential Random Graph Model, which is an advanced statistical method that analyzes social network data. The TERGM allows me to obtain statistical results from the data while controlling for complex interdependencies and accounting for endogenous network structures such as triadic closures, in/out-2-star and mixed-2-star effects.[19] As Cranmer, Desmarais and Menninga (2012) note, not accounting for endogenous network statistics may lead to the problem of omitted variable bias, which can render our statistical results unreliable.

[19] An "in-2-star" effect refers to two nodes having directed connections to the same third node, but those two nodes are not connected to one another. Substantively, this means that two countries are exporters to a popular third country (popularity effects) but the two countries do not trade among themselves. An "out-2-star" refers to a country that exports extensively to other countries, engaging in a lot of export activities, but those countries that it exports to do not trade with each other. A mixed-2-star is a directed path of length 2 from node i to k via j. Also, the triadic closure here refers to a transitive triple, which is made up of a out-2-star with a directed tie established among the two originally unconnected nodes. A transitive triple can indicate clustering in the network.

4.5.3 Thresholding and Creating the Dependent Variable

While the TERGM is a powerful statistical network method, it is limited by its binary dependent variable input.[20] Thus, in order to use the TERGM, I need to transform my dependent variables into binary forms. In order to convert the weighted dependent variables to a binary ones, we need to first assign a threshold or cut-point. Subsequently, any export volume that has a value at or more than the threshold will be assigned '1', and those values below the threshold will be assigned '0'. As Cranmer and Desmarais (2011) note, the cut-point is quite arbitrary, with different scholars adopting different criteria. However, percentage thresholds, due to their flexibility, are likely to be more accurate compared to absolute ones. Fortunately for the case of trade networks, econo-physicists[21] have recommended three distinct thresholds: 0%, 1%, and 2%. Notably, a 0% threshold just indicates the mere existence of trade among two countries and hence it is the least restrictive threshold that is not usually the best. Moreover, a 0% threshold would mean that an export of 1 million dollars becomes equivalent to an export of 10 dollars, since both would now constitute a tie of value '1' in the network.

In order to thin my network more and to ensure that only substantial ties are counted, I use a 2% threshold. To add, Kali and Reyes (2010) note that the 1 or 2% thresholds "are close to embodying meaningful or representative trade" (p.1085). I thus select the higher threshold for greater robustness.[22] Figures A.1 and A.2 in the appendix show the intermediate and final network visualization corresponding to the different thresholds (1% and 2%) as well as the respective degree distributions of actors in the network; figures A.3 and A.4 shows an enlarged version of the intermediate and final trade networks at 2% threshold in 2013[23]:

Formally, letting y_{ijt} to represent my outcome variable (intermediate or final exports), I have:

$$y_{ijt} = \begin{cases} 1 & \text{if exports, } E_{ijt} \geq 2\% \text{ of total exports of the exporter in a given year } t \\ 0 & \text{otherwise} \end{cases}$$

[20] Software development of a valued-edge ERGM or GERGM (Generalized Exponential Random Graph Model) is underway. Another method that can model valued edges is the Latent Space Model, but this model is limited to cross-sectional analysis and does not allow users to model time-series data.

[21] Econo-physicists are interdisciplinary scholars who apply methods in physics to the study of economic phenomena.

[22] To ensure greater validity of results, I conduct tests using 1% and 2% thresholds and found that the results were largely similar.

[23] This is just a sample year for the illustration of thresholding effects.

4.6 TERGM Results and Analysis

Six separate models were run. Models 1 and 2 are the TERGM intermediate export models based on the 2% and 1% thresholds respectively, while models 3 and 4 are the corresponding models in the export of final goods. Models 5 and 6 are additional robustness test models (TERGM at 2% threshold) based on the 2007-08 financial crisis.

Maximum Pseudo Likelihood (MPL) is used to produce consistent estimates of the parameters. In addition, the computational tractability of the pseudo-likelihood function makes it a very attractive alternative to the common full likelihood function. As Cranmer and Desmarais (2011) note, "the computational burden associated with the use of MCMC-MLE is insurmountable given current technology" (p.81). Besides using the MPL method, I also implement a bootstrap resampling method for computing the 95% confidence intervals. 1000 bootstrap iterations are used in each of my TERGM models and the respective confidence intervals are calculated using the 2.5th and 97.5th percentiles of the sample of bootstrap estimates. Results for my main independent variables are reported in tables 4.1 and A.2. The full TERGM results are reported in the appendix.

From table 4.1 below, the *Crisis* variable is negative and statistically significant at the 0.05 level for both models 1 and 2. On the other hand, we find no conclusive statistical evidence for *Crisis* dampening exports in final products (models 3 and 4). At first glance, this may seem to be a verification of the bullwhip effect, as economic crisis hurts intermediate exports more than final exports. However, given that *Crisis* is conditional on the various state capacity variables and whether or not the exporter is a developmental state, the main effect of *Crisis* is only suitable for direct inference when the state capacity variables tend to zero and when the exporter is not a developmental state. Notably, all the interaction terms will be eliminated when state capacity scores are zero and when the exporter is not a developmental state. Inspecting the data, a zero state capacity score is possible, with countries like Myanmar, Cambodia and Bangladesh having zero or near zero state capacity scores. Overall, a substantive interpretation of *Crisis* is that an economic crisis decreases the odds of intermediate exports by 50.68% on average for only very weak non-developmental states, conditional on the rest of the intermediate trade network at the 2% threshold.[24]

[24]The substantive importance of the crisis variable in the 1% intermediate trade network is not computed here as my main model is model 1. Model 2 is just to compare the similarity of results in the main independent variables.

Table 4.1: Partial TERGM Results for Intermediate and Final Networks (1996-2013)

	Model 1 (2%)	Model 2 (1%)	Model 3 (2%)	Model 4 (1%)
Crisis	-0.410*	-0.463*	0.181	0.487
	[-1.140, -0.000]	[-0.905, -0.024]	[-3.668, 4.701]	[-1.971, 3.757]
Developmental State x Crisis	0.023	0.004	-0.256	-0.132
	[-0.158, 0.220]	[-0.135, 0.193]	[-0.476, 0.242]	[-0.400, 0.533]
Government x Crisis	-0.017	0.137	0.806	1.003
	[-0.248, 0.164]	[-0.208, 0.332]	[-0.276, 1.638]	[-0.076, 1.757]
Regulatory Quality x Crisis	0.128	0.020	0.045	0.015
	[-0.092, 0.455]	[-0.216, 0.283]	[-1.220, 0.599]	[-0.678, 0.475]
Transparency x Crisis	-0.020	-0.062	0.729	-0.918
	[-0.175, 0.109]	[-0.149, 0.087]	[-1.393, 0.332]	[-1.582, 0.053]
Developmental State (Exporter)	0.369*	0.543*	0.067	0.118
	[0.245, 0.495]	[0.419, 0.695]	[-0.140, 0.345]	[-0.032, 0.326]
Developmental State (Importer)	-0.720*	-0.689*	-0.938*	-0.899*
	[-0.821, -0.614]	[-0.775, -0.601]	[-1.289, -0.548]	[-1.487, -0.374]
Government	-0.002	0.039	-0.274	-0.022
	[-0.119, 0.109]	[-0.101, 0.173]	[-0.937, 0.374]	[-0.841, 0.337]
Regulatory Quality	-0.106	-0.091	0.207	0.184
	[-0.236, 0.024]	[-0.244, 0.082]	[-0.027, 0.481]	[-0.105, 0.515]
Transparency	0.132	0.125*	-0.026	0.065
	[-0.002, 0.271]	[0.028, 0.239]	[-0.491, 0.418]	[-0.369, 0.504]
Triadic Closure/Transitivity	0.446*	0.456*	0.552*	0.758*
	[0.354, 0.540]	[0.299, 0.642]	[0.407, 0.656]	[0.306, 1.176]

*$p<0.05$. Models 1-4 show the TERGM estimates given in the columns with 95% confidence intervals in the brackets. Confidence intervals not containing zero are statistically significant at the 0.05 level. N = 59,508.

In addition, it is noteworthy to point out that scholars exploring the bullwhip effect have often omitted the effects of government institutions[25], assuming that states do not intervene in economic affairs or that those interventions are futile. This is analogous to the special case in my model where we consider a group of very weak and non-developmental states.[26] Thus, results from my statistical models still point to the bullwhip effect, but caution that reality is made more complex via government involvement in the economy during a crisis. For the majority of cases, I found no conclusive evidence for the bullwhip effect in the TV and communication industry after accounting for state capacity variables. Indeed, some recent studies on the bullwhip effect have also noted the absence and variation of the bullwhip across industries. For instance, Cachon, Randall and Schmidt

[25]See Lee, Padmanabhan and Wang (1997), Altomonte et al. (2012), and Zavacka (2012).

[26]In this case, the states do not have sufficient capacity to intervene.

(2007) note that the bullwhip effect is often contested in empirical studies and may not be evident from industry-level data. In fact, the authors even found contrary evidence to the bullwhip effect, with retail demand more volatile than manufacturing demand. Consequently, the partial confirmation of the bullwhip effect in my results point to more interesting and complex dynamics that involve the simultaneous interplay of shock amplifiers and absorbers.

Although not directly related to the hypotheses of this paper, I find evidence of developmental states as export enhancers in the intermediate trade network of TV and communication equipment. From model 1, the odds of establishing an export relation is increased by 44.63% on average, if the country is a developmental state and when no economic crisis occurs. This relationship is also reflected in model 2, with a larger percentage increase of 72.12%, due to the denser network. However, no conclusive statistical evidence is derived from exports in final products at both 2% and 1% levels. This may be due to the fact that developmental states are much more embedded in intermediate than final goods exports. Indeed, my results provide evidence to the 'Factory Asia' phenomenon, where Northeast and Southeast Asian countries, many of them being developmental states, are heavily engaged in intermediate goods manufacturing. In addition, if a country is a developmental state, then the odds of establishing an *import* relationship with another country will decrease, in the absence of an economic crisis. This result is consistent across all four models. For my main models (2% threshold), being a developmental state will decrease the odds of intermediate and final imports by 51.32% and 60.86% respectively on average, when no crisis occurs. Substantively, developmental states are production-oriented states that aim to gain economic growth and competitiveness through exports, and hence may not favor imports that hurt trade surpluses. Moreover, a number of the developmental states in the dataset are electronics powerhouses (e.g. South Korea, Taiwan, Japan and Singapore) that are likely to export TV and communication with high domestic content.

In terms of the endogenous covariates, the most important variable is *Triadic Closure/Transitivity*, as it relates to the propensity of the network to cluster.[27] Across all four models, *Triadic Closure/Transitivity* is positive and statistically significant at the 0.05 level. Moreover, models 3 and

[27]The 2-star covariates are all negative and statistically significant at the 0.05 level, indicating that these network configurations are unlikely to exist in both the intermediate and final trade networks. The in/out-degree measures serve as indication for highly connected or centralized nodes, and we find that highly centralized nodes are likely to be present in all the four models. Edges are similar to the y-intercept in linear regression. Substantively, the edges variable is irrelevant here as some of the covariates such as GDP and trade openness cannot be zero.

4 show higher coefficient estimates for triadic closure compared to models 1 and 2, indicating that clustering is more likely in the final trade network. As hypothesis 1 posits, the higher the clustering within the network, the greater the crisis contagion.[28] Indeed, my statistical results point to a more susceptible final trade network to economic crisis contagion. Notably, this is not to say that the final trade network would be hit *harder* by the crisis compared to the intermediate trade network. As discussed in the earlier paragraphs, the *impact* of crisis is more severe on weak non-developmental states in the intermediate trade network. For other states in the international system, we cannot conclude whether the crisis hits intermediate or final trade harder.

4.6.1 TERGM Results Robustness Check

As my interaction variables in models 1 through 4 are not statistically significant, I am unable to confirm the hypotheses on the importance of state capacity and the developmental state in mitigating economic crises. Importantly, treating all crises as the same might not be very accurate. In fact, out of the three crises coded in my data, the recent global financial meltdown has the most widespread and destructive consequences, which led to the 'great trade collapse' as described earlier (Eichengreen and O'Rourke (2009)). Consequently, in order to explore hypotheses 3 and 4 further, I run two additional models that focus solely on the recent global financial crisis. Models 5 and 6 below represent the intermediate and final export networks at the 2% threshold:

Table 4.2: Partial TERGM Results for Intermediate and Final Networks (2007-08)

	Model 5 (intermediate 2%)	Model 6 (final 2%)
Developmental State (Exporter)	0.135*	-0.032
	[0.090, 0.174]	[-0.032, 0.506]
Developmental State (Importer)	-0.563*	-0.798*
	[-0.699, -0.471]	[-9.388, -0.675]
Government	0.010	0.270*
	[-0.021, 0.028]	[0.270, 0.582]
Regulatory Quality	0.072	-0.179
	[-0.070, 0.151]	[-0.179, 0.701]
Transparency	-0.014	-0.070
	[-0.071, 0.089]	[-0.368, 0.070]

*$p<0.05$. Models 5 & 6 show the TERGM estimates given in the columns with 95% confidence intervals in the brackets. Confidence intervals not containing zero are statistically significant at the 0.05 level. N = 6612. Note that some of the estimates are near or on the confidence interval boundaries due to rounding off to 3 decimal places.

[28]This claim will be assessed via agent-based modeling in the next section.

From Model 5, we see that despite a crisis situation, developmental states still have a positive impact on exports in intermediate TV and communication equipment. Substantively, if a country is a developmental state, it will increase the odds of establishing export relations with another country by 14.45% on average, conditional on the rest of the network. However, this percentage increase is lower than the 44.63% for the full model, indicating that the financial crisis might have dampened the propensity and capacity to trade to some extent. Nonetheless, the statistical significance of the developmental state (exporter) variable points to the salience of developmental states in pushing for intermediate goods exports and managing the crisis. Inconclusive evidence remain for the three general state capacity variables.

Model 6, on the other hand, presents a different set of results: the developmental state (exporter) variable is not statistically significant at the 0.05 level, but government effectiveness (*Government*) is positive and statistically significant. As discussed earlier, developmental states are usually more actively involved in intermediate rather than final goods exports, consistent with the 'Factory Asia' phenomenon. The government effectiveness variable, however, is more interesting here because it points to the importance of the civil service in times of crisis. From the results, a 1-unit increase in the government effectiveness score of a country increases the odds of establishing export relations in final products with another country by 31.00%. In addition, since countries that export final goods in TV and communication equipment are likely to be emerging markets that assemble intermediate products to make the final good, a strong civil service is necessary to formulate and implement economic strategies that facilitate exports during a crisis. This echoes a UNDP report that highlights the importance of a highly institutionalized civil service in developing countries to help manage a crisis more efficiently (UNDP (2011)). Overall, model 6 provides support for hypothesis 3a.

4.6.2 TERGM Goodness-of-Fit Tests

Given that the TERGM is estimated using a bootstrap pseudo-likelihood method, it does not provide straightforward model fit statistics such as the AIC, BIC, or R^2 that are commonly seen in traditional regression analysis. Instead, simulated networks, which are based on the parameters estimated in the models, are compared to observed networks to compute the goodness-of-fit (Cranmer, Desmarais and Menninga (2012)). I thus conduct robustness tests on my main models (with 2% threshold). The goodness-of-fit plots for each model are shown in the appendix.

In general, a model is a good fit if the medians of the box plots, which are based on simulated networks, come close to the line that plots the values in the observed network. As Lusher, Koskinen and Robins (2014) note, the goodness-of-fit for exponential random graph models allow us to "know whether the specified model for our observed data represents particular network structures or graph features well" (p.179). Importantly, the goodness-of-fit plots of the TERGM focuses on model fit with regards to network topology. From figure A.5, we see that on four of seven plots, the intermediate export model (1996-2013) fits very well. However, the model does not perform as well for the in- and out-star distributions as well as the geodesic distribution plots. On the other, from figure A.6, the final export model (1996-2013) performs much better for most the network structural types, but the out-star plot is still lacking. For the networks that look at the recent global financial crisis (figures A.7 and A.8), similar patterns of fit can be seen, though the edge-wise shared partners plots performed slightly worse than the full models. Importantly, while the models fit well on certain network structural types, they fall short on other topologies. What could then be said of the overall fit of the respective models?

In order to further investigate model fit, I use the Receiver Operator Characteric (ROC) curve that allows me to assess the in-sample predictive performance of the models.[29] Indeed, the ROC goes beyond network topologies to assess model fit. The ROC curve plots the rate of true positive predictions against the rate of false positive predictions. In our context, true positives are those states predicted to establish export ties under certain conditions in the model which actually go on to export in reality (as backed by the data provided). On the other hand, false positives are those states predicted to establish export relations but do not actually do that. As such, a model that gives results of pure chance would produce a diagonal ROC plot. Moreover, as Cranmer and Desmarais (2011) note, the resulting area under the ROC curve, called the AUC, gives the "integrated difference between the predictive success and predictive error of a classifier, and represents a scalar-valued measure of model fit" (p.83). Indeed, an ROC curve that is a diagonal straight line is produced by chance and has an AUC of 0.5, whereas a perfectly predictive model will have an AUC of 1

[29] Other papers such as Cranmer and Desmarais (2011) and Saul and Filkov (2007) also use the ROC to assess predictive performance of exponential random graph models.

(Kemshall and Wilkinson (2011)). As a yardstick, models with AUCs greater than 0.6 are suitable to be used in research (ibid).[30]

From figures A.9 and A.10 in the appendix, we see that all the main models have AUCs greater than 0.8, indicating very good predictive performance of the models. In fact, the AUC for the intermediate exports full model (see figure A.9(a)) has a very high value of 0.9246985.[31] Overall, the AUC values provide confidence in the TERGM results.

4.7 Complementing the TERGM: Using ABM in Modeling Shock Propagation

Although the TERGM is a powerful method to account for complex interdependencies and endogenous effects, it cannot simulate the dynamics of economic shocks. Neither can the TERGM account for feedback effects that are inherent during a crisis. For instance, a country that is recovering from a crisis is still very weak and highly susceptible to further shocks that might pull it down again. ABM allows interactions among multiple agents to take place simultaneously, with simulations that model the complexity of economic relations and shock propagation. I use the ABM to to test hypothesis 1 to see whether a dense and highly clustered network would lead to greater chance of crisis contagion and slower recovery time.

I conduct my investigation on economic shock propagation on the 2008 intermediate and final trade networks, as 2008 marked the start of the great trade collapse, with full effects manifested later that year. While most ABM models only provide abstractions of reality by simulating computer-generated networks, I input real data into my simulations to make results more realistic. Besides feeding in real export data to form my networks, I used state capacity variables to help determine the recovery chance from a crisis. Indeed, countries that have high state capacity and/or are development states might be able to implement policy measures and economic strategy more quickly to lift the country out of crisis.[32] In addition, states that export to multiple export markets (high out-degree centrality) are also less likely to be affected by the crisis if only a few of their export destinations are

[30] Of course, the closer the AUC is to 1, the better the model fit.

[31] The TERGM goodness-of-fit test computes the AUC for each year in the model. The final AUC value of each model is thus the mean of AUCs across all years considered in the model.

[32] Note that I also consider states with strong capacity and/or developmental states to have increased chance of non-contagion, especially states encounter a minor regional crisis occurs. However, this consideration is not applicable in this case given the severity of the US subprime crisis. The function was added in my model for future reference.

crisis-struck.[33] On the other hand, having connected to multiple markets can be disadvantageous if the majority of those markets are crisis-laden. I thus run my models based on these considerations, with the results shown below[34].

Given that the financial crisis started in the US, my networks begin with the US as the crisis node. I then explore how the crisis is spread throughout the network, noting the time taken (or number of 'ticks' in Netlogo) for the whole network to stabilize with no nodes in crisis. Importantly, the graph density and clustering coefficient for the intermediate export network is 0.2447066 and 0.5032473 respectively, while those of the final export network are 0.3021779 and 0.5917315, indicating that the final trade network is more dense and clustered under the 2% threshold.[35] To note, a larger clustering coefficient and graph density point to the propensity for crisis spread (as described in hypothesis 1) but is not indicative of crisis *impact*.[36] From figure 4.2, we see that although the networks have recovered (i.e. no crisis nodes), a large proportion of countries are still highly susceptible (shown by the orange line), with a smaller percentage resistant to falling back into crisis (blue line). Moreover, the final export network progression plot in figure 4.2(b) resulted in a higher percentage of countries susceptible to crisis even after the network has stabilized with no crisis node left. The gap between resistant countries and susceptible ones is also greater than that of the intermediate export network's. Importantly, the time taken for the intermediate trade network to stabilize is approximately 1104.66 ticks on average based on 100 simulations on Netlogo's BehaviorSpace, while the final trade network takes about 1351.68 ticks.[37] Overall, my models provide evidence to hypothesis 1, asserting that networks with higher density and clustering coefficient will be more susceptible to crisis contagion.

[33] As my networks have already been thinned to reflect the 2% threshold, I treat all remaining connection ties to be substantial and equally likely in transmitting a crisis. The networks used here are the directed (but unweighted) networks used in my TERGM models.

[34] My ABM model modifies the "Virus in a Network" model to suit the context of this paper. See Stonedahl and Wilensky (2008) for the original model.

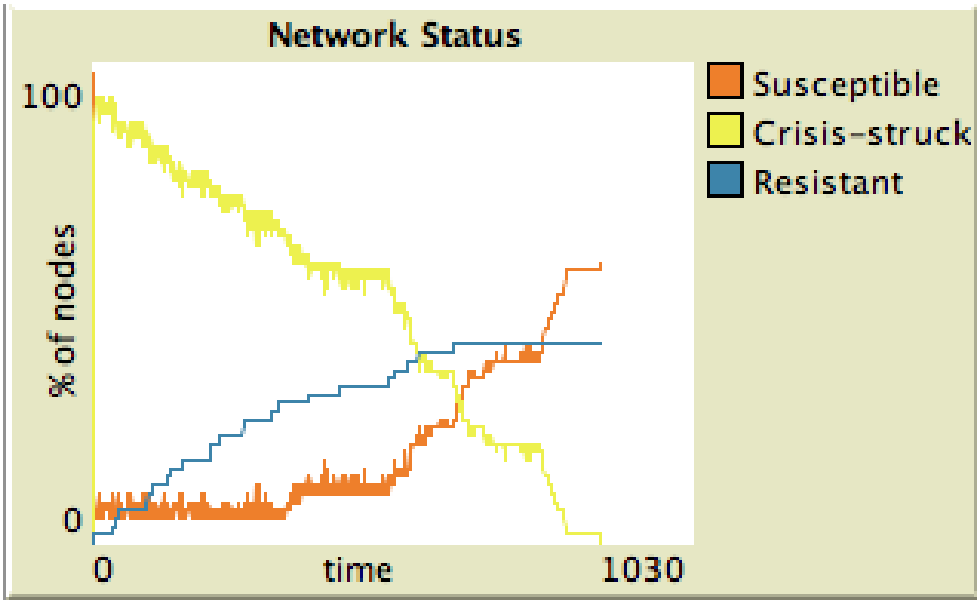
[35] In general, figures A.11 and A.12 in the appendix depict the full network of the respective Netlogo runs for reference purposes.

[36] Assessments of crisis impact are shown in my TERGM models instead.

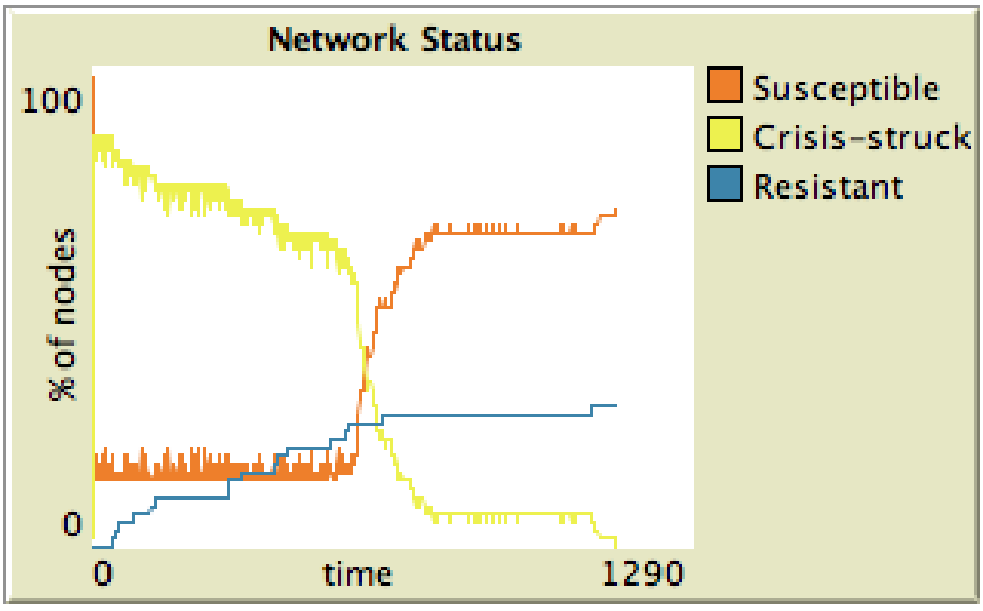
[37] Note that this has nothing to do with the bullwhip effect as I am modeling the networks separately and Netlogo treats these two networks as distinct entities. The lack of available data makes combining the intermediate and final trade networks into a multiplex network difficult. Moreover, Netlogo does not allow the formation of multiple edges between a pair of nodes.

Figure 4.2: Crisis Simulation for Intermediate and Final Export Networks (2%)

(a) Progression Plot (Intermediate Export Network)



(b) Progression Plot (Final Export Network)



4.8 Conclusion

This paper points to the significance of complex interdependencies and network topology in shock propagation during an economic crisis. Besides shock amplifiers that relate to the structure and patterns of connections in the trade network, shock absorbers are also important. Indeed, the developmental state helps to mitigate the effects of a crisis with its strong state capacity and political will. To some extent, state capacity pertaining to government effectiveness in the civil service may also moderate a crisis through efficiency in policy formulation and implementation. Overall, the resulting impact of an economic crisis depends on the complex interplay between shock amplifiers and absorbers.

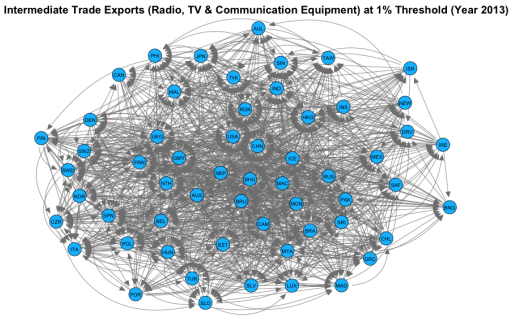
The bullwhip effect is less evident when the government intervenes in the economy. Only in cases where state capacity or intervention is very low does the bullwhip effect manifest. Indeed, existing studies that neglect political variables might have bias and inaccurate results. Future research should thus investigate more on the role of the state and how government policies mitigate the bullwhip effect.

While scholars in business management and economics have long studied supply chain shocks and ways to strengthen the chain, international political economy scholars have yet to explore this increasingly important branch of research. Given the fragmentation and dispersion of world trade, economic shocks in one area of the world can easily affect another region due to interconnectedness and clustering in the supply chain network. Moreover, the impact of shocks might be different for intermediate and final goods. With increasing data availability, IPE scholars should pay more attention to GVCs in order to better assess the global economy. In addition, with innovations in social network analysis and agent-based modeling methods, researchers can use a wide variety of tools to gauge trade and financial dynamics. Overall, research on GVCs by political scientists would add more perspective and diversity to the existing scholarship.

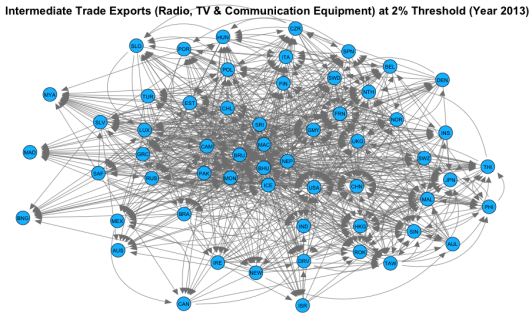
APPENDIX

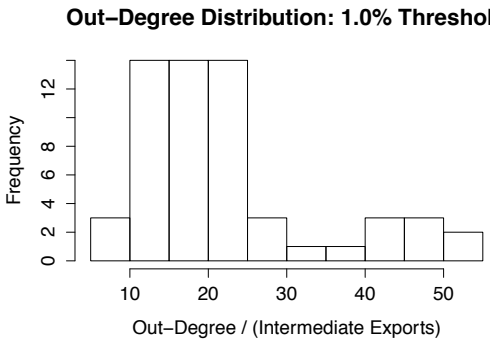
Figure A.1: Thresholding for intermediate trade and out-degree distributions (2013)

(a) 1.0%



(b) 2.0%





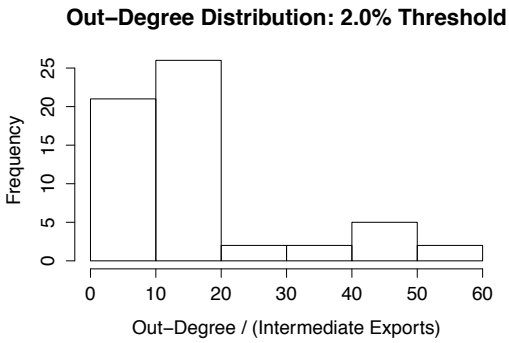
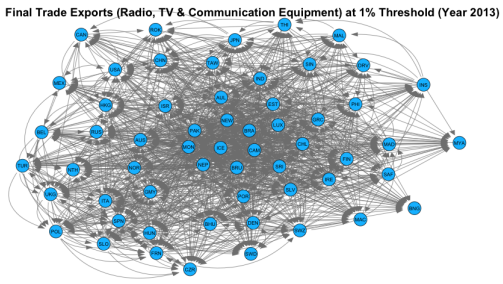
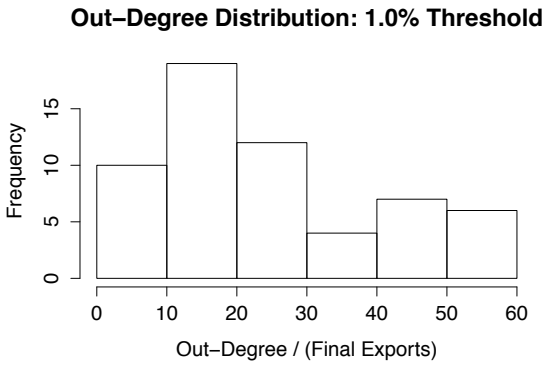


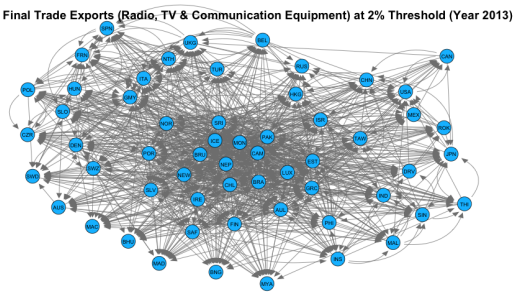
Figure A.2: Thresholding for final trade and out-degree distributions (2013)

(a) 1.0%





(b) 2.0%



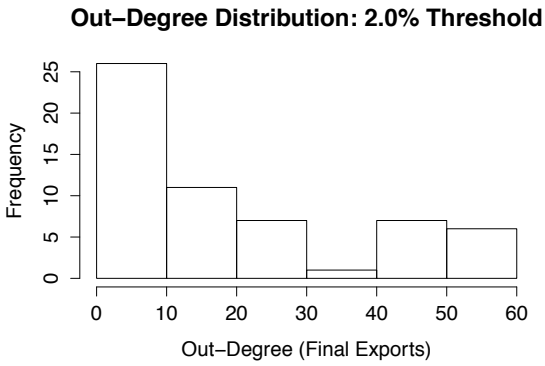


Figure A.3: Intermediate Trade Network 2013

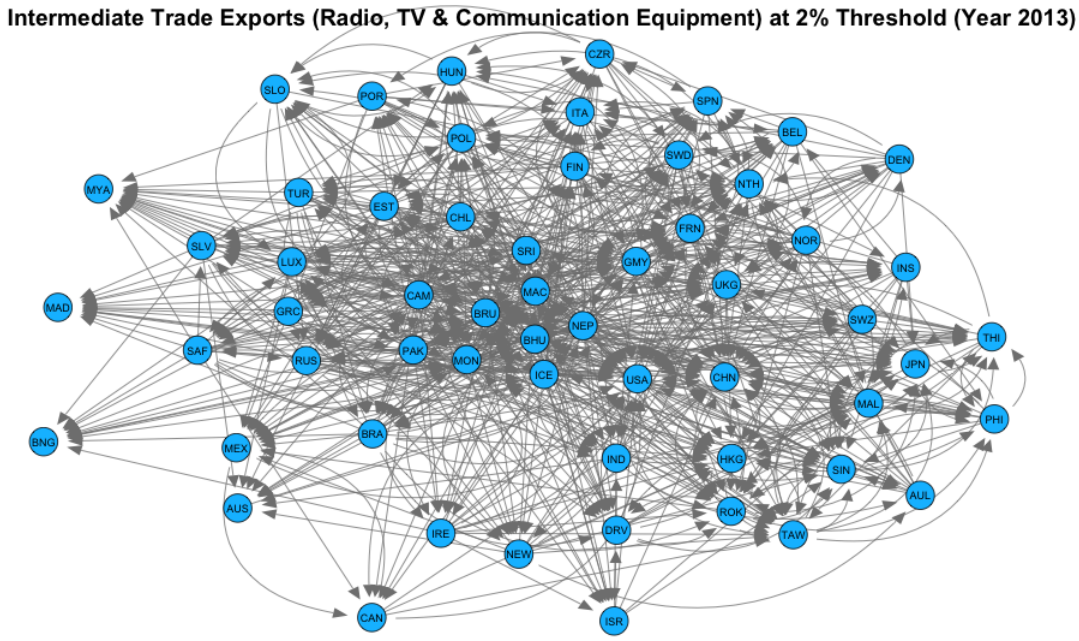


Figure A.4: Final Trade Network 2013

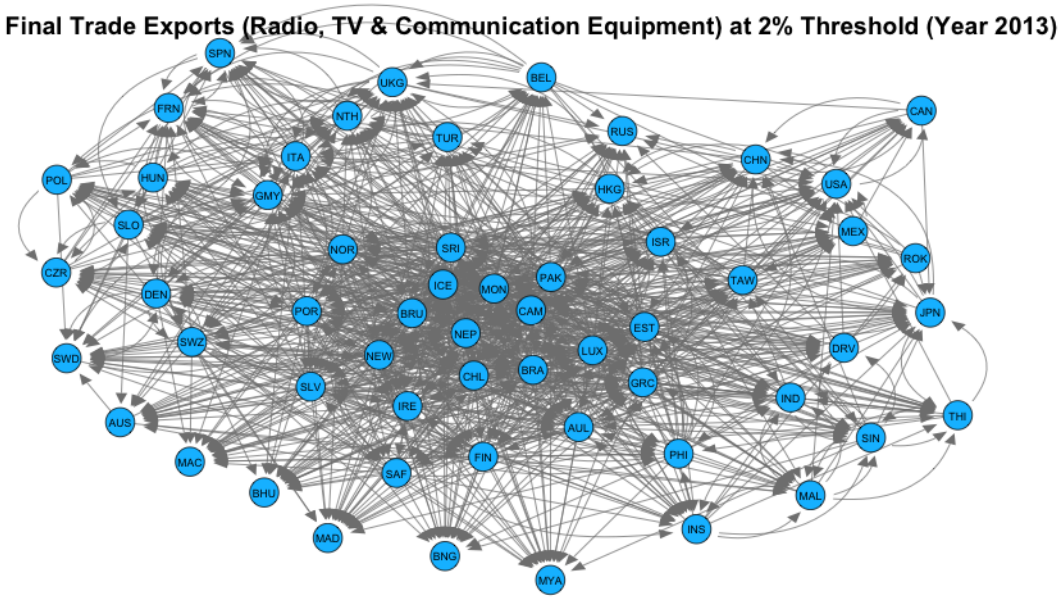


Table A.1: Full TERGM Results for Intermediate and Final Networks (1996-2013)

	Model 1 (2%)	Model 2 (1%)	Model 3 (2%)	Model 4 (1%)
Crisis	-0.410*	-0.463*	0.181	0.487
	[-1.140, -0.000]	[-0.905, -0.024]	[-3.668, 4.701]	[-1.971, 3.757]
Developmental State x Crisis	0.023	0.004	-0.256	-0.132
	[-0.158, 0.220]	[-0.135, 0.193]	[-0.476, 0.242]	[-0.400, 0.533]
Government x Crisis	-0.017	0.137	0.806	1.003
	[-0.248, 0.164]	[-0.208, 0.332]	[-0.276, 1.638]	[-0.076, 1.757]
Regulatory Quality x Crisis	0.128	0.020	0.045	0.015
	[-0.092, 0.455]	[-0.216, 0.283]	[-1.220, 0.599]	[-0.678, 0.475]
Transparency x Crisis	-0.020	-0.062	0.729	-0.918
	[-0.175, 0.109]	[-0.149, 0.087]	[-1.393, 0.332]	[-1.582, 0.053]
Developmental State (Exporter)	0.369*	0.543*	0.067	0.118
	[0.245, 0.495]	[0.419, 0.695]	[-0.140, 0.345]	[-0.032, 0.326]
Developmental State (Importer)	-0.720*	-0.689*	-0.938*	-0.899*
	[-0.821, -0.614]	[-0.775, -0.601]	[-1.289, -0.548]	[-1.487, -0.374]
Government	-0.002	0.039	-0.274	-0.022
	[-0.119, 0.109]	[-0.101, 0.173]	[-0.937, 0.374]	[-0.841, 0.337]
Regulatory Quality	-0.106	-0.091	0.207	0.184
	[-0.236, 0.024]	[-0.244, 0.082]	[-0.027, 0.481]	[-0.105, 0.515]
Transparency	0.132	0.125*	-0.026	0.065
	[-0.002, 0.271]	[0.028, 0.239]	[-0.491, 0.418]	[-0.369, 0.504]
Democratic Dyad	-0.002	-0.017*	-0.053*	-0.031*
	[-0.011, 0.007]	[-0.028, -0.009]	[-0.083, -0.021]	[-0.051, -0.012]
GDP	0.000*	0.000*	0.000*	0.000*
	[0.000, 0.000]	[0.000, 0.000]	[0.000, 0.000]	[0.000, 0.000]
Trade Openness	0.001	0.001*	-0.001	-0.002
	[-0.000, 0.002]	[0.001, 0.002]	[-0.003, 0.002]	[-0.002, 0.002]
Lagged Export	3.288*	3.029*	2.340*	2.188*
	[3.090, 3.619]	[2.849, 3.313]	[2.030, 2.712]	[1.923, 2.489]
Triadic Closure/Transitivity	0.446*	0.456*	0.552*	0.758*
	[0.354, 0.540]	[0.299, 0.642]	[0.407, 0.656]	[0.306, 1.176]
in-2-star	-0.952*	-1.070*	-5.306*	-5.901*
	[-1.036, -0.878]	[-1.200, -0.969]	[-6.938, -4.567]	[-7.469, -5.287]
out-2-star	-0.255*	-0.505*	-0.151*	-0.161*
	[-0.316, -0.204]	[-0.580, -0.436]	[-0.212, -0.073]	[-0.225, -0.094]
m-2-star	-0.014*	-0.013*	-0.017*	-0.018*
	[-0.016, -0.012]	[-0.016, -0.011]	[-0.024, -0.007]	[-0.028, -0.007]
in-degree	8.999*	11.24*	50.273*	63.584*
	[8.289, 9.833]	[10.216, 12.624]	[45.225, 70.381]	[56.555, 81.044]
out-degree	3.306*	6.083*	2.111*	2.288*
	[2.875, 3.860]	[5.379, 6.838]	[1.369, 2.681]	[1.606, 2.974]
Edges	-32.438*	-47.665*	-137.410*	-179.760*
	[-34.933, -30.609]	[-51.785, -45.076]	[-183.417, -118.202]	[-229.139, -160.573]

*p<0.05. Models 1-4 show the TERGM estimates given in the columns with 95% confidence intervals in the brackets. Confidence intervals not containing zero are statistically significant at the 0.05 level. N = 59,508.

Table A.2: Full TERGM Results for Intermediate and Final Networks (2007-08)

	Model 5 (intermediate 2%)	Model 6 (final 2%)
Developmental State (Exporter)	0.135*	-0.032
	[0.090, 0.174]	[-0.032, 0.506]
Developmental State (Importer)	-0.563*	-0.798*
	[-0.699, -0.471]	[-9.388, -0.675]
Government	0.010	0.270*
	[-0.021, 0.028]	[0.270, 0.582]
Regulatory Quality	0.072	-0.179
	[-0.070, 0.151]	[-0.179, 0.701]
Transparency	-0.014	-0.070
	[-0.071, 0.089]	[-0.368, 0.070]
Democratic Dyad	-0.027*	0.008
	[-0.047, -0.010]	[-0.010, 0.038]
GDP	0.000*	0.000*
	[0.000, 0.000]	[0.000, 0.000]
Trade Openness	0.001*	-0.002*
	[0.000, 0.001]	[-0.009, -0.002]
Triadic Closure/Transitivity	0.604*	0.509*
	[0.484, 0.692]	[0.045, 0.571]
in-2-star	-0.748*	-8.449*
	[-0.830, -0.729]	[-73.647, -8.449]
out-2-star	-0.317*	-0.085
	[-0.343, -0.313]	[-0.128, 0.011]
m-2-star	-0.020*	-0.006*
	[-0.021, -0.019]	[-0.007, -0.001]
in-degree	7.121*	78.241*
	[6.804, 7.995]	[78.241, 660.298]
out-degree	3.909*	1.601*
	[3.832, 4.080]	[0.800, 2.114]
Edges	-27.526*	-187.670*
	[-28.986, -27.259]	[-1488.760, -187.668]

*$p<0.05$. Models 5 & 6 show the TERGM estimates given in the columns with 95% confidence intervals in the brackets. Confidence intervals not containing zero are statistically significant at the 0.05 level. N = 6612. Note that some of the estimates are near or on the confidence interval boundaries due to rounding off to 3 decimal places.

Figure A.5: Goodness-of-Fit Plots for Intermediate Exports (1996-2013) at 2% threshold

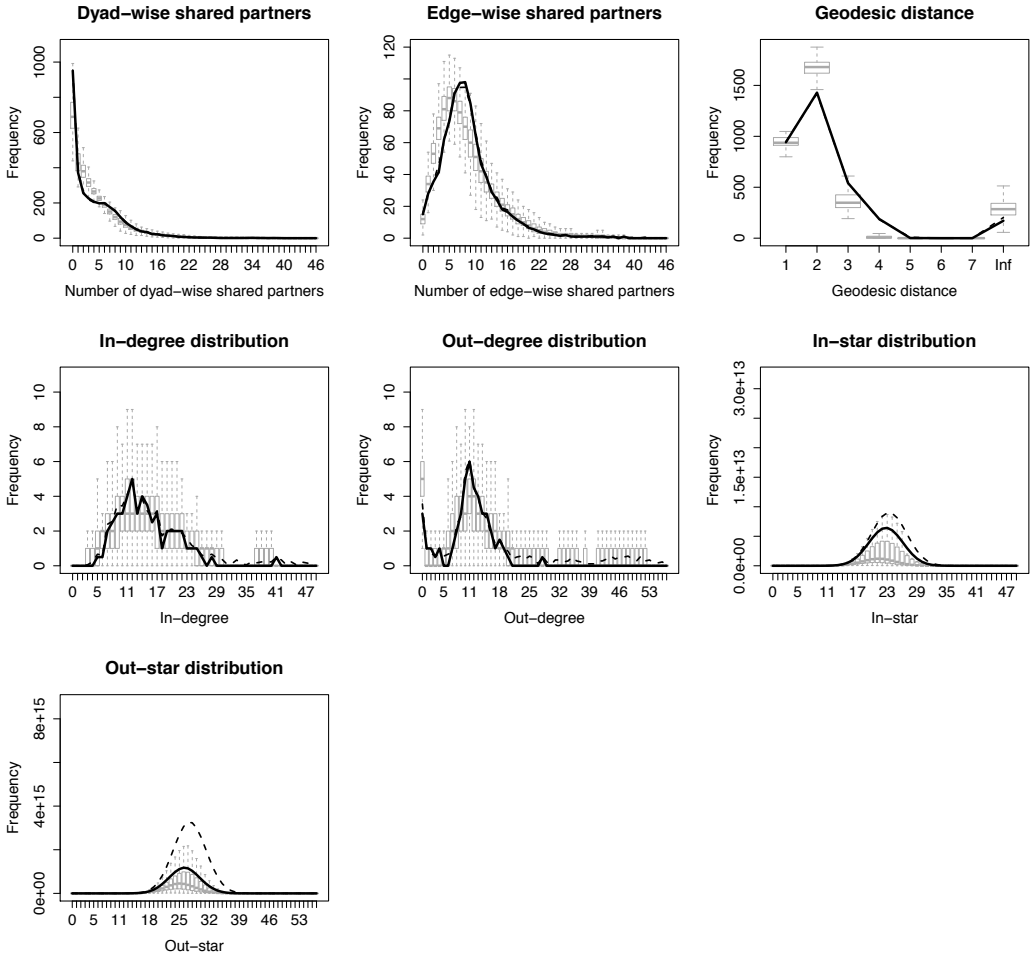


Figure A.6: Goodness-of-Fit Plots for Final Exports (1996-2013) at 2% threshold

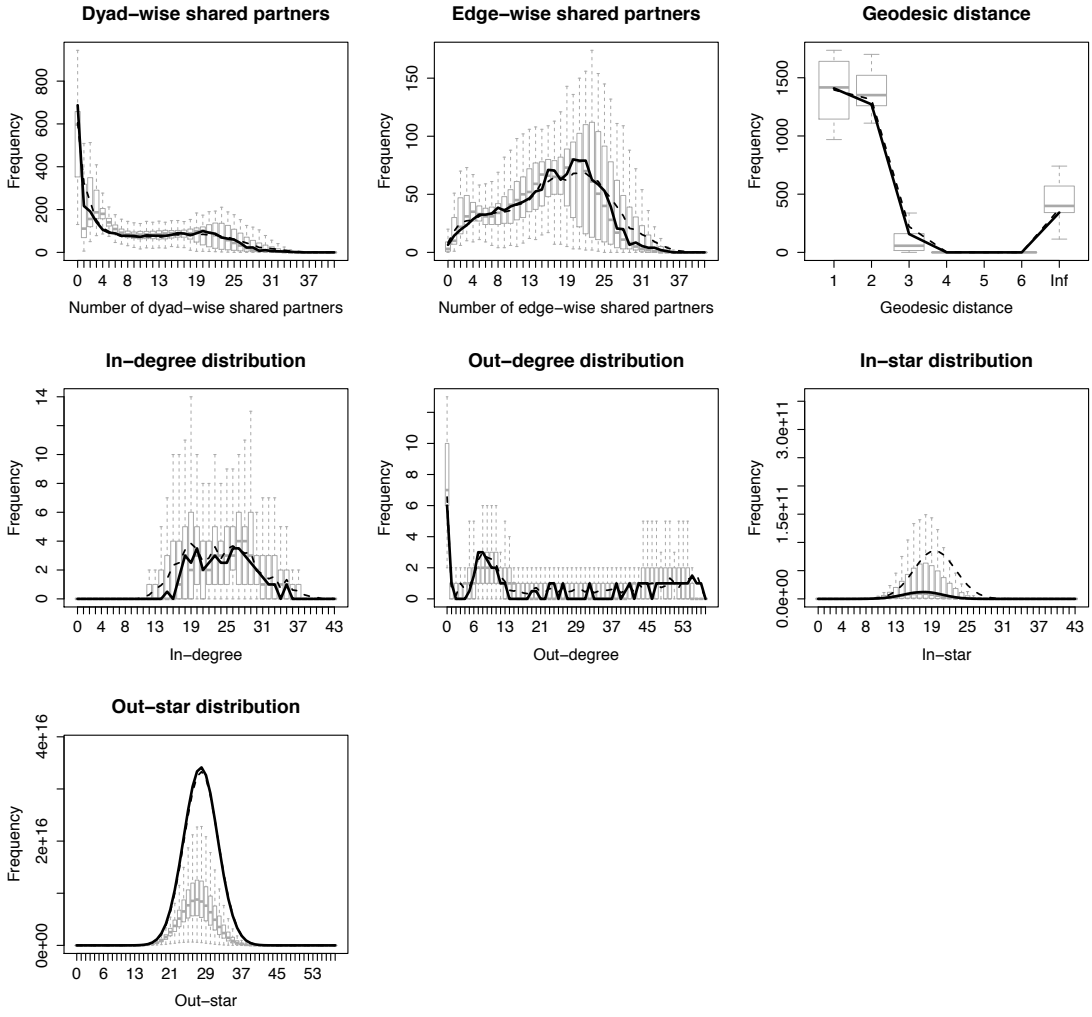


Figure A.7: Goodness-of-Fit Plots for Intermediate Exports (2007-08) at 2% threshold

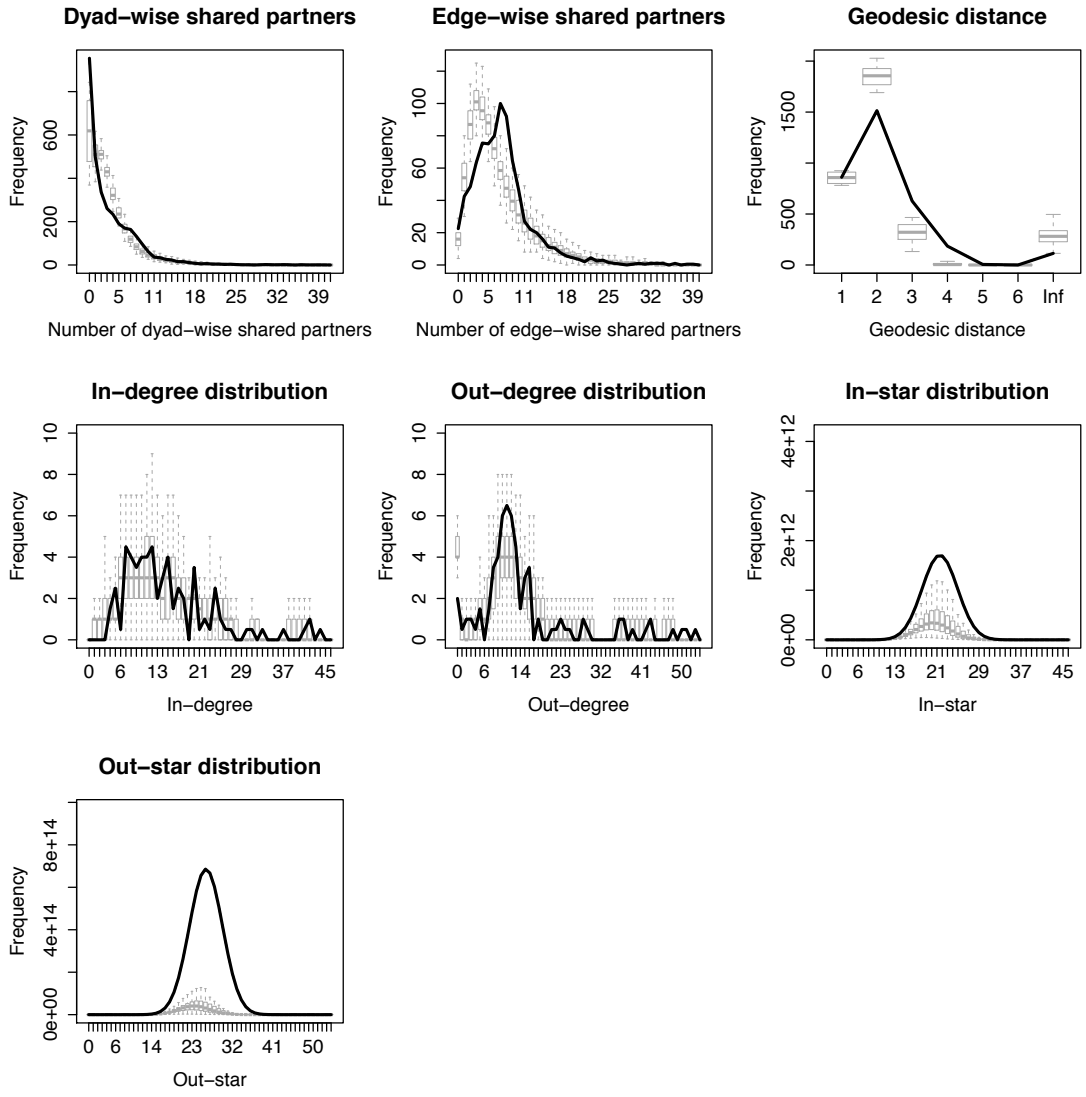


Figure A.8: Goodness-of-Fit Plots for Final Exports (2007-08) at 2% threshold

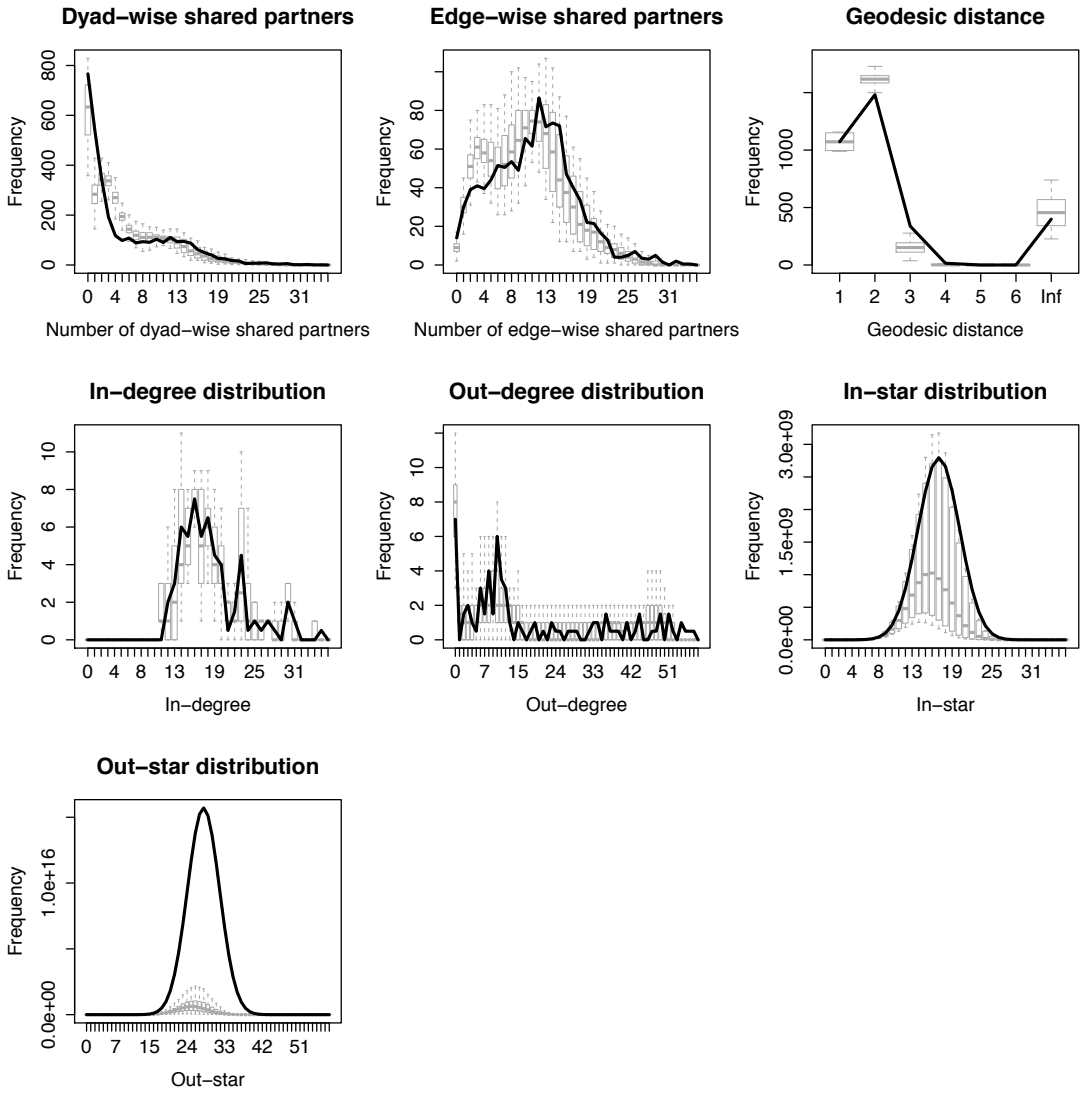
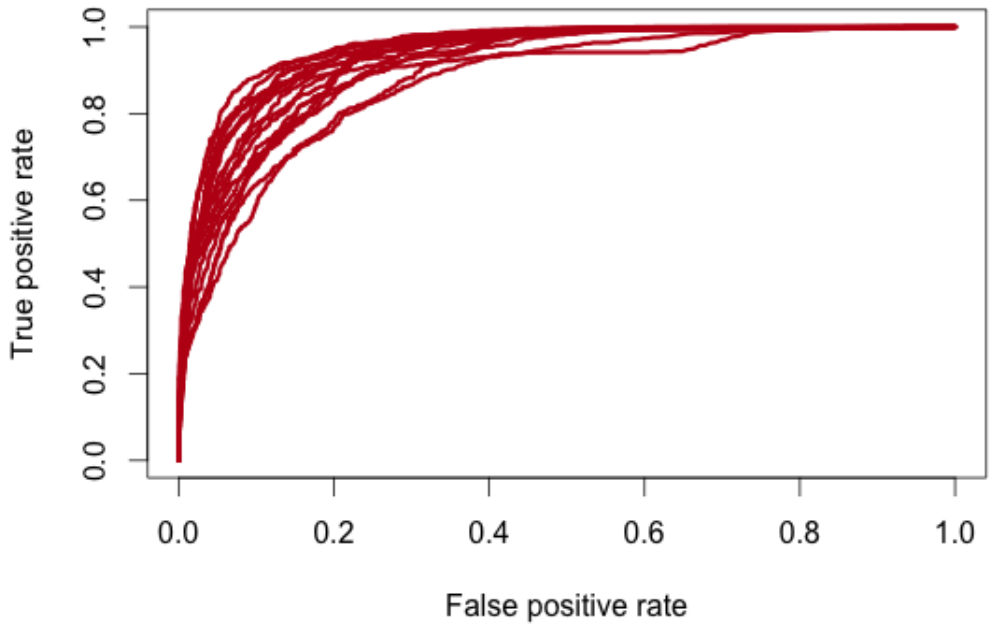


Figure A.9: Intermediate and Final Exports (2%) ROC Plots (for each year from 1996-2013)

(a) Intermediate Exports ROC (Mean AUC = 0.9246985)



(b) Final Exports ROC (Mean AUC = 0.8726622)

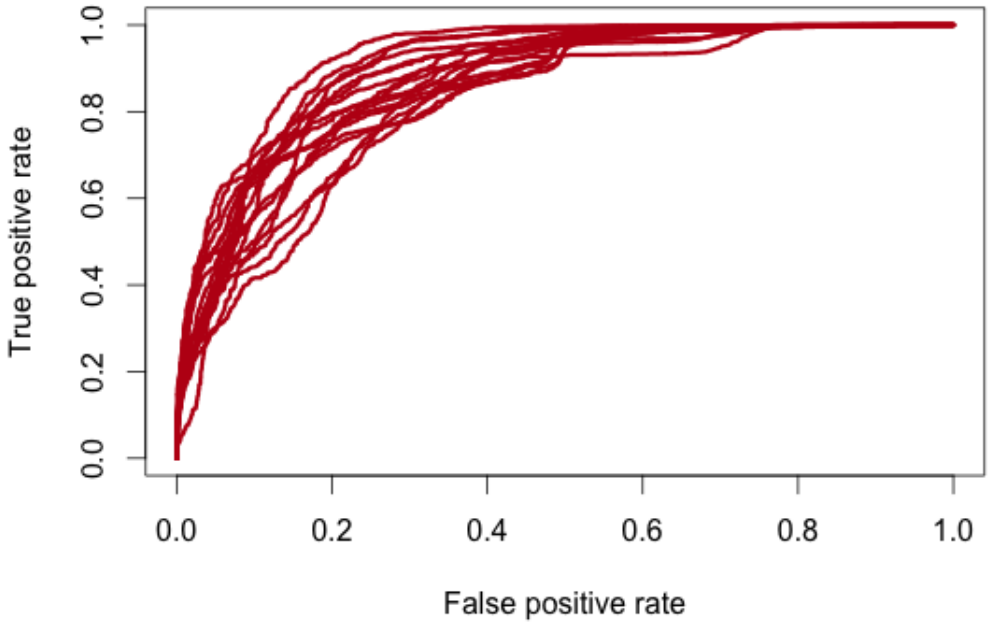
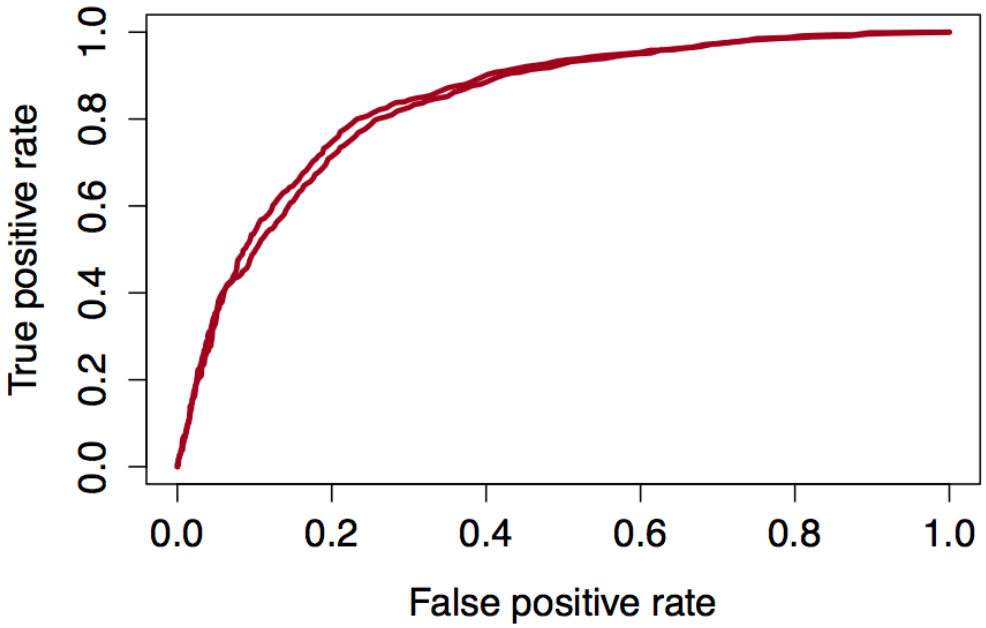


Figure A.10: Intermediate and Final Exports (2%) ROC Plots (for the two years of 2007-08)

(a) Intermediate Exports ROC (Mean AUC = 0.8390024)



(b) Final Exports ROC (Mean AUC = 0.873395)

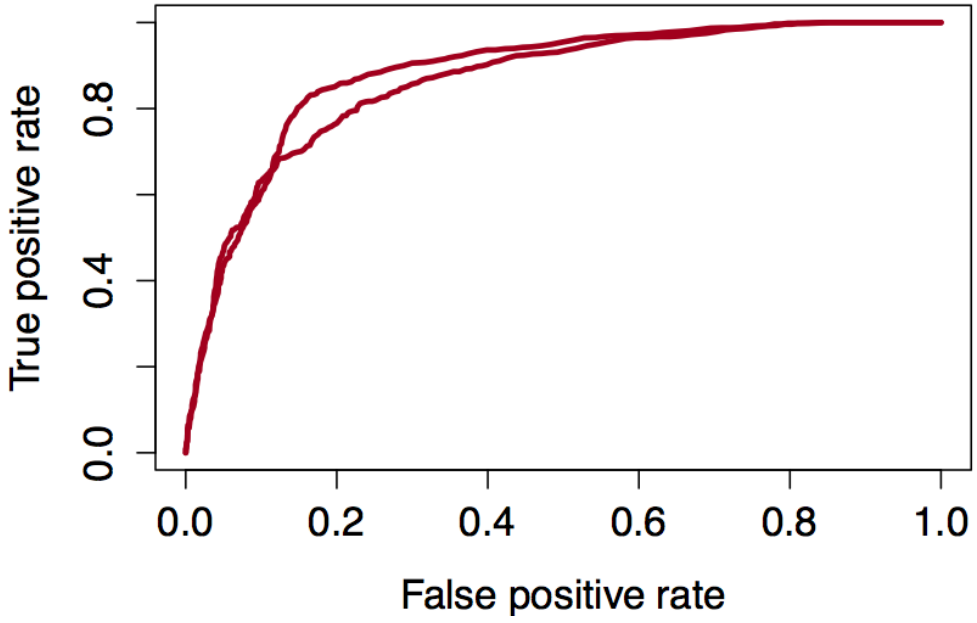
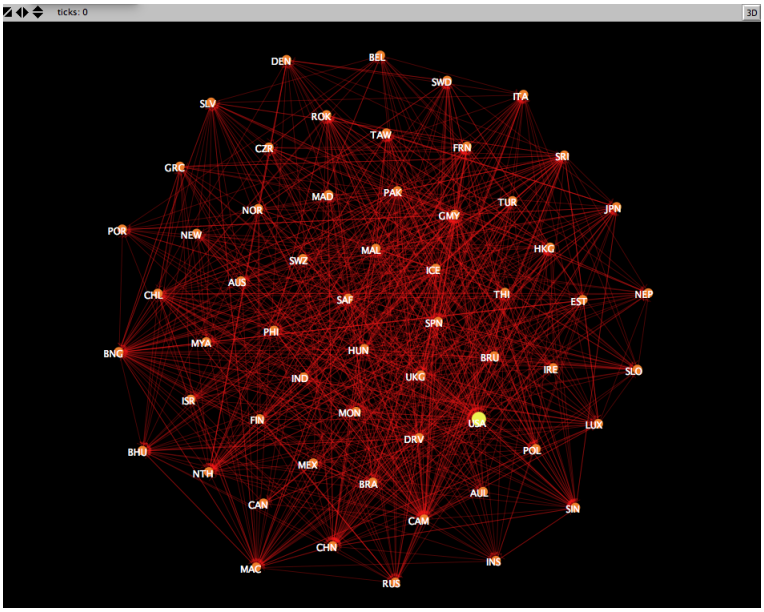


Figure A.11: Netlogo Intermediate Export Network (2%)

(a) Network (begin)



(b) Network (end): note that due to randomness introduced in the resistant chance, the individual countries that are resistant here may not be representative. The progression plot would be a more accurate representation of the dynamics of crisis propagation and outcome.

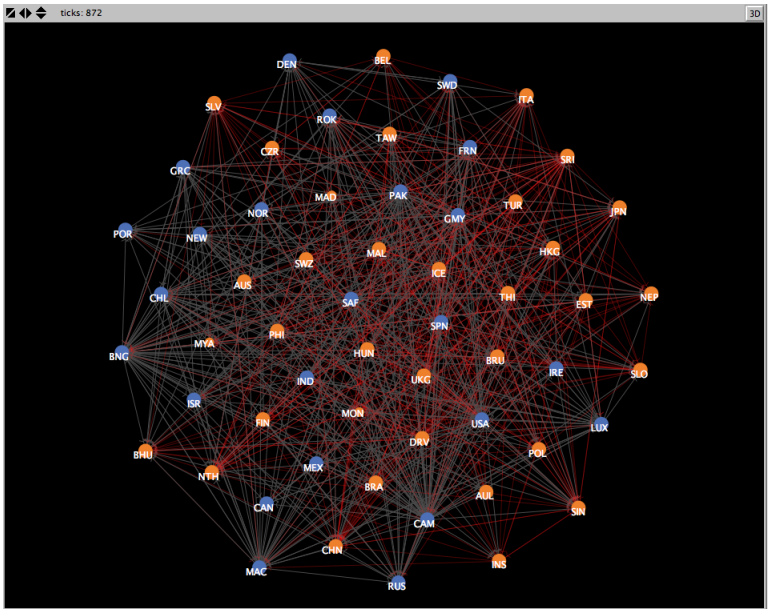
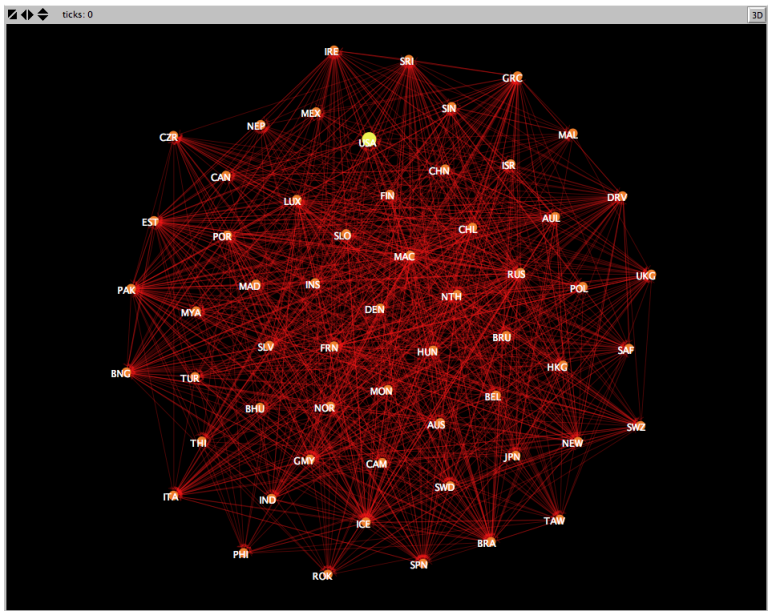
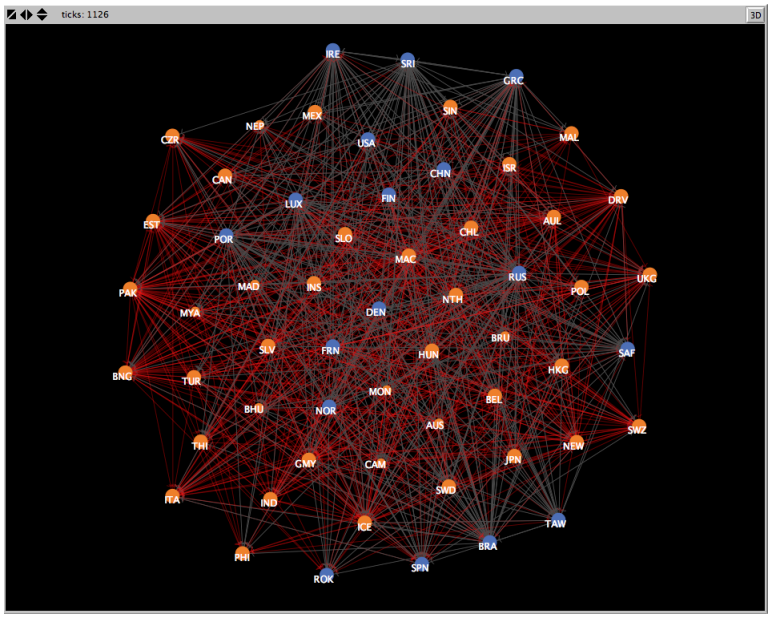


Figure A.12: Netlogo Final Export Network (2%)

(a) Network (begin)



(b) Network (end): note that due to randomness introduced in the resistant chance, the individual countries that are resistant here may not be representative. The progression plot would be a more accurate representation of the dynamics of crisis propagation and outcome.



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