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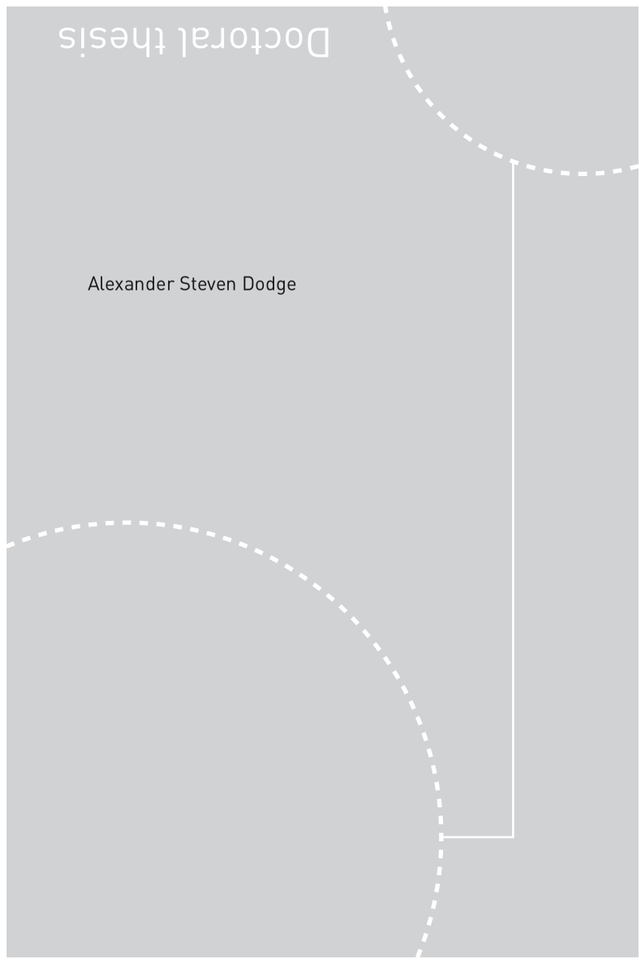
Alexander Steven Dodge

Reassembling Liquefied Natural Gas Production Networks

The globalization of gas markets and the implications for energy development and politics in Southeast Asia



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Abstract

The center of gravity of the global energy system is shifting towards Asia. The International Energy Agency forecasted in its 2017 new policies scenario that Asia would account for 62 percent of global energy demand growth from 2016 to 2040. Nearly 18 percent of this growth is expected to occur in Southeast Asia. Today, considerable portions of the population in Southeast Asia live with minimal or no access to electricity. Southeast Asia will face a considerable energy dilemma. Satisfying energy demand and increasing electricity access can lead to growing fossil fuel consumption, which will subsequently increase global climate emissions. Southeast Asia is one of the most vulnerable regions to climate change in the world, especially as typhoons, floods, and draughts become more frequent due to global heating. Meeting these energy challenges will require a transition to more sustainable energy systems.

Several geographers have argued for the need for a stronger analytical focus on the notion of territoriality in energy transitions research. An analytical focus on territoriality entails accounting for the scales and arenas of political action that govern energy transitions. Territoriality is particularly relevant as energy systems become increasingly global through cross-border energy investment and energy market deregulation. The international natural gas industry is currently poised at a conjunctionally specific moment where the territoriality of natural gas markets is evolving as markets are becoming global to a similar scale as other energy commodities such as oil. Industry proponents claim that the globalization of natural gas is leading to imperatives for market development in emerging economies, particularly in Asia. Proponents claim that emerging economies can reduce their climate emissions by using natural gas to transition away from coal and oil. They claim that natural gas produces fewer climate emissions than these fuels. In this thesis, I will discuss the dynamics by which natural gas markets are globalizing, the limitations of this globalization, and the implications for energy development and politics in Southeast Asia. To answer these questions, I draw upon three extended case studies in Singapore, Thailand, and Indonesia to explore the globalization of natural gas markets and how these changes are shaping energy development and politics in these countries. The case studies are covered separately in the three research articles included in this thesis.

To explain the evolving territoriality of natural gas markets, I draw upon relational thinking and the concepts of global production networks, power, and materiality. However, despite the utility of these concepts, I find that there is a need for more dynamic conceptualizations of these concepts to explain the globalization of natural gas markets, its limitations, and the implications for energy development. Therefore, in this thesis, I will make a conceptual contribution to economic and energy geography by drawing upon assemblage thinking as developed by Gilles Deleuze. I suggest that assemblage thinking gives analytical purchase by recognizing a) how the provisional territoriality of gas markets

emerges through relations between actors and materials, b) the instability and transformation of these relations, and c) what is transformed by globalization and what remains unaffected by globalization.

Drawing on this theoretical framework, I discuss how the governance of natural gas markets has historically been exclusive to the territorial authority of the nation-state due to the physical properties of natural gas and the materiality of its production and consumption. However, in the past few decades, the territoriality of natural gas markets has been evolving due to market liberalization reforms, the development of standardized pricing regimes, and the considerable expansion of liquefied natural gas trade in the past two decades. The latter development is particularly significant, as the liquefication and seaborne transport of natural gas enables it to be traded beyond the continental limits of pipelines. Historically, strong inter-firm governance in liquefied natural gas (LNG) production networks and the inflexibility of trading entailed the exclusion of emerging markets. However, such arrangements are changing due to the considerable expansion of LNG production and emerging interlinkages with commodity trading and financial markets. The three case studies of this thesis, based on qualitative fieldwork in Singapore, Thailand, and Indonesia, point to the different strategies among government officials, corporations, and financial intermediaries to reshape the territoriality of natural gas markets and to develop new markets in Southeast Asia.

The main contributions of this thesis are two-fold. First, this thesis contributes theoretically to economic and energy geography by drawing upon assemblage and topological thinking to develop more dynamic conceptualizations surrounding complexity, instability, and transformation in the international political economy. Second, utilizing this theoretical framework, this thesis contributes empirically to geographic research on the changing political economy of natural gas in the overall global economy. The key empirical findings of this thesis are as follows: a) the globalization of natural gas markets emerges from the co-evolution between emerging arrangements in LNG production networks and state strategies surrounding energy development and politics, b) the dynamics by which state strategies emerge can be contradictory to emergent arrangements in LNG production networks and, therefore, certain aspects surrounding the globalization of natural gas markets is limited, and c) these limitations point to a scenario where growth in commodity trading and flexible LNG trading arrangements is constrained, which may result in governments in Southeast Asia bearing considerable risk to secure LNG supply.

Acknowledgements

> "A book is an assemblage and as such is unattributable. It is a multiplicity – but we don't know yet what the multiple entails when it is no longer attributed, that is, after it has been elevated to the status of the substantive…. there is no difference between what a book talks about and how is made. Therefore, a book also has no object. As an assemblage, a book has only itself, in connection other assemblages." – Gilles Deleuze and Felix Guattari, *A Thousand Plateaus*

While I am fully responsible for what it written in this thesis, it is not attributable to my efforts alone. Writing this thesis would not be possible without the support and help from others who have been involved in its making both directly and indirectly. The thesis is an assemblage, one that extends beyond the confines of my own thoughts in my office, and is connected to the efforts and support of my family, friends, colleagues, and interviewees who have helped make this thesis possible.

- I would like to thank my main supervisor, Ståle Angen Rye and my co-supervisor, Asbjørn Karlsen. I have known Ståle and Asbjørn since I started the Master in Entrepreneurship and Society program at the Department of Geography at NTNU. I was lucky enough to be one of the first students in the newly minted master program that Ståle and Asbjørn established. Ståle has been supervising me since the start of my master's program, nearly six years. I do not think I can count the number of times I have popped into Stale's office for discussions, and he never tired it (hopefully). Ståle and I have spent many hours discussing assemblage thinking, topology, realism, nationalism, resource governance, and politics in Southeast Asia. Ståle has been there to guide and help mold me into the researcher I am today. Asbjørn has always had a sense of humor, wit, and positivity that has made him a great discussing partner and an excellent companion at conferences in Boston, Cologne, and Singapore. Asbjørn's many years of experience in the field of economic geography helped ensure that the abstract philosophies and conceptualizations stayed relevant to the discipline.

- I have been fortunate to be part of a dynamic and supportive environment at the Department of Geography at the Norwegian University of Science and Technology. I want to thank the administration and my colleagues at the department for the support they have given me throughout the process.

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- Beata, I could not have done this and many other things without your love, support, and companionship.

Contents

Abbreviations

ANT	Actor-Network Theory
ASEAN	Association of Southeast Asian Nations
EPPO	Energy Planning and Policy Office in Thailand
ERC	Energy Regulatory Commission in Thailand
FID	Foreign Direct Investment
GDP	Gross Domestic Product
GPN	Global Production Network
IEA	International Energy Agency
IGU	International Gas Union
Kwh	Kilowatt-Hour
LNG	Liquefied Natural Gas
mb/d	Million Barrels per Day
MJ/L	Megajoules per Liter
MTPA	Million Tons per Annum
NEPO	National Energy Planning Office in Thailand
NTNU	Norwegian University of Science and Technology
PPP	Public-Private Partnership
Rp	Indonesian Rupiah
SEA	Southeast Asia
TPA	Third Party Access

PART I

Introduction 1

天 地 人 - Heaven, Earth, Humans

The Chinese triad, spoken *Tian Di Ren*, signifies the harmonious relationships between heaven, earth, and humans needed to sustain the spiritual, ecological, and social needs of society. In Boshu philosophy, empires consist of heavenly, earthly, and humanly components, and empires endure to the extent that these components remain in balance with each other (Peerenboom, 1995). *Tian Di Ren* constituted the philosophical foundation for integrated farming systems in traditional Chinese agriculture. Good harvests were maintained by sustaining the relationships between heaven, earth, and humans. Crops were planted by humans, raised by the earth, and fed by rain form the heavens (Liu, 2014). *Ren* (humans) refers to the collective human effort surrounding interventions in farming involving knowledge and technology. Together with *Di* (earth), this represents the relationship between technology and non-human nature. *Tian* (heaven) is crucial for harmonizing the relationships between humans, technology, and nature. Heaven signified rainfall and seasonal changes according to the Chinese lunar calendar. *Tian Di Ren* in Boshu philosophy entails that human society is not dualistically opposed to nature, or that the universe is a machine operated by humans (Peerenboom, 1995). Instead human society emerges from the symbiotic relationships between humans, heaven, and nature.

Chapter 1

The French philosopher of the 1960's, Gilles Deleuze, akin to Boshu philosophy, was radically opposed to the notion of humanism. In particular, he contested the idea that humans have essential traits separating us from nature (the ability to reason, self-awareness, sense of justice, language, etc.) (Laurie, 2015). Deleuze disputed the notion that humans and natural objects gain their identity from essences and that human society can be reduced to the sum aggregate of the reified generalities that compose it (markets, states, families, language, etc.) (DeLanda, 2013). Manual DeLanda (2006), who is well known for reconstructing Deleuze's philosophy, claims that essentialism starts with reified generalities as finished products, discovers through logical analysis the necessary properties that characterize these products, and then makes these sets of properties into a defining essence. Essentialist thinking claims that essences, or the necessary conditions of the objects, can be separated from the historical conditions by which such individual objects emerge (DeLanda and Harman, 2017). Deleuze discards these notions, and instead develops an immanent and materialist philosophy where he conceptualizes the markets, states, cities, languages, etc. that compose human society as assemblages that are emergent from the self-organizing potentials found in material and expressive multiplicities (DeLanda, 2016). Such assemblages are irreducible to their material and expressive component parts, but at the same time would cease to exist if the parts stopped interacting with each other. Similarly, *Tian Di Ren* implies that empires emerge from the relationships between heavenly, earthly, and humanly components and would cease to exist if these relationships were no longer harmonious with each other.

A philosophy of immanence constitutes the ontological and epistemological basis for the systemic analysis of globalization in natural gas markets and the developmental and political implications of globalization for Southeast Asia (SEA) that is developed in this thesis. The international natural gas industry is poised at a conjunctionally specific moment where natural gas markets are becoming global to a similar scale as other commodities such as oil. Currently, natural gas trade is mostly localized, and the majority of natural gas consumed world-wide is consumed in the country where it is produced (Bridge and Bradshaw, 2017).

Unlike global oil markets, where global standardized pricing regimes have been developed and oil is traded flexibly on a cargo-by-cargo basis, these developments have been limited in the natural gas industry (Corbeau, 2016b). Natural gas pricing regimes and trading are primarily self-contained in Atlantic and Pacific "basins", and, therefore, natural gas is not considered to be a globally integrated market compared to other commodities (Bridge and Bradshaw, 2017). Nevertheless, as I discuss in this thesis, the spatiality of markets is evolving primarily because of a) market liberalization reforms in the United States, Europe, and Asia since the 1980s, b) the development of standardized pricing regimes, and c) the considerable expansion of liquefied natural gas (LNG) trade. The latter is especially important, as the liquefication and seaborne transport of natural gas enables natural gas to be traded beyond the continental limits of pipelines (Bridge and Bradshaw, 2017).

There is no immediate shortage of reports, books, and articles by consultancies, international agencies, and independent research centers detailing how global LNG markets may develop, the likelihood of these developments, and when such developments are expected to occur (Jensen, 2004; Corbeau and Ledesma, 2016; Victor et al., 2006; Pirrong, 2014; IEA, 2017c; Rogers, 2015). Indeed, a whole cottage industry has emerged in the last decade devoted to modeling, analyzing, and assessing different hypotheticals for global LNG markets. Many of the assessments in these reports are of high quality and are incorporated in the analytical arguments developed in this thesis. However, as Bridge and Bradshaw (2017) note, such work tends to be methodologically nationalist as industry researchers tend to focus on trade data at the nation-state level, and the work tends to be uncritical in the sense "that they *talk up* the future prospects of the industry, and often specific regions and projects, to reassure current and potential investors in the supply chain" (224).

Natural gas after all, is a fossil fuel with an uncertain future given efforts to mitigate climate change. This is despite claims from the industry that natural gas produces less carbon emissions than other fossil fuels and is a bridge to a

renewable future (see Stern, 2017). Furthermore, the 2014 price crisis in the oil and gas industry and slowing demand growth in mature natural gas markets in Europe and Japan, has led to fewer final investment decisions on infrastructure, specifically in LNG production terminals (IGU, 2017). According to a 2018 outlook by the Shell Corporation, supply shortages in LNG production are expected by the mid-2020s unless investments pick up (Shell, 2018). Along with other industry opinions, the outlook points to a scenario where the spatial expansion of LNG markets may be part of a "boom-bust" cycle (Weber, 2018; Ross, 2018). According to Corbeau (2016a): "There is a danger that supply will be inadequate when demand picks up, striking a damaging blow to the gas industry" (555). Some of the previously mentioned publications, such as the book *LNG Markets in Transition: The Great Reconfiguration* by Corbeau and Ledesma (2016) do not overlook such scenarios, but forecast that emerging business practices and market liberalization reforms will eventually result in new investment decisions and will balance markets. I argue in this thesis that these forecasts tend to overlook the power relationships, materiality, and distributed agencies that constitute the non-linear causal dynamics by which the political economy of natural gas is evolving. Furthermore, I suggest that these dynamics point to the instability and uncertainty surrounding the globalization of natural gas markets.

Haarstad and Wanvik (2017) claim that research in energy studies tends to stress path dependency and inertia in fossil fuel energy systems, and consequently reproduce narratives about the future of oil and gas and its inevitability. Haarstad and Wanvik (2017) suggest that there is a need in energy studies to "appreciate the change and ruptures that may not overthrow the system as a whole, but nevertheless represent significant change" (2). Instead of conceptualizing oil and gas regimes through essences or nessecary relationships, or fixed identities that hold these regimes together, Haarstad and Wanvik draw on the ontology of Deleuze (1994) and DeLanda (2016) to consider the historical processes by which oil and gas regimes emerge from the co-functioning of various interrelated social and material entities (states, resources, corporations, and infrastructures) and the dynamics that reproduce these relationships despite instability. In doing so,

Haarstad and Wanvik utilize an immanent, materialist philosophy to recongnize how small events or phenomenon can have significant impacts on the capacities of oil and gas regimes to reproduce and expand their integration in the global economy.

Southeast Asia (SEA), which constitutes the geographical and empirical scope of this thesis, is a strategically important continental sub-region for the globalization of natural gas markets. The region is expected to be one of the largest growing consumers of liquefied natural gas (IEA, 2017c). The evolving spatiality of natural gas markets, and the limitations of this evolution have significant implications for energy development and energy policies in SEA. The aim of this thesis is to describe and explain the immanent dynamics by which natural gas markets are globalizing. In doing so, the thesis aims to account for the implications of globalizing natural gas markets for energy development and politics in SEA. At the same time, the current research project aims to explore the barriers and limitations of market globalization based on three extended case studies examined in this thesis related to natural gas markets in Singapore, Thailand, and Indonesia. Realizing these aims requires a detailed and empirically rich examination of the political economy surrounding natural gas markets in SEA.

Drawing wider conclusions on energy development and politics in Southeast Asia on the basis of situated case studies in three individual countries in the region is difficult. The region is comprised of 11 countries and is incredibly diverse, both politically and economically (Bertrand, 2013). The three case studies themselves demonstrate the region's diversity, as they elude to the divergent political and developmental implications of the ongoing globalization of natural gas markets. It is the region's diversity, according to Huat (2014), that provides a basis for inter-referencing. Inter-referencing entails examining the "affinities" between locations by accounting for how political strategies and business practices in certain locations in SEA becomes points of reference for others. As I will discuss in more detail in Chapter 4 in this thesis, the events studied in each of the three case studies are interrelated due to the outcomes of events in one country acting as

reference for political strategies in another. I suggest that the outcomes of events in the three different case studies and relations between these events have wider political and developmental implications for the rest of SEA.

A key reason why the events in Singapore, Thailand, and Indonesia have wider implications for SEA is because the region is interconnected both politically and economically. In 1961, the Association of Southeast Asian Nations (ASEAN) was established with the purpose of accelerating economic growth, social progress, and cultural development (Henderson, 2014). The ASEAN economic community has the ambition of strenghtening political economic relations between and creating a single market across ASEAN member states. One such initative has been the development of a trans-ASEAN natural gas pipeline and the regionalization of natural gas markets in Southeast Asia (Sovacool, 2009). The trans-Asean gas pipeline demonstrates wider efforts by political actors to "regionalize" natural gas markets in Southeast Asia.

Another reason why I draw on wider conclusions based on the three case studies is simply that the region shares common geological and demographical features (Gupta, 2005). The region is characterized by the worlds greatest concentration of deep-water marginal basins, which is of great interest to the petroleum industry. Most countries in SEA have, therefore, developed petroleum and natural gas sectors. Myanmar, Thailand, Malaysia, Vietnam, Papua New Gunieua, Brunei, Cambodia, East Timor, and the Phillipines all produce natural gas in Southeast Asia (International Energy Agency, 2013). As demonstrated in the case studies in Thailand and Indonesia, the globalization of natural gas markets has significant implications for energy development in other regional gas producing nations.

Furthermore, SEA is one of the most distinct and unique coastal regions in the world and has an extensive coastline due to the exensional tetonics in the region (Gupta, 2005). The majority of people in SEA live along the coast, and populations are scattered across coastlines and islands. These shared geological and demographical features have common implications for energy and natural gas

market development. On one hand, populations are seperated by seaways and mountains, and building natural gas pipelines is fraught with difficulty (DNV-GL, 2012). On other hand, many population centers in the region are accessible by sea, and LNG is transported primarily through maritime carriers. As I will discuss, my research in Indonesia points to the economical and technological challenges of distributing natural gas and LNG to peripherial regions on multiple islands. Countries like the Phillipines and Vietnam with multiple islands and long coastlines would experience similar issues.

In the next section of this introductory chapter, I discuss the challenges of climate change, energy development, and energy transitions in SEA. I explain how natural gas power generation, if it replaces coal and oil-fueled power generation, could reduce the growth of climate emissions. I explain that a key challenge for developing natural gas markets is that liquefied natural gas markets in Asia have historically been exclusive to high-income markets, particularly in North Asia.

1.1. Energy and Natural Gas Development and Politics in Southeast Asia

The global energy system is shifting its center of gravity to Asia. Energy demand in SEA is expected to increase nearly two-thirds by 2040 (International Energy Agency (IEA), 2017c). The annual average rate of gross domestic product (GDP) growth from 2019 to 2023 in ASEAN is expected to be 5.2% (OECD, 2018). The rise in GDP growth and the increasing demand for energy in SEA will require significant energy transitions. Energy transitions in developing countries require the development of affordable and accessible modern energy services, but at the same time such services may increase the carbon intensity of consumption (Bradshaw, 2010b). SEA is one of the most vulnerable regions to climate change in the world, particularly as typhoons and floods become more intense and frequent. The Asian Development Bank estimates that climate change could cause GDP in the region to fall by 11 percent in 2100 (Raitzer et al., 2015). Citizens in Southeast Asian countries have increasingly pressured their governments to mitigate climate emissions. For example, NGOs and the residents of Krabi, a popular tourist destination in Thailand, have vigorously opposed the development of a coal-fired

power plant in the local area which has led to subsequent delays of the power plant and most likely to its cancelation (Phoonphongphiphat, 2017). Despite social movements, SEA countries continue to draw up plans for and develop coal-fired power plants. Nonetheless, governments in SEA, among other reasons, are considering energy alternatives to avoid protests and delays (Kotani, 2018).

Figure 1 - Greenpeace Action in Krabi, Thailand. Source: Greenpeace (2014). All Rights Reserved.

Another key challenge for energy development in SEA, as shown in Figure 2 below, is increasing oil deficits. In 2016, SEA went from being self-sufficient in oil production to a net-importer. Oil production is SEA fell from 2.9 million barrels per day (mb/d) in 2003 to 2.5 mb/d in 2016. In Indonesia, domestic production dropped nearly 40 percent since 2000 (IEA, 2016). Oil accounts for 11.49% of the electricity generation mix in Indonesia (Seah, 2014; Thomas, 2017). Outside of Java, Indonesia's central and most populous island, oil fuels account for 62% of energy production. Fuel oil is a massive cost for electricity generation in Indonesia, with the national energy company reporting that diesel accounts for 28% of the total costs for electricity generation (PLN, 2016). The average generation cost for fuel oil is 3,286 Indonesian rupiah (rp) per kilowatt-hour (Kwh) (ESDM, 2016). Comparatively, the generation costs for coal are 719.52 Rp/Kwh and 1,159.2 Rp/Kwh for combined cycle natural gas. If it was not for the government subsidies of 101,207 billion Rp in 2013, the national electricity company in Indonesia would

have run with a 64,714 billion Rp loss (Statistics Indonesia, 2016). In 2014, fuel oil subsidies accounted for nearly 18 percent of government budget expenditures (Seah, 2014).

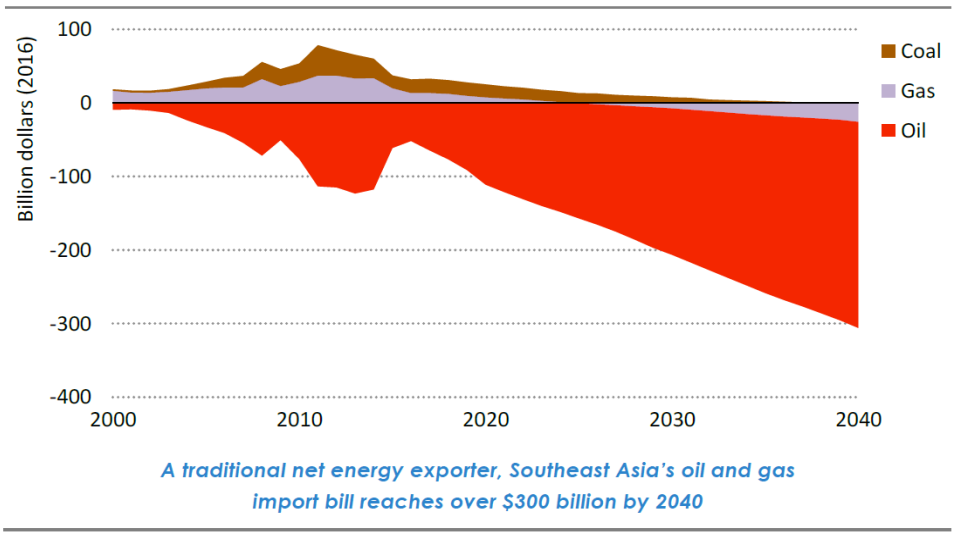

Figure 2 - Fossil Fuel Trade Balance in Southeast Asia in the New Policies Scenario Source: IEA (2017). All rights reserved.

The use of fuel oil, and its associated costs, is a significant obstacle for increasing electricity generation capacity, particularly in the more peripheral regions in SEA. Like Indonesia, fossil-fuels are subsidized in Brunei, Malaysia, Myanmar, Thailand, and Vietnam (IEA, 2017b). In Myanmar, mini-grids, that run on diesel generators in rural areas disconnected from national grid infrastructure, can cost around two to five US dollars a month for a couple hours of electricity during the evenings (Rabin and Madden, 2015). Such costs can be 10 to 20 times the cost of government subsidized grid infrastructure. In addition to being expensive, diesel generators produce sulfur and nitrate oxide emissions that are harmful for public health. The use of fuel oil and coal for power generation, particularly in Indonesia, persists despite large reserves of natural gas found in SEA. Natural gas is both cheaper and produces almost negligent sulfur and nitrate oxide emissions in power production. A lifecycle assessment by PACE Global found that LNG fired power plants produces on average two and half times less lifecycle climate

emission than newly built coal-fired power plants[1] (PACE Global, 2015). Furthermore, a report by the global energy consultancy, Wood Mackenzie, estimated that replacing half of the current oil product consumption with LNG in the eastern parts of Indonesia would save the government nearly US$ 365 million per year in fuel procurement costs[2] (WoodMackenzie, 2015).

Despite being the 14th largest holder of proven natural gas reserves in the world, nearly 45 percent of Indonesia's natural gas production is exported by pipelines to Singapore and by the seaborne transport of LNG (CIA 2017; IEA, 2017c). Until 2006, Indonesia was the largest exporter of LNG in the world since the 1980's (Seah, 2014). When the first LNG production terminals in Indonesia were being developed, authorities perceived gas fields to be too far away and domestic demand to be too insufficient to warrant the development and financing of pipelines (Mehden and Lewis, 2006). Instead natural gas was to be liquefied, by cryogenically cooling it to -162°C, which reduces its energy density 600-fold. LNG could then be shipped on carriers with specially designed cryogenic containment systems to high-income markets in Japan, where it would be re-gasified with vaporizer systems and shipped through pipelines to end users (electricity generation, industry, heating, cooking, etc.). In addition to Indonesia, Malaysia and Brunei have historically exported LNG to markets in Japan and North Asia (Corbeau et al., 2014).

Liquefying natural gas is a technological and capital-intensive process. First, the natural gas must be refined so that CO_2 and H_20 molecules, which may freeze during cooling, are removed (Tusiani and Shearer, 2007). In addition, propane and butane molecules are removed and used for different value chains, such as bottled propane. Then natural gas must be passed through a heat exchanger where it is cooled and liquefied. The LNG is then stored in large, insulated storage tanks and transported in carriers. However, while the storage tanks and LNG carriers are

[1] However, the report bases its assumptions on the EIA and EPA estimates of fugitive methane leakage. Methane is nearly 84 times a more potent greenhouse gas than CO2. EIA and EPA estimates have been critiqued for underestimating methane emissions from North American natural gas systems (Brandt et al., 2014).

[2] At an oil price of US$ 85 a barrel.

well insulated, LNG does eventually boil off. The boiled off gas must then be reliquefied or used as an energy fuel, further increasing the operating costs for storing and transporting LNG. Ledesma (2016) estimates that nearly 12.5 to 19.5 percent of gas is lost in the LNG value chain. Compared to other hydrocarbon value chains, the LNG value chains are significantly risky, costly, and inefficient (Zalik, 2008). Despite this contradiction, capitalism makes LNG value chains work, because natural gas is comparatively cheaper to extract, produce, and is relatively abundant compared to oil (resulting in lower market prices) (Bridge, 2004).

The Indonesian government, led by the autocratic regime of president Soeharto, used export revenues from LNG to consolidate political power as revenues were directed to rural development schemes, infrastructure spending, and fuel oil subsidies (Aspinall, 2013). The history of LNG in Indonesia reflects a situation where state development strategies in natural gas resource rich countries in Southeast Asia has been limited to what Jessop and Sum (2006) term as "exportism." This situation is similar in Myanmar where nearly 80 percent of its natural gas production was exported to China and Thailand, while only 31% of its populations had access to electricity in 2012 (Dobermann, 2016). A key challenge is that populations in Myanmar and Indonesia are dispersed geographically, and building natural gas pipelines to small demand centers would be more expensive than using fuel oils (Seah, 2014). However, while some peripheral markets in SEA may not be accessible by pipelines, technical advisors at DNV GL calculated that the costs of supplying natural gas to small demand centers could be reduced through small scale LNG supply chains (Choy, 2011).

Despite the technological and economic feasibility of delivering LNG to domestic markets in SEA, Corbeau and Ledesma (2016) claim that the LNG industry has historically been an exclusive club. LNG trade has traditionally consisted of long-term bilateral agreements between a few selling consortiums governed by international, national oil companies, and buyer consortiums governed by buyers with regulated monopolies in high-income, urban markets. The sheer costs of developing liquefaction facilities and transporting LNG ensured that only a few

countries stood for the brunt of LNG supply and consumption[3]. High costs entailed that to reduce the per-unit costs of LNG, producers had to generally rely on economies of scale by increasing the size of the liquefaction terminals, ships, and import terminals (Songhurst, 2014). To secure financing for large infrastructure projects, investment decisions have traditionally been underpinned by guaranteed revenue streams via take-or-pay clauses in long-term contracts (Corbeau, 2016a). Take-or-pay clauses obligate buyers, usually regulated natural gas utilities, to pay for contracted volumes of LNG over a 15 to 20 year period, even if the buyer does not need these volumes.

Take-or-pay forces the buyer to assume the risk of investments in LNG production facilities, transport, and import terminals by guaranteeing to pay regardless of the actual market demand over a long-term period (Jensen, 2004). By agreeing to take-or-pay conditions, energy systems become locked into long-term contracted import quantities. If energy consumption falls, for example during a recession, weather changes, sudden prices change, etc., then buyers are obligated to pay for annual contracted quantities even if they are not needed (Corbeau, 2016b). In addition, buyers have historically been forced to sign destination clauses in LNG supply contracts, which prohibited them from reselling in markets other than the ones contracted. By agreeing to such contract obligations, governments are at risk of locking in their energy systems to long-term imports despite volatile prices swings in energy markets. In high income countries such as Japan, where markets are dominated by regulated monopolies, utilities can pass costs and risks onto customers (Jensen, 2004). However, in most Southeast Asian countries, except for the Philippines and Singapore, electricity prices are capped at subsidized tariff rates, and governments in these countries would bear significant market risks by signing take-or-pay clauses. In addition, LNG buyers in emerging economies were deemed insufficiently creditworthy for LNG trade and were generally excluded from accessing LNG supplies by traditional LNG producers (Corbeau, 2016b).

[3] In 1971 there were only six importing countries and three exporting countries, and the number only rose to eleven importing and twelve exporting in 2000 (Corbeau and Ledesma, 2016).

Another key challenge of developing LNG markets, particularly in Asia, is that LNG supply is priced according to oil indexes. Early buyers of LNG in Asia were mainly concerned with replacing crude oil imports with LNG. Therefore, in the absence of reliable price benchmarks and spot markets, LNG buyers and producers agreed upon linking the price of LNG to imported crude oil based on a slope, which entailed that sellers were protected against low oil prices and buyers were protected against large increases in oil prices (Stern, 2014). Since 2000, there has been a shift away from pricing mechanisms based on oil indexation to "gas-to-gas competition" in Europe and the USA (Ten Kate et al., 2013). "Gas-to-gas competition" is a pricing mechanism indexed to prices reported by traders through market exchanges. However, oil indexation continues to dominate markets in Asia. The consequence of regionally differentiated pricing regimes is that Asian, European, and American gas markets are not fully integrated, and Asian consumers have historically paid significantly higher prices for natural gas than American and European buyers (Stern, 2014). Before the 2014 oil price crash, LNG supply for electricity generation had been considerably more expensive than coal fired power plants in SEA due to oil indexation in the LNG industry.

While take-or-pay clauses, destination clauses, and oil indexation in long-term LNG contracts have entailed the exclusion of low and middle income markets in SEA, the LNG industry and natural gas markets are currently evolving. As a result, new opportunities for market development in low and middle income markets are emerging. The global LNG industry has witnessed a significant expansion of trade from 100 million metric tons per annum (MTPA) in 2002 to 248 MTPA in 2015 (Bridge and Bradshaw, 2017). This growth has mainly been achieved through the expansion of LNG production in Qatar and Australia in addition to smaller exporters that have entered the market. Whereas LNG markets have traditionally been exclusive to a few high income countries, the number of LNG importers has increased from 11 countries in 2000 to 35 countries in 2016 (Corbeau, 2016a). The increase in exporting and importing countries has greatly increased the liquidity of LNG markets, possibly resulting in greater LNG supply contract flexibility. In the early years of the LNG industry, take-or-pay obligations represented between 90

and 100 percent of contracted volumes. However, spot (single cargo) and short-term (four years or less) trades increased from five to 28 percent of global trade between 2000 and 2015 (Corbeau, 2016a). The growth in spot markets has allowed buyers to reduce take-or-pay obligations by purchasing LNG through spot trades and short-term contracts (Stern, 2014).

The growth in spot markets has developed particularly as countries such as Qatar and Australia began to expand and build LNG terminals without fully dedicating production capacity to specific long-term contracts. Based on increasing liquidity and expected sales in the United States and North Asia, producers intended to sell LNG through spot markets (Corbeau, 2016a). Spot markets grew particularly after the shutdown of nuclear plants in Japan after the Fukushima disaster in 2011, leading to an increase in demand. Nevertheless, spot trades and short-term contracts have traditionally been priced at much higher premiums than long-term contracts (Stern, 2014). Since 2014, however, premiums for spot cargos and short-term contracts have decreased signifncant due to the oversupply of LNG in global markets. This decrease in spot market prices is the result of the boom in domestic shale gas production in the US, which was previously expected to be a significant importer of LNG and the stagnation of LNG demand growth in Japan and South Korea since 2014 (Bridge and Bradshaw, 2017; Corbeau and Ledesma, 2016). Japan, the largest LNG importer with 88.9 MPTA (second largest is South Korea at 38 MPTA), is restarting its nuclear reactors after the Fukushima disaster in 2011. South Korea is also building new nuclear reactors and is expecting to lower the demand for LNG. Bridge and Bradshaw (2017) argue that these events constitute significant shocks to the traditional practices by which LNG has been traded.

Global overcapacity and sudden price changes have led to emerging imperatives for market development in low and middle-income countries. As seen in Figure 3, the International Energy Agency (2017a) forecasts that LNG imports are expected to shrink in OECD countries, while LNG imports in non-OECD countries is expected to increase significantly. In addition, changes in the LNG industry have shifted in

power from LNG producers to buyers. Whereas producers previously maintained tight control over the value chain through take-or-pay contracts and destination clauses in LNG contracts, the growth of spot markets and increasing liquidity in LNG markets is resulting in shifting power relations in LNG supply contract negotiations. Buyers like Tokyo Electric Power Co. and Chubu Electric power have refused to sign destination clauses. Furthermore, buyers are leveraging purchasing power through low prices on LNG spot markets to reduce take-or-pay commitments (Corbeau et al., , 2014).

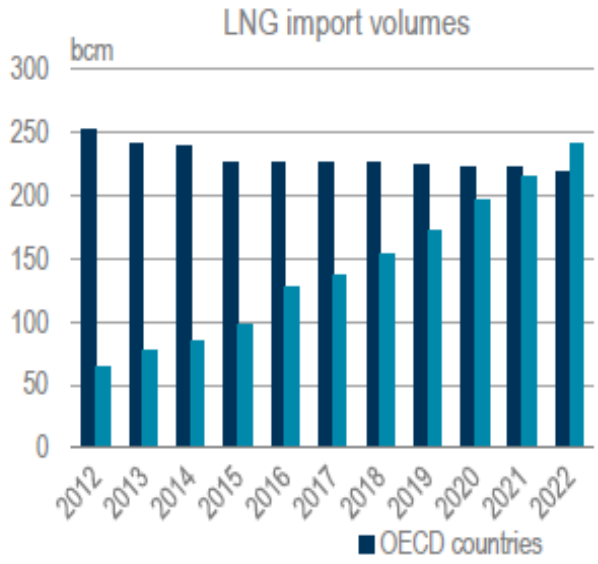

Figure 3 - World LNG Imports, OECD and Non-OECD, 2012-22. Source IEA (2017a). All rights reserved.

The sharp growth in LNG production capacity has led several Southeast Asian countries since 2011, to start importing liquefied natural gas. Figure 4 below shows that the largest change in LNG demand between 2016 and 2022 will be in non-OECD Asia. Thailand was the first nation to commission an LNG receiving terminal in 2011, followed by Indonesia, Singapore, and Malaysia. The importation of LNG in Southeast Asia is driven by several factors, including concerns over energy access and energy security. While Indonesia is a large LNG exporter, it has high economic growth, and its current president, Joko Widodo, has campaigned on

reducing Indonesia's economic reliance on commodity exports in favor of domestic infrastructure and industry development (Seah, 2014). However, Indonesia continues to be bound to long-term natural gas export agreements and lacks domestic pipeline infrastructure from fields to markets, particularly in the more peripheral regions of their territories where energy access is low and expensive. Indonesia is, therefore, planning to develop domestic LNG infrastructure as an alternative to building pipelines in addition to importing LNG to meet demand and to continue to uphold export agreements. However, at the same time several export agreements are expected to expire, and Indonesia is planning to increase domestic market obligations for new natural gas production projects (Purwanto et al., 2016).

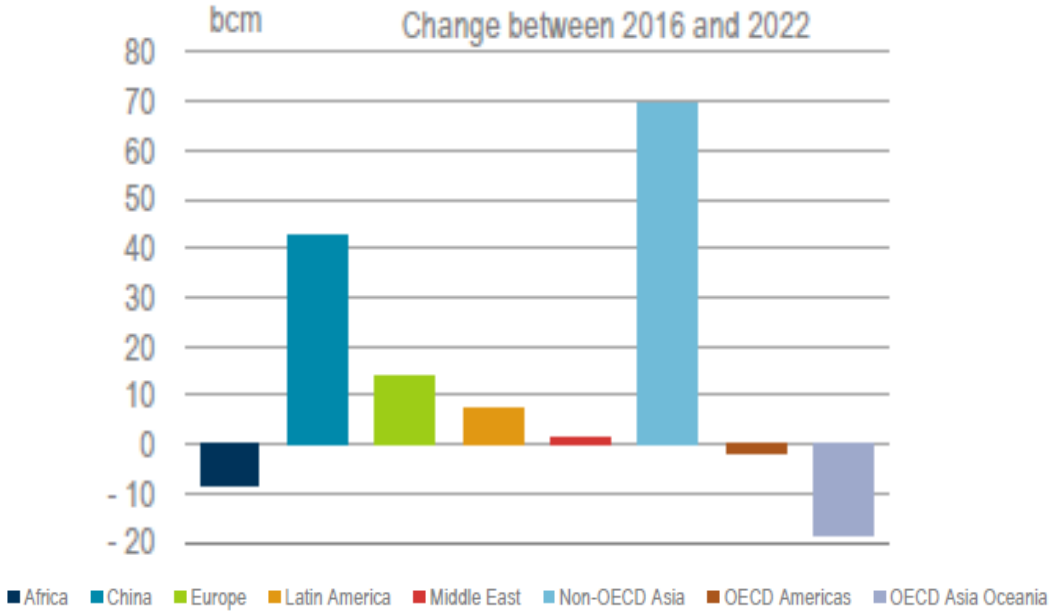

Figure 4 - World LNG imports by Region, 2012-22. Source: IEA (2017). All rights reserved.,

Thailand and Singapore rely heavily on natural gas for electricity generation and are also primarily dependent upon Myanmar and Indonesia respectively for natural gas imports through pipelines (Sovacool, 2009). Both countries have drawn concern at expiring natural gas contracts and geopolitical tensions. As

discussed in the research articles, Singapore and Thailand are importing LNG from multiple sources, including the USA, Qatar, and Australia, to address energy security concerns. Liquefied natural gas production capacity is expected to increase significantly resulting in substantial global overcapacity that will put pressure on long-term contracts and prices on LNG supply contracts. A 2018 report by DNV-GL expects that global LNG export capacity will increase by 45% between the years 2017 and 2022, with 90% of this capacity coming from projects already sanctioned in the US and Australia. The increase in capacity is driving the spatial expansion of LNG trade, particularly to markets in low and middle-income countries. The map in Figure 5 shows both existing and planned LNG infrastructure in Southeast Asia.

The consequence of evolving imperatives for market development in emerging economies is that traditional organizational arrangements in the LNG industry are evolving as LNG producers seek to avoid trading risk on spot markets by selling LNG on long-term contracts to previously excluded commodity traders (Bridge and Bradshaw, 2017). Traders are willing to mitigate risk by arbitraging opportunities between regional markets and through speculative instruments in financial markets (Ziomas, 2017). In this way, the bordering-process that traditionally excluded emerging economies such as Indonesia from LNG markets are being extended as new practices are reshaping the relationship between buyers and sellers in terms of contract flexibility and pricing (Berndt and Boeckler, 2012). Based on these events, there is a need for research on the implications of the globalization of LNG for energy development and policies in Southeast Asia.

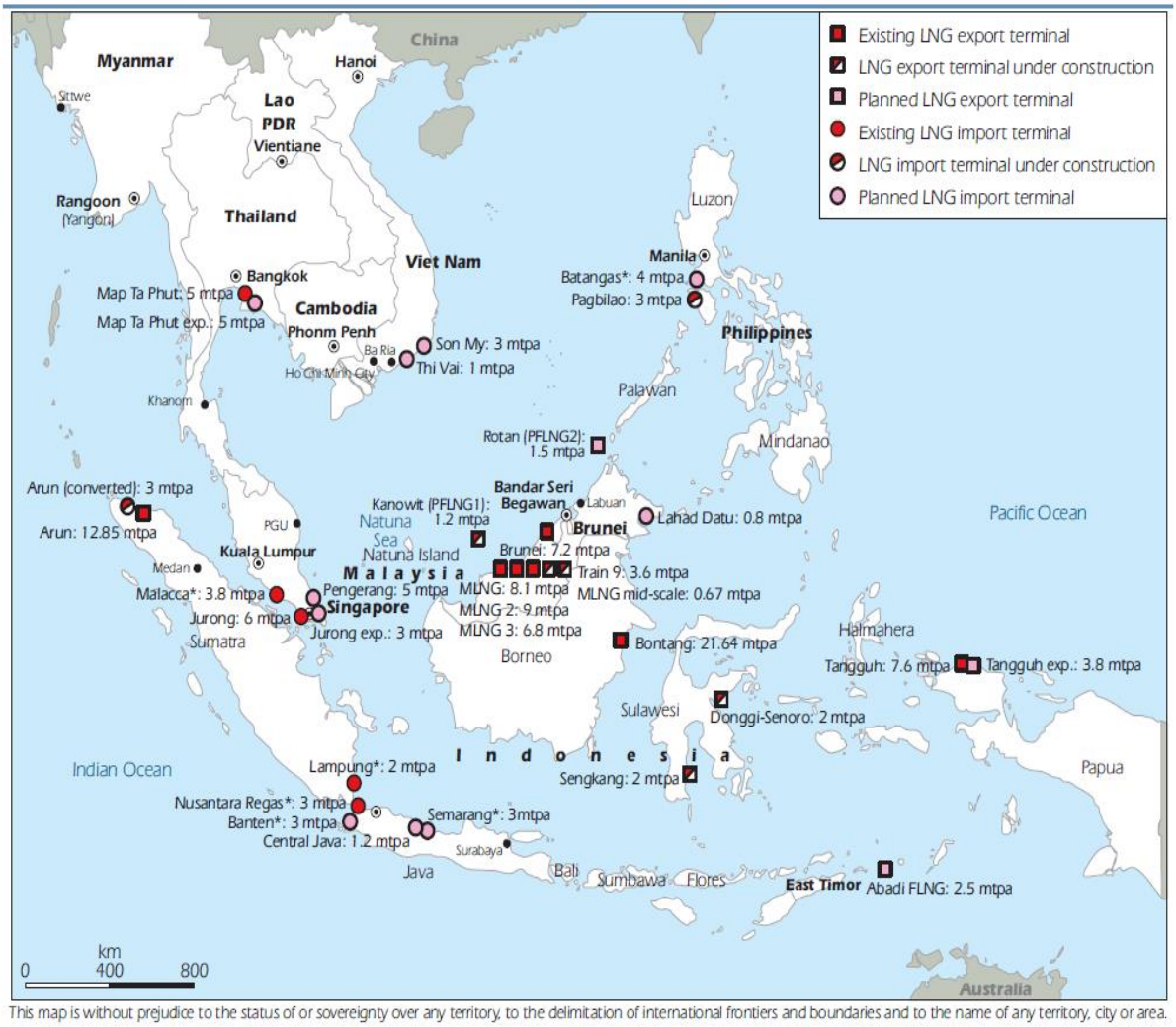

Figure 5 - LNG terminals in the ASEAN. Source: IEA, Corbeau et al. (2014), All rights reserved.

1.2. Theoretical Ambitions

The main aim of this thesis is to explain the situation surrounding natural gas markets, globalization, energy development, and energy politics in Southeast Asia. Specifically, the thesis considers the intersection between the spatial and organizational evolution of LNG markets and state strategies for energy development and market reform. The systematic analysis of this thesis draws on literature from the fields of economic geography and energy geography (Among others: Coe and Yeung, 2015; Bridge and Bradshaw, 2017; Smith, 2015; Huber, 2018; Bridge et al., 2018; Bridge, 2008). Specifically, the current research project draws upon several key concepts, including global production networks, territoriality, and materiality. By utilizing these concepts, this thesis frames the globalization of LNG markets in terms of the evolutionary dynamics that are reconfiguring the territoriality of natural gas markets and how these dynamics both shape and are shaped by emerging spatial and interorganizational arrangements in global production networks.

Natural gas is a relatively under researched sector in both economic geography and energy geography. Sica (2018a) explains that in both energy studies and energy geography, natural gas tends to be either relatively neglected compared to oil-related discussions or conflated with oil in broader discussions regarding fossil fuels. Despite the relative neglect of natural gas, geographers such as Carlo Sica (2018a; 2018b), and Michael Bradshaw and Gavin Bridge (2017) have provided detailed and systematic analyses regarding the evolving territoriality and politics of natural gas energy systems. According to Bridge et al. (2013) focusing on the territoriality of energy systems, such as natural gas, "draws attention to the different scales and arenas of political action that govern energy systems because of the way they are spatially constituted." Bridge and Bradshaw (2017) provide the first systematic analysis within economic geography on the globalization of the LNG sector and its influence on global gas markets. Bridge and Bradshaw explain that the globalization of natural gas markets can be best understood through the

dynamics by which the organizational structures and coordinating strategies between firms in LNG production networks are evolving. In addition, Bridge and Bradshaw explain that the "materiality" of natural gas, in terms of the material transformations that occur through liquefication and regasification, enables and shapes the dynamics by which LNG production networks have emerged and are evolving. These evolutionary dynamics are subsequently reconfiguring the territoriality of global gas markets.

While the empirical analysis in this thesis draws upon the notions of GPNs, territoriality, and materiality to account for the globalization of natural gas markets, the empirical analysis in the three research articles points to the limitations of current literature and conceptualizations in these fields. Specifically, in the three research articles I suggest that there is a need to a) further conceptualize the political and institutional dynamics by which GPNs evolve and the capacity of states to shape the evolving territoriality of natural gas markets, b) further conceptualize the different modalities of power (both topological and territorial) by which powerful actors reproduce their control and authority over energy resources and infrastructure, and c) develop a more dynamic conceptualization of materiality in the GPN approach.

This research project addresses the current conceptual limitations described above by drawing on assemblage and topological thinking as developed by Gilles Deleuze (1994), Manuel DeLanda (2016), and John Allen (2016). In doing so, I aim to make several conceptual contributions to economic and energy geography. Specifically, I draw upon assemblage and topological thinking to discuss the status of mind-independent existence of properties and events and the relations between properties and capacities in self-organizing, complex systems. Furthermore, I discuss the ontological and epistemological implications of assemblage and topological thinking for considering globalization and the implications for development in economic and energy geography. Therefore, in addition to the empirical aims, this thesis also has a main theoretical ambition to demonstrate how assemblage thinking can give analytical purchase for more dynamic and non-

linear conceptualizations of globalization in geography. In the theoretical discussions in this thesis, I suggest that markets, states, global production networks, etc. can be conceptualized as assemblages that are emergent, yet irreducible to their component parts, but at the same time would cease to exist if the parts stopped interacting with each other. This overarching ontological position not only understates the conceptual relatedness of all three articles in this thesis, but also their empirical relatedness which will be elaborated upon in the chapter 4 in this thesis.

1.3. Research Questions and Introduction to Articles

In line with the theoretical ambitions and the main aim of explaining the situation surrounding natural gas markets, globalization, energy development, and politics in SEA, this thesis intends to answer the following main research questions:

> **Main Research Questions:** What are the dynamics by which natural gas trade and markets are globalizing? To what extent is this globalization limited? What are the implications of these dynamics and limitations for energy development and politics in Southeast Asia?

To answer these main research questions, this thesis draws upon three case studies in Singapore, Thailand, and Indonesia. These case studies are incorporated in three research three articles that constitute the core of this thesis. Each one focuses on different yet related research questions. This thesis is not designed as a cross-comparative analysis of case studies in different countries. Rather, the thesis intends to explore how the seemingly different situations described in the cases in Singapore, Thailand, and Indonesia are interrelated and the implications of these relations for the dynamics by which natural gas markets are globalizing. Furthermore, I draw upon assemblage and topological thinking to answer the research questions in each of the three research articles. In doing so, I aim to demonstrate the analytical value of assemblage and topological thinking for economic and energy geography. The research questions addressed in the articles are as follows:

> **Research Question 1:** How are public and private actors in global cities shaping the evolutionary trajectories of LNG production networks by reassembling unbundled authorities that were formerly exclusive to the nation-state?
>
> **Research Question 2**: How do state-owned natural gas companies utilize different modalities of power to reproduce their monopoly over natural gas markets despite liberalization attempts by authorities?
>
> **Research Question 3**: How does the materiality of natural gas constrain and enable political and energy development outcomes in dynamic liquefied natural gas production networks?

Article 1, labelled the Singapore article, is titled *The Singaporean Gas Hub: Reassembling Liquefied Natural Gas Production Networks and Markets in Asia.* In the Singapore article, I address the first research question by drawing upon a case study of the efforts of public and private authorities in Singapore to establish a hub for LNG trading. I suggest that through the initiative to establish an LNG trading hub for Asia, public and private authorities are attempting to shape the globalization of LNG markets, which are currently limited due to the lack of standardized pricing regimes and immature market places in Asia. I find that due to Singapore's small market size, the capacity of Singapore to establish an LNG hub is dependent upon establishing connectivity with countries in Southeast Asia.

Article 2, labelled the Thailand article, is titled *The 'Changing Same of Power': Contentious Politics and Natural Gas Market Liberalization in Thailand.* In the Thailand article, I address the second research question by drawing upon a case study of market liberalization reforms in the Thai natural gas sector. I explain that despite multiple reform efforts since the 1990's, the partially privatized, state-owned natural gas company, PTT, in Thailand continues to hold an effective monopoly over natural gas markets in Thailand. To explain why market liberalization efforts have failed, I discuss the contentious politics by which the authority and sovereignty of the Thai nation-state over natural gas markets has historically and continues to be transformed and contested. I find that PTT quietly works through regulations, long-term contracts, and pricing regimes to reproduce its control over natural gas markets in Thailand.

Article 3, labelled "the Indonesia article" is titled *State Strategies and Materiality in Dynamic Liquefied Natural Gas Production Networks*. In the Indonesia article, I address the third research question through a case study of an LNG supply tender to 21 power plants across the islands of Kalimantan, Sulawesi, and Nusa Tenggara. I explain that although Indonesia has historically been one of the largest LNG exporters in the world, domestic markets have been excluded from LNG production networks due to the materiality of natural gas and the relations of production that traditionally made value creation from natural gas possible. Such relations of production in LNG production networks are nevertheless being transformed by the emergence of more organizationally fragmented and spatially diverse production networks. In this context, the Indonesian government has sought to rearticulate Indonesia as a significant LNG consumer in production networks. I find that state strategies are limited as the materiality by which such strategies are potentially realized contradict the dynamics by which LNG production networks are evolving.

1.4. Structure of the Thesis

The thesis is comprised of two parts and is organized in the following way. The first part includes a comprehensive introduction that elaborates on the theoretical and methodological aspects of the thesis. I addition, I discuss the key findings and overall conclusions of the thesis. In the theoretical chapter (Chapter 2), I introduce the reader to the concepts of territoriality and global production networks, address the limitations of current conceptualizations, and outline the analytical purchase of assemblage and topological thinking. In the methodology chapter (Chapter 3), I outline the research process, my methodological choices, and the epistemological implications of assemblage thinking for analyzing the empirical data. In the concluding chapter (Chapter 4), I summarize the key findings from the three research articles, outline the overall conclusions of the thesis, and provide directions for further research. The second part of the thesis comprises of the three research articles described in section 1.3.

Theoretical Perspectives 2

This chapter introduces the main theoretical perspectives used in this thesis to explain the dynamics by which natural gas markets are globalizing, the extent to which this globalization is limited, and the implications for developmental and political outcomes in Southeast Asia. I begin by discussing the limitations of current literature on the globalization of natural gas markets, which draws primarily upon neoclassical-economic approaches. I then explain how the globalization of natural gas markets may be better understood through relational thinking, particularly through the concepts of materiality, global production networks, and territoriality. While relational thinking can be useful, I discuss the critiques made by critical realists in geography of relational approaches that have a basis in the ontology of actor-network theory. I agree with the call by these scholars for realism in relational thinking. However, I point to the limitations of critical realist approaches and introduce assemblage thinking as an alternative realist ontology that can give analytical purchase to relational thinking in economic and energy geography. The theoretical arguments developed in this chapter are intended to give further grounding to the theoretical frameworks developed in the research articles.

2.1. Materiality and the Limits of Neoclassical Economics

Asking "what makes commodities global?" may seem like a good starting point for discussing the globalization of LNG trade. Several reports from independent research centers take a neo-classical economics approach to outlining the globalization of LNG. First, these reports highlight the importance of open and competitive markets enabling enables buyers and sellers to set commodity prices without government interference (i.e., tariffs and price caps) (Jensen, 2004; Ten Kate et al., 2013). Second, these reports envision a shift away from inflexible destination clauses and long-term contracts that constrain the trading of commodity on a single-cargo (spot) or short-term (two to four year) basis (Corbeau, 2016b; Corbeau et al., 2014). Third, these reports envision the establishment of global price benchmarks for commodity trading on spot markets that represent supply/demand market fundamentals (Stern, 2014; Stern, 2016). Finally, the accounts by the research centers foresee interlinkages with financial and emerging market places for financial risk management instruments such as derivatives and swaps (Fulwood, 2018; Heather, 2016). Figure 6 exemplifies how the evolution of natural gas markets is modeled.

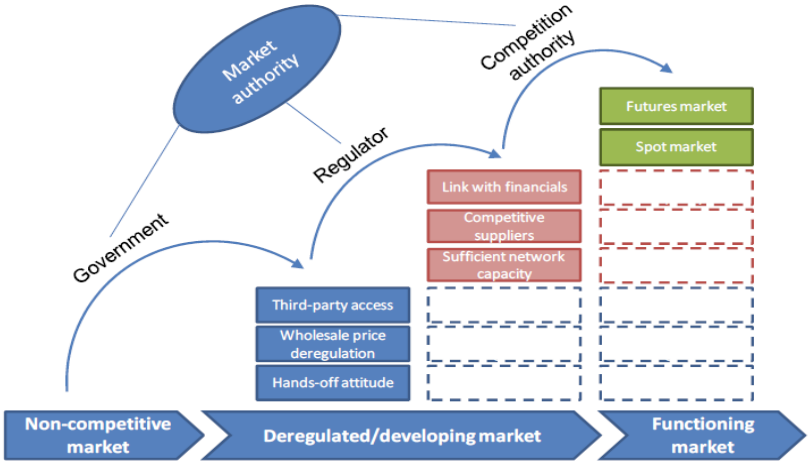

Figure 6 - Creating a competitive wholesale natural gas market. Source: IEA, Ten Kate et al. (2013). All rights reserved.

While the above-mentioned literature provides neat and deterministic models on how global commodity markets emerge, natural gas is difficult to commoditize due to its physical properties. Natural gas has an energy density of .0364 megajoules per liter (MJ/L). Comparatively, crude oil, which is a globally traded commodity, has an energy density of 28 to 31 MJ/L (Tusiani and Shearer, 2007). The consequence of the low energy density of natural gas is that large quantities of natural gas need to be transported to operate power plants at the same efficiency as other denser fossil fuels. The low energy density of natural gas is related to the materiality of its production, transport, and consumption.

Birch and Calvert (2015) suggest that by drawing attention to the "materiality" of resources, researchers can better explain how the properties of materials influence relations of production and how these relations of production enable and constrain political-economic possibilities, such as commodification. Commodification, according to Bakker (2006), entails the creation of an economic good through the application of mechanisms intended to appropriate and standardize a class of goods, thereby enabling these goods to be sold at a price determined through markets exchanges. Bakker further explains that:

> Commodification is a process whereby goods, formerly outside marketized spheres of existence, enter the world of money and, as such, is multidimensional: *Socioeconomic*, entailing changes in pricing, charging methods, and allocation and exchange mechanisms; *discursive*, entailing transformations in the identities of values ascribed to natural objects such that they can be abstracted from their biophysical context, valued and displaced, and *material*, entailing physical interventions and adaptions such that desired nature can be alienated from their context as standardized goods. (545)

Certain materials can be *uncooperative* to commodification due to their biophysical properties constraining their commercialization. Water, according to Bakker (2003), is an example of an uncooperative commodity due to its "density." It is a heavy substance that is expensive to transport relative to its value and requires large-scale capital investments in infrastructure networks as well as being a highly localized resource. Similarly, Bridge (2004) explains that the low-energy density of natural gas entails that its transport requires both large-scale capital investments

and requires the "labors of science, capital and law" (396). Bakker and Bridge (2006) suggest that studies of the materiality of resources addresses the analytical significance of differences in the material world that enables and constrains social relations necessary for resource production and commodification.

In the case of natural gas, instead of asking "what makes commodities global," a more precise and relevant question would be "what are the relations of production that make commodification and globalization possible, and to what extent does the materiality of resources enable and constrain such outcomes?" One way to answer such a question is by conceptualizing global production networks (GPN). Dicken (2004) explains that, by itself, quantitative data such as trade and investment flows between nations does not necessarily prove the globalization of commodity and service trade in the world economy. Early globalization sceptics, such as Hirst and Thompson (1992), showed that the international economy was subject to similar periods of internationalization of trade, capital flows, and the monetary system from 1870 to 1914. While this may have been the case, Dicken (2004), nevertheless explains that the integration of the global economy can be accounted for by recognizing significant qualitative changes in the stretching and intensification of economic relations within the global economy. Through the GPN approach, Dicken and other geographers have sought to account for globalization by drawing upon a relational approach that focuses on the stakeholders and their relationships involved in the production and distribution of commodities in the global economy (Hudson, 2008; Murphy, 2012; Henderson et al., 2002). One of the main arguments of GPN scholars is that by identifying the dynamics of global production networks, one can better understand how global capitalism both structures and is structured by GPNs.

The GPN approach entails that the "globalization" of commodities is not realized simply through the internationalization of production and trade, but through the functional integration of inter-organizational relationships in the global economy through which value creation and value capture is unevenly distributed (Coe et al.,

2008). In the next section, I elaborate on how relational thinking and the GPN approach can be used to better account for globalization.

2.2. Global Production Networks

For the past couple of decades, economic geographers have drawn upon relational approaches to understand the globalization of the production and consumption of commodities and services occurring since the 1980's (Peck and Yeung, 2003; Dicken et al., 2001; Henderson et al., 2002; Coe et al., 2004). Relational thinking emphasizes how people and places are connected across space and time, and how goods, information, and capital flows are channeled through these relationships. According to Dicken and Malmberg (2001), relational thinking can be useful to explain the dynamics by which the internal and external power structures of firms become configured and reconfigured through corporate decision-making. In addition, relational thinking can account for the spatial outcomes that result from the interdependent strategies of key firm and non-firm actors (states, civil society organization, multilateral institutions, etc.) who shape the global economy (Dicken et al., 2001; Coe et al., 2004). Relational networks are conceived as both social structures and ongoing processes that are constituted, transformed, and reproduced through asymmetrical power relationships between intentional corporate actors, their intermediaries, as well as a wider range of entities such as states, global regulatory bodies, and civil society organizations (Henderson et al., 2002; Coe et al., 2004; Hess, 2008).

Global production networks (GPNs) emerged from relational thinking in economic geography as a heuristic framework that accounts for the web of international economic relationships through which commodities and services are produced, distributed, and consumed (Hess, 2016; Peck and Yeung, 2003; Henderson et al., 2002). Similar approaches, such as global value chains (see Gereffi et al., 2005), focus on the linear stages of activities in the global economy that results in final commodities. The GPN approach, instead, seeks to understand how flows of materials, design, knowledge, services, etc. are organized horizontally, vertically, and diagonally through inter-organizational networks

across geographical locations (Henderson et al., 2002). Furthermore, the GPN approach has sought to explain how global production networks operate through and are embedded within wider structures of social, economic, and political rules, procedures, and conventions (Dicken 2004). The aim of this research is to explain the global dynamics of uneven development by exploring how value is created, enhanced, and captured as territorially embedded assets, such as labor or natural recourses, are coupled to GPNs (Coe et al., 2004).

In the Indonesia article I explain that, originally, the relational ontology of the GPN approach was partially based on that of actor-network theory (ANT). Henderson et al. (2002) explain that ANT "emphasizes the relationality of both objects and agency in heterogenous networks, pointing out that entities in networks are shaped by and can only be understood through, their relations and connectivity to other entities" (442). GPN scholars originally suggested that ANT could be used to conceptualize international business activities as being performatively affected by the interorganizational practices that shape relationships between actors (corporations, states, unions, NGOs, etc.) and the technologies/material objects these actors use to engage in such practices (Henderson et al., 2002; Dicken et al., 2001). Through this network approach, GPN scholars suggest that the power of actors, both firm and non-firm, to control material and immaterial resources and capture value, is constituted by an actor's positionality within networks (Coe et al., 2008). Several GPN scholars have drawn upon the notion of materiality to account for the co-constitutive relationships between material scarcity or material resistivity with firm strategies in GPNs (Gibson and Warren, 2016; Bridge, 2008; Irarrázaval and Bustos-Gallardo, 2018).

Scholars have noted that emerging organizational and spatial relations in global production networks have causal powers and emergent affects that are greater than the sum of the individual actors who constitute networks (Dicken et al., 2001; Coe and Yeung, 2015). Yeung (2005) notes that relations between actors, such as firms, constitute specific relational geometries that lock firms into ongoing power relationships and dependencies. In turn, these relational geometries produce

concrete spatial and organizational outcomes among the actors who constitute these relational geometries. The territoriality of GPNs is emergent through the processes and scales by which actors exercise power through relational geometries (Coe and Yeung, 2015).

Bridge and Bradshaw (2017) suggest that the GPN approach can be used to understand how the territoriality of natural gas markets, in terms of the authority and control over natural gas resources and infrastructure over space, emerges from the coordinating strategies of firms, extra-economic actors, and intermediaries in global production networks. In their systematic analysis of evolving LNG production networks, Bridge and Bradshaw (2017) demonstrate that the globalization of natural gas markets is related to the evolution of LNG production networks from a:

> …floating pipeline model of point-to-point, binational flows orchestrated by producing and consuming companies and governed under long-term contracts, to a more geographic and organizationally complex production network that is constitutive of an emergent global gas market (215).

Going beyond the analysis of patterns of natural gas trade, as is common in neoclassical economist inspired studies, Bridge and Bradshaw (2017) utilize the GPN approach to explain how significant changes in organizational structures and emerging territorial forms are integral to the ways in which natural gas markets are becoming global.

In line with the research of Bridge and Bradshaw, this thesis uses the GPN approach to explain how the territoriality of global gas markets is evolving. In the Indonesia article I use the GPN approach to explain why the capacity of the Indonesian state to realize state strategies for creating domestic markets for LNG is constrained by organizational and spatial arrangements in GPNs. I explain that uncooperative materiality of natural gas and the interorganizational arrangements that make value creation from natural gas possible, entails the exclusion of certain development outcomes from LNG production networks. In the next section, I discuss how an analytical focus on the territoriality of energy systems and energy

transitions can be used to explain the implications of globalizing natural gas markets for energy development and politics in SEA.

2.3. The Territoriality of Energy Systems

Bradshaw (2010a) claims that the world faces a global energy dilemma: "How to satisfy the ever-growing demand for energy without doing comparable damage to the planet's ecosystem" (287). Bradshaw notes that economic globalization is a key driver of the demand for energy services as increasing international trade propels new economic activity in addition to industrialization and urbanization in emerging economies. According to Bradshaw, there is a need for further research on the socio-economic processes that underlie both energy development, economic globalization, and climate change policy as the economies of the global south become the center of gravity for the global energy system. Bridge et al. (2013) claim that meeting global energy challenges will require the transition towards more "sustainable energy systems characterized by universal access to energy services, and security and reliability of supply from efficient, low-carbon sources" (331).

Bridge et al. (2013) suggests that while the current literature on energy transitions provides some clarity to temporal processes behind transitions in a given geographic unit, the organization of energy systems and economic activity within and across space is under researched. Therefore, a better understanding on the spatial dynamics of energy systems is needed. The geography of energy transitions is related to the "distribution of energy related activities across space and the underlying processes that have given rise to these patterns" (Bridge et al., 2013, 333). The shift from coal-fired power development to natural gas-based electricity generations would entail significant energy transitions in the global south (Smil, 2015). In this thesis, in line with other geographers, I argue for the need to understand such transitions in terms of networked geographies of connection, dependency, and control.

Recently, several geographers have argued for a stronger analytical focus on the notion of territoriality in energy systems in order to highlight and problematize the geographical and spatial forms created through energy systems and their transformations (Bridge and Bradshaw, 2017; Bridge, 2018; Bouzarovski et al., 2015). Bridge explains that "focusing on how energy systems are territorialized draws attention to the different scales and arenas of political action that govern energy systems because of the way they are spatially constituted" (Bridge et al., 2013, 336). Territoriality is a particularly relevant concept for energy research as energy systems in recent decades have become increasingly global through growing cross-border energy investments and energy market deregulation (Overland, 2016; Bridge and Bradshaw, 2015). In the natural gas sector, these trends have significant political-economic implications for state authority in relation to energy governance, energy security, and energy access (Bridge and Bradshaw, 2017).

Natural gas energy systems and markets in many countries have been historically territorialized at the scale of, and under the exclusive authority of, the nation-state. Bouzarovski et al. (2015) detail that in the early 1960's, localized municipal systems were gradually consolidated into national-grid systems in Europe. Natural gas systems have also traditionally been territorialized at the scale of the nation-state due to the low energy density of natural gas, and the networked, capital-intensive infrastructure needed for its distribution. Scholars in the neoclassical economist tradition assert that certain markets entail natural monopolies that occur in markets where the average cost of production decreases as output expands (i.e., economies of scale) and where multiple goods can be produced by one firm at a lower total cost than if produced separately by two firms (i.e., economies of scope) (Train, 1991). Natural monopolies in the natural gas sector have historically justified the intervention of governments to regulate natural gas markets, as exemplified by the passing of the 1938 Natural Gas Act in the USA (Sica, 2018b). Furthermore, the cross-border flows and the international trade of natural gas has historically been significantly limited, and today most natural gas is consumed in the country of production (IEA, 2016).

However, while natural gas markets have been traditionally territorialized at the scale of the nation-state, such boundaries are being reconfigured through liberalization, international market integration, and globalization in the form of liquefied natural gas (LNG) trade (Bouzarovski et al., 2015; Bridge and Bradshaw, 2017). Bouzarovski et al. (2015) explain that in the last two decades in Europe, the European Union has been undertaking a set of directives and policies for facilitating the cross-border integration of national gas markets under the governance of a common regulator. Similar processes have occurred in Southeast Asia since the 1990's, where the Association of Southeast Asian Nations (ASEAN) has envisioned the supranational regionalization of natural gas markets through the development of the trans-ASEAN gas pipeline (TAGP) in order to improve the regions self-sufficiency in energy supply (Sovacool, 2009). Despite these efforts, Sovacool (2009) points out that after 26 years, only half of the planned pipelines have been built, and these pipelines have been driven primarily by bilateral trading interests rather than interest in the functional cross-border integration of markets.

Bridge and Bradshaw (2017) explain that these spatial reconfigurations and diversifications in LNG production networks are reshaping the territoriality of natural gas markets. For example, Bridge and Bradshaw explain that the ownership of upstream liquefication facilities is being separated from the ownership of upstream gas supply through tolling or merchant models in LNG production network terminals (Bridge and Bradshaw 2017). These changes have led to a growing number of equity participants in upstream LNG production projects, which subsequently has led to the spatial expansion of LNG terminal development to new exporting countries. The changing territoriality of natural gas markets is discussed particularly in the Singapore article and the Thailand article included in this thesis. In the Singapore article, I discuss how government officials, corporations, and financial intermediaries are attempting to reassemble authorities over natural gas markets, formerly exclusive to the territorial authority of nation-states, by establishing a hub for LNG trading and finance. In the Thailand article, I use the notion of territoriality to explain how the traditional nation-state

authority over natural gas markets is becoming upended due to the importation of liquefied natural gas and its implications for market liberalization policies in Thailand. Both articles demonstrate how the evolving territoriality of natural gas markets intersects with the globalization of liquefied natural gas trade.

Despite the usefulness of the GPN approach and concept of territoriality, I find that the GPN approach has limited explanatory power. In the next section, I draw attention in this theoretical chapter to the limitations of the global production network framework and recent calls by critical realists to further conceptualize causal mechanisms and emergence in relational thinking (Sunley, 2008; Jones, 2009; Coe and Yeung, 2015). Afterwards, I proceed to discuss the similarities and differences between the realist ontology of assemblage thinking and critical realism, and why I suggest that assemblage thinking is better suited to account for the dynamics of change in global production networks. I do this by introducing the reader to assemblage thinking and discussing the potential contribution of assemblage thinking to economic geography.

2.4. Relational Thinking and Realism

The focus on corporate decision-making, agency, and relationships in relational economic geography originally emerged from a dissatisfaction with the structural predetermination associated with macro-process-oriented studies of geographical industrialization (Yeung and Peck, 2003; Jones, 2014). According to Boggs and Rantisi (2003), structure-oriented approaches in economic geography focus on conceptualizing general laws, regularities, and patterns as the structural conditions by which markets reproduce themselves. Spatial entities, such as regions and cities, exist as expressions of such structural conditions. The downside of structural approaches, according to Boggs and Rantisi, is the notion that individual and firm choices follow naturally from identified patterns and relations between structures and agents in closed systems. Bathelt (2006), another scholar in relational geography, claims that traditional approaches in economic geography tend to focus on regions as if “they are actors, while the real agents, i.e. those

people who act and interact in firms and other organizations to produce economic value, are often neglected" (224).

Sunley (2008) claims that by dismissing regularities, patterns, categories, and processes, relational thinking makes it difficult to distinguish between types and forms of relations that are purely incidental and contingent from those that are consequential and causal. Sunley (2008) claims that:

> In reacting so strongly against identifying patterns and structures in economic landscapes and in rejecting both analytical and substantive boundaries, relational economic geography has lost sight of many of the valuable insights of institutionalist and critical realist approaches (3).

By claiming that relations, and not institutional and spatial entities, should be the key foundational unit of analysis, relational thinking has paid little attention to the emergence of economic institutions and their implications for uneven development (Sunley, 2008; Thompson, 2003). According to Sunley, there is a need to account for how geographic entities, such as regions, industrial districts and states, exert causal influence on and allow for interdependencies among their constituent entities. Jones (2009) argues that relational thinking fails to explain the distinctive ways thing are connected, and what it is about related objects that govern their existence through internal and external spatial relationships. Jones cites Malament (1976) who argues: "It must be by virtue of some structural features of the world that material objects, were they present, would enter into certain patterns of relations and not others" (315).

Jessop et al. (2008) suggest that instead of one-side, reductionist accounts of networks, researchers should account for the polymorphic relationships between scales, networks, territories, and places in an analysis of a post-national, unevenly developing global economy. Through the TPSN (territories, place, scales, networks) framework developed by Jessop et al. (2008), the emergence of GPNs and state spatial restructuring could be considered as different, mutually constituted dimensions of socio-spatial relations. In the Singapore article, I aim to explain the agencies and practices that rework nation-state authority over natural gas

markets, and in doing so, they also shape global production networks. I suggest, in line with Mackinnon et al. (2019) and Smith (2015), the need to account for the emergence of state-economy intersections and the role of these industrial formations in the construction and restructuring of GPNs. I explain the limits of explaining outcomes in LNG production networks by virtue of relations alone (as actor-network theory does) as such relations are continuously subject to change and instability. I suggest, therefore, that there is a need to better account for how capacities to reconfigure LNG production networks are casually affected by assemblages with dynamics and limitations that emerge from the mind-independent features of material and social entities. The entities and their relations that constitute assemblages may be material, such as natural gas and technology, and social, such as the internationalities and agencies of firms, states, intermediaries, etc. and their relations. Achieving such aims requires an ontological commitment to realism.

Sunley (2008) and Jones (2009) both claim that there is a need for introducing critical realist perspectives to relational thinking in economic geography. Sunley argues that, "If we are to explain economic relations properly, then we must adopt the realist notion of social structure as involving internal relations between actors occupying positions that have sets of responsibilities and capabilities attached to them" (11). Responding to the claims made by Sunley and others (see Starosta, 2010), the GPN 2.0 approach, developed by Coe and Yeung (2015), focuses on the causal power and competitive dynamics of capitalist structures to drive inter-firm and extra-firm networks coordinated by lead-firms in GPNs, by which the conditions for value capture and uneven development are industrially and geographically contingent. Coe and Yeung base their approach on a critical realist epistemology by seeking to causally explain development in the global economy by identifying the generative mechanisms that drive different configurations of what they call inter-firm, intra-firm, and extra-firm network strategies in GPNs. Uneven development, in this framework, is contingent upon historically and spatially defined value capture trajectories, in terms of the extent by which certain firms, regions, and nations can capture gains from being enrolled in certain production

networks. Coe and Yeung (2015) suggest that the degree to which certain industrial or geographical settings challenge the dominant lines of causality becomes an empirical question.

Through their critical realist epistemology, Coe and Yeung implicitly derive that behind the competitive dynamics of GPNs are *essential features* of dynamic capitalist structures. Roy Bhaskar (2013), the initiator of the critical realist ontological movement, has claimed that essences need to be presupposed in order to classify a group of things, even if essences cannot be known empirically. Bhaskar's object-oriented philosophy entails that the real essence of things is understood in reference to their intrinsic structures that constitute the real basis for their causal powers and tendencies in open systems. Bhaskar (2013) writes:

> The world consists of things, not events. Most things are complex objects in virtue of which they possess an ensemble of tendencies, liabilities and powers. It is by reference to the exercise of their tendencies, liabilities and powers that the phenomena of the world are explained (43)

Bhaskar claims that ontological essentialism is useful, and at the same time it avoids positivist accounts that assume the privilege of knowing such essences and acting upon them (DeLanda and Harman, 2017). Sayer (2010) explains that:

> To be practically-adequate, knowledge must grasp the differentiations of the world. We need a way of individuating objects and of characterizing their attributes and relationships. To be adequate for a specific purpose, it must abstract from particular conditions, excluding those which have no significant effect in order to focus on this which do. (86).

Realism implies a view of the world that exists outside our representations of it. The world consists of entities within fields of force that are organized in systems whose boundaries are set through causal relations. (Searle, 1995). Whether or not a proposition of the world is true, depends on its correspondence with facts. While Hume argued that knowledge is sense experience, critical realists suggest that *a priori* categories must exist for sense experience to be possible even if we do not have direct access to such essences (Baert, 2005).

Critical realists argue that the social world is an open system, and the same causal powers can produce different outcomes under different spatial and temporal conditions (Sayer, 2010). Events are, therefore, not predetermined before they happen, but are dependent upon contingent conditions. A generative mechanism, according to Bhaskar, is a generalization of how things act (Bhaskar, 2013). Things endure, and under appropriate circumstances are exercised, as long as there are properties that account for their persistence. Objects, according to Sayer (2010), are conceptualized through abstraction and structural analysis, which involves an examination of the nature of relations and structures. Knowledge needs to grasp the differentiations of the world, and therefore objects need to be adequately individuated and characterized according to their attributes and relationships. This is done through conceptualizing concrete objects: persons, institutions, etc. Abstraction distinguishes incidental characteristics from essential characteristics, and contingent relations from necessary relations.

"Structures," for Sayer (2010), refers to internally related objects or practices that occupy positions associated with certain roles, They are invariant under certain transformations and they can continue to exist while their constituents undergo changes in attributes. The qualitative question becomes: "what is it about these structures that produce the effects at issue?". Structures do not endure automatically and are rarely intentional, but are reproduced as certain actions are only possible through structures. Causal explanation results not from the relationship between two discrete events, but through causal powers or liabilities of objects or relations related to their mechanisms (Sayer, 2010). Causal powers inhere not in single objects or individuals, but in the social relations and structures they form.

> A causal explanation is not about a regularity between separate things or events, but what an object is like, what it can do, and only derivatively what it would do in any particular situation (Sayer, 2010, 105).

The effects of causal powers and their mechanisms are not fixed, but *contingent*. Jessop et al. (2008) suggest that drawing attention to causal powers and

mechanisms entails going beyond a one-sided, reductionist account of networks to conceptualize the capitalist structures and political-economy by which global production networks emerge.

In the GPN 2.0 framework, Coe and Yeung (2015) have abstracted certain causal powers from what they generalize as capitalist structures. These causal powers result in the generative mechanisms by which intra-firm, inter-firm, and extra-firm relationships emerge. However, I find that the critical realist approach in the GPN 2.0 framework by Coe and Yeung is limited, but not because the lines of causality defined are inadequately represented, on the contrary. Rather, I argue that there is a risk of failing to recognize the socio-material conditions by which such lines of causality are made possible. The Indonesia and Thailand articles point to the materiality of natural gas and internal power-relations in nation-states as constituting such socio-material conditions. In addition, there is a risk of failing to recognize the dynamics and distributed agencies of a multiplicity of actors, to transform these socio-material conditions. As Hess (2008) notes: "Much of the political economy literature in the realist tradition tends to emphasize social and economic structures at the expense of analyzing - although not denying – the agencies, interactions and connects that led to the emergence of these structures" (453). Furthermore, Jones (2014) claims that the critique of relational thinking by Sunley (2008) fails to take into account the original dissatisfaction against spatial constructs such as regions, the over-stabilized structural concepts, and the inadequate conceptualization of agency that provoked the "relational turn" in the first place.

A key challenge with the critical realist approach, such as the TSPN framework described earlier, is that it reduces socio-spatial relations to already known and recognized patterns, principles, and forms (Anderson et al., 2012). Furthermore, Anderson et al. (2012) argue that there is a risk of mischaracterizing the novelty and historical contingency of the spatiotemporal context by which such socio-spatial relations are co-articulated. Another challenge of critical realism and its adherence to essentialist thinking is the claim that the necessary conditions of

objects, or relations of interiority, can be analytically distinguished from their contingent conditions. Internal relations are those where the very nature of the *relata* depend on the relation (Sayer, 2013). Internal relations are intrinsic to essences of the related entities. Rutzou (2017) explains that while Bhaskar does recognize the world as a dynamic system characterized by continual change and transformation, these aspects are generally theorized as contingent phenomenon, and, consequently, Bhaskar is more concerned with internal relations, structures, and structured relations as necessary conditions for change and transformation.

2.5. Assemblage Thinking and Relations of Exteriority

In Coe and Yeung's (2015) GPN 2.0 framework, the variation in interorganizational arrangements in different GPNs and development across geographical locations is a contingent outcome of capitalist dynamics that persist as necessary conditions. It is the assumption of necessary conditions and internal relations: however, that is problematic according to Deleuze's process-oriented ontology. Deleuze avoids the notion of transcendent, "deeper realities," such as essences, and claims that reality should be affirmed according to difference, heterogeneity, and change (DeLanda, 2016). In other words, instead of assuming, as the GPN 2.0 framework does, that capitalist structures have the causal power to shape production networks, assemblage thinking would entail questioning what the conditions are for the causal power of capitalist structures to emerge. According to Rutzou (2017), Deleuze argues that there is no essence or unchanging internal structures of capitalism (as critical realists tend to conceptualize), but rather capitalism itself is differentiated, inconsistent, and always changing across time and space. Deleuze and Guattari (1987) state:

> There is no universal capitalism, there is no capitalism in itself, capitalism is at the crossroads of all kinds of formation, it is neocapitalism by nature. (20)

Instead of conceptualizing the structural relationships and mechanisms that operate behind and produce capitalism a priori, Deleuze suggests that such mechanisms are relatively stable, but contingent processes arising from

differential relations among heterogeneous entities continuously subject to instability and transformation (Deleuze and Guattari, 1984). Capital is not a transcendent power, but can be conceptualized as an axiomatic or a "a set of questions and relationships that determines and combines variable and coefficients immediately and equally across various terrains without reference to prior and fixed definitions and terms." (Hardt and Negri, 2001, 327). According to Deleuze's ontology it is:

> …identity and homogeneity which needs to be accounted for, not difference and change; difference and change are the givens, and identity is the peculiarity" (Rutzou, 2017, 405).

In other words, instead of understanding phenomenon as differentiated actualizations of relatively stable structures characterized by internal relations, Deleuze reverses this ontology by claiming that difference is given and that relatively stable structures emerge through process. It is through this process-oriented philosophy, referred to as assemblage thinking, that I frame the theoretical contributions of this thesis.

Several economic geographers have drawn upon the work of Deleuze, particularly in terms of non-representational theory (see Thrift, 2008; Hess, 2004). However, Anderson et al. (2012) and Müller and Schurr (2016) claim that geographers tend to end up conflating assemblage thinking with actor-network theory without considering their differences. Scholars such as Manual Delanda (2013), Levi Bryant (2008), and Mark Bonta and John Protevi (2004) have detailed to a great extent the connections between the work of Deleuze (in partnership with Felix Guttarri) to complexity theory, in particular dynamic systems theory. In complex dynamic systems, the casual relationships in systems are not linear, rather they are non-linear. Delanda (2006) explains non-linear causality in the following way:

> When one (in statistical causality) says that, in a given population of smokers, 'smoking cigarettes causes cancer', the claim cannot be that one repeated event (smoking) produces the same event (the onset of cancer) in every single case. The genetic predispositions of the members of the population must also be taken into account, and this implies that the cause will produce its effect only in a high percentage of cases. (20)

Similar to complexity theory, assemblage thinking entails conceptualizing social and material systems according to non-linear casual dynamics, and thinking of material and social systems in terms of their powers of immanent self-organization (Protevi, 2006). Delanda (2017) claims that while actor-network theory is anti-realist in its relationalism, the relationality of assemblage thinking is characterized by realism. Based on how the above mentioned scholars systematize Deleuze's concepts, I attempt to develop a novel, more dynamic, and non-linear conceptualizations of emergence, transformation, and causality in global production networks. I suggest that by doing so, GPN scholars can better account for spatial and political outcomes in dynamics GPNs.

DeLanda (2016) systematizes the works of Deleuze (and his work together with Felix Guttarri) into a theory of assemblages. For the purpose of this thesis, I avoid the term "assemblage theory" and opt for referring to Deleuze's ontology and epistemology as "assemblage thinking." I do this to avoid the confusion surrounding the use of the concept of assemblages in geography, as mirrored by the debates in the Scientific Journal, *City*. McFarlane's (2011a) article on the use of the assemblage concept in critical urban geography was accused by Brenner et al. (2011) of having an unstated agenda of bypassing political economy or structure. McFarlane (2011b) claimed that this was not his intention and suggested that assemblage thinking can make generative contributions to political-economic concepts by conceptualizing the casual power of economic orders and structures as immanent to contingent socio-material achievements. Similarly, it is not the agenda of this thesis to replace concepts and theories in geography with those from assemblage theory, but to instead discuss how thinking ontologically and epistemologically through assemblages can give analytical purchase to already existing theories in energy and economic geography.

Assemblage thinking draws several similarities to actor-network theory, which as previously mentioned, partially constitutes the ontological basis for the GPN approach. Like actor-networks, assemblages are provisional forms irreducible to the human and non-human entities that compose these forms (Anderson et al.,

2012). Both ANT and assemblage thinking draw attention to relational materiality in that the capacities of social actors or material objects to affect relationships and outcomes are the capacities that are affected by other relationships within the actor-networks or assemblage (Müller and Schurr, 2016). Furthermore, both assemblage thinking and actor-network emphasize how accounting for the full workings of social phenomenon requires an analysis of the processes by which associations between actors, both human and non-human, are assembled (Elder-Vass, 2008). However, in contrast to actor-networks, assemblages are characterized by "relations of exteriority". As Deleuze (2007) explains, an assemblage is:

> A multiplicity which is made up of many heterogenous terms and which establishes liaisons, relations between them…the assemblages only unity is that of a co-functioning: It is a symbiosis, a 'sympathy'. (52)

Through the notion relations of exteriority, assemblage thinking recognizes the relationality of capacities, but at the same time adopts a realist ontology and suggests that the properties and identities of social actors and material entities are mind-independent and external to the relations in the networks that they are a part of. This realist approach stands in contrast with actor-network theory which entails tracing associations and relating humans and non-humans in their co-production of networks, as if these associations are *logically necessary* and nothing stands outside these descriptions (Anderson et al., 2012). The challenge with actor-network theory is that it does not consider the extent to which currently actualized associations are only, as DeLanda (2006) terms, "contingently obligatory". By thinking of relations as only "contingently obligatory," assemblage thinking can be used to consider the extent to which human and non-human entities may be unplugged from an existing assemblage and replugged into new assemblages with different interactions and emergent causalities while retaining their properties and identities. The implications of distinguishing between properties and capacities is that while the properties of entities are not the final cause for capacities in assemblages (which are relational), such capacities of entities to affect and be affected are enabled and constrained by the properties of

entities. In the Indonesia article, I suggest that the unplugging/replugging situation is characteristic of the dynamics by which natural gas is being unplugged from traditional inter-organizational arrangements in LNG production networks and replugged through new integrations with financial intermediaries and markets. By analyzing these dynamics, I suggest that new patterns of uneven development can be identified and outcomes can be accounted for.

Thinking through relations of exteriority, according to Haarstad and Wanvik (2017), can help researchers better recognize the instability of fossil fuel GPNs, such as LNG production networks. Haarstad and Wanvik explain that geographers tend to conceptualize fossil fuel regimes in terms of stable and path-dependent, matter-society relationships held together by centers of power or seamless totalities composed of relations between fossil fuels, technology, and human behavior. Consequently, researchers underemphasize how fossil fuel GPNs are continuously being destabilized by sudden prices changes, technological shifts, geopolitical conflicts, market changes, and political movements. Similarly, Allen (2016) suggests that instead of accounting for the power of certain social actors as a given outcome of social position or resource control, researchers should focus on the actual, relational and material workings of power. In doing so, researchers can consider the capacities to realize certain outcomes as being relational, and continuously subject to change. These relational arrangements of power are, therefore, not guaranteed. These notions are in line with the argument by Coe et al. (2008) that GPNs are "inherently dynamic, they are always, by definition, in a process of flux – in the process of becoming – both organizationally and geographically" (272).

Assemblage thinking adheres to a realist and materialist ontology that starts with a chaotic experience of an open and heterogenous world that is irreducibly complex, dynamic, and characterized by a multiplicity of different agencies, human internationalities, behaviors, materialities, etc. (Rutzou, 2017). A commitment to materialism, however, does not entail a rejection of explanation but entails that phenomenon, and, therefore, explanation is immanent to matter in its multiplicity.

As was mentioned in the beginning of this chapter, a key aim of this thesis is to explain how the territoriality of natural gas markets are evolving. I would argue that assemblage thinking entails a commitment to accounting for the territoriality of markets and the configuration of GPNs as immanent to a multiplicity of distributed agencies and materialities. The territoriality and form of GPNs that emerge from such multiplicities as material tendencies and certain patterns of behavior are continuously repeated despite a complex, heterogenous, and differentiated world. As Deleuze (1994) explains:

> If repetition can be found, even in nature, it is in the name of a power which affirms itself against the law and works underneath laws, perhaps superior to laws. If repetition exists, it expresses at once a singularity opposed to the general, a universality opposed to the particular, a distinctive opposed to the ordinary, an instantaneity opposed to variation and an eternity opposed to permanence. In every respect, repetition is a transgression. It puts law into question, it denounces its nominal or general character in favor of a more profound and more artistic reality (2-3).

Unlike other relational ontologies, such as actor-network theory, that reject attributing structures and entities, such as nation-states or capital, with emergent causal powers and structures, assemblage thinking recognizes the possibility for such realist explanations. Nevertheless, Rutzou (2017) claims that affirming relations of exteriority entails that representations are never final and must be themselves both dynamic and heterogeneous. As DeLanda (2013) explains, "the world would not sit still long enough for us to take a snapshot of it and present it as the final truth" (5). In the Indonesia article, I explain that moments of transformation and instability introduce a degree of complexity and uncertainty in causal explanation. I explain that while the exclusive territoriality of traditional LNG production networks historically emerged from the uncooperative materiality of natural gas and causal power of capitalist structures, such causal explanations are harder to account for during moments of transformation and instability. During such moments there is a need to account for the capacities that arise through interactions between agencies and materialities affecting the conditions by which value creation in global production networks are realized.

Assemblage thinking does not deny the reality of the structural dynamics identified by critical realists by which the causal powers of nation-states, GPNs, markets, etc. emerge in economic geography. As Sayer (2013) explains, Delenda's social ontology shares a lot with critical realism but differs principally in "arguing that there are no internal relations," only relations of exteriority (similar to contingent relations in critical realism) (22). Actually, Delanda (2016) does recognize that relations of interiority do exist, but argues that these relations are usually confined to linguistic niches, such as social roles defined by conventions. The intrinsic relation between landlords and tenants is one example. Delanda argues that the majority of relations in the world are relations of exteriority. Assemblage thinking is an attempt to consider the conditions of possibility for such structures without relying on final and transcendent truths such as internal relations and essences.

Instead of conceptualizing the essences and mechanisms that shape the causal power of nation-states and markets a priori, Deleuze would refer to the ontological status of persons, communities, organizations, cities, nation-states, etc. as that of unique, historically individuated assemblages (DeLanda, 2006). The research objective that comes from such thinking is to account for the morphogenetic processes by which the intentionality of human and capitalist desires come into relation with materials resulting in an upward causality that shapes the form, identity, and causal powers of nation-states, corporations, markets, etc.. In the Singapore article, I explain how the capacity of Singapore to shape the evolutionary trajectories of global production networks is located in the complex dynamics of assembly by which unbundled authorities over gas markets are reassembled through new interactions with financial markets by public and private actors in Singapore.

At the same time, as assemblages emerge DeLanda (2016) explains that assemblages immediately start acting as a source of limitations and opportunities (downward causality) for their component parts. Delanda continues to state that such dynamics can be located along the parameters that define the degree of

territorialization in assemblages. Territorialization refers to the morphogenetic processes by which the emerging form and capacities of assemblages arise from the co-functioning of ideas and inputs, and how the ongoing repetition of these relationships sharpen the borders of assemblages while enabling certain interactions and excluding others thereby strengthening the emerging identity or singularity of the assemblage (DeLanda, 2006). Territorialization is similar to how Bair and Werner (2011) use the concept of (dis)articulation in global commodity chains an global production networks research. Bair and Werner explain that literature on global production networks and global commodity chains tends to have an inclusionary bias, which prioritizes an account of development in relation to how a particular region is incorporated in GPNs instead of questioning how the dynamics that make capital accumulation in GPNs possible both constitute and are constituted by geographies of exclusion. Like the process of territorialization, the social and spatial processes by which global production networks are articulated can often entail the disarticulation or exclusion of certain actors and territories resulting in uneven development in the global economy.

In the Indonesia article, I explain that the dynamics by which LNG production networks have been historically territorialized/articulated entailed the contingent exclusion/disarticulation of domestic natural gas markets from production networks for value creation from Indonesian natural gas reserves to be realized. I note however, that while such outcomes are have been historically dependent upon the properties of natural gas, such relationships do not have these properties as their final cause. I explain that the processes of territorialization do not necessarily preclude the potential for new associations that can transform the configuration of production networks. Instead, I explain that dynamics by which LNG production networks are currently transforming lead to new patterns of behavior and processes of territorialization that affect spatial and political outcomes in new ways. In the following section of this chapter, I explain the dynamics by which such transformations occur and how assemblage thinking draws upon topological ideas to conceptualize relations between transformation and durability in assemblages.

2.6. Transformation and Complexity in Assemblage Thinking

Anderson et al. (2012) explain that assemblage thinking entails a focus not just on how agency produces resultant forms as assemblages, but also on how the agency of emerging assemblages will affect the capacities of its component parts. DeLanda (2016) explains that at any given point in time, an assemblage can be "characterized by enduring states defined by properties that are existing in the here and now" (108). However, the ongoing interactions of component entities in assemblages are never fully territorialized because agencies are distributed, and relationships are external to the related entities (DeLanda, 2016). In addition, the component parts of assemblages can also be part of multiple assemblages simultaneously and subject to multiple dynamics and new interactions, which can result in novel capacities for transformation in assemblages. Such an ontology entails an epistemological commitment to accounting for the potential of distributed agencies and initiatives to either transform or maintain global production networks and territoriality.

Transformation and change in assemblages are therefore given; they are continuously "becoming." As Deleuze and Guattari (1987) explain, becomings

> bring about the deterritorialization of one term and the reterritorialization of the other; the two becomings interlink and forms relays in a circulation of intensities pushing the deterritorialization ever further. There is neither imitation nor resemblance, only an exploding of two heterogenous series on at the line of flight composed by a common rhizome that can no longer be attributed or subjugated by anything signifying. (10)

Assemblages are continuously subject to lines of flights of "deterritorialization" and "reterritorialization." They are continuously changing. Deterritorialization refers to the processes where:

> relations, meanings, operations, and entities, flow more readily and freely, resulting in more chaotic, heterogenous, and dynamic sets of interconnected entities with fuzzy boundaries (Rutzou, 2017, 408).

Assemblages never stay still; they are always different and continuously transforming. To account for the stability and durability of form and order in an

open, changing and chaotic world, Deleuze (1994) draws upon mathematical topology, particularly the notion of equivalence. While the notion of topology is not new in geography and is used to develop more relational, non-metric concepts of space, Allen (2011) claims that terms from mathematical topology, such as equivalence, are rarely drawn upon. Equivalence is used by mathematical topologists to explain how shapes and figures can be distorted yet possess a similarity of form (Allen, 2016). While change and difference are given, Deleuze, according to DeLanda (2016) differentiates between intensive differences and extensive differences. Intensive differences are events resulting in qualitatively different systems and patterns of behavior in assemblages. Extensive differences are quantitative or metric changes such as new relationships between actors that may change the boundaries of assemblages but not the overall patterns of behavior. Temperature changes and phase transitions in materials highlight the differences between extensive and intensive changes. For example increasing the temperature of water from 20 to 45 degrees results in a quantitative change in temperature, while increasing temperature from 99 to 100 degrees results in an intensive, transformative phase transition (from liquid to steam). In the Thailand article, I draw upon John Allen's (2016) notion of the "changing same of power" to explain the relation between extensive and intensive arrangements of power to describe how the partially state-owned natural gas company in Thailand, PTT, maintains its monopoly over the country's natural gas markets despite the deterritorialization of traditional forms of nation-state authority over natural gas markets through market liberalization reforms and globalization. Allen draws upon Deleuze to explain the difference between *extensive arrangements of power*, which refers to authorities that are extensive across fixed, topographical representations of space, and *intensive arrangements of power*, which focus on the relations and interplay between different institutional interests and authorities. In intensive arrangements of power, power relationships are mediated through events, technologies, and practices for specific political and economic ends. I explain that through intensive arrangements of power, PTT's control and research into Thailand's natural gas markets remain invariant or unchanged by the

upending of extensive arrangements of power due to globalization and liberalization.

This thesis utilizes topological concepts such as (de)territorialization, reterritorialization, equivalence, intensive and extensive differences, invariance, to account for spatial and political outcomes of evolving LNG production networks and the globalization of natural gas markets. As I explain in the Indonesia article, assemblage thinking invites researchers to go beyond identifying the causal powers of entities and relations of production to explain political and spatial outcomes, and to instead find explanations in the morphogenetic processes by which GPNs are transformed. Assemblage and topological thinking contributes to economic and energy geography by drawing attention to how the form and configuration of territoriality and global production networks emerge from multiplicities of materials and agencies, are continuously subject to transformation, and yet holds to possibility for explanation of stability and form. At the same time the research articles in this thesis utilize assemblage thinking and its attention to relations of exteriority to point towards the limitations of globalization.

2.7. Summary of Theoretical Perspectives and Contribution

In the beginning of this chapter, I explained the limitations of neoclassical economic perspectives on the globalization of LNG commodity trade. The neat deterministic models used in industry reports do not reflect the messiness and complexity of globalization and commodification, particularly of an "uncooperative" commodity such as natural gas. The notion of natural gas as a globally traded commodity has been a topic of discussion for a long time now. James Jensen at the Oxford Institute for Energy Studies discussed the development of a global LNG market back in 2004 (Jensen, 2004). Around the same time, the Baker Institute's World Gas Trade Model was developed to predict the development of a global gas market by tracking the determinants of natural gas use in the world, including level of economic development, the price of natural gas, the price of competing fuels, and population growth (Hartley and Medlock, 2006).

More recently, other industry researchers have pointed to the rise in short-term contracts, new technologies, business models, etc. to claim that natural gas markets are globalizing (Corbeau and Ledesma, 2016). However, despite these forecasts, markets continue to be distinctively regionalized between Atlantic and Pacific basins, and Asian markets continue to be primarily governed under the authority of the nation-state. In addition, despite the rise in spot and short-term trades, long-term contracts continue to be required for final investment decisions on new LNG production networks terminals (Shell, 2018; IEA, 2017a).

The current situation in international LNG markets seems to reflect a difference between extensive and intensive changes. The empirical data used by neoclassical economists point to several extensive changes in markets in terms of prices, trade, technologies, etc., but the emergence of an integrated, global gas market suggests a more intensive change that has yet to materialize. In line with Bridge and Bradshaw (2017), I have argued in this section for the need to account for the territoriality of gas markets and their globalization in terms of the dynamics by which inter-organizational relationships are reconfigured in GPNs and how commodification is realized through such dynamics. At the same time, I point to the limitations of the GPN approach for accounting for the complexity and non-linear causal dynamics of transformation in LNG production networks. In doing so, I have aimed to make a theoretical contribution to economic geography and the global production network approach through assemblage thinking.

Based on the theoretical discussion in this chapter and further discussions in the three research articles, I argue that assemblage thinking contributes to economic geography in three ways. First, I suggest that that assemblage thinking, like actor-network theory, recognizes the provisionality of emerging forms and draws attention to how structures emerge from relations between actors and materials. Unlike ANT, assemblage thinking does not fuse together entities in seamless totalities but recognizes that relationships are only contingently obligatory. Through its commitment to relations of exteriority, assemblage thinking can be used to recognize how the dynamics by which the properties of

natural gas enable and constrain capacities as it is unplugged from an existing assemblage and replugged into a new assemblage. This conceptual move can be used to account for how the materiality of natural gas continues to affect outcomes and the territoriality of natural gas markets, albeit in different ways, as global production networks evolve.

Second, assemblage thinking can be used to recognize the instability and continuous transformation of global production networks and opens for more dynamic and non-linear explanations of outcomes. Such a framework can be used to consider how the territoriality of LNG production networks is immanent to a multiplicity of materials and distributed agencies resulting in upward causalities, which subsequently leads to downward causalities that both enable and exclude certain energy development and political outcomes. Such processes are recognized through the ongoing processes of territorialization and deterritorialization.

Finally, by drawing on topology, assemblage thinking can be used to identify what is transformed through territorialization and deterritorialization and what remains invariant, or unaffected, by such transformations. This final point is important, because it allows for an explanation of globalization of natural gas markets and simultaneously points to the limitations of this globalization by recognizing the difference between extensive and intensive changes. In the following methodological chapter of this thesis, I outline the epistemological implications of the conceptual contributions of this chapter. Furthermore, I explain the methodology by which the empirical data for the research articles was collected and analyzed.

Methodological Reflections 3

> The exteriority of relations is not a principle, it is a vital protest against principles….If relations are external and irreducible to their terms, then difference cannot be between the sensible and the intelligible, but only between two sorts of ideas, or two sorts of experiences, that of terms and that of relations. (Deleuze and Parnet, 2007, 55-56)

The quote above by Deleuze shows how relations of exteriority points to the limitations, but not the rejection of, empiricism. Deleuze explains that instead of defining empiricism as a theory where the intelligible comes from experience, empiricism should be an inquiry into "ideas, and then the relations between these ideas, relationships which may vary without the ideas varying, and then the circumstances, actions, and passions, which make these relations vary" (Deleuze and Parnet, 2007, 56). Deleuze's radical interpretation of empiricism is that immediate experience cannot be the epistemological foundation for relations because relations are not empirically reducible (Rölli and Hertz-Ohmes, 2016). Deleuze writes:

> The 'glass is on the table' relation is neither internal to one of the terms which would consequently be subject, nor the two together. Moreover, a relation may change without the terms changing. One may object that the glass is perhaps altered when it is moved off the table, but that is not true. The ideas of the glass and the table, which are true terms of the relations, are not altered. Relations are in the middle, and exist as such (Deleuze and Parnet, 2007, 55).

Deleuze's theory of empiricism is called transcendental empiricism. Despite its oxymoronic name, transcendental empiricism is not an inquiry into a priori transcendental natures of reality, such as laws foundations, representations, and essences. Transcendental empiricism is rather defined as a philosophical position which strives to articulate the conditions of possibility for existence and experience (Bryant, 2008). A transcendental analysis arises as a second order reflection upon our engagement, activity, and experience (empiricism) of the world (Rutzou, 2017).

In this methodological chapter, I will discuss how epistemology of assemblage thinking has influenced my methodological choices during the research process. I will do so by outlining the research process that led me to the conclusion that my "experience" of the relations between the strategies of firms and governments and the materiality of natural gas was, by itself, not sufficient to explain energy development and policy outcomes in the context of globalizing natural gas markets. The purpose of this chapter is to both justify the choices that have been made during the research process, and also to reflect upon the messiness, uncertainty, risks, and limitations pertaining to collecting and interpreting empirical data. This chapter is significantly more personal than the rest of the thesis. In the chapter, I intend to chronologically show the reader the journey and detours that led to the production of this thesis. The rest of this methodological chapter is organized as follows. The next section provides a detailed overview of the empirical material. In section 3.2, I will present a detailed account of how my research design has developed and changed since I started my doctoral program over four years ago. In section 3.3, I further discuss the epistemological implications of assemblage thinking for methodology.

3.1. Overview of Empirical Material

The empirical data that has informed this thesis is primarily a result of multiple periods of fieldwork in Singapore, Indonesia, Thailand, and Myanmar (see Figure 5 for an oversight). Due to the limitations of my empirical material and time constraints, my research on the political economy of the natural gas sector in

Myanmar was not included in this research project. Nonetheless, I briefly draw upon my experience in Myanmar as it pertains to the research process that has informed the discussions in this thesis. The empirical material in this thesis is primarily qualitative. The empirical data can be divided into three categories. First, I conducted a total of 40 interviews, 23 of which took place in Singapore, four in Jakarta, Indonesia, nine in Bangkok, Thailand, and four in Yangon, Myanmar. Interviews were conducted with government officials, in addition to corporate executives and business development managers at a wide range of LNG-related companies including equipment suppliers, infrastructure owners and operators, advisory firms, and electricity companies (see Appendix for overview). The second category of empirical material includes participation, observation, and short conversations at different events. Such events included LNG industry conferences, seminars, and workshops organized by different entities. The third category of empirical material includes desktop research consisting of industry-related reports, newspaper articles, government statistics, and historical documents. The following table (Figure 7) provides an oversight over fieldwork and event participations.

Time Frame	Location	Details
2015		
20-30 September	Singapore	Participant in NTNU Innovation Delegation to Singapore and "TechInnovation" Conference *Seven Interviews*
2016		
22 January to 3 May 2016	Singapore	Fieldwork Singapore *Sixteen Interviews*
10 February 2016	Yangon, Myanmar	Attended "The LNG Alternative" Workshop hosted by Royal Norwegian Embassy in Yangon
28 February to 2 March 2016	Singapore	Attended "LNGc Asia Conference" hosted by Informa Connect
3-4 March 2016	Jakarta, Indonesia	Attended "Small LNG Infrastructure and Ships Roundtable Forum" hosted by LNG Forum Series
15-17 March 2016	Jakarta, Indonesia	Attended "Gas Indonesia Summit and Exhibition" hosted by Gastech
18-19 April 2016	Jakarta, Indonesia	Fieldwork Jakarta *Four Interviews*
2017		
1-16 February 2017	Bangkok, Thailand	Fieldwork for «Thailand LNG Sector Evaluation" Project commissioned by Royal Norwegian Embassy in Bangkok *Nine Interviews*
27 February to 3 March 2017	Yangon, Myanmar	Fieldwork for «Myanmar LNG Sector Evaluation" Project commissioned by Royal Norwegian Embassy in Bangkok *Four Interviews*
25-27 June 2017	Bangkok, Thailand	Attended as Speaker and Panelist at "Norway-Thailand LNG Partnership Seminar" hosted by Thailand's Ministry of Energy

Figure 7 - List of fieldworks and event attendances associated with research project

3.2. Research Process

Reading the works of Deleuze, including those in partnership with Felix Guattari, is admittedly difficult, tiring, and confusing (see Deleuze and Guattari, 1984; Deleuze, 1994; Deleuze and Guattari, 1987). Trying to read a single page multiple times to understand Deleuze is a hurdle. Trying then to translate the work of Deleuze into meaningful statements relevant for economic and energy geographers is an even larger hurdle. DeLanda (2013) explains that Deleuze tends to change his terminology in every one of his books and never really gives explicit definitions. Deleuze and Guattari (1987) metaphorically liken their style of writing to a rhizome that "ceaselessly establishes connections between semiotic chains, organizations of power, and circumstances relative to the arts, sciences, and social struggles" (7).

Rhizomes are biologically defined as subterranean plant stems that grow into networks of roots and nodes spreading both horizontally and vertically. Parts of the rhizomes can be destroyed or separated without damaging the whole plant. According to Deleuze, rhizomatic writing, in the metaphorical sense, entails a process of perpetual transformation with no stabilizing function, but rather multiple journeys disconnected and reconnected in new ways (Colman, 2010). Looking back and reflecting on the research process and the methodological choices I have made, I would describe the accumulative research process of this thesis according to a rhizomatic form; a process that has networked in multiple journeys that have been continuously connected, disconnected, destroyed, and replanted. This written thesis is less of a result and more of a momentary conjunction of processes that continue to shoot out into multiple directions and ideas. In this section, I will discuss the research process behind this thesis in further detail.

3.2.1. Entering the Field

Four years ago, the objectives, aims, and theoretical perspectives I brought into the research process were significantly different from those written in this thesis.

Originally, my research aim was to investigate the cultural embeddedness of global innovation networks by studying the role of relational positionality across spatial scales. With an aim of combining my knowledge of ethnography and culture from my bachelor studies in social anthropology and my master's degree in innovation and entrepreneurship, I aimed to ethnographically investigate knowledge translation as Norwegian companies bring new technological products and services to markets in Asia. Based on my readings of actor-network theory and global production networks, I aimed to both follow Norwegian firms and investigate their relational positionality in wider social networks and the role of these networks in technology commercialization.

In May 2015, my supervisor put me in contact with Morten Øien, a senior advisor at the Rector's office at the Norwegian University of Science and Technology (NTNU), who was putting together a delegation of researchers and NTNU spin-off companies to send to Singapore to arrange a stand at the TechInnovation Conference in Singapore in September 2015. I decided that researching technology and innovation linkages between Singapore and Norway would be a suitable direction, as the two countries have a long history of collaboration in the maritime industry. Øien put me in contact with a start-up company from the NTNU Entrepreneurship School that had developed a new floating jetty system for loading and offloading LNG from maritime vessels. At the time, I knew very little of natural gas markets and LNG technology other than that Norway is a large gas and gas technology exporter. I agreed with the owners of the company that I would "hang out" with them at the TechInnovation conference, observing their interactions with other participants at the conference, and engaging in short conversations every now and then. In addition, Øien also helped me get in contact with interviewees from Innovation Norway, the National University of Singapore, Rolls Royce, and Gaspartners who I would interview in Singapore the week after the delegation tour. I eventually met Egil Rensvik, the science and technology counselor at the Innovation Norway (the Norwegian government's support apparatus for industry and enterprises) in Singapore. Rensvik explained that Innovation Norway and Norwegian companies had been

working since 2009 to implement small-scale LNG bunkering in the Singapore maritime sector.

Rensvik further explained that since 1998, Norway has had experience with developing a small-scale LNG supply chain across the Norwegian coastline, primarily for fueling ships as an alternative to diesel to reduce nitrogen oxide and sulfur oxide pollutants and CO^2 emissions. Norwegian companies have, therefore, considerable experience in LNG-fueled maritime engine systems and small-scale LNG distribution technology including LNG carriers and small-LNG import terminals. Norway has several small-demand centers for LNG scattered across the long Norwegian coastline, which are accessible by maritime transport. Such technologies, however, are fairly novel as the use of LNG in maritime traffic is not widespread. In addition to LNG maritime bunkering, Norwegian distribution technology can be utilized to supply LNG to small demand centers across Southeast Asia. Like Norway, Indonesia has several small-demand centers scattered across its numerous islands. Innovation Norway together with Norwegian companies saw a potential for commercializing small-scale LNG technology in Southeast Asia.

After returning to Norway, I decided to narrow my research focus on systems innovation in LNG markets in Singapore and Indonesia. I started to plan a four-month research period in Singapore starting in January 2016. Drawing upon actor-network theory, my intention was to investigate interconnections between the narratives of actors occupying different positionalities in networks related to systems innovation in the LNG industry. In line with Czarniawska's (2004, 4) approach to interviewing in organizational studies, I planned to conduct interviews with the goal of not only understanding the strategies of different corporate actors, but the settings in which such strategies take place. The interview situation can be described as a discussion that brings about a production of knowledge through a narrative mode of knowing. The narrative mode of knowing consists of organizing experience with the help of a scheme that assumes the intentionality of human actions (Bruner, 1991). This scheme is referred to as a narrative or a story line where actors and intermediaries are enrolled and become

protagonists and antagonists within the narrative. Building on actor-network theory, I intended to account for how such narratives are preformed with regard to the actor's positionality in the wider corporate networks connecting multiple localities. By addressing how narratives are preformed through actor-networks, my original research aim was to explain the challenges of commercializing Norwegian technology in Asia.

3.2.2. A Global Ethnography

Burawoy et al. (2000) claim that traditional ethnographies of capitalism find themselves limited when trying to comprehend the fragmented, dispersed, volatile, and lived experiences of global capitalism. A key challenge for ethnographers is to develop the theoretical tools to "work from the ground upward…to delve into the connections between micro practices and macro-structures" (3). Burawoy et al. (2000) suggest that despite its limitations, ethnography enables researchers to attune themselves to the lived experiences of globalization by studying others in their space and time. Furthermore, ethnographers can ground their ethnographies in local histories, using archives, official documents, newspapers, etc. to explore changes brought by globalization. Global ethnography consists of delving into external forces, exploring connections between cites, and uncovering the distilled imaginations from daily life. In this section, I will explain how my fieldwork in Singapore and Jakarta pertained to the lived experience of global capitalism.

My fieldwork in Singapore, Bangkok, Jakarta, and Yangon can be characterized as global ethnography. The Norwegian managing partners at Gaspartners, Tom Preststulen, and Rolv Stokkmo, whom I met during the NTNU delegation trip, offered me office space for my second round of fieldwork in a building on the famous Telok Ayer street in the central business district of Singapore. The office space was located in the Orkla building that housed several Norwegian companies including Elkem Chartering, Jotun, SingNordic, Borregaard, and Esmart systems. Gaspartners was involved in designing LNG ISO containers, which are used to store and transport small amounts of LNG for mini-power generation systems, industry, and maritime transport. The company had been working for several years on

commercializing the ISO containers to enable the small-scale distribution of LNG in Southeast Asia. Stokkmo explained that the primary challenge was access LNG supply and finding potential buyers, specifically in Indonesia.

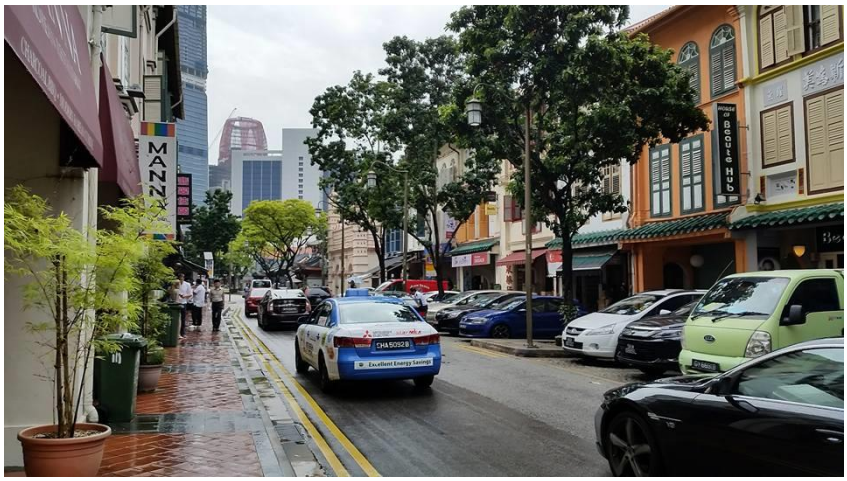

Figure 3 - Picture taken from Telok Ayer Street

Singapore's central business district is notably at the center of global economic activity in Southeast Asia. In the Singapore article, I explain in more detail how the country is trying to establish itself at the center of LNG trading in Southeast Asia, specifically by attracting financial intermediaries and commodity traders – most of whom are locating in the central business district. Singapore also has a significant maritime industry and shipbuilding industry heavily involved in building LNG carriers and, more recently, floating storage and regasification facilities. Singapore was, therefore, a central location in my fieldwork as many interviewees I interviewed, who worked in multinational corporations with commercial interests in Thailand, Indonesia, and Myanmar, were located in Singapore.

Figure 4 – Picture taken from the Central Business District in Singapore

At the beginning of my fieldwork in Singapore, gaining access to interviewees was notably difficult. Although I had some contact with Norwegian companies, specifically DNV-GL, getting access to other LNG-related companies was difficult. I was more successful in getting into contact with several Norwegian companies located in Singapore by travelling to Myanmar. Rensvik put me in touch with Axel Blom who at the time was the director of Innovation Norway in Thailand and Myanmar. Blom invited me to a workshop hosted by the Norwegian Embassy in Yangon with the topic of discussing Norwegian LNG power solutions as an alternative to coal-fired power development in Myanmar. Myanmar, as mentioned in the introductory chapter, has a significant challenge of providing electricity to nearly 70 percent of the country. At the seminar, Norwegian firms discussed the possibility of distributing LNG to distributed populations by sea, roadways, and rivers.

Many of the Norwegian companies I had met in Myanmar also had commercial interests in Indonesia. Specifically, their interests were related to a significant

small-scale LNG tender for LNG supply to 21 locations in the eastern parts of Indonesia that was underway. Since the 1970's, Indonesia has exported LNG primarily to North Asia and often at the expense of domestic energy development. However, in 2012, Indonesia built its first LNG terminal near Jakarta and a second terminal in Lampung in Sumatra. According to interviews with representatives at Norwegian LNG-related companies, Indonesia was expected to be a significant market for small-scale LNG trade. A key challenge for energy development in Indonesia is that its population is scattered across numerous islands in the archipelago nation, and the costs of supplying electricity are significantly higher than the central areas of the country. Indonesia relies heavily on fuel oil for power generation in the peripheral regions of the country, despite holding ample quantities of natural gas.

This LNG tender would eventually become the subject of the extended case study in the Indonesia article. An extended case study, according to Burawoy et al. (2000), is one that extends beyond the local observations of participants into studies of globalization by a) extending observations over space and time, b) extending out from microprocesses to microforces, and c) the extension of theory (27). It became apparent, quite early on in my research on the Indonesian LNG tender, that the tender was linked to dynamics that extended beyond the local scope of the tender. I came to this conclusion as I observed presentations at conferences in Jakarta. My interviewees in Singapore recommended I attend the Small LNG Infrastructure and Ships Roundtable Forum and the Gas Indonesia Summit and Exhibition, both taking place in Jakarta in March 2016. My interviewees explained that representatives from many LNG-related firms attend these events and it would be a good opportunity for me to network. Karlsen (2018) claims that, "Events can appear as significant arenas for core actors to negotiate industry formation" (155). Karlsen suggests that visiting conferences and exhibitions at trade fairs is a useful arena for investigating the institutional, regulatory, and governance features of an industry, particularly in their formative phases. Although the LNG industry has existed since the 1950's, it became clear from the presentations and panel debates at the events I attended that industry

proponents believed current changes in the LNG industry was nothing short of revolutionary. While the different presenters mostly agreed that the LNG industry was globalizing, the implications of the LNG revolution for Indonesia was a topic of disagreement. Specifically, there was a disagreement on the extent to which Indonesia should continue its role as an LNG producer and exporter, or if it should focus on developing infrastructure for domestic LNG markets and eventually start importing LNG. Although Indonesia has fairly large reserves of natural gas, a substantial portion of Indonesian natural gas is still locked in long-term export contracts. In addition, the maturity of several gas fields has led to a growing decline in production. Furthermore, the 2014 oil price crisis was dissuading investors from developing new gas fields in the country. Some presenters argued that Indonesia should spend its resources in stimulating investment, while other presenters, such as the national electricity company, argued that Indonesia should invest in domestic infrastructure and import LNG.

Figure 5 – Picture taken of the Central Business District in Jakarta

Attending the LNG conferences drew my attention towards the globalization of LNG and the implications for energy development and politics in Indonesia. The LNG conferences were also an excellent arena for small conversations with participants regarding the presentations and their "on-the-ground" experience with projects in Indonesia. Through these conversations I became aware of the

various complications and contestations between private companies and government officials surrounding LNG market development projects in Indonesia. I would later follow up on several of these conversations by contacting conference participants and requesting an interview. My research topic was received well by participants at the conference, and I was able to book interviews with many of the participants I contacted. Most of these interviews were conducted face-to-face in Singapore where most of my interviewees were located. In addition, I travelled to Jakarta for interviews with the national electricity company and a company that operates the LNG import terminal near Jakarta.

My interviews revealed two aspects that would later become the overall themes of this PhD thesis. First, the interviews revealed that the globalization dynamics surrounding the LNG industry do not take place in external, global spaces, but are continuously negotiated and preformed by corporations and government officials. These global dynamics are localized in everyday activities in Singapore and Jakarta and occur within global production networks. In the Singapore article I detail to a great extent how corporations and government officials are facilitating the globalization of natural gas markets in Asia by attempting to establish a hub for LNG trading. The emphasis on negotiations and everyday practices is in line with Murphy (2012) who notes the need to further conceptualize the agency of buyers and sellers to establish and maintain relationships in production networks, and for conceptualizing the power struggles that occur over the terms and conditions of such relationships. This perspective calls for attention to a processual account of GPNs, by which the territorial configuration of production networks are shaped and maintained through the action of individual agents (Bridge and Bradshaw, 2017). Specifically, Murphy (2012) and Bridge and Bradshaw (2017) explain the need for empirical studies that illuminate the agency and practices of actors, besides lead firms, to reconfigure the organizational and spatial arrangements of production networks. While presenters at conferences and my interviews with consultants presented abstract models on globalization and statistics on LNG trade patterns, my interviews of representatives with everyday experiences of such negotiations pointed to a more grounded reality.

3.2.3. Desktop Research

When I came back to Norway from Singapore in May 2016, I found that my empirical material was largely fragmented, varied, and difficult to piece together. While the quality of the empirical material reflects the novelty of investigating international business, and my tendency to change my research interests while conducting fieldwork, it also reflects the complexity of international business in the LNG industry. Regarding international business research, Hansen (2008) suggests

> As researchers studying complex realities we can always consult additional sources, invent new questions and approaches, disturb the daily routines of just one manager, but we can never capture the full complexity of the situations a phenomenon we attempt to study. What we can do is to occasionally reframe realities in scope, leave our studies and take a look at the far side in order to learn from the unknown (51).

After endlessly transcribing my interview material and vainly coding the texts in NVIVO (a software program for analyzing qualitative data), I found several gaps in my empirical material. The material, nevertheless, pointed me in the direction of analyzing the globalization of the LNG industry and the implications for development under the GPN framework. To fill out the gaps in my empirical material, I turned to other sources of empirical data.

One such source of data are the research houses of stockbroker firms, investment banks, credit-rating agencies, and other institutional "pseudo-researchers" that Yeung (2003) claims conduct "research through personal interviews, focus-group discussions, gossipy talks over lunches and dinners with executives from corporations, and reading company files and records" (452). Yeung claims that economic geographers can exploit such material while recognizing that the information lacks reflexivity and can be biased. It may come as no surprise that natural gas and the petroleum industry is well documented by trade journals, newspapers, auditors, commodity price reporting agencies, consultancy groups, international financial institutions, etc. In addition, several energy research institutions such as the Oxford Institute for Energy Studies,

International Energy Agency (IEA), International Gas Union (IGU), and US Energy Information Administration (EIA) have written extensive and detailed books, reports, and summaries of the natural gas industry.

The book, *LNG Markets in Transitions: The Great Reconfiguration* by the Oxford Institute for Energy Studies has been particularly useful in detailing the history of the LNG industry and the changes that have occurred since the last two decades, which the authors suggest point to a significant paradigm shift in the industry. The book also specifies how the globalization and commoditization of LNG has historically and continues to be dependent on market liberalization reforms, particularly in Asia. Clearly the authors and the Oxford Institute for Energy Studies subscribe to what Sica (2018a) describes as a neoliberal agenda for reducing nation-state authority over pricing regulation and subsidies in natural gas markets, and the growing role of commodity traders and the finance industry.

There is much to be critical of such agendas, and the Indonesia article points to how the globalization of the natural gas industry reduces the capacity of governments to systematically coordinate infrastructure projects to achieve energy development in the peripheral regions of the country. At the same time, however, these neoliberal accounts do reflect the potential capacities of global gas markets. Deleuze and Guattari (1984) suggest that subjective actors (such as the energy industry researcher) have access knowledge of potential capacities through thoughts and desire (Deleuze and Guattari, 1984). It should not be precluded that these thoughts and desires, in turn, have expressive capacities to actualize themselves in the real world through the agencies of and networks of interactions between social actors and material entities (technologies, natural gas, etc.). In other words, if we are to account for globalization, there is a need to take seriously the performative ideas and models through which such globalizations are realized. Based on my readings of LNG industry reports and books, I discovered that I lacked empirical material regarding the evolving political economy of natural gas markets. As explained earlier in the beginning of the theoretical chapter, natural gas markets tend to be governed under the exclusive authority of the nation-state,

which in turn has historically limited the globalization of LNG trade (I discuss these aspects in more detail in the Singapore article). My lack of empirical material on the political-economy of natural gas factored in my decision to research natural gas market liberalization in Thailand.

3.2.4. Globography and going back to the field

Næss' (2014) style of ethnography, which he calls "globography," is a methodological process of systematizing ethnographical inquiries in multiple locations and analyzing how the content of these ethnographies are connected and influence each other. Næss suggests that globography incorporates aspects of both multi-sited ethnography and global ethnography. Globography entails that researchers conduct ethnographic field word in multiple sites and follow the social processes as "red-threads" that connect localities. Such an approach, I argue, is similar to the rhizomatic research described earlier that involves multiple journey's and ideas that emerge during the research process.

In September 2016, I received a call from Axel Blom from Innovation Norway asking if I would be interested in a research project commissioned by the Norwegian Embassies in Thailand and Myanmar and financed by the Norwegian Ministry of Foreign Affairs. The project involved an evaluation of the drivers and situation of the LNG sector in Myanmar and Thailand along with the opportunities, barriers, risks, and strengths for Norwegian companies. The project would finance two months of research and fieldwork in Myanmar and Thailand. Originally Blom had intended for the Norwegian Maritime Advisory Company, DNV GL, to do the study since they had done similar studies for Indonesia and the Philippines, but DNV-GL declined this time. Blom was interested in my research and suggested to the embassy that I would be a good candidate to conduct the study.

After conducting desktop research (newspaper articles, reports, etc.) on natural gas markets in Thailand, I found that Thai authorities were currently involved in implementing natural gas market reforms. Additionally, I found that Thailand, which heavily relies on natural gas for power generation, was struggling to

increase domestic gas production and was forecasted to rely heavily on LNG imports in the near future. My decision to accept the offer from Blom was also influenced by a conversation with a commodity trader in Singapore during my fieldwork in April 2016, who explained that the key challenge with developing a regional commodity market in Southeast Asia is that governments continue to regulate tariffs and pricing in domestic gas markets. I accepted Blom's offer on the terms that I would have full rights to use the empirical material collected during the project for my thesis and I would have copyright on the report. I considered the embassy project as a considerable opportunity to research the evolving political economy of natural gas markets in Thailand, and to incorporate the empirical material into a wider study of globalization in my thesis.

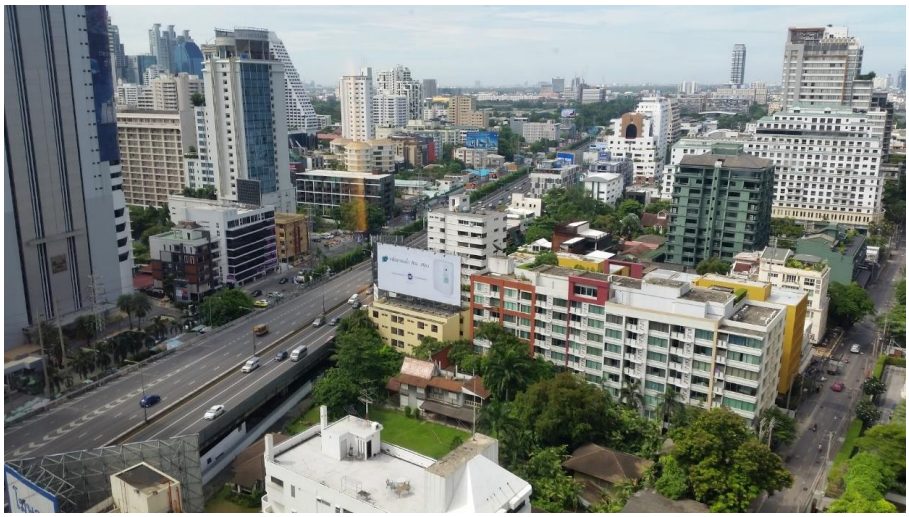

Figure 6 - Picture taken of Lumphini Subdistrict in Bangkok

I travelled to Bangkok in February 2017 and stayed for nearly three weeks. I was based at the office for Innovation Norway and the Thai-Norwegian Chamber of Commerce in the Lumphini subdistrict. I received support from Innovation Norway to book interviews with employees from companies and government agencies, which I had selected as relevant for my PhD research and the embassy project. The secretary at Innovation Norway booked interviews with senior managers at energy-related companies in Bangkok and senior government

officials, staff with whom I most likely would not have gained access to without Innovation Norway's support. A significant challenge in my research was asking questions related to both my PhD research and the project for the embassy, even-though there were some synergies. It was challenging to maintain the reflexivity of academic research in a project that was akin to the pseudo-research described earlier. Despite this challenge, I was able to gather considerable empirical material that would form the basis for the Thailand article. My interviews revealed that while Thai authorities had attempted to implement reforms in the natural gas sector since 1980s, the national gas company, PTT, has continued to maintain an effective monopoly over domestic markets. This situation has resulted in political contestation as PTT was partially privatized in 2001 – generating monopoly benefits to private shareholders. I was able to incorporate my research from the embassy project into an interesting and relevant case for my thesis.

After my fieldwork in Thailand, I travelled to Myanmar for a week for additional research related to my thesis. A challenge with conducting fieldwork in Myanmar is that few multinational companies have offices in Myanmar. Most LNG-related companies that have activities in Myanmar are located in Singapore. Instead of LNG-related companies, I primarily interviewed law consultants in Myanmar, which I discovered played a key role in helping firms navigate the complexity of the inner-workings of the Myanmar government. My research in Myanmar was interesting, particularly due to the geopolitics of natural gas trade between Myanmar, Thailand, and China. However, I found that there were too many gaps in my fieldwork to write a proper research article on the situation in Myanmar.

Figure 7 - Picture taken outside Schwedagon Pagoda in Yangon

The embassy research project in Thailand and Myanmar was ethically challenging in terms of informed consent (Fine and Shulman, 2009). Conducting interviews on behalf of the Norwegian embassy was ethically challenging, as my interviewees may not have been fully aware of the scope of my research. I therefore always started the interview by explaining my PhD project and explaining that the information from the interview could be incorporated into my thesis. Since I was located right outside Blom's office, I was able to have many discussions with him explaining the topic of my PhD thesis. However, according to Fine and Shulman (2009), even if researchers are straightforward about their intentions, informed consent is complicated by grounded theory in ethnography as "good ethnographers do not know what they are looking for until they have found it" (6). To some extent, ethnographers must reflect that the line between being informed and uninformed is uncertain as ethnographers themselves may not be aware of what they will find during their fieldwork.

3.3. Analysis and the limits of empiricism

I returned to Norway in March 2017 with a range of interview transcripts, reports, newspaper articles, notes, and historical documents from four different countries in Southeast Asia. Based on my initial analysis of the empirical material, I had decided to organize my research into three different yet interconnected extended case studies. The three case studies would include the development of an LNG hub in Singapore, market liberalization reforms in Thailand, and the tender for LNG supply in Indonesia. In line with the literature of extended case studies, the purpose of the three case studies was to extend the local experiences, observed qualitatively through interviews and participations at events, into a wider study of the globalization of natural gas markets. Burawoy et al. (2000) suggest that by grounding ethnographies in local histories, or ethnohistories, researchers can explore changes in globalization. Therefore, the three case studies draw upon the work of historians, political economists, documents, newspaper articles, etc. to better understand how the globalization of natural gas markets has changed the strategies of corporations and governments. It is through these grounded ethnographies and ethnohistories that the implications of globalization for energy development and politics in Southeast Asia are accounted for in my research articles.

Næss (2014) explains that generalizing overarching theories and representations to say something beyond the phenomenon being studied can be challenging in multi-sited ethnographic studies, given the complex contextual aspects of such studies. Nevertheless, Næss suggest that ethnographic studies can be used to draw wider lessons in terms of how researchers have come to their conclusions. Specifically, researchers can share their experience in how they have approached the complexity of the phenomenon studied in their analysis and how they draw lines between ideas and text. In this section, I explain how I have approached the complexity of my research on natural gas markets and politics in Southeast Asia using assemblage thinking, with the intent of demonstrating how assemblage thinking can be used to account for globalization.

In addition to accounting for the implications of globalization, my analysis in the three case studies pointed to a divergence between the everyday experiences of interviewees in Singapore, Indonesia, and Thailand with the globalization narratives of industry proponents in LNG industry reports and conference PowerPoint slides. For example, LNG industry reports showed graphs of spot markets as a growing share of LNG trade and concluded that long-term take-or-pay contracts were becoming a thing of the past. However, as discussed in the Indonesia article, interviewees revealed that one of the key barriers to developing the LNG tender in Indonesia was that the government was refusing to commit to long-term contracts. Interviewees argued that that the complexity of distributing LNG across the Indonesia archipelago, due to challenges of shipping and storage, necessitated long-term, take-or-pay contracts even though short-term contracts are becoming more prevalent.

Based on my initial analysis of the empirical material, it seemed that the properties of natural gas made natural gas difficult to commodify. At the time I was inspired by the actor-network theory's sensitivity to the material inventions of matter in how agency and politics are constituted, and that materials and technologies can become political (Barry, 2013). Furthermore, an article by Gavin Bridge (2004) inspired me. Bridge's article drew on the work of Karen Bakker (2003) on uncooperative commodities to suggest that natural gas is uncooperative to its commodification due to the difficulties of creating exchange value. In addition, Bridge, together with Michael Bradshaw, had also recently published an article analyzing the globalization of natural gas markets through the spatial and organizational diversification of LNG production networks (Bridge and Bradshaw, 2017). The GPN approach, which has an ontological foundation in actor-network theory, calls for empirically tracing the connections between actors and materials along production networks, and accounting for the nature of these connections to account for the globalization of goods and services (Dicken et al., 2001; Henderson et al., 2002).

Based on the methodological implications of the GPN approach, I intended to connect the strategies of actors and the dynamics by which LNG production networks were evolving to account for the implications of these networks for development outcomes. The causal loop diagram in Figure 11 demonstrates my early attempts to trace the strategies and non-linear causal dynamics by which traditional business practices in the LNG industry are being transformed and how these transformations contradict with the development strategies of the Indonesian government. Tracing networks through causal loop diagrams was useful to visualize the distributed agency and non-linear causality by which LNG production networks are transformed. However, during my analysis I became frustrated with the empiricism of actor-network theory (and the endless tracing of networks), materiality studies, and the GPN approach.

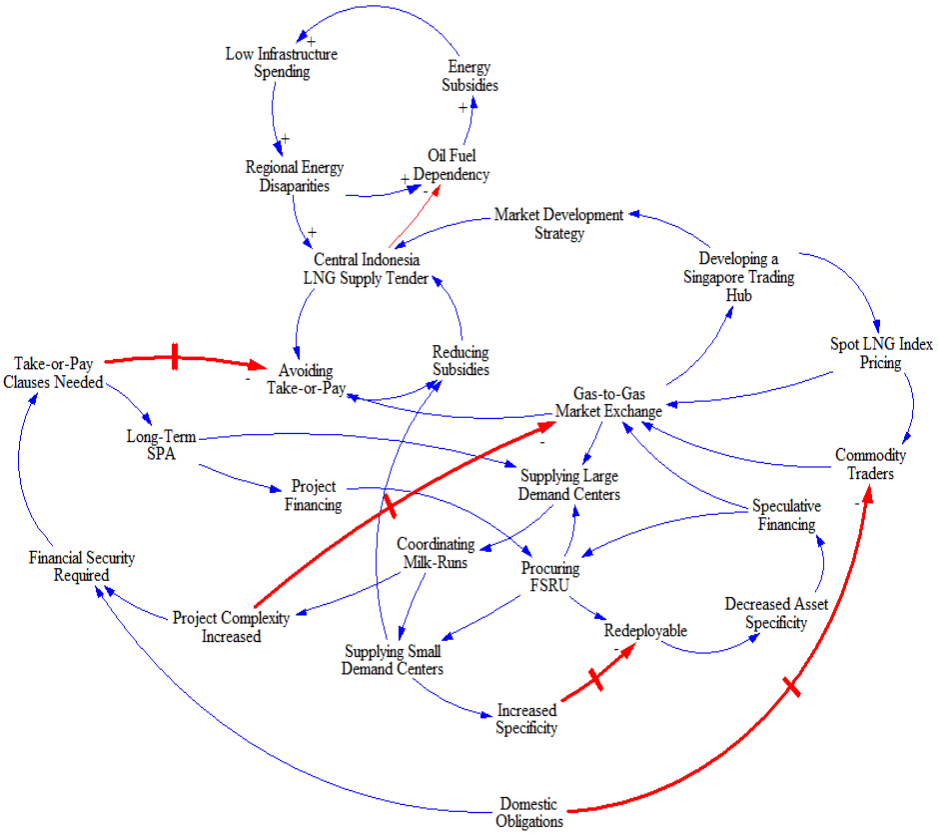

Figure 8 - Casual loop diagrams visualize how different variables in systems are interrelated. The blue lines enable how capacities are affected through relations. The red lines symbolize contradictions in the systems.

While the GPN approach and actor-network theory is useful for accounting for a wide spectrum of different dynamics by which markets are globalizing, it was difficult to distinguish between changes that were significant (intensive) from those that are trivial (extensive). As mentioned in the theoretical section, the complexity of globalization can be better recognized by accounting for the differences between intensive and extensive changes. Furthermore, as Tolia-Kelly (2013) claims, studies of materiality tend to endlessly describe materialities without reflection, critique, or political engagement. I elaborate further on the limitations of current literature on materiality, specifically by GPN scholars, in the Indonesia article. My empirical material pointed to the limitations of empirically tracing relationships between the material and the social in LNG production networks, since such relationships were continuously being destabilized and transformed. Conversations with different interviewees regarding the Indonesia tender revealed a large degree of uncertainty and contestation between government officials and companies on what the implications of globalization are for LNG projects in Indonesia. These conversations centered on the materiality of natural gas and what the possibilities for its distribution across the Indonesia archipelago entail.

By claiming that every entity, human and non-human alike, is preformed through relations in actor-networks, actor-network theory lacks the epistemological basis to methodologically analyze the extent to which the materiality of natural gas affects political outcomes. Particularly as the inter-organizational relationships, that make value creation possible, are transformed. This is because such considerations are not empirically reducible. By conceptualizing entities as fully determined by their actual relations, it becomes impossible to account for the causal power of currently unexpressed capacities to potentially affect outcomes (Anderson et al., 2012). While I was analyzing my empirical material, my supervisor had introduced me to assemblage thinking, which he had used himself to conceptualize transnational student mobility (see

Lysgård and Rye, 2017). Through the notion relations of exteriority, assemblage thinking differentiates between the properties of component parts in assemblages, which can be specified without reference to anything else, and the capacities to affect, which must always be thought in relation to capacities to be affected (DeLanda, 2011). Capacities depend on properties, but at the same time are not reducible to such properties since capacities are relational.

Assemblage thinking differs from actor-network theory in that it defines the ontological status on non-currently exercised capacities and non-presently manifested dispositions (DeLanda and Harman, 2017). Assemblage thinking, through relations of exteriority, defines capacities and tendencies that are not currently exercised as virtual (real, but not actual). DeLanda (2006) writes that:

> The ontological status of assemblages is two-sided: As actual entities all the differentially scaled social assemblages are individual singularities, but the possibilities open to them at any given time are constrained by a distribution of universal singularities, the diagram of the assemblage, which is not actual but virtual (40).

Since assemblage thinking considers relationships as exterior to the properties and identities of human and non-human entities, non-actual capacities may be nearly given the sheer number of possible relations (Dittmer, 2014). Deleuze borrows the notion of "phase space" from dynamical systems theory which conceptualizes the multitude of virtual capacities immanent from multiplicities of materials and agencies through which assemblages may or may not be transformed (DeLanda, 2013). By associating entities, such as natural gas, with a corresponding phase space, or possibility space, assemblage thinking builds a foundation to consider the possible capacities by which value creation from natural gas may or may not be realized.

Delanda (2017) claims that assemblage thinking is not ontologically committed to mapping the entirety of possible capacities in possibility spaces, as it would be impossible to characterize the entire multitude of possibilities. Instead, assemblage thinking is concerned with the structure of possibility spaces. While relations between entities are exterior to the properties of entities, the properties of entities

are nevertheless associated with the relative tendencies of entities. An empirical investigation of relative tendencies can be used to determine the distinction between ordinary and special possibilities. Natural gas, when passed through a heat exchanger and cryogenically cooled to -163 degrees, has the relative tendency to liquefy. When liquefied natural gas is exposed to heat, it has the relative tendency to evaporate. Relative tendencies are not limited to material entities – corporations have an empirically observed, relative tendencies or dispositions for profit maximization under differentiated circumstances (i.e. shareholder capitalism). Dispositions and relative tendencies point to the structure of possibility spaces that provide an ontological basis for understanding the rate of change and relative degrees of stability (Anderson et al., 2012).

While assemblage thinking points to the limitations of empiricism, it remains committed to empiricism. The structure of possibility spaces is established posteriori, after experience, because this structure is immanent to multiplicities. However, using empiricism to map the structure of possibility spaces, or the diagram of assemblages, is difficult in assemblages characterized by relativity stable patterns of behavior. While such behavior may fluctuate overtime, such changes do not qualitatively change the patterns of behavior of assemblages. As explained in section 2.5 of the theory chapter, extensive differences may change the boundaries of assemblages, but not result in a qualitative difference in patterns of behavior. What is virtual reveals itself in situations characterized by far-from-equilibrium, which is characterized by instability and transformation where intensive differences are observed. These situations reveal complex, non-linear dynamics where patterns of behavior in assemblages become qualitatively different. DeLanda (2013) writes:

> One of the tasks of a philosopher attempting to create a theory of virtuality is to locate those areas of the world where the virtual is still expressed, and use the unactualized tendencies and capacities one discovers as sources of insight into the nature of virtual multiplicities (67).

My empirical material revealed that LNG production networks can be characterized by the deterritorialization of traditional patterns of behavior,

characterized by point-to-point LNG flows governed by long-term contracts. These patterns of behavior are reterritorialized through emerging interactions, and agencies with potential capacities to reconfigure LNG production networks. My empirical study differs from empirical studies by other geographers who observe relatively stable GPNs (f.eks. Bridge, 2008; Gibson and Warren, 2016; Yeung, 2016).

Analyzing my empirical material through assemblage thinking entailed accounting for both the capacities and tendencies of corporations, governments, and other strategic actors. Furthermore, assemblage thinking entails accounting for how these capacities and tendencies are transformed by emerging business practices, technologies, new interactions, and the capacities and tendencies that remain invariant or unaffected by these transformations. As explained in section 2.5 in the theoretical chapter, difference and transformation is given, but patterns of behavior can remain equivalent through such differences. By mapping the structure of possibility spaces, I sought to identify the points or thresholds by patterns of behavior that are intensively or qualitatively changed. My interviews on the LNG tender in Indonesia revealed that despite new business practices and technologies, the relative tendency of natural gas to evaporate during transport has been largely unaffected due to the properties of natural gas. As I describe in the Indonesia article, the consequence of these capacities that remain invariant is that they require the systematic coordination of LNG projects in Indonesia, which in turn limit the capacity of traders to supply LNG on short-term contracts. Therefore, the globalization of natural gas markets does not qualitatively change the inter-organizational arrangements by which LNG is supplied in Indonesia. My empirical research, therefore, points to multiple patterns of behavior by which LNG production networks are both transformed and remain the same. It is through these grounded, empirical observations that the structure of possibility spaces can be conceptualized, and political and energy development outcomes can be accounted for.

Summary of Articles and Conclusions 4

> The orchid deterritorializes by forming an image, a tracing of a wasp; but the wasp reterritorializes on that image. The wasp is nevertheless deterritorialized, becoming a piece in the orchid's reproductive apparatus. But it reterritorializes the orchid by transporting its pollen…a becoming-wasp of the orchid and a becoming-orchid of the wasp. (Deleuze and Guattari, 1987, 10)

The quote above points to Deleuze's conceptualization of "becomings" or emergence as immanent to the evolution of ecological relations of symbiosis among heterogeneous entities. These are not mutually constitutive relationships but relations of exteriority. In the theory and methodological chapters of this thesis, I have discussed the implications of the notion relations of exteriority for analysis and explanation in economic and energy geography. The evolutionary history of certain species of orchids and wasps (and bees) demonstrate that orchids have evolved certain fragrance compounds that wasps use for courtship delay, in addition to traps designed to stick pollen sacks on the wasps before they fly away. The wasps, in turn, reproduce orchids by transporting the pollen to other orchids. In the start of this thesis, I reflected on how in Boshu philosophy there is nothing essential about the relations between heaven, earth, and humans (*Tian Di*

Ren), but human society emerges and progresses to the extent that such relationships, like those of the orchid and the wasp, are symbiotic and harmonious. In the theory and methodology chapter of this thesis, I outlined how Deleuze's philosophy of immanence and the notion of relations of exteriority has constituted the ontological and epistemological basis of this thesis.

In this chapter, I intend to summarize the key findings from the three research articles and present the main conclusions of this thesis. The main ambition of this thesis has been to explain *the dynamics by which natural gas trade and markets are globalizing*, *the extent to which this globalization is limited, and the implications of these dynamics and limitations for energy development and politics in Southeast Asia*. Furthermore, this thesis has aimed to contribute to economic, political, and energy geography by drawing on assemblage and topological thinking to give analytical purchase to the global production network approach and the notions of territoriality and materiality.

In this chapter, I present the main conclusion of this thesis: *The globalization of natural gas markets potentially emerges from the co-evolution between emerging arrangements in LNG production networks and state strategies surrounding energy development and policy.* This finding, by itself, does not contribute to a significantly different understanding of globalization in economic geography. Dicken (2004), among other geographers, recognized that globalization is a process of mutually constitutive relationships between the intensification and stretching of networks across the global economy and the emerging rules and conventions of the global capitalist market economy, the commodification of production and inputs, and the multiplication of scales. However, instead of conceptualizing globalization as emergent from mutually constitutive relations among inter-organizational arrangements in GPNs and evolving state strategies, I draw on assemblage thinking and the findings from the three research articles to conceptualize these relations as only contingently obligatory. In other words, these relations, like those of the orchid and the wasp, can be characterized by the notion "relations of exteriority."

The relationship between global production networks and state strategies are transformed and sustained to the extent that GPNs are deterritorialized and reterritorialized by emerging state strategies, and state strategies are deterritorialized and reterritorialized by emerging inter-organizational arrangements. Furthermore, these processes occur through complex dynamic systems characterized by non-linear causality as explained in the theoretical section. Based on the theoretical framework and key findings developed in the research articles included in this thesis, I suggest that the relationships between emerging arrangements in LNG production networks and state strategies are non-linear causal relationships, where the relations between cause and effect is related to questions surrounding the materiality of natural gas, internal power dynamics, and individual nation-states. In addition, based on the key findings from the research articles in this thesis, I suggest that these dynamics are characterized by instability and, therefore, point to the limitations of globalization of natural gas markets.

The rest of this chapter is organized as follows. In the next section the empirical background for the three research articles is summarized. I then sum up the theoretical and empirical contributions of the three research articles. Section 4.2 presents the key findings and main conclusions of this thesis. Section 4.3. is an outline of the theoretical contributions of this thesis to economic and energy geography. Finally, section 4.4 suggests directions for further research.

4.1. Summary of Articles

In this thesis, I have explained that the geography of international natural gas trade is rapidly shifting. As discussed in the introductory chapter of this thesis, most of the world's natural gas is consumed in the countries where it is produced or is traded through cross-border pipeline connections between nations (IGU, 2017). Liquefying natural gas by cryogenically cooling it to -163° C enables the seaborne and long-distance transport of natural gas. Historically, LNG trade has been exclusive to a few bilateral trade agreements between seller consortiums led by oil and gas producers in low-income economies and buyer consortiums led by natural

gas companies in high-income economies (Corbeau and Ledesma, 2016). However, in the last decade, LNG production has expanded rapidly, primarily led by Qatar and Australia, and more recently the United States. While the United States was once a large importer of LNG, natural gas production has increased rapidly with the advent of hydraulic fracturing technology and shale gas production. Furthermore, traditional LNG consumers, such as Japan, have seen a decline in LNG demand growth.

Growth in global energy production, high economic growth, and the increasing need for energy supply and security have led several Southeast Asian countries, including Singapore, Thailand, Indonesia, Myanmar, Philippines, Vietnam, and Malaysia to begin importing or drawing up plans to import LNG (IEA, 2017b). Industry proponents claim that natural gas can be a bridge to a low carbon future, as natural gas constitutes a lower carbon emitting alternative to oil-fired and coal-fired electricity generation (Rapier, 2018; Stern, 2017; IEA, 2017a). With long coastlines and scattered populations, several countries in Southeast Asia have considered using LNG to replace oil-fired power plants in peripheral regions (Walker, 2018). The importation of LNG is significant considering that the region has historically been a major exporter of natural gas, primarily to North Asia (Sovacool, 2009).

In line with Bridge and Bradshaw (2017), I have used the GPN approach in this thesis to explain the dynamics by which interorganizational and spatial arrangements in LNG production networks are evolving and how these dynamics are reshaping the territoriality of global natural gas markets. Whereas traditional LNG production networks have been characterized by tight inter-firm relations governed by long-term, take-or-pay contracts, LNG production networks are currently becoming more organizationally fragmented and complex. Since the early 2000s, emerging corporate practices have led to the gradual separation of ownership of different activities along the LNG value chain (Bridge and Bradshaw, 2017; Ledesma, 2016). For example, through tolling arrangements, the ownership of upstream natural gas extraction is separated from the ownership of liquefaction

and storage terminals (Ledesma, 2016). The separation of ownership opens for multiple actors to make equity investments on liquefaction terminals. These inter-organizational arrangements in LNG production networks have enabled the growth of "portfolio suppliers" who invest equity on multiple LNG terminals around the world and use those investments to arbitrage supply opportunities. In addition, corporations that have historically been buyers of LNG, are now moving upstream by taking equity investments in upstream terminals (Ledesma, 2016). Increased equity investments have in turn led to more LNG being sold outside long-term, take-or-pay contracts through spot markets. Spot markets have grown considerably and have become increasingly less expensive, particularly after the oil price crisis in 2014 (IGU, 2017). Electricity in emerging economies is generally capped with tariffs by governments, and governments in lower income markets bear significant credit risk in signing long-term contracts. Therefore, the growth in LNG spot markets and the corresponding flexibility in LNG supply have significant implications for LNG demand growth in emerging economies.

While the GPN approach is useful for explaining how the territoriality of natural gas markets is evolving, I have suggested in the theoretical chapter that assemblage and topological thinking can be used to develop more dynamic and non-linear conceptualizations of causality and transformation in natural gas markets. I draw upon assemblage and topological thinking to analyze three case studies based on fieldwork in Singapore, Thailand, and Indonesia. These papers are related both conceptually and empirically. The three case studies constitute the three research articles presented in part two of this thesis. In the rest of this section, I will present a summary of each of the articles by outlining their key findings and main theoretical contributions. While summarizing the three case studies, I will additionally explain how the three case studies are empirically interrelated.

4.1.1. Article 1 (The "Singapore" Article)

Dodge, A. (Under Review). A Singaporean LNG hub: reassembling liquefied natural gas production networks in Southeast Asia. *Journal of Economic Geography.*

The first article explains that a key limitation for the globalization of natural gas markets are immature marketplaces and a lack of standardized pricing benchmarks for natural gas in Asia where 85 percent of expected demand growth in global LNG markets is expected to occur (IEA, 2017c). In the paper, I explain how the unbundled authority over natural gas markets, that were formally exclusive to the nation-state, are being reassembled by public and private actors in global cities. I draw upon the global production network approach to explain how the territoriality of LNG production networks are evolving through the coordinating strategies of firms, extra-economic actors, and intermediaries.

In line with Smith (2015) and MacKinnon et al. (2018), I suggest the need to better account for the centrality of economy-state intersections in GPNs and to understand industrial formations in the context of the wider political economy that they are a part of. I do so by utilizing assemblage thinking and the work of Saksia Sassen (2006) to draw attention to the agencies and initiatives of public and private authorities that rework nation-state authority and reorient regulatory frameworks and infrastructure towards global agendas, thus constituting novel geographies of authority within emerging global assemblages. I suggest that these dynamics shape the evolutionary trajectories of global production networks. Drawing on the notion of relations of exteriority from assemblage thinking, I explain that the capacities of public and private authorities to constitute novel geographies of authority, and thus shape LNG production networks, are not guaranteed. Such dynamics are sustained through specialized functions (accounting, financial, technical, etc.) typically located in global cities (Sassen, 2000). However, the capacity of global cities to shape the global economy is not only about holding in reserve the right mix of resources and service functions, but also a question of the capacity of financial, political, and corporate elite to employ resources that establish and sustain connectivity beyond the city itself (Allen, 2010).

Through this theoretical framework, I explain that inter-firm relationships in LNG production networks, particularly in Asia, have been traditionally governed

under the authority of nation-states, such as Japan, with the financial and regulatory capacity to support utilities and corporations in securing LNG imports. These traditional arrangements are nevertheless being deterritorialized through the decline of demand growth in mature importing countries and new imperatives for market development in emerging economies, such as Indonesia. A key challenge is that emerging economies are pressuring suppliers to offer more flexible and shorter contracts, which is resulting in a mismatch with the continued need for long-term contracts to underpin investments in upstream LNG projects. In this context, commodity traders may play a key role in hedging the risk of long-term contracts and trading LNG on spot markets. However, a key challenge for growth in commodity trading is that LNG markets in Asia are insufficiently financialized.

By establishing an LNG hub, public and private authorities in Singapore intend to facilitate the growth of LNG commodity trading markets in Asia and, therefore, shape LNG production networks. The Singapore article finds that Singapore's capacity to shape LNG production networks is dependent upon the capacity of public and private actors in Singapore to reassemble authorities, reorient regulatory frameworks, and establish cross-border connectivity to neighboring markets in SEA. While 95 percent of electricity generation in Singapore is fueled by natural gas, Singapore's domestic natural gas market is too small to generate enough liquidity to establish a reliable market place and pricing benchmark in Singapore. Therefore, Singapore is attempting to establish its physical connectivity to natural gas markets in neighboring countries by importing large cargos of LNG and re-exporting small cargos to small demand centers. In doing so, Singapore could establish a regional market for natural gas trading in SEA and eventually establish a price benchmark for LNG trading in the rest of Asia.

4.1.2. Article 2 (The "Thailand" Article)

Dodge, A. (Under Review). The 'changing same of power:' contentious politics and natural gas market liberalization in Thailand. *Geoforum*.

One of the key challenges for developing a regional gas market is that Singapore's neighboring countries, such as Thailand, have natural gas markets that are firmly controlled by regulated monopolies, which subsequently limits the prospect for commodity trading. Singapore is therefore dependent upon the willingness and capacity of neighboring countries to implement market liberalization reforms to break domestic monopolies. The second article of this thesis addresses the following research question: How do state-owned natural gas companies utilize different modalities of power to reproduce their monopoly over natural gas markets despite liberalization attempts by authorities.

The article discusses that despite liberalization efforts from state authorities since the 1990's in Thailand, the state-owned natural gas company, PTT, continues to maintain an effective monopoly over Thailand's natural gas markets. In the Thailand article, I discuss how the natural gas markets, as is the case in Thailand, has been historically governed under the exclusive authority of nation-state. It is through the exclusive authority of the nation-state that PTT has maintained its extensive power and monopoly over natural markets in Thailand. In the empirical analysis of the article, I find that the evolving territoriality of natural gas markets in Thailand through globalization (via LNG imports) and market reforms point to the limitations of territorial notions of power.

Building on the work of John Allen (2016), I explain that topological notions of power can be used to draw attention to the quieter, more spatially distorted registers of power by which PTT reproduces its dominance over markets in Thailand. Allen (2016) explains that territorial notions of power tend to conceptualize power as extensive across space through scales and networks. Intensive arrangements of power, on the other hand, focus on the relationships and interplay between different institutional interests and authorities, where power relationships are mediated through events, technologies, and practices for specific political and economic ends. In the empirical analysis in the article, I find that the globalization of natural gas markets, through LNG imports and market reforms, threaten PTT's monopoly. Despite these threats, the article finds that PTT

continues to maintain its monopolistic advantage over gas markets relationally through infrastructure, contracts, and price regimes.

The findings from the Thailand article point to the limited capacity of private and public actors in Singapore to establish a regional trading market for LNG due to the limitations of market reform attempts in neighboring markets in Southeast Asia.

4.1.3. Article 3 (The "Indonesia" Article)

Dodge, A. and Rye, S. (Submitted). State strategies and materiality in dynamic liquefied natural gas production networks. *Economic Geography.*

Another key challenge for Singapore to establish its physical connectivity to neighboring natural gas markets in Southeast Asia is that while Indonesia has a large potential market for small LNG cargos from Singapore, market development in Indonesia has been stalled. The third article of this thesis addresses how the materiality of natural gas constrains and enables political and energy development outcomes in dynamic liquefied natural gas production networks.

In the third article, I discuss how a public-private partnership project to supply 21 power plants across the islands of Kalimantan, Sulawesi, and Nusa Tenggara was slated for completion by 2018 has yet to be realized due to disagreement between the national electricity company of Indonesia and potential commercial partners. In the Indonesia article, I discuss why state strategies for LNG market development in Indonesia are limited vis-à-vis evolving interorganizational and spatial arrangements in LNG production networks. Following Bridge and Bradshaw (2017), I explain that the materiality of natural gas is integral to its circulation and both enable and limit certain political possibilities in LNG production networks. At the same time, I argue that current conceptualizations of materiality in the GPN approach are insufficient to explain how the materiality of natural gas limits political outcomes in dynamic LNG production networks. I suggest that by drawing upon insights from assemblage thinking a more nonlinear and dynamic conceptualization of materiality can be developed. Specifically, I

suggest that assemblage thinking can be utilized to consider the dynamics by which LNG production networks are deterritorialized and reterritorialized while identifying the aspects of materiality that remain invariant to such transformations. In doing so, the emerging forms and boundaries by which certain political and economic outcomes are excluded from GPNs can be accounted for.

The Indonesia article explains that while Indonesia has historically been a large exporter of LNG, domestic markets in Indonesia have been traditionally excluded by binational, point-to-point flows governed by long-term contracts in LNG production networks. In 2015, the government launched plans to reconfigure the national energy system to reduce the use of expensive fuel oil and increase energy access in line with president Jokowi's promise to modernize infrastructure in rural Indonesia. State authorities in Indonesia have therefore sought to take advantage of the expansion in LNG production and growth in LNG spot markets by importing LNG to supply domestic markets in Indonesia. To do so, Indonesian authorities are leveraging their purchasing power in oversupplied global LNG markets by requiring companies to supply rural regions with low profit margins in order to access to more profitable markets in urban regions. The Indonesia article finds that the materiality by which LNG may be potentially distributed across the archipelago nation, particularly to rural regions, contingently requires the systematic coordination of LNG projects. The article finds that systematic coordination of LNG projects subsequently contradicts the dynamics by which organizational and spatial arrangements in LNG production networks are currently evolving. Consequently, the capacities of the Indonesian state to realize its strategies are limited. As a result, LNG projects in Indonesia have been stalled.

The findings from the Indonesia article point to the limits of developing regional LNG trading markets in Southeast Asia as the desire of states to increase electricity access through LNG may require the systematic coordination of LNG projects, which in turn limits the growth of commodity trading. As mentioned previously, the capacity of Singapore to realize its ambitions for developing an LNG hub is

dependent upon establishing cross-border trading with neighboring markets such as Indonesia.

4.2. Main Conclusions

Based on the findings in the three research articles, this thesis concludes that natural gas markets are globalizing through the deterritorialization and reterritorialization of LNG production networks and state strategies through emerging interactions with new technologies, financial intermediaries, etc.. Nevertheless, the globalization of LNG markets is limited by certain aspects surrounding the political economy and materiality of natural gas which remain *invariant*, or to a large degree unaffected by the globalization of global natural gas trade. As demonstrated in the Indonesia article, natural gas continues to remain an *uncooperative* commodity. The production, distribution, and supply of natural gas continues to require significant upfront costs in infrastructure. LNG continues to "boil-off" during storage and transport resulting in high operation costs. Historically, the uncooperative materiality of natural gas has justified the territorialization of natural gas markets under the exclusive authority of the nation-state. While such authorities are becoming unbundled through gas market liberalization reforms, as demonstrated in the Thailand article, the nation-state still plays a key role in implementing such regulations. Specifically, the nation-state enforces the separation of the ownership of commercial infrastructure from the commercial marketing of natural gas.

The main conclusions of this thesis are as follows. First, the thesis shows that the dynamics by which natural gas trade and markets are globalizing is related to the growth of LNG commodity trading through the standardization of pricing regimes and growing liquidity of market places. The Singapore article shows that these developments co-evolve with the unbundling of authorities formally exclusive to the nation-state and the emergence novel geographies of authority. These dynamics are related to state strategies on energy development and policy. While emerging arrangements in LNG productions networks affect state strategies, as demonstrated in the three research articles, the relationship between emerging

arrangements and state strategies can be characterized by *relations of exteriority*. State strategies, as discussed in the Singapore article, can be related to particular modes of development intended to consolidate power and stabilize social struggles within the state and are, therefore, partially external to arrangements in global production networks (Smith, 2015). Based on the findings from the research articles, I suggest that the relationships between emerging LNG production networks and state strategies are only stable to the extent that they are symbiotic. The extent to which such relationships are symbiotic is a question of the spatiotemporal context, in terms of materiality and political-economy, through which such relations become co-articulated.

Second, the thesis demonstrates that the dynamics, by which state strategies surrounding energy development and policy are constituted, are contradictory to emerging arrangements in LNG production networks. While state strategies may be deterritorialized and subsequently reterritorialized through emerging arrangements in LNG production networks, these relations are not mutually constitutive. The Indonesia article explains that state strategies in Indonesia related to modernizing infrastructures in rural regions contradicts the dynamics by which LNG production networks are evolving. These contradictions subsequently point to the limitations and instability surrounding the globalization of natural gas markets. As the development of an LNG trading hub in Singapore is related to the liberalization reforms and increasing demand in regional markets, Singapore's capacity to develop an LNG hub is limited due to its small market size and challenges of establishing connectivity to neighboring markets in Southeast Asia. Subsequently, the capacity of commodity traders to hedge risk on long-term LNG contracts and supply flexible LNG supplies to Southeast Asia is limited without the development of a liquid commodity trading market and a standardized pricing regime. For example, in 2018, the commodity trading house Trafigura booked a $250 million-dollar loss on oil and gas market hedges, primarily due to the complexities surrounding hedging long-term LNG contracts due to the lack of liquidity in global LNG prices (Zhdannikov, 2019). Under the current situation, the

growth in commodity trading and LNG spot markets is limited, which in turn points to the limitations of the globalization of natural gas markets.

Finally, this thesis shows that the globalization dynamics in natural gas markets and the limitations of these dynamics has several implications for energy development and politics in Southeast Asia. The Indonesia article demonstrates that certain energy development outcomes are excluded by the dynamics by which LNG production networks are deterritorialized and reterritorialized. Specifically, the capacity of the government to systematically coordinate LNG projects to achieve energy development outcomes in rural regions is limited, as doing so would require long-term, take-or-pay contracts. Furthermore, the limits of globalization point to a scenario where commodity trading on spot markets and flexible LNG contracts may be limited and long-term contracts may continue to be the norm in the global LNG industry. Signing long-term, inflexible LNG contracts comes at considerable risk. In the Indonesia article, I explain how long-term contracts lock energy systems into long-term contracted LNG imports despite the circumstances that may arise, which comes at following risks: First, a significant rise in LNG prices could increase current account deficits which would have a negative economic impact. Second, electricity demand, especially in peripheral regions, can be unstable and uncertain and governments in emerging economies would bear the risk of demand shortfalls straining federal budgets. Third, despite decreasing costs, governments would have little incentive to invest in renewables, as doing so would decrease the utilization rates of contracted LNG quantities and associated infrastructure capacities. These implications point to a complicated picture surrounding the role of LNG in solving the global energy dilemma discussed in the theoretical chapter. Namely, these implications point to the limited capacity of LNG to achieve energy development goals in low and middle-income nations, while at the same time contributing to the reduction of global climate emissions.

4.3. Main Theoretical Contributions

In this thesis, I have argued that assemblage and topological thinking can be utilized to develop more dynamic and non-linear conceptualizations of emergence, transformation, and causality in economic and energy geography. Specifically, I have used assemblage and topological thinking to further conceptualize territoriality, global production networks, materiality, and power. I have previously suggested in the theoretical section that assemblage thinking gives analytical purchase to economic and energy geography by 1) recognizing the provisionality of emerging forms and draws attention to how structures emerge from relations between actors and materials, 2) recognizing the instability and continuous transformation of global production networks and opens up for more dynamic and non-linear causal explanations of outcomes, and 3) identifying what is transformed through territorialization and deterritorializations and what remains invariant or unaffected by such transformations.

In addition to the main theoretical contributions outlined above, the three research articles summarized earlier also contribute theoretically to the concepts of territoriality, materiality, and power in economic geography. The three theoretical contributions of the research articles constitute a meta-theoretical framework that can give analytical purchase for more dynamic and non-linear conceptualizations of globalization in geography. In the Singapore article, I suggest that research in geography on political-economy and globalization, such as that of Brenner (2004), tends to frame globalization in terms of nation-scales being destabilized by the growth of supranational institutions and undermined by the decentralization of decision-making powers to sub-national institutions embedded in regional and urban scales. This research tends to underemphasize the looser, more negotiable sets of political arrangements that stretch both within, across, and beyond given scales and boundaries, which are part of emerging socio-spatial assemblages. I suggest that assemblage thinking can be used to better conceptualize the initiatives of public and private actors that rework nation-state authorities and reorient regulatory frameworks and infrastructure towards global

agendas, thus constituting global assemblages. Furthermore, I suggest that assemblage thinking can be useful to highlight the uncertainty and instability of such processes, as such assemblages are not held together by virtue of dominance over resources, but through symbiosis and self-organizing potential. Drawing on the work of Saksia Sassen (2006), I explain how emerging geographies of authority in global assemblages can shape global production networks, and vice versa. The Singapore article, therefore, points to, as described earlier, my main conclusion that globalization emerges from the co-evolution of inter-organizational arrangements in global production networks and state strategies. At the same time, by drawing on assemblage thinking, the Singapore article points to these relations as not mutually constitutive and subject to instability.

Overall, in this thesis, assemblage and topological thinking has helped me reconcile with the complexity of globalization at a conjunctionally specific moment where LNG production networks and gas markets can be characterized by instability and transformation. Transformation and instability in assemblages is given, as relations are exterior to the related terms and relationships are continuously being deterritorialized and reterritorialized. However, assemblage thinking entails conceptualizing the difference between extensive and intensive changes. Extensive changes may lead to up to, but don't necessarily result in changes in the quality or intensity of overall patterns of behavior in assemblages. Intensive changes are reminiscent of what Sassen (2006) describes as tipping points that leads to new organizational logics and the reconfiguration of territories, authorities, and rights that subsequently leads to a shift from national to global assemblages. In the theory chapter, I explained that temperature changes and phase transitions in materials such as water highlight the differences between extensive and intensive changes. Such phase changes are associated with the relative tendencies of assemblages and structure of possibility spaces described in the end of the methodological chapter. At the end of the methodological section, I explained that the structure of possibility spaces provides an ontological basis for understanding the rate of change and relative degrees of stability. In my articles, I have suggested that changes in inter-organizational relationships in LNG

production networks coincide with changes in state authorities surrounding natural gas markets at specific thresholds where intensive changes occur.

While changes in global production networks and state strategies are related, these are not linear casual relationships, but relations of exteriority in complex systems. Inter-organizational and spatial arrangements in global production networks can change without state strategies changing, and vice-versa. Furthermore, extensive changes in global production networks, by itself, does not result in an intensive change from national to global assemblages. As explained in the Singapore article, while global LNG production networks are evolving, this evolution is limited by the lack of standardized pricing regimes and liberalization in Asia. Nevertheless, an intensive change from national assemblages into global assemblages may occur at a specific critical point, or juncture, by which both state strategies and global production networks change, resulting in an intensive change from nation-assemblages. Furthermore, the stability of both national and global assemblages is not guaranteed, as assemblages are continuously prone to instability and crisis.

The transformation of national assemblages to global assemblages is not guaranteed, as such transformations are immanent to non-linear casual relationships among the materiality of resources and the distributed agencies and strategies of firms, intermediaries, and states. As described earlier in the theoretical section, while statistical causality might show that casual effects may occur in a high number of cases, one cannot make the claim that such casual effects will occur in every single case. Just as genetic predispositions may influence if smoking will cause cancer in an individual, the political-economy and materiality of industries influence the conditions by which globalization may or may not be realized through the co-evolution of state strategies and global production networks. These issues are highlighted in the Thailand and Indonesia articles included in this thesis.

In the Thailand and Indonesia article, I point to how internal power structures in states and the materiality of natural gas shape the spatiotemporal contexts

through which changes in state strategies and dynamic global production networks are co-articulated. In doing so, I have aimed to explain how the materiality and political-economy of natural gas might limit the globalization of natural gas markets. In the Thailand article, I suggest that energy geographers can use topological thinking and the conceptual difference between intensive and extensive arrangements of power to demonstrate how powerful actors reproduce their control and authority over energy resources and infrastructure. I suggest that by accounting for these different modalities of power, energy geographers can better explain why energy laws and regulations, especially those intended to break monopolies, are not always successful. In the Indonesia article, I suggest that assemblage thinking can be used in the GPN approach to go beyond identifying the material properties of natural resources and relations of production to explain political outcomes, and instead find explanations in the morphogenetic processes by which GPNs are transformed. This way, the GPN approach can better account for how the materiality of resources shapes spatial and political outcomes in dynamics GPNs.

Based on how I have utilized assemblage thinking to explain the situation surrounding the globalization of natural gas markets, I suggest that assemblage thinking can provide the ontological and epistemological basis for new conceptualizations surrounding globalization and the instability and evolution of the international political economy. The need for further conceptualization regarding the instability and evolution of the international political economy in economic geography was recently highlighted by the editors of a recent special issue titled the *Cambridge Journal of Regions, Economy, and Society*: *Globalization at a Critical Conjuncture*. In their editorial, the editors suggest that the 2008 financial crisis, looming trade wars, rise in populism, and increasing inequality refutes the dominant narrative by consultants, academic experts, public intellectuals, etc. that globalization is an ineluctable 'force of nature' and represents the new logic of the political economy (Martin et al., 2018). Instead, the editors suggest that globalization is a "complex admixture of different, though interrelated, historically evolving developments and transformations – economic, technological, cultural

and social" (Martin et al., 2018, 4). I suggest that assemblage thinking can help researchers can problematize the mutual constitution of state strategies and globalization dynamics by considering the exteriority of such relations. In doing so, researchers can better account for how critical junctures such as populist movements, financial crises, new nationalisms, and global inequality are reshaping the co-evolutionary dynamics between shifting political-economies and globalization in the world economy.

4.4. Further Research

This thesis has pointed to the limitations of current research, specifically those of neoclassical economic inspired researchers, who claim that the LNG industry is on the brink of a revolution and natural gas markets are globalizing. These researchers use data points, such as expanding LNG production, increasing spot trades, and increasing LNG demand to justify their arguments. This research paper has taken a different approach by drawing upon grounded case studies to explore how LNG production networks and the territoriality of natural gas markets are evolving and the limitations of these dynamics. Specifically, the thesis has found that the globalization of LNG markets is emergent through the relationship between emerging LNG production network arrangements and state strategies for energy policy and development. These relationships endure to the extent that such relations are symbiotic and, therefore, can be characterized by instability.

There is a need for further case studies to examine the intersection between state strategies and emerging LNG production networks to establish the wider implications of these instabilities for global gas markets. Doing so would give better insight into how the political economy of natural gas is evolving, and the implications for energy resource management, energy investments, energy access, and energy security. In addition, the wider implications of the evolving political economy of natural gas for long-term investments in the LNG industry should be better understood. Currently several countries, particularly emerging economies in Africa, Latin America, and Asia, are making long-term investments in gas field and LNG production. Based on the findings from this thesis, I suggest that there is a

need to consider the long-term prospects of these investments. Furthermore, a larger inquiry into the economic and environmental sustainability of natural gas and LNG trade is needed to further analyze the extent to which growing natural gas trade is compatible with energy development and emission reduction goals in emerging economies.

At the onset of this thesis, I explained that in Boshu philosophy human society was not considered to be dualistically opposed to nature. *Tian Di Ren* emphasizes that human society and its advancement cannot be sustained unless the relationships between humans, heaven, and nature are balanced. Global heating is a dire and immense challenge for human society brought on by our dependence on fossilized energy, and it threatens our safety and production of food. At the same time, these relations are only contingently obligatory, and I believe that the potential capacities for reassembling the relationship of humans to energy and nature do exist and can be identified. In this thesis, I have not drawn any final conclusions on the sustainability of natural gas towards meeting the challenges of global warming. The extent to which natural gas is sustainable will depend on the capacity of natural gas to provide clean and affordable energy to parts of the human population which need it the most, the extent to which it becomes a low-carbon alternative to other fossil fuels such as coal, and a question on if natural gas consumption is complementary to the rapid implementation of zero-emission solutions. This thesis demonstrates that the answer to these questions is complicated.

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PART II: Articles

The Singaporean Natural Gas Hub: Reassembling Global Production Networks and Markets in Asia

(Under Review at The Journal of Economic Geography)

Alexander Dodge

Abstract

Recently, economic geographers have sought to account for how regional and national initiatives shape the strategic decisions of actors in Global Production Networks (GPN). In this paper, I intend to discuss the political and institutional dynamics by which GPNs evolve, and the capacity of states to shape emerging organizational and spatial arrangements in dynamic GPNs. Building on assemblage thinking, I conceptualize these political and institutional dynamics as the unbundling of legal, regulatory, and institutional components of nation-state authorities that govern GPNs, and the subsequent reassembling of these components through emerging interactions with finance, technology, and new forms of private authority. These emerging global assemblages are both partially embedded in global cities and stretch across and within the borders of nation-states. Building on this conceptual framework, this paper explains how the exclusive nation-state authorities that traditionally governed liquefied natural gas (LNG) trade and markets are becoming unbundled. The paper focuses on the initiatives of public and private actors in Singapore who are attempting to shape evolutionary dynamics in GPNs by establishing a hub for LNG trading and speculative financing in Asia. The paper finds that Singapore's capacity to shape LNG production networks is dependent upon the capacity of public and private actors in Singapore to establish cross-border connectivity to markets in Southeast Asia.

Keywords: global production networks, nation-state authority, liquefied natural gas, assemblage
JEL classifications: G18, P18, Q48
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1. Introduction

Recently, economic geographers have sought to account for how regional initiatives shape the strategic decisions of key actors in Global Production Networks (GPN). In particular, geographers are focusing on the institutional and political processes by which regional and national actors work to pull GPNs into regions (Mackinnon et al., 2019; Smith, 2015). Furthermore, GPN scholars have suggested the need for further research

into how the strategies and activities of regional and national actors co-evolve with the dynamics by which GPNs become reconfigured (Bridge and Bradshaw, 2017; Mackinnon et al., 2019; MacKinnon et al., 2018). These recent considerations are in line with other scholars who have called for conceptualizing the capitalist structures, international political economy, and geopolitics by which GPNs emerge (Starosta, 2010; Coe and Yeung, 2015; Pritchard and Yeung, 2014; Yeung, 2016; Glassman, 2011). However, there is a risk in these approaches of failing to account for the distributed agencies, practices and processes that shape the dynamics by which GPNs emerge and are transformed (Hess, 2008).

In this paper, I utilize assemblage thinking to account for how the initiatives that rework nation-state authority over markets shape the dynamics by which GPNs evolve. The conceptual framework developed in this paper uses Sassen's (2006) account of how the global economy is continuously being shaped as traditional nation-state authorities become unbundled, and political arrangements, physical infrastructure, codes and flows both within and across national borders are subsequently brought together within emergent global assemblages. According to Sassen, these global assemblages become partially embedded in global cities through the embedding initiatives of corporate, financial, and government actors who play a key role in reassembling unbundled authorities. In addition to Sassen's account of emerging global assemblages, I suggest the need to conceptualize the instability of these assemblages, and for the dynamics by which they are actively reproduced and maintained (DeLanda, 2006; Haarstad and Wanvik, 2017; Anderson et al., 2012). My analysis of the dynamics by which nation-state authority becomes reworked is framed by the initiatives of financial intermediaries, public authorities, and corporations in Singapore to establish a hub for Liquefied Natural Gas (LNG) trading in Asia.

Historically, natural gas markets and the cross-border trading of natural gas has been assumed under the authority of the nation-state and, consequently, international gas trade has been limited. However, since the early 1990s, natural gas trade has been evolving through neoliberal market reform and international market integration through long-distance gas pipelines and the seaborne transportation of liquefied natural gas (LNG). In their analysis, Bridge and Bradshaw (2017) explain that the reconfiguration of spatial and organizational arrangements in LNG production networks is constituting a global market for natural gas. Nevertheless, a key challenge for the globalization of markets are distinctively regional pricing regimes (Stern, 2016). While the United States and parts of Europe have established marketplaces and standardized pricing for natural gas, LNG marketplaces in Asia are immature and LNG is indexed according to the price of oil. These pricing schemes were originally established when LNG competed with oil in electricity generation markets in the 1970s. Since 85 percent of expected growth in LNG markets is expected to occur in Asia, the dependence on oil indexation is considered by industry experts to be a significant hinder for the integration of global gas markets (Haze, 2018; Stern, 2014).

Evolving spatial and organizational arrangements in LNG production networks and the limitations of market development provides a "window of opportunity" for Singapore to capture value by establishing a hub for LNG trading. In doing so, Singapore could develop a pricing benchmark in Asia that would further shape the evolutionary dynamics occurring in LNG production networks. In this paper, I intend to discuss how Singapore's capacity to shape and capture value from LNG production

networks is dependent upon the unbundling of nation-state authorities in LNG production networks and the initiatives of corporate, financial, and government actors in Singapore to rework and embed unbundled authorities in the city-state. In my analysis, I find that Singapore's role as a future LNG trading hub is dependent on its capacity to establish and maintain connectivity to regional markets in Southeast Asia.

The remainder of the article is structured as follows: The next section introduces recent discussions surrounding the role of states in shaping GPNs and the contribution that assemblage thinking provides to these discussions. The subsequent section examines the dynamics by which LNG production networks are evolving, the current limitations to further growth, and how public and private actors in Singapore are establishing the basis for continued growth by reworking authorities over natural gas markets through emerging global assemblages.

2. Nation-States, Global Production Networks, and Assemblages

Recently, GPN scholars have sought to incorporate more dynamic and processual conceptualizations of how GPNs emerge and are transformed (Bridge and Bradshaw, 2017; Coe and Yeung, 2015). In their analysis of LNG production networks, Bridge and Bradshaw (2017) draw attention to how the territoriality of production networks is evolving through the coordinating strategies of firms, extra-economic actors, and intermediaries. Similarly, Coe et al. (2008) claim that GPNs are "inherently dynamic; they are always, by definition, in a process of flux—in the process of becoming—both organizationally and geographically" (272). Coe and Yeung (2015) develop a more dynamic GPN theory (GPN 2.0) by conceptualizing the capitalist structural dynamics that shape intra-firm, inter-firm, and extra-firm strategies in GPNs, which in turn, shape opportunities for value capture and strategic coupling processes in regions and nations. However, Mackinnon et al. (2019) suggest that the GPN 2.0 approach to strategic coupling primarily focuses on one-directional considerations of causality, that reduce development to the outcome of firm strategies and value capture trajectories. As a consequence, Mackinnon et al. (2019) claim that GPN theory neglects the significance of the nation-state in the construction and restructuring of GPNs. Mackinnon et. al refers to Smith (2015) who suggests that GPNs are embedded within and constitute particular regimes of accumulation in national and macro-regional spaces, which are articulated with regulatory and state regimes at different scales. Smith notes the need to recognize the centrality of economy-state intersections in GPNs, and to understand emerging industrial formations in the context of the wider political economies that they are a part of.

Conceptualizing the state in GPN theory is in line with recent work to account for the capitalist structures and the political economy through which GPNs emerge (Starosta, 2010; Smith, 2015; Coe and Yeung, 2015; Pritchard and Yeung, 2014; Yeung, 2016). Similarly, Jessop et al. (2008) suggest that instead of one-sided, reductionist accounts of networks, researchers should account for the polymorphic relationships between scales, networks, territories and places. Such a framework offers an opportunity to consider both GPN emergence and state spatial restructuring as different, mutually constituted dimensions of sociospatial relations. However, by reducing socio-spatial relations to already known and recognized patterns and forms, there is a risk of mischaracterizing

the novelty and historical contingency by which such socio-spatial relations emerge (Anderson et al., 2012; Allen and Cochrane, 2010). Hess (2008) claims that "much of the political economy literature in the realist tradition tends to emphasize social and economic structures at the expense of analyzing - although not denying – the agencies, interactions and connections that led to the emergence of these structures" (453). Anderson et al. (2012) suggests that instead of making a priori claims about the form of socio-spatial relations, researchers should consider the provisional conditions under which socio-spatial relations emerge and endure across differences and amid transformations through assemblage thinking.

Assemblage thinking draws attention to the self-organizing potential and morphogenetic processes by which entities become co-related into emerging patterns and forms (DeLanda, 2016). Assemblage thinking is similar to actor-network theory, which partially constitutes an ontological basis for the GPN framework (see Dicken et al., 2001; Henderson et al., 2002). Both approaches account for the distributed agency by which social actors and material entities are continuously ordered and reordered within networks (Müller, 2015). In addition, both assemblages and actor-networks are considered to be provisional unities that have emergent or complex causalities that are irreducible to the social and material entities that compose them (Anderson et al., 2012). However, whereas actor-network theory conceptualizes the agency and agency of social and material entities as solely constituted by their relations with other entities, assemblage thinking characterizes emerging wholes according to the notion of "relations of exteriority". Relations of exteriority entails that while the capacities of entities to affect outcomes are emergent through relationships, the identity and properties of these entities are external to such relationships (DeLanda, 2006; Deleuze and Parnet, 2007). Assemblage thinking can be utilized to account for how GPNs emerge from both the networks by which value creation is realized, and from the "features" of material entities, such as natural gas and related-technologies, and the agencies of firms, states, intermediaries, etc. However, assemblage thinking also entails that assemblages do not hold together simply by virtue of networks of relations between material and social entities. The reproduction and durability of assemblages depends on the continuous co-functioning of the identities and properties of entities in assemblages, by which the capacities to structure and form assemblages emerge (Bonta and Protevi, 2004; DeLanda, 2016).

Dittmer (2014) suggests that assemblage thinking can be used to consider how states and political actors produce desired outcomes, by identifying the dynamics by which entities enter relationships, and the processes by which such relationships endure. Using assemblage thinking, Bouzarovski et al. (2015) demonstrates how an integrated, European gas market is emerging from the erosion of traditional forms of state authority over markets. As nation-state authority is deterritorialized, natural gas markets in Europe become reterritorialized through new assemblages of energy security narratives, cross-border pipeline development, EU commission directives for market deregulation, market exchanges, and standardized pricing regimes. Bouzarovski's et al. (2015) research on gas markets in Europe draws similarities to the emergence of markets in Southeast Asia. In the empirical section, I discuss how public and private actors in Singapore are attempting to reassemble deterritorialized and unbundled authorities over natural gas markets in Asia. To do so, I draw on the work of scholars, who argue that the power of private and public actors to reassemble authorities is mediated through

global assemblages (Sassen, 2006; Allen and Cochrane, 2010; Allen, 2009; Sassen, 2000).

Research in political geography and state spatial restructuring tends to frame globalization in terms of national scales being destabilized by the growth of supranational institutions, and undermined by the decentralization of decision-making powers to sub-national institutions embedded in regional and urban scales (Brenner, 2004; Jones, 2001). Allen and Cochrane (2010) note that because this research primarily emphasizes the powers of the state that are extensive through multiscale institutional hierarchies, this research ends up underemphasizing the looser, more negotiable sets of political arrangements that stretch within, across and beyond given scales and boundaries. To better account for the dynamics of globalization, Allen and Cochrane draw on Sassen (2006), who accounts for novel geographies of authority through emergent global assemblages. These global assemblages emerge as the legal, regulatory, and institutional components, that originated under the exclusive authority of the nation-state, become unbundled by distributed agencies, and reoriented towards global agendas and systems through new interactions with financial institutions, corporate logics, and hypermobile capital flows. In Sassen's account, these dynamics are embedded in nation-states, as new legal forms necessary for globalization are implemented through state institutions. These global assemblages are highly contingent, emerging from the agencies and initiatives of public and private actors (Allen and Cochrane, 2010; Allen and Cochrane, 2007). In addition, global assemblages are inherently unstable, because different economic, political, and legal elements operate according to "different temporal rhythms and institutional paces that come together in both enabling and contesting ways" (Allen and Cochrane, 2010, 1078).

Sassen (2000) shows that the dynamics by which emerging global assemblages are held together should not be taken for given, or merely understood as the function of the power of multinational corporations and financial markets. Instead, Sassen points to the vast array of specialized functions (legal, accounting, financial, technical, etc.) that need to be sustained for global assemblages to persist, that go beyond the control of corporations. Global cities play a significant role as sites for the production of these specialized functions that run and coordinate the global economy (Sassen, 2013). Therefore, a key aspect of emerging global assemblages is that reworked authorities are partially "lodged" in global cities. In my empirical analysis, I apply Sassen's account on global cities to analyze how public and private authorities in the global city of Singapore are actively involved in the reassembling of unbundled authorities over natural gas markets in Asia by establishing an LNG trading hub. I suggest that these initiatives may facilitate the evolution of LNG production networks. This position on global cities is in line with research in GPN theory on how certain GPNs become spatially reorganized through cities (Breul and Diez, 2018; Jacobs et al., 2010; Brown et al., 2010).

However, while Sassen's account of global assemblages is useful for describing the ongoing dynamics by which nation-state authority is being reworked, her use of assemblages is for the most part descriptive, according to Anderson et al. (2012). Anderson et al. notes that assemblage thinking in the Deleuzian tradition can be used, not only to describe new forms of spatial organization, but also to account for how emerging forms and orders are continuously reproduced and endure, despite the inherent instability of assemblages. Relations of exteriority implies that assemblages aren't held

together by centers of powers, nor essences, nor totalities, but are held together through symbiosis and "sympathy" (Haarstad and Wanvik, 2017; Deleuze and Guattari, 1987). Similarly, Allen (2010) argues that the power of cities to shape the global economy is not only about dominance and holding "in reserve" a right mix of service functions and financial resources, but the capacity of financial, political and corporate actors to employ resources that establish and sustain connectivity beyond the city itself. Therefore, in addition to analyzing Singapore's role in reassembling authorities over natural gas markets in Asia, I also account for the agencies and initiatives by which Singapore is establishing its connectivity to markets beyond the city-state itself and the challenges of developing these connections. In doing so, I aim to consider the processes and limitations by which emerging global assemblages are sustained.

3. Methods

In the remainder of this paper, I continue the theoretical discussions through an empirical study of an initiative by public authorities, financial intermediaries, and corporations in Singapore to shape LNG production networks by establishing a hub for LNG trading. The initiative to establish an LNG hub is particularly interesting because of its relative significance for shaping emerging organizational and spatial arrangements in LNG production networks. Furthermore, the initiative demonstrates a conjunctionally specific moment where the Singapore is attempting to capture development opportunities from transformations in LNG production networks by enrolling a new set of actors and technologies into emerging global assemblages.

The empirical analysis is divided into two sections. The first section provides an account on how nation-state authority and governance over LNG trade and markets has been contingently necessary for the emergence of LNG production networks in Asia. In addition, the section explains how in the last decade, LNG trade has expanded significantly, and how an LNG trading hub in Asia could facilitate continued expansion. The empirical evidence for this section draws from Bridge and Bradshaw's (2017) account of LNG production networks, as well as other authors who have written on the subject (Mehden and Lewis, 2006; Corbeau and Ledesma, 2016). The development of LNG hubs and the role that LNG hubs play for the evolution of markets in Asia is a significant topic of discussion among international energy agencies and independent energy research institutes (Stern, 2014; Fulwood, 2018; Ten Kate et al., 2013; Corbeau and Ledesma, 2016). These organizations have published reports that provide hypotheticals on the conditions by which LNG hubs in Asia may develop, usually based on their analysis of how hubs developed in Europe. Singapore is identified by these reports as a possible location for an LNG hub, even though these reports detail several limitations that must be overcome for Singapore to do so. While these reports are useful, and provide a basis for the following empirical discussion, I find that they tend to naturalize the evolution of markets in Asia as if these fates are predetermined. Missing from these reports is an account of the political agencies, resources, and strategies that are employed by corporations, governments, and financial actors to reassemble markets in Asia.

The second part of the empirical section utilizes the conceptual framework developed in this paper to analyze how the agencies and initiatives by which public and private

authorities in Singapore are attempting to establish a hub for LNG trading. The empirical evidence for this section is primarily based on multiple visits to Singapore in autumn 2015 and winter 2016. The primary purpose of these visits was to conduct interviews with managers at LNG-related companies in Singapore. These LNG-related companies included technical advisory agencies, financial consulting groups, commodity-trading groups, shipyard owners, and equipment suppliers. The informants held positions with regional oversight and were well aware of the activities related with the Singapore government's effort to establish an LNG trading hub in the region. In total, twenty-one interviews were conducted. Informants were identified and selected during attendance at conferences and seminars by the author and through snowball sampling.

4. Nation-State Authority and LNG Production Networks

Historically, the governance of inter-firm relationships in LNG production networks was initially assumed under the authority of nation-states with the financial and regulatory capacity to support utilities and corporations in securing LNG supplies. The traditional relationship between LNG production networks and nation-states can be exemplified by the initial role that the Japanese government played in constituting the conditions for value creation in LNG production networks in Asia. Japan was the first country in Asia to import LNG and is currently the largest importer of LNG in the world (IGU, 2017). The first shipment of LNG arrived in Japan from Alaska in 1969 (Stern and Koyama, 2016). At the time, Japan heavily relied on imported fuel oil for electricity generation, but the 1973 oil crisis prompted the country to expand LNG imports significantly due to energy security concerns by state officials. The Japanese government played a key role in generating demand for LNG, by providing different tax incentives and subsidies to promote fuel switching for power generation and city gas (cooking and heating) (Mehden and Lewis, 2006). In addition, Japanese corporations were loaned funds with lucrative interest rates by the export-import bank of Japan to invest in upstream LNG production terminals in Indonesia and Malaysia. The initial LNG production terminals in Malaysia, Brunei, and Indonesia were co-owned by international oil companies (Shell, Total, Vico), national oil companies (Pertamina, Petronas), and Japanese consortiums (Mitsubishi, JILCO, Mitsui) (Mehden and Lewis, 2006).

In addition to the strong presence of nation-state authorities in overseeing, facilitating, and creating demand for LNG trade, the regulation of natural gas markets and the allocation of markets to government-owned utilities or government monopolies played a key role in shaping interorganizational arrangements, due to the capital intensity of infrastructure in LNG production networks. While natural gas extraction and power generation is generally less expensive than alternative fossil fuel sources, such as coal and oil, the liquefication, transport, and regasification of natural gas is highly capital intensive. In order to reduce the costs per unit of natural gas, making it affordable compared to other fossil fuels, producers have generally relied on economies of scale by increasing the size of liquefication terminals, LNG carriers, and regasification terminals. According to Bridge and Bradshaw (2017), LNG production networks have traditionally assumed a project character, as the sheer costs of

developing LNG terminals (in the tens of billions of dollars) entailed that investment decisions for LNG terminals both in Asia and around the world have been underpinned by guaranteed revenue streams through long-term contracts, around 15 to 20 years, with take-or-pay clauses. Take-or-pay clauses imply that LNG buyers are bound to pay for a pre-specified minimum quantity of LNG whether or not they actually import the gas (Stern and Koyama, 2016). These contracts impose significant market risk on LNG buyers, who need to pay for agreed upon LNG quantities over a long-term period, despite market swings, recessions, etc. Therefore, final investment decisions on LNG terminals have been based on the creditworthiness of LNG buyers, who have traditionally been government-owned natural gas companies or regulated utilities, with the capacity to pass risks onto consumers due to their regulated monopoly position (Corbeau, 2016b). Furthermore, LNG markets in Asia were typically exclusive to high-income countries like Japan, Taiwan, and South Korea, as power utilities in lower income markets were not considered sufficiently creditworthy to guarantee long-term LNG contracts (Corbeau et al., 2014).

While the capacity of LNG production networks to realize value creation may have been emergent from the exclusive authorities of nation-states and their relations within interorganizational relationships, these relations, in line with assemblage thinking, can be characterized by the notion "relations of exteriority". The continuity of such relationships are dependent upon their co-functioning, but are nevertheless subject to instability and transformation. This is exemplified as the authority of nation-states to oversee and govern LNG trade becomes unbundled by the deregulation and commercialization of natural gas markets. These reform initiatives have increased the pressure on traditional utilities to seek more flexible LNG supply contracts to maintain their advantage in more competitive markets. Historically, such options were excluded due to long-term LNG contracts, however surplus capacity in LNG production and slowing demand in high-income markets threaten the traditional organization of LNG production networks. Since the early 2000's, the global LNG industry witnessed a significant expansion in LNG production capacity. This has been a consequence of host governments for LNG production terminals such as Trinidad & Tobago, that have sought to attract private investors, by offering more equity on LNG terminals (Hayes and Victor, 2006). As a result, more equity investors have been participating in LNG terminal development. Furthermore, investors in Qatar and Australia began to expand and build LNG terminals without fully dedicating production capacity to specific long-term contracts. Instead, extra-capacity was sold through spot (single-cargo) and short-term trades (four years or less), which eventually increased from 5 to 28 percent of global trade between 2000 and 2015 (Corbeau, 2016a). Bridge and Bradshaw (2017) explain that the consequence of these shifts is that LNG production networks are evolving from a:

> Relatively simple floating pipeline model of point-to-point, binational flows orchestrated by producing and consuming companies governed by long-term contracts, to a more geographic and organizationally complex production networks that is constitutive of a global gas market. (215)

The growth in spot markets has allowed buyers to reduce take-or-pay obligations by purchasing LNG through spot trades and short-term contracts (Stern, 2014). Spot markets grew particularly after the shutdown of nuclear plants in Japan after the

Fukushima disaster in 2011, and the need for short-term trades to fill the gap in electricity supply (Corbeau, 2016a). Nevertheless, spot trades and short-term contracts, particularly in Asia before 2014, been priced at much higher premiums, and have therefore been less attractive than long-term contracts (Stern, 2014). Since 2014, however, premiums for spot cargos and short-term contracts have decreased due to the boom in domestic shale gas production in the USA which was historically a significant LNG importer, while simultaneously LNG demand growth in Japan, Korea, and China has been slowing (Bridge and Bradshaw, 2017). With excess supply and availability of LNG on spot markets, LNG buyers are leveraging their purchasing power to pressure LNG producers to offer more flexible and shorter LNG supply contracts. The deregulation of natural gas markets in Asia is a significant driver for these developments. In addition, with LNG prices at historic lows, LNG producers are dependent upon the significant expansion of LNG markets if they are to maintain their capital gains (Corbeau et al., 2014). As an interviewed management consultant at a global energy advisory firm in Singapore explained:

> In the current market situation, you have huge amounts of new supply coming in from the US and Australia. So, there is a huge imbalance in the market between demand and supply, and the LNG needs to go somewhere. First, the spot prices will go down, and second, new demand needs to be created. But demand won't come from large consumers in Japan or Korea; it is probably going to come from smaller demand centers in Indonesia, China, Philippines, and Sri Lanka. So, how do we access that?

The economic consultant further explained how potential LNG buyers in emerging economies are now leveraging purchasing power through low prices on LNG spot markets to reduce take-or-pay commitments. However, despite the growth in demand for LNG in emerging economies, a 2018 outlook by the Shell Corporation, notes that few final investment decisions (FIDs) on new LNG terminals have been made since 2015 (Shell, 2018). Growth in LNG demand is expected to overtake LNG supply by the mid 2020's, unless new FIDs are taken in the next few years. According to the outlook, the lack of FIDs is a result of a mismatch between increasing demand for flexible LNG contracts, and the continued need for long-term contracts to underpin financing for upstream LNG projects. The Shell outlook, along with other industry opinions, point to a situation where the recent expansion of LNG markets may be part of a "boom-bust" cycle (Ross, 2018; Weber, 2018). According to Corbeau (2016a): "there is a danger that supply will be inadequate when demand picks up, striking a damaging blow to the gas industry" (555).

LNG production networks can be characterized by a moment of deterritorialization and instability, where the traditional relationships that held production networks together are becoming unraveled. Similar to Bouzarovski et al. (2015) analysis of European gas markets, deterritorialization leads to the potential for new relationships within assemblages. In the context of a pending "boom-bust" cycle in the LNG industry, commodity traders are starting to play a significant role as "middle-men" in LNG production networks, by assuming the risk of long-term LNG contracts with upstream suppliers, in order to provide flexible short-term agreements with downstream buyers (Ten Kate et al., 2013; Corbeau and Ledesma, 2016; LNG World News, 2018). The interviewed management consultant in Singapore explained the role of commodity traders in the following way:

> The big companies and oil majors are going to take a lot more time to realize the change. LNG producers do not want to deal with the difficulties of buyers in low-income emerging economies, and they are going to say 'wow, this is too much work for such a small margin, I am happy to give up these volume rights'. So, what we will see is that commodity traders who didn't have much of a role to play in LNG before because of these controlled value chain mechanisms are going to step in. These traders are going to sign long-term contracts and take the risk downstream by selling LNG through spot and short-term deals at a premium.

While the bankers and financiers of LNG terminals are hesitant to invest speculatively in LNG terminals without securing long-term contracts, commodity traders may play an initial role as "middle-men" in LNG production networks by assuming the risk of long-term contracts, and selling at a profit in spot markets. In other commodity markets, such as oil, trading houses provide liquidity in spot markets, supposedly reducing the need for long-term contracts (Corbeau, 2016b). However, a key limitation for further growth is that markets for LNG trading in Asia are immature.

Commodity trading markets in the LNG industry in Asia are immature because LNG trade is insufficiently financialized. Labban (2010) notes that financialization is associated with liberalizing "the circulation (i.e. expansion) of value from material production and exchange at the same time that it brought the production of value and its realization in exchange under the dominance of financial logic." (542). Commodity traders realize profits by actively monitoring prices for commodities at different delivery locations and different delivery dates (i.e. buy now, sell later) (Trafigura, 2018). Physical traders use derivatives, such as future contracts, swaps, and options, as price hedging instruments to ensure profitability despite price volatility in markets. Physical trading in the LNG industry is not without significant risk, as economic downturns, weather, and supply disruptions produce significant volatility in physical commodity trading. Whereas LNG buyers assumed the risk of LNG trading through "take-or-pay" agreements, traders mitigate these risks by hedging their portfolios through financial markets as "insurance" against demand shortfalls and price declines. Financial markets accumulate profits through interest, dividends, and settlement prices for futures, options and swaps (Labban, 2010).

Due to space constraints, the complexities of commodity trading in the LNG industry won't be discussed in this paper[4]. What is important to emphasize, however, is that commodity trading uses real-time price signals across different locations in global markets to realize a profit. In addition, real-time price signals are a basis for financial risk management, where profit actualized through exchange markets, which "separates space into one space where capital reproduces itself as the circulation of titles of ownership through future contracts and swaps, and another space in which the material production and exchange of commodities takes place as an unavoidable middle term, a necessary evil for the purpose of money making" (Labban, 2010, 542). Establishing reliable price signals is therefore dependent upon the development of market exchanges and price benchmarks where spot cargos are continuously traded and the contract prices between buyers and sellers are reported transparently. While these market exchanges and price benchmarks have been established in the oil industry since the 1980's, these financial institutions have historically played a limited role in the LNG industry for

[4] There are many practical guides that explain the working of commodity trading and financial management, see Trafigura (2018), Burger et al. (2008), Pilipovic (2007)

three key reasons: first, since the majority of LNG trade has been through long-term contracts, spot trades have been historically limited. Second, governments in Asia have typically regulated natural gas prices, thus distorting markets and making price signals unreliable. Finally, with no reliable pricing benchmarks, LNG pricing has historically been fixed to crude-oil linked prices[5] (Fulwood, 2018; Shi, 2016; Corbeau and Ledesma, 2016).

Since 2000, there has been a shift away from pricing mechanisms based on oil indexation to "gas-to-gas competition" in Europe and the USA (Heather, 2016). However, oil indexation continues to dominate markets in Asia (Stern, 2014). "Gas-to-gas competition" is a pricing mechanism that is indexed to prices reported by traders through market exchanges. Industry experts claim that the continued growth of spot markets is contingent on the development of reliable price benchmarks in Asia, where the growth of LNG is expected to be the highest (Corbeau, 2016b; Ten Kate et al., 2013; Shi, 2016). Pricing benchmarks in Europe and the USA is linked to natural gas trading hubs, such as the national balancing point in the UK, which are platforms where the ownership or "title" of natural gas is exchanged between buyers and sellers[6] (Heather, 2016). The point is that traders are obligated through regulations to report to electronic notification systems that state the volumes of gas transferred, the time period, the quality of gas, and the buying and selling parties (Fulwood, 2018). The price of natural gas is established through pricing indexes, run by private exchanges, which calculate pricing based on the assessments of physical traders participating in the exchange. In Europe and the USA, mature and reliable pricing benchmarks established at natural gas trading hubs are used to index prices in contracts between buyers and sellers, even if the gas is not physically traded at the hub itself. In the next section, I discuss how assemblage thinking can be used to explain the initiatives by which public and private authorities in Singapore are attempting to establish an LNG hub for Asia.

5. Singapore as an Emerging LNG Hub

As previously mentioned in the theoretical section, there is a need to account for how GPNs are part of wider accumulation strategies that articulate with state regulation to attempt to stabilize economic development trajectories (Smith, 2015). The financialization of LNG markets is not only significant in terms of its potential role in establishing the basis for further growth in LNG production networks, but for capital accumulation in commodity trading and finance. Asian countries such as Japan, Malaysia, Thailand, China, and South Korea have begun implementing natural gas market reforms, by privatizing government owned utilities, deregulating price controls, and implementing third-party access. By unbundling traditional forms of state authority, these reforms open the opportunity for standardized pricing regimes and commodity trading as is being developed in Europe (Stern, 2014; Bouzarovski et al., 2015).

[5] Early buyers of LNG were mainly concerned with replacing crude oil imports with LNG. Therefore, in the absence of reliable price benchmarks and spot markets, LNG buyers and producers agreed upon linking the price of LNG to imported crude oil.

[6] A trading hub is not necessarily a single location where natural gas is physically traded, but refers to the points in a countries national-transmission system where physical flows of natural gas enter and exit the system.

Commodity trading houses, such as Trafigura, Guvinor, and Vitol, which have historically played little role in LNG trading in Asia, are starting to enter the industry. In order to capture value from these new players, Singapore has sought to strategically couple to LNG production networks by establishing a hub for LNG trade in Asia. In doing so, public and private actors in Singapore are attempting to establish the city-state as a "first-mover" in the industry, by establishing an exchange market for both physical LNG trade and a futures market. In line with assemblage thinking, the capacity of Singapore to establish an LNG hub, can be thought of as emergent through relations within global assemblages between government authorities, regulators, corporations and financial intermediaries and their initiatives to reorient legal institutions, regulatory frameworks and infrastructure towards financialization and global commodity trading.

Nearly 95 percent of Singapore's electricity is generated through natural gas. Historically, Singapore has imported its natural gas through pipelines from Malaysia and Indonesia. However, due to power outages as a result of pipeline failures, Singapore sought to diversify its natural gas imports (SLNG, 2014). In 2006, the Minister for Trade and Industry announced that Singapore would build an LNG terminal to import LNG (MTI, 2012). The Energy Market Authority incorporated Singapore LNG (SLNG) to own and operate an import terminal on Jurong Island. The terminal was commissioned in 2013. While the government of Singapore commissioned the Jurong LNG terminal for energy security concerns, the energy market authority in Singapore has sought to establish a hub for LNG trading by leveraging Singapore's position as a financial center and trading hub for oil (Ten Kate et al., 2013). These strategies are in line with Singapore's position as a global city in Asia. As Olds and Yeung (2004) note:

> The developmental city-state of Singapore never misses an opportunity to convey how the small city must cope with and exploit (ride) global and regional systemic change in an aggressive and strategic fashion. (491)

Although Singapore has no oil and gas within its city boundaries and has a much smaller market for natural gas than its neighboring countries, Singapore is a key oil trading center in Asia. Singapore has a mature financial market for derivatives trading and is home to many trading houses in the oil industry.

Singapore's attempts to develop an LNG hub can be situated within a relatively consistent economic development trajectory occurring over the past three decades. Facing an overaccumulation crisis in the late 1980's due to its reliance on an export-led accumulation regime and its limited market size, the government recognized the need to develop a "second wing" to make sure public and private capital does not concentrate in the domestic market (Yeung, 1999; Régnier, 1993). The Singaporean government in collaboration with industrial partners has focused largely on maintaining its position as an international business hub competing for regional headquarters by developing attractive regulatory frameworks (Olds and Yeung, 2004). Furthermore, the government has looked outward for opportunities to invest in Southeast Asia. According to interviews with LNG-related firms in Singapore, establishing an LNG hub is a development opportunity for Singapore to establish itself at the center of LNG trade and financial risk management in Asia and to encourage commodity trading houses and LNG firms to set up trading desks in Singapore.

Olds and Yeung (2004) note that Singapore is unique, in that as a city-state, it is able to draw upon the capacities of both a nation-state and a global city to develop, maintain,

and refashion "world-class" infrastructure, legal, and financial systems with the aim of "embedding Singapore within the evolving lattice of network relations that propel the global economy" (491). A report by the international energy agency notes that for an LNG hub in Asia to be developed, governments would need to develop a hands-off approach and enable competition by actively separating the transport, storage and regasification of LNG from its commercial marketing and ensuring that market participants have non-discriminatory access to facilities (Ten Kate et al., 2013). The report subsequently found that Singapore has come furthest along in this process compared to other Asian countries such as China and Japan and notes that Singapore has considerable experience in regulating energy commodity trade as it is one of the major oil-trading hubs in Asia. Singapore has a world-class supporting system to facilitate trading and financial risk management. As a manager from the LNG terminal corporation in Singapore noted:

> Singapore has clear structures, clear stakeholders, good governance, follows timelines, and is a first mover. Some say Singapore can be autocratic, but it thinks things out well ahead of time and gets feedback from the industry.

Since the Gas Act of 2001, the Singapore gas sector has set on a firm course towards deregulation and the unbundling of commercial marketing from transport and storage, and oversight is entrusted to the independent energy regulator (Six and Corbeau, 2017). The LNG terminal is the first open access terminal in Asia. In addition, instead of establishing a state-owned company for LNG procurement, Singapore appointed the multi-national company, BG Singapore Gas Marketing Pte., to be the LNG aggregator. As an LNG aggregator, BG would aggregate the demand for regasified LNG from all end-users in Singapore.

By unbundling traditional forms of nation-state authority over its natural gas market and establishing third-party access, Singapore's legal and regulatory institutions can be reoriented towards its global ambitions through new interactions with emerging corporate logics and finance in emerging global assemblages. These initiatives are being enacted by a new coalition of public and private actors that are working towards a common agenda to establish an LNG hub in Singapore. In 2015, the Singapore Exchange (SGX) established the Singapore SGX LNG index, which is a real-time price assessment tool based on the average reported prices of traders, exporters, and importers that participate in the exchange (Shi and Variam, 2016). In addition, SGX is developing a marketplace for speculative financial instruments for LNG trading such as swaps and future contracts. The Singaporean wealth fund, Temasek Holdings Pte. Ltd., incorporated Pavilion Energy with 1 billion SGD in initial capital to invest in LNG trading (Soh, 2017). Among others, LNG firms such as CNOOC, JERA, Aramco, ENI and PTT have set up LNG trading desks in Singapore. In addition to LNG firms, commodity trading houses such as Trafigura, Guvnor, and Vitol have trading activities in Singapore (Daiss, 2016). Although other Asian countries such as Japan and China have also sought to establish an LNG hub, Singapore's capacity to quickly establish legal and regulatory institutions has given it a competitive advantage over other countries (Ten Kate et al., 2013). A survey of 80 senior energy industry leaders by the management-consulting corporation, Deloitte, revealed that 74 percent of the respondents believed Singapore would attain the position as an LNG hub by 2023

(Deloitte, 2018). In the media release, the Deloitte oil and gas Asia-pacific leader claimed:

> Singapore fits all the criteria of an ideal trading hub. It has a world class trading infrastructure already in place, excellent institutions, offers low geopolitical risk whilst situated in an ideal geographic location with deep and liquid financial and capital markets, in addition to an attractive tax and regulatory regime.

The quote from Deloitte expresses how Singapore, as a global city, is a significant site for the services and specialized functions that enable global commodity trading, and therefore is a preferred site for multinational corporations to set up their operations. Yet, despite Singapore's financial, institutional, and human assets, these resources by themselves are not sufficient to consolidate Singapore's position as an LNG trading hub. As a report on LNG trading hubs in Asia from the Columbia University Center on Global Energy Policy explains:

> Almost every player in the LNG industry has set up significant operations in Singapore to trade LNG. However, that doesn't make Singapore a location for a LNG trading hub as the trading of LNG could be cargos anywhere in Asia, or even globally, with traders simply 'meeting' in Singapore (Fulwood, 2018, 30)

The quote from the report reflects an argument made previously in the theoretical section, that cities do not retain influence and power because over their control over service functions or financial resources, but in the capacity of financial, business, and political actors in establishing and sustaining connectivity in the global economy. Despite Singapore's capacity to develop "world-class" infrastructure for trading by deregulating its market and establishing market exchanges, a key challenge is for developing an LNG trading hub is that the Singaporean natural gas market is simply too small compared to other Asian markets.

According to several reports, the limited size of Singapore's market means that natural gas trades are unable to generate enough liquidity to provide a transparent and legitimate price signal (Fulwood, 2018; Stern, 2014). According to Heather (2016), the size of a gas market is related to the churn rate of that market, or the number of times a cargo of gas is traded and re-traded between its initial sale by the producer and the final purchase by the consumer. The participation of financial actors on markets are contingent on high-churn rates in markets. A business development manager at an LNG-related corporation, with experience of European gas market deregulation, noted that the Singapore pricing index, SLInG is: "really a fuss, it is just a marketing tool. They have good PR people working in the government". Singapore, the manager noted, has a small market and despite pipeline connections to neighboring countries, these pipelines do not have the same technical functionality as cross-border connections in Northwest Europe. According to the manager, current pipelines from neighboring countries are only designed for one-way flows into Singapore and are not currently suitable for trade. Therefore, a major hinder for Singapore's ambitions to become an LNG hub is its lack of physical connectivity to larger natural gas markets in other countries. To develop a mature trading hub, Singapore would need to establish physical connectivity with natural gas markets in neighboring countries. Ten Kate et al. (2013) suggests that Singapore may be able to do so, by using its LNG import terminal to service neighboring markets in Southeast Asia. In doing so, Singapore could develop

the liquidity and maturity of its LNG trading hub, an establish a price benchmark for trading in Southeast Asia and eventually the rest of Asia.

As discussed in the theoretical section, assemblages emerge through the symbiosis and co-functioning of social and material entities. Similar to how Allen (2010) describes power in global cities, the financial resources and service functions of Singapore by themselves does not guarantee its capacity to shape LNG production networks. Instead, the capacity of Singapore to develop an LNG hub needs to be actively constituted by the capacity of financial, business, and political actors to deploy infrastructural, financial, and institutional resources to establish connectivity with surrounding markets in Southeast Asia. These strategies are in line with an outward direct investment strategy in Singapore labeled "extending the second wing", which focuses on the regionalization of the Singaporean economy in order to overcome the limits of the small Singaporean market (Blomqvist, 2002). However, in line with assemblage thinking, since relations are exterior to related entities, emerging capacities for regionalization depend on the mutual co-functioning of an emerging LNG hub in Singapore, and new national strategies for energy development and security in neighboring countries.

A key challenge for developing LNG markets in neighboring countries, such as Indonesia and the Philippines, is that the populations of these countries are spread across multiple islands (DNV-GL, 2012). While these countries seek to take advantage of low LNG prices for energy development, these markets are too small for importing LNG cargos directly from producers (who rely on economies of scale to reduce unit costs) (Choy, 2011). According to the manager at SLNG, private and public authorities in Singapore have sought to facilitate the physical trade of LNG to neighboring markets, by offering storage and reloading services at the LNG terminal in Singapore. To do so, authorities in Singapore commissioned the terminal to be built with additional storage and regasification capacity than is needed for the Singapore energy market alone. In addition, authorities in 2017 gave Pavillion Energy the rights to storage and reload services for two years (Tey, 2017). By using the Singapore LNG terminal for importing large cargos of LNG, and reloading cargos on smaller LNG carriers to reach multiple, small demand centers in neighboring countries, the overall costs of supply can be significantly reduced. In addition, an interview with a business development manager at the Singaporean offshore and maritime conglomerate, Keppel Corporation, has develop a line of small LNG carriers and import terminals to service regional markets in Southeast Asia, according to an interviewed business manager at the corporation. Keppel and Pavilion Energy have co-signed an agreement with the Indonesian government to explore opportunities for Indonesian LNG to be delivered to Singapore, and then re-exported to small markets in west Sumatra (Thomas, 2017).

Through small LNG trade, a large LNG cargo can be physically imported into Singapore, and then re-traded through a number of smaller parcels distributed through Southeast Asia. This type of trading could increase the number of participants and volumes traded through the Singapore LNG hub. According to a manager at Pavilion Energy, these type of trades could constitute an integrated regional market in Southeast Asia. However, according to interviews with managers at LNG-related firms in Singapore, a key challenge is that while countries like Indonesia is a potentially significant market for re-exports from Singapore, authorities have struggled to come to agreement with partners on the terms and conditions of LNG projects, and market development has been stalled. Another key challenge for development, according to

interview with an executive at an LNG trading firm, is that despite efforts of authorities in neighboring countries to deregulate natural gas markets, LNG markets in Southeast Asia continue to be either firmly regulated by state authorities and controlled by utilities with monopolies on markets. Several countries, including Indonesia, Thailand and Malaysia have initiated gas market reforms, however the pace of reforms has been slow. While Thailand may be furthest along in terms of legally implementing reforms, the market continues to be dominated by the national natural gas utility and heavily regulated (Dodge, 2016). To facilitate LNG trading, pricing should be more transparent in Southeast Asia, but currently different tariff regimes distort the market according to the manager at Pavilion Energy. This results in a "chicken-or-the-egg" scenario, where deregulation increases the pressure of LNG buyers to buy LNG from commodity traders in Singapore, and Singapore is dependent on deregulation in neighboring markets to increase the liquidity of its LNG hub to support commodity trading.

6. Conclusion

The main aim of this paper has been to use assemblage thinking to account for how the agencies and initiatives that reassemble unbundled authorities and governance over markets shape GPNs. The empirical study demonstrates that as the exclusive authorities of the nation-state that traditionally oversaw and governed LNG production networks become unbundled and limits to further growth emerge, new windows of opportunity for value capture exist in facilitating new value creation opportunities. In this article, I discuss how public and private authorities in Singapore have sought to strategically couple to LNG production networks by establishing an LNG hub, and in doing so facilitate the emergence of commodity trading in LNG production networks. These strategies are in line with a relatively consistent economic development trajectory occurring in Singapore over the past three decades.

Assemblage thinking points to the initiatives of public and private actors that rework nation-state authorities and reorient regulatory frameworks and infrastructure towards global agendas, thus constituting global assemblages. By establishing an LNG hub, corporate, financial, and government actors form coalitions that work to embed unbundled authorities over LNG trade in Singapore as a global city. To do so, these actors need to establish a space for capital to reproduce itself as the circulation of titles of ownership so that commodity traders and financial speculators can realize profits from financial risk management. Singaporean authorities have established third party access regimes, the Singapore Exchange has established a price benchmark and marketplace for derivatives, and commodity traders have established trading desks in Singapore. Nevertheless, Singapore's domestic market, and its financial and institutional resources, are by themselves not enough to increase the maturity and liquidity of an LNG trading hub. Therefore, public and private actors in Singapore have sought to establish their physical connectivity to surrounding LNG markets by establishing an LNG re-export terminal and commercializing technologies to reach smaller markets that have normally been excluded by traditional LNG production networks. Assemblage thinking highlights the uncertainty and instability of such processes, as assemblages are not held together by virtue of dominance or resources, but through symbiosis and self-organizing potential. As market development in neighboring

countries is limited, and liberalization efforts not fully implemented, Singapore’s capacity to establish an LNG hub may be limited.

The empirical study of an emerging LNG hub in Singapore points to questions for further research. Bridge and Bradshaw (2017) claim that evolving LNG production networks are constituting a global market for natural gas, but given the challenges of establishing an LNG hub in Singapore, are there limits to this globalization? If Singapore is unable to establish an LNG hub in Asia due to the uncertainties described above, are other countries like Japan and China more likely to succeed? What happens if none of these countries manage to establish a mature LNG trading hub in Asia? How would this affect current evolutionary trajectories in LNG production networks?

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The 'Changing Same of Power': State Territoriality and Natural Gas Market Liberalization in Thailand

(Under Review at Geoforum)

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Abstract

Natural gas markets have been traditionally territorialized within the nation-state apparatus. However, since the early 1980s, the territoriality of these markets has been evolving through liberalization, cross-border market integration, and globalization in the form of liquefied natural gas (LNG) trade. These dynamics have materialized unevenly across the global economy. While natural gas market liberalization has been implemented in the United States and Europe, natural gas markets in most Asian countries continue to be firmly controlled by regulated or state-owned natural gas companies. This is the case in Thailand, where despite multiple reform efforts since the 1990's, the partially privatized, state-owned natural gas company, PTT Public Company Limited, continues to hold a lucrative monopoly over markets in Thailand. In this article, I explain why natural gas market liberalization in Thailand has failed to materialize by drawing upon an analytical toolkit that includes both territorial and topological notions of power. In doing so, I aim to contribute to geographical studies of energy by demonstrating the different modalities by which powerful actors may reproduce their authority over energy systems. PTT has historically maintained its reach over natural gas markets through the exclusive yet contested authority of the Thai-state over domestic natural gas resources and infrastructure. However, more recently, this authority has been transformed by LNG imports and the introduction of natural gas sector reforms in Thailand. Nevertheless, I find that PTT continues to reproduce its monopoly in gas markets by quietly working through regulations, contracts, and pricing regimes.

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1. Introduction

Recently, several energy geographers have argued for a stronger analytical focus on the notion of territoriality in order to highlight and problematize the geographical and spatial forms created through energy systems and their transformations (Bridge and Bradshaw, 2017; Bridge, 2018; Bouzarovski et al., 2015). Bridge argues that "focusing on how energy systems are territorialized draws attention to the different scales and arenas of political action that govern energy systems because of the way they are spatially constituted" (Bridge et al., 2013, 336). Territoriality is a particularly relevant concept for energy research as energy systems in recent decades have become increasingly global through growing cross-border energy investments and energy

market deregulation (Overland, 2016; Bridge and Bradshaw, 2015). In the natural gas sector, these trends have significant political-economic implications for state authority in relation to energy governance, energy security, and energy access (Bridge and Bradshaw, 2017).

While natural gas markets have been traditionally territorialized at the scale of the nation-state, such boundaries are being reconfigured through emerging political technologies and socio-technical practices (Bouzarovski et al., 2015). Historically cross-border flows and the international trade of natural gas has been significantly limited and most natural gas has been consumed in the country of production (IEA, 2016). However, since the late 1980's, the territoriality of gas markets has evolved through liberalization, international market integration, and globalization in the form of liquefied natural gas (LNG) trade (Bouzarovski et al., 2015; Bridge and Bradshaw, 2017). These trends towards market liberalization are not geographically uniform. While natural gas markets in the US and parts of Europe have become deregulated through the unbundling of natural gas transmission networks and development of wholesale markets, natural gas markets in Asia continue to be firmly regulated under nation-state authorities, mainly through national petroleum companies (Stern, 2014; Six and Corbeau, 2017). This is the case in Thailand, where national natural gas markets continue to be monopolized, despite the attempts of authorities in Thailand to introduce competition into domestic natural gas markets since the 1990's. In this paper, I analyze the limits of natural gas liberalization through an empirical study of natural gas sector reform policies in Thailand.

Initially, deregulation and liberalization was due to pressure from the World Bank, who made natural gas sector reform a condition of structural adjustment loans after Thailand sought emergency assistance from the international monetary fund (Greacen and Greacen, 2004). Thailand's power generation sector relies heavily on natural gas, which accounted for nearly 64 percent of the energy fuel mix in 2014. Over the past couple of decades, the implementation of natural gas sector reforms has been politically contentious. Despite Thai authorities enacting the legal framework for liberalization in the natural gas sector, the sector is virtually monopolized by the national energy company, PTT public company limited (Nikomborirak, 2017). PTT is the largest corporation in Thailand and the only Thai firm to rank in the Fortune Global 500 with a revenue of 58 Billion US dollars (DeCarlo, 2017). PTT's dominating role in Thailand's energy sector has been the subject of heated political debate in Thailand in the last two decades, where the costs of energy and the allocation of benefits have been continuously contested (Kosit, 2013; Changsorn, 2016; Wannathepsakul, 2016).

In this paper, I intend to explain why natural gas liberalization in Thailand has repeatedly failed to materialize by analyzing how PTTs monopoly in Thailand's natural gas markets has been continuously reproduced. To do so, I draw on an analytical toolkit that includes both territorial and topological notions of power. While territorial notions of power are useful for analyzing powers that are extensive to the authority of the nation-state, topological notions of power draw attention to the quieter registers of power that reproduce advantage (Allen, 2009). Regarding topologies of power, I draw upon Allen's (2016) conceptualization of the *changing same of power*, which draws attention to the intensive, relational arrangements by which power is exercised differently, yet remains invariant to transformation. Furthermore, I suggest in this paper that topological and territorial notions of power can be related to each other during

analysis to explain how both extensive and intensive arrangements are used simultaneously in powers reproduction. In my empirical analysis, I discuss how PTTs dominance over natural gas markets has been historically maintained through the extensive authorities of the nation-state. Nevertheless, I find that these exclusive authorities are being reassembled due to declining domestic production, LNG imports, and natural gas sector reform. Through my conceptual framework, I explain that while PTTs dominance over natural gas markets is under pressure from the evolving territoriality of natural gas markets in Thailand, PTT continues to maintain its monopolistic advantage in natural gas markets through more spatially distorted forms of power mediated through infrastructure, contracts, and price regimes. The relational powers are realized due to territorial (legal and regulatory) powers of the Thai state that have been unaltered by market reforms.

This paper aims to contribute to geographical studies of energy by demonstrating how both topological and territorial representations of power can be utilized, and related to each other in analysis, to explain how powerful actors reproduce their control and authority over energy resources and infrastructure. The rest of the paper is organized as follows: In the next section, I outline the theoretical background for the paper by discussing the notion of territoriality, and how energy systems become territorialized at different scales, and the dynamics by which such scalar organizations are transformed and contested. I then explain the limitations of the territoriality concept, and suggest the need for topological notions of power that work together with territorial notions of power. I draw on the work of Allen (2009; 2016; 2003) to explain the different modalities by which power is continuously reproduced despite transformation. In the third section, I continue the theoretical discussion through an empirical analysis of the territorial and topological arrangements of power by which PTTs monopoly over natural gas markets in Thailand has been reproduced, despite liberalization efforts since the 1990's.

2. Energy, Territoriality, and Topologies of Power

In the past decade, several discussions in geography have emerged around how energy systems both constitute and are constituted by the social production of space. (Bridge et al., 2013; Calvert, 2016; Zimmerer, 2011). The "spatial-turn" in energy research entails not only accounting for the spatial outcomes of certain technologies and practices, but also analyzing how socio-spatial processes shape and form energy systems (Bridge, 2018). By alluding to these processes, energy geographers aim to explain the spatial configuration and scales of organization in energy systems, in addition to highlighting geographical differences, and drawing attention to spatial relations of production and consumption (Bridge et al., 2013). In doing so, energy geographers can contribute to current knowledge and debates about the spatial scales by which energy systems are governed, and the politics by which such scalar organizations are contested and transformed (Frantál et al., 2014; Sovacool and Drupady, 2016; Sovacool and Cooper, 2013). One focus area where geographical insights has been particularly well positioned is drawing attention to the territoriality of energy resources and energy systems (Bridge et al., 2013; Huber, 2018).

2.1. The Territoriality of Energy Resources and Infrastructure

Energy geographers have used the notion of territoriality to explain how political and economic actors exercise authority and commercial power over energy resources and infrastructure by delimiting and asserting their control over space (Bridge et al., 2018; Bridge et al., 2013; Huber, 2018). The territoriality of energy resources can refer to how resources become embedded in the proprietorial, institutional, and cultural-political structures of the nation-state (Bridge, 2008). Analyzing nation-state territoriality and the politics of resources, according to Huber (2018), is not only a question of accounting for the politics of control and governance over resources, but to also explain how the state is actively constituted through limiting and maintaining control and access to resources. The core and fundamental feature of the modern capitalist state, according to Parenti (2014), is its role in delivering the utilities of resources to capital by controlling the terrain and portions of the earth where these utilities exist. The state does this by legally and militarily seizing parts of the surface of the earth and encasing resources within the techno-managerial apparatus of administration, science, and governance.

Through the territorial delimitation of resource access and control, states assert their sovereignty in addition to delivering the utilities of resources to capital. Energy resources and infrastructure can play a key role in reproducing political power through claims of national significance (Huber, 2018; Bridge et al., 2018). Resources both constitute the institutional state apparatus and a cultural imagery of a shared nation-hood. The states control over territory relies on popular understandings and forms of consent to state power (Huber, 2018). Therefore, while states deliver the utilities of resources to capital, the state may simultaneously stand as enactor of nationalist politics against the global work of capital to naturalize its control over territory. These issues reflect a need to further draw upon debates in energy studies on how the capacity of states, corporations, and civil society to influence and shape energy outcomes is constituted in terms of territoriality.

Bridge et al. (2013) notes that energy infrastructure has been territorialized in different ways over time. Modern industrial capitalism evolved through its intensive vertical reliance upon subterranean stocks of energy that required relatively little surface land to harness (Huber and McCarthy, 2017). Energy infrastructure, according to Bridge et al. (2018), form the "central nervous systems" of economies, and entails more than moving, converting, or storing infrastructure. Infrastructure also has the capacity to organize social relations in significant ways, and energy systems have politics or create political affects. Energy infrastructures are significant for the reproduction of political-power through claims of national significance. The modernization of the nation, as a political project, has been tied with reterritorializing energy systems at the scale of the nation by replacing localized municipal systems with a national-grid (Bridge et al., 2013). For example, Correlje et al. (2003) explains that after the discovery of the giant Groningen gas field in 1959, the Dutch government played a key role by collaborating with Exxon and Shell to develop the institutional framework and infrastructure that would transform the Dutch gas regime from fragmented, municipal utilities to a national system. States therefore have historically played a key role in collaborating with capital to shape the territoriality of energy systems under the authority of the nation-state.

The territoriality of energy systems is also shaped by the materiality of energy resources (Bridge, 2008). The production, distribution and use of energy resources underpins both material and immaterial relations (Calvert, 2016). Energy resources and energy systems have particular materialities that are implicated in political-economic possibilities and constraints, and therefore play a role in enabling and sustaining different forms of political economy (Birch and Calvert, 2015; Bridge et al., 2018; Mitchell, 2009). Natural gas, compared to other fossil fuels like coal and oil, requires lumpy and asset-specific infrastructures that have high fixed start-up costs, creating a high-barrier to entry for competitors, thus generating natural monopolies (Sica, 2018; Balmaceda, 2018). Sica (2018) explains that prior to the passing of the 1938 Natural Gas Act in the US, an oligopoly of utilities that owned interstate pipelines effectively blocked independent producers from selling gas to out-of-state markets to avoid competition and keep prices high[7]. To combat this market failure, the Natural Gas Act established the authority of the federal power commission to oversee interstate pipeline construction plans and audit price rates to combat price gouging. As in the US, the authority of the nation-state over natural gas infrastructure and markets in most countries has been justified by concerns about market failure and energy security (Victor et al., 2006). Therefore, the authority of the nation-state over natural gas markets is closely related to the materiality of natural gas resources and infrastructure.

While the territoriality of energy resources and infrastructure is typically related to the authority and power of the nation-state, the territorial state is highly ambiguous and contradictory, and includes accommodating or contesting forms of territorial rules beyond the state itself (Bridge et al., 2018; Bridge et al., 2013). Energy infrastructure draws together material interests from specific actors and groups across multiple scales, including international capital (Bridge et al., 2018). Energy infrastructure is significant to the processes of financialization and has been a site of experimentation for neo-liberal agendas (Eren, 2018; Purcell and Martinez, 2018). The territoriality of energy resources and energy infrastructure is not limited to the borders of nation-states, and is subject to multiple forms and scales of governance (Bridge et al., 2013; Bouzarovski et al., 2015). Since the 1980's, the territoriality of natural gas markets has been evolving through market deregulation and the globalization of LNG trade (Bridge and Bradshaw, 2017). Deregulation of natural gas markets started in the United States after the passing of the natural gas policy act in 1978 (Sica, 2018). In 1986, deregulation started in Europe, when the United Kingdom privatized the national gas company, British Gas. Bouzarovski et al. (2015) shows that in the last two decades, the European Union has been undertaking a set of directives and policies for deregulating and facilitating the cross-border integration of national gas markets under the governance of a common regulator. Bouzarovski et al. (2015) suggest that the territoriality of a common gas market does not exceed and work beyond individual nation-states but can be described as an assemblage that emerges as smaller gas transmission networks are integrated under a set of common codes and regulations implemented by nation-states.

While the materiality of natural gas historically constrained the spatiality and territoriality of natural gas markets, Bridge and Bradshaw (2017) note that the territoriality of natural gas markets are being reshaped by significant growth in LNG

[7] This had the consequence of generating huge waste, as producers vented and flared natural gas in order to extract small amounts of oil fuels which were easier to sell to markets.

trade in the last two decades. By cryogenically liquefying natural gas, the density can be reduced six-hundred fold, and transported by sea – going beyond the continental limits of gas pipelines. Although the territoriality of LNG trade has historically been limited by high capital intensity and strong inter-firm relations in LNG production networks, Bridge and Bradshaw note that a significant expansion in global LNG production capacity in the last decade and emerging organizational arrangements are constituting global LNG markets. Overall, the notion of territoriality is useful to account for how the governance and authority of natural gas resources, infrastructure, and markets has traditionally been territorialized at the national-scale, and the processes by which the territoriality of natural gas markets is shifting due to liberalization and globalization.

Drawing attention to the territoriality of natural gas resources and infrastructure can also explain notions of national identity and highlight how different social groups and actors contest over the allocation and benefits of energy infrastructure, and highlight the recent trend for "renationalizing" energy infrastructure (Bridge et al., 2018). The privatization of energy production, distribution and supply has led to discontent and protests. Building on the notion of territoriality, I explain in the empirical section the dynamics by which nation-state authority over natural gas resources and markets in Thailand is evolving through privatization, liberalization, and globalization and how these evolving forms of territoriality are contested by different consumer and civil society groups. However, while highlighting the relations between territory, capital, and states provides a framework by which power, authority and politics may be studied, there are limitations of territorial notions of power that I suggest can be addressed through topological notions.

2.2. Beyond Territory: Energy and Power Topologies

The territoriality of energy points to a conceptualization of nation-state authority and power over energy infrastructure and resources in terms of administrative, regulatory, and jurisdictional scales from the local, to the regional, to the national, and to the global (Bridge et al., 2013). Based on these conceptualizations, I propose that understanding how power and authority is territorialized at different scales, and showing how territoriality is deterritorialized and reterritorialized through globalization and market reform, provides a basis for explaining how authorities and power over natural gas markets are evolving. However, territorial conceptualizations of power, according to Allen (2009), tends to take the spatial geometry of power for granted. Allen claims that basic notions of territory and scales tends to assume that decisions of administrative power is impelled out from centralized authorities across demarcated spaces. Bridge and Bradshaw (2017) and Bouzarovski et al. (2015) avoid these basic notions by showing how the territoriality of natural gas markets are being reshaped by global networks and reterritorialized through cross-border assemblages. However, these notions of rescaled and networked markets do not break with the notion that power and authority is extensive across fixed, topographical representations of space, and consequentially these notions miss the other, more subtle ways by which authority over infrastructure and resources are realized (Allen and Cochrane, 2010).

Allen (2009) suggests that a topological framing of power may be better suited to account for how the exclusive authority of the nation-state becomes blurred, unbundled, and re-embedded through new forms of private authority. Topologies of power are concerned with actual workings of power, not with what actors "can do" given their resources or legal authority associated with particular scales (Allen, 2016). Based on Allen's (2016) approach to topologies of power, I suggest that focusing on the actual workings of power in energy systems entails analyzing how different actors act upon and respond to the contingencies that confront them, such as price shifts, declining energy resources, new policies, etc. Furthermore, the capacity of powerful actors to respond to contingencies and secure certain outcomes is not guaranteed. Borrowing from mathematical studies of topology, Allen (2016) uses the terms "equivalence" and "invariance" to conceptualize power as something that can be continuously reproduced through processes of spatial distortion. The "changing same of power" refers to the different modalities by which power is practiced and reproduced by institutions and actors by drawing other actors into their reach or keeping them at a distance. For example, when blunt displays of power or territorially-extensive authorities are no longer successful, some powerful actors may do better to establish their advantage through quieter registers of power that reproduce their presence by drawing other actors into their relational proximity. In the empirical section below, I demonstrate how PTT reproduces its power by maintaining its relational proximity to gas buyers in Thailand and excluding other possible competitors by doing so.

Topologies of power directs research towards more intensive arrangements of power, that focuses on the relationships and interplay between different institutional interests and authorities, where power relationships are mediated through events, technologies, and practices for specific political and economic ends (Allen, 2011). Allen notes how actors use technologies to create a simultaneous presence in a diversity of settings, so that the gap between here and there is bridged relationally (Allen, 2003). These intensive arrangements of power are not foreign to studies in social science on energy that have discussed how material artifacts, such as pipelines, audits, calculative agencies, contracts, pricing regimes, etc. can be used to mediate relationships between states, corporations, stakeholders and publics (Barry, 2013; Birch and Calvert, 2015; Mitchell, 2009; Boyer, 2014). Allen (2016) suggests that powerful actors are not only powerful because they possess resources or authority over territory, but because they can "hook-up" other actors and reach into their everyday lives through practices and technologies. Through Allen's topologies of power approach, I suggest the need to account for relations between actors and material objects such as gas transmission codes, gas supply contracts, and pricing regimes, and analyze how these relations constitute intensive arrangements of power in natural gas markets.

While Allen suggests that territorial notions of power miss the many relational arrangements by which power works, he maintains that territorial and topological notions of power are not mutually exclusive, and both framings of power could work along-side each other (Allen, 2009; Allen, 2011; Allen, 2016). However, Allen does not discuss the extent to which these framings of power can be simultaneously drawn upon to analyze how intensive and extensive arrangements are related in the reproduction of power. Allen and Cochrane (2010) discusses how the spatial reach over territory is reassembled through intensive arrangements. Allen and Cochrane detail how these intensive arrangements of power can reproduce a government's reach, but they don't

account for other, unaltered forms of spatial reach and extensive authorities, such as legislative and regulatory powers, that may be contingently necessary for intensive arrangements of power to be realized. In the following empirical section, I demonstrate that both territorial and topological notions of power can be used, and related to each other, to explain why PTTs dominance in Thailand's natural gas markets has continuously been reproduced, despite attempts to implement liberalization reforms since the 1990's.

3. Natural Gas Monopoly and Liberalization in Thailand

In this section, I further develop the discussions surrounding the different modalities of power in energy systems based on a theoretically informed case study of natural gas sector reforms in Thailand. The case study is based on an empirical research period in Bangkok, Thailand in February 2017 in addition to desk-based research. Similar to other countries, the territoriality of natural gas resources and markets in Thailand has been primarily exclusive to the authority of the nation-state. It is through this territoriality that PTT has been granted monopolistic control over natural gas resources and markets in Thailand. Since the 1980's, this territoriality has been subject to contesting forms of territorial rules beyond the state itself, through pressure to liberalize and deregulate natural gas markets by the International Monetary Fund (IMF) and the World Bank. At the same time, reforms have sparked nationalist backlash against structural adjustment programs, nationalist forms of capitalism, and civil society movements. In other words, the territoriality of natural gas resources and markets in Thailand has been highly ambiguous and contradictory.

This empirical section is divided into three parts. In the first section, I detail the dynamics of territoriality through an historical analysis of natural gas markets, reforms, and contentious politics in Thailand. The historical analysis is based on the work of researchers who have written on the topic of energy reform and politics in Thailand. In addition, I also analyze different policy documents, laws, reports, and newspaper articles. In the second and third part of the empirical section, I account for the current situation surrounding natural gas market reforms by explaining how the globalization of the Thai natural gas sector through LNG imports threaten PTTs monopoly over natural gas markets in Thailand. Nevertheless, despite these changes, PTT continues to reproduce its dominance through intensive arrangements of power. My analysis in the second section is based primarily on 12 in-depth interviews conducted in February 2016, and industry reports. The interviewees included government regulatory and planning officials in Thailand. In addition, executives at energy-related companies in Thailand, both state-owned and private, and an energy consultant with considerable experience on the topic were interviewed. The interviews uncovered the various issues and challenges (at the time of the interviews) that were associated with market liberalization in the Thai natural gas sector.

3.1. History of Natural Gas Sector Reform in Thailand and Territorial Power

The 1971 Petroleum Act in Thailand exemplifies what Parenti (2014) describes as states judicially controlling portions of the earth and delivering the utilities of environmental resources to capital. After Thailand claimed the continental shelf in the Andaman Sea in 1971, it granted, through the Petroleum Act, the rights to private parties to explore, produce, store, transport and sell petroleum in concession areas (Ruangsuvan, 1981; Hongladaromp, 1985). A concession agreement with Union Oil Co. (Chevron today) led to the discovery of the major Erawan gas field. Following the discovery, the Thai government established the Natural Gas Organization of Thailand (NGOT) in 1977 with the directive of developing and implementing projects that would enable the use of natural gas for the benefit of the country. The push to develop natural gas production and consumption in Thailand followed the 1973 oil crisis. At the time, Thailand was almost entirely dependent on imported crude oil to meet its petroleum needs, particularly in the power sector (Hongladaromp, 1985). Thailand received loans from the World Bank to construct the pipeline. Following advisement from the World Bank, Thailand established the Petroleum Authority of Thailand which would eventually be merged with NGOT to form the State-Owned Enterprise, PTT company limited (World Bank, 1979). The incorporation of PTT consolidated the territoriality of natural gas resources and infrastructure under the authority of the nation-state. PTT was assigned a broad range of responsibilities, including procuring, exploring for, developing and producing petroleum and natural gas in addition to constructing ports for petroleum business activities, storage, transport systems, and refineries (Hongladaromp, 1985).

The access to low cost oil and natural gas reserves played a significant role in Thailand's economic development. Natural Gas resources and infrastructure formed the "central nervous system" of the Thai economy. Natural gas has been linked to the transition from a primarily agricultural to an export-led industrial economy (Barron, 2016). Low-cost natural gas resources and labor attracted significant foreign direct investment in manufacturing and petrochemicals (Dixon, 2001). Economic growth in Thailand sharply accelerated during the mid-1980s. The share of natural gas in Thailand's energy mix grew significantly, and in 2015 natural gas accounted for nearly 64 percent of electricity generation in Thailand (Energy Policy and Planning Office, 2015). PTT has acted as the sole purchaser, transporter and distributer of natural gas in Thailand, and purchases all indigenous gas from producers (Nikomborirak, 2013). These arrangements that territorialized natural gas systems at the scale of the nation-state were tied to the modernization of the nation, which as explained later in this section, is tied to nationalist backlash against neoliberal reforms.

The authority of the nation-state and the territoriality of natural gas infrastructure came under pressure by multi-lateral donor organizations in the 1980s. The reliance on expensive, imported crude oils after the oil crisis in the 1970's, led to the accumulation of high public sector debt (Wisuttisak, 2012). The economic boom and high growth in urbanization in the 1980s, in addition to subsidized electricity tariff rates, led to a massive increase in electricity demand and power shortages (Jarvis, 2011). Due to political pressure to maintain low electricity tariffs, Thailand sought emergency assistance from the International Monetary Fund. In 1982, Thailand took out structural adjustment loans from the World Bank with the condition of deregulating and

liberalizing the utilities sector and implementing measures to privatize state-owned enterprises (Wisuttisak, 2012).

Greacen and Greacen (2004) label the 1990's as the "neoliberal" era in Thailand's energy history, as authorities sought to introduce competition into the utilities market. Authorities enacted new regulatory frameworks, largely adopted from models developed in the UK, in order to rapidly deploy new energy infrastructure. According the Greacen and Greacen, after the 1991 military coup of the Chatchai administration, the Military sought to maintain legitimacy in the eyes of the World Bank and the IMF, and curtailed the power of labor unions to fight subsequent moves to privatize state-owned enterprises such as PTT. In this way, the regulatory apparatus of the Thai state included forms of territorial rule beyond the state itself (i.e. The World Bank and IMF). In 1992, the National Energy Policy office (NEPO) was established and tasked with reorganizing the institutions involved in the energy sector. Dr. Piyasvasti Amranand, the secretary general of NEPO at the time, spearheaded the deregulation efforts (Jarvis, 2011). Dr. Piyasvasti drove forward a strong agenda of market rationalism and privatization, and lobbied the prime minister and cabinet for reform in the energy sector. NEPO at the time was a largely influential body and assumed significant powers over most facets of energy policy, planning and pricing.

NEPO secured technical assistance from the Word Bank to assist in privatization of the energy sector. After the financial crisis in 1997, the Thai government drew up and approved the "Master Plan for State Sector Reform" as part of Thailand's bailout package from the IMF (National Energy Policy Office, 1998). In 1998, the business management consultancy, London Economics, submitted a World Bank funded report outlining the plan for reform and restructuring of the Thai energy sector. The report suggested the establishment of an independent regulatory agency, providing companies with incentives through price regulation, facilitating a role for the private sector, and developing a primary legislation for the regulatory office (London Economics, 1998). In addition, the report suggested limiting PTTs monopoly and make room for competitors by preventing PTT from entering further take-or-pay contracts and from contracting for all the gas in any new gas field. In addition, the report suggested introducing account separation between PTT's commercial marketing and transmission system operation activities.

Following the London economics report, in 1998, NEPO proposed the plan "Privatization and Liberalization of the Energy Sector in Thailand" (Jarvis, 2011). The cabinet, led by then Prime Minister Chuan Leekpai, accepted NEPO's plan and agreed to implement the reform of the gas sector (Jarvis, 2011). The reforms included partially privatizing PTT, and establishing a legal separation of PTT's transmission from its marketing business through establishing PTT Transmission Co. Ltd. This energy reform agenda, which entailed significantly reworking nation-state authority in the energy sector, was not without discontent in Thai society and sparked nationalist backlash (Barron, 2016). Unions protested privatization of state-owned enterprises, and Thai nationalists felt that energy reforms would lead to takeover by foreign interests (Greacen and Greacen, 2004). Consumers feared the uneven distribution of benefits such as increased power prices and that reforms would lead to privatized monopolies. The press feared corruption and favoritism in the privatization process.

Contentious politics surrounding the energy reform agenda mirrored wider discontent with neoliberalism after the 1997 Asian financial crisis, and the blaming of

IMF structural adjustment programs and foreigners for Thailand's economic ills (Glassman, 2004). These resentments towards global neoliberalism helped propel the Thai Rak Thai Party led by Thaksin Shinawatra into power in 2001. Greacen and Greacen (2004) label this period in Thai history as the "National Champion" era. Thaksin's version of "nationalism" was complicated as it was opposed to IMF market liberalization reforms, but carried on with the privatization of state-owned enterprises (Simpson, 2016). PTT was partially incorporated and 49 percent equity share was floated on the Thai Stock Exchange. Through the corporatization of PTT and other State-Owned Enterprises, Thaksin intended to build up cash flows to avoid IMF loan obligations and carry out a number of populist programs such as a moratorium on debt for farmers, national health insurance, and infrastructure expenditures (Glassman, 2007; Jarvis, 2011). In 2002, Dr. Piyasvasti was transferred out of NEPO. NEPO was renamed as the Energy Policy and Planning Office (EPPO) and its electricity policy-making role was relocated to the ministry of energy. EPPO lost its reformative power and energy policy was controlled firmly inside the executive branch and subject to direct political considerations. Therefore, the Thaksin regime was able to undo the IMF's influence and reestablish the extensive authority of the state over Thailand's energy system. Despite its privatization, the state continued to grant PTT its monopoly.

The privatization of PTT and other state-owned enterprises led to strong protest movements from consumer protection NGOs (Sirasoontorn and Quiggin, 2007). In August 2006, a Supreme Court took up a case against the corporatization of PTT filed by the federation of consumers who petitioned to renationalize PTT (Nikomborirak, 2013). During the court case, the Thaksin government was ousted following a military coup in September 2006. In October 2006, Dr. Piyasvasti, was reinstated as the minister of energy. The post-coup period provided a brief "window of opportunity" for energy liberalization. One of the key initiatives that Dr. Piyasvasti took during this time period was the passage of the Energy Industry Act in 2007 (Jarvis, 2011). The Energy Industry Act established a single regulatory body, the Energy Regulatory Commission (ERC) and was modelled after the UK Office of Gas and Electricity Markets (Nikomborirak, 2013). The ERC would be responsible for promoting competitive practices, having oversight over tariff review, distributing licenses, etc. The Energy Industry Act was an important factor for the December 2007 decision of the administrative court not to force the delisting and renationalization of PTT (Jarvis, 2011). Instead, the court ordered that state land and gas pipeline assets that belonged to the Thai State should be transferred to the Ministry of Finance.

However, the reform period from 2006 was short-lived, as in 2008, Dr. Piyasvasti was again moved from his position as the Thai Minister of Energy (Jarvis 2011). The subsequent Thai cabinets adopted a "go-slow" attitude towards the ERC, and delayed approval for its budget. Simpson (2016) explains that while these cabinets did not abandon all the neoliberal philosophies underpinning energy reform, these cabinets did not proceed with reforms due to political instability at the time. Since the passage of the Energy Industry Act, PTT continues to act as the sole purchaser of natural gas in Thailand and operates pipelines on a monopoly basis (Nikomborirak, 2013). PTT maintained its monopoly, because, as explained in the theoretical section, the materiality of natural gas creates natural monopolies (Sica, 2018). While PTT returned some of its natural gas pipelines to the state, it reserved the entirety of pipeline capacity through legacy contracts and effectively blocked competitors from using the pipelines

(Nikomborirak, 2013). In addition, PTT was required by the supreme court ruling to only return gas pipelines that were commissioned before PTT's privatization, so PTT continued to control large parts of natural gas transmission networks in Thailand. In 2012, The Ministry of Energy and Finance was accused by the Foundation of Consumers of not enforcing PTT to return pipelines that were owned by the state, specifically offshore pipelines that were built before PTT was privatized (Thip-Osod, 2012). By continuing to own offshore pipelines, PTT continued to maintain exclusive access to domestic natural gas reserves in Thailand.

The history of natural gas sector reforms in Thailand has been highly turbulent and contentious, as various groups and political actors have contested over the territoriality of natural gas resources and infrastructure in Thailand. Despite privatization and market reform efforts, PTT has continued to operate under the extensive authority of the nation-state in Thailand, allowing PTT to enjoy a regulated, yet lucrative monopoly over Thai natural gas markets. PTTs power seems to reach into everyday aspects of Thai life, as natural gas is primary a source of fuel for electricity generation, natural gas vehicles, and cooking. Nevertheless, the Energy Industry Act has continued to live on through the operations of the ERC and EPPO, even if the act was not necessarily being pushed politically by political authorities. In the next section, we discuss how the importation of LNG starting in 2011, and the Third Party Access (TPA) regime issued by the ERC is threatening the extensive power arrangements that have traditionally enabled PTT to dominate Thailand's natural gas sector. Responding to these contingencies, I find that PTT draws upon on more intensive arrangements of power to reproduce its advantage in Thai gas markets.

3.2. The 'Changing Same of Power' in Thailand's Natural Gas Markets

As previously discussed in the theoretical section, territorial notions of power are useful to conceptualize how authority and power are extensive to administrative, regulatory, and jurisdictional scales, such as that of the nation-state, and the contentious politics through which nation-state territoriality is transformed through privatization, liberalization, and globalization. However, as the exclusive authority of the nation-state becomes blurred and unbundled, power becomes more difficult to account for, even with a vocabulary associated with rescaling (Allen, 2016). Working together with conventional territorial framings of power, a topological framing of power in energy systems draws attention to the more relational, intensive arrangements by which advantage can be reproduced.

The key challenge to liberalization in the Thai natural gas sector has been that PTT has held monopolistic rights on pipelines. The capacity of competitors, such as concessioners on Thai gas fields, to sell natural gas to markets was effectively blocked. However, since 2011, the territoriality of natural gas markets in Thailand has been transformed by the importation of LNG. While Thailand has historically enjoyed the benefits of having ample quantities of low-cost natural gas resources, natural gas reserves in Thailand peaked in 2004, and since then the reserve to production ratio has dramatically declined (Barron, 2016). Since 1998, Thailand has become increasingly dependent on importing natural gas from Myanmar to sustain its growing consumption. In 2014, nearly 18 percent of gas supply in Thailand was imported from Myanmar. As

expanded imports from Myanmar is uncertain, and domestic production declining, the Thai government sought to diversify its energy sources by commissioning the Map Ta Phut LNG terminal in 2011 (Interview, Energy Planning Official, February 2016). At the same time, PTT has signed a number of LNG supply contracts with different international suppliers, including Malaysian Petronas, Qatar Gas, BP, and Shell.

Although PTT has traditionally maintained its advantage through the territorialities of natural gas resources and infrastructure exclusive to the nation-state in Thailand, LNG opens new windows of opportunities for natural gas liberalization in Thailand. While PTTs control over offshore pipelines continues to be disputed in courts, the energy regulatory commission has the authority to break PTTs monopoly by issuing Third Party Access on LNG terminals and onshore gas transmission networks (Koomsup and Sirasoontorn, 2007). The ERC enacted the Third-Party Access Regime for Thailand in 2014. The TPA regime was enacted through the Energy Industry Act, Section 81 "A Licensee who owns an energy network system must allow other licenses or energy industry operators to utilize or connect to his system in accordance with the terms stipulated and announced by the licensee" (2007). The TPA regime forces the operators of LNG terminals to allow access to third parties to utilize terminal capacity under regulated conditions (ERC, 2014). Therefore, PTT is obligated to allow access to the use of the Map Ta Phut Terminal and onshore transmission pipelines (Interview, Energy Regulatory Official, 2017).

However, despite issuing the TPA regime, the ERC has not issued any licenses to any third-party gas retailers (Interview, Energy Regulatory Official, 2017). Today, PTT continues to be responsible for all LNG imports in Thailand. According to an energy regulatory official in Thailand, officials have struggled to find a new third-party retailer for LNG terminals in Thailand. Utilizing a topology of power framework, I discuss three different modalities of power by which PTT reproduces its advantage by keeping domestic buyers in reach, and competitors at a distance, despite the TPA regime. First, PTT maintains its advantage as network codes are quietly manipulated to guarantee that PTT is the sole user of natural gas pipelines and terminals. Second, PTTs relational proximity to gas buyers is maintained through existing long-term contracts with no exit clauses. Third, pricing mechanisms in Thailand allows PTT to reproduce its monopolistic advantage, by always being able to sell natural gas at a lower price than possible competitors. At the same time, I explain that these intensive arrangements of power are not mutually exclusive to the extensive arrangements of power that have been unaltered by the TPA regime.

3.3. Power Topologies in Thailand's Gas Markets

The "quieter registers of power" discussed in the theoretical section are exemplified by the modalities by which PTT continues to effectively reserve 100 percent of pipeline and LNG terminal capacity through the network codes established under the TPA regime. Consequently, through these topologies of power, PTT is able to effectively keep competitors at a distance, as they are blocked from using pipelines and LNG terminals in Thailand. However, these intensive arrangements of power are not divorced from the extensive authorities of the nation-state, as exemplified by the decision of regulators not to enforce ownership separation. In EU regulations regarding TPA

terminals, the operator of the LNG terminal should operate as a separate entity than the terminal users, as the operator is expected to grant non-discriminatory access to terminals (Heather, 2016). In Thailand, however, regulators opted only to enforce a legal separation of PTTs LNG subsidiary that operates the Map Ta Phut LNG terminal from its mother corporation. In addition, regulators enforced only an account unbundling of PTT Natural Gas Distribution, which operates natural gas pipelines in Thailand. In an interview, a government regulatory official justified the reluctance to enforce ownership separation:

> Europe promoted ownership separation to make sure there is 100 percent transparency, but in Thailand we are still under a process, and we still don't know if we should enforce ownership separation, but we will try to make it as transparent as we can. (Interview, government regulatory official, 2016)

Under the Thai TPA regime, transmission system and LNG terminal operators are expected to ensure that operators should "promote fair and transparent service of an energy network system with unjust discrimination", and the operator should allow third parties to connect to and/or utilize natural gas facilities (ERC, 2014). Capacity should be allocated on a first-come-first-serve basis. Nevertheless, the TPA regime requires that natural gas facility operators allocate available capacity on a grandfathered basis (ERCEnergy Regulatory Commission, 2014). "Grandfathered" is the continuation of existing contractual rights to use a natural gas facility. Through this clause, PTT continues to control 100 percent of reserved pipeline and LNG capacity (Interview, government regulatory official, 2016). However, the TPA regime also includes a use-it-or-lose-it obligation, where if the shipper has not utilized its capacity for a period defined by the natural gas facilitator of up to 12 months, then the terminal operator should require the use to release the capacity for allocation (ERC, 2014).

While PTT holds 100 percent of reserved capacity, the LNG terminal at Map Ta Phut is currently underutilized. PTT has argued that there are brief periods where full terminal capacity is utilized and therefore is not required to give up their capacity (Interview, Consultant, Energy Management Agency, 2016). While the TPA regime allows transmission system operators to allow this, a consultant at an energy management agency noted that:

> If the regulator wanted to, they could probably make the case that PTT should give up their capacity (on the LNG terminal), but the problem is that PTT owns PTTLNG, and PTTLNG is unlikely to make the case for forcing PTT to give up their capacity. And in terms of political power, if the regulator is in dispute with PTT, then PTT will win. (Interview, Consultant, Energy Management Agency, 2016)

The quote from the consultant points to a situation where PTT is able to quietly reproduce its advantage by working through the codes and regulations defined by the TPA regime. While arrangements are relational, they also work due to the reluctance of the Thai state to enforce ownership separation and are therefore also related to extensive arrangements of power.

The second register by which PTT maintains its dominance over natural gas markets is by reproducing its relational proximity to buyers in the Thai gas market. PTT maintains these proximities through long-term gas supply agreements that were signed before the ERC enacted the third-party access regime. In its recommendations for the liberalization of the Thai natural gas sector, the London Economics report noted that

PTT should not be able to enter in further take-or-pay contracts, or allowed to contract for all the gas in any new fields (London Economics, 1998). These recommendations were disregarded by Thai authorities at the time. Today, the challenge is that while the TPA regime was launched in 2014, PTT continues to hold all long-term gas supply agreements (GSA) with currently operating power plants in Thailand (Interview, government regulatory official, 2016). A GSA is required before a Power Purchase Agreement (PPA) is signed, and the GSA normally lasts the lifetime of the PPA (15-20 years). (Interview, Executive Manager, Independent Power Producer, 2016). Exit clauses were not incorporated in the GSA, as PTT was previously the sole retailer of natural gas in Thailand.

> "If the government really wanted competition in the gas supply, then they should have a clause that says an existing customer can renegotiate gas agreements with PTT, but now they can't because they are locked in" (Interview, Executive Manager, Independent Power Producer, 2016).

Again, as reflected in the quote, PTT is able to maintain relational proximities through long-term contracts, due to the reluctance of the government to draw on its extensive authority to require exit clauses to be added to existing contracts. These arrangements keep competitors at a distance, since it will only be possible for third-party retailer to enter the market if there is a need for a new GSA. New GSAs are hard to come by, as energy planners ultimately plan to reduce natural gas consumption, as Thailand is expected to become further dependent on LNG, which is more expensive than domestic gas and Myanmar imports (Interview, government planning official, 2016). Through long-term GSA, current gas operators remain effectively "hooked-up" to PTT for the duration of the GSA, and therefore gas operators are unable to switch suppliers.

The third register by which PTT reproduces its presence in Thai natural gas markets is through the mechanisms by which natural gas is priced in Thailand. Gas prices in Thailand comprises of the wellhead gas price, a marketing margin, a transmission tariff and a distribution tariff (Nikomborirak, 2013). The domestic wellhead gas price is specified in the gas purchase contract signed between the producer and PTT. EPPO, through its extensive authority over natural gas markets, regulates the marketing margin, which is based on gas pool pricing. Gas pool pricing is the weighted average price of gas from domestic sources, Myanmar imports, and LNG imports (Nikomborirak, 2014). The challenge of pool pricing for prospective third parties is that it gives PTT an unfair competitive advantage. As mentioned previously, PTT has an effective monopoly over domestic gas procurement and domestic natural gas supply in Thailand is considerably less expensive than imported LNG.

> While gulf gas is declining at the moment, PTT still has the advantage of gas supply through pool pricing because gulf gas is less expensive. If you want to use TPA, your LNG import price will not be able to compete with PTTs price. How do you resolve this? Only PTT has access to Gulf Gas. For a TPA to work, everyone must compete on the same prices and then you can compete on the logistics of operations (Interview, Executive Manager, Independent Power Producer, 2016).

The situation explained in the quote reflects how PTTs presence in Thai gas markets is mediated through pricing mechanisms in Thailand, that reproduces PTTs advantage over competitors.

PTT continues to maintain its monopoly through pricing regimes, TPA codes, and contracts, even if its monopoly is no longer legally granted by the extensive authority of the nation-state. Nevertheless, the success of these intensive arrangements are not guaranteed. Intensive arrangements of power in the Thai case continue to rely on the extensive authority of the state to regulate contracts, pricing regimes, and TPA codes which have remained unaltered by the TPA regime and Energy Industry Act. The energy consultant speculated on why the Thai government was reluctant to use its legal and regulatory powers to liberalize Thai markets.

> The ERC was required to pass the TPA regime (due to the 2007 Energy Industry Act), but I don't think anyone in the government is actually committed to it. It's not like they are doing this for competition, they are obliged to do it. The current government is not the sort that is going to undermine PTT to create competition. (Interview, Consultant, Energy Management Agency, 2016)

The consultant's speculations reflect how power can be reproduced by quieter, relational registers which are realized through territorial forms of power. As PTT is a state-owned company, although it is partially privatized, and regulated under government legislation, its ability to reproduce its power through intensive arrangements, in turn reproduces the authority of the government over natural gas markets. While PTTs extensive control over pipelines have been previously opposed by social movements (as is the case with the 2006 court case and the 2012 accusations by the foundations of consumers as mentioned previously), quieter registers, as Allen (2016) suggests, are more difficult to mobilize opposition against. Unless this situation changes, natural gas markets will most likely continue to be territorialized at the scale of the nation-state, despite neo-liberal reforms and globalization.

4. Conclusion

The main aim of this paper has been to contribute to geographical studies of energy by demonstrating how both topological and territorial framings of power can be utilized, and related to each other, to explain how powerful actors reproduce their control and authority over energy resources and infrastructure. Based on this paper's empirical case study of natural gas reforms in Thailand, I conclude that such an analytical approach can better equip energy geographers to explain why the territoriality of energy systems is geographically differentiated according to different national contexts. While market liberalization and deregulation has transformed natural gas infrastructure and markets in the US and Europe since the 1980's, natural gas markets in Thailand continues to remain effectively monopolized by PTT despite the implementation of market reforms. The history of natural gas sector reform in Thailand shows that reform initiatives have been sporadic due to regime changes, political contestation, and lack of political will. As a result, PTT has historically maintained its monopoly through the extensive authority of the nation-state over natural gas markets. These powers are not guaranteed and in Thailand PTT's authority has been deterritorialized by the TPA regime issued by the ERC. The TPA regime seems to be less politically motivated than it is obligated, as the liberalization of the Thai energy sector was the basis by which the supreme court rejected delisting and renationalizing PTT in 2006. Furthermore, PTTs extensive power

over gas markets is also being deterritorialized by declining domestic reserves and LNG imports.

Based on the case study, I also conclude that by accounting for different modalities of power and their relatedness, energy geographers can better explain why energy laws and regulations, specifically those intended to break monopolies, aren't always successful. Instead of framing dominance as solely the virtue of an actor's resources or social positionalities, topologies of power highlight the quieter registers and relations by which power can be reproduced. Furthermore, geographers can consider how the territorial powers of governments, that remains unaltered by deregulation, may be related to the intensive arrangements by which power is reproduced. Since these registers of power are quiet, and are not necessarily illegal, the capacity of social movements (such as the foundation of consumers in Thailand) might be limited. In doing so, geographers can point to the limitations of neoliberalism in energy systems. The empirical case study demonstrated that quieter registers of power allow PTT to abide regulations and laws, but maintain its dominance through network codes, contracts, and price regimes, which are in turn enabled by unaltered, extensive authorities of the nation-state in Thailand. The case of Thailand pertains to neo-liberal reforms, but the same lessons may be drawn for research on attempts to increase public participation and democracy in energy transitions or how incumbents reproduce fossil fuel regimes despite government policies for meeting climate emission targets and decarbonization.

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State Strategies and Materiality in Dynamic Liquefied Natural Gas Production Networks

(Submitted to Economic Geography)

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Abstract

Recently, scholars have sought to explain the dynamics by which global production networks (GPNs) evolve and the spatial and political consequences. However, the literature has yet to fully account for how political action becomes limited by the material transformations and distributed agencies that shape emerging GPNs, which we theoretically address in this article through an empirical study of state-driven energy development strategies in Indonesia. Indonesia has traditionally exported liquefied natural gas (LNG) at the expense of domestic energy markets. State strategies surrounding "exportism" emerged in relation to the "uncooperative" materiality of natural gas and the strong interfirm arrangement's that made value creation possible. Nevertheless, these arrangements are being transformed by the emergence of more organizationally fragmented and spatially diverse production networks. In this context, the Indonesian government has sought to rearticulate Indonesia as a significant LNG consumer in production networks through public-private partnerships. By building a conceptual framework based on assemblage thinking, we find that the state strategies in Indonesia are nevertheless limited because the materiality by which such strategies are potentially realized contradict the dynamics by which LNG production networks are being transformed.

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1. Emerging GPNs and Contested LNG Supply Projects in Indonesia

In a 2016 speech, the president of Indonesia, Joko Widodo (Jokowi), claimed, "We will develop areas such as Entikong, Natuna, and Atambua so that the world sees Indonesia as a great nation that pays attention to every inch of its land" (The Business Times, 2016). Jokowi's statement reflects a situation where large economic disparities persist between the core and peripheral regions of Indonesia despite high economic growth. Key challenges for national development include substantial energy infrastructure deficits and a high reliance on expensive, net-imported fuel oil for electricity generation, particularly in the peripheral regions of Indonesia (Seah, 2014; Ray and Ing, 2016). To reconfigure the energy system, President Jokowi commissioned, in 2015, the national electricity company, Persusahaan Listrik Negara (PLN), to launch a public-private partnership (PPP) tender for liquefied natural gas (LNG) supply to 21 power plants across the islands of Kalimantan, Sulawesi and Nusa Tenggara (Poten & Partners, 2015). Indonesian authorities and energy consultants argue that LNG would be cleaner and more cost-effective than fuel oil for energy generation (ESDM, 2016; DNV-GL,

2012). This strategy challenges an energy trajectory in which fuel oil has been the main source for power generation despite Indonesia being historically one of the largest LNG exporters in the world. However, as will be discussed in more detail in this article, despite the planned project completion in 2018, PLN and potential commercial partners have struggled to agree on the terms of the project, and the PPPs have yet to be realized.

Similar project failures in the Indonesian energy-sector have been previously explained by the World Bank (2005), Jarvis (2012), Gunningham (2013), and Dutu (2016). These studies such energy projects are be difficult to implement due to the lack of strong public sector leadership, ineffective institutional arrangements, coordination problems, and inefficient legal frameworks. Conversely, in this paper we suggest that such assessments limit the scale of analysis to the nation-state and does not fully explain why the capacity of the state to realize political strategies is limited in the context of emerging spatial and organizational reconfigurations in the production and consumption of LNG. We develop our explanation by building on the global production network (GPN) approach, which has been used to explore the inter-organizational networks by which multinational companies and non-economic actors create, enhance and capture surplus value to account for the spatiality of production and consumption in the global economy (Henderson et al., 2002; Coe et al., 2008; Coe and Yeung, 2015). Within this perspective, the state has been attributed particular significance as a key actor in shaping and capturing value from GPNs because assets, such as natural gas, are often territorially embedded within the institutional structures of states (Coe et al., 2008; Bridge, 2008; Stephenson and Agnew, 2015). Despite the capacity of the state to shape global production networks, Bridge (2008) notes that the institutional capacity of resource-holding states to realize certain value capture strategies is limited by the physicality of oil and gas resource occurrence in global hydrocarbon production networks. For these reasons, Smith (2015) suggests that state strategies may be limited to "exportism", as processes of refining, transportation, finance, R&D and consumption are typically located outside the control of the resource-holding state. This illustrates how, despite the territorial embeddedness of assets, the capacity and power of the states to determine the access to and utilization of natural resources may be limited by organizational and spatial arrangements in GPNs (Coe et al., 2008). In this paper, we suggest that these discussions are similar to the situation surrounding LNG exports in Indonesia.

In this paper we further explore the possibilities and limitation of state strategies in GPNs by developing the a more nuanced conceptualization of materiality. Our aim is in line with the recent discussions by Bridge and Bradshaw (2017) who, through their systematic analysis of LNG Production Networks, have explored how the "materiality" of natural gas is integral to its circulation in LNG production networks and both enables and constrains opportunities for market development. Their focus on materiality is in line with other scholars who discuss how the resistivity or scarcity of natural resources shapes the spatial and organizational configuration of GPNs (Bridge, 2008; Gibson and Warren, 2016; Hudson, 2008; Irarrázaval and Bustos-Gallardo, 2018). While materiality is significant to explain the spatial and inter-organizational arrangements in LNG production networks, Bridge and Bradshaw (2017) also explain that materiality, by itself, is not sufficient to account for the more recent changes in LNG production networks. As we explain in our empirical analysis introduced later in this paper, a key challenge for domestic LNG market development is related to the spatial and

organizational arrangements in LNG production networks by which value creation from Indonesian gas reserves were historically realized. However, while these outcomes may have emerged in relation to the materiality of natural gas, Bridge and Bradshaw (2017) claim that LNG production networks are currently evolving due to lower demand in mature LNG-importing countries and surplus capacity in global LNG production. In our empirical analysis, we discuss how these dynamics are currently driving new imperatives for market development in previously excluded markets such as Indonesia.

While Bridge and Bradshaw (2017) point to the limitations of the materiality perspective to fully account for emerging dynamics in LNG production networks, they don't discuss in their work the novel ways by which the materiality of natural gas affects the evolving spatiality of LNG production networks and what the implications are for energy development. Therefore, in this paper we aim to explain how the materiality of natural gas constrains and enable political possibilities in dynamic LNG production networks and the implications for state strategies in Indonesia. Moreover, we find that current conceptualizations of materiality in GPN literature are insufficient to explain how the materiality enables and constrains state strategies in dynamic GPNs. Therefore, we also aim in this paper to develop a more nonlinear and dynamic conceptualization of materiality in the GPN framework by building on insights from assemblage thinking as developed by Deleuze and Guattari (1987) and DeLanda (2006). Through this conceptual framework we explore how the materiality by which state strategies for LNG market development in Indonesia may possibly be realized contradict the dynamics by which organizational and spatial arrangements in LNG Production Networks are currently evolving, and as a result, the capacity of the Indonesian state to realize its strategies are limited.

In the following sections, we develop our conceptual framework by addressing the current limitations of research on materiality in GPN studies and how a more dynamic conceptualization of materiality can be achieved through assemblage thinking. Thereafter, we describe our research design and data. We continue the discussion by analyzing the empirical case of LNG supply projects in Indonesia. We conclude by arguing that assemblage thinking gives analytical purchase to GPN theory by pointing to the exteriority of relations and the morphogenetic processes by which the capacities for natural resources to affect political outcomes emerge.

2. Materiality in Global Production Networks

Hudson (2008), explains that relations of production, exchange, and consumption in GPNs can be conceived in terms of the materiality of natural resources and their transformations within GPNs, whereby the laws of thermodynamics provides key insights into the implications of such transformations for uneven development. The use of the materiality concept in the GPN approach has been demonstrated by several scholars (Gibson and Warren, 2016; Afewerki et al., 2018; Bridge, 2008; Bridge and Bradshaw, 2017; Irarrázaval and Bustos-Gallardo, 2018). Gibson and Warren (2016), for example, explain how the production and regulation of scarcity in tonewoods for manufacturing acoustic guitars has rearranged interorganizational dynamics and firm strategies in GPNs. Irarrázaval and Bustos-Gallardo (2018) describe how the spatio-temporality of ecological contradictions in salmon production present obstacles to

commodity production and consequently shape firm strategies and the territoriality of GPNs. These rich, empirical descriptions of materiality in GPNs can be seen as primarily the outcome of methodologically tracing the co-constitutive relationships between material scarcity or material resistivity with firm strategies in GPNs.

In line with Hudson's discussion surrounding materiality (2008), we suggest that relations of production, exchange and consumption in LNG production networks can be characterized by the transformation and management of thermodynamic entropy for commodity production to be possible. First, LNG must be produced at liquefaction facilities by cryogenically cooling natural gas to -163 °C (Tusiani and Shearer, 2007). Second, the LNG is loaded onto carriers specifically designed to insulate and handle the cryogenic liquid during transport. Third, the LNG is offloaded at import terminals, where it is stored in cryogenic tanks and later regasified for use in power plants and other end users. Altogether, this implies that managing the thermodynamic entropy of natural gas requires specialized equipment and personnel for operation and a high degree of compliance with standards and regulations for safety. The infrastructure necessary to make commodity production possible is extraordinarily capital intensive[8], and daily shipping and storage costs are high. Consequentially, unlike other production networks, where logistics account for 10 to 15 percent of the final cost of the finished products (Coe, 2014), logistics (liquefaction, shipping and import) account for nearly 85 percent of the final costs in LNG production networks (Corbeau and Ledesma, 2016). As a consequence of the high costs of transport, natural gas can be described as an "uncooperative commodity" (Bridge, 2004).

Bakker (2003) suggests that certain resources can be "uncooperative" to commodity production as a result of specific biophysical characteristics, or the materiality of resources, that simultaneously enable, constrain, and therefore shape the relations of production. For example, in her research, Bakker suggests that water is uncooperative with regard to commodity production due to its "density". Water is a heavy substance that is expensive to transport relative to its use value and thus requires large infrastructure investments to commodify. The high logistical costs in the LNG trade, due to the uncooperative materiality of gas, entailed that to reduce the per-unit costs and therefore generate surplus value, LNG producers have generally increased the size of the liquefaction terminals, ships and import terminals, thus enabling economies of scale (Corbeau and Ledesma, 2016). To secure financing for infrastructure to manage the thermodynamic entropy of natural gas, investment decisions for LNG projects have traditionally been underpinned by guaranteed revenue via take-or-pay clauses in contracts. Take-or-pay clauses obligate buyers, usually regulated natural gas utilities, to pay for contracted volumes of LNG over a 15- to 20-year period, even if the buyer does not need these volumes. Take-or-pay forces the buyer to assume the risk of investments in LNG production facilities, transport, and import terminals by guaranteeing to pay regardless of the actual market demand over a long-term period. As a consequence of these practices, LNG trade in Asia since the 1970's been spatially exclusive to trades between a few LNG exporters, such as Indonesia and Malaysia, and high-income importers such as Japan and South Korea (Corbeau and Ledesma, 2016).

[8] Corbeau and Ledesma (2016) estimate capital costs in the LNG value chain from 8.6 to 16.5 billion US dollars for an 8 MTPA liquefication plant.

However, although such outcomes can be seen as being related to the materiality of natural gas, Bridge and Bradshaw (2017) also point towards the limitations of the materiality concept when they explain that materiality, by itself, is not sufficient to explain how the *spatial rules* of LNG production networks are being reconfigured by the actions of individual agents and their relationships. In their analysis, Bridge and Bradshaw suggest that LNG production networks are evolving from a:

> …floating pipeline model of point-to-point, binational flows orchestrated by producing and consuming companies and governed by long-term contracts, to a more geographic and organizationally complex production network that is constitutive of an emergent global gas market (1).

Bridge and Bradshaw elaborate that, in the past decade, buyers and sellers in LNG production networks have been negotiating flexibility around traditional long-term contracts. These negotiations have been rearranging LNG production networks and resulting in their spatial expansion. In particular, Bridge and Bradshaw note from 2000 to 2015, spot (single cargo) and short term (four years or less) have increased between 5 and 28 percent. This shift away from strong inter-firm controls in LNG production networks has led the global LNG industry has witness a significant expansion of trade from 100 million metric tons per annum (MTPA) in 2002 to 248 MTPA in 2015. Based on their analysis of LNG production networks, Bridge and Bradshaw (2017) call for a more dynamic account of GPNs, by which the territorial configuration of production networks emerges through the actions of individual agents and emerging relationships between practices, technology, and materiality. However, while Bridge and Bradshaw push towards the limitations of current conceptualizations of materiality in the GPN approach, they don't consider the extent to which the materiality of natural gas continues to shape the evolving spatial rules of LNG production networks and the extent to which these spatial rules limit certain energy development outcomes. To account for these outcomes, we suggest the need to further conceptualize the underlying dynamics by which the capacities of material objects are affected by emergent relations in GPNs and the implications of these dynamics for spatial and political outcomes. Specifically, we suggest that assemblage thinking can give analytical purchases to further conceptualization of materiality in dynamic GPNs.

3. Assemblage Thinking and Relations of Exteriority

The need to further conceptualize the materiality perspective is highlighted by Haarstad and Wanvik (2017), who show that research on how fossil fuels enable and constrain political-economic possibilities tends to analyze fossil fuels as seamlessly interwoven within infrastructure, politics, and power relations in stable and path-dependent "landscapes". Similarly, I find that the previously mentioned studies of materiality in salmon and guitar GPNs tend to describe relations between material and firm strategies as more or less path-dependent trajectories. In the cases described by these researchers, such analytical strategies are not unfounded. However, Haarstad and Wanvik (2017) claim that literature on mutually constitutive and path-dependent matter-society relationships in fossil fuel industries tend to downplay the instability and transformation of GPNs through sudden price changes, technological innovations, market shifts and political movements. Utilizing assemblage thinking, Haarstad and Wanvik (2017)

conceptualize oil and natural gas GPNs as "composed of various interrelated parts subject to change and destabilization through their involvement with other assemblages" (2). This approach to materiality is in line with the assertion that GPNs are "inherently dynamic; they are always, by definition, in a process of flux—in the process of becoming—both organizationally and geographically" (Coe et al., 2008, 272). In this section, we aim to utilize assemblage thinking to develop a more dynamic conceptualization of materiality in GPN theory.

First, it should be noted that the relational ontology of GPN theory provides a basis for assemblage thinking through its critical adoption of actor-network theory (ANT) (Henderson et al., 2002). GPN scholars originally borrowed the notion of relational materiality from ANT to conceptualize international business activities as a performatively affected of the interorganizational practices that shape relationships between actors (corporations, states, unions, NGOs, etc.) and the technologies/material objects these actors use to engage in such practices (Henderson et al., 2002; Dicken et al., 2001). At the same time, early GPN scholars did not adopt the ANT notion of non-human agency, as they saw the need to maintain the centrality of intentional human agency in their analysis (Dicken et al., 2001). The use of actor-network theory in GPN research and relational economic geography in general was later criticized by Sunley (2008) for conceptualizing relational networks as open and endless without explaining how the form and boundaries of such networks emerge. Furthermore, Sunley critiques scholars who focus on static networks or map relationships at a given point in time for missing the dynamism of actors and entities. We suggest that assemblage thinking can be used to work around these critiques, while at the same time retaining the notion of relational materiality.

While there are many similarities between assemblage thinking and ANT, Anderson et al. (2012) and Müller and Schurr (2016) claim that a number of geographers have ended up conflating and using the two approaches interchangeably without considering their differences. Both ANT and assemblage thinking draw attention to relational materiality, in that the capacity any social actor or material object component to affect relationships and outcomes, are capacities that are affected by other relationships within the actor-network or assemblage. Through these notions, it can be implied that the capacity of states to realize strategies, or firms to create and capture surplus value, both affect and are affected by relations between multiple firms, states, technologies, and natural resources in networks. However, in contrast to ANT, assemblage thinking avoids the trappings of characterizing GPNs as seamless wholes composed of human and nonhuman entities whose identities or properties are solely constituted in relation to other parts of the whole.

Anderson et al. (2012) claim that ANT entails tracing associations, and relating humans and non-humans in their co-production of networks, as if these associations are logically necessary and nothing stands outside these descriptions. The consequence of these analytical arrangements, according to Müller and Schurr (2016), is that ANT fails to deal with empirical situations characterized by uncertainty and transformation, and is unable to be more "anticipatory" in terms of future possibilities or becomings. Through it ontological basis on ANT, the GPN approach is lacking the epistemological tools to conceptualize the extent to which currently actualized associations are only, as DeLanda (2006) terms, *contingently obligatory*, and the extent to which human and non-human entities may be unplugged from an existing set of relations and replugged into new set

of relations with different interactions and emergent causalities while retaining their properties and identities. This unplugging/replugging situation is characteristic of how Bridge and Bradshaw (2017) describe the processes of vertical disintegration and specialization by which the ownership liquefication terminals, LNG carriers, and regasification terminals is being separated from the commercial marketing of LNG through new business models. These dynamics subsequently open for new integrations between traditional LNG actors with banks, commodity trading houses, and financial markets that capture value from the emerging spatial flexibility in markets.

Unlike ANT, assemblage thinking adopts a realist ontology and suggests that the properties and identities of entities are mind-independent and are external to the relations in the networks they are a part of (Deleuze and Guattari, 1987; DeLanda and Harman, 2017). At the same time, DeLanda (2016) claims that assemblage thinking avoids essentializing properties, by suggesting that the properties of entities that compose assemblages are themselves emergent. For example, natural gas is primarily made of methane molecules (CH_4) whose properties emerge from the ionic bonds between carbon and hydrogen atoms (both with different properties than methane). While the capacity for material and social entities to affect and be affected is relational, the properties and identities of entities nevertheless shape their relative tendencies (DeLanda, 2006). For example, methane is a gaseous at room temperature but has a relative tendency to liquefy when cryogenically cooled by heat exchangers at -163 °C. At the same time, liquefied natural gas has the relative tendency to "boil-off" during transport and storage as current containment solutions are not able to fully insulate the cryogenic liquid during transport and storage (Tusiani and Shearer, 2007). As "boil-off" gas increases tank pressure, which in turn increases the heat of the cargo, boil-off gas must be removed from the tank, and reliquefied or used as fuel, which significantly increases the costs of transport and storage. While the properties of entities, as Bonta and Protevi (2004) note, are not the final cause for their capacities and relative tendencies (which are relational) in assemblages, the capacities by which value creation and state strategies in GPNs can be realized do depend on the properties of material entities. This notion of relative tendencies is not limited to material objects, as the relative tendencies of firms, nation-states, cities, networks etc. might also be considered as emergent from the relations that compose these historically individuated entities (DeLanda, 2006). For example, we suggest that it would be coherent with assemblage thinking to describe state strategies as historically and contingently emerging from particular modes of development intended to consolidate power and stabilize social struggles with the state (Smith 2015).

Moments of transformation introduce a degree of complexity and uncertainty in casual explanation, and consequently it becomes difficult to trace relationships to explain how non-human entities affect outcomes in networks, as is the current approach in GPN literature. Since relationships are exterior to the properties and agencies of human and nonhuman entities, emergent capacities may be nearly infinite given the sheer number of possible relations (Dittmer, 2014). Nevertheless, assemblages are not without form, identity, or spatiality, since such aspects are considered to be emergent from the interactive processes of assembly where assemblages are shaped as they are made (Anderson et al., 2012). Unlike ANT, which as noted earlier, tends to neglect the intentional agency of social actors, assemblage thinking recognizes the specifically human capacities of desire that shape and sustain the formation of assemblages (Müller

and Schurr, 2016). In this way, assemblage thinking recognizes the intentionality of states and corporations in terms of desires (f.eks. desire for consolidation of power or desire for capital accumulation) (Deleuze and Guattari, 1984). While capacities of desire are specifically human and social, such capacities are nevertheless emergent from relations between humans and materials. Assemblages thinking draws attention to the morphogenetic processes by which capacities emerge from self-organizing relationships between human desire and the relative tendencies of materials, while at the same time recognizing that emergent capacities are irreducible to its component parts. At the same time, the emergent capacities of assemblages enable and constrain the capacities of its component parts, and in this way shapes the form, identity and boundaries of assemblages. Similarly, Bair and Werner (2011) explain that the articulatory dynamics that make capital accumulation in GPNs possible, also entail the exclusion of places and people from these networks.

Assemblage thinking points to the processes of formation and boundary making, labeled as territorialization, where emerging capacities arise from the co-functioning of heterogenous entities, and how the ongoing repletion of these relationships exclude other possible spatial, organizational and political relations. As will be explained in the empirical section, the territorialization of traditional LNG production networks arrangements initially excluded the development of domestic LNG markets in Indonesia. However, such ongoing interactions are never fully territorialized because agencies are distributed, and relationships remain external to the related entities (DeLanda, 2016). In this way, assemblage thinking continuously opens the possibility of novel interactions and events in GPNs. Assemblage thinking proposes that patterns of territorialization can change because new catalytic agencies and events may constitute moments of instability and transformation that trigger the deterritorialization or unraveling of stable relationships (Bonta and Protevi, 2004). These catalytic events are similar to what Bridge and Bradshaw (2017) describe as shocks that led to the vertical disintegration and specialization of activities in traditional LNG arrangements. Bridge notes that these shocks include the growth of US shale gas production which led to the loss of a potential market (many investments anticipated the growth of US LNG imports). Another shock includes the fall of oil prices since the mid-2014[9]. These shocks lead to the possibility of new interactions between previously unrelated actors and material entities, through which novel patterns of reterritorialization may emerge (Deleuze and Guattari, 1987). As will be explained in the later sections, the deterritorialization of LNG production networks is driving new market imperatives to develop markets in previously excluded economies such as Indonesia.

We argue that of political and spatial outcomes can be accounted for by locating explanation in the analysis of the processes by which dynamic GPNs are deterritorialized and reterritorialized. This process-sensitive approach diverges with current approaches to materiality that analyze relationships between firm strategies and materials. Instead, assemblage thinking focuses on the capacities that emerge from relations between state strategies, firm strategies, and the relative tendencies of resources. At the same time, assemblage thinking implies affirming relations of exteriority, and considering the extent to which emerging capacities are dependent on

[9] LNG prices, particularly in Asia, are linked to oil pricing. These pricing regimes emerged from when oil was the primary fuel for power generation in the 1970s (Corbeau and Ledesma, 2016).

the relative tendencies of materials. While natural gas may be unplugged from traditional arrangements in LNG production networks, it continues to retain its properties when it is replugged into new arrangements. Relative tendencies not only shape the capacities to be affected by new interactions, but also the capacities that remain unaffected by certain interactions. For example, as will be elaborated in the empirical case study, imperatives for market development have driven LNG-related technology firms to design different LNG ships and regasification terminals that can be used to circumvent the challenges of distributing LNG across the Indonesian archipelago. Nevertheless, these technologies are mostly a repurposing of LNG carriers and regasification equipment, and the relative tendencies of LNG to boil-off during transport and storage still remains a challenge. As the capacities to realize value creation are shaped by deterritorialization and reterritorialization of relationships in LNG production networks, we argue that certain political and spatial outcomes may be anticipated to some degree by considering the extent by which such outcomes are excluded by these morphogenetic processes. In our case study, we do this by anticipating how the relations by which LNG projects are possibly realized contradict the dynamics by which LNG production networks are being deterritorialized and reterritorialized.

4. Methods and data

In the following sections, we develop our discussions based on a theoretically informed case study of how Indonesian state authorities have sought to develop Indonesia's market for LNG. Our case study is based on an empirical three-month research period in Singapore in 2016, which included multiple visits to Jakarta in addition to desk-based research. During the research period in Singapore, 24 in-depth interviews were conducted and transcribed. The interviewees primarily included executive managers at firms that were currently pursuing opportunities for market development in Indonesia. The firms were selected according to their positions and functions within LNG production networks and their involvement with LNG projects in Indonesia.

Most of the research interviews were conducted in Singapore, where the regional headquarters of LNG-related businesses are typically located. Representatives of the state-owned national electricity company and two firms were also interviewed during a visit to Jakarta. The interviews revealed a diversity of strategies for market development and the often-conflicting opinions on LNG projects in Indonesia, and they provided insight into the contentious relationship between LNG-related firms and the state-owned electricity company and highlighted the differences between firm and state strategies. These opinions and strategies reflected a general situation in the LNG industry, in which business models and industrial practices for LNG supply in peripheral demand centers are fairly immature (Reinlund, 2017).

Desk-based research includes industry-related reports and provided important insights for understanding the contest of state strategies and market developments in Indonesia. In addition to interviews and desk-based research, one LNG-related business conference was attended in Singapore, and two were attended in Jakarta. As Karlsen (2018) notes, "Events can appear as significant arenas for core actors to negotiate industry formation" (155). In this way, attendance at the conferences and the

observation of conference presentations provided a basis for the desk-based research and the formulation of interview questions. The conferences also provided important arenas for meeting and selecting informants for interviews.

5. LNG Production Networks and State Strategies in Indonesia

Until the 1970s, the difficulty of transporting natural gas and producing "exchange value" entailed that natural gas played only a minor role in the Indonesian petroleum industry (Mehden and Lewis, 2006). Although some natural gas was used to enhance oil production or was sold to fertilizer plants as a feedstock, 60 percent of natural gas was discarded through flaring or venting (Bee, 1982). This situation changed in 1971, when the Mobil Oil Corporation discovered the Arun natural gas field in Northern Sumatra (Mehden and Lewis, 2006). At the time, natural gas around the world was mainly transported through pipelines, but authorities perceived the Arun gas field to be too far from population centers in Indonesia and domestic demand too insufficient to warrant the development and financing of pipelines. Instead, natural gas from the field was cryogenically liquefied, making it economically feasible to export the LNG by cargo ships to distant markets in Japan.

Mehden and Lewis (2006) explain that the Arun gas field has proven to be one of the most lucrative LNG operations in the twentieth century. The coinciding development of the Bontang LNG terminal would lead Indonesia to become the largest exporter of LNG in the world, a position that the country held until 2006 (Seah, 2014). By coupling Indonesia's natural gas assets to LNG production networks, the government secured considerable rents (Mehden and Lewis, 2006). However, these strategies occurred at the expense of domestic energy development. Although some development of pipeline transmission networks and LNG import facilities has occurred in Southern Sumatra and Western Java, infrastructure in the eastern parts of the country is underdeveloped (ESDM, 2016). Instead, nearly 83 percent of electricity outside Java and Sumatra is generated using expensive, imported fuel oil. Because fuel oil is heavily subsidized in Indonesia, its use for power generation has placed a significant burden on government budgets, accounting for nearly 18 percent of government expenditures in 2014 (Seah, 2014).

A key challenge for natural gas market development in Indonesia is that the population is fragmented and dispersed across numerous islands in the archipelago nation. As mentioned in the previous sections, LNG production networks have generally relied on economies of scale to reduce the per-unit costs due to the materiality of LNG. According to interviews with LNG-related technology firms, delivering LNG to each location would require the development of the necessary harbor infrastructure and regasification terminals. Physical distance and low rates of consumption limit the possibility of achieving economies of scale; and therefore, producers have generally excluded domestic markets from production networks in favor of higher-income, more urban markets in countries like Japan and South Korea. An interviewed business manager at an LNG-related shipyard expressed the following:

> The small islands and consumers—boy, are you in trouble—no one wants to bring the LNG to you because they can't make the numbers work.

However, despite the skepticism of the interviewed business manager on LNG market development in Indonesia, a report published by the multinational classification society DNV-GL calculated that the costs of supplying LNG to small, remote import terminals could be profitable. The capacity to reduce costs could possibly be established by developing intermediate storage hubs for the delivery of large LNG cargos and then aggregating the demand of urban locations with smaller, more remote islands through "milk runs"[10] (Choy, 2011). By aggregating demand through milk runs, Indonesian authorities can improve the economies of scale in the LNG logistics chains, thus developing possible capacities for secure supply for domestic markets and enable value creation.

Although LNG could be distributed and supplied to the peripheral regions of Indonesia at a lower price than fuel oil through milk-runs, the capacity of the Indonesian government to determine the access to natural gas for domestic market development has nevertheless been largely constrained by the dynamics by which LNG production networks have been historically territorialized. As mentioned in the previous sections, production network activities from the wellhead to production, liquefaction, shipping, and regasification have been territorialized through tight interfirm arrangements and governed by long-term contracts between vertically integrated buyer and seller consortia (Bridge and Bradshaw, 2017). The ongoing repetition of these arrangements has historically excluded market development in Indonesia. A key challenge for LNG projects is that the Indonesian government subsidizes electricity through tariffs, and unlike buyers (usually government monopolies) in higher-income countries that pass costs onto customers, it bears significant financial risk in signing long-term contracts with take-or-pay conditions (Seah, 2014; Corbeau and Ledesma, 2016). An interviewed energy market consultant discussed these challenged in the following way:

> The big issue is that after the suppliers have calculated the price and logistics of it all, they are going to say 'Here is your contract. Sign here for a 20-year deal', and the consumer is going to say 'Wow, that is something I don't understand. Why are you putting all kinds of risk on me? If I want to buy a cargo of oil, I call the trader and he sends me the next cargo. Buying oil is easy; why is buying LNG so complex? Why do I need to sign a 100-page contract?

Signing such contracts implies that the government needs to assume the risk of shocks to energy demand, such as during an economic downturn, by continuing to pay for contracted volumes—even if the LNG cargos are not needed—or pay a fine[11]. The consequence of these arrangements is that LNG production infrastructure in Indonesia was dedicated to specific long-term contracts, and there was little separation of ownership along the production network. Furthermore, These arrangements excluded the possibility for speculative decisions on infrastructure and the possibilities for short-term commodity trading and risk mitigation through financial instruments and market arbitrage (Corbeau and Ledesma, 2016).

State development strategies in Indonesia have therefore been limited to "exportism" because domestic LNG production has been dedicated to high-income markets,

[10] "Milk runs" is a term for a route where small LNG carriers offload partial cargos to multiple supply points.

[11] The government previously encountered this risk with a large LNG import terminal project in Sumatra that ended up standing idle for several months due to unexpected low economic growth and energy demand in the region. Due to contract inflexibility and caps on energy prices, the state lost approximately US$250 million (Tempo.co, 2015).

primarily in North Asia (Mehden and Lewis, 2006). However, the spatial and organizational relations that have traditionally excluded domestic markets can be described as relations of exteriority, as such arrangements are only contingently obligatory for value creation to be realized. LNG production networks, as mentioned in the previous sections, are currently being deterritorialized by catalytic events including declining demand in mature markets, increasing global LNG supply, low prices, and new imperatives for market development in emerging economies (Corbeau and Ledesma, 2016). As one economic consultant explained:

> In the current market situation, you have huge amounts of new supply coming in from the US and Australia. So, there is a huge imbalance in the market between demand and supply, and the LNG needs to go somewhere. First, the spot prices will go down, and second, new demand needs to be created. But demand won't come from large consumers in Japan or Korea; it is probably going to come from smaller demand centers in Indonesia, China, Philippines, and Sri Lanka. So, how do we access that?

As LNG production networks become deterritorialized and production network activities become vertically disintegrated and specialized, the possibility for new patterns of reterritorialization emerge. Emerging business models are enabling an increasing number of participants to invest equity in facilities. As a result, infrastructure is becoming less dedicated to specific long-term contracts between producer and buyer consortia (Bridge and Bradshaw, 2017). Numerous major oil and gas corporations are investing equity in multiple liquefaction projects and regasification projects to allocate risk and capture value along production networks (Ledesma, 2016). In doing so, corporations aggregate LNG supplies from different sources into "portfolios", which are then shipped to the most favorable destinations instead of dedicating LNG projects to particular customers (Bridge and Bradshaw, 2017). The flexibility of LNG markets is being further developed as emerging players such as commodity trading houses are purchasing LNG on long-term contracts to arbitrage opportunities between markets through spot trading (Stern, 2014). Commodity traders are starting to participate in LNG production networks, by mitigating the risk for spot trading through market arbitrage and speculative financial instruments such as derivatives and commodity futures. In addition, a number of interviewed LNG-related technology companies have developed a range of technological solutions for small-scale LNG transport and regasification to develop markets through milk-runs. It is through these morphogenetic processes of reterritorialization by which the capacities to realize market development in previous excluded countries where long-term contracts have been problematic, such as Indonesia, emerge.

In the context of emerging market imperatives and flexibility in LNG production networks, President Jokowi's government launched plans in 2015 to reconfigure the country's energy system through a 35 gigawatt (GW) fast-track power project to be installed by 2019, 13 GW of which is to be supplied by natural gas (Figure 1) (Seah, 2014). In doing so, the government desires to reduce the use of expensive fuel oil and increase access to electricity, particularly in the peripheral regions of Indonesia. Such strategies can be understood through Jokowi's approach to governance as appeasing a nationalist, state-centric development narrative by promising to relieve poverty in Indonesia by "modernizing" physical infrastructure, particularly in rural Indonesia (Yusuf and Sumner, 2015; Warburton, 2016). However, despite the potential cost

savings of replacing fuel oil with natural gas[12], a significant challenge for developing the nationwide distribution and supply of natural gas in Indonesia is that the country lacks the infrastructure needed to distribute natural gas to domestic markets (Choy, 2011). To secure the financing and technology required for distributing natural gas, the Jokowi regime directed the national electricity company, PLN, to launch a "request for proposals" for LNG supply to 21 power plants on the islands of Kalimantan, Sulawesi, and Nusa Tenggara in March 2015 (Figure 1) (Poten & Partners, 2015). The locations of the power plants included both high-demand centers, such as Makassar in Sulawesi (1.3 million people), and low-demand centers, such as Palau Rote in Nusa Tenggara (119,000 people) (ESDM, 2016).

Interestingly, PLN did not simply delegate the project to the state-owned oil and gas corporation; Pertamina, who, according to an interview with a manager at an LNG technology corporation, has the capacity to procure the necessary infrastructure for the project and is obligated to supply domestic markets through Government Regulation No. 55/2009 (Purwanto et al., 2016). Instead, PLN designed the project as a PPP based on a 10-year "build-operate-transfer" basis[13], with the initial investments and LNG supply secured by private developers. Shortly after the tender was announced, 11 prequalified consortia were approved, consisting of both domestic and international companies. An agreement with the winning bidder was expected to be signed in the middle of 2016, with operations commencing by late 2018 (conveniently in time for the 2019 presidential elections) (Poten & Partners, 2015).

PLN has developed a strategy in which to secure the best and most flexible terms and conditions for LNG supply across the Indonesian archipelago, it has planned to actively create markets for public infrastructure through PPPs and to import LNG instead of relying on domestic sources. At a 2016 natural gas industry conference attended by one of the authors in Jakarta, the head of the oil and gas division at PLN explained their strategy:

> Should we import LNG now or later? Currently, PLN has received many offers for importing LNG at a much lower price than domestic prices. Should we deny all of those offers and stick to domestic LNG? Wouldn't this hinder PLN from trying to reduce the electricity subsidy? If developing gas production in Indonesia is currently not economical, why don't we just wait until it becomes economical? The gas in the belly of the earth is not going anywhere... The reason why PLN prefers an open tender is that the discussions with Pertamina take too long, sometimes over three years.

The quote from the PLN representative alludes to a situation in which domestic natural gas production is stagnating, particularly due to lackluster investments following the decline in gas prices after 2014. At the time of the conference, it was expected that if Indonesia were to realize its plans for domestic market development, it would need to import LNG by 2019. In doing so, Indonesia's position as a significant producer and

[12] A report by a global energy consultancy, Wood Mackenzie, noted that replacing half of the current oil product consumption with LNG in the central and eastern parts of Indonesia would save the government nearly US$365 million per year in fuel procurement at an oil price of $85 per barrel (WoodMackenzie, 2015).

[13] In addition to procuring LNG, the winning bidders are expected to commission and operate the necessary infrastructure required for supply, including intermediate storage hubs, LNG carriers, storage, and regasification terminals, including the necessary jetties, port, and pipeline infrastructure. At the end of the concession agreement, the facilities are to be transferred to public administration.

exporter of LNG in global LNG production networks would be rearticulated to that of a consumer. Although securing long-term gas supply to domestic markets might stimulate investments in production during a period of low prices, domestic supply is actually more expensive than LNG imports (The Jakarta Post, 2017). In addition, Jokowi's government has pushed domestic companies to engage in PPPs to attract investment in public infrastructure (Negara, 2016).

The LNG supply tender has attracted considerable interest from major LNG-related companies such as Shell, Gas Natural Fenosa, Marubeni Corporation, and Osaka Gas who desire to capture value through market development opportunities (Hwee, 2015). Despite considerable interest in the project, interviews with LNG firms both directly and indirectly engaged with the PLN tender during the research period revealed that little progress was being made on the project. One Singapore-based, prequalified bidder expressed the following in an interview:

> Frankly speaking, LNG projects in Indonesia seem almost impossible… I think it is unrealistic to proceed with the whole package. Under these conditions, we would not be able to proceed.

This quote illustrates a contradiction between the LNG production network's need to sustain current levels of production by creating new markets such as Indonesia, and the capacity of the Indonesian state to realize political strategies for energy development.

According to interviews, one of the key reasons why projects did not move forwards are related to issues surrounding take-or-pay contracts. In the context of increasing flexibility in LNG production networks, PLN desires to reduce its share of take-or-pay commitments in contracted quantities of LNG. This is reflected in a citation from the 2016-2025 energy business supply plan from PLN:

> As one of the biggest gas consumers in Indonesia, PLN seeks flexibility in regulating gas supply to avoid, as much as possible, the take-or-pay penalty in addition to the ease of acquiring gas supply from the market so that it may fulfill the needs of power generation at a competitive price (PLN, 2016, 90. personal translation).

However, despite the reluctance of PLN to sign take-or-pay commitments and the emerging capacity of LNG suppliers to mitigate risk through spot and short-term trading markets, several interviewees from LNG suppliers and third-party engineering companies emphasized that PLN will need to sign take-or-pay obligations for projects to go forward. A consultant from an energy advisory firm described the situation as a "tug of war", in which LNG producers need to create markets for excess supply, and PLN is bargaining for contracts that are more flexible. The energy advisor further explained how projects were likely to be developed by emerging commodity traders who are more willing to accept market risk by taking advantage of market arbitrage opportunities. Despite the capacity of commodity traders to offer short-term LNG supplies, an executive manager at a commodity trading firm explained that they too would require long-term take-or-pay commitments from PLN:

> A challenge is that PLN does not want to engage in take-or-pay contracts, but in such an underdeveloped market, they will need to do this. How long we engage the customer in a contract is dependent on the situation. In some situations, it may be important to have a ten-year contract.

This quote reflects a situation in which, despite emerging arrangements and excess LNG production capacity, PPPs in Indonesia appear to be excluded from the dynamics by which LNG production networks are being reterritorialized.

6. The limitations of LNG market development in Indonesia

Jessop (1999) claims that the success of PPPs depends on the capacity of the nation-state to govern interorganizational networks to balance the realization of political strategies with the processes of capital accumulation in markets. As previously mentioned, a significant challenge for the development of LNG supply to the 21 locations in the LNG tender is that the electricity consumption rates at several locations are too low to warrant development on stand-alone fiscal terms due to the high upfront costs of LNG infrastructure. The capacity to realize value creation from LNG projects and state strategies can nevertheless be realized by reducing costs by aggregating the demand of multiple islands through milk runs. According to a sales manager at an LNG technology firm, PLN has sought to leverage its monopoly position and purchasing power by requiring the winning bidders to supply LNG to all locations in the tender. The sales manager noted the following:

> PLN, being a government organization, is in a position to do things in a different manner compared to an open market. I mean, if it was an open market, LNG would never take off, not in these circumstances.

Despite the possible capacity to realize PPPs, the sales manager further explained that although milk runs may reduce the costs of supplying remote demand centers, the logistics of such projects increase the need for developers to systematically coordinate LNG supply with investments in ships, storage, and regasification facilities across multiple locations. As mentioned in the previous sections, the properties of natural gas shapes its relative tendencies, by which capacities to affect and to be affected are dependent. Despite incremental improvements in liquefaction technology and more efficient storage and transport containment solutions, liquefaction costs per unit have actually increased over the last decade (Songhurst, 2014). In addition, the technological solutions for milk-runs generally a repurposing existing technologies according to interviews. Therefore, projects in Indonesia continue to require significant upfront costs in infrastructure and high financial risks, even though they are driven by reduced LNG prices in global markets. As a consequence, the relative tendency to boil off during heating and compression under storage and transport due to its entropic properties, which in turn raises capital and operational costs remains unaffected by changes in LNG production networks. According to an interview with an LNG shipping consultant, the challenge of milk runs is that establishing intermediate hubs and terminals at all 21 locations in the tender increases the total amount of LNG stored in the system, thereby expanding storage costs. In addition, offloading a single carrier at multiple ports increases the daily shipping costs. According to the sales manager, shipping and storage costs can be optimized by tightly coordinating storage and LNG shipping routes. In this way, developers can maintain a profit while suppling LNG to remote locations.

Although developers could maintain a profit on LNG projects in Indonesia, PLN and developers, as mentioned previously, disagreed on the allocation of risk for LNG projects through take-or-pay commitments. To explain these disagreements, the capacity of the government to reduce take-or-pay commitments must involve reference to the morphogenetic processes by which LNG production networks are being deterritorialized and reterritorialized. These dynamics include the processes by which the ownership of LNG production, LNG carriers, and regasification terminals are

separated from the commercial marketing of natural gas, opening the possibility for new participants, such as commodity traders, to mitigate risk through spatial flexibility and market arbitrage. However, the systematic coordination of LNG projects in Indonesia would contradict the dynamics of deterritorialization and reterritorialization of LNG production networks. The capacity of the Indonesian government to realize PPPs is dependent upon the coordination of simultaneous investments in facilities at intermediate hubs, procuring LNG carriers and developing regasification terminals and the necessary supporting infrastructure at each of the locations specified in the tender. The organization of these investments in infrastructure would entail projects being organized through point-to-point flows, governed under strong interfirm relations and vertically integrated under agreements between single-seller consortia and PLN. Through strong interfirm relations, LNG carriers and import terminals become "dedicated" to LNG supply agreements, thus limiting the possibility for flexible, short-term arrangements between partners involved in the LNG tender. A technical advisor at a classification society noted the following:

> Doing milk runs could be economical, but then you have 5 to 6 points of contact that need to line up, and they all need investment, and then you need a person to build the carriers, so you need to have very good contractual arrangements between them, and therefore, you will need long-term contracts. However, the people taking the gas, they want to avoid buying LNG on long-term agreements.

A consequence of systematically coordinating milk runs in Indonesia is that such agencies contradict the processes by which the character of traditional LNG production networks is deterritorialized and reterritorialized through increasing organizational fragmentation. A sales manager at an LNG technology company noted the following:

> Because it is small scale, you have a logistics chain involved, and the risks multiply. This power plant, with so much capacity factor, will offtake so much, but what happens if it doesn't offtake? Because you have stored a certain volume, with a basis that it will be regasified and consumed, and if it doesn't get consumed, the vessel is wasted. One time, fine, you can adjust it. But you have 90 deliveries a month, and then your offtake has come down by 15 to 20 percent, and you still need to pay your supplier.

This quote reflects a situation in which milk runs limit the capacities of suppliers to mitigate risks by arbitraging trading opportunities between markets. Such limitations are displayed in the skepticism of LNG-related firms to engage in speculative markets and financing for LNG infrastructure. As a business manager at an LNG-related shipyard expressed, *"In order for an LNG project to take off, you need (bangs on table) reliable offtake"*. Therefore, based on our analysis of LNG production networks and projects in Indonesia, we argue that the deterritorialization and reterritorialization of organizational and spatial arrangements are predicated upon the morphogenetic processes that exclude the capacities to systematically coordinate LNG projects across multiple locations. In this way, the materiality of natural gas and the relations to production contingently necessary to distribute natural gas across the Indonesian archipelago impose critical restraints on the capacity of the Indonesian government to realize state strategies in dynamic LNG production networks.

Furthermore, we suggest that the limited capacity of the Indonesian government to realize state strategies has wider political and economic implications for energy development policies surrounding privatization and markets in LNG production networks. As reflected in the quote at the beginning of this article, President Jokowi has

sought to develop "every inch" of Indonesia. To achieve such strategies, government agencies have sought private financing and LNG imports for energy development projects instead of relying on domestic sources of natural gas. Although importing LNG might enable a cost-effective distribution of natural gas across the Indonesian archipelago, it comes at considerable risk. As we have shown, the capacity of the government to realize energy development strategies while reducing take-or-pay commitments is limited. If the government agrees to take-or-pay obligations, the energy systems in the peripheral regions of Indonesia will be locked into long-term contracted LNG import quantities despite the circumstances that may arise. PLN will have little incentive to invest in renewables despite the potential decreases in costs because doing so could decrease the utilization rates of contracted LNG quantities and associated infrastructure capacities (Chung, 2017). Because electricity tariffs in Indonesia are capped at specific rates, PLN would need to bear the costs of price increases in global LNG markets (Seah, 2014). In addition, electricity demand in the peripheral regions of the country is unstable and uncertain, and PLN would need to bear the risk of demand shortfalls. The government would most likely need to step in with subsidies, but the objective of LNG projects in Indonesia is to reduce such subsidies. Based on these dilemmas, we argue that our empirical case points to a contradiction between realizing energy development strategies through government intervention, systematic coordination, and risk mitigation through PPPs in LNG production networks despite the new imperatives for market development and the emerging flexibility in the LNG industry.

7. Conclusion

A main goal of this paper was to develop the GPN approach so that it better accounts for materiality of emergent and dynamic GPNs to explain spatial and political outcomes. We have argued that by characterizing the properties of material objects and their capacities according to relations of exteriority, researchers can better account for the emergent capacities and dynamics by which political possibilities in GPNs are shaped and limited. Our empirical case study demonstrates that although the capacity of the Indonesian state to realize domestic market development may be limited by the spatial and organizational arrangements that have made capital accumulation from natural gas possible, such arrangements are not reducible to the properties of natural gas. Furthermore, we argued that GPNs may be subject to moments of instability and transformation through emerging agencies and interactions that affect the capacities through which political and economic outcomes are realized (Haarstad and Wanvik, 2017). We build on Bridge and Bradshaw's (2017) analysis of LNG production networks to demonstrate these dynamics. In our empirical study, we show how the vertical disintegration of binational and point-to-point flows in LNG production networks through the separation of ownership along production networks and the emergence of global markets affect the potential capacity of states, such as buyers of LNG, to negotiate flexibility in LNG supply and purchase agreements.

The temporality, instability and distributed agency by which GPNs, such as LNG production networks, are transformed pose a degree of uncertainty for conventional analysis of materiality in GPN studies. Assemblage thinking invites researchers to go

beyond identifying the material properties of natural resources and relations of production to explain political outcomes and instead find explanations in the morphogenetic processes by which GPNs are transformed. By identifying the agencies and dynamics by which GPNs are deterritorialized and reterritorialized while affirming the exteriority of relations, researchers can characterize the emerging forms and boundaries by which certain political and spatial outcomes are excluded from GPNs. In our empirical case study, we find that the capacity of the Indonesian government to realize LNG market development strategies are dependent on the systematic coordination of infrastructure development in Indonesia in order to deliver LNG at a lower cost than fuel oil. We suggest that such dependencies, which are a consequence of the relative tendencies of natural gas, contradicts the deterritorialization and reterritorialization of LNG production networks. Therefore, the possibilities of state strategies for energy development in Indonesia are limited despite the emerging flexibility and new imperatives for market development in LNG production networks. Furthermore, the case of Indonesia points to how the materiality of natural gas shapes the emerging spatial rules and alludes to the limitations of spatial expansion in LNG production networks.

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Appendix A – List of Interviewed Firms

Organization	Type of Organization	Position of Informant	Time	Location
DNV-GL, Maritime	Maritime Advisory	Corporate Executive	September 2015	Singapore
Rolls Royce	LNG Equipment Supplier for Maritime Vessels	Corporate Executive	September 2015	Singapore
Gravifloat	LNG Equipment Supplier	Corporate Executive	September 2015	Singapore
DNV-GL, Energy	Energy Advisory	Country Manager	September 2015	Singapore
Gaspartners	LNG Equipment Supplier	CEO	September 2015	Singapore
Center for Offshore Research and Engineering – National University of Singapore	Research Center	Director	September 2015	Singapore
DNV GL, LNG	LNG and Gas Advisory	Business Development Manager	January 2016	Singapore
Rolls Royce	LNG Equipment Supplier for Maritime Vessels	Corporate Executive	February 2016	Singapore
LMG Marine	LNG Equipment Supplier	Corporate Executive	March 2016	Skype
Norgas Carriers	LNG Carrier Owner/Operator	Corporate Executive	April 2016	Singapore
Seatech Solutions	LNG Equipment Supplier	CEO	March 2016	Singapore
BW Maritime	FSRU and LNG carrier Owner/Operator	Corporate Executive	March 2016	Singapore
Singapore LNG Corporation	LNG Terminal Operator	Business Development Manager	April 2016	Singapore
Keppel Singmarine	LNG Technology Firm and Shipyard	Business Development Manager	April 2016	Singapore

Osaka Gas	Gas Marketing	Corporate Executive	April 2016	Singapore
Keppel Smit	Ship Owner	Business Development Manager	April 2016	Singapore
Amec Foster Wheeler	Engineering, Procurement, and Construction Manager	Business Development Manager	April 2016	Singapore
PT Wartsilia	LNG Technology Company	Business Development Manager	April 2016	Jakarta
Pavillion Gas	LNG Commodity Trader	Corporate Executive	April 2016	Jakarta
Nusantara Regas	FSRU Operator	Corporate Executive	April 2016	Jakarta
PLN	National Electricity Company of Indonesia	Business Development Manager	April 2016	Jakarta
Shell	LNG Technology and Commercialization	Business Development Manager	April 2016	Singapore
Galway Group	Energy Market Advisory	Senior Consultant	April 2016	Singapore
Innovation Norway	Norwegian Government Innovation Office	Science and Technology Counselor	April 2016	Singapore
Vopak	LNG Storage Owner/Operator	Business Development Manager	January 2017	Singapore
PTT LNG	LNG Terminal Operator	Corporate Executive	February 2017	Bangkok
PTT Gas Marketing	National Oil and Gas Company of Thailand	Business Development Manager	February 2017	Bangkok
Petroleum Institute of Thailand	Energy Sector Research Institute	Director	February 2017	Bangkok
Electricity Generation Authority of Thailand	National Electricity Company of Thailand	Business Development Manager	February 2017	Bangkok

Electricity Generating Company Limited	Independent Power Producer	Corporate Executive	February 2017	Bangkok
Ministry of Energy Thailand	Energy Regulation	Senior Official	February 2017	Bangkok
Ministry of Energy Thailand	Energy Planning	Senior Official	February 2017	Bangkok
ECA Consultants	Energy Market Advisory	Senior Consultant	February 2017	Bangkok
ADB Development Bank	Financial Institution	Senior Investment Officer	February 2017	Bangkok
World Bank	Financial Institution	Senior Energy Specialist	March 2017	Yangon
Statoil	National Oil Company of Norway	Corporate Executive	March 2017	Yangon
DFDL Myanmar	Legal Advisory Firm	Senior Consultant	March 2017	Yangon
VDB Loi	Legal Advisory Firm	Senior Consultant	March 2017	Yangon