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Sanctioning an Unruly Ally: Understanding Sino-North Korean Trade through the People's Daily

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Sanctioning an Unruly Ally:
Understanding Sino-North Korean Trade through the
People's Daily

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Abstract

China opposes North Korean proliferation while practically “funding” a large part of it through increasing trade. By analyzing the *People's Daily*, China's official newspaper, I show the alliance between the two countries has significantly weakened since the Korean War. I provide an explanation in a model: If North Korea initiates a conflict, the damage to China—including a possible attack by North Korea—will be higher if its sanctions on North Korea are tougher. China's trade with North Korea, therefore, can be explained by its incentives to reduce such damage. This theory has important implications for the world's nonproliferation efforts.

Keywords: China, North Korea, nonproliferation, nuclear crisis, People's Daily, sanctions, trade

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1 Introduction

The nuclearization of North Korea presents one of the gravest dangers facing the world in recent years. In addition to six nuclear tests since 2006, North Korea has launched 95 missiles under Kim Jong-un’s rule as of September 20, 2017, compared to 44 under his father’s and 17 under his grandfather’s. Its latest missiles are likely able to reach as far as the continental US, Europe and Australia (Center for Strategic and International Studies 2017).

As North Korea’s only remaining patron, China has long been the linchpin of the world’s efforts to resolve the nuclear crisis. In US policy toward North Korea, for example, China has been recognized as an indispensable factor at least since the Clinton Administration.² China has also played a decisive role in mediating the six-party talks, a years-long but fruitless effort to convince North Korea to terminate its nuclear program.

However, recent developments in Sino-North Korean trade raise a puzzling question about China’s role on the Korean Peninsula. For the past decade, China has substantially increased trade with North Korea, which now accounts for nearly 90% of the latter’s total trade flows.³ With North Korea spending nearly a quarter of its annual GDP on the military—the highest proportion in the world—China is practically “funding” a large part of its arms proliferation.⁴ But, as the Chinese government has repeatedly stressed, a nuclearized North Korea and the resulting destabilization of the Peninsula are certainly against China’s national interest. Why then does China not impose (more) economic sanctions on its “unruly” ally?⁵

To be fair, part of China’s dominance of North Korea’s overall trade is due to other countries severing economic ties with North Korea, as a result of a series of United Nations

²See, e.g., Kim (1994).

³See the International Monetary Fund (2016) for North Korea’s trade data. Trade flow is defined as the sum of exports and imports. Besides trade, China has also provided North Korea with a large amount of aid, primarily in food and energy (see Manyin and Nikitin 2014).

⁴See US Department of State (2016) for military spending data.

⁵Throughout this paper, I make no distinction between the implementation of existing multilateral sanctions against North Korea and the reduction in bilateral trade with North Korea. While the two have practical differences, their economic consequences are treated the same.

Security Council (UNSC) sanctions since 2006. It is also widely believed that preventing the North Korean regime from collapsing and its refugees from pouring into China motivated the latter to maintain a certain level of trade with North Korea. This paper does not refute these existing accounts. However, the fact that China *ramped up* its economic support for North Korea in recent years—almost single-handedly driving North Korea’s overall trade from \$4.8 billion in 2006 to as high as \$7.8 billion in 2013—calls for an explanation beyond the received wisdom.

Another common reaction to the question is to argue that sanctioning North Korea would not “work.” In general, the effectiveness of sanctions in changing the target country’s behavior is widely debated in the literature. But in the case of North Korea, where sanctions are imposed primarily through the UNSC, the claim that they do not “work” often means the lack of enforcement of the sanctions measures by member countries, particularly China, but not the effect of them had they been fully carried out (Haggard 2016). In fact, it is widely recognized that China, with the overwhelming economic leverage over North Korea, has the ability to curb the latter’s nuclear ambitions.⁶ This again bears the question of why has China not done more.

This paper provides a possible answer to the question from a novel angle. It starts with the recognition that trade serves a primarily strategic purpose in China’s policy toward North Korea.⁷ Using the texts of the *People’s Daily*, an official publication of the Communist Party of China, I first show that the socialist alliance between China and North Korea has significantly weakened since the Korean War. Not only has China distanced itself from North Korea, but the Kim regime’s attitude toward its only patron has grown more negative and, at

⁶Even Chinese officials have acknowledged that China can and should put at least some amount of pressure on North Korea (Glaser and Billingsley 2012, 20).

⁷According to the International Monetary Fund (2016), in 2016, China’s trade with North Korea (the sum of imports from and exports to North Korea) accounts for only 0.15% of its total trade flows with the rest of the world. Such a negligible share lends support to the premise that China’s incentives to trade with North Korea are not economic, but strategic.

times, hostile.⁸ I then postulate in a dynamic model that, if North Korea initiates a conflict with other countries, the damage caused to China—including a possible attack by North Korea—will be higher if China imposes more sanctions on North Korea. China’s growing trade with North Korea in recent years, therefore, can be rationalized by China’s incentives to reduce the damage to itself in case its unruly ally spins out of control. Since China is the lifeline of North Korea, this theory yields important implications on the rest of the world’s efforts against North Korean proliferation.

Section 2 reviews evidence from *People’s Daily* articles between 1950 and 2016 that motivates the theory. I quantify for the first time in the literature China’s relations with the two Koreas in the post-Korean War era, in three stylized facts: (1) China’s attitude toward North Korea has turned substantially more negative since considerably before the bilateral trade started to increase; (2) China’s attitude toward South Korea has grown warmer since the early 1990s, despite the recent dispute over South Korea’s deployment of an American missile defense system;⁹ (3) the nuclear crisis is becoming China’s most pressing concern regarding the Peninsula as North Korean proliferation escalates. The section also reviews evidence of North Korea’s growing discontent about what it believes is China’s repeated betrayal of the socialist alliance and a nuclear attack Pyongyang reportedly threatened China.

Section 3 formalizes the theory in a stylized dynamic optimization problem. In the model, a patron (i.e., China) is faced with the problem of sanctioning an ally (i.e., North Korea) that is developing weapons of mass destruction. The weapons program can lead to a disastrous outcome when the ally initiates a conflict with other countries or, if it has not after a certain time, when a third country undertakes a preemptive strike against the ally. An ally-initiated conflict causes more harm to the patron if its sanctions on the ally are tougher—or, the trade ties are weaker. But a preemptive strike by a third country damages the patron more if the ally’s weapons program is more developed. Therefore, by reducing trade, sanctions have three effects on the patron’s payoffs: reducing the economic gains from trade, risking

⁸See Section 2 for evidence.

⁹Terminal High Altitude Area Defense, or THAAD.

larger damage (to itself) in an ally-initiated conflict, and slowing down the development of the ally's weapons program. The patron's optimal sanctions on the ally over time depend on the trade-off among these three effects.

Section 4 then presents comparative-dynamic results that show how the time path of the optimal sanctions is affected by exogenous parameters. When viewed over the entire time horizon, the patron sanctions the ally less if the ally's weapons technology progresses more rapidly, the economic gains from trade are larger for the patron, the relations between the patron and the ally are more strained, or other countries are more patient in deciding on the preemptive strike. In each of the four scenarios, the patron's increased trade with the ally worsens the weapons crisis.

Section 5 discusses the implications of the results on a variety of important foreign-policy issues regarding North Korea. Besides explaining the increasing Sino-North Korean trade in recent years, the theory also suggests that: the UNSC sanctions regime, with its inherent lack of enforcement, may have been counter-productive in curbing North Korea's nuclear ambitions; due to China's key role on the Peninsula, secondary sanctions and (secondary) economic inducements on China may yield a positive effect on containing North Korean proliferation; the tolerance of North Korea in US policy, such as the Obama Administration's "strategic patience," could incentivize China to reduce sanctions on North Korea in response; for the international community, responding to North Korean provocations in kind may also cause China to increase trade with North Korea.

The subsection below reviews the related literature. Details about the content analysis of *People's Daily* articles and proofs of the main results are relegated to Appendix A.1 and A.2, respectively. Section 6 concludes.

1.1 Related Literature

The literature on economic sanctions is vast, and the studies therein share two main themes: when sanctions are imposed by the sanctioning country (commonly called the "sender" in the literature) and, if imposed, whether they are effective in obtaining the target country's

concessions. While the first stream of this literature is most relevant to this paper, the conditions identified there cannot explain China's lack of sanctions on North Korea. Some studies emphasize the target's strength. In a game-theoretic model, Krustev (2010) shows that when the target is in a weaker bargaining position against the sender—due to low costs for the sender to impose sanctions or high costs for the target to endure them—sanctions are more likely to take place and, when they do, the sender demands more concessions. Spaniel and Smith (2014) show theoretically and empirically that when the leader of the target country is newer in office, which is a proxy for a higher uncertainty about the leader's domestic power consolidation, sanctions are more likely. North Korea appears to be an exception to these two arguments: China has become North Korea's lifeline, and Kim Jong-un's six-year tenure so far is shorter than his father's and grandfather's. Yet, China has been trading more with North Korea in recent years.

Some other studies use the sender's reputational concerns to explain the imposition of sanctions. Lacy and Niou (2004) use a game-theoretic model to show that the incentives to enhance the reputation as a resolute player can motivate the sender to impose sanctions, even if they may not lead to concessions. Drezner (1998) shows theoretically and empirically that the sender is more likely to impose sanctions on an adversary than on an ally because, with an adversary, the sender expects more future conflicts and, hence, values its reputation more than with an ally. While it is difficult to observe how much China values its reputation as a resolute player, recent developments (established in detail in the next section) suggests that Sino-North Korean relations have substantially soured since the Korea War, and North Korean proliferation has become a contentious issue between the two countries. The increasing bilateral trade, therefore, does not support these two theories.

Lastly, some studies attribute the imposition of sanctions to the sender's domestic politics (e.g., Kaempfer and Lowenberg 1998, 2002; Dorussen and Mo 2001). According to these studies, if domestic support of sanctions by interest groups is stronger, sanctions are more likely to be imposed or, once they are imposed, less likely to be lifted. While intuitive in general, it does not fit the case of China where close to 60% of the firms trading with and

benefiting from North Korea are small, private enterprises,¹⁰ which are not a politically strong group in China.

The second stream of the sanctions literature is focused on the effectiveness of sanctions that are imposed. The pioneering work by Hufbauer, Schott, and Elliott (1990), which examines 116 sanctions episodes from 1914 to 1990 and concludes a 34% success rate,¹¹ led to a heated, empirical debate in this literature. Subsequent findings, however, are largely inconclusive (see Baldwin 1999 and the references therein). Since the sender's decision to impose sanctions is interdependent with the effectiveness of the imposed sanctions, it is not surprising that looking only at the imposed ones does not fully inform us about the success of sanctions. It is established by a succession of theoretical papers in this literature (e.g., Eaton and Engers 1992; Smith 1996; Nooruddin 2002; Lacy and Niu 2004) that threatening and carrying out sanctions are two integrated stages of the sender-target interaction. Drezner (2003) takes into account sanctions that are threatened but not carried out—either because the target acquiesces or because the sender backs down—and shows that the success rate of sanctions is significantly higher than otherwise.

The (narrower) studies on the effectiveness of multilateral sanctions, such as UNSC sanctions, have a different focus. It is argued theoretically (e.g., Fearon 1998) and shown empirically (e.g., Drezner 2000) that the lack of enforcement significantly undermines the effectiveness of multilateral sanctions. This is further confirmed in case studies on nonproliferation sanctions imposed by the UNSC, such as the sanctions on Iran (Eckert 2009) and North Korea (Noland 2009; Habib 2016). This paper shares the concern with this literature and emphasizes that it is in large part China's reluctance to comply that drives the ineffectiveness of UNSC sanctions on North Korea.

Studies on Sino-North Korean relations and the increasing bilateral trade are ample (e.g., Kim 2007; Snyder 2009; Haggard and Noland 2017). There are two commonly held views in this literature. First, the bilateral trade moves in the same direction as the strength of

¹⁰See, e.g., Haggard and Noland (2017, 143).

¹¹See Hufbauer et al. (2007) for an update of their study.

the alliance. Hence, the trade ties are strong because the alliance is strong. Second, China's motive to trade with North Korea is to gain leverage to change North Korea's behavior, such as abandoning its weapons program and reforming its economy, but the efforts have so far failed. This paper contrasts with both views. As shown in the next section, Sino-North Korean trade increases as the strength of their socialist alliance weakens. Instead of a failed effort to denuclearize North Korea, China's trade policy toward North Korea is rationalized as a strategy to protect itself from the unruly ally.

This paper is to my knowledge the first in the literature that quantifies Sino-North Korean relations across such a long period. Snyder (2012) measures the bilateral relations by the number of high-level exchanges between the two governments from 2000 to 2011, which shows a largely increasing trend. More exchanges, however, do not necessarily mean closer relations. For example, months before China normalized diplomatic ties with South Korea in 1992, Beijing had twice sent top officials to Pyongyang just to obtain Kim Il-sung's approval. The second envoy was even given a chilly reception in North Korea (Funabashi 2007, 264-265). Exchanges as such indicate the *opposite* of close ties.

Regarding method, this paper joins a growing literature that uses the *People's Daily* to examine the Chinese government's positions on issues. From an insider's perspective, Wu (1997) documents in great detail the production process of editorials in the *People's Daily* and the government's control over it. That the newspaper distinctively represents China's official public voice has been shown in contrast with the *Beijing Evening News*, a local, more commercialized newspaper in China (Stockmann 2011), *The New York Times* (Parsons and Xu 2001), and *The Guardian* (Seo 2013). It is also demonstrated in case studies how the newspaper boasted about the 2008 Olympic Games in Beijing (Zhang 2012) and how it propagated the revival of Confucianism during the 2010s (Wu 2014).

2 Relations between China and the Two Koreas

This section reviews evidence, mainly from *People's Daily* articles, that motivates the theory. Words in the *People's Daily* matter because, since 1949, this newspaper has been used by the Chinese authorities to make important announcements, propagate official viewpoints, and signal new policy directions to the country and the rest of the world.¹² Words in this propaganda “machine,” therefore, are very different from that in any local, commercialized newspaper.¹³

I conduct text analysis on 84,202 articles published in the *People's Daily* between 1950 and 2016 that mention North Korea, South Korea, or the Korean Peninsula. Throughout the period, each of the three geographic objects has been referred to by the newspapers using different Chinese names. Some are terms translated from the Korean language that are preferred by the North while the others are terms preferred by the South. For example, in the Korean language, Korea as a nominally unified nation has long been called “Chōson” in the North but “Hanguk” in the South. Therefore, when the *People's Daily* changes its wording, it signals a shift in China’s attitude toward Peninsula-related issues.

2.1 China’s Attitude toward the Two Koreas

The post-Korean War era has seen a pronounced paradigm shift in China’s attitude toward the two Koreas: distancing itself from the North and warming to the South. The shift is marked by several critical events: the death of Mao Zedong and Kim Il-sung, the beginning

¹²A rare and brief exception is the few months leading up to the Tiananmen Square protests of 1989. Although largely following the party line, the newspaper had shown some subtle signs of defiance against the political authorities (Tan 1990).

¹³For example, on the front page of the *People's Daily* on December 4, 2015, Chinese President Xi Jinping’s name appears in 11 of the 12 headlines and, in the only exception, in the sub-headline (Sonmez 2015). In comparison, among the *Beijing News*, the *Oriental Morning Post*, and the *Southern Metropolis Daily*—three of China’s most popular and commercialized newspapers based in Beijing, Shanghai, and Guangzhou, respectively—Xi’s name appears in none of the front-page headlines that day. The contrast is an obvious sign of the massive consolidation of power by Xi since he came to office in 2012. Also, see Stockmann (2013) for the commercialization of Chinese media.

of China’s economic reforms, and the normalization of Sino-South Korean relations.

Figure 1 plots the number of mentions of North Korea by the *People’s Daily* and the quantity of Sino-North Korean trade. Throughout this section, I normalize the mentions in each year on a per-article basis, as the number of articles published by the newspaper fluctuates over time.¹⁴ The newspaper has referred to North Korea by two names: “Chōson,” the term preferred by the North and suggestive of the North’s claim to the Peninsula; and the “Democratic People’s Republic of Korea” (DPRK), the full name of the northern regime. The mentions of “Chōson” have decreased substantially, especially after Mao Zedong died and China’s economic reforms took off. In the early 1950s, the number of mentions averaged about once per article, per year. In recent years, however, the number hovers around 0.01 times per article, per year—an all-time low. The newspaper occasionally mentioned DPRK before 1978, as a form of recognition of the regime, but virtually stopped doing so afterward. Furthermore, the decline in the mentions of North Korea occurred much earlier than the bilateral trade started to rise. Given that Sino-North Korea trade is negligible in China’s total trade flows, the figure suggests that the increasing trade may be China’s strategic response to the souring bilateral relations.

Note that the quantity of mentions of North Korea in the newspaper is a direct indicator of China’s attitude toward its ally. After the Korean War, the two countries signed the Treaty of Friendship, Cooperation, and Mutual Assistance in 1961, obligating each country to “immediately render military and other assistance by all means at its disposal” should its ally be subjected to any attack by other countries. Bound by the socialist alliance, China has never allowed its official newspaper to publish articles negatively disposed toward North Korea. In Appendix A.1, the content of *People’s Daily* articles mentioning North Korea was analyzed in more detail for the two periods before and after 1978. It is shown that, in both periods, North Korea has been covered in a positive or neutral tone, but not in a negative one. Since there is no negative coverage, the amount of coverage in itself is indicative of China’s attitude toward North Korea.

¹⁴Using the total number of mentions (without normalization) shows a similar pattern, omitted here.

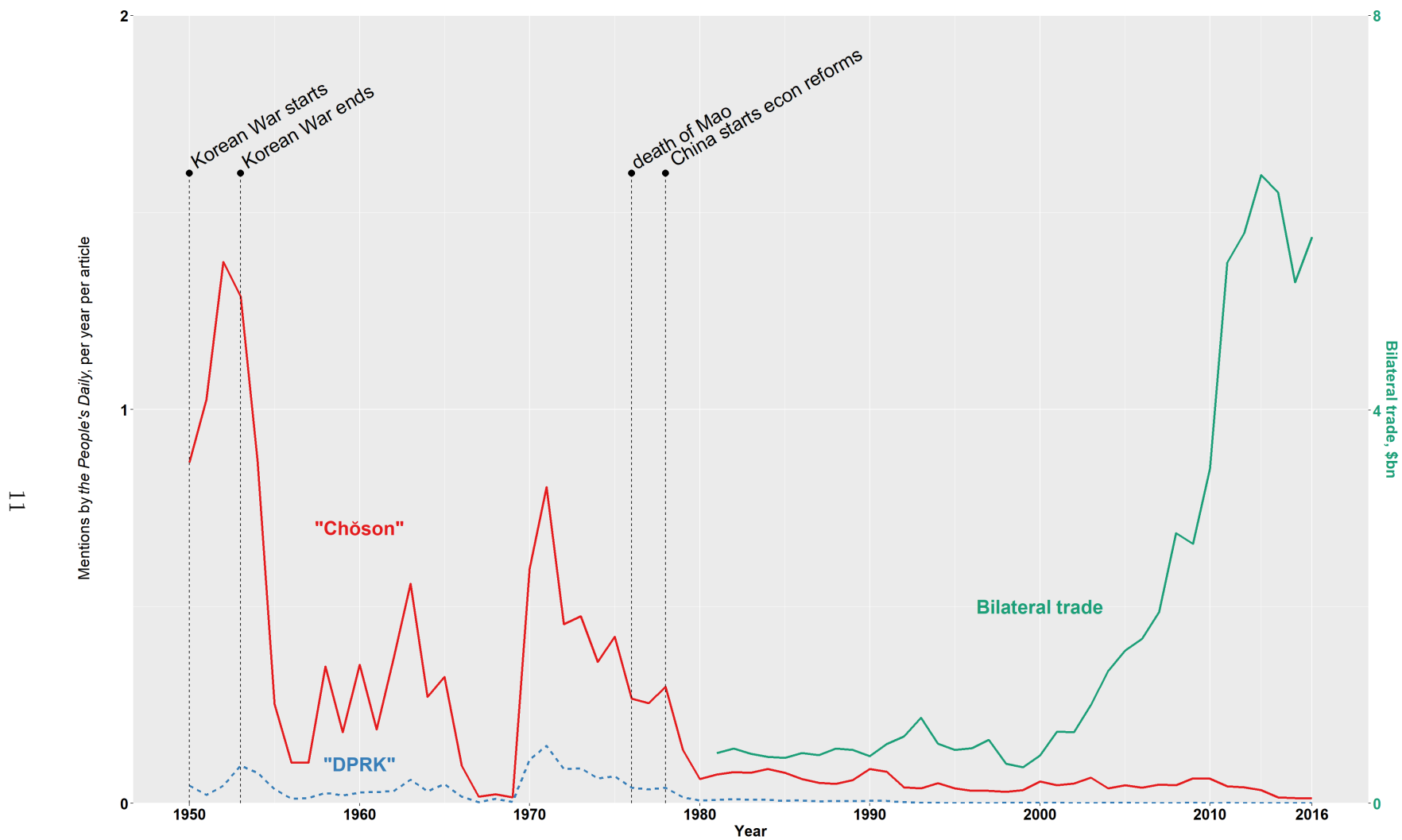


Figure 1. China's attitude toward North Korea and Sino-North Korean trade

Source: *the People's Daily* and International Monetary Fund. The number of mentions in a year is normalized to a per-article basis to adjust for the number of articles. The bilateral trade is the sum of imports and exports.

China’s implicit break away from North Korea is coupled with a more friendly attitude toward the South. Despite Beijing’s recent protest against Seoul’s deployment of Terminal High Altitude Area Defense—an American missile defense system—the two countries have enjoyed thawing relations since the early 1990s, as shown in Figure 2. The figure plots the number of times South Korea is mentioned in the *People’s Daily*, by two names: “South Chōson,” as preferred by the North; and “Hanguk,” as preferred by the South. The figure shows a clear change in the early 1990s when China established diplomatic ties with South Korea and Kim Il-sung died.

Further content analysis (see Appendix A.1 for details) shows that the mentions of “South Chōson” before 1992 were primarily negative, while that of “Hanguk” after 1992 were neutral or positive. For instance, the newspaper called the southern regime a “puppet state” under “American imperialism” before 1992. But after 1992, it frequently reported news about South Korea’s (democratically) elected presidents and their activities, such as meetings with Chinese officials.

2.2 China’s Priorities on the Korean Peninsula

As China’s attitude toward the two Koreas shifted, North Korean proliferation became an increasingly pressing concern for China’s national interest.

The mentions of the Peninsula by the *People’s Daily*, shown in Figure 3, allow us to see the change in China’s attitude toward Peninsula-related issues. The Peninsula has been referred to by the newspaper by two names: “South and North Chōson,” emphasizing the division between the two regimes; and “Chōson Peninsula,” a more neutral term. The figure again shows a clear paradigm shift around the beginning of China’s economic reforms in 1978. Moreover, as North Korean proliferation escalated in the post-1978 period, “Chōson Peninsula” was mentioned in the newspaper more frequently.

Further analysis of the articles’ content (explained in Appendix A.1) reveals an important change in priorities on China’s Peninsula policy. Before 1978, the emphasis regarding “South and North Chōson” reflected on China’s support for the unification of the two Koreas, presum-

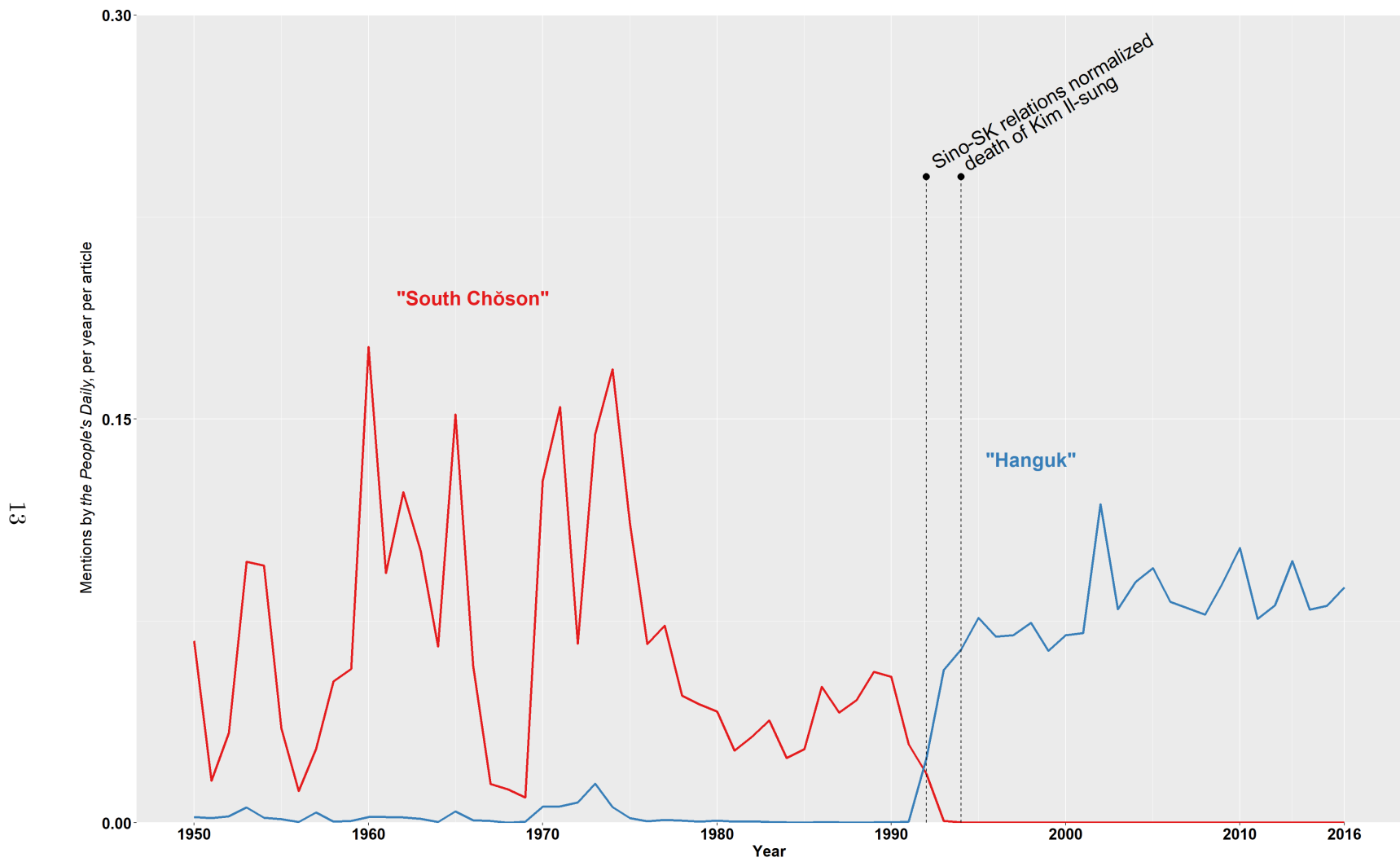


Figure 2. China's attitude toward South Korea

Source: *the People's Daily*. The number of mentions in a year is normalized to a per-article basis to adjust for the number of articles.

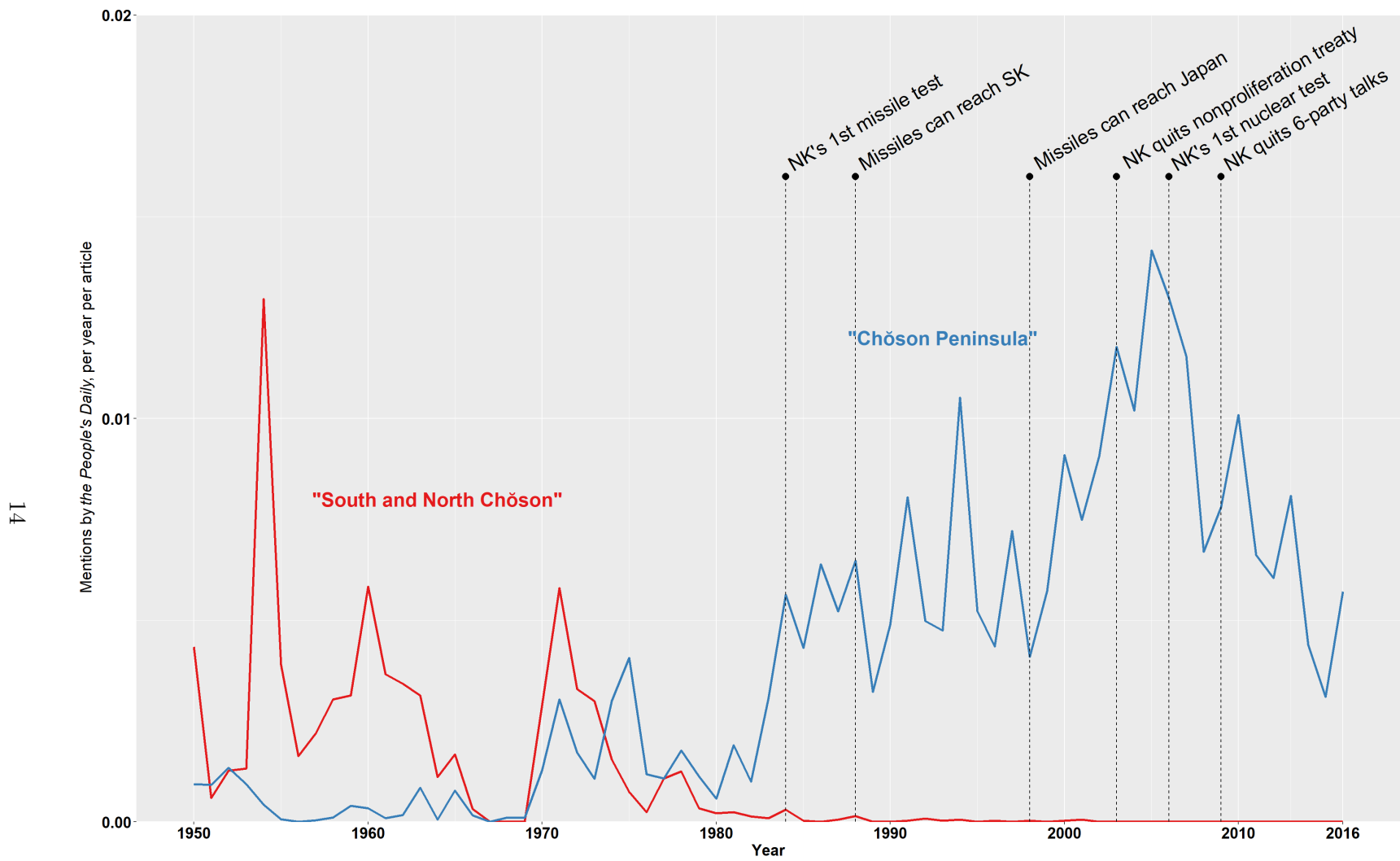


Figure 3. China's attitude toward the Korean Peninsula

Source: *the People's Daily*. The number of mentions in a year is normalized to a per-article basis to adjust for the number of articles.

ably on the North's terms more than the South's. After 1978, however, the focus regarding "Chōson Peninsula" shifted to the nuclear crisis and the importance of achieving peace on the Peninsula. The change is consistent with the repeated calls for the denuclearization of the Peninsula by Chinese officials in recent years.

2.3 North Korea's Attitude toward China

The possibility that North Korean proliferation brings more harm to China if its sanctions on North Korea are tougher is further supported by evidence showing North Korea's increasingly negative attitude toward China.

First, it is crucial to North Korea that China, as its patron, is a socialist state. During a conversation in 1984 between Kim Il-sung and Erich Honecker, the then-East German leader, Kim reportedly said: "Because of our position—the length of our border with China, confrontation with the US and Japan—what we are most afraid of is that China will not stick with socialism... We have to make sure that they follow the socialist path rather than some other path" (Person 2010, 370). The reform path China has taken after 1978 is obviously against Kim's wishes.¹⁵

Second, from North Korea's perspective, the establishment of diplomatic ties between China and South Korea in 1992 was another major betrayal of the "socialist ideals" on China's part. North Korea was so dismayed by China's move that it threatened to open economic relations with Taiwan as revenge (Yonhap News Agency 2002, 571-572).

Third, as China put increasing pressures on North Korea over its nuclear ambitions, including voting for UNSC resolutions to sanction North Korea, North Korea started to criticize its patron openly. On May 4, 2017, North Korea's state media publicly criticized the Chinese government for the first time. Insisting that its nuclear program was critical to the existence and development of the country, North Korea warned China of "the grave

¹⁵Unsurprisingly, advocates in North Korea of Chinese-style economic reforms were fiercely attacked by the dominant, military factions in the North Korean government. The critics went so far as calling the reformists "the enemy of the proletariat" (Funabashi 2007, 452).

consequences to be entailed by its reckless act of chopping down the pillar[s] of the DPRK-China relations” (Choe 2017). An internal document dated March 10, 2016, and leaked from the Workers’ Party of Korea even commands its people to actively confront China with a “nuclear storm” because of China’s opposition to its proliferation (Kim 2016). On May 20, 2017, a North Korean propaganda official reportedly told a cadre of local officials explicitly that, because of the “success” of the Hwasong-12,¹⁶ “China is now completely trapped by our network of missiles” (Shim 2017).

The evidence established in this section together shows that Sino-North Korean relations have turned from a strong alliance during the Korean War to borderline antagonism in recent years, and that North Korean proliferation is increasingly threatening China’s national security. The next sections will show that increasing bilateral trade—or, reducing sanctions—can be China’s optimal response to these developments.

3 A Model of Sanctions on an Ally

3.1 Setup

I study a dynamic optimization problem of a patron which has an ally that is pursuing a hazardous activity, assumed to be a program to develop weapons of mass destruction. The ally’s weapons program may cause two possible disastrous outcomes: The ally may initiate a conflict with a third country using its weapons, or a third country may undertake a preemptive strike against the ally. To limit the impact of the potential disaster, the patron decides the optimal level of sanctions on the ally, by changing the bilateral trade, before any disaster occurs. Sanctions are assumed to be effective in that they make it costlier for the ally to develop its weapons.

The horizon is indefinite, with time running from $t = 0$ until a disaster occurs. At any time t before the occurrence of a disaster, the patron can impose sanctions by adjusting the quantity of trade, $q(t)$, with the ally. The patron’s pre-disaster current payoffs from

¹⁶An intermediate-range ballistic missile North Korea unveiled in April 2017.

trade at time t are given by $B(q(t))$. B is assumed to be continuously differentiable, strictly increasing and strictly concave.

Sanctions slow down the ally's progress in the weapons program by causing its economic hardship. Let $x(t)$ denote the ally's level of weapons development at time t . I assume that $x(0) = 0$ and the dynamics of x follow the constraint

$$\dot{x}(t) = q(t) + \alpha,$$

where the dot denotes the derivative with respect to time, and $\alpha \geq 0$ represents the base rate of progression of the ally's weapons program that is exogenous to the patron's choice on trade. Trade, therefore, is assumed to directly feed the acceleration of the ally's weapons program. In practice, α can represent technological progress on the ally's part, or a defensive reaction to provocation by other countries.

If and when the ally initiates a conflict with a third country is governed by a stochastic process. Let $F(t)$ denote the probability that a conflict has been initiated by the ally by time t , with $F(0) = 0$. The conditional probability of the initiation of a conflict at time t , given that it has not been initiated before time t yet, is given by

$$(1) \quad \frac{\dot{F}(t)}{1 - F(t)} = h(t),$$

where $h(t) > 0$ is the time-dependent hazard rate. The hazard rate is meant to capture factors out of the patron's control that determine when the ally initiates a conflict—or, simply, how unruly the ally is. Those factors might include the ally's military ambitions or its sense of insecurity. The sign of $\dot{h}(t)$ is left unspecified.

Let $T > 0$ denote an exogenous point in time. The time horizon ends if one of the following two events occurs: if and when the ally initiates a conflict at any time $t < T$ or, if it does not, when a third country undertakes a preemptive strike against the ally at time $t = T$.¹⁷ The parameter T , therefore, can represent the level of patience the third country

¹⁷Alternatively, one can assume that a third country undertakes a preemptive strike once the ally's weapons

has in deciding when to undertake a preemptive strike against the ally.

If a conflict occurs at some time $t < T$, then, at time t , the patron receives a one-time damage given by $D(q(t))$, where D depends on how well trade relations, $q(t)$, stand when the conflict occurs. D is assumed to be continuously differentiable, strictly decreasing and strictly convex. Hence, the damage to the patron is larger if the patron imposes tougher sanctions on the ally. In practice, the damage might mean that the ally is more willing to take actions against the patron's national interest, including perhaps an attack on the patron itself if the imposed sanctions are tough enough. The dependence of D on $q(t)$, in such negative way, is for capturing a key feature in Sino-North Korean relations: the weakened alliance potentially causes China more harm from a North Korea-initiated conflict *if it does not trade with North Korea enough*. If D were absent from the patron's objective function, there would be no strategic reason for the patron to "fund" the ally's weapons program.

If no conflict occurs before time T , then, at time T , the preemptive strike by a third country causes a one-time damage to the patron given by $\sigma x(T)$, where $\sigma > 0$. Therefore, the more developed the ally's weapons program at the endpoint, the more the patron shares the blame by the third country as a "financer" of the weapons program. In practice, this captures the growing discontent with China other countries have for its continuing support for North Korea's economy and, indirectly, its military ambitions.

The key curvature assumptions on the functions B and D are summarized as follows.

Assumption 1 (i) $B(q)$ is strictly increasing and strictly concave in q , (ii) $D(q)$ is strictly decreasing and strictly convex in q .

The patron's objective is to maximize the present value of its expected future payoffs over the indefinite time horizon, running from $t = 0$ until a disaster occurs. Since the probability that the ally has not initiated a conflict with a third country before time $t < T$ is $1 - F(t)$, while the probability that such a conflict is initiated exactly at time t is $\dot{F}(t)$, the patron's progress, $x(t)$, reaches an exogenous level X at some time t . This alternative setup would yield a qualitatively similar result. Details are hence omitted.

expected payoff at $t = 0$ is given by

$$\int_0^T e^{-rt} \left[(1 - F) B(q) - \dot{F} D(q) \right] dt - e^{-rT} (1 - F(T)) \sigma x(T),$$

where r denotes the discount rate. Define $\phi(t) \equiv e^{-rt} (1 - F(t))$ and use (1) to rewrite the patron's problem as

$$(2) \quad \max_{q(\cdot), x_T} \int_0^T \phi [B(q) - hD(q)] dt - \phi(T) \sigma x_T$$

by choosing function q and endpoint x_T , subject to constraints

$$(3) \quad \dot{x} = q + \alpha,$$

$$(4) \quad x(0) = 0, \quad x(T) = x_T$$

where the dependence on t is suppressed in the notations. I abstract from any other constraints on x or q .

The main trade-off facing the patron, therefore, is one between the strategic benefit from trade, which alleviates the potential damage to itself from a conflict initiated by the ally, and the strategic cost of trade, which worsens the potential damage to itself in the event of a preemptive strike by a third country.

3.2 Optimal Sanctions

Problem (2)-(4) is a standard, free-endpoint optimal control problem with q as the control and x as the state variable.

Define the Hamiltonian as

$$H(q, \lambda) \equiv \phi [B(q) - hD(q)] + \lambda (q + \alpha).$$

It follows from Pontryagin's maximum principle (Pontryagin et al. 1962) that, if (q^*, x^*, λ^*)

is an optimal solution to the problem, they must satisfy the following necessary conditions:

$$(5) \quad H_q(q^*, \lambda^*) = \phi [B_q(q^*) - hD_q(q^*)] + \lambda^* = 0,$$

$$(6) \quad \dot{\lambda}^* = -H_x(q^*, \lambda^*) = 0,$$

$$(7) \quad \dot{x}^* = H_\lambda(q^*, \lambda^*) = q^* + \alpha,$$

$$(8) \quad x^*(0) = 0,$$

$$(9) \quad \lambda^*(T) = -\phi(T) \sigma.$$

Moreover, Assumption 1 implies that a tuple satisfying conditions (5)-(9) is in fact the unique optimal solution to the problem.¹⁸

The necessary conditions have standard economic interpretations. In particular, (5) implies that $\lambda^* < 0$, and the condition can be rewritten as

$$\phi [B_q(q^*) - hD_q(q^*)] = -\lambda^*.$$

At the optimum, the quantity of trade at any time is chosen such that the marginal benefit of having a little more trade (i.e., more flow payoffs and less damage (to itself) in an ally-initiated conflict) is equal to the marginal cost of doing so (i.e., facilitating the ally's weapons development by a little more).

Although the generality of the model's setup does not yield an analytical solution to the optimal control, the necessary conditions reveal what can affect the time path of q^* . Differentiating (5) with respect to time and using (5) and (6) to simplify terms yield

$$\dot{q}^* = \frac{\dot{\phi} [B_q(q^*) - hD_q(q^*)]}{-H_{qq}(q^*, \lambda^*)} + \frac{-\phi D_q(q^*)}{-H_{qq}(q^*, \lambda^*)} \dot{h}.$$

¹⁸Specifically, by Mangasarian's sufficient conditions (1966), if $H(q, \lambda)$ is strictly concave in q , then the necessary conditions are also sufficient, and they specify the unique global maximizer of the objective function. That $H(q, \lambda)$ is strictly concave in q follows from the strict concavity of B and strict convexity of D given in Assumption 1.

Although the denominators on the right-hand side are positive due to Assumption 1, the sign of \dot{q}^* is ambiguous.

In particular, since D is strictly decreasing, $\frac{-\phi D_q(q^*)}{-H_{qq}(q^*, \lambda^*)}$ is positive. Therefore, q^* can be increasing in time if $\dot{h} > 0$ is large enough. In other words, the patron may find it optimal to increase trade at times when the ally's weapons program is increasingly hazardous. The intuition of this result is as follow. Suppose the disaster has not occurred by time t . In this case, a large \dot{h} means that, as time goes by, the conditional probability of an ally-initiated conflict occurring at the very next moment is increasing drastically. Since the conflict is imminent, the patron has the incentives to quickly mend the bilateral relations by increasing trade with the unruly ally. Therefore, when \dot{h} is large enough, such strategic consideration will dominate, and the optimal trade, q^* , will be increasing in time.

This result suggests a possible explanation, from a dynamic perspective, to the increasing Sino-North Korean trade in recent years. Due to the weakening of the socialist alliance, there is a strategic gain for China to reduce sanctions on North Korea. At a time when North Korea's weapons program is increasingly hazardous, such strategic consideration can drive up the bilateral trade. This implication is discussed in more detail in Section 5.

4 Comparative Dynamics

This section focuses on how the time path of the optimal sanctions analyzed in Section 3 is affected by factors exogenous to the patron's control. This analysis is relevant to the rest of the world's nonproliferation efforts because the ally's weapons program adversely affects other countries as well. From an outsider's point of view, one would prefer a smaller magnitude of the disaster if and when it occurs, which, in the language of the model, means a flatter time path of the function x^* resulting from the patron's optimization problem. I lay out the comparative-dynamic results here and defer their policy implications to the next section.

I first parameterize the model in Section 3 with $B = B(q; \beta)$ and $D(q; \delta)$, where β and δ are exogenous parameters. The following assumption is made on the partial derivatives of

the two functions.

Assumption 2 (i) $B_\beta > 0$ and $B_{\beta q} > 0$; (ii) $D_\delta > 0$ and $D_{\delta q} < 0$; (iii) $B_{\beta qq} = 0$ and $D_{\delta qq} = 0$.

By Assumption 2, as β increases, both the gross and marginal payoffs from trade before the disaster occurs are larger. Similarly, as δ increases, the gross damage to the patron from the disaster is larger, and the extent to which reducing sanctions alleviates the damage is larger as well (i.e., D_q , which is negative, is decreasing in δ). Therefore, an increase in δ is interpreted hereafter as a deterioration of the relations between the two countries and an increasing importance of trade in limiting the potential damage to the patron. Part (iii) of the assumption is made to simplify the analytical results shown later. Also of interest are the parameter α , which represents the base rate of the ally's weapons development, and the parameter T , which represents how patient the third country is in deciding on the preemptive strike. Let a vector

$$\Theta \equiv (\alpha, \beta, \delta, T) \in \mathbb{R}^4$$

represent all four parameters to be studied below, and let $\theta \in \Theta$ denote the generic parameter among the four.

In reality, β can be interpreted as a measure of the economic gains from trade. For example, if the rest of the world sanctioned the patron for not imposing enough sanctions on the ally (i.e., the so-called "secondary sanctions"), the act would be seen as a lower β from the patron's perspective. An increase in δ can be interpreted as growing discontent and hostility between the patron and the ally as their alliance weakens. In the case of Sino-North Korea relations, the divergence in political ideologies and economic institutions between the two countries can be seen as an increase in δ for China's optimal sanctions problem. Finally, as mentioned earlier, an increase in α can be interpreted as a consequence of technological progress in the ally's weapon's program or its reaction to provocation by a third country, and a higher T might mean that the third country is more tolerant of the ally's military ambitions.

I follow the primal-dual approach in Caputo (1990) to derive the comparative dynamic results.

Let $V(\Theta)$ denote the value function of problem (2)-(4) given parameter vector Θ , i.e.,

$$V(\Theta) \equiv \int_0^T \phi [B(q^*(\Theta); \beta) - hD(q^*(\Theta); \delta)] dt - \phi(T) \sigma x^*(T; \Theta).$$

Consider the following dual problem in which the parameter vector Θ , rather than the quantity of trade q , is the choice variable:

$$(10) \quad \max_{\Theta} L(\Theta; \bar{\Theta}) \equiv \int_0^T \phi [B(q^*(\bar{\Theta}); \beta) - hD(q^*(\bar{\Theta}); \delta)] dt - \phi(T) \sigma x^*(T; \bar{\Theta}) - V(\Theta),$$

subject to the constraint

$$(11) \quad q^*(\bar{\Theta}) + \alpha = \dot{x}^*(\bar{\Theta}),$$

where $\bar{\Theta}$ is an arbitrary, fixed parameter vector, and the constraint is one for the choice of α . By construction, $L(\Theta; \bar{\Theta})$ is non-positive, and it attains its maximum, which equals zero, when $\Theta = \bar{\Theta}$. Examining the solution to problem (10)-(11) allows us to derive comparative dynamic results for the original problem (2)-(4).

The Lagrangian of the dual problem is given by

$$(12) \quad \begin{aligned} & \mathcal{L}(\Theta; \bar{\Theta}) \\ & \equiv \int_0^T \{ \phi [B(q^*(\bar{\Theta}); \beta) - hD(q^*(\bar{\Theta}); \delta)] + \lambda^*(\bar{\Theta}) (q^*(\bar{\Theta}) + \alpha - \dot{x}^*(\bar{\Theta})) \} dt \\ & \quad - \phi(T) \sigma x^*(T; \bar{\Theta}) - V(\Theta) \\ & = \int_0^T [H(q^*(\bar{\Theta}), \lambda^*(\bar{\Theta}); \alpha, \beta, \delta) - \lambda^*(\bar{\Theta}) \dot{x}^*(\bar{\Theta})] dt \\ & \quad - \phi(T) \sigma x^*(T; \bar{\Theta}) - V(\Theta). \end{aligned}$$

For any generic parameter $\theta \in \Theta$, the first-order condition

$$(13) \quad \mathcal{L}_\theta (\Theta; \bar{\Theta}) = 0$$

holds at $\Theta = \bar{\Theta}$. Condition (13) thus implies the standard envelope theorem results in the proposition below.

Proposition 1 *Under Assumptions 1 and 2, the value function $V(\Theta)$ satisfies*

$$\begin{aligned} V_\alpha (\Theta) &= \int_0^\infty \lambda^* (\Theta) dt < 0, \\ V_\beta (\Theta) &= \int_0^\infty \phi B_\beta (q^* (\Theta); \beta) dt > 0, \\ V_\delta (\Theta) &= \int_0^\infty -\phi h D_\delta (q^* (\Theta); \delta) dt < 0, \end{aligned}$$

while the sign of $V_T (\Theta)$ is ambiguous.

The envelope-theorem results admit standard economic interpretations: The patron's value from the optimal control problem is higher if trade generates more flow payoffs before the disaster occurs. The patron's value is lower if the base rate of the ally's weapons development is higher, or if the alliance between the two countries deteriorates.

The impact of an increase in T on the patron's value is indeterminate. This is because, on the one hand, the patience of the third country delays the damage of a preemptive strike to the patron while, on the other hand, the longer time horizon prolongs the patron's flow payoffs before T which may be negative.

More important, the comparative dynamics of functions $q^* (\Theta)$ and $x^* (\Theta)$ can be derived from the second-order condition for the dual problem. The second-order condition has it that $\mathcal{L} (\Theta; \bar{\Theta})$ is locally concave in Θ , which is equivalent to the Hessian matrix $\mathcal{L}_{\Theta\Theta} (\Theta; \bar{\Theta})$ being negative semi-definite at $\Theta = \bar{\Theta}$. The negative semi-definiteness of $\mathcal{L}_{\Theta\Theta} (\Theta; \bar{\Theta})$ implies that all of its diagonal elements are non-positive. The next proposition sums up the implications of this property:

Proposition 2 *Under Assumptions 1 and 2, the optimal trade $q^*(\Theta)$ and the optimal weapons development $x^*(\Theta)$ satisfy*

$$(i) \int_0^T -H_{qq}(\Theta) q_\alpha^*(\Theta) dt \geq 0;$$

$$(ii) \int_0^T \phi q_\beta^*(\Theta) dt \geq 0 \text{ and } \int_0^T (r+h) \phi x_\beta^*(\Theta) dt + \phi(T) x_\beta^*(T; \Theta) \geq 0;$$

$$(iii) \int_0^T \phi h q_\delta^*(\Theta) dt \geq 0 \text{ and } \int_0^T \frac{d(-\phi h)}{dt} x_\delta^*(\Theta) dt + \phi(T) h(T) x_\delta^*(T; \Theta) \geq 0;$$

$$(iv) \int_0^T q_T^*(\Theta) dt \geq 0 \text{ and } x_T^*(T; \Theta) \geq 0;$$

where $H_{qq}(\Theta)$ is the shorthand for $H_{qq}(q^*(\Theta), \lambda^*(\Theta); \alpha, \beta, \delta)$.

Part (i) of the proposition means the impact of an increase in α , resulting from the ally's technological progress, for example, is a (weak) increase in the *weighted, cumulative* trade. In particular, for any time \hat{t} , the weight assigned to $q_\alpha^*(\hat{t}; \Theta)$ is $-H_{qq}(\hat{t}; \Theta)$. Note that this comparative dynamic effect, as well as the others in the proposition, holds for the entire time horizon, with no implications on the effect at any specific time or any specific subset of the time horizon. For example, $q_\alpha^*(\tilde{t}; \Theta) < 0$ for some \tilde{t} would *not* contradict part (i) of the proposition. The implication of this result, therefore, is that, as the base rate α increases, the patron's response is to increase the overall trade, further aggravating the ally's weapons proliferation.

Part (ii) admits a similar interpretation. The marginal impact of an increase in β , raising the patron's economic gains from trade with the ally, is that both the *weighted, cumulative* trade and the *weighted, cumulative* weapons development are non-decreasing. Similar to part (i), for any time $\hat{t} < T$, the weight assigned to $q_\beta^*(\hat{t}; \Theta)$ is $\phi(\hat{t})$, while the weight assigned to $x_\beta^*(\hat{t}; \Theta)$ is $(r+h(\hat{t}))\phi(\hat{t})$. Viewed over the entire time horizon, an increase in β tends to make the time paths of $q^*(\Theta)$ and $x^*(\Theta)$ steeper, making the rest of the world worse off.

Similarly, part (iii) means that, as the relations between the patron and the ally become more strained (with a larger δ), the patron (weakly) increases the *weighted, cumulative* trade to limit the damage it may suffer. This, in turn, causes the *weighted, cumulative* weapons

development to (weakly) increase as well. Similar to part (i), for any time \hat{t} , the weight assigned to $q_\delta^*(\hat{t}; \Theta)$ is $\phi(\hat{t}) h(\hat{t})$, and the weight assigned to $x_\delta^*(\hat{t}; \Theta)$ is $\frac{d(-\phi h)}{dt}$ evaluated at $t = \hat{t}$.

Finally, part (iv) shows the *indirect* effect of an increase in the time horizon T on trade and the weapons development at the endpoint. To see that, take the total derivative of $x^*(T; \Theta) = \int_0^T (q^*(t; \Theta) + \alpha) dt$ (by construction) with respect to T :

$$\begin{aligned} \dot{x}^*(T; \Theta) + x_T^*(T; \Theta) &= (q^*(T; \Theta) + \alpha) + \int_0^T q_T^*(\Theta) dt, \\ x_T^*(T; \Theta) &= \int_0^T q_T^*(\Theta) dt, \end{aligned}$$

where the second equality follows from condition (7). The term $x_T^*(T; \Theta)$ is the indirect effect of an increase in T on the endpoint weapons development $x^*(T; \Theta)$, while $\dot{x}^*(T; \Theta)$ is the direct effect. Similarly, $\int_0^T q_T^*(\Theta) dt$ is the indirect effect of an increase in T on $\int_0^T (q^*(t; \Theta) + \alpha) dt$, while $q^*(T; \Theta) + \alpha$ is the direct effect. Thus far, the model has not imposed sign restrictions on $q(t)$ or $\dot{x}(t)$, leaving the direct effects ambiguous. But, if $q^*(T; \Theta) \geq 0$ holds at the optimum, then part (iv) of the proposition would imply the *total* effect of an increase in the third country's tolerance is such that both the cumulative trade and the weapons development at the endpoint—when the third country undertakes the preemptive strike—weakly increase, again making the rest of the world worse off.

5 Policy Implications

The theory developed thus far not only can explain Sino-North Korean trade but also sheds light on policy options toward North Korea that are available to other countries and the international community. The approach taken in this section is to assume, in an overly simplified manner, that these policies are exogenous to the optimization problem facing China. Under this assumption, they are interpreted as changes in exogenous parameters, such as Θ , and their effects follow directly from the results in Section 4.

An immediate implication of the dynamic model is that the effectiveness of a policy change (i.e., a parameter change) should *not* be evaluated by the change in the optimal solution *at a specific time*, but rather over the entire time horizon. For example, a policy change that would cause the weighted, cumulative Sino-North Korean trade to decrease does not imply that the bilateral trade would decline the moment after the policy change is instated. All the implications discussed below should, therefore, be interpreted through the entire time horizon.

The Increasing Sino-North Korean Trade The general model provides a possible explanation to the increasing Sino-North Korean trade in recent years: enhancing trade ties can reduce the damage to China in the event of a North Korea-initiated conflict. Such incentives can appear in three channels. First, from a comparative dynamic perspective, the increasing trade may be driven by a chronic deterioration of Sino-North Korean relations (i.e., an increase in δ) which makes the damage D more sensitive to the amount of sanctions China imposes on North Korea. This explanation is consistent with the stylized fact about Sino-North Korea relations established in Section 2.

Second, again from a comparative dynamic perspective, the increasing trade may also be driven by a technological progress in North Korea's weapons program (modeled as an increase in α). This is evidenced by increasingly frequent nuclear and missile tests conducted by North Korea and the significantly improved success rate of those tests in recent years. Such progress can also motive China to reduce the damage to itself from a North Korea-initiated conflict.

Third, from a dynamic perspective, the increasing trade can be viewed as an increase of $q^*(t)$ in t during a certain period. This, in turn, can be driven by North Korea becoming more and more unruly in China's perspective (that is, the hazard rate $\dot{h}(t)$ being higher for some t). In that case, China's incentives to increase trade lie in the imminence of a North Korea-initiated conflict, such as the latter's ambition to unify the Peninsula by force or to attempt an attack on US territories.

UNSC Sanctions Perhaps surprisingly, the theory suggests that the current sanctions regime of the UNSC may have been counter-productive in containing North Korean proliferation.

Because of China’s veto power in the Security Council, the UN sanctions against North Korea have been made either narrow in scope (e.g., only restricted to certain types of goods¹⁹) or lenient in scale (e.g., containing caveats that avail China the discretion on whether to implement the measures²⁰) in exchange for China’s support. It is widely recognized that, because of these limitations, the UNSC sanctions on North Korea have not achieved the stated goals (e.g., Habib 2016; Haggard and Noland 2017).

More important, due to China’s key role, the passage of sanctions resolutions has in the past aggravated North Korea’s hostility toward China. Since the sanctions measures lacked enforcement, the only remaining effect, in the language of the model, was an increase in the parameter δ —that is, a deterioration of Sino-North Korean relations. By the comparative dynamics, this implies an increase in Sino-North Korean trade which, in turn, leads to progression in North Korean proliferation. In other words, sanctions without enforcement can make the rest of the world worse off than not imposing those sanctions in the first place. For future sanctions to be effective, it is important to improve the enforcement mechanism, so that China’s interest is more aligned with other UN member countries.

Secondary Sanctions and Secondary Inducements In the latest round of the North Korean nuclear crisis in 2017, the call for the US to impose secondary sanctions on China—that is, placing economic restrictions on Chinese companies violating existing UNSC sanctions—has not only gained support in policy debate but also shown signs of being adopted in the

¹⁹For example, UNSC Resolution 1718 (2006) is restricted to luxury goods and materials that can be used in weapons of mass destruction-related programs.

²⁰See UNSC Resolution 2270 (2016), which allows a state to determine whether a certain type of activities are for humanitarian or livelihood purpose, and whether they are not related to any activities explicitly prohibited by the UNSC. Both caveats can be used to justify not sanctioning some transactions with North Korea.

Trump Administration’s policies. The theory suggests that these measures can be effective in curbing North Korean nuclear ambitions.

China’s incentives in the sanctions problem imply that the level of sanctions it finds optimal is necessarily lower than the level the rest of the world, particularly the US, would prefer. However, it would make a difference if the US conditions its economic relations with China on the level of sanctions China imposes on North Korea. For example, if the US punishes Chinese companies that deal with North Korea (secondary sanctions) and improves its trade relations with China if China accepts the risk of being tough on North Korea (“secondary inducements”), the effect would be a decrease in the parameter β —that is, the decline in China’s economic gains from trade with North Korea. The result would be a decrease in Sino-North Korean trade and, accordingly, a decrease in North Korean proliferation. Given that the US is China’s largest trading partner, the effect of such strategy can be significant.

This is not to say that secondary sanctions and secondary inducements are necessarily optimal from the US’ perspective. The above discussion does not take into account the costs of such policy changes, which might include jeopardizing the economic relations between China and the US, setting an undesirable precedent for future US trade policy toward other countries, and the possibility that the secondary sanctions or secondary inducements will be challenged on legal grounds.²¹ The theory only goes so far as to suggest that if these secondary measures were in place, North Korea’s nuclear ambitions could be curbed more effectively.

“Strategic Patience” US policy toward North Korea under the Obama Administration has been characterized as “strategic patience,” a vaguely defined policy that amounts to waiting for North Korea to decide to denuclearize itself (Snyder 2013). The theory explains why such a policy is counter-productive, for two reasons.

In the language of the model, “strategic patience” can be interpreted as the time horizon T being very large. This has two effects, both leading to more progress in the ally’s weapons

²¹See, for example, Meyer (2014) for a discussion on the legality of secondary sanctions.

program. The first effect is direct: When North Korea has more time to invest in arms, the eventual level of its weapons development will be higher. More important, the comparative dynamics uncover a second, indirect effect: Part of North Korea's increased weapons progress is due to more Sino-North Korean trade, which is China's optimal response to a longer planning horizon. China's unique role on the Peninsula, hence, gives rise to additional, adverse effect of patience on the US's part.

Provoking the “Rocket Man” Advances in North Korean proliferation are rightly seen by other countries as provocations. A question not so obvious is how other countries should respond to these provocations. For the US, the Trump Administration's response, at least in its early months, is largely in kind. Following a series of North Korean missile tests, the US president himself has nicknamed Kim Jong-un a “rocket man,” threatened North Korea with “fire and fury... this world has never seen before” (Baker and Choe 2017) and to “totally destroy North Korea” (Stokols and Fassihi 2017). The theory suggests that escalating provocations are also counter-productive.

Unless the US is actually considering a preemptive strike against North Korea (i.e., shortening the time horizon T), the role of escalating provocations would amount to prompting North Korea to speed up its weapons program (i.e., an increase in α) and raising the chance of a nuclear war (i.e., an increase in \dot{h}). As in the discussion of “strategic patience,” these changes also have a direct and indirect, adverse effects. Besides the obvious, direct effect, both an increase in the base rate of progression, α , and an increase in the hazard rate, \dot{h} , will lead to more trade between China and North Korea, resulting in an even more rapid proliferation. The international community, therefore, should respond to North Korean provocations with cautions and beware of the negative impact through China's trade policy toward North Korea.

6 Conclusion

This paper is motivated by a puzzle in China’s policy toward North Korea: It opposes North Korean proliferation on the one hand and, on the other, practically “funds” a large part of North Korea’s weapons program through increasing bilateral trade. Using the texts of the *People’s Daily*, the Chinese government’s official public voice, I have shown that the socialist alliance between China and North Korea has significantly weakened since the Korean War. Faced with discontent and hostility from North Korea, China may be motivated to trade with North Korea to reduce the damage to itself in the event of this unruly ally initiating a conflict with other countries. I have formalized this explanation with a dynamic optimization model in which a patron optimizes the level of sanctions on its unruly ally. The comparative dynamics are shown to have important implications on foreign-policy issues regarding North Korean proliferation, such as why the UNSC sanctions regime may be counter-productive, why it may be effective for a third country to impose secondary sanctions and secondary inducements on China, why “strategic patience” on the US’ part may worsen the crisis, and why the international community should not respond to North Korean provocations in kind.

The analysis did not model the decision problems for third-party countries and international organizations. The comparative dynamics addressed the “benefit side” of their policy options, such as how effective secondary sanctions on China would be for the US, but did not touch on the “cost side” of the problems, such as the possibility of straining the Sino-US economic relations. Explicitly modeling the US trade policy toward China and the bargaining problem among UNSC member countries would lead to new insights into the rest of the world’s nonproliferation efforts. I leave these interesting issues for future studies.

Appendix

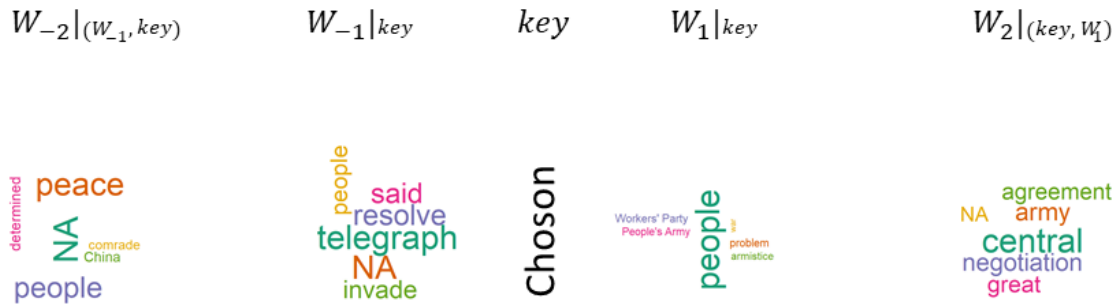
A.1 More on Content Analysis

This appendix complements Section 2 with further analysis of *People’s Daily* articles that mention North Korea, South Korea, or the Korean Peninsula. The analysis aims to make inferences on the newspaper’s sentiment by examining the words it uses when mentioning such terms as “Chōson” and “Hanguk.”

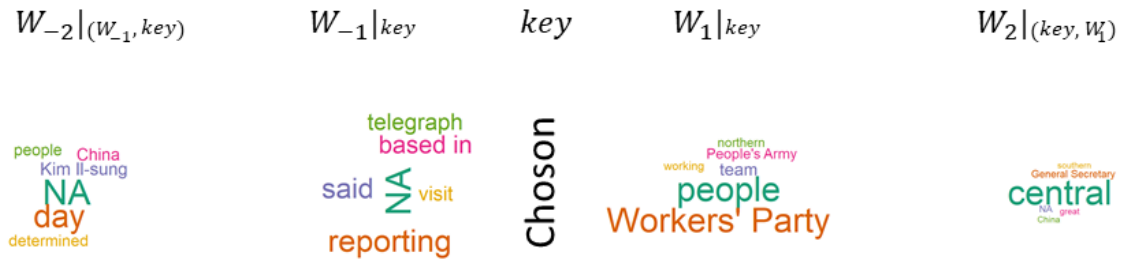
Figure 4 examines the most frequently used words surrounding “Chōson,” the principal name of North Korea used in the newspaper. Panel (a) of the figure plots the word clouds of the two words preceding and the two words following the keyword, “Chōson,” for the period before 1978. Panel (b) shows the analogous word clouds for the period after 1978. Although the use of “Chōson” had declined substantially in the second period (recall Figure 1), the sentiment of the words surrounding it, positive or neutral, has changed little.²² Both the Workers’ Party of Korea and the Korean People’s Army, for example, are frequently mentioned in both periods. The figure hence suggests that, over the decades after the Korean War, China’s attitude toward North Korea should be seen from how often its official newspaper mentions North Korea, rather than how friendly the sentiment is when it does. It also suggests that, at least on the surface, maintaining an apparent warmth toward the ally is in China’s interest.

Figure 5 compares two terms the newspaper has used to refer to South Korea: “South Chōson,” primarily used before 1992, and “Hanguk,” primarily used after 1992. Panel (a) shows that, before 1992, words surrounding “South Chōson” are mostly negative about the southern regime. The newspaper depicted South Korea as a “puppet state” under the “American imperialism.” It demanded that the American troops withdraw from the Peninsula, and it emphasized the “struggle” of the South Korean people against their government. In contrast, since China established diplomatic ties with the South in 1992, the sentiment shown in panel (b) changed drastically. In the post-1992 period, the newspaper often covered news

²²The analysis of words surrounding the keyword “DPRK” shows a similar pattern (omitted here).



(a) pre-1978



(b) post-1978

Figure 4. China’s attitude toward the North Korea: sentiment

Source: *the People’s Daily*. The size of a word depends on its frequency conditional on the appearance of the neighbor word on the left/right. “NA” means the texts have not started/have ended.

about South Korea’s appearances at the Olympic Games. It also frequently mentioned presidents of South Korea—who are democratically elected—and their activities such as meetings with government officials of China. The sentiment analysis, therefore, shows a clear paradigm shift in China’s attitude toward the South, from very negative talks to neutral or positive talks.

Finally, a similar analysis of China’s attitude toward the Peninsula is shown in Figure 6. When the newspaper used the term “South and North Chōson,” primarily before 1978, it stressed the unification of the two Koreas (in panel (a)). Furthermore, given that China’s attitude before 1978 was positive toward the North and negative toward the South, the path to unification China supported was presumably on the North’s terms. In the post-1978 period, however, China’s attitude toward the Peninsula changed drastically as well (in panel (b)). The emphasis of the newspaper was placed predominantly on North Korean proliferation. It called for easing the tension, resolving the nuclear crisis, and maintaining peace and stability on the Peninsula. The comparison shows that, as Sino-North Korean relations soured, North Korean proliferation became a more concerning problem for the Chinese government.

A.2 Proofs

Proof of Proposition 1. To reduce notations, I suppress the arguments of H and write $H(\Theta; \bar{\Theta})$ as the shorthand for $H(q^*(\bar{\Theta}), \lambda^*(\bar{\Theta}); \alpha, \beta, \delta)$ for the rest of the appendix.

Differentiating (12) with respect to $\theta \in \{\alpha, \beta, \delta\}$ and T gives

$$(14) \quad \mathcal{L}_\theta(\Theta; \bar{\Theta}) = \int_0^T H_\theta(\Theta; \bar{\Theta}) dt - V_\theta(\Theta),$$

$$(15) \quad \begin{aligned} \mathcal{L}_T(\Theta; \bar{\Theta}) &= H(T; \Theta; \bar{\Theta}) - \lambda^*(T; \bar{\Theta}) \dot{x}^*(T; \bar{\Theta}) \\ &\quad - \phi'(T) \sigma x^*(T; \bar{\Theta}) - \phi(T) \sigma \dot{x}^*(T; \bar{\Theta}) - V_T(\Theta), \end{aligned}$$

both of which equal zero at $\Theta = \bar{\Theta}$. Furthermore, by (9), $\mathcal{L}_T(\bar{\Theta}; \bar{\Theta})$ can be simplified to

$$\mathcal{L}_T(\bar{\Theta}; \bar{\Theta}) = H(\bar{T}; \bar{\Theta}; \bar{\Theta}) - \phi'(\bar{T}) \sigma x^*(\bar{T}; \bar{\Theta}) - V_T(\bar{\Theta})$$

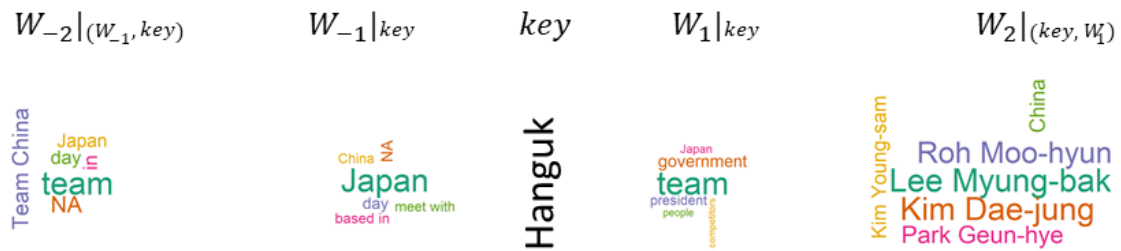
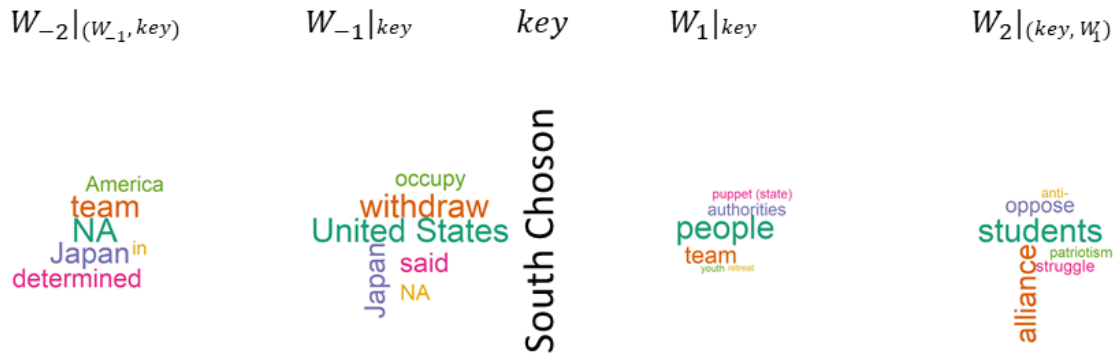
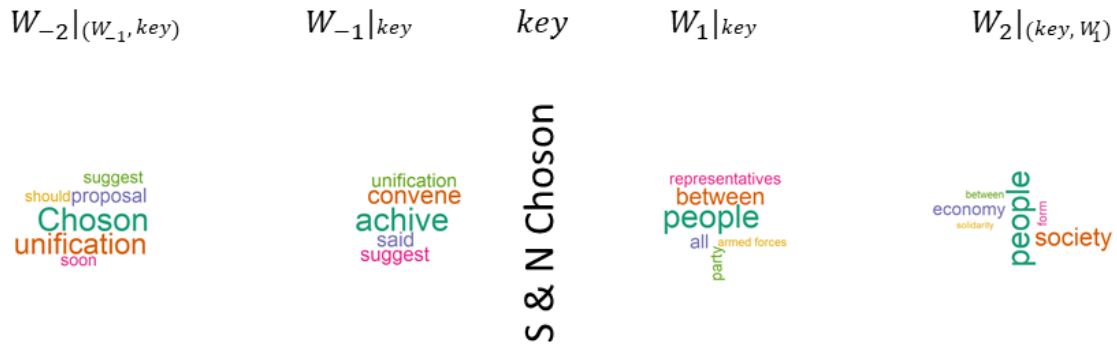
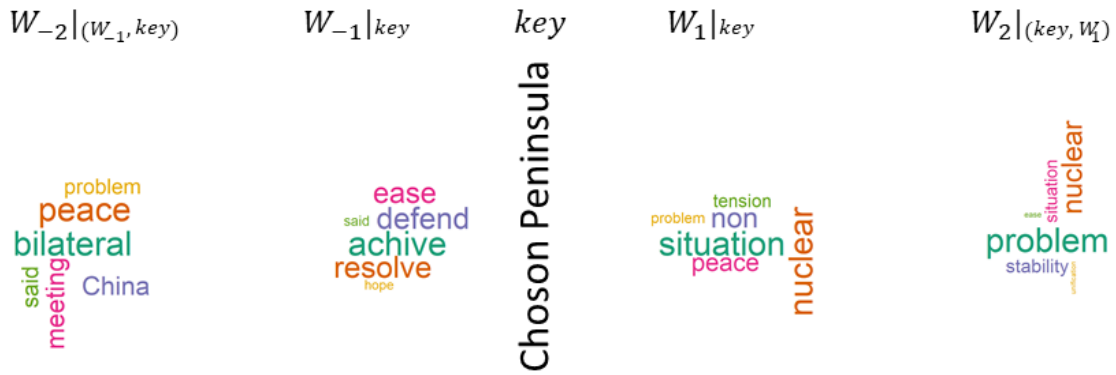


Figure 5. China’s attitude toward the South Korea: sentiment

Source: *the People’s Daily*. The size of a word depends on its frequency conditional on the appearance of the neighbor word on the left/right. “NA” means the texts have not started/have ended.



(a) pre-1978



(b) post-1978

Figure 6. China's attitude toward the Korean Peninsula: sentiment

Source: *the People's Daily*. The size of a word depends on its frequency conditional on the appearance of the neighbor word on the left/right. "NA" means the texts have not started/have ended.

Since $\bar{\Theta}$, although fixed, is an arbitrary parameter vector, $\mathcal{L}_\theta(\bar{\Theta}; \bar{\Theta}) = 0$ and $\mathcal{L}_T(\bar{\Theta}; \bar{\Theta}) = 0$ hold for $\bar{\Theta} = \Theta$ as well, which gives the expressions in the proposition. The signs of first derivatives given in Assumption 1 then imply the signs of first derivatives of $V_\theta(\Theta)$ for $\theta \in \{\alpha, \beta, \delta\}$. The sign of $V_T(\Theta)$ is ambiguous, because the sign of $H(T; \Theta; \Theta)$ is ambiguous.

■

Proof of Proposition 2.

Results with respect to α , β , and δ :

Differentiating (14) with respect to $\theta \in \{\alpha, \beta, \delta\}$ and evaluating it at $\Theta = \bar{\Theta}$ gives

$$(16) \quad \mathcal{L}_{\theta\theta}(\bar{\Theta}; \bar{\Theta}) = \int_0^T H_{\theta\theta}(\bar{\Theta}; \bar{\Theta}) dt - V_{\theta\theta}(\bar{\Theta}).$$

Recall that

$$(17) \quad V_\theta(\Theta) = \int_0^T H_\theta(\Theta; \Theta) dt.$$

Differentiating (17) with respect to $\theta \in \{\alpha, \beta, \delta\}$ and evaluating it at $\Theta = \bar{\Theta}$ gives

$$(18) \quad V_{\theta\theta}(\bar{\Theta}) = \int_0^T \left(H_{\theta\theta}(\bar{\Theta}; \bar{\Theta}) + H_{\theta q}(\bar{\Theta}; \bar{\Theta}) \frac{\partial q^*(\bar{\Theta})}{\partial \theta} + H_{\theta\lambda}(\bar{\Theta}; \bar{\Theta}) \frac{\partial \lambda^*(\bar{\Theta})}{\partial \theta} \right) dt.$$

Substituting (18) into (16) yields

$$(19) \quad \mathcal{L}_{\theta\theta}(\bar{\Theta}; \bar{\Theta}) = - \int_0^T \left(H_{\theta q}(\bar{\Theta}; \bar{\Theta}) \frac{\partial q^*(\bar{\Theta})}{\partial \theta} + H_{\theta\lambda}(\bar{\Theta}; \bar{\Theta}) \frac{\partial \lambda^*(\bar{\Theta})}{\partial \theta} \right) dt.$$

Since $\bar{\Theta}$ is an arbitrary parameter vector, (19) holds for $\bar{\Theta} = \Theta$ as well.

Applying (19) to $\theta = \alpha$ yields

$$\mathcal{L}_{\alpha\alpha}(\Theta; \Theta) = - \int_0^T H_{\alpha\lambda}(\Theta; \Theta) \frac{\partial \lambda^*(\Theta)}{\partial \alpha} dt = - \int_0^T \frac{\partial \lambda^*(\Theta)}{\partial \alpha} dt.$$

By condition (5), $\mathcal{L}_{\alpha\alpha}(\Theta; \Theta)$ is equivalent to

$$\begin{aligned} \mathcal{L}_{\alpha\alpha}(\Theta; \Theta) &= \int_0^T \frac{\partial}{\partial \alpha} \{ \phi [B_q(q^*(\Theta); \beta) - hD_q(q^*(\Theta); \delta)] \} dt \\ &= \int_0^T \phi [B_{qq}(q^*(\Theta); \beta) - hD_{qq}(q^*(\Theta); \delta)] \frac{\partial q^*(\Theta)}{\partial \alpha} dt \\ &= \int_0^T H_{qq}(\Theta; \Theta) q_\alpha^*(\Theta) dt. \end{aligned}$$

Because $H_{qq}(\Theta; \Theta) < 0$, $\mathcal{L}_{\alpha\alpha}(\Theta; \Theta) \leq 0$ implies $\int_0^T -H_{qq}(\Theta; \Theta) q_\alpha^*(\Theta) dt \geq 0$. But note that $\mathcal{L}_{\alpha\alpha}(\Theta; \Theta) \leq 0$ does not imply the sign of the weighted, cumulative effect $x_\alpha^*(\Theta)$. To see this, rewrite $\mathcal{L}_{\alpha\alpha}(\Theta; \Theta)$ using condition (7), as

$$\begin{aligned} \mathcal{L}_{\alpha\alpha}(\Theta; \Theta) &= \int_0^T H_{qq}(\Theta; \Theta) \frac{dx_\alpha^*(\Theta)}{dt} dt \\ &= [H_{qq}(\Theta; \Theta) x_\alpha^*(\Theta)]_0^T - \int_0^T \frac{dH_{qq}(\Theta; \Theta)}{dt} x_\alpha^*(\Theta) dt, \end{aligned}$$

where the term $\frac{dH_{qq}(\Theta; \Theta)}{dt}$ contains third derivatives of $H(\Theta; \Theta)$, the signs of which are ambiguous without imposing further assumptions.

Applying (19) to $\theta = \beta$ yields

$$\mathcal{L}_{\beta\beta}(\Theta; \Theta) = - \int_0^T H_{\beta q}(\Theta; \Theta) \frac{\partial q^*(\Theta)}{\partial \beta} dt = - \int_0^T \phi B_{\beta q}(q^*(\Theta); \beta) q_\beta^*(\Theta) dt.$$

By condition (7), $\mathcal{L}_{\beta\beta}(\Theta; \Theta)$ is equivalent to

$$\begin{aligned}
\mathcal{L}_{\beta\beta}(\Theta; \Theta) &= - \int_0^T \phi B_{\beta q}(q^*(\Theta); \beta) \frac{dx_{\beta}^*(\Theta)}{dt} dt \\
&= - [\phi B_{\beta q}(q^*(\Theta); \beta) x_{\beta}^*(\Theta)]_0^T + \int_0^T \frac{d[\phi B_{\beta q}(q^*(\Theta); \beta)]}{dt} x_{\beta}^*(\Theta) dt \\
&= -\phi(T) B_{\beta q}(q^*(T; \Theta); \beta) x_{\beta}^*(T; \Theta) + \int_0^T \dot{\phi} B_{\beta q}(q^*(\Theta); \beta) x_{\beta}^*(\Theta) dt \\
&= -\phi(T) B_{\beta q}(q^*(T; \Theta); \beta) x_{\beta}^*(T; \Theta) - \int_0^T (r+h) \phi B_{\beta q}(q^*(\Theta); \beta) x_{\beta}^*(\Theta) dt
\end{aligned}$$

where the second equality follows from integration by parts, the third from $B_{\beta qq} = 0$ in Assumption 2.(iii), and the last from the definition of ϕ . Because $B_{\beta qq} = 0$, $B_{\beta q}(q^*(\Theta); \beta)$ does not depend on t and, hence, $\mathcal{L}_{\beta\beta}(\Theta; \Theta) \leq 0$ implies $\int_0^T \phi q_{\beta}^*(\Theta) dt \geq 0$ and

$$\int_0^T (r+h) \phi x_{\beta}^*(\Theta) dt + \phi(T) x_{\beta}^*(T; \Theta) \geq 0.$$

Applying (19) to $\theta = \delta$ yields

$$\mathcal{L}_{\delta\delta}(\Theta; \Theta) = - \int_0^T H_{\delta q}(\Theta; \Theta) \frac{\partial q^*(\Theta)}{\partial \delta} dt = - \int_0^T \phi h D_{\delta q}(q^*(\Theta); \delta) q_{\delta}^*(\Theta) dt.$$

Similar to the result with respect to β , by condition (7), $\mathcal{L}_{\delta\delta}(\Theta; \Theta)$ is equivalent to

$$\begin{aligned}
\mathcal{L}_{\delta\delta}(\Theta; \Theta) &= -\phi(T) h(T) D_{\delta q}(q^*(T; \Theta); \delta) x_{\delta}^*(T; \Theta) \\
&\quad + \int_0^T \frac{d(\phi h)}{dt} D_{\delta q}(q^*(\Theta); \delta) x_{\delta}^*(\Theta) dt.
\end{aligned}$$

As $D_{\delta q}(q^*(\Theta); \delta)$ does not depend on t , $\mathcal{L}_{\delta\delta}(\Theta; \Theta) \leq 0$ implies $\int_0^T \phi h q_{\delta}^*(\Theta) dt \geq 0$ and

$$\int_0^T \frac{d(-\phi h)}{dt} x_{\delta}^*(\Theta) dt + \phi(T) h(T) x_{\delta}^*(T; \Theta) \geq 0.$$

Result with respect to T :

Differentiating (15) with respect to T and evaluating it at $\Theta = \bar{\Theta}$ gives

$$\begin{aligned}
(20) \quad \mathcal{L}_{TT}(\bar{\Theta}; \bar{\Theta}) &= \dot{H}(\bar{T}; \bar{\Theta}; \bar{\Theta}) + H_q(\bar{T}; \bar{\Theta}; \bar{\Theta}) \dot{q}^*(\bar{T}; \bar{\Theta}) + H_\lambda(\bar{T}; \bar{\Theta}; \bar{\Theta}) \dot{\lambda}^*(\bar{T}; \bar{\Theta}) \\
&\quad - \dot{\lambda}^*(\bar{T}; \bar{\Theta}) \dot{x}^*(\bar{T}; \bar{\Theta}) - \lambda^*(\bar{T}; \bar{\Theta}) \ddot{x}^*(\bar{T}; \bar{\Theta}) \\
&\quad - \phi''(\bar{T}) \sigma x^*(\bar{T}; \bar{\Theta}) - \phi'(\bar{T}) \sigma \dot{x}^*(\bar{T}; \bar{\Theta}) \\
&\quad - \phi'(\bar{T}) \sigma \dot{x}^*(\bar{T}; \bar{\Theta}) - \phi(\bar{T}) \sigma \ddot{x}^*(\bar{T}; \bar{\Theta}) - V_{TT}(\bar{\Theta}) \\
&= \dot{H}(\bar{T}; \bar{\Theta}; \bar{\Theta}) - \phi''(\bar{T}) \sigma x^*(\bar{T}; \bar{\Theta}) - 2\phi'(\bar{T}) \sigma \dot{x}^*(\bar{T}; \bar{\Theta}) \\
&\quad - V_{TT}(\bar{\Theta}),
\end{aligned}$$

where the second equality follows from conditions (5)-(9). Recall that

$$(21) \quad V_T(\Theta) = H(T; \Theta; \Theta) - \phi'(T) \sigma x^*(T; \Theta).$$

Differentiating (21) with respect to T and evaluating it at $\Theta = \bar{\Theta}$ gives

$$\begin{aligned}
(22) \quad V_{TT}(\bar{\Theta}) &= \dot{H}(\bar{T}; \bar{\Theta}; \bar{\Theta}) + H_q(\bar{T}; \bar{\Theta}; \bar{\Theta}) \left(\dot{q}^*(\bar{T}; \bar{\Theta}) + \frac{\partial q^*(\bar{T}; \bar{\Theta})}{\partial T} \right) \\
&\quad + H_\lambda(\bar{T}; \bar{\Theta}; \bar{\Theta}) \left(\dot{\lambda}^*(\bar{T}; \bar{\Theta}) + \frac{\partial \lambda^*(\bar{T}; \bar{\Theta})}{\partial T} \right) \\
&\quad - \phi''(\bar{T}) \sigma x^*(\bar{T}; \bar{\Theta}) - \phi'(\bar{T}) \sigma \left(\dot{x}^*(\bar{T}; \bar{\Theta}) + \frac{\partial x^*(\bar{T}; \bar{\Theta})}{\partial T} \right) \\
&= \dot{H}(\bar{T}; \bar{\Theta}; \bar{\Theta}) + H_\lambda(\bar{T}; \bar{\Theta}; \bar{\Theta}) \left(\dot{\lambda}^*(\bar{T}; \bar{\Theta}) + \frac{\partial \lambda^*(\bar{T}; \bar{\Theta})}{\partial T} \right) \\
&\quad - \phi''(\bar{T}) \sigma x^*(\bar{T}; \bar{\Theta}) - \phi'(\bar{T}) \sigma \left(\dot{x}^*(\bar{T}; \bar{\Theta}) + \frac{\partial x^*(\bar{T}; \bar{\Theta})}{\partial T} \right),
\end{aligned}$$

where the second equality follows from condition (5). Substituting (22) into (20) yields

$$(23) \quad \begin{aligned} \mathcal{L}_{TT}(\bar{\Theta}; \bar{\Theta}) &= \phi'(\bar{T}) \sigma \frac{\partial x^*(\bar{T}; \bar{\Theta})}{\partial T} - \phi'(\bar{T}) \sigma \dot{x}^*(\bar{T}; \bar{\Theta}) \\ &\quad - H_\lambda(\bar{T}; \bar{\Theta}; \bar{\Theta}) \left(\dot{\lambda}^*(\bar{T}; \bar{\Theta}) + \frac{\partial \lambda^*(\bar{T}; \bar{\Theta})}{\partial T} \right). \end{aligned}$$

Differentiating condition (9) with respect to T and evaluating it at $\Theta = \bar{\Theta}$ gives

$$\dot{\lambda}^*(\bar{T}; \bar{\Theta}) + \frac{\partial \lambda^*(\bar{T}; \bar{\Theta})}{\partial T} = -\phi'(\bar{T}) \sigma.$$

Therefore, (23) can be rewritten as

$$(24) \quad \begin{aligned} \mathcal{L}_{TT}(\bar{\Theta}; \bar{\Theta}) &= \phi'(\bar{T}) \sigma \frac{\partial x^*(\bar{T}; \bar{\Theta})}{\partial T} - \phi'(\bar{T}) \sigma \dot{x}^*(\bar{T}; \bar{\Theta}) + H_\lambda(\bar{T}; \bar{\Theta}; \bar{\Theta}) \phi'(\bar{T}) \sigma \\ &= \phi'(\bar{T}) \sigma \frac{\partial x^*(\bar{T}; \bar{\Theta})}{\partial T}, \end{aligned}$$

where the second equality follows from condition (7). Since $\bar{\Theta}$ is an arbitrary parameter vector, (24) holds for $\bar{\Theta} = \Theta$ as well. Therefore, $\mathcal{L}_{TT}(\Theta; \Theta) \leq 0$ implies $x_T^*(T; \Theta) \geq 0$.

Finally, since $x^*(T; \Theta) = \int_0^T (q^*(t; \Theta) + \alpha) dt$,

$$\dot{x}^*(T; \Theta) + x_T^*(T; \Theta) = (q^*(T; \Theta) + \alpha) + \int_0^T q_T^*(\Theta) dt$$

and, by condition (7), $\mathcal{L}_{TT}(\Theta; \Theta) \leq 0$ implies $\int_0^T q_T^*(\Theta) dt \geq 0$ as well. ■

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