COUNCIL on FOREIGN RELATIONS

ENERGY REPORT

Oil Security and Conventional War

Lessons From a China-Taiwan Air Scenario

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October 2013

This report is made possible through the generous support of the Alfred P. Sloan Foundation.

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INTRODUCTION

In the past, conventional militaries were plagued by wartime oil shortages that severely undermined their battlefield effectiveness. Both Germany and Japan in World War II found themselves crippled by skyrocketing military fuel requirements that their naturally petroleum-poor territories had no hope of meeting. Fuel supply limitations forced the German army to rely heavily on horse-drawn transportation, resulting in military disaster when the Wehrmacht encountered the highly mechanized Red Army on the eastern front.[1] By 1945, Allied attacks on Japanese oil tankers had so devastated military fuel stockpiles that the Japanese navy retrofitted its fleet to run on coal. Meanwhile, kamikaze attacks were increasingly used as a means of conserving oil because "suicide flight[s]…required fuel for one way only."[2]

Could oil shortages threaten military effectiveness in a large-scale conventional conflict today or in the future? Or are troubles of the kind faced by Germany and Japan things of the past? The answer matters for more than understanding the roots of battlefield performance. As recent research shows, expectations about military and essential civilian fuel needs in wartime influence countries' strategic calculations, and thus their foreign policies.[3] Beyond contributing to Germany and Japan's military defeat in World War II, oil deficiency also profoundly shaped each country's behavior prior to and throughout the conflict. Anticipating wartime oil shortages, Germany invested heavily in alternative fuels and pursued economic alliances with Europe's two largest producers, Romania and Russia. Japan took a more drastic step: it invaded the oil-rich Dutch East Indies and destroyed the U.S. Pacific fleet at Pearl Harbor to eliminate the American naval threat to petroleum shipping. As these cases illustrate, understanding a country's military fuel situation can provide insight into its current and future geopolitical behavior.

Yet wartime fuel requirements are poorly understood. Observers commonly assume that the amount of oil consumed today for military purposes is small compared to production and civilian demand, and thus that wartime shortages are unlikely. But, this assumption has not been subject to rigorous evaluation in the unclassified literature. Closer scrutiny reveals it to be flawed.

This paper analyzes a specific conflict scenario—an air war between the People's Republic of China (PRC) and Taiwan (also known as the Republic of China or ROC)—to enhance broader knowledge about fuel requirements in wartime. (Examining an air war scenario is especially significant because China would have to establish air superiority over Taiwan before any plausible amphibious invasion attempt.) Insight gained from modeling such a conflict makes it possible to provide a rough estimate of potential fuel requirements and assess whether military demand could strain countries' supplies in the present, as it did in the past. If it can, this suggests that oil-deficient countries are likely to pursue foreign policies with an eye toward preserving petroleum access in the event of a crisis or emergency. In addition to the broad implications, modeling fuel requirements in a PRC-ROC war has inherent value because the dispute is one of few flash points that could conceivably draw China into conflict with the United States.[4] The results confirm that oil and fuel supplies could become significant constraints on China and Taiwan in the event of war.

METHODOLOGY: ESTIMATING MILITARY DEMAND IN A CHINA-TAIWAN AIR CONFRONTATION

Analyzing wartime fuel requirements requires making assumptions in the face of uncertainty. Even the most transparent countries, including the United States, avoid divulging military fuel needs. (Although the U.S. Department of Defense releases fuel procurement numbers, these are incomplete because they do not include consumption by contractors and fail to account for oil received as in-kind contributions from allies.[5]) Military planners and policy analysts alike must grapple with this. This paper adopts maximalist assumptions that set a "worst case" ceiling for petroleum demand ("worst case" in the sense that its estimates are of the upper limit of the quantity of oil needed to fight effectively). This is appropriate because "worst case" thinking dominates international politics and especially military planning. It is reasonable to believe that pessimistic assumptions regarding petroleum are most likely to reflect countries' strategic calculations and drive their foreign policies in regards to oil.

To estimate "military demand" for fuel, this paper focuses on the petroleum-based fuel necessary to power military transportation during a period of combat operations. This fuel consists of the gasoline, diesel, bunker oil, and jet fuel burned to create motive energy for vehicles such as trucks, ships, and aircraft. To simplify, this definition of military demand is narrowed to exclude petroleum products used for other purposes, such as lubricants, asphalts, or generator fuel used to produce electricity in the field. It likewise excludes demand by manufacturers within the country's military-industrial base responsible for producing the weapons, machinery, or other goods that lay the broad economic foundation for military power.

The following basic equation is used to estimate demand for military aviation during a PRC-ROC wartime scenario:

(fuel/sortie) x (sortie/day) = fuel/day

FUEL PER SORTIE

To calculate fuel per combat sortie, it is necessary first to determine a likely order of battle for both the People's Liberation Army Air Force (PLAAF) and the Republic of China Air Force (ROCAF). Models of the scenario constructed by RAND Corporation in 2000 and 2009 suggest that China would devote 967 aircraft to a Taiwan air conflict—including the majority of the PRC's most advanced fourth-generation fighters—out of a total PLAAF fleet numbering roughly 2,120 operational combat aircraft, according to U.S. government estimates. This number reflects three operational constraints identified by the RAND authors. First, because China's air force currently lacks a robust capability for in-flight refueling, the PRC could only field aircraft from PLAAF airbases within unrefueled range of Taiwan. ("Unrefueled range" means that an aircraft can travel roundtrip to and from the target without refueling.) Airbase capacity limitations, therefore, play a critical role. Second, the compact size of the operational theater would limit the amount of air traffic that either side could maintain in the skies at one time. Third, PLAAF efforts would be hampered by command and control problems arising from its inexperience with massive air battles. RAND projects that, of the 967 aircraft China could field at any given time taking into account base capacity, command and control issues, and the limited airspace over Taiwan, the PLAAF force would consist of 631 fighters, including 73 Su-30, 116 Su-27, 100 J-10, and 342 J-8 fighters, as well as 336 bombers, including 40 JH-7, 200 Q-5, and 96 H-6 fighters. The ROCAF is projected to deploy 317 aircraft in this scenario, consisting of 132 F-16 fighters, 57 Mirage 2000 fighters, and 128 IDF fighters (see Tables 1 and 2).[6]

For simplicity, assume that the amount of fuel burned per sortie flown is equal to the aircraft's maximum internal fuel load, which varies by aircraft model. What this means is that planes take off with their internal tanks 100 percent full and stay in the air as long as their fuel supplies allow, only returning to base when low fuel levels force them to do so. (This is a maximalist assumption that may slightly overestimate demand because, in practice, some aircraft may return to base with partially filled tanks if they use all of their ammunition before running low on fuel, or because combat damage necessitates repairs.) If instead a plane gets shot down during the mission, its fuel tank is also lost and thus effectively "used."

SORTIES PER DAY

Two factors are of primary importance for determining the number of sorties flown per day: the sortie generation rate and attrition. The RAND studies calculated daily sortie generation rates for each model of Chinese and Taiwanese aircraft, taking into account the roundtrip distance they must travel between base and target, airspace constraints, and the ground time necessary for maintenance and refueling.[7] A sortie rate of 1.0 indicates that the plane is expected to participate in one attack wave daily, whereas a rate of 2.0 means the plane should average two attack waves per day.

Table 1: China-PLAAF Fuel Consumption Analysis

Attrition could reduce the number of sorties, and thus decrease fuel demand, because a plane

Model	Quantity*	Maximum Fuel Consumption, U.S. Gallons**	Sortie Rate***	Daily Sorties****	Total Daily Fuel Consumption, U.S. Gallons
Su-30	73	3,110	2.0	146	454,060
Su-27	116	3,110	2.0	232	721,520
J-10	100	1,308	1.5	150	196,200
J-8	342	1,426	1.0	342	487,692
JH-7	40	1,387	1.0	40	55,480
Q-5	200	964	1.0	200	192,800
H-6	96	11,360	1.0	96	1,090,560
Total	967	-	-	1,206	**3,198,312**
Total Daily Fuel Consumption, Converted to Barrels***					**76,150**

Notes: *Projected by Shlapak et al. 2009, p. 54, as available for a 2013 Taiwan contingency. Excludes helicopters, special forces, and the PLA Naval Air Force.

**Data from *Jane's All the World's Aircraft*, multiple years. Assumes maximum internal fuel load only (no auxiliary external fuel tanks), and no in-flight refueling.

***Estimated by Shlapak et al. 2000, p. 79, accounting for distance from base to target, ground refueling time, and aircraft model.

****Shlapak et al. 2000, p. 75, allows PLAAF forces to surge by 125 percent of the base sortie rate in the campaign's first forty-eight hours. The numbers above do not take this initial surge into account.

*****One barrel equals forty-two U.S. gallons.

destroyed during its mission cannot be used for future attacks. To simplify, however, this analysis assumes attrition will not significantly alter sortie rates—another maximalist assumption that may bias the consumption estimates upward. For the PRC, however, the effect is likely to be small for two reasons. First, China would retain nearly 1,200 additional combat planes that could be deployed forward as necessary to replace losses. After all, the main constraints on PLAAF sorties flown are airbase capacity and the small size of the theater, not the number of combat aircraft in its fleet. Assuming China could move substitute planes from bases in the country's interior into unrefueled range within a day's time, it could maintain full strength in its attack force, at least for all aircraft expected to fly a single sortie per day or for those lost on the final sortie of the day. The sortie rate would dip only when aircraft expected to fly 1.5 or 2.0 sorties daily were shot down during their first trip, thus leaving inadequate time for a replacement to arrive for another sortie on the same day. But this dip would be temporary, as a new plane would come available for combat the following day. Roughly 70 percent of the PLAAF aircraft are projected to fly only one sortie per day. If the one-day turnaround replacement assumption holds, losses to this portion of the force would not affect sortie rates.

The assumption that attrition will not alter sortie generation rates may introduce a larger bias into estimates of Taiwan's jet fuel needs. First, the ROCAF lacks the vast reserve of additional aircraft that China has available for the PLAAF. According to the International Institute for Strategic Studies' *Military Balance 2012*, Taiwan possesses only 501 combat-capable aircraft, excluding helicopters, leaving a reserve force of just 184 planes to replace losses. Second, all Taiwanese aircraft are expected to fly multiple sorties per day, so any losses during a day's first attack wave would reduce the sorties available for the second wave. Consequently, the potential overestimation of Taiwan's jet fuel consumption may be higher than the possible bias in China's demand.

Multiplying the quantity of each aircraft model by its maximum fuel load and sortie rate yields a worst-case estimate of the daily fuel consumption of both the PLAAF and ROCAF forces. By this method, China's Air Force would consume over three million gallons, or approximately 76,000 barrels, of jet fuel for each day of the conflict. Taiwan's daily consumption during such a conflict would be approximately 670,000 gallons of jet fuel, or 15,900 barrels.

Table 2: Taiwan-ROCAF Fuel Consumption Analysis

Model	Quantity*	Maximum Fuel Consumption, U.S. Gallons**	Sortie Rate***	Daily Sorties****	Total Daily Fuel Consumption, U.S. Gallons
F-16	132	1,056	2.0	264	278,784
Mirage 2000	57	1,036	2.0	114	118,104
IDF	128	1,056	2.0	256	270,336
Total	317	-	-	634	**667,224**
Total Daily Fuel Consumption, Converted to Barrels*****					**15,886**

Notes: *Projected by Shlapak et al. 2009, p. 56, as available for a 2013 Taiwan Strait contingency. Excludes helicopters, special forces, and ROC naval air forces.
**Data from *Jane's All the World's Aircraft*, multiple years. Fuel information is unavailable for the IDF, thus the 1,056 gallon fuel capacity of the F-16 is used as they are very similar models. Assumes maximum internal fuel load only (no auxiliary external tanks), and no in-flight refueling.
***Estimated by Shlapak et al. 2000, p. 79. Does not take into account degradation in Taiwan's sortie generation rates due to damage caused by Chinese attacks on Taiwanese air bases.
****Shlapak et al. 2000, p. 75, allows ROCAF forces to surge by 150 percent of base sortie rate in the campaign's first forty-eight hours. The numbers above do not take this initial surge into account.
*****One barrel equals forty-two U.S. gallons.

LENGTH OF THE CONFLICT

The million-dollar question for modeling fuel consumption in a PRC-ROC air war is how many days the conflict would persist. Ideally, the approximation would look like this:

(fuel/sortie) x (sorties/day) x (days/conflict) = fuel/conflict

However, this approach is problematic because the duration of a potential conflict is a political question, and as such, is highly uncertain. Though the RAND studies provide useful estimates for the order of battle and sortie generation rates, they do not offer predictions about how long a China-Taiwan air war would last. To determine the likely victor in the scenario, the RAND studies use a decision threshold for who "wins" air superiority by comparing the loss ratios between sides with the initial force size ratio. (The initial force size ratio is simply the proportion by which one side outnumbers the other at the war's start. Loss ratios represent relative rates of attrition. For example, a loss ratio of 2:1 favoring Taiwan would mean that two Chinese aircraft were shot down for each Taiwanese plane destroyed.) In the RAND studies, as soon as one side achieved a loss ratio 1.5 times the initial force ratio, that side was deemed the "winner." For example, if China's initial force size advantage was 3:1, Taiwan would "win" as soon as it attained a 4.5:1 loss ratio in its favor—even if China still had hundreds of planes left to fly. Across hundreds of simulations, RAND observed that one side or the other usually fought well enough to attain a "winning" ratio after just four days of fighting. Yet, this does not indicate that the conflict actually would wrap up so quickly. The four-day campaign length "should not be interpreted as suggesting that one or the other side is likely to give up after a few days of pitched fighting," the RAND authors caution, because "if Taiwan were left to stand alone against the mainland, China would stand a relatively good chance of grinding down the ROC's defenses in a protracted war of attrition."[8]

In fact, the four-day window should be viewed with skepticism. It is driven by exceptionally high attrition rates of 30 percent per PLAAF sortie and 15 percent per ROCAF sortie, yielding a total conflict attrition rate of 75 percent of China's force and 45 percent of Taiwan's force across a four-day span. These rates are peculiar by historical standards. On its worst day of the 1973 Arab-Israeli War, the Israeli Air Force experienced an attrition rate of 4.5 percent, losing 108 aircraft in the course of 7,290 sorties—and this was considered high.[9] With more modest attrition rates in line with historical standards, the conflict could drag on for a significantly longer period. Nevertheless, even if one side clearly had a losing trajectory after just four days, it might press on. The decision to end the conflict is ultimately a political one, and there is no reason to believe it would correspond with the decision threshold RAND uses.

Recognizing that the conflict's duration is highly uncertain, the analysis approaches the question in a way that allows it to remain agnostic as to how long the confrontation might last. It does this by determining each belligerent's supply of jet fuel and asking, "For how many days could China and Taiwan sustain military operations, given the likely amount of jet fuel available to each?" To answer the question, this paper compares daily military consumption to daily jet fuel supply, estimating the latter below.

GAUGING AVIATION FUEL SUPPLY RELATIVE TO EXPECTED DEMAND

How does the daily military demand for jet fuel compare to each country's ability to supply it? As long as China and Taiwan retain access to international petroleum markets, they could buy plenty of jet fuel to prosecute the air war. Globally, refiners produce roughly five million barrels of jet fuel per day, of which 1.3 million barrels are exported, dwarfing the daily military needs of both countries.[10]

However, nations cannot take for granted that they will be able to purchase oil freely from global markets—particularly during a war—and cross-strait conflict between China and Taiwan could disrupt international trade to the belligerents in a variety of ways. For instance, the PRC might seek strategic advantage by imposing a blockade that severs or sharply reduces Taiwan's petroleum imports. Such an aggressive move by China could spur U.S. intervention on behalf of Taiwan, but Taipei would be reckless to bank on an American rescue as its sole hope of withstanding a Chinese blockade. At the same time, Chinese leaders clearly worry that the United States could use its naval supremacy in a showdown over Taiwan to close critical sea lanes, such as the Strait of Malacca, through which 80 percent of China's petroleum imports travel.[11]

Unfettered access to the global petroleum market represents the best-case supply scenario for China and Taiwan. Yet, to fully understand the situation each country confronts, examining the worst-case scenario is equally important. What if China and Taiwan had to rely strictly on within-country supplies of petroleum for the air war? In the absence of market access, could either nation achieve self-sufficiency in jet fuel? China and Taiwan could likely meet military demand from domestic sources for a significant period of time. However, civilian fuel consumption would suffer severely—particularly in China. The PRC could fuel an air war against Taiwan indefinitely, but only at the cost of slashing civilian jet fuel consumption by as much as 75 percent. This would mean serious reductions in airfreight volumes as well as in passenger travel.

TAIWAN'S SUPPLY SITUATION

Taiwan lacks natural petroleum reserves and produces only negligible amounts of crude oil. Therefore, in a worst-case scenario in which the country could not import petroleum, its demand would have to be met entirely by commercial and government stockpiles. Sharply aware of its energy vulnerability, Taiwan mandates that the oil industry and government maintain strategic reserves totaling no less than sixty and thirty days' supply, respectively, although the consistency with which Taiwan's government and private refiners observe the law remains unclear. Reports over the years suggest that compliance is uneven. In December 2002, a military expert estimated that the total stockpile would last only thirty days against a Chinese blockade—not the 120 days the government claimed was available at the time.[12] A similar incident occurred in March 2008, when the media reported oil stocks had fallen to only twenty days of supply.[13] Nevertheless, the analysis here assumes that Taiwan's government and private enterprises comply with the mandatory minimums, though it is impossible to verify that this is actually the case.

For commercial stockpiles, the law requires that domestic refineries maintain security reserves of "no less than sixty days supply…based on the average domestic sales and private consumption of the past twelve months."[14] The law does not explicitly specify whether these stockpiles should consist of crude oil, finished products, or a combination of both. However, because crude oil is neither sold domestically nor consumed directly, a sixty-day supply based on private sales and consumption would be zero. This analysis therefore assumes that these stockpiles contain sixty days' worth of petroleum products. Further strengthening this assumption is the fact that the Chinese Petroleum Corporation (CPC), which had a national oil monopoly in Taiwan until Formosa Petrochemical Corporation (FPCC) entered the market in 2000, historically held its sixty-day emergency stockpile in petroleum products.[15] In 2011, Taiwan consumed about 1.5 million total barrels of jet fuel, or roughly 4,200 barrels per day, amounting to a legally required commercial jet fuel inventory about 250,000 barrels strong.[16] Although adequate for two months of civilian aviation consumption, military demand for an air war with China resembling the one modeled above would exhaust commercially held reserves in just sixteen days. If Taiwan attempted to meet the 4,200 barrels of normal civilian demand in addition to the 15,866 barrels of military consumption, commercial stocks would last for only twelve days.

Taiwanese law additionally requires the government to maintain strategic reserves totaling at least thirty days of normal domestic consumption. Taiwan consumed approximately 287 million barrels of petroleum products in 2011, and thus a thirty day stockpile held by the government should total approximately twenty-four million barrels.[17] The murky language of Taiwan's Petroleum Administration Act leaves the ratio of crude oil to petroleum products unclear. However, it is known that the government tendered 1.6 million barrels of finished jet fuel between 2004 and 2007 from Taiwan's two refining companies, CPC and FPCC.[18] Subsequent contracts with CPC and FPCC for filling the reserve suggest that crude oil comprises roughly 50 percent of the stockpile, or about twelve million barrels.[19] Holding strategic reserves in crude is advantageous because of its flexibility; petroleum held as crude could be refined into various products to meet needs in response to strategic contingencies. (Crude is also less flammable.) This paper assumes that the remaining ten million barrels in the stockpile are neither jet fuel nor crude oil, instead representing other finished products such as gasoline, fuel oil, and diesel.

The national crude oil stockpile, therefore, represents an additional source of potential jet fuel available in a crisis. Just how much jet fuel could the ROC produce from these twelve million barrels of government-held crude oil? Taiwan has four major refineries with a combined daily capacity of 1.3 million barrels.[20] In 2010, these refineries produced about 28 million barrels of jet fuel from a total refinery input of about 320 million barrels of crude, amounting to a jet fuel yield of 8.8 percent.[21] This rate implies that Taiwanese refiners could produce a minimum baseline of roughly 1.1 million barrels of jet fuel from the government stockpile over a nine-day span, if they made no refinery adjustments and the refineries continued to operate undamaged (the extent to which bombing could disable refineries is discussed below).

There is some possibility that refinery reconfiguration could increase yield, though the gains would be small. In a national security crisis, the government almost certainly would intervene and order refiners to boost jet fuel yield as much as possible, regardless of cost. Physical boundaries, however, would constrain refiners' ability to ratchet up yields. The highest possible yield of jet fuel obtainable from crude feedstock is about 30 percent. This figure represents a physical constraint—i.e., the mix of hydrocarbons naturally present in the crude oil—as opposed to a marginal cost constraint.[22] As a point of comparison, average jet fuel yield from U.S. refineries was 12 percent in 2011. According to the Energy Information Administration (EIA), annual jet fuel yield for refineries configured to maximize jet fuel capacity did not surpass 29 percent that year, though the exact amount varies depending on the quality of the crude feedstock.[23] Taiwanese operators, however, could not attain the maximum in an acceptable time frame. In Taiwan's case, hitting the 30 percent ceiling would mean tripling jet fuel yields. Yet wiggle room for upping yields with existing equipment is limited. To achieve a large boost, refineries would have to install new cracking equipment, which would require going off-line for a period of weeks or months. Delta Air Lines' experience since buying an oil refinery in May 2012 is instructional in this regard. Delta set ambitious initial projections of doubling the refinery's jet fuel yield from 14 percent to 32 percent, generating industry skepticism. The airline expected to hit the 32 percent target by investing $100 million in refinery upgrades to be completed within three months of closing the deal. As of June 2013—nearly a year into the project—Delta's refinery yield has not broken 22 percent.[24] It is highly unlikely that the ROC government would halt jet fuel production—essential for even the prospect of ultimately obtaining very high jet fuel yields—during an air war with China.

Assuming generously that Taiwan could boost jet fuel yields immediately to 10 percent in a crisis, it could produce 1.2 million barrels of jet fuel from its government crude stockpiles in a nine-day span. Added to the 1.85 million barrels of government and commercial stocks already held in jet fuel, Taiwan possesses an effective jet fuel reserve stockpile of about three million barrels.

As Table 3 shows, Taiwan's total stockpile from government and commercial sources could provide 732 days, or about two years, of civilian consumption. Such an amount is beyond adequate for a plausible emergency scenario, assuming there is no active military component. Factoring in military demand, however, causes the days of available supply to drop precipitously. In an air war such as the one modeled above, Taiwan could supply 100 percent of military needs and 100 percent of civilian needs for 152 days, or about five months—still a solid emergency cushion, though a much smaller one. Given that Taiwan is unlikely to need to fend for itself for civilian purposes alone for nearly two years, its stockpiling program strongly suggests that the country estimates its needs with military contingencies firmly in mind.

Table 3: Taiwan's Jet Fuel Supply and Demand

Reserve Type	Jet Fuel, in Barrels	Civilian Jet Fuel Demand Only, Days	Military Jet Fuel Demand Only, Days	Civilian and Military Jet Fuel Demand, Days
Commercial Stockpiles Held as Jet Fuel	250,000	60	16	12
Government Stockpiles Held as Jet Fuel	1,600,000	384	101	80
Potential Jet Fuel Refined From Government Crude Stocks (Assuming 10 Percent Yield)	1,200,000	288	76	60
Total Effective Jet Fuel Stockpiles	**3,050,000**	**732**	**192**	**152**

Source: Author's calculations; data from *Taiwan Energy Statistics Handbook 2011*; *Platt's Oilgram Price Report; Platt's Oilgram News; Formosa Petrochemical Corporation and Subsidiaries Consolidated Financial Statements for the Years Ended December 31, 2010 and 2011.*

CHINA'S SUPPLY SITUATION

Despite becoming a net petroleum importer in the early 1990s, China produces a significant quantity of crude oil on its territory. Its daily output of 4.2 million barrels in 2012 makes it the fourth-largest petroleum producing nation in the world.[25] As recently as 2008, China lacked a strategic petroleum reserve, but a major buildup of government stockpiles is currently under way. Although the Chinese government aims to amass five hundred million barrels worth of crude in its reserve by 2020, the current stockpile is believed to contain little more than one hundred million barrels. Experts have estimated that commercial stockpiles in China amount to two hundred million barrels, creating a total reserve supply of three hundred million barrels.[26] China has the refinery capacity to process 10.8 million barrels of crude oil per day.[27]

CHINA'S JET FUEL SUPPLY

How much jet fuel could China produce on its own territory, and how does this compare to military and civilian demand? First, consider the quantity of fuel China could supply if it could refine only its indigenous crude production of 4.1 million barrels daily. In 2011, Chinese refineries processed about 3.3 billion barrels of crude feedstock to produce about ninety million barrels of jet fuel.[28] This amounts to a jet fuel yield of 2.8 percent. At this rate, China could produce at least 113,000 barrels of jet fuel daily from its indigenous crude production of 4.1 million barrels per day, assuming no refinery adjustments. However, as in the case of Taiwan, China's government would likely step in and order operators to boost jet fuel yield for national security purposes. For the same reasons discussed above, refineries could not significantly increase jet fuel yield without interrupting production to refurbish their facilities—an outcome that Chinese leaders would find unpalatable. Assuming China could boost yield to 4 percent immediately (to give China the same leeway as Taiwan), potential daily jet fuel production from indigenous crude feedstock would rise to 164,000 barrels. Thus, from indigenous sources alone, China could accommodate its daily military requirement of roughly 76,000 barrels indefinitely. (This means, though, that military needs would consume nearly half of domestic production.) However, it would fall far short of requirements for domestic civilian aviation, which consumed roughly 340,000 barrels of jet fuel daily in 2011, and even shorter for combined military and civilian demand of about 416,000 barrels.[29] Assuming China would maintain military consumption at 100 percent in an air war, civilian consumption would have to be cut by 252,000 barrels of jet fuel daily—in other words, by nearly 75 percent.

Table 4: China's Jet Fuel Supply and Demand

Source	Jet Fuel, Barrels per Day
Indigenous Crude Production	164,000
Military Demand	76,000
Civilian Demand	340,000
Military and Civilian Demand	416,000
Daily Supply Deficit	**(252,000)**

Source: Author calculations; data from *Platts Oilgram Price Report*; *BP Statistical Review of World Energy 2012;* Shlapak et al. 2000; Shlapak et al. 2009; and *Jane's All the World's Aircraft*.

To decrease the deficit, China would almost certainly draw down oil from government and commercial stockpiles to supplement its domestic jet fuel production. For how many days could China meet both 100 percent civilian and 100 percent military demand of jet fuel? Assuming that 252,000 barrels of jet fuel per day had to be produced from stockpiles to zero out the fuel deficit, government stockpiles would run out in sixteen days, with total stockpiles being exhausted within forty-eight days. In other words, China could plug its supply deficit for roughly 1.5 months before exhausting its fuel reserves. After this time, China would be forced to cut civilian consumption by nearly 75 percent to meet its military demand, or else face major degradations in combat effectiveness.

Table 5: China's Daily Supply and Demand, Indigenous Oil and Stockpiles

Reserve Type	**Total Crude, in Barrels**	**Potential Jet Fuel Refined From Crude Oil Stocks, in Barrels (Assuming 4 Percent Yield)**	**Number of Days That Combined Supply Could Be Met 100 Percent**
Government Crude Stockpiles	100,000,000	4,000,000	16
Commercial Crude Stockpiles	200,000,000	8,000,000	32
Total Crude Stockpiles	**300,000,000**	**12,000,000**	**48**

Source: Author's calculations; and data from the *Wall Street Journal*.

Of course, China is unlikely to supply both military and civilian aviation at 100 percent for forty-eight days, only to slash civilian consumption by 75 percent on day forty-nine. To blunt the economic disruption caused by a sudden cut of such magnitude, the PRC would probably ration civilian supplies to stretch them out as long as possible. How much could the Chinese government reduce civilian consumption in such a scenario? There is always some bare minimum of essential civilian needs that must be met to keep a country functioning. What that bare minimum would be for China's case is unclear from both a technical and political standpoint. An analysis of how much civilian consumption could be diverted without causing severe damage to the economy is beyond the scope of this study. But it is noteworthy that whatever the essential number is—50 percent? 60 percent?—a separate, and perhaps decisive, question is whether Chinese citizens would tolerate it.

Some nationalistic populations have accepted even severe economic privations when vital national interests were at stake. In World War II, the Japanese public remained supportive of the government up until—and even after—it surrendered, even though war imperatives had squeezed nonmilitary oil consumption in 1944 down to only 3 percent of what it was in 1940.[30] On the other hand, observers often argue that the political legitimacy of the Chinese regime hinges less on nationalism than on the country's rapid economic growth.[31] Although it is unclear how politically destabilizing large declines in prosperity could be, China's leaders have an incentive to avoid getting stuck between a military rock and a political hard place. In this context, China's efforts to increase its strategic petroleum stockpile make sense.

DAMAGE TO FUEL PRODUCTION AND STORAGE FACILITIES

Until now, the above analysis has assumed that refineries and stockpiles would remain intact throughout the conflict. For China, such facilities would probably continue to operate relatively unscathed; the country has twenty-one large-scale oil refineries spread all across the country—thus making it unlikely that the ROCAF could attack more than a fraction of them.[32] Taiwan, however, possesses a mere four refineries on a territory roughly the size of Maryland. These would make tempting targets for Chinese missiles, as might Taiwanese fuel stockpiles.

The threat to Taiwan's oil infrastructure depends on many factors, including the accuracy of Chinese weapons and the quality of Taiwanese air defenses. Although a full analysis of this threat lies beyond the scope of this paper, recent conflicts suggest such facilities could be highly vulnerable to military force and require months to rebuild. Iraq and Iran targeted each other's oil refineries during the 1980–88 Iran-Iraq War, causing significant damage. Iraq's Basra oil refinery, which was heavily damaged in the conflict, required three months of repairs to reopen at half its prewar capacity. Meanwhile, it took Iran five months of "around-the-clock" reconstruction to restore Abadan, the country's largest oil refining facility, to just 20 percent of its prewar output. Similarly, Iraqi sabotage of Kuwait's oil refineries during the 1991 Persian Gulf War was so extensive that the country's premier facility, the Mina al-Ahmadi refinery, could only resume production after six months of rebuilding—even with help from American contractors such as Halliburton.[33]

These examples suggest that Taiwan's oil security in a conflict with China hinges upon its ability to defend refineries and stockpiles. If China were to destroy them, Taiwan's jet fuel supply would be more than strained; it would be nonexistent, with devastating results for Taiwanese airpower. Depending on the political circumstances that precipitated the war, such a situation could trigger American intervention, if for no other reason than to resupply Taiwan.

CONCLUSIONS

Several important implications arise from these results. Most broadly, the analysis suggests that military demand for petroleum products during a major conventional conflict is significantly larger than commonly assumed—and potentially large enough to strain supplies, particularly when civilian demand is figured in. Both China and Taiwan face a tighter wartime fuel supply situation than default assumptions about military consumption would suggest. PLAAF requirements in the air war scenario are sizeable; military demand alone totals 76,000 barrels of jet fuel daily, which would eat up nearly half of China's projected 164,000 barrels of indigenous jet fuel production. This figure is remarkable given that China is the fourth-largest petroleum producer in the world.[34] By drawing down from its stockpiles, China could meet full military and civilian needs for about a month and a half, after which it would have to slash its civilian consumption of 340,000 barrels daily by about seventy-five percent to meet military requirements. Taiwan's daily military jet fuel demand is almost 16,000 barrels—nearly four times larger than its civilian consumption of 4,200. If Taiwan could protect its oil refineries and strategic reserves in a war with China, it could meet all of its combined military and civilian jet fuel needs in an air war for five months—about three times longer than China could. However, the vulnerability of Taiwan's oil facilities to attack potentially undermines this advantage.

The analysis also emphasizes the value of anticipatory measures, particularly stockpiling and air defense, for bolstering national security in an emergency. In particular, military fuel requirements should not be overlooked. Although petroleum stockpiles are often measured according to how many days' worth of normal civilian demand they can fulfill, the more important factor may be the number of days they can provide of *emergency* demand—taking into account military scenarios that may push overall requirements significantly above peacetime consumption.

The potential strain on both countries' fuel supplies may encourage them to pursue foreign policies that would bolster oil access in a worst-case conflict scenario. This is unsurprising for Taiwan, which has no crude oil resources to speak of, and has already stocked its strategic oil reserves with military contingencies in mind. It is surprising for China, though, given its domestic petroleum resources. China could produce enough jet fuel indigenously to prosecute an air war with Taiwan indefinitely, but not without risking political consequences to the Communist Party. This finding casts a new light on China's "going out" initiatives to secure petroleum through equity oil arrangements and closer ties with exporters like Saudi Arabia. Already China has built overland pipelines to Kazakhstan, which diversifies its petroleum transit routes away from reliance on the Strait of Malacca. Additionally, it is building a commercial port that some speculate may later lead to further naval facilities in Gwadar, Pakistan (just outside the Persian Gulf) and developing infrastructure for overland trade to the Middle East.[35] If Beijing truly fears the prospects of a U.S. naval blockade during a war with Taiwan, such efforts are likely to increase.

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