

*Working Paper*

## **China's Evolving Oil Demand Slowing Overall Growth, Gasoline Replacing Diesel as Demand Driver, Refined Product Exports Rising Substantially**

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## Executive Summary:

- **Three key factors characterize the “new normal” of China’s oil demand:** (1) overall annual oil products demand growth will likely slow from an average of nearly 5% annually to one closer to 2.8% between now and 2020; (2) the country’s oil demand profile has become primarily gasoline-driven, and (3) oil refinery overcapacity is making China one of the world’s largest net exporters of refined products, a trend likely to continue looking out to 2020.
- *In 2016, China’s incremental crude oil demand will likely increase by approximately 360 kbd—roughly the average daily consumption of the Philippines.*
- *China’s oil demand is becoming increasingly consumer-driven. Gasoline has become the prime mover of China’s oil demand as car ownership rises and industrially-driven diesel use declines. Rising domestic air travel has also significantly increased kerosene demand, although the macro impact is not nearly as large as that of gasoline.*
- *Consumer-driven oil demand is likely to be significantly more volatile in the short-term. Consumer sentiments and behavior evolve and shift much more rapidly than China’s traditional oil demand pattern, which was underpinned by industrial diesel fuel use and was closely tied to the 5-Year Plans. Greater demand-side volatility in China stands to have profound effects on the global crude oil and refined products markets—particularly if the Chinese government does not become more regular and transparent in its disclosures of energy data. Better disclosure would reduce market participants’ need to speculate as to the true state of supply and demand balances within the Chinese oil ecosystem. This in turn would help smooth the spikes as prices respond to market fundamentals, benefitting producers and consumers.*
- **Three core “wild cards” merit close attention over the next five years** for their ability to influence China’s oil demand trajectory: (1) road congestion that may reduce vehicle use despite continuing strong sales of new cars, (2) penetration of more efficient gasoline-powered vehicles and electric vehicles as China’s growing middle class pushes back against severe air pollution in many cities, and (3) the degree to which an increasingly brittle Chinese political leadership can craft successful, sustainable solutions to multi-dimensional economic policy challenges.
- *Policymaking missteps that accelerate declines in China’s economic growth rate would substantially enhance the risk that prices continue to trade in a narrow band. Currently, the most likely scenario is that a slowing—but still relatively oil-thirsty—Chinese economy combines with deep global CAPEX cuts and marginal costs of new supply exceeding \$65/bbl to yield a global benchmark crude oil price range averaging \$60-70/bbl between now and 2020.*

## I. China's Oil Demand Will Remain Influential Even as the Global Market Remains Oversupplied

China's economic growth trajectory of the past 15 years appears to be at an inflection point. As the country's high annual oil demand growth rate downshifts to a slower one, market perceptions put downward pressure on oil prices. Indeed, the carnage in global oil markets over the past 24 months has come about in part because China's slowing growth in its real economy and energy consumption coincided with a rapid increase in unconventional oil supplies. China's economic slowdown—and the commensurate deceleration of the oil demand growth rate—is in many ways natural. The economy must grow off a much higher base than was the case ten, five, or even two years ago. Independent of the base effects, oil intensity per unit of economic output is also decreasing as the economy gradually favors service, consumer, and light industrial activity (more on this in Section II, below).

A key downside risk to global oil prices is that recent internal political developments exacerbate the risk of an economic hard landing, which could depress China's oil demand growth much more rapidly than the structural economic trends mentioned above. To that point, it bears noting that China's leadership currently grapples with a degree of policy disunity not seen in the PRC's upper echelons of government since at least the late 1980s.<sup>1</sup>

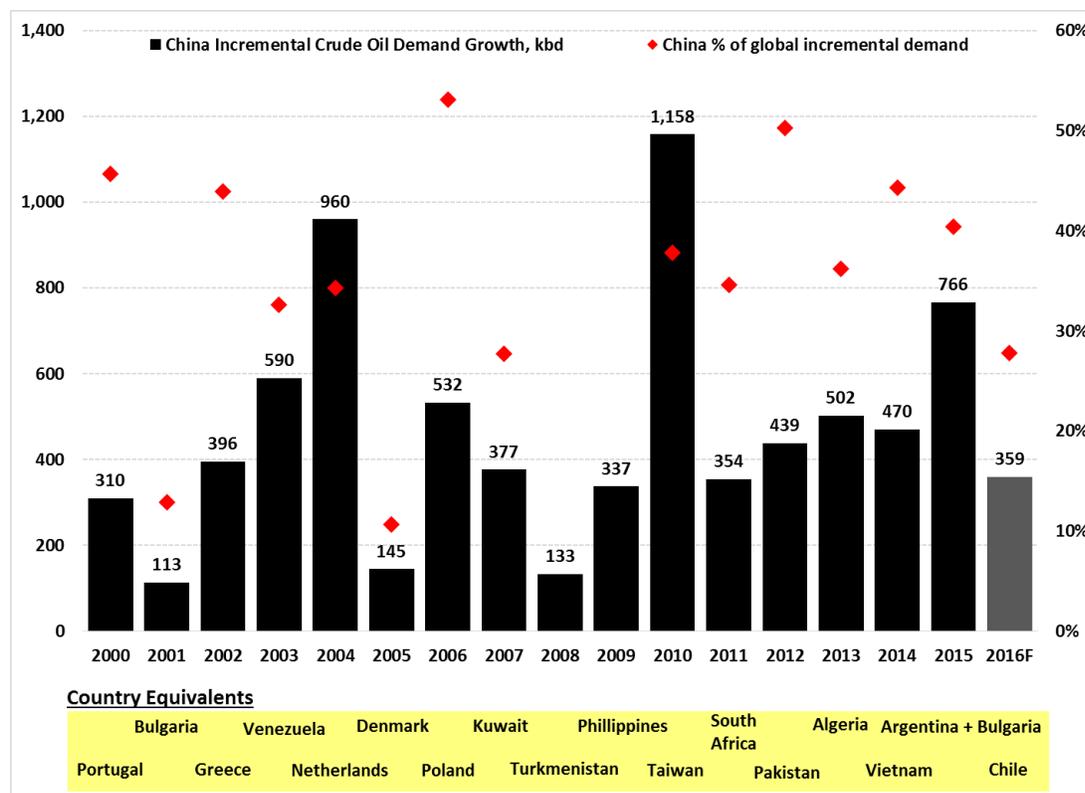
A more sustained China oil demand slowdown would be a serious headwind for prices given the country's inexorably increasing importance as the global oil markets' "consumer of last resort." China accounted for approximately 43% of global incremental oil demand growth between 2009 and 2015 (**Exhibit 1**). This demand growth helped underpin global oil prices despite overall weakness in the global economy. To put China's annual incremental oil demand growth during this period into perspective, China's incremental crude oil demand in 2009 grew by 275 kbd—roughly the daily consumption of the Philippines and by 1,158 kbd in 2010, roughly the daily consumption of Taiwan, one of the world's most industrialized economies.

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<sup>1</sup> Lingling Wei and Jeremy Page, "Discord Between China's Top Two Leaders Spills Into the Open," The Wall Street Journal, 22 July 2016, <http://www.wsj.com/articles/discord-between-chinas-top-two-leaders-spills-into-the-open-1469134110>

## Exhibit 1: Chinese Incremental Demand Powered Global Oil Prices Over the Past Decade

Left axis: incremental oil demand growth (kbd), Right axis: China's % of global incremental oil demand growth



Source: BP, IEA, Author's Analysis

As Chinese oil demand ramped up, it impacted prices on two inter-related fronts. First, China's growing thirst for crude directly increased global crude prices. Second came the demand increases in commodity-producing (e.g., iron, copper, etc.) countries whose economies were riding high on the back of robust Chinese demand for raw materials. Indeed, the five regional groupings that account for the majority of commodity exports to China (MENA, Latin America, Southeast Asia, Former Soviet Union, and Sub-Saharan Africa), accounted for roughly 10.5 million barrels per day of oil products demand increase between 2000 and 2015—1.6 times the amount that China's own oil products demand grew by during that time.<sup>2</sup>

The global oil market currently labors under: (1) a continued supply overhang from bloated global crude and refined products inventories and (2) burgeoning production from OPEC members seeking to gain market share and pay for expansive military campaigns and domestic political support (Saudi Arabia and Iraq) and those seeking to rejoin the global oil market (Iran). Russia

<sup>2</sup> Calculated from BP Statistical Yearbook 2016 Data, Original concept drawn from Gabe Collins, "How Extensively Could China's Slowdown Impact Global Oil Prices?," China Oil Trader™, No. 1 (23 May 2012), <http://www.chinaoiltrader.com/?p=37>

also continues to robustly increase production as Russian E&P companies capitalize on lower service costs—roughly 80% of which are priced in devalued rubles—while oil exports are priced in more valuable dollars, and as the Kremlin continues to encourage activity in one of its few globally competitive industries.

A reduction in China’s oil demand growth rate from roughly 5% annually over the past five years to 2.8%—which is this author’s base case outlook for China’s crude oil demand growth over the next five years—would cast a pall over oil prices. Data from the BP Statistical Review of World Energy 2016 shows that only five of the 10 largest global oil consuming countries by volume actually saw positive demand growth in 2015, despite the lowest average oil prices in a decade.<sup>3</sup> These 10 countries collectively accounted for 60% of global crude oil demand in 2015. The five large consumers who experienced growth in demand during 2015 were (in order of demand growth): China, India, the U.S., Saudi Arabia, and South Korea. China’s 2015 oil demand growth according to the BP data came in at 766 kbd: nearly 30% higher than the incremental growth of India and the U.S. combined and basically equal to the combined incremental demand growth of the U.S., India, and Saudi Arabia.

Here it is worthwhile to zoom in on India, which some analysts view as having the potential to offset China’s slowing oil demand growth.<sup>4</sup> Using the BP data as a baseline, consider that 6.0% annual demand growth between 2016 and 2020 would mean Indian oil demand growth averaging 281 kbd. Raising the average annual demand growth rate to 8.0%—an optimistic assumption given that the Indian government likely cannot unleash an infrastructure and heavy industrial boom on the scale of what China has done—would raise average Indian oil demand growth to 390 kbd between 2016 and 2020. For reference, China’s annual incremental oil demand growth has averaged nearly 475 kbd over the past decade. This suggests that even in a high-growth scenario, India’s incremental oil demand would struggle to offset the combination of a significant Chinese demand slowdown coupled with continued structural decline in Eurozone oil use and the worldwide phase-in of more fuel-efficient automobiles.

China’s massive incremental demand growth contribution and the relative lack of a positive demand response to low crude prices in other major consuming countries suggests that even with lower crude prices, other consumers may not be able to compensate for a significant demand slowdown in China. As such, absent significant lost production from deferred and cancelled upstream CAPEX expenditures, a slowing China would substantially enhance the risk that prices of \$45-50/bbl could become a “new normal” for the global Brent and WTI crude oil benchmarks.

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<sup>3</sup> The BP Statistical Review of World Energy calculates demand using the following formula: Inland demand plus international aviation and marine bunkers and refinery fuel and loss. Consumption of biogasoline (such as ethanol), biodiesel and derivatives of coal and natural gas are also included.

<sup>4</sup> See, for instance: Amrita Sen and Anupama Sen, “India’s Oil Demand: On the Verge of ‘Take-Off’?,” March 2016, The Oxford Institute for Energy Studies, pdf available for download at <https://www.oxfordenergy.org/publications/indias-oil-demand/>.

At this point, perhaps the most likely scenario is that a slowing—but still relatively oil-thirsty—Chinese economy combines with deep global CAPEX cuts and marginal costs of supply of around \$65/bbl to yield a global benchmark crude oil price range averaging \$50-65/bbl between now and 2020. This price view draws heavily upon global liquids supply cost data published in late 2015 by Rystad Energy, as well as recent data from the IEA showing that global upstream oil and gas investment fell 25% in 2015, is expected to decline by an additional 24% in 2016, and could continue falling through 2017, which would mean an unprecedented three consecutive years of industry investment cuts.<sup>5</sup>

Chinese oil refineries currently take in, on average, more than 10 million barrels per day of crude oil, and during peak demand periods in summer 2015 ran nearly 12 million barrels per day. These figures come from the Joint Oil Data Initiative (“JODI”) and reflect the intake of crude oil that is actually destined to be converted into products.<sup>6</sup> The numbers’ reflect the Middle Kingdom’s hefty and growing crude oil demand role: in 2000, China accounted for 5.8% of global crude oil demand. By 2015, that figure exceeded 12%—roughly one in every eight barrels used worldwide.

Against this backdrop, it becomes clear why oil producers, traders, consumers, and other parties with exposure to the global crude oil value chain seek to better understand the potential trajectories of oil consumption in China over the next three to five years. China’s oil demand ecosystem is immense and complicated, and in many ways, still quite opaque. The study adapts to these realities by focusing not on providing an encyclopedic overview, but rather, identifying and then investigating key “influence factors” that are coming to drive China’s oil demand, and are likely to do so in the next five to ten years as well.

Simply watching broad high-level flows such as imports or refinery crude intake only tells a partial story. Barrels may flow into a refinery—or into strategic storage. Barrels may flow into a refinery, but then be processed into diesel fuel that is exported. Or they may be turned into gasoline to power the country’s more than 120 million passenger vehicles, the vast majority of which are gasoline-fueled.

To tease out the underlying trends, this analysis employs a range of data sources and techniques—including local Chinese language media, company data, and official statistics from

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<sup>5</sup> “GLOBAL LIQUIDS COST CURVE (OCTOBER 2015),” Rystad Energy, <http://www.rystadenergy.com/NewsEvents/PressReleases/global-liquids-supply-cost-curve>; See also Benoit Faucon, “Oil, Gas-Field Investment Set to Fall for Two Straight Years, IEA Report Says,” The Wall Street Journal, 13 September 2016, <http://www.wsj.com/articles/oil-gas-field-investment-set-to-fall-for-two-straight-years-iea-report-says-1473795274>

<sup>6</sup> “Refinery Intake,” JODI-Oil World Database - Full Version (Primary Products Table), <http://www.jodidb.org/TableViewer/summary.aspx> (accessed 1 August 2016). The caveat matters. In the first 11 months of 2015, purchases of crude oil slated to fill China’s growing strategic petroleum reserve (“SPR”) boosted the country’s apparent crude oil intake by more than 440 kbd—roughly the average daily crude oil use of Pakistan. This study focuses on “demand” in the sense of barrels of oil that are actually broken down in a refinery, burned, or otherwise physically transformed. As such, it does not address China’s SPR, which stores—but does not transform—crude.

the local, provincial, and national levels. Where at all possible, the study employs independent data sources, since official Chinese energy statistics frequently fail to provide the granularity, regularity, or reliability necessary to draw analytically useful conclusions.<sup>7</sup>

## II. Key Macro-Level Factors Influencing Oil Demand in China

Three themes dominate the macro-level oil demand picture in China. First, China's oil demand growth rate is clearly slowing in both percentage and absolute volume terms. Yet even if China moves onto a slower growth trajectory, the baseline numbers are now large enough that even a slower annual percentage growth rate can still yield significant absolute oil demand volume increases each year.

Second, China's oil demand structure is currently at a transition point. Transportation demand is now transitioning to a gasoline-driven structure as passenger vehicles increasingly supplant diesel-powered trucks and industrial machinery as a source of incremental fuel demand. Third, the country's heavy industrial sector is stagnating and declining as a proportion of national economic output. As factories run at lower utilization rates, miners dig and transport less coal and iron ore, and fewer goods are trucked from factory to port, diesel fuel demand—which is heavily leveraged to industrial activity—suffers a commensurate demand impact.

### Theme 1: China's Oil Consumption Is Fundamentally Transportation Driven

Gasoline is now taking over from diesel fuel as the baseline driver of oil demand in China. Diesel fuel use is distinctly seasonal, with intra-year variations between the spring "trough" and winter "peak" of as much as 1,500 kbd (**Exhibit 2**). Diesel use has also stagnated since the winter of 2010/11 and contracted in each of the past two years, with a 3.7% YoY decline in diesel demand during 2015.<sup>8</sup> Gasoline demand, in contrast, rose 7% YoY in 2015, mirroring the sharp and sustained rise in passenger car sales that has characterized much of the past decade in China.<sup>9</sup>

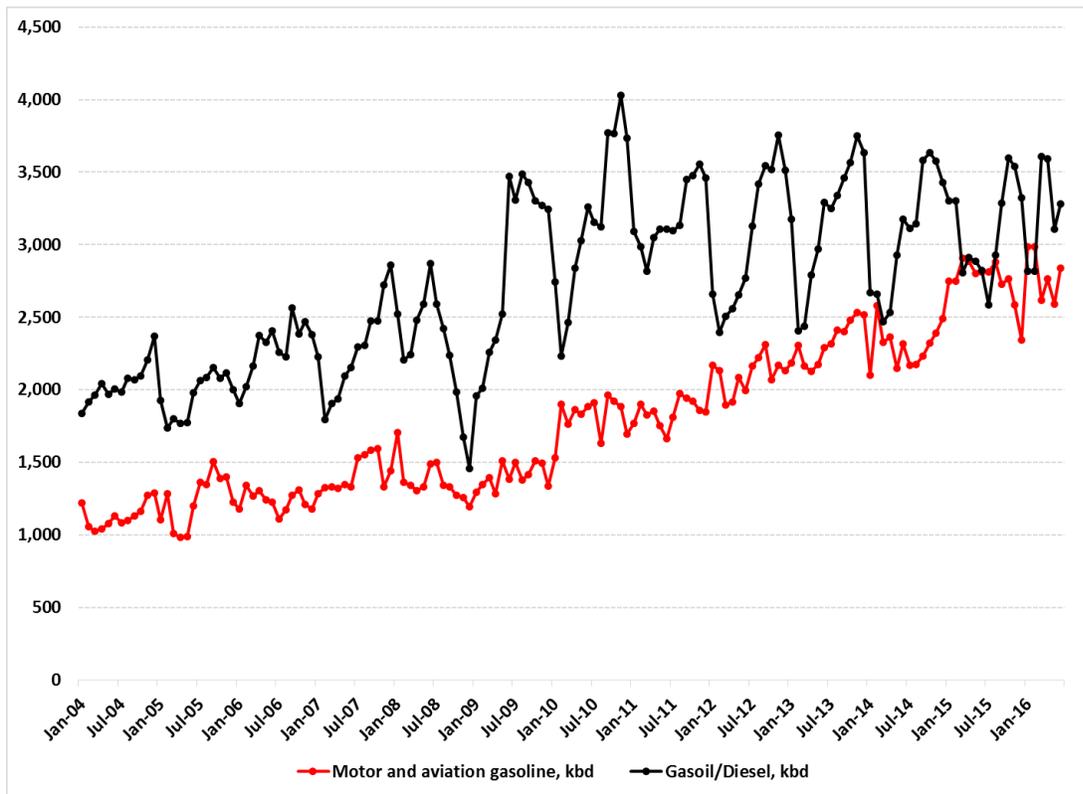
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<sup>7</sup> Chinese energy data are still sometimes unreliable, as illustrated by the sizeable revisions made in 2015 to coal consumption data dating back to at least 2000. Coal data is plagued by a greater degree of reliability problems because there are thousands of producers—some of whom operate illegally—and an even large number of consumers who can procure coal directly from the producer. Such is not the case in the oil sector, where fewer than 10 companies account for the vast majority of refining capacity and downstream oil product distribution and sales, functions which give deep insight into demand. In the oil sector, supply chain concentration enhances observability and improves reliability of the data. This is reinforced by the fact that oil smuggling has been greatly minimized in recent years, making customs data on imports and exports of refined products much more reliable and accurate.

<sup>8</sup> "China Diesel Use Slumps as Natural Gas, Gasoline Demand Gains," Bloomberg, 24 January 2016, <http://www.bloomberg.com/news/articles/2016-01-25/china-diesel-use-slumps-as-natural-gas-gasoline-demand-gains>

<sup>9</sup> Id.

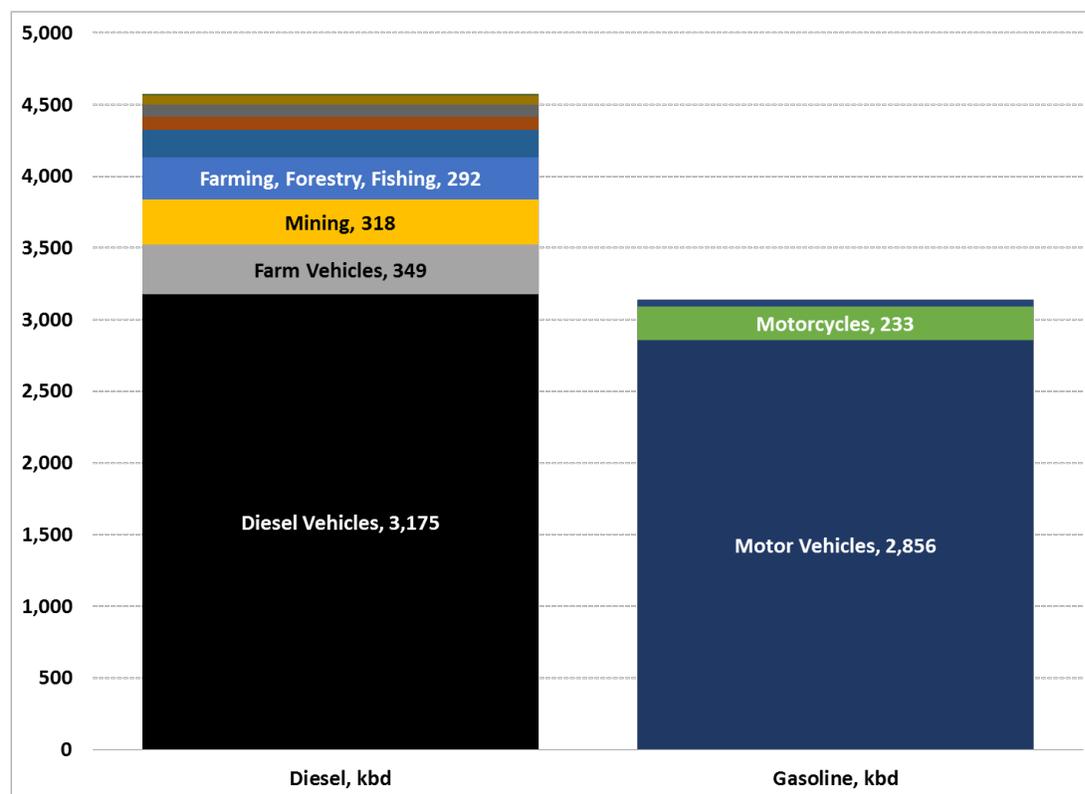
**Exhibit 2: Consumption of Gasoline and Diesel Fuel in China, kbd**



Source: JODI, Author's Analysis

Granular data from researchers at Sinopec, China's largest oil refiner by volume, show that diesel and gasoline demand in the country overwhelmingly stems from transport applications. Nearly 70% of diesel demand comes from on-road transport applications, while motor vehicle demand accounts for nearly all gasoline demand—91% from vehicles with more than two wheels and 7.4% from motorcycles (**Exhibit 3**).

**Exhibit 3: Estimated Diesel and Gasoline Demand in China by End User, 4Q2015**



Source: Sinopec Presentation, September 2015

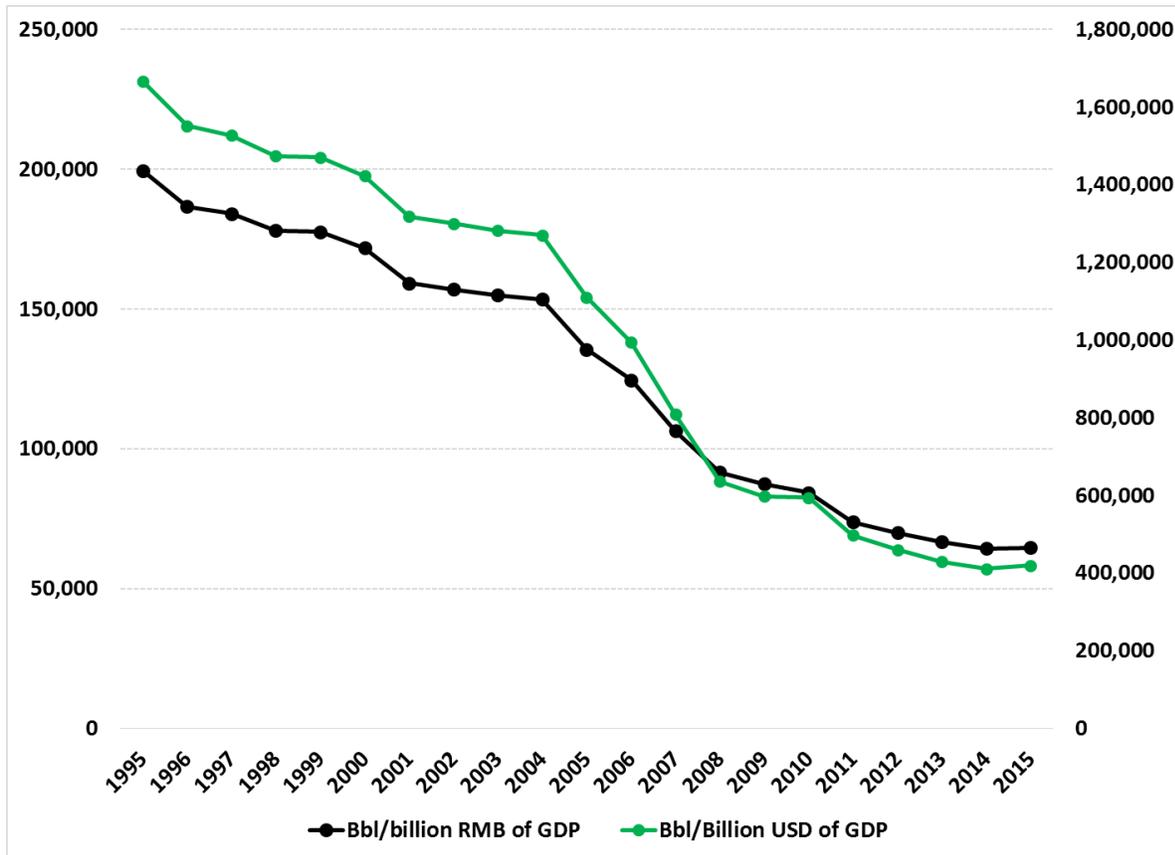
**Theme 2: The Oil Intensity Level of China’s Economy Has Declined Substantially**

Over the past 20 years, China’s economic output has become much less oil intensive. Producing one billion RMB’ worth of GDP required 200,000 bbl of oil in 1995, but that same billion RMB required only 64,500 bbl in 2015 (**Exhibit 4**). In dollar terms, this means that producing one billion USD’ worth of GDP in 1995 consumed nearly 1.7 million barrels of oil, but in 2015, producing the same billion USD’ worth of GDP only required about 418 thousand barrels of crude.

Over the past five years, China’s oil intensity curve has noticeably flattened. This suggests that the country is settling into a trend whereby each billion RMB of economic output will require in the neighborhood of 60,000 to 65,000 barrels of crude oil. Barring a wholesale return to fixed asset-led growth—which is unlikely due to rising concerns about pollution and unsustainable debt burdens incurred from financing underutilized big-ticket infrastructure projects—the country’s oil intensity is likely to continue gradually trending downward as services and light industry come to comprise a greater portion of economic activity.

#### Exhibit 4: Oil Intensity of China's Economy

Left axis: Barrels of Crude Oil per Billion RMB of GDP, Right axis: Barrels of Crude Oil Per Billion USD of GDP



Source: BP, NBS China, Author's Analysis

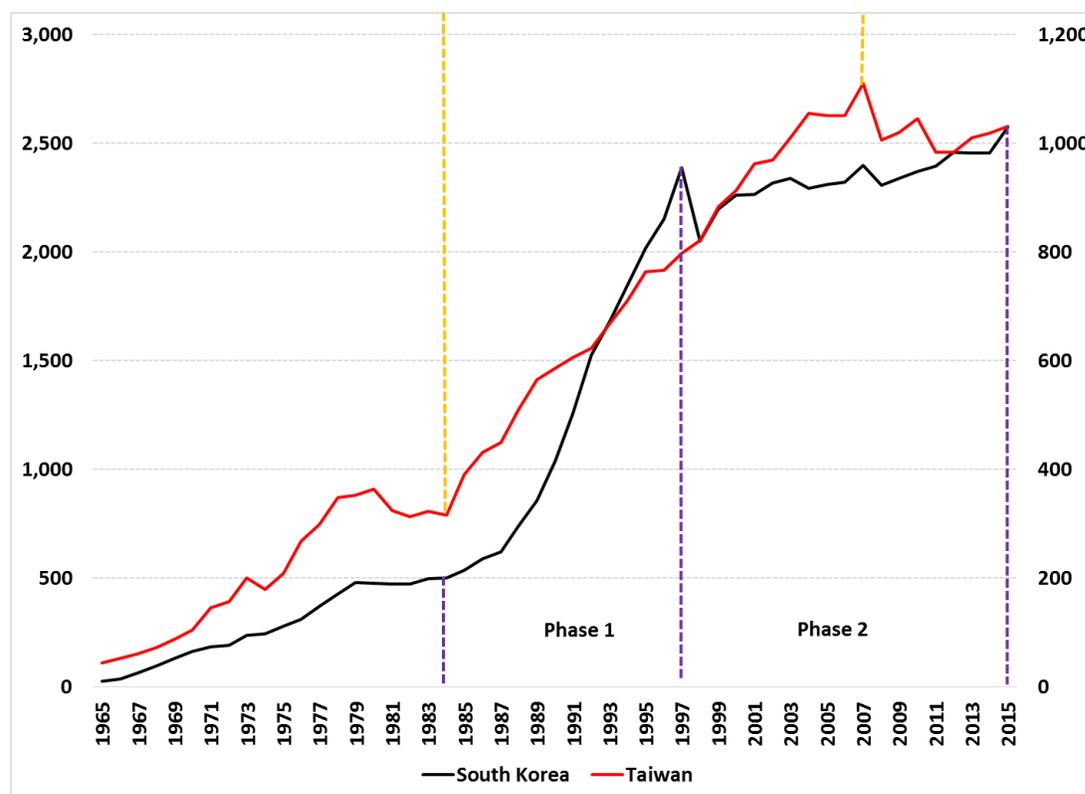
#### Theme 3: China's Oil Demand Likely Faces an Economic Transition

As China became the world's manufacturing floor in the 1980-2008 period, oil demand that might have otherwise occurred elsewhere in the world instead happened in China. As the country loses manufacturing competitiveness and its economy slows overall, China's oil demand growth rate is likely to draw ever closer to the global baseline rate—which since 2005 has averaged 1.2% annually, according to BP.

As China increasingly confronts the necessity of reducing fixed-asset investment as a proportion of total economic activity, oil demand growth may slow in a fashion akin to the trajectories of Taiwan and South Korea (**Exhibit 5**). In each jurisdiction, a period of 15-20 years of rapid economic expansion and oil demand growth was followed by a period in which oil demand declined from peak levels (Taiwan) or grew much more slowly (South Korea).

## Exhibit 5: Oil Demand Profiles of Taiwan and South Korea

Thousand Barrels Per Day of Crude Oil Demand, Left axis: South Korea, Right axis: Taiwan



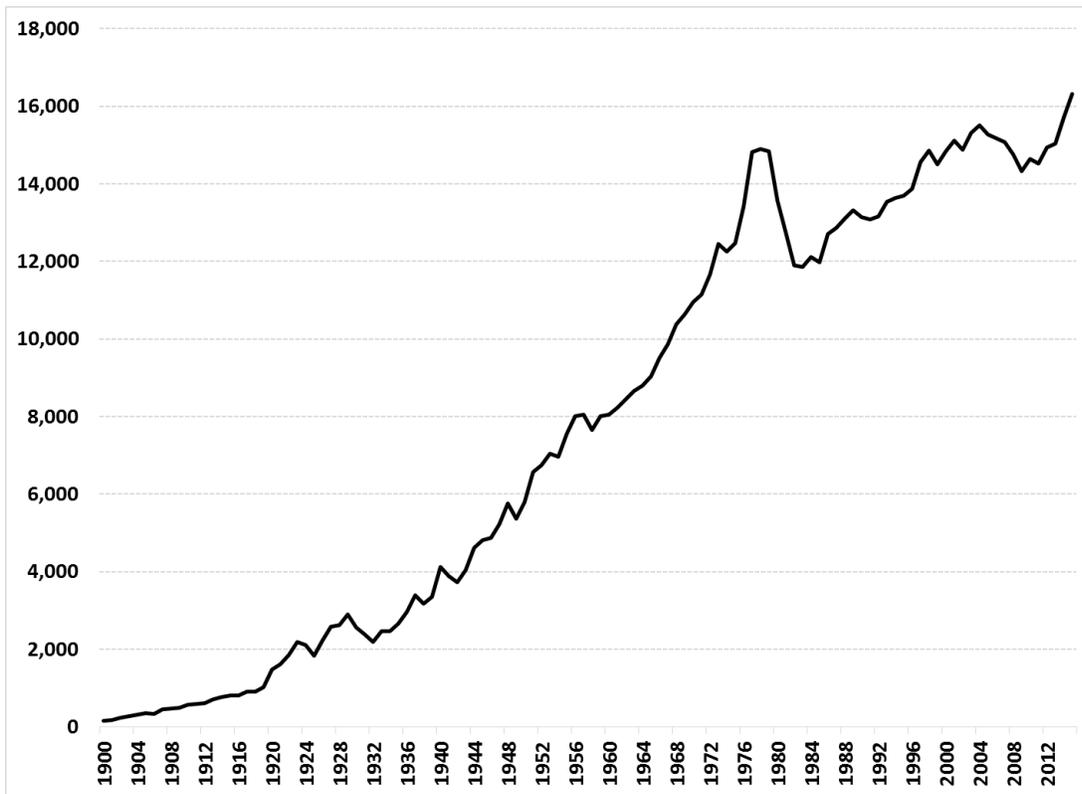
Source: BP Statistical Review, Author's analysis

It is also instructive to consider the oil demand profile of the United States, since its oil demand is more dependent on transportation, as opposed to the Asian Tigers, where industrial activity dominates oil consumption. After a torrid period of demand growth after World War II, U.S. oil demand temporarily peaked in the early 1970s with the first Oil Shock (**Exhibit 6**). But it then grew essentially unbroken for approximately 25 years until the Global Financial Crisis crashed demand. The low oil prices since late 2014 have helped re-animate car sales, driving activity, and gasoline demand, which has underpinned a third wave of U.S. oil demand growth.

In South Korea, the past decade has witnessed a milder, smoother oil demand recovery. The U.S., in contrast, has seen a much steeper demand increase since the bleakest times of the Global Financial Crisis in 2008 and 2009. The U.S. and South Korean oil demand profiles, while vastly different, illustrate the potential for a “second wind” that re-animates oil demand growth after a major economic shock or structural change. Under a scenario in which China’s policymakers “get it right” or other serendipitous events intervene catalyze renewed economic vigor, a resumption of more robust oil demand growth is an upside risk factor that merits serious consideration.

## Exhibit 6: Oil Demand Growth Profile of Transportation-Led United States

Thousand Barrels Per Day



Source: EIA

Against the macro backdrop provided above, the study will now provide an in depth analysis of the three key sectors that drive China's oil demand and how they are likely to evolve in the next five years. First is road transportation, the second is fuel oil (formerly used as refinery feedstock and also used as marine fuel) and jet fuel, while the third comes from crude oil-derived chemical feedstocks.

### III. How Oil Demand is Changing in Key Sectors of the Chinese Economy

#### A. Transportation

China's own official data suggest near term diesel fuel demand may have peaked in at least 13 provinces, which collectively account for nearly 60% of the country's diesel fuel use (**Exhibit 7**). This development matters greatly because diesel accounted for nearly 1/3 of Chinese oil product consumption in 2015.<sup>10</sup> Furthermore, China's share of global diesel fuel consumption has increased from 9.6% in 2005 to 13.1% in 2015, and China accounted for nearly 36% of the global net increase in diesel fuel consumption, according to JODI data. Sinopec, China's largest refiner, takes in approximately 3.27 barrels of crude oil for each barrel of diesel fuel produced.<sup>11</sup> Because the vast majority of diesel fuel used in China is refined in the country, this ratio suggests that conservatively, each 100kbd of diesel consumed requires that refineries process at least 300 kbd of crude.

China's national diesel consumption declined in both 2014 and 2015. Consecutive years of contraction, coupled with weakness in other physical indicators of industrial activity, increasingly suggest that China's diesel demand architecture is structurally evolving. It remains premature to conclude that China's diesel demand has "permanently" peaked. But the evidence increasingly suggests that for one-to-four year oil price path analysis purposes, the Middle Kingdom's diesel demand is not coming back. Indeed, the IEA itself forecasts a continued decline in Chinese diesel consumption in 2016.<sup>12</sup>

China's tectonic diesel consumption shift has given pause to the global oil market. And it will continue to do so as producers, traders, and capital providers adjust to a new normal in which sustained massive oil demand growth from China can no longer be taken for granted.

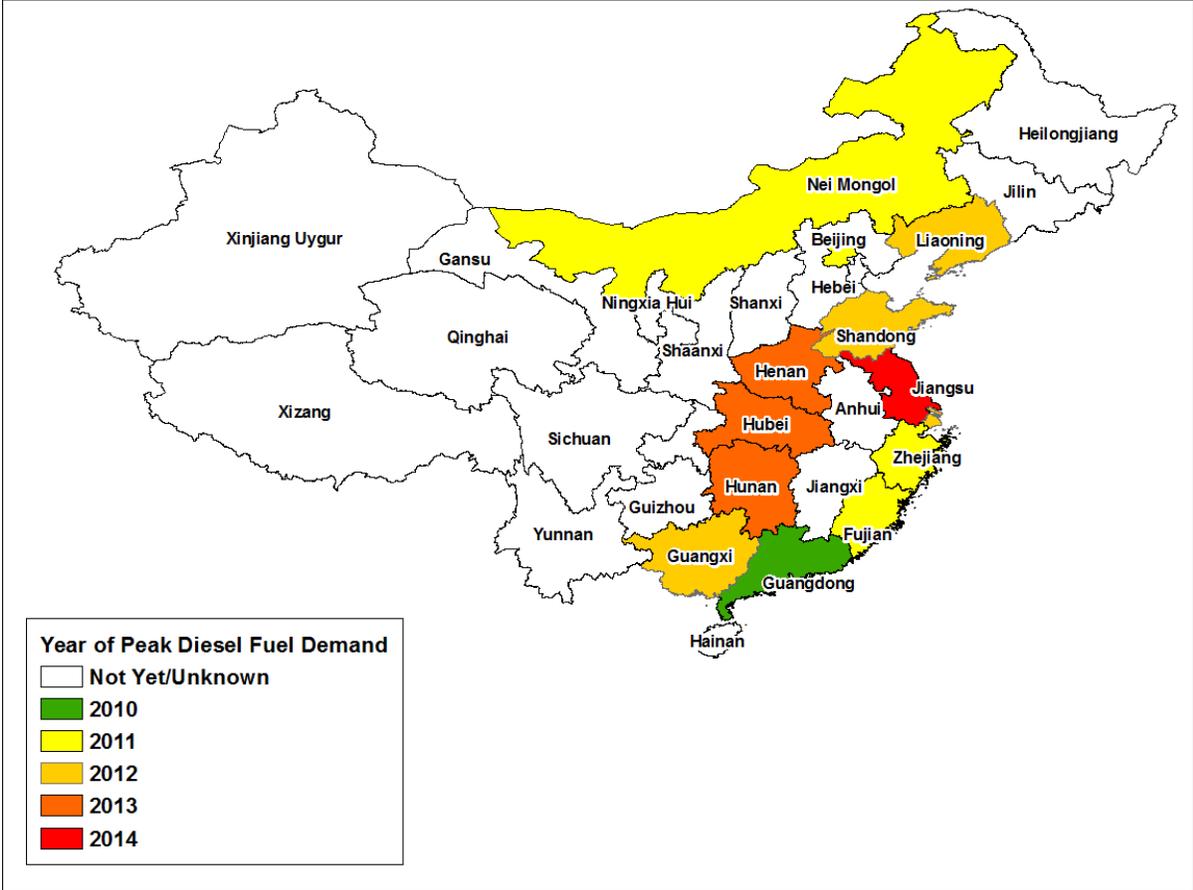
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<sup>10</sup> IEA Oil Market Report, 13 July 2016, <https://www.iea.org/oilmarketreport/omrpublic/currentreport/#Demand>

<sup>11</sup> China Petroleum & Chemical Corporation, Third Quarterly Report, 2015.  
[http://english.sinopec.com/investor\\_center/reports/](http://english.sinopec.com/investor_center/reports/)

<sup>12</sup> IEA Oil Market Report, 13 July 2016, <https://www.iea.org/oilmarketreport/omrpublic/currentreport/#Demand>

**Exhibit 7: Chinese Provinces Where Diesel Fuel Demand Appears to Have Already Reached a Near-Term Peak**



Source: NBS China, Provincial Statistical Bureaus, Author’s Analysis

The provinces where diesel demand appears to have peaked fall into three primary groups. **First** are the export-focused provinces/cities of Beijing, Fujian, Guangdong, Shanghai, and Zhejiang. These areas face stagnant demand abroad for many Chinese-made products and the rising wage and other costs that are undermining China’s historical export competitiveness.

**Second** are the rustbelt and coal belt provinces of Inner Mongolia, Liaoning, and Shandong, where overcapacity and slowing heavy industrial activity are crimping diesel fuel demand. Given that China has likely hit Peak Coal, it is difficult to imagine diesel demand recovering in these provinces in the next five years. **Third** are the Hinterland Provinces: Henan, Hubei, and Hunan. The massive economic stimulus efforts of 2008-2010 focused heavily on these areas. China’s stimulus created unsustainably high levels of fixed asset investment and construction activity in these three provinces and after several years of elevated activity, diesel demand began to decline.

China diesel bulls could disagree and say that the apparent provincial demand peaks are simply “local maxima” as opposed to being definitive structural inflection points. To pre-empt this

potential criticism, the present analysis divides the peak diesel provinces into two main groups: (1) those which are “clearly in structural demand decline” and (2) those which remains “susceptible to stimulus.”

A stimulus package similar in magnitude to what China unleashed in 2008-2010 (4 trillion RMB) could potentially temporarily revive diesel demand in borderline provinces such as Jiangsu.<sup>13</sup> Such a large infrastructure-oriented stimulus effort could very well temporarily prop up demand for diesel. But it would do so at high cost and introduce risks the Central leadership seeks to avoid. For one, a large stimulus package would increase systemic risk by further bloating the country’s balance sheet. It would also pressure existing real estate and infrastructure assets that are already seriously debt-laden and underutilized, while creating additional Ghost Cities and other “zombie” assets.<sup>14</sup> Finally, it would seriously undermine Beijing’s policy goals of eliminating overcapacity, reducing pollution, and shifting China’s economy toward a more sustainable consumption-oriented structure.

### 1. Drivers of China’s Diesel Demand Slowdown

The demand slowdown in China’s prime diesel consuming regions reflects a broader slowdown in industrial activity. A number of industrial activity metrics corroborate the diesel demand decline reflected in official data. Foremost is electricity demand, which is driven primarily by industrial use. Power consumption began plateauing in 2013 and has seen demand growth slow meaningfully each year since (**Exhibit 8**).<sup>15</sup>

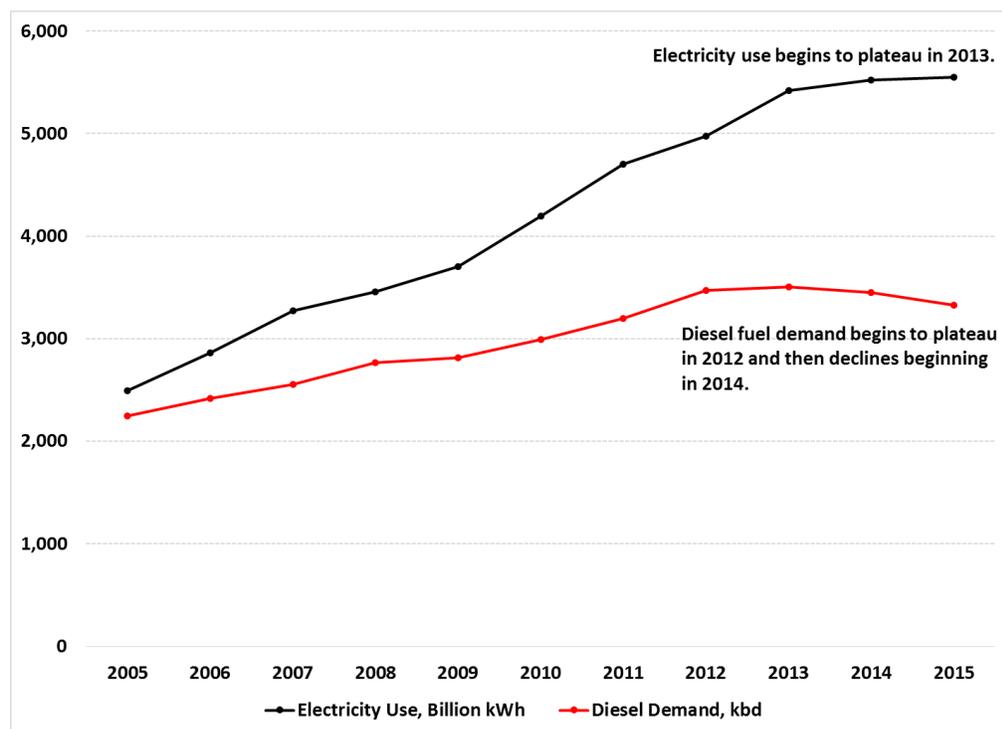
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<sup>13</sup> “China’s 4 trillion yuan stimulus to boost economy, domestic demand,” Xinhua, 9 November 2008, [http://news.xinhuanet.com/english/2008-11/09/content\\_10331324.htm](http://news.xinhuanet.com/english/2008-11/09/content_10331324.htm)

<sup>14</sup> The phenomenon of so-called “Ghost Cities” that are built to house large numbers of people, but remain virtually uninhabited has proliferated as the real estate boom in China runs up against fundamental demand constraints. Multiple media sources have documented the existence of these cities, with extensive coverage beginning in the 2013 timeframe. Consider for instance “China’s Ghost Towns: Strolling the Thames (VICE on HBO Ep. #6 Extended),” <https://www.youtube.com/watch?v=qPjGWcM3Awc> and “China’s Ghost Cities - 60 Minutes Australia,” [https://www.youtube.com/watch?v=F1ZsVUB\\_-gg](https://www.youtube.com/watch?v=F1ZsVUB_-gg). (last accessed on 27 August 2016).

<sup>15</sup> Gabriel B. Collins and Andrew S. Erickson, “China’s Stock Market Boom: Buckle Up for a Wild Ride!” China SignPost™ (洞察中国) 89 (14 June 2015). <http://www.chinasignpost.com/2015/06/14/chinas-stock-market-boom-buckle-up-for-a-wild-ride/>

## Exhibit 8: China's Electricity Consumption Slowdown Tracks Declining Diesel Fuel Use



Source: NBS China

Electricity demand is a high-confidence data set for several reasons. First, China's power supply comes from a small set of generators and grid operators, allowing throughput to be easily tracked. Second, unlike oil, coal, and other energy commodities, the generation and transmission of electricity correlate closely with actual use because electrons cannot be stored economically on a scale large enough to induce potential inventory calculation problems of the type which plague analysis of other commodity markets in China. Third, electricity use is pervasive throughout the industrial sector, since virtually every manufacturing activity has multiple steps for which electricity is an input. For these reasons, the steady and significant slowdown in electricity demand across the Chinese economy suggests that the official diesel fuel demand numbers are probably sufficiently accurate to give confidence in the trends they are showing.

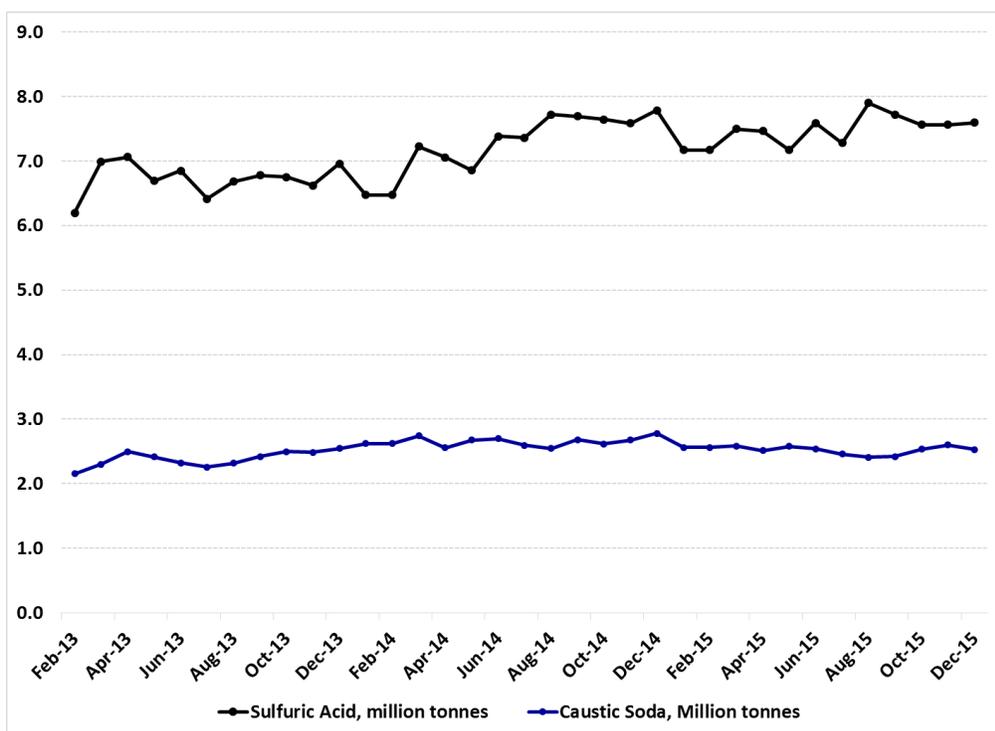
Second, other physical indicators of industrial activity in China have also flat-lined over the past 18 months. Aside from electricity, sulfuric acid and caustic soda also pervade a broad range of industrial processes, making demand for them a lead indicator for the health of an industrial economy. To that point, alkalis (foremost among them caustic soda) are key foundations for the American Chemistry Council's Chemical Activity Barometer, an index based on comparing more than 60 years' of data correlating demand for key industrial input chemicals with cycles in the overall US economy.<sup>16</sup> Chinese data only show monthly production of sulfuric acid and caustic

<sup>16</sup> "Chemical Activity Barometer," American Chemistry Council, <https://www.americanchemistry.com/jobs/cab/Barometer.pdf>

soda, not actual “consumption.” Nonetheless, because the country is largely self-sufficient in both chemicals and a relatively small share of total output is exported, the production data provide an acceptable proxy for local usage.

Since late summer 2014, production of each chemical has flat-lined (**Exhibit 9**). Sulfuric acid production is “choppy” in part because a substantial portion of China’s acid output is a byproduct of oil refining and metal smelting. The lack of growth in caustic soda output is especially noteworthy because from early 2014 onwards, the country has faced a significant overcapacity situation, which would normally prompt increased exports.<sup>17</sup> The lack of such a development suggests weak demand abroad (Australia, for one is a key market for Chinese-made caustic soda), which in turn further weighs on Chinese domestic industrial activity that drives diesel fuel demand.

**Exhibit 9: Production of Sulfuric Acid and Caustic Soda in China, Million Tonnes per Month**



Source: NBS China

<sup>17</sup> “2015 Caustic and Sulfuric Acid Market Analysis: Balancing faces Many Challenges” (2015年烧碱市场分析：仍将面临多重挑战), Tianjin Tiankai Chemical Industries Import and Export Corporation, <http://tiankaichem.com/a/xinwendongtai/2/259.html>

## 2. Why China's Diesel Fuel Demand Likely Will Not Recover to Its Prior Peak in the Next Five Years—If Ever

*Reason one* is that China has likely passed “Peak Truck.” The CEO of Cummins stated in the company's fourth quarter 2015 earnings call that with regard to the number of trucks sold in the country, “it's not clear that we'll ever hit that number again.”<sup>18</sup> Cummins data also show that truck engine sales in China declined sharply from more than one million units in 2013 to 750,000 units in 2015, with sales forecast to decline a further 4% year-on-year in 2016. The company's statement merit close attention because it supplies nearly one in every five diesel engines going into heavy and medium duty trucks manufactured in China, giving it deep visibility into the market (Cummins 2015 Analyst Day Presentation). Slowing truck engine sales strongly suggest that truck replacement rates are declining as the slower pace of infrastructure activity and manufacturing reduces the miles driven each year by much of the truck fleet in China.

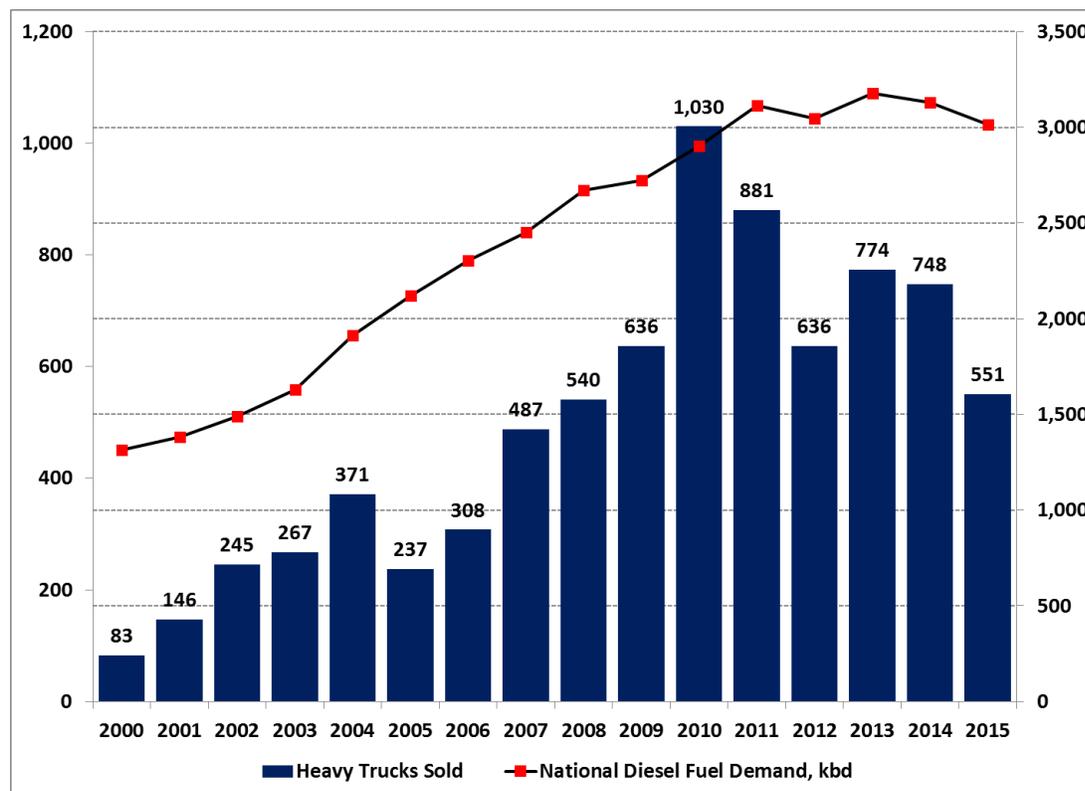
Heavy truck sales reflect this trend, as the boom period that saw new vehicle sales rise from 237 thousand heavy-duty trucks in 2005, to a peak of more than one million in 2010 (**Exhibit 10**). New heavy truck sales have now fallen back to 2008 levels, with 551 thousand vehicles sold in 2015, according to industry data. The fact that China's nationwide diesel fuel consumption tapered off in 2014 and 2015 despite nearly 1.3 million new heavy trucks entering the fleet suggests trucking activity has slowed substantially as industrial activity levels decline.

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<sup>18</sup> Cummins 4Q2015 Earnings Call Transcript, SeekingAlpha, <http://seekingalpha.com/article/3867056-cummins-cmi-n-thomas-linebarger-q4-2015-results-earnings-call-transcript?part=single>

### Exhibit 10: China New Heavy Truck Sales vs. National Diesel Fuel Demand

Thousand trucks, left y-axis; Thousand barrels per day of diesel fuel, right y-axis.



Source: CAAM, NBS China, Truck Industry Research, Ltd.

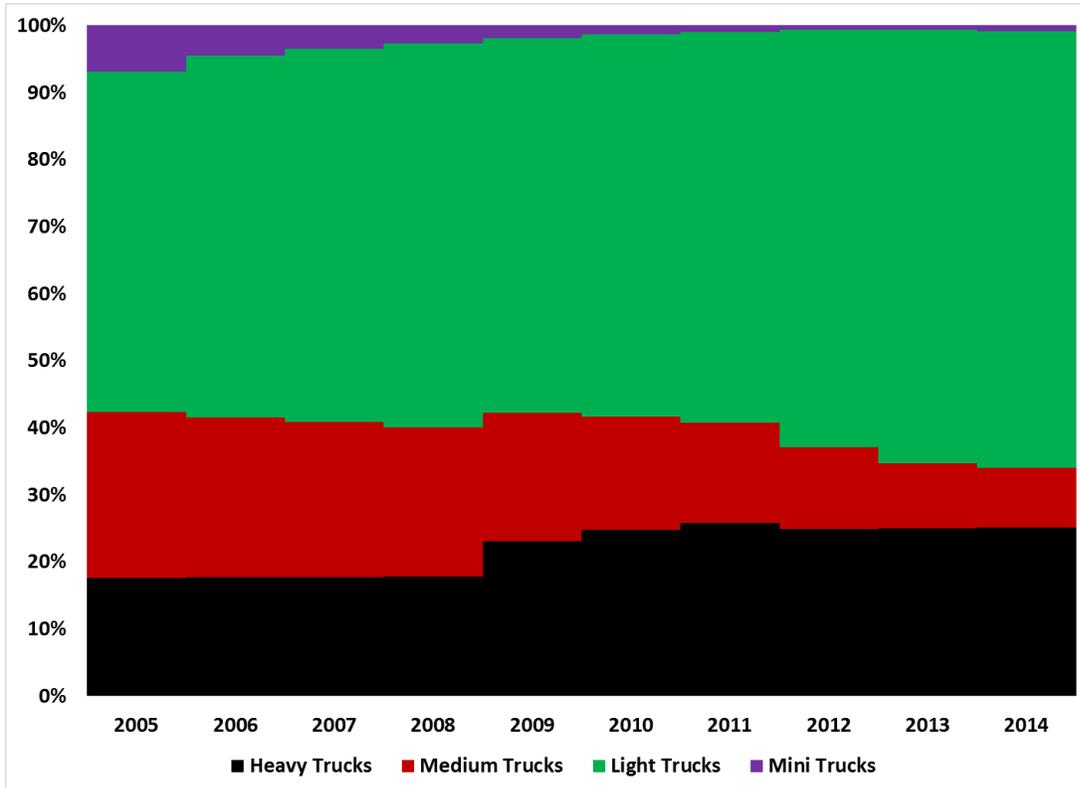
China's truck fleet is also moving to favor smaller vehicles that use less fuel. Between 2005 and 2014, "light duty trucks" steadily took fleet share from medium duty trucks, while heavy trucks' fleet share stagnated (**Exhibit 11**). Between 2009 and 2014, heavy trucks' share of the fleet hovered at approximately 25%, while light trucks have steadily gained share over the past decade, climbing from 51% in 2005, to 57% in 2010, to more than 65% in 2014, according to NBS data.

Chinese heavy trucks typically use a smaller displacement engine (e.g. 6 to 10 liters) than those used by trucks sold in the U.S. and European markets (10 to 15 L).<sup>19</sup> Nonetheless, their engines are many times larger than those used in the light duty trucks that have grabbed fleet share from heavy and medium-duty machines. For instance, a typical light duty diesel-powered truck in China has an engine displacement of 2.0-to-2.5 liters—as little as 1/5 that of a heavy duty

<sup>19</sup> Gabe Collins and Andrew Erickson, "Counting the Barrels: Heavy truck sales are a better barometer than car sales of China's oil demand growth," China SignPost™ (洞察中国), No. 20 (31 January 2011). <http://www.chinasignpost.com/2011/01/31/counting-the-barrels-heavy-truck-sales-are-a-better-barometer-of-chinas-oil-demand-growth-than-car-sales/>

vehicle.<sup>20</sup> Furthermore, the light duty trucks are less likely to be making the longer-distance hauls typically made by larger vehicles, meaning that they not only use less fuel per kilometer than their larger cousins, but are also driving fewer kilometers per vehicle over a given time period. Each of these dynamics reduces diesel fuel consumption from the trucking sector, which is China’s primary diesel fuel demand driver at present.

**Exhibit 12: China Truck Fleet by Truck Class**  
Percentage of total fleet



Source: NBS China, Author’s Analysis

*Reason two:* increasing concerns over diesel engine emissions. Volkswagen’s diesel exhaust emissions scandal crystallized concerns that have been building for some time concerning diesel engine exhaust emissions. Most pointedly, data suggest that even if diesel engines have not been rigged to game emissions tests, they still pose significant health risks due to their propensity to emit small particulates and nitrogen oxides. Chinese policymakers are almost certainly taking note of the air quality problems afflicting many European capitals following many countries’ strategic decision in the 1990s to increase diesel engine use in passenger cars as a way of reducing carbon dioxide emissions. France, for instance, began moving in mid-2015 to retract [diesel-](#)

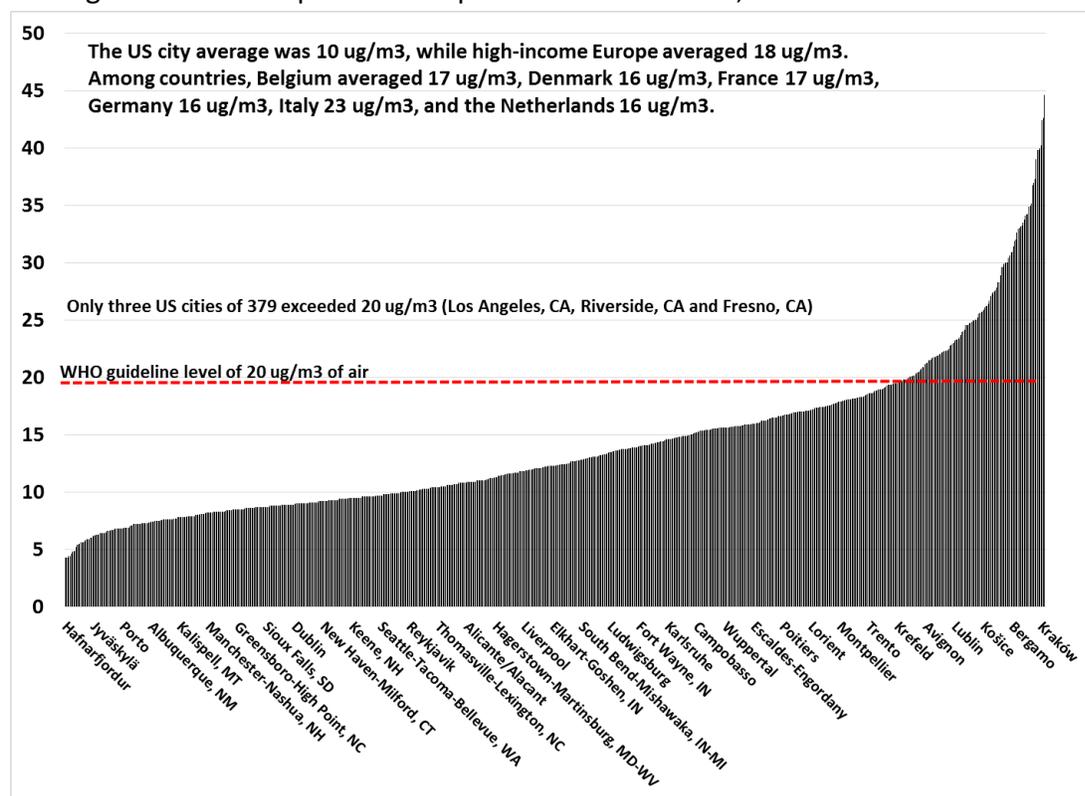
<sup>20</sup>“Taking a Comprehensive Look at 2.5 Liter Diesel Engines,” (结构参数一起看 细说那些2.5升柴油机), [http://www.360che.com/tech/160314/52811\\_all.html](http://www.360che.com/tech/160314/52811_all.html)

[friendly policies](#) and reportedly plans to ban diesel vehicles manufactured before 2011 from Paris by 2020.<sup>21</sup>

World Health Organization data on PM2.5 particulate emissions support European authorities' concerns. The latest annual readings showed that Paris had an annual mean PM2.5 level of 17 micrograms per cubic meter of air (**Exhibit 13**). This figure is nearly 24% higher than the reading for car-choked Houston, which has nearly 2.5 times the rate of per capita vehicle ownership as Paris and also has substantial petrochemical and manufacturing activity within the same air pollution sampling zone.<sup>22</sup> The key difference is that most passenger vehicles in Houston are gasoline-powered, while the overall French passenger car fleet is nearly 80% diesel-propelled. Less CO2, but much more PM2.5 per mile driven.

### Exhibit 13: Diesel Exhaust Emissions Cause Serious Particulate Pollution

Micrograms of PM2.5 particulates per cubic meter of air, 2014



Source: WHO, Author's Analysis

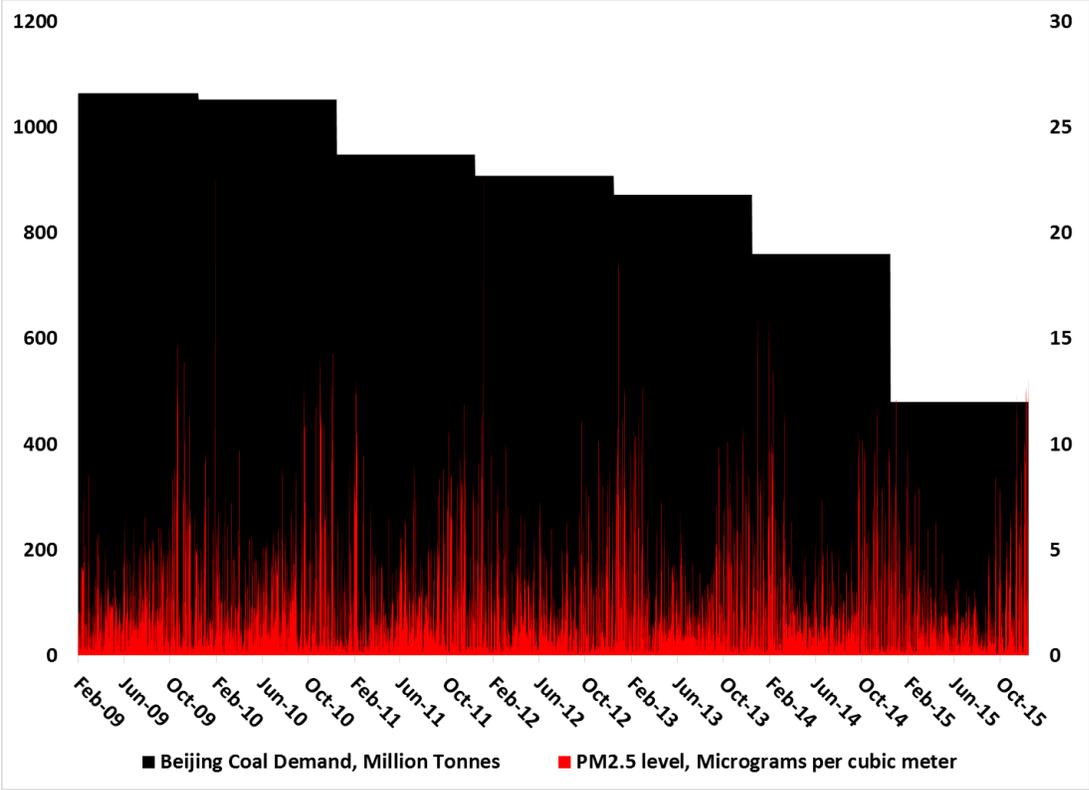
<sup>21</sup> "Automakers slam French decision on clean diesels," Automotive News Europe, 26 June 2015, <http://europe.autonews.com/article/20150626/ANE/150629983/automakers-slam-french-decision-on-clean-diesels>

<sup>22</sup> Harris County Vehicle Registration Data, [http://www.txdmv.gov/reports-and-data/publications-reports/cat\\_view/13-publications/25-reports-data/65-veh](http://www.txdmv.gov/reports-and-data/publications-reports/cat_view/13-publications/25-reports-data/65-veh); <http://www.harriscountytexas.gov/CmpDocuments/74/Budget/FY16%20Population%20Study.pdf>; Nombre de Voitures en France, [http://www.statistiques-mondiales.com/france\\_voitures.htm](http://www.statistiques-mondiales.com/france_voitures.htm) (last accessed on 30 July 2016)

Beijing, China’s car ownership capital, exemplifies why Chinese policymakers will likely maintain a jaundiced eye toward any attempts to increase the use of diesel-powered vehicles in the country. Gasoline-powered cars currently dominate passenger car sales (and in the overall fleet). Despite the fuel economy benefits of small, modern diesel engines, policymakers are likely to shun them due to emissions concerns. Reinforcing the likely role of autos as a driver of air pollution problems, since 2009, Beijing has cut its coal consumption in half, yet PM2.5 pollution as measured by the US Embassy remains severe and has declined much more slowly than would be expected given plummeting local coal use (**Exhibit 14**).

**Exhibit 14: Beijing’s Particulate Pollution Problems Remain Despite Falling Coal Use**

PM2.5 level in micrograms per cubic meter of air on left vertical axis, coal use in million tonnes per year on right vertical axis



Source: US State Department, Author’s Analysis

There are two possible explanations for Beijing’s persistent PM2.5 pollution problems: (1) pollution from surrounding provinces continues to drift into Beijing or (2) motor vehicle tailpipes are in fact the core source of Beijing’s PM2.5 emissions problems. The likely answer is that both are responsible, but that the data affirm motor vehicles’ responsibility for a substantial portion of Beijing’s PM2.5 problems.

Officials in Hebei Province, which is China’s largest steel producer and surrounds the Beijing municipality, say they are eliminating millions of tonnes of output capacity across emissions-

intensive heavy industrial sectors including steel, cement, and plate glass.<sup>23</sup> Yet production data for high-emissions commodities show a more mixed picture. Local data show that Hebei's cement production declined nearly 15% YoY in 2015, but steel products output rose 5.5% YoY.<sup>24</sup> Meanwhile, National Bureau of Statistics data show that Hebei's electricity production declined very slightly YoY in 2015, but rallied significantly in the past four months of the year.

Uncertainty aside, aggregate heavy industrial activity in Hebei is likely on the low side of the normal range that has defined the past several years. Moreover, Beijing has achieved dramatic reductions in local coal burning, which has been replaced to a large degree by clean natural gas. Such a backdrop suggests that if industry were the primary culprit, PM2.5 levels should have declined more significantly than they have. Yet the data instead appear to validate the view that motor vehicle emissions are indeed a key source of PM2.5 emissions in Beijing.

Even though the bulk of the fleet there is gasoline-powered, the fact that air pollution remains a persistent problem and diesel vehicles clearly drive serious air quality issues in European cities suggests policymakers here and elsewhere in China will restrict the sale and use of diesel vehicles more severely. Indeed, the European cities assessed above have little heavy industrial activity and do not burn coal for power, yet have serious particulate emissions problems, for which diesel vehicles appear to be the primary culprit.

## **B. Transportation Theme 2: Rising Gasoline Demand Means China's Crude Oil Use is Decoupling from the Industrial Economy**

Gasoline has taken over as the main driver of incremental oil products demand growth in China. This ties China's crude oil appetite more tightly to consumer trends, as opposed to industrial growth. In the Chinese market, it takes approximately 19 passenger cars to equal the annual crude oil demand created by one heavy-duty diesel truck.<sup>25</sup> In 2015, 551,000 new heavy trucks

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<sup>23</sup> "Pollution control slashes GDP growth in Hebei," China Daily, 8 January 2015, [http://www.chinadaily.com.cn/china/2015-01/08/content\\_19276430.htm](http://www.chinadaily.com.cn/china/2015-01/08/content_19276430.htm)

<sup>24</sup> "Hebei 2015 Economic and Social Development Report" (河北省2015年国民经济和社会发展统计公报发布), Great Wall Network, 1 March 2016, [http://news.hebei.com.cn/system/2016/03/01/016694836\\_01.shtml](http://news.hebei.com.cn/system/2016/03/01/016694836_01.shtml)

<sup>25</sup> This estimate uses the following assumptions: (1) Fuel use—Each heavy truck in China consumes 44 liters of diesel fuel per 100km (Ben Sharpe and Rachel Muncrief, "Literature Review: Real-World Fuel Consumption Of Heavy-Duty Vehicles In The United States, China, And The European Union," The ICCT, White Paper, January 2015, [http://www.theicct.org/sites/default/files/publications/ICCT\\_HDV\\_FC\\_lit-review\\_20150209.pdf](http://www.theicct.org/sites/default/files/publications/ICCT_HDV_FC_lit-review_20150209.pdf)) while China's passenger car fleet had an average fuel economy of 7.12 liters/100km in 2015 ("China Passenger Vehicle Fuel Consumption," 2015 Development Annual Report, The Innovation Center for Energy and Transportation December 2015, <http://www.icet.org.cn/english/admin/upload/2015120241280305.pdf>.) (2) Annual vehicle km travelled—52,000 km per year for heavy trucks (H. Huo et al. / Energy Policy 43 (2012) 6–16 (10), [http://www.tsinghua.edu.cn/publish/ess/7835/20120719144509070242457/\[8\]%20Huo\\_EP\\_2012.pdf](http://www.tsinghua.edu.cn/publish/ess/7835/20120719144509070242457/[8]%20Huo_EP_2012.pdf)) and 13,000 km/year for passenger cars (He, K., Huo, H., Zhang, Q., He, D., An, F., Wang, M., Walsh, M., 2005, "Oil Consumption and CO2 Emissions in China's Road Transport: Current Status, Future Trends, and Policy Implications," *Energy Policy* 33 (2005): 1499–1507). Diesel and gasoline yields per unit of crude oil run through refinery are derived from Sinopec's 2015 Form 20-F report.

were sold in China, versus 21.2 million new passenger cars—a 38:1 ratio, meaning that passenger cars and their gasoline thirst are now decisively driving incremental oil demand growth in China.

For the next three years, each million new passenger cars sold in China will likely create approximately 10 kbd of incremental gasoline demand. This is worth approximately 3.8 barrels of crude throughput in a “typical” Chinese refinery.<sup>26</sup> Beyond 2018-19, higher scrapping rates and technological changes in vehicle powertrains that increase fuel efficiency will likely reduce the incremental fuel demand impact of each new car sold in China. The rising importance of gasoline demand and the decline in diesel use reflect a broad structural shift: crude oil is rapidly becoming a consumer good in China, not an industrial commodity as it was during the halcyon years of burgeoning diesel fuel demand.

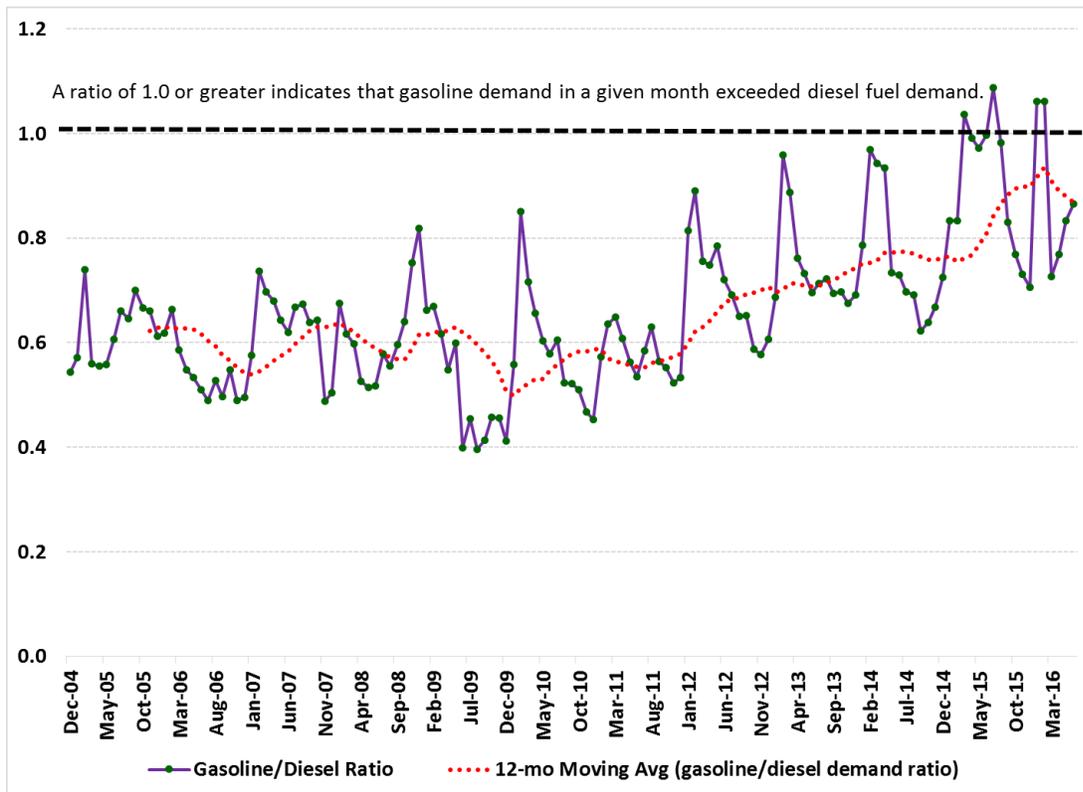
Between 2003 and 2012, China’s crude oil demand used to be driven primarily by diesel fuel from the trucks, bulldozers, and generators that powered the country’s industrial boom. Yet as heavy industrial activity slowed and gasoline became a more important source of oil demand growth, crude oil started becoming more of a consumer good, as opposed to an industrial one. This shift will profoundly influence global crude oil and refined products markets.

China’s gasoline demand upshifted dramatically in recent years, as passenger car sales skyrocketed. In early 2012, the ratio of gasoline consumption to diesel consumption in China began to rise noticeably (**Exhibit 15**). This accelerated dramatically in 2015 as gasoline consumption continued to grow while diesel demand contracted slightly. The ratio currently stands at approximately 0.94 barrels of gasoline consumed per barrel of diesel. Notably, in January, February, and March of 2016, China actually consumed more gasoline than diesel fuel, a development that likely portends a gasoline-dominated future in the China refined products market.

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<sup>26</sup> Sinopec is China's largest oil refiner by volume. Sinopec refined approximately 236 million tonnes of crude (1.726 billion bbl at 7.3 bbl/tonne) in 2015 and produced approximately 54 million tonnes of gasoline (0.458 billion bbl at 8.5 bbl/tonne). This ratio of approximately 0.265 bbl of gasoline per bbl of crude suggests that the "typical" Chinese refinery runs about 3.8 barrels of crude per barrel of gasoline produced.

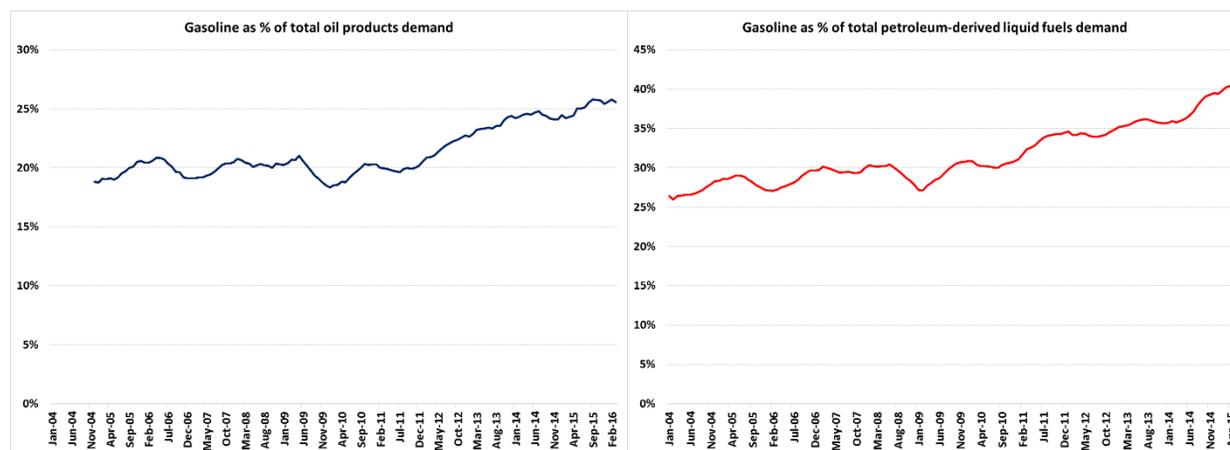
**Exhibit 15: Ratio of Gasoline to Diesel Demand in China**



Source: JODI, Author’s Analysis

Gasoline has also steadily gobbled up share in China’s total petroleum liquid fuels and total oil products markets (**Exhibit 16**). Among petroleum-derived liquid fuels, gasoline’s share rose from 26% in January 2004 to more than 40% by March 2016, with the growth heavily biased toward the past four years. Note that during this same time frame, gasoline gained share while overall petroleum-derived liquid fuels demand rose by 68%. The fact that gasoline gained a major chunk of market share amidst rapid overall oil products demand growth shows just how dramatic China’s gasoline transformation has been. The analysis uses a 12-month moving average to smooth seasonal demand spikes and make long-term trends more visually apparent.

## Exhibit 16: Gasoline as a Percentage of Total Oil Products and Liquid Fuel Demand in China



Source: JODI, Author's Analysis

### 1. Passenger Car Sales Are Driving Gasoline Demand

Gasoline-led oil demand growth stems from years of robust passenger car sales growth at a rate and scale not seen since the automobile first took the United States market by storm in the early 20<sup>th</sup> Century. In 2009, when the China personal car boom took off, the country sold 10.3 million units, a big jump from the 6.7 million cars sold in 2008, according to data from the China Association of Automobile Manufacturers (CAAM). By 2015, 21.2 million passenger cars were sold in China—significantly more than the 17.5 million light cars and trucks sold in the US, long the world's dominant passenger vehicle market.<sup>27</sup> Scarcely any passenger cars in China are diesel-powered.<sup>28</sup>

New car sales numbers closely track the rapid increase in passenger-hauling vehicles' proportion of the overall fleet in China. Because the cars that have entered the fleet during the recent car buying spree still have many years of service left in them, scrapping rates remain low, and the relationship between new cars sold and the number of cars entering the vehicle fleet on a net basis is much closer to one-to-one than it would be in a more mature market.

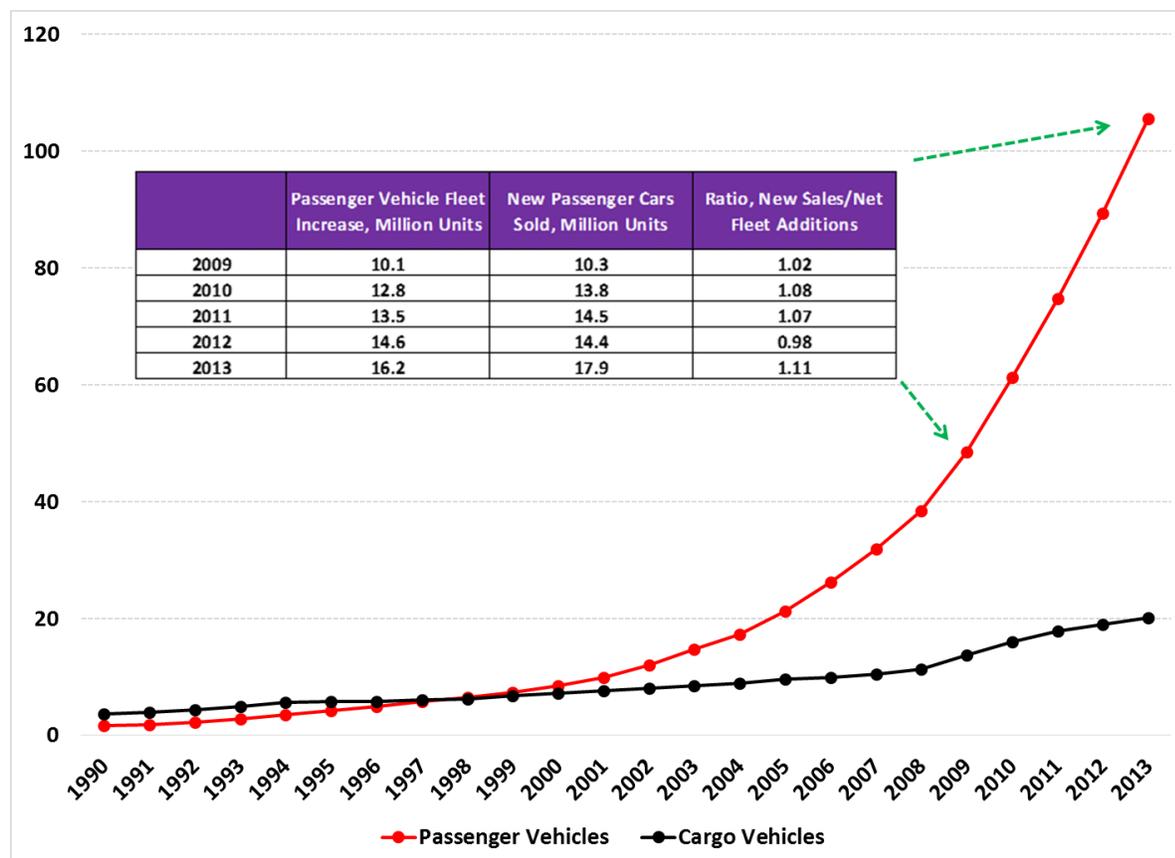
Supporting that thesis, the absolute and relative growth rates in the number of passenger-carrying vehicles has risen sharply since 2009, which correlates strongly with new passenger car sales (**Exhibit 17**). The ratio of new passenger car sales to net additions in the passenger-carrying vehicle fleet between 2009 and 2013 hovered between 0.98 and 1.11, which suggests that on the whole, more than 9 of every 10 new cars sold represented a net addition to the passenger vehicle fleet.

<sup>27</sup> Mike Spector, Jeff Bennett, and John D. Stoll, "U.S. Car Sales Set Record in 2015," *The Wall Street Journal*, 5 January 2016, <http://www.wsj.com/articles/u-s-car-sales-poised-for-their-best-month-ever-1451999939>.

<sup>28</sup> "Why Volkswagen's Problems Don't Include China," China Real Time Report, *Wall Street Journal*, 28 September 2015, <http://blogs.wsj.com/chinarealtime/2015/09/28/why-volkswagens-problems-dont-include-china/>.

## Exhibit 17: Passenger Carrying Vehicles vs. Cargo Carrying Vehicles in China's Civilian Vehicle Fleet

Million vehicles



Source: NBS China, Author's Analysis

### 2. China's Gasoline Demand Outlook For 2016-2018

Three fundamental factors drive gasoline use: vehicle fleet size, how the fleet is driven, and what type of powertrain options are available. Industry, government, and private analysts hold a range of views on China's gasoline demand outlook. At the bullish end of the spectrum, Credit Suisse believes that China's crude oil demand will grow at a 4% annual rate in 2016 and 2017 (i.e., more than 415 kbd each year).<sup>29</sup> The bank believes gasoline demand will be the prime mover of Chinese oil demand growth, with its baseline forecast projecting gasoline demand will increase by between 280 kbd and 360 kbd in both 2016 and 2017.<sup>30</sup> Chinese state oil giant CNPC's in-house team forecasts a 4.3% increase in crude oil demand in 2016.<sup>31</sup>

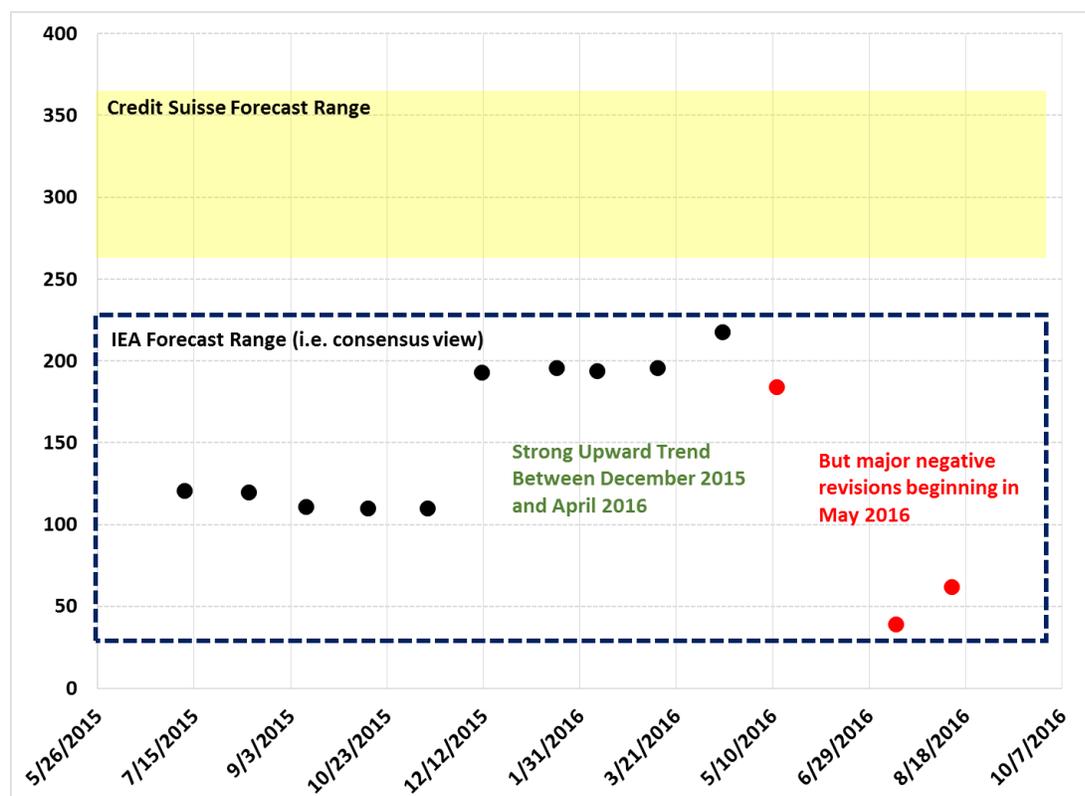
<sup>29</sup> "Connections Series: Oil and...Chinese Consumers," Credit Suisse, 19 November 2015, Global Equity Research.

<sup>30</sup> Ibid.

<sup>31</sup> "China Oil Demand to Grow 4.3 Percent in 2016: CNPC Research," Reuters, 26 January 2016, <http://www.cnbc.com/2016/01/26/china-oil-demand-to-grow-43-percent-in-2016-cnpc-research.html>.

Credit Suisse was much more bullish than the November 2015 IEA Oil Market Report—the “consensus view”—that called for Chinese gasoline demand to rise by only 110 kbd in 2016.<sup>32</sup> The IEA analytical staff became much more bullish in late 2015, as the December 2015 OMR basically doubled the agency’s 2016 China gasoline demand forecast. Subsequent IEA OMRs continued increasing the outlook, which by April stood at 228 kbd.<sup>33</sup> But beginning in May 2016, the IEA begin dramatically trimming its China gasoline demand forecast as it realized that many barrels of gasoline formerly counted as demand were actually being exported and that real demand was in fact not nearly as robust as widely thought (**Exhibit 18**).

**Exhibit 18: IEA’s 2016 China Gasoline Demand Forecast Trimmed Dramatically**  
Projected 2016 gasoline demand growth, kbd



Source: Credit Suisse, IEA Oil Market Report, Author’s Analysis

To put demand estimates in perspective, consider the additional implied gasoline demand per million new cars sold in China. Essentially, because new cars in China correlate to net passenger vehicle fleet growth at high rates because scrappage remains low (see **Exhibit 18**, above), dividing annual incremental gasoline consumption growth by the number of new cars sold yields an

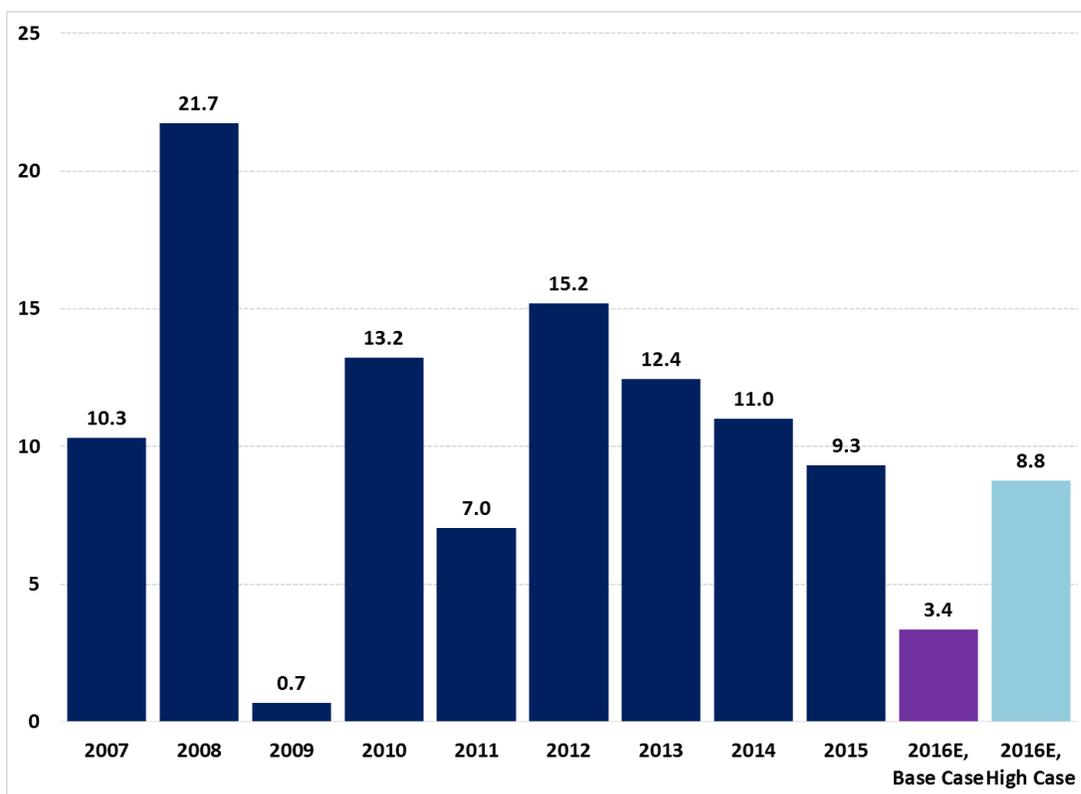
<sup>32</sup> IEA Oil Market Report, 13 November 2015, <https://www.iea.org/oilmarketreport/reports/2015/1115/#Demand>

<sup>33</sup> IEA Oil Market Report, 16 April 2016, <https://www.iea.org/oilmarketreport/reports/2016/0416/#Demand>

approximate “rule of thumb” for how many barrels of gasoline per day each million new cars sold in China are likely to consume.<sup>34</sup>

The past five years of car sales and gasoline consumption levels shows that each million new cars sold yields an average of 11 kbd in additional gasoline demand (**Exhibit 19**). The curve has trended downward and the IEA data suggest 2016 could see real gasoline demand growth in China sharply slow. Based on these data, the author projects that Chinese gasoline demand will grow by 75-to-120 kbd in 2016, 2017, and 2018. The high growth case would see gasoline demand grow by 180-to-200 kbd in each of those years. At Sinopec’s 2015 refinery gasoline yield rate of 26.5%, Chinese refiners would need to process approximately 280-to-450 kbd of crude oil to produce the base case gasoline volume and 680-to-750 kbd of crude oil under the high case scenario.<sup>35</sup>

**Exhibit 19: China Implied Gasoline Demand Growth Per Million New Cars Sold**



Source: CAAM, NBS China, Author’s Analysis

<sup>34</sup> For original study, see Gabriel B. Collins and Andrew S. Erickson, “Gasoline Alley: How Much Gasoline Demand Are Each Million Cars Sold in China Worth?” *China SignPost™* (洞察中国) 82 (3 November 2014), <http://www.chinasignpost.com/2014/11/03/gasoline-alley-how-much-gasoline-demand-are-each-million-cars-sold-in-china-worth/>.

<sup>35</sup> Sinopec 2015 Form 20-F, [http://english.sinopec.com/download\\_center/reports/2015/20160425/download/2016042502.PDF](http://english.sinopec.com/download_center/reports/2015/20160425/download/2016042502.PDF).

### 3. Gasoline Demand Outlook and Implications

Gasoline demand in China is likely to increase by 75-to-120 kbd in 2016 and 2017. Beyond that point, the confluence of vehicle powertrain innovation and other factors—particularly congestion on Chinese roadways—will likely begin to trim incremental gasoline demand growth. This is important because China’s diesel demand has very likely already reached a permanent peak, which stands to make gasoline the key driver of additional crude oil demand.<sup>36</sup>

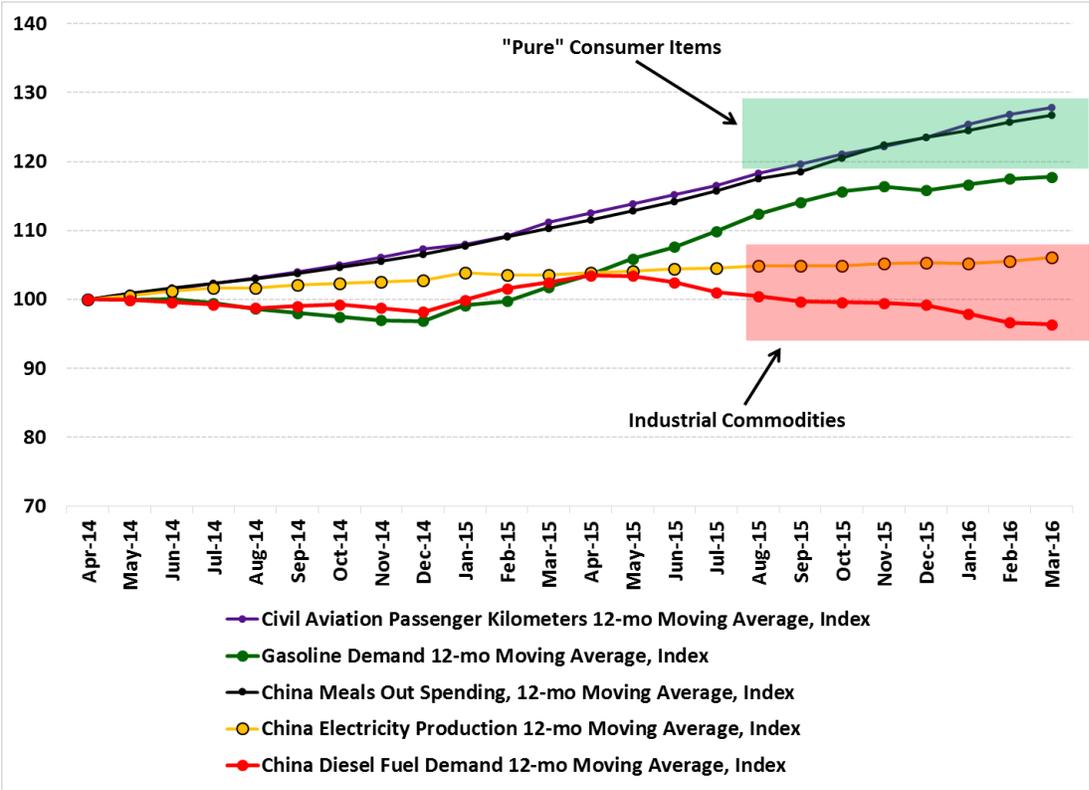
The chairman of Sinopec, China’s largest oil refiner, believes the country’s gasoline demand will peak around 2025, while ExxonMobil’s latest China energy outlook forecasts that passenger car fuel demand (i.e. primarily gasoline) will level off around 2030.<sup>37</sup> As gasoline demand continues to de-couple from heavy industrial indicators (**Exhibit 20**) and comprise a larger share of China’s overall oil products demand, things like personal air travel data and spending on meals outside the home will likely become better leading indicators of gasoline demand than the traditional measures such as electricity that would have historically more closely tracked Chinese oil product consumption.

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<sup>36</sup> Gabriel Collins, “China Peak Diesel Poses a Serious Challenge to Saudi Arabia, May Help Force OPEC Production Cut,” *China SignPost™* (洞察中国) 94 (5 April 2016). <http://www.chinasignpost.com/2016/04/05/china-peak-diesel-poses-a-serious-challenge-to-saudi-arabia-may-help-force-opec-production-cut/>.

<sup>37</sup> Timothy Coulter, “China’s Fuel Demand to Peak Sooner Than Oil Giants Expect,” Bloomberg, 1 April 2015, <http://www.bloomberg.com/news/articles/2015-04-01/china-s-fuel-demand-to-peak-sooner-than-oil-giants-expect>; “The Outlook for Energy: A View to 2040,” ExxonMobil, 24, <http://cdn.exxonmobil.com/~media/global/files/outlook-for-energy/2016/2016-outlook-for-energy.pdf>.

**Exhibit 20: China Gasoline Demand vs. Consumer and Industrial Activity Indicators**  
 Index, April 2014=100



Source: NBS China, Author’s Analysis

**4. Gasoline Likely to Remain China’s Dominant Car Fuel Until At Least 2025, But Fleet is Becoming Much More Efficient**

Gasoline will be China’s dominant passenger car fuel for the next decade, and likely beyond, due to gasoline’s superior power density and logistical advantages relative to pure electric cars and competing liquid fuels. But the gasoline will be burned more efficiently. Gasoline motors are being downsized and turbocharged and/or linked with electric propulsion systems to form more efficient gasoline-electric drivetrains that wring out significantly more miles per gallon while delivering high performance that makes driving fun. Lower kilometers driven per vehicle, drivetrain technology improvements, and a gradual increase in scrapping rates mean that by 2018, sales of new cars in China will likely need to be at least 10-to-15% higher than they were in 2015 simply to sustain the 2015 incremental gasoline demand growth rate of approximately 200 kbd.

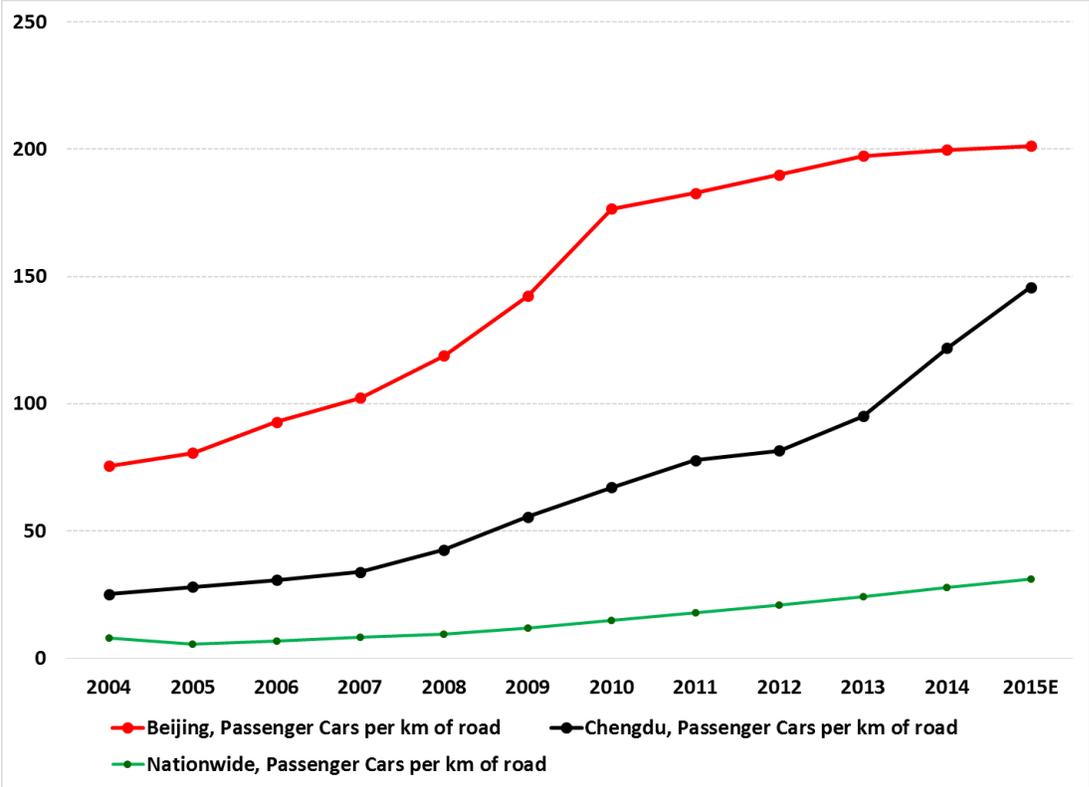
Despite the high confidence expressed by the China gasoline bulls, three core structural factors deserve close scrutiny given their deep influence over how cars are—and will be able to be—driven in China now and in coming years. These factors are: (1) traffic problems, (2) potential changes in car owner sentiment and behavior driven by congestion and other issues, and (3)

improvements in fuel efficiency from rising penetration of more advanced drivetrain technologies. The interplay of these factors raises the risk that gasoline demand growth in each of the next three years could fall below the base case of 75-to-120 kbd that the author currently forecasts.

**A. Traffic Troubles**

China’s grinding gridlock continues to worsen in many cities as car sales outpace highway construction. It is not yet fully clear what the “saturation” point is for vehicle ownership, but that tipping point is ultimately much more likely to be driven by a lack of road space than by any per capita car ownership threshold. The data from Beijing—China’s most mature car market—suggest that at around 200 cars per km of roadway, large Chinese cities will begin to see ownership rates level off (**Exhibit 21**).

**Exhibit 21: Private Passenger Cars Per KM of Road in the Beijing and Chengdu Metro Areas**



Source: Local Statistical Bureaus, NBS China

Urban consumers dominate the Chinese car market thus far, and so the national car density numbers are misleading, because they factor in rural areas where many residents still cannot afford cars. As the used car market grows in China, it is possible that rural areas could become a more significant source of fuel demand. But at this point and for the next five years, the proper

focus will be on cities, as Tier 1 and 2 markets reach saturation and car sellers increasingly look to Tier 3-6 markets to prop up sales.<sup>38</sup>

To be sure, Beijing has imposed substantial restrictions on car purchases—for instance, setting an annual quota of cars that can be sold and issuing license plates via a lottery—as well as actual use of private passenger vehicles in the city.<sup>39</sup> Yet the trend of roadway saturation plateauing in the 200 cars per km range is likely fundamentally rooted in physical constraints, as opposed to administrative ones.

Such factors include low road density relative to populated area. For instance, a September 2013 study by Singapore’s Land Transport Authority reveals that Beijing had only 1.7 km of roadway per square kilometer of land area.<sup>40</sup> Contrast this with Seoul and Tokyo, which had 13.5 km/km<sup>2</sup> of road and 19.1km/km<sup>2</sup>, respectively.<sup>41</sup> New York has 12.9 km of road per square kilometer.<sup>42</sup> Harris County, Texas has 263 passenger vehicles per km of road—30% higher than Beijing—but a road density of approximately 2.8 km/km<sup>2</sup>, or 65% higher than Beijing’s.<sup>43</sup>

## **B. Data Show World-Class Car Sales...And World-Class Congestion**

Granular data reveal just how deep China’s traffic congestion problems are. TomTom, a leading global navigational aid manufacturer, uses an historical database with 14 trillion historical travel time measurements that is continually updated and measures congestion on the road networks of 295 cities in 50 countries around the world.<sup>44</sup> The index is expressed in the form of a percentage number that reflects the increase in travel time as compared to an uncongested “free flow” traffic situation.

TomTom’s 2016 Traffic Index yields two important insights. First, China’s large cities are already among some of the world’s worst in terms of traffic congestion. For instance, of the world’s 25 most-congested cities in 2015 according to the TomTom data, five were located in China (**Exhibit 22**).

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<sup>38</sup> Gabriel B. Collins and Andrew S. Erickson, “Gasoline Alley: How Much Gasoline Demand Are Each Million Cars Sold in China Worth?” China SignPost™ (洞察中国) 82 (3 November 2014), <http://www.chinasignpost.com/2014/11/03/gasoline-alley-how-much-gasoline-demand-are-each-million-cars-sold-in-china-worth/>

<sup>39</sup> “Beijing Said to Expand Restrictions on Vehicle Use to Fight Smog,” Bloomberg, 8 January 2016, <http://www.bloomberg.com/news/articles/2016-01-08/beijing-said-to-expand-restrictions-on-vehicle-use-to-fight-smog>

<sup>40</sup> Pan Di, “Key Transport Statistics of World Cities,” Journeys, September 2013, [http://www.lta.gov.sg/ltaacademy/doc/13Sep105-Pan\\_KeyTransportStatistics.pdf](http://www.lta.gov.sg/ltaacademy/doc/13Sep105-Pan_KeyTransportStatistics.pdf)

<sup>41</sup> Ibid.

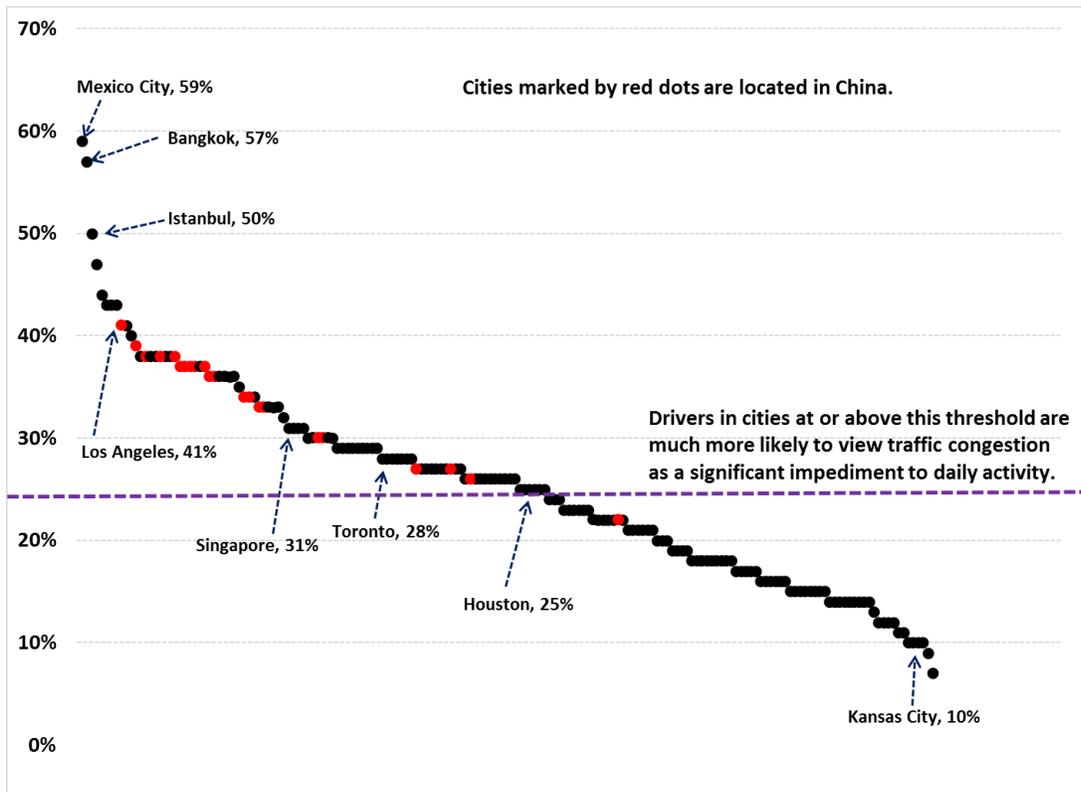
<sup>42</sup> Ibid.

<sup>43</sup> Texas DMV Registration Data by County, CY2014, [http://www.txdmv.gov/reports-and-data/cat\\_view/13-publications/25-reports-data/65-vehicle-titles-registration/229-number-of-vehicles-registered](http://www.txdmv.gov/reports-and-data/cat_view/13-publications/25-reports-data/65-vehicle-titles-registration/229-number-of-vehicles-registered); “Harris County Profile,” The County Information Program, Texas Association of Counties, <http://www.txcip.org/tac/census/profile.php?FIPS=48201> (accessed on 20 May 2016)

<sup>44</sup> “TomTom Traffic Index, Measuring Congestion Worldwide,” 2015, [http://www.tomtom.com/en\\_gb/trafficindex/](http://www.tomtom.com/en_gb/trafficindex/)

## Exhibit 22: TomTom Global Cities Road Congestion Ratings

Increase in travel time compared to a free flow road condition with no congestion



Source: TomTom, Author's Analysis

Second, congestion worsened in 14 of the 22 Chinese cities on the list, suggesting that the country's traffic struggles will likely become more serious despite a slowing economy as car sales outpace urban road construction. The TomTom data read like a "who's who" of large and growing Chinese car markets. Key cities include: Beijing, Chengdu, Chongqing, Guangzhou, Nanjing, Tianjin, and Wuhan, as well as emerging car markets such as Changsha, Ningbo, Quanzhou, and Shijiazhuang. In short, congestion issues are not only plaguing the powerhouse coastal vehicle markets—they are also affecting key inland demand hubs.

Adding more color, 21 of the 22 Chinese cities on the list had worse average congestion readings than the city of Houston, Texas, which is legendary for its traffic issues. The 10 most congested Chinese cities in the TomTom dataset accounted for roughly one in every five passenger vehicles owned in China at year-end 2014, so many Chinese drivers are already in the thick of serious traffic jams that are not likely to improve in the next few years.

### C. How Might Driver and Car Buyer Sentiments and Behavior be Changing in China?

China gasoline market analysts face the critically important question: how much do Chinese car owners actually drive? The question is a complicated one in practice because the Chinese government does not report vehicle miles travelled (“VMT”) data as, for instance, the US Department of Transportation does.<sup>45</sup> Researchers in China have worked to bridge this gap, using two primary methodologies.

The first entails using regularly reported total freight or passenger traffic volume to estimate VMT per vehicle.<sup>46</sup> The second method estimated the relationship between VMT and vehicle age and applied this to the vehicle age distribution of the Chinese vehicle fleet in a particular year.<sup>47</sup> An analysis from Argonne National Laboratory states that in the 2001-2004 period, the annual VMT of cars in China’s cities was between 24,000 and 27,000 km.<sup>48</sup>

This number has likely fallen significantly in recent years, because the early estimates were inflated by the large proportion of taxis in China’s car fleet—16.4% of vehicles in 2002 and 10.1% in 2004.<sup>49</sup> The Argonne researchers project that by 2030, the average VMT of Chinese passenger cars will be 13,000 km—a figure more closely aligned with actual data from Japan and Western Europe in the late 1990s.<sup>50</sup>

Privately owned cars are coming to dominate China’s passenger car fleet and annual VMT per car continues to regress toward the 10,000-13,000 km level. Traffic congestion like that illustrated in the TomTom data could prompt drivers to use their vehicles less, a potentially deeply consequential factor for China’s future gasoline consumption trajectory. A 2015 study by consultancy Bain and Company showed that nearly a third of current car owners surveyed might get rid of their vehicles if traffic congestion became “significantly worse,” while such a congestion level would prompt nearly 30% of prospective car buyers to refrain from purchasing a vehicle.<sup>51</sup> Bain canvassed a reasonably large sample size, surveying more than 2,100 respondents in six Tier-1 and Tier-2 cities.

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<sup>45</sup> C.Y. Cynthia Lin, Jieyin (Jean) Zeng, “The Elasticity of Demand for Gasoline in China,” Department of Agricultural and Resource Economics, UC Davis, [http://www.des.ucdavis.edu/faculty/lin/China\\_gasoline\\_elasticity\\_paper.pdf](http://www.des.ucdavis.edu/faculty/lin/China_gasoline_elasticity_paper.pdf) (25)

<sup>46</sup> He, K., Huo, H., Zhang, Q., He, D., An, F., Wang, M., Walsh, M., 2005. Oil consumption and CO2 emissions in China’s road transport: current status, future trends, and policy implications. *Energy Policy*, 33 (2005) 1499–1507

<sup>47</sup> Lin, X., Tang, D., Ding, Y., Yin, H., Ji, J., 2009. Study on the Distribution of Vehicle Mileage Travelled in China. *Research of Environmental Sciences*, 22(3).; See also Oliver et.al, “In-use Vehicle Emissions in China: Beijing Study,” Belfer Center for Science and International Affairs, Harvard University, March 2009, <http://belfercenter.ksg.harvard.edu/files/2009-05-ETIP-Oliver-et-al-2.pdf>

<sup>48</sup> M. Wang, D. He, H. Huo, and L. Johnson, “Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO2 Emissions through 2050,” December 2006, Argonne National Laboratory, <https://greet.es.anl.gov/files/rwdz78ca>

<sup>49</sup> Id.

<sup>50</sup> Id.

<sup>51</sup> “China New Mobility Study: 2015,” Bain & Company, [http://www.bain.com/Images/BAIN\\_DIGEST\\_China\\_new\\_mobility.pdf](http://www.bain.com/Images/BAIN_DIGEST_China_new_mobility.pdf)

The survey’s question prompt relies on drivers’ subjective perceptions of how bad traffic is relative to the current conditions used as a baseline. But despite that potential weakness, it suggests that continued gridlock could: slow new vehicle sales, prompt current owners to drive less, and in a worst case, induce car owners in China’s largest metro areas to abandon personal car use and ownership entirely. This would be deeply problematic for oil markets since the core metros are China’s major centers of gasoline demand.

**Exhibit 23: Primary Bearish Factors That Could Reduce Car Ownership and/or Sales in China**

		Would stop owning a car	Would refrain from buying a car
		Car Owners	Prospective Buyers
Traffic Congestion	Significantly Worse	32%	29%
	Moderately Worse	16%	13%
	Does Not Get Worse	11%	5%
Average Gasoline Price	9.5 RMB/l (\$5.46/gal)	31%	27%
	8.5 RMB/l (\$4.88/gal)	13%	9%
	7.5 RMB/l (\$4.31/gal)	11%	5%

Source: Bain and Company, Author’s Analysis

Traffic problems are also much more likely to affect car use and sales (and thus, gasoline demand) than is the other key bearish factor: gasoline prices. Congestion affects drivers here and now and it impacts them every single time they drive anywhere beyond their immediate area of residence. Gasoline prices, in contrast only cause pain when a driver has to fill up—something that likely happens once per week or less. Secondly, changing global oil market conditions make it very unlikely that gasoline prices in China will rise high enough to negatively impact car ownership and sales.

Bain’s survey data suggests that the “pain point” for current and prospective Chinese drivers begins when gasoline prices climb to 7.5 RMB a liter or higher (\$4.31/gallon). The sharpest pain does not hit until prices climb above 8.5 RMB/l (\$4.88/gallon). These thresholds are surprisingly high—particularly from an American perspective—and reflect the fact that Chinese vehicle owners are generally wealthier than average and that passenger cars are still a luxury good, rather than the daily necessity that they have become in other parts of the world.

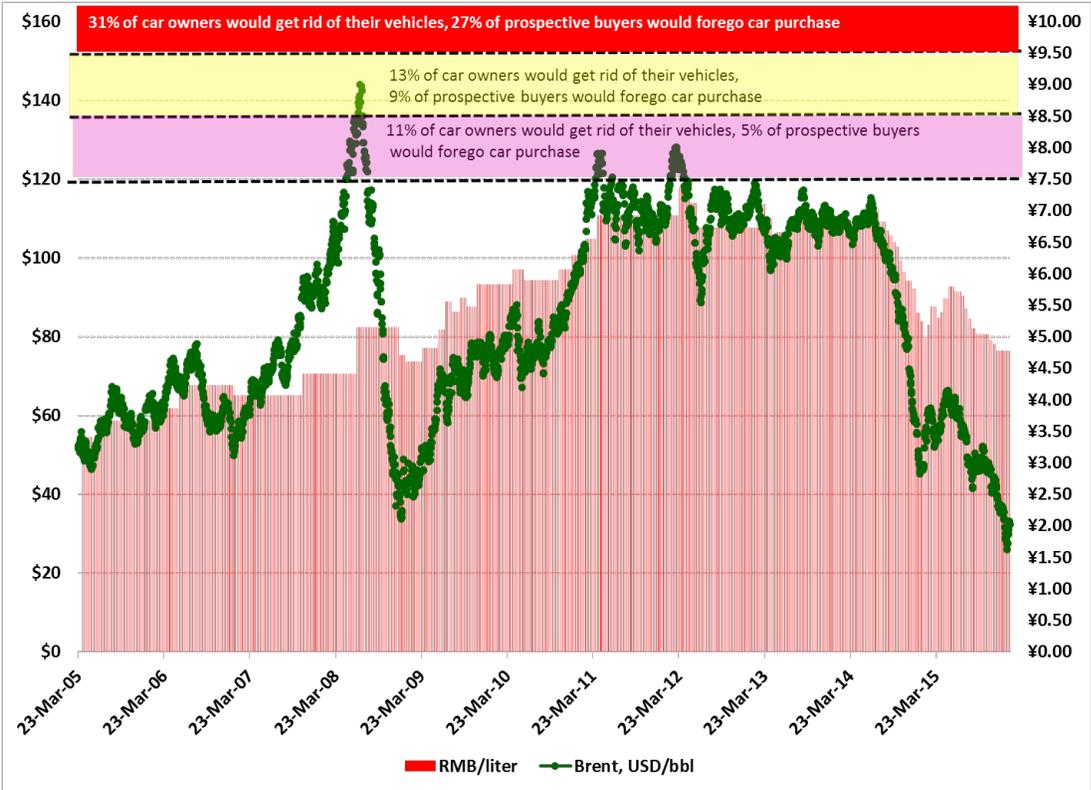
To assess the risk that gasoline demand might pose to car sales and ownership rates in China, the author plotted China’s baseline retail gasoline price for #93 fuel against the daily spot price of Brent crude, the broad international crude oil price benchmark. The result suggests that it would take an oil price spike akin to that experienced in 2008 to drive Chinese retail gasoline prices to levels likely to adversely affect sales and ownership of personal cars.

For instance, retail gasoline prices in China have historically not approached the 7.5 RMB/l mark unless Brent crude was trading at close to \$120/bbl. The true pain threshold of 9.5 RMB per liter of gasoline would likely require Brent crude to trade close to \$160 per barrel (**Exhibit 24**). The

author is highly cognizant that a truly severe geopolitical shock—such as large-scale disruption of oil transit through the Strait of Hormuz by military conflict—could trigger price spikes of such magnitude. Yet such events also lie very far out on the probability curve.

**Exhibit 24: China Retail Gasoline Prices vs. Brent Crude Daily Spot Price**

Left axis: Brent crude price (USD/barrel), Right axis: Retail #90 gasoline price (RMB/liter)



Source: EIA, NDRC, Chinese Media

The Bain survey data suggest that traffic congestion and gasoline prices will—by a significant margin—be the strongest influences on car purchase and use decisions in China. Of the three “secondary factors” surveyed, only one—taxi/ride sharing availability—comes close in terms of potential influence. If taxi availability were “easy,” 18% of respondents would consider getting rid of their cars, while 13% would consider doing so if it were “easy” to rent a car.

Two core conclusions flow from this data: first, there is indeed significant market space for the growth of car rentals and ride sharing in China, which would explain Uber’s intense drive to compete in the China market.<sup>52</sup> Second, there is a significant gap in the responses of car owners and prospective car buyers to the taxi and rental car availability questions, as well as the question

<sup>52</sup> Leslie Hook, “Saudi wealth fund takes \$3.5bn Uber stake,” Financial Times, 1 June 2016, <http://www.ft.com/intl/cms/s/0/a7e31c58-282c-11e6-8b18-91555f2f4fde.html#axzz4B1qWnLw7>

aimed at gauging willingness to use public transport in lieu of a car. Those respondents who had not yet purchased a car were not nearly as influenced by rental/taxi availability.

*China SignPost's* prior research suggests a possible explanation: prospective car buyers seek cars not just for social status reasons, but for practical ones as well.<sup>53</sup> For a person who seeks to carry groceries, travel in more comfort than public transport offers, and have personal transportation available at a time and place of their choice, a personal car fits the bill. But once such an individual buys the car and begins to face the burdens of car ownership in China—for instance, extreme difficulties finding parking space—the initial allure fades and a bit of buyer's remorse kicks in.<sup>54</sup>

### Exhibit 25: Secondary Bearish Factors That Could Impact Car Sales and Use in China

		Would stop owning a car	Would refrain from buying a car
		Car Owners	Prospective Buyers
Taxi Availability	Easy	18%	7%
	Moderate	11%	5%
	Difficult	11%	5%
Car Rental Accessibility	Easy	13%	6%
	Moderate	12%	5%
	Difficult	11%	5%
Development of Public Transport	Targeted Improvement	11%	6%
	Intermodal Connectedness	10%	5%
	Comprehensive Improvement	8%	5%
Cost of Obtaining a Local Car Plate	Difficult	N/A	8%
	Moderate	N/A	6%
	Remains the Same	N/A	5%

Source: Bain and Company, Author's Analysis

#### D. Key Factor: Evolving Powertrains

Over the past decade, SUVs have become increasingly popular in China and are the fastest growing passenger vehicle segment. Data from JATO Dynamics show that the rapid sales growth continues, with more than four million SUVs sold in China during 2014 and six million in 2015—accounting for nearly 1/3 of all passenger vehicles sold in the country.<sup>55</sup>

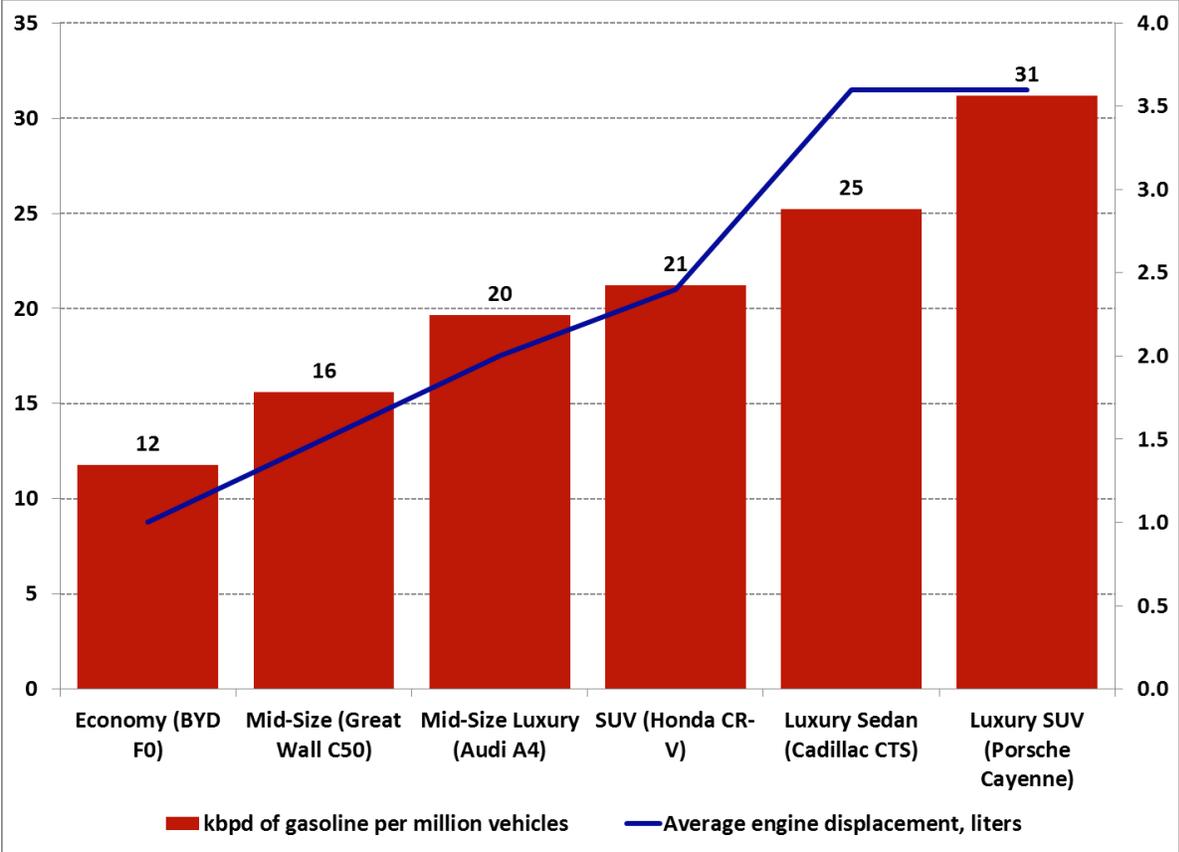
<sup>53</sup> Gabe Collins and Andrew Erickson, "Counting Cars: Rising Private Automobile Ownership in Chinese Cities Paves Road for Gasoline Demand," *China SignPost™* (洞察中国) 71 (24 June 2013), <http://www.chinasignpost.com/2013/06/23/counting-cars-rising-private-automobile-ownership-in-chinese-cities-paves-road-for-gasoline-demand/>

<sup>54</sup> Gabe Collins and Andrew Erickson, "Dying for a Spot: China's Car Ownership Growth is Driving a National Parking Space Shortage," *China SignPost™* (洞察中国) 17 (10 January 2011), <http://www.chinasignpost.com/2011/01/10/dying-for-a-spot-chinas-car-ownership-growth-is-driving-a-national-parking-space-shortage/>

<sup>55</sup> "FOCUS ON CHINA. 2015 MARKET OVERVIEW: IMPACTS AND OPPORTUNITIES OF CAR PURCHASE RESTRICTIONS," JATO, March 2016, <http://www.jato.com/wp-content/uploads/2016/04/JATO-Market-Focus-China-Car-Purchase-restrictions-and-Market-overview-2015-Final.pdf>

SUVs’ rapid penetration directly impacts gasoline consumption, since these vehicles tend to have higher-displacement engines that, all things held equal, generally consume more fuel than the motors used in smaller, lighter sedans. For instance, this author’s model for gasoline use per million vehicles indicates that a million small economy cars driven an average of 13,000 km per year create approximately 12 kbd of incremental gasoline demand. Yet a million midsize SUVs such as the Honda CR-V use 21 kbd of gasoline--75% more (**Exhibit 26**). A million large SUV’s—such as the Porsche Cayenne—raises the daily gasoline demand per million vehicles figure to 31 kbd. To put the gasoline numbers in perspective, to produce a barrel of gasoline, Chinese refiners typically must run approximately 3.8 barrels of crude oil. This means that to supply gasoline for each additional million SUVs entering the fleet, the Chinese refining sector will likely need to process 80-to-120 kbd of crude oil.

**Exhibit 26: Estimated Incremental Gasoline Demand Per Million Vehicles, kbd**



Source: Company Reports, Author’s Analysis

Strong SUV sales may make it difficult for China to meet its ambitious national fuel economy standards, which call for an average (i.e. all vehicles old and new) fleet fuel use of nearly 48 miles per gallon (“mpg”) by 2020. China released Phase IV fuel consumption standards for passenger

vehicles (GB19578-2014) in December 2014 and the rules took effect on January 1, 2016.<sup>56</sup> The Phase IV standards use a curb-weight index to establish maximum fuel consumption limits and determine compliance based on the corporate-average fuel consumption (CAFC) of manufacturers in a given year. There are two sets of limit values: one for regular cars and another for special cars.

To put China's 2020 fuel economy standards in perspective, U.S. regulators seek a fleet-wide standard of 38.9 mpg for light-duty vehicles and 44.8 mpg for cars.<sup>57</sup> The difficult part is that as a local car culture takes hold, Chinese consumers increasingly seek vehicles that are fuel-efficient but also powerful and fun to drive. For instance, in 2014, Honeywell Turbo Technologies surveyed visitors to auto.163.com and yangche51.com, two of China's most popular automotive news and information portals (combined daily traffic of 340,000 during the survey period) to gauge consumer expectations of new vehicles coming to market.<sup>58</sup>

Only 1/3 of respondents were satisfied with their current vehicle's fuel economy and power, while 80 percent would seek fuel economy savings of at least 10 to 30 percent to be satisfied with their next vehicle purchase. Furthermore, 94% of respondents indicated engine performance was an "important" or "very important" factor for purchasing a vehicle and 68% of respondents said they would prefer to buy a smaller car if it could still perform like a vehicle with a larger engine.<sup>59</sup>

Results such as these suggest Chinese drivers may follow a path at least somewhat akin to American drivers, who place a significant premium on powerful vehicles. In the U.S. market, manufacturers responded strongly to drivers' dual demand for miserly mileage and generous horsepower, as fleet-wide average fuel economy doubled between 1975 and 2014 and average horsepower per vehicle rose nearly 50% (**Exhibit 27**).

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<sup>56</sup> "China: Light Duty-Fuel Consumption," transportpolicy.net,

[http://www.transportpolicy.net/index.php?title=China: Light-duty: Fuel Consumption.](http://www.transportpolicy.net/index.php?title=China:_Light-duty:_Fuel_Consumption)

<sup>57</sup> "Light-duty vehicle" means a passenger car or passenger car derivative capable of seating 12 passengers or less.

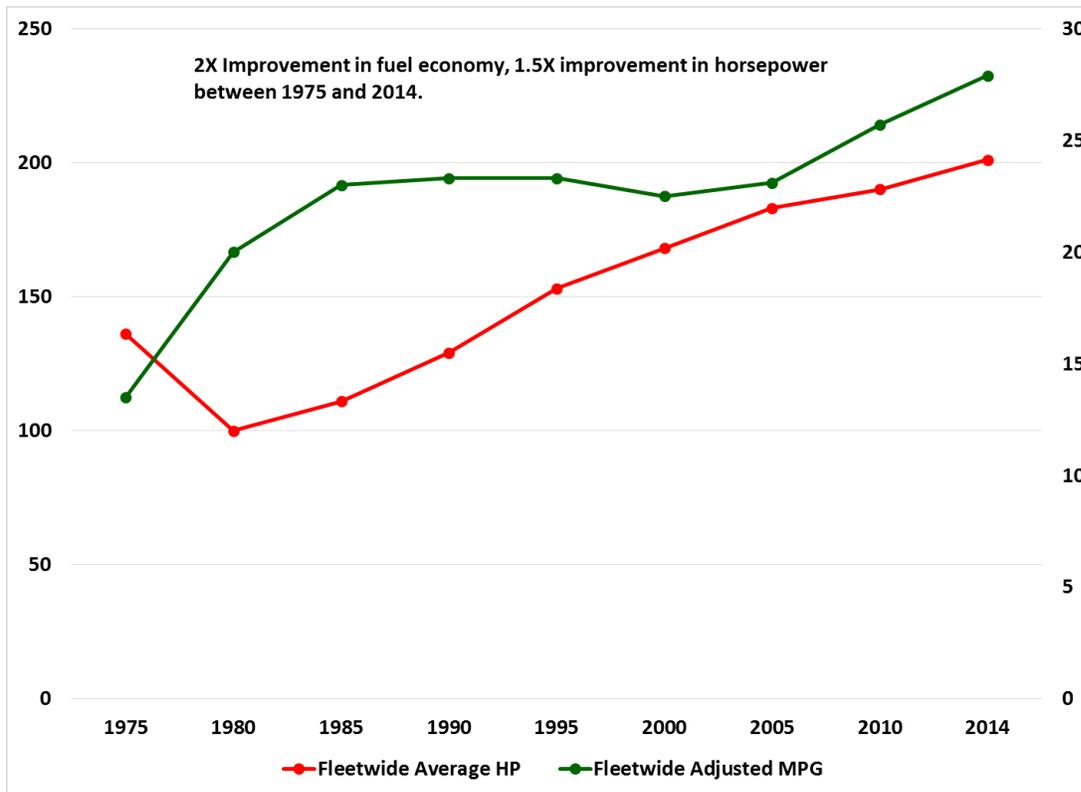
42 U.S.C. 7401 <https://www.gpo.gov/fdsys/pkg/CFR-2011-title40-vol19/pdf/CFR-2011-title40-vol19-sec86-1803-01.pdf>.

<sup>58</sup> "Eighty Percent of Chinese Drivers Seek Fuel Economy Improvements with Next Vehicle Purchase, Survey Says," Honeywell, 2 July 2014, <https://turbo.honeywell.com/whats-new-in-turbo/press-release/eighty-percent-of-chinese-drivers-seek-fuel-economy-improvements-with-next-vehicle-purchase-survey-says/>.

<sup>59</sup> Shrinking vehicle dimensions while preserving performance may also be driven by the scarcity of parking space in China. See, for instance, Gabe Collins and Andrew Erickson, "Dying for a Spot: China's car ownership growth is driving a national parking space shortage," China SignPost™ (洞察中国), No. 17 (10 January 2011).

## Exhibit 27: Fuel Economy and Horsepower Both Improved Dramatically in US Car Fleet Over The Last 40 Years

Average horsepower per vehicle (left axis), average miles per gallon (right axis)



Source: NHTSA, Author's Analysis

The U.S. auto sector's ability to balance fuel economy and power output demands has been remarkable and contrasts sharply with the EU vehicle fleet, where fuel economy clearly won out over power. Indeed, comparing 2011 EU passenger vehicle fleet data (the latest available) to the 2010 numbers from the US showed that the typical European passenger car got 57% better mileage than its US equivalent, but had 61% less horsepower.<sup>60</sup> The chief difference appears to be in the vehicles' powertrains, as the typical European vehicle was only 14% lighter than its US counterpart—likely insufficient to explain the substantial fuel economy and power disparities.

### E. Cars Sold in China Will Increasingly Use Turbochargers and Partial Hybrid Propulsion to Balance Fuel Economy and Power Output Demands

China's car fleet is likely to be increasingly permeated by powertrain technologies that enhance fuel economy without detracting from vehicle performance. There are three primary ways of accomplishing this, each of which must balance equipment cost and user convenience. First is to move towards a fully electric vehicle fleet. The second is to make engine displacement smaller

<sup>60</sup>"EUROPEAN VEHICLE MARKET STATISTICS: Pocketbook 2014,"The International Council on Clean Transportation, [http://www.theicct.org/sites/default/files/publications/EU\\_pocketbook\\_2014.pdf](http://www.theicct.org/sites/default/files/publications/EU_pocketbook_2014.pdf)

and use turbochargers to maintain power levels. The third is to incorporate partial electric vehicle technologies—“mild hybrids” in industry parlance.

Pure electric vehicles are at a disadvantage for several reasons. To begin with, fully electric cars likely will not reduce China’s severe air pollution burden and will simply trade “oil security” issues for “air security” problems.<sup>61</sup> Despite the rapid growth rate in wind and solar generation capacity, China still relies overwhelmingly on coal-fired plants to generate its electricity. As such, electric cars simply shift pollution problems from a semi-dirty vehicle tailpipe to a potentially much more emissions-intensive power plant smokestack.

### **Pure electric cars not so clean in China due to coal-dependent power generation...**

Each million plug-in electric passenger cars would likely create an additional 740,000 tonnes per year of coal demand in China—equivalent in CO2 emissions terms to approximately one million BYD F0 gasoline-powered passenger sedans.<sup>62</sup> In this sense, a pure plug-in electric car running on grid power in many parts of China (aside from areas where grid supply comes primarily from hydro or nuclear plants) is effectively still as carbon intensive as a fully gasoline-powered compact car, virtually negating the environmental benefits of going full electric. Moreover, burning coal also releases far more sulfur than burning an equivalent amount of gasoline, not to mention mercury and other toxics not typically emitted in meaningful amounts by gasoline engines.

This “road to grid” linkage increases coal demand and air pollution and could disrupt local electrical grids where there are higher concentrations of such cars. Additionally, EV infrastructure likely cannot be easily or cheaply socialized and hence will represent a barrier to entry for consumers. Expenses, inconvenience, range limitations, and the costs of chargers and other supporting systems fall on the individual owner whereas the costs of liquid-fuel infrastructure like gas stations are distributed across society because so many people use them.<sup>63</sup>

As such, China—like other major global markets—is most likely to continue using gasoline propulsion for passenger vehicles. But powertrains will adopt much different configurations than drivers are currently accustomed to. In short, the use of smaller engines with turbocharging and mild hybrids will continue growing rapidly.

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<sup>61</sup> Aibing Guo, “Teslas May Be Making Hong Kong's Pollution Worse,” Bloomberg, 13 April 2016, <http://www.bloomberg.com/news/articles/2016-04-14/hong-kong-teslas-linked-to-more-co2-emissions-than-gasoline-cars>

<sup>62</sup> Based on data from “Carbon Dioxide Emissions Coefficients,” EIA, 2 February 2016, [https://www.eia.gov/environment/emissions/co2\\_vol\\_mass.cfm](https://www.eia.gov/environment/emissions/co2_vol_mass.cfm). 1.854 tonnes of CO2 emitted per tonne of sub-bituminous coal burned. Burning one gallon of gasoline emits 8.89 kg of CO2, which means 373 kg per barrel, or 3.17 tonnes of CO2 per tonne of gasoline (8.5 barrels per tonne of motor gasoline). 1.9 million tonnes of sub-bituminous coal emits 3.52 million tonnes of CO2, the same as 1.1 million tonnes of gasoline or 26 kbd annualized.

<sup>63</sup> Gabriel B. Collins and Andrew S. Erickson, “China Car Sales: New Pockets of Opportunity,” China SignPost™ (洞察中国) 79 (29 December 2013). <http://www.chinasignpost.com/2013/12/29/china-car-sales-new-pockets-of-opportunity/>.

Turbochargers enable engines to generate significantly more power from smaller displacements, which preserves performance while increasing fuel economy. For instance, data from Honeywell indicates that a 2.0 liter turbocharged four cylinder engine can generate the same horsepower as a 3.0 liter six-cylinder motor, while using 25% less fuel and emitting 20% less CO<sub>2</sub>.<sup>64</sup> At present, roughly one in four cars in China uses turbocharging, but this penetration rate is expected to climb to nearly 50% by 2020.<sup>65</sup> Dozens of cars sold in China now incorporate turbochargers, as evidenced by the Auto Shanghai 2015 show, where more than 50 vehicles using turbochargers were on display.<sup>66</sup>

“Mild hybrids” are a compromise technology employing a 48-volt electric system (as opposed to the standard 12-volt auto battery) to boost fuel efficiency by assisting the car’s initial acceleration. In a mild hybrid, the electric motors provide a boost at lower speeds but only serve as a power booster or starter-generator, or both.<sup>67</sup> Electric motors in these vehicles can't propel the car forward on their own.<sup>68</sup> In contrast, Autotrader defines a “full hybrid” as a vehicle that has both “an electric motor and a rechargeable battery, which can work independently or in conjunction with each other.”<sup>69</sup> The electrical motors in a full hybrid vehicle are powerful enough to propel it without running the internal combustion engine during very light cruising and light acceleration. Once the vehicle requires additional power is needed, the internal combustion engine then activates and provides full power.<sup>70</sup>

Data suggest that mild hybrids can deliver fuel economy gains of approximately 15%, but at only about a third the cost of a full hybrid system.<sup>71</sup> Large Chinese carmakers such as Geely and FAW plan to begin selling 48-volt mild hybrids within the next two years.<sup>72</sup> Furthermore, A123 Systems, a leading global battery maker owned by Wanxiang Group says “we see all major Chinese auto makers on or sourcing 48-volt batteries” and that they will phase such systems in over the next three years.<sup>73</sup>

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<sup>64</sup> Honeywell Corporation, Investor Presentations, 2 March 2016 Investor Presentation, <http://investor.honeywell.com/Events-and-Presentations>.

<sup>65</sup> Id.

<sup>66</sup> “Honeywell Plans Turbo Future in China; More than 50 Vehicles Highlighted at Auto Shanghai 2015,” 14 May 2015, <http://www.honeywell.com/newsroom/news/2015/05/honeywell-plans-turbo-future-in-china-more-than-50-vehicles-highlighted-at-auto-shanghai-2015>

<sup>67</sup> “Mild or Full? Hybrid Distinctions Defined,” Autotrader.com, <http://www.autotrader.com/car-news/mild-or-full-hybrid-distinctions-defined-36605> (last accessed on 15 September 2016)

<sup>68</sup> Id.

<sup>69</sup> Id.

<sup>70</sup> Id.

<sup>71</sup> Mike Ramsey, “China’s Car Makers Pioneer ‘Mild Hybrids’”, The Wall Street Journal, 8 March 2016, <http://www.wsj.com/articles/china-car-makers-pioneer-mild-hybrids-1457433002> ; See also Continental Corporation Investor Presentation, 2 February 2016, [http://www.continental-corporation.com/www/download/portal\\_com\\_en/themes/ir/events/20160202\\_hsbcsri\\_ffm\\_en.pdf](http://www.continental-corporation.com/www/download/portal_com_en/themes/ir/events/20160202_hsbcsri_ffm_en.pdf) (Slide 13)

<sup>72</sup> Ibid.

<sup>73</sup> Ibid.

As vehicles with turbochargers and 48-volt mild hybrid technology come to comprise a larger portion of China's vehicle fleet, the incremental gasoline demand of each million vehicles sold could decline by 15-to-20%, assuming mileage and driving habits remain constant. The effects in 2016 and 2017 will be more muted, but potentially still material. This author believes China's gasoline demand will feel the full impact of more efficient propulsion technologies in the 2019-20 timeframe. Accordingly, a key question will be: "does numerical growth in car sales remain strong enough to power overall annual gasoline demand growth in the 200 kbd range despite cars becoming more fuel-efficient?" The next analysis will assess recent passenger vehicle sales trends in China, as well as potential growth trajectories moving forward.

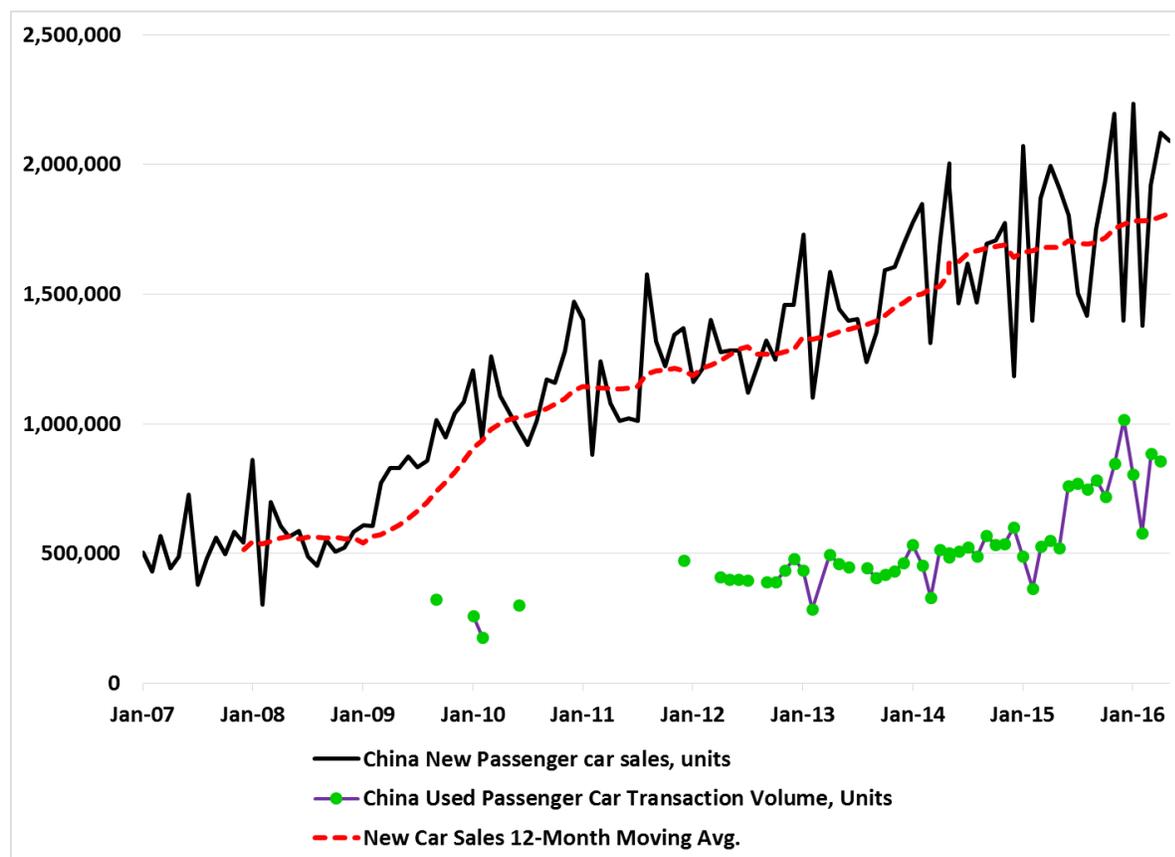
#### **F. China Passenger Car Fleet Growth Outlook Over the Next Decade**

China's overall passenger fleet car growth will likely be the single most consequential element influencing China's gasoline demand growth profile over the next two to five years. On a 12-month rolling basis, new car sales are still on an upward trend, but have slowed from the growth rates seen a few years ago (**Exhibit 28**). The China Association of Automobile Manufacturers forecasts that new passenger vehicle sales will rise by 6% YoY in 2016.<sup>74</sup> Last year saw 21.2 million new passenger vehicles sold in China, so CAAM's forecast suggests new vehicle sales could rise to approximately 22.5 million vehicles in 2016.

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<sup>74</sup> Natasha Li, "CAAM Predicted a 6% Growth in the 2016 Chinese Auto Market," Gasgoo.com, 13 January 2016, <http://autonews.gasgoo.com/china-news/caam-predicted-a-6-growth-in-the-2016-chinese-aut-160113.shtml>.

**Exhibit 28: China New and Used Passenger Car Sales**



Source: CAAM, CADA

Used vehicle sales are also increasingly important from an oil use perspective, as they help drive further market penetration. December 2015 marked the first time monthly used car transactions in China broke the one million mark. China’s nascent—but increasingly robust—used car market is a positive sign for the next 24 months in the country’s car market overall. Detailed used car sales data from 2015 suggest that Chinese new car owners in many cases turn their vehicles over quite rapidly: vehicles one-to-three years old accounted for 26% of used cars sold in 2015, while three-to-five year old vehicles made up 37% of total sales.<sup>75</sup> Vehicles eight years and older made up 19% of total used car sales in 2015.<sup>76</sup> Lightly used vehicles offer aspiring car owners the chance to acquire premium brands such as Volkswagen at significant discounts relative to what a new vehicle would cost.

<sup>75</sup> “2015 China Used Car Market Report” (2015年中国二手车交易数据报告), QQ.com, 22 January 2016, [http://auto.qq.com/a/20160122/052375\\_all.htm](http://auto.qq.com/a/20160122/052375_all.htm).

<sup>76</sup> Ibid.

Consider the following example: Sina.com’s used car portal lists a 2009 VW Passat with a manual transmission and 86,000 km on the odometer for 86,800 RMB.<sup>77</sup> The 2016 model year of the vehicle—which is listed for sale in Jining, Shandong—would cost nearly 230,000 RMB including taxes.<sup>78</sup> Based on these economic facts, it becomes clear that the heavy discounts (62% from current new vehicle sticker price in this case) strongly attract buyers who may not be flush with money, but seek quality vehicles capable of comfortably carrying several passengers plus goods and luggage.

Nearly 70% of China’s used car transactions in 2015 were done for 100,000 RMB or less, which suggests that this is an important pricing point for potential buyers.<sup>79</sup> In turn, as the cars sold during the sales spike in 2008-11 begin to age into the 5-year-plus category, used car transactions could rise sharply over the next 2-3 years as wealthier owners seek new rides while less well-heeled drivers capitalize on the growing availability of quality mid-sized vehicles coming onto the used market.

In the 2011 timeframe, many independent used car dealers in China complained about being unable to secure sufficient inventory.<sup>80</sup> Yet as current vehicle owners upgrade their cars and more quality vehicles hit the used market, the growing availability of attractive bargains may spur further purchasing and ownership penetration in both core markets and areas on their periphery—for instance the constellations of cities surrounding Shanghai and Guangzhou, two of China’s largest markets for new and used vehicles.

On the policy side, several factors contribute to growing month-to-month volatility in sales numbers. The Chinese government cut taxes on small displacement vehicles (engine size less than 1.6 L) in October 2015, which helped prop up sales.<sup>81</sup> In addition, over the past two years, periodic discussions of various ownership restrictions by key municipalities have fueled panic buying as prospective car owners rush to beat ownership caps, higher license plate fees, and the like.<sup>82</sup>

Amidst rising monthly sales variance between months, one trend is clear: China’s wealthier Eastern provinces have been the force behind the bulk of civilian vehicle fleet additions over the past several years. China’s seven largest civilian vehicle owning provinces—Shandong,

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<sup>77</sup>“VW Passat Sedan, 2009 Model, 1.8T, High-End Edition With Manual Transmission” (大众 帕萨特领驭 09款 1.8T 手动 尊品型), Sina.com, <http://usedcar.auto.sina.com.cn/buycar/d/1543632>. Accessed 22 June 2016

<sup>78</sup> Ibid.

<sup>79</sup> “2015 China Used Car Market Report” (2015年中国二手车交易数据报告), QQ.com, 22 January 2016, [http://auto.qq.com/a/20160122/052375\\_all.htm](http://auto.qq.com/a/20160122/052375_all.htm).

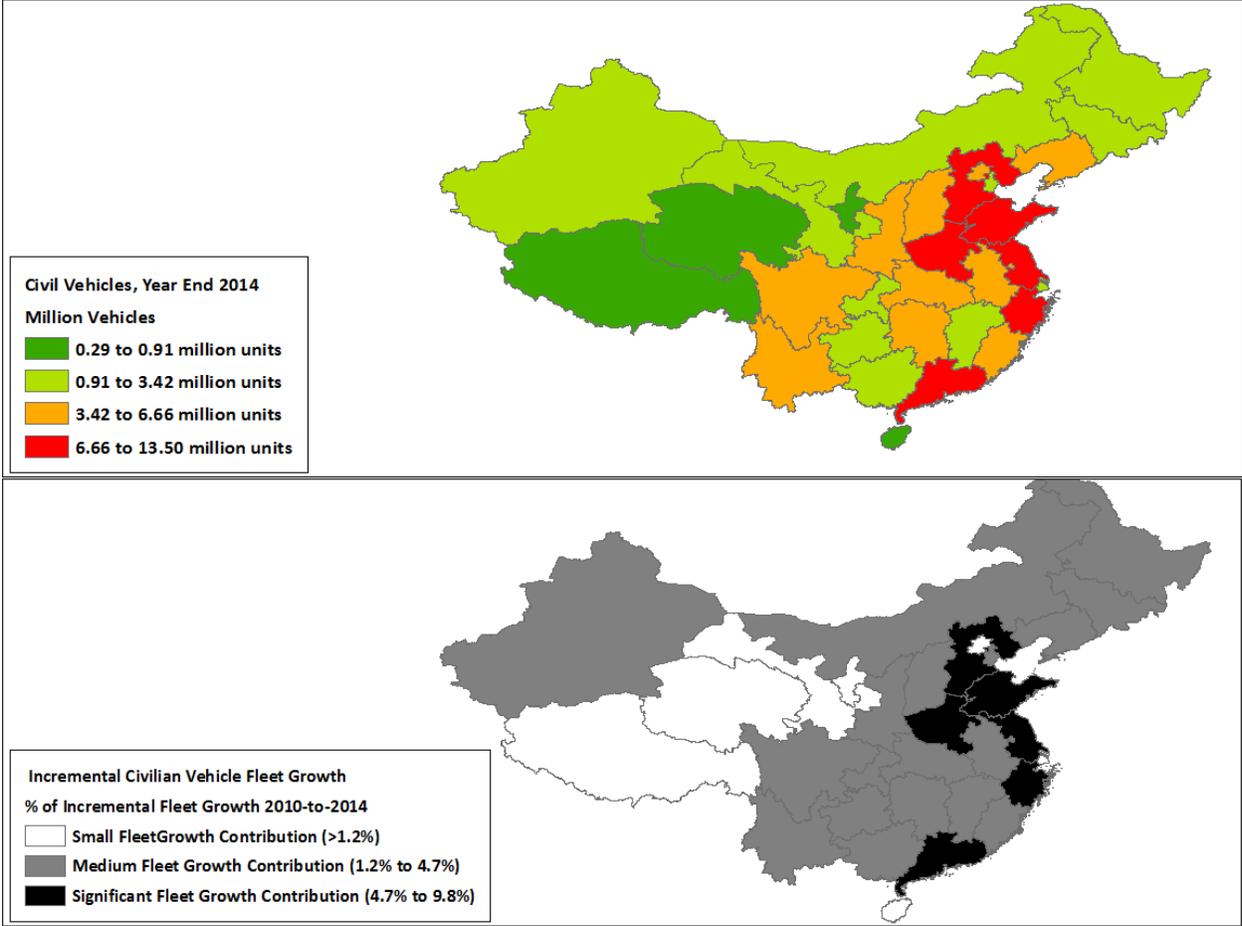
<sup>80</sup> Bob Tita, “Deere Profit Tumbles Amid Glut of Used Farm Equipment at Dealers,” *The Wall Street Journal*, 21 August 2015, <http://www.wsj.com/articles/deere-reports-decline-in-profit-as-sales-tumble-1440158935>; Bill Russo, Arnold Sun, Edward Tse, Ken Zhong, “A New Model for Selling Used Cars in China,” Booz & Co., March 2011.

<sup>81</sup> Christian Shepherd and Tim Mitchell, “China car sales accelerate after tax cuts,” FT, 12 January 2016, <http://www.ft.com/cms/s/0/c44622a0-b914-11e5-b151-8e15c9a029fb.html#axzz4CK3Y1gfo>.

<sup>82</sup> “China’s car sales up 13% as buyers rush to beat ownership limits,” *Automotive News*, 9 May 2014, <http://www.autonews.com/article/20140509/GLOBAL03/140509801/chinas-car-sales-up-13-as-buyers-rush-to-beat-ownership-limits>.

Guangdong, Jiangsu, Zhejiang, Hebei, and Henan—held approximately 46% of China’s total civilian vehicle fleet at year-end 2014. More notably, these seven provinces accounted for nearly 50% of incremental fleet growth between 2010 and 2014 (Exhibit 29). It appears that the big, predominantly coastal, vehicle owning regions continue to drive the national market.

**Exhibit 29: China Civilian Vehicle Fleet by Province and Provincial Contributions to Incremental Fleet Growth Between 2010 and 2014 (民用汽车保有量)**



Source: NBS China, Author’s Analysis

## G. Diving Deeper Into China Vehicle Sales Picture—Detailed Provincial-/City-Level Analysis

To gain province- and city-level insights into the behavior of Chinese new car buyers, this analysis draws on and updates an analysis originally done in December 2014 for *China SignPost*<sup>83</sup> that used Volkswagen as an analytical lens to gain insights into the evolving geography of passenger car sales.<sup>83</sup> VW was—and remains—the largest passenger car seller in China’s massive market, accounting for roughly one in every five passenger cars sold in the country. As such, the *China SignPost* study viewed VW’s sales and service infrastructure decisions as a useful barometer for assessing how the “smart money” saw passenger car demand unfolding in various regions of China.<sup>84</sup> The dataset was updated in June 2015 and May 2016 by obtaining additional VW disclosures of provincial-level dealership data.

VW disclosed data for dealerships by province at approximately quarterly intervals between the fourth quarter of 2012 and the second quarter of 2016. Our analysis of the data showed that the 10 provinces with the largest increase in number of dealerships during this time were (in descending order): (1) Jiangsu, (2) Zhejiang, (3) Hebei, (4) Shandong, (5) Guangdong, (6) Sichuan, (7) Henan, (8) Yunnan, (9) Anhui, and (10) a tie between Anhui and Hunan.<sup>85</sup> These 10 provinces reflect a significant East Coast bias in the China sales strategy of one of the world’s premier automakers. Indeed, by the author’s count using VW’s own data, more than 45% of its new China dealerships added between 4Q2012 and 2Q2016 were opened in East Coast provinces that account for little more than 1/3 of China’s population (**Exhibit 30**).

Provinces in Central and Southwestern China saw significant growth in the number of VW dealerships, but at a proportion lower than one would expect based on the provinces’ population and latent demographic and economic potential for increasing auto sales. Dealership additions in Northeast, Northwest, and Western China (Xinjiang, Tibet, Ningxia, Qinghai) were low relative to population, but this is less surprising given these regions’ relative poverty compared to places like Jiangsu and Sichuan.

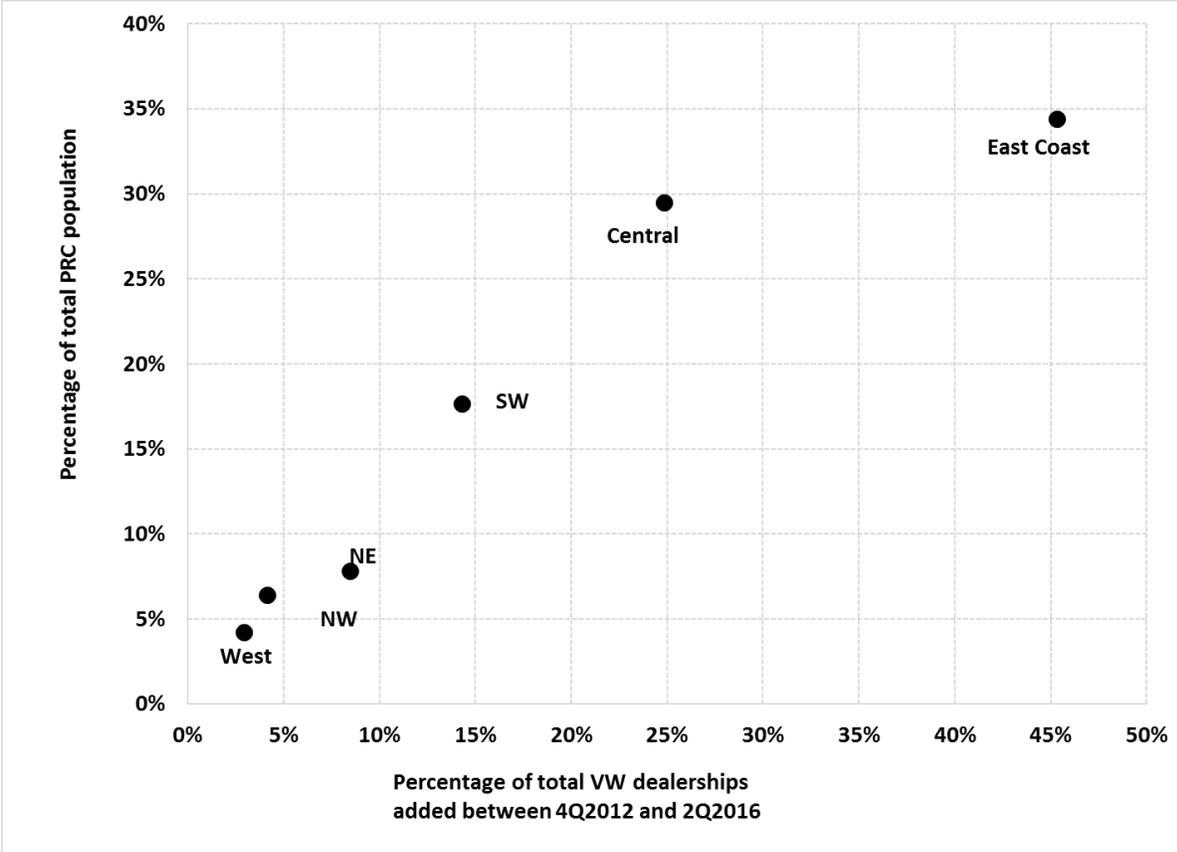
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<sup>83</sup> Note that this analysis counts dealerships for all of the three core VW brands: VW itself, Audi, and Skoda.

<sup>84</sup> Gabriel B. Collins and Andrew S. Erickson, “Volkswagen’s China Dealership Expansions Suggest Substantial Upside for Continued Growth in Car Sales—and Gasoline Consumption,” *China SignPost*<sup>TM</sup> (洞察中国) 87 (17 December 2014).

<sup>85</sup> Ibid.

**Exhibit 30: VW Dealership Additions by Region in China, 4Q2012 to 2Q2016**

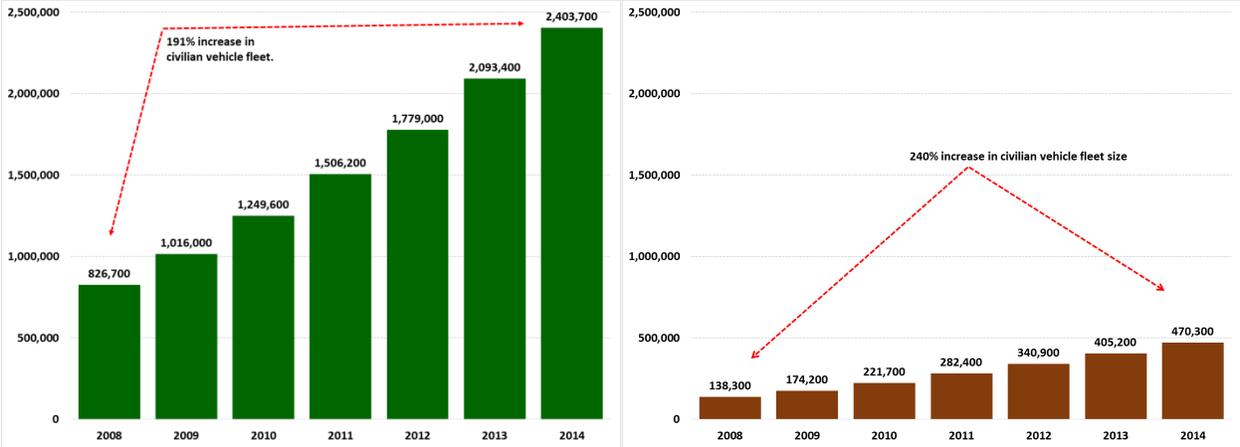


Source: Company Reports, NBS China, Author’s Analysis

Examining trajectories of different cities in the same high growth province—in this case, Jiangsu and Zhejiang—further reinforces the theme of just how locally concentrated much of China’s passenger car fleet growth has been. This is an important wrinkle because it suggests that the market may need to price in a more nuanced auto sales and gasoline demand growth picture that is more complex than simply envisioning a wave of cars washing over a vast a populous country.

Consider, for instance, the cities of Suzhou in Jiangsu Province and Taizhou in Zhejiang Province, two adjacent areas which comprise one of China’s largest passenger car (and gasoline) markets. The Suzhou metro area, which lies approximately 60 miles northwest of Shanghai, is home to roughly 11 million people. In a seven-year span from 2008 to 2014, Suzhou’s passenger vehicle fleet grew by 191% to 2.4 million vehicles (**Exhibit 31**). In contrast, the Taizhou metro area, which sits 190 miles south of Shanghai and counts approximately 6 million residents, saw its passenger vehicle fleet grow by 240% during the same timeframe, rising to 470 thousand vehicles. While Taizhou’s fleet did grow somewhat faster than Suzhou’s, it started from a much lower absolute numerical baseline and was not nearly rapid enough to compensate for the significant arithmetical disparity between the cities’ respective vehicle fleets.

**Exhibit 31: Civilian Vehicle Ownership in Suzhou, Jiangsu and Taizhou, Zhejiang**



Source: NBS China, Author’s Analysis

**H. Sales of New Cars Are Slowing**

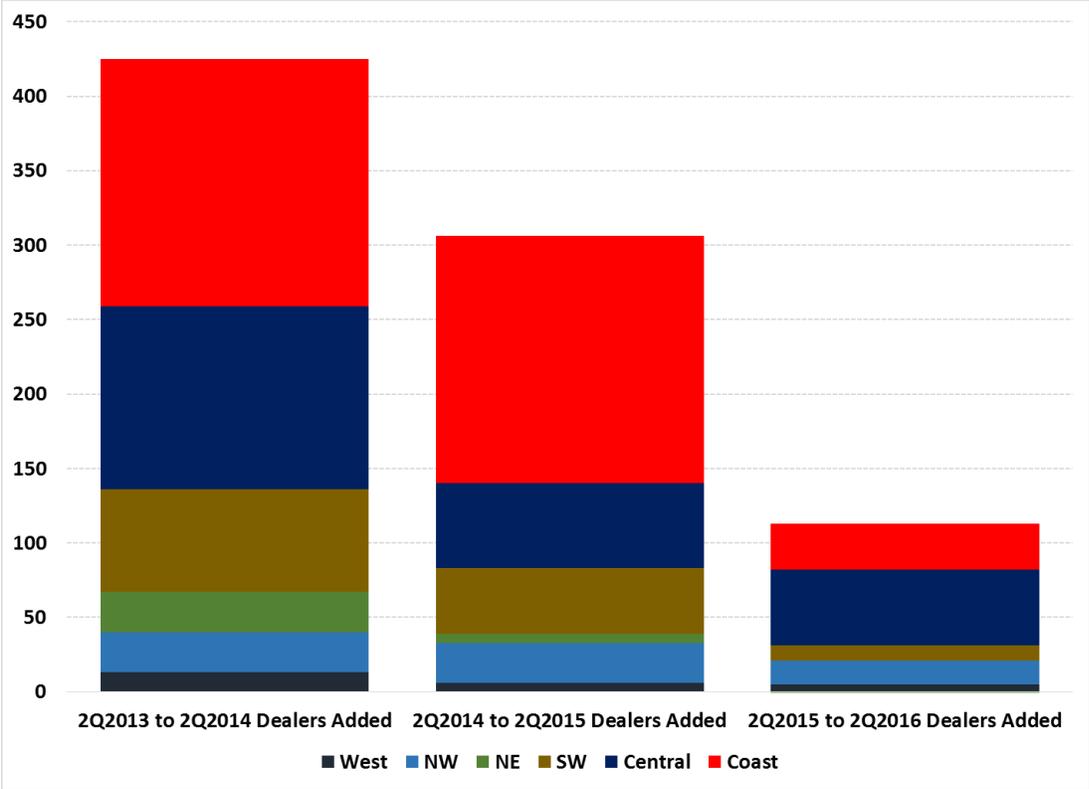
VW data suggests that the company sold approximately 1,655 vehicles per dealership in China during 2012.<sup>86</sup> By 2015, this number declined to an estimated 1,265 vehicles per dealer. The trend is important here because it transcends a common argument—that there are “too many” car dealers in China.<sup>87</sup> From the perspective of dealership economic and profitability, this thesis may well hold. But even consolidating dealerships will not reverse the slowdown in new car sales growth rates, which are the core focus of this analysis due to their significant effects on China’s gasoline demand outlook.

Consider the significant recent slowdown in VW’s China dealership buildout rate, from 425 net dealerships added between 2Q2013 and 2Q2014, 306 net dealerships added between 2Q2014 and 2Q2015, to just 110 net dealerships added from 2Q2015 to 2Q2016 (**Exhibit 32**). When one of the largest car dealers in a market rapidly scales back their dealership addition rate, the action strongly suggests the operator sees much less sales upside than they perceived even a few quarters prior.

<sup>86</sup> The author uses the word “suggests” because while car sales are calculated on an annualized basis, VW has continually added dealerships during each of the years in question. Because we do not know when these dealerships opened during a given quarter or what their operational “ramp up” period is, we treat the average sales per dealer as an approximation that reflects an overall trend, as opposed to an exact, time-adjusted number.

<sup>87</sup> “Auto Dealers in China, Ubiquitous as KFCs, Face Shakeout,” Bloomberg, 24 April 2016, <http://www.bloomberg.com/news/articles/2016-04-24/foreign-car-dealers-in-china-ubiquitous-as-kfcs-face-shakeout>.

**Exhibit 32: Net VW Dealership Additions in China by Region Have Slowed Dramatically in Past Two Years**



Source: Company Reports, Author’s Analysis

Perhaps the most notable trend emerging from this granular VW data is that between 2015 and 2016, the company clearly began to test the limits of dealership penetration in Coastal China.<sup>88</sup> Dealership expansion also slowed significantly in Southwest China, which based on its still low rates of personal car ownership, would be considered a fertile growth market. VW is not alone in realizing that passenger car demand in Western China has grown slower than expected. Several other multinational and domestic automakers saw their sales underperform expectations in Western China beginning as early as June 2015.<sup>89</sup>

Central China dealership additions shrank the least, which suggests that consumers there still have a healthy appetite for VW vehicles. In turn, if consumers can afford premium foreign marks such as VW, this strongly implies that there is also sufficient local purchasing power to drive continued sales growth among other makes, particularly lower cost domestic brands and used

<sup>88</sup> It is possible that some of the sales and dealership expansion slowdown stems from VW’s emissions scandal. Yet the company’s sales in China are dominated by gasoline-powered cars, as opposed to the TDI diesel vehicles VW was pushing in the United States market.

<sup>89</sup> “Car Sales Slow in China’s West, Denting Hopes of Global Auto Industry: Sales shift down a gear in region where auto makers saw potential for faster growth,” *The Wall Street Journal*, 10 June 2015, <http://www.wsj.com/articles/car-sales-slow-in-chinas-west-denting-hopes-of-global-auto-industry-1433936986>

vehicles. Dealers are also likely targeting Central China for new car sales because the past few years' intensive focus on East Coast markets is driving saturation and increases in the traffic congestion issues that dissuade drivers from using their vehicles—or in some cases, even buying a car to begin with.<sup>90</sup>

### I. China's New Car Sales Outlook

China's new car market is transitioning into a period where sales will likely expand more slowly than the boom times of the past eight years. Industry data provider IHS expects a compensated annual sales growth rate of 5% between now and 2020.<sup>91</sup> The baseline sales volume is already high enough that even a 5% CAGR means that sales can grow by more than 1 million cars per year. Moreover, China's car fleet remains young enough that significant scrapping activity most likely will not begin for at least 3-4 more years. As such, net fleet growth will have commensurate impacts on oil demand. Each million new cars sold in China could consume a volume of gasoline equivalent to approximately 15-to-40 kbd of crude oil.<sup>92</sup>

Even if car sales slow more significantly than the consensus forecast, the volume of vehicles on the road today, coupled with the fact that each car's service life is likely to be at least 10 years, means significant gasoline demand is already "baked in." This holds true even as more efficient vehicles like those described earlier in this section come to comprise a greater share of China's passenger car fleet in coming years.

## Demand Sector 2: Fuel Oil and Jet Fuel

### A. Fuel Oil

Unlike gasoline, which has enjoyed a years' long streak of steadily increasing consumption, fuel oil demand in China has steadily declined over the past decade. In 2004, fuel oil accounted for nearly one in every four barrels of petroleum-derived liquid fuel consumed in China. By early 2015, this proportion had steadily declined to approximately 8%—roughly a third of its level slightly over a decade before (**Exhibit 33**).

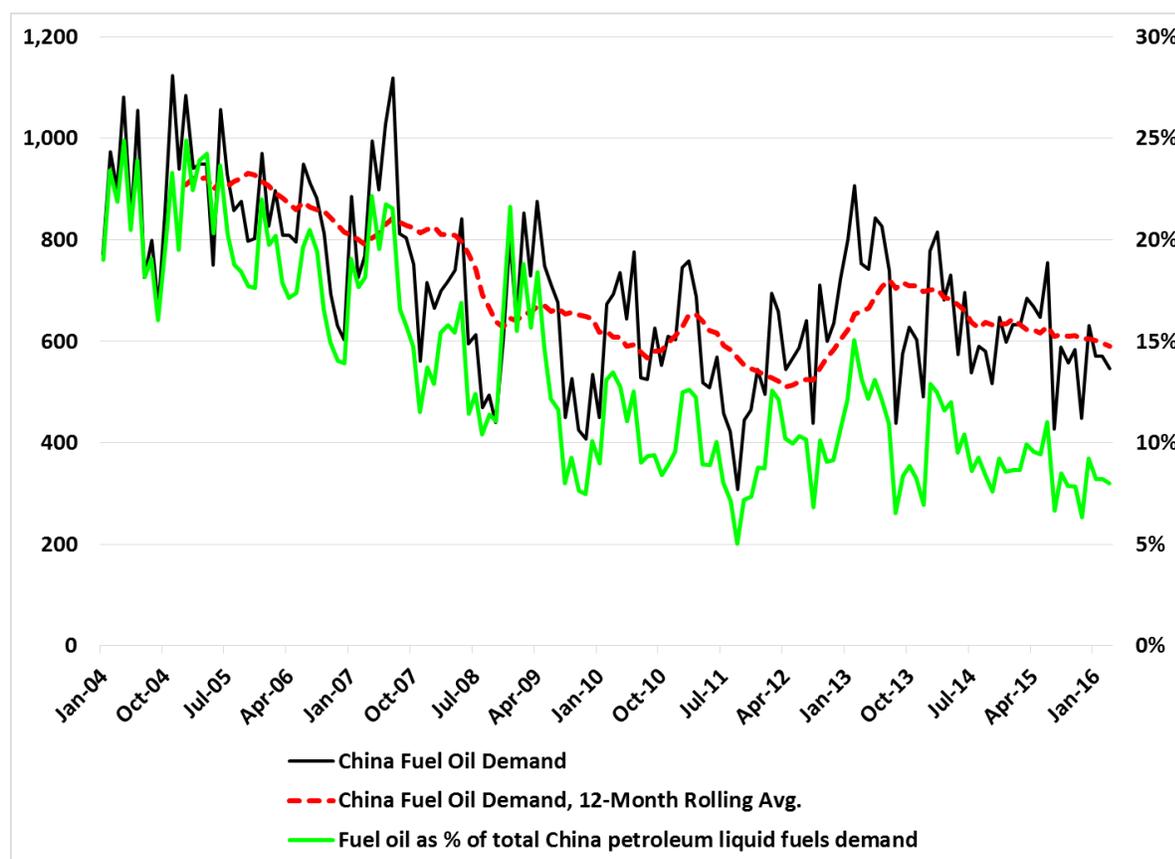
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<sup>90</sup> Gabriel Collins, "Exploring Potential Limits to Gasoline Demand Growth in China," *China SignPost*<sup>™</sup> (洞察中国) 96 (13 June 2016), <http://www.chinasignpost.com/2016/06/13/exploring-potential-limits-to-gasoline-demand-growth-in-china/>.

<sup>91</sup> Volkswagen Group China – Balancing the "New Normal," 13 June 2016, [http://www.volkswagenag.com/content/vwcorp/info\\_center/en/talks\\_and\\_presentations/talks\\_and\\_presentations.html](http://www.volkswagenag.com/content/vwcorp/info_center/en/talks_and_presentations/talks_and_presentations.html).

<sup>92</sup> The implied volume of crude oil necessary to produce a given amount of gasoline given the predominant product output slates at Chinese refineries. See, for instance, Gabriel Collins, "Rising Gasoline Demand Means China's Crude Oil Use is Decoupling from the Industrial Economy," *China SignPost*<sup>™</sup> (洞察中国) 95 (3 June 2016), <http://www.chinasignpost.com/2016/06/03/rising-gasoline-demand-means-chinas-crude-oil-use-is-decoupling-from-the-industrial-economy/>.

**Exhibit 33: Fuel Oil Losing Importance as a Driver of Oil Products Demand in China**



Source: JODI, Author’s Analysis

The principal factor behind declining fuel demand is the rise of China’s increasingly sophisticated independent oil refiners. Broadly described as “teapots” (茶壶), these plants formerly could not import crude oil and were thus forced to use heavy fuel oil as a feedstock. Regulatory changes dramatically shifted the landscape in 2015, as the NDRC began granting significant import quotas to a range of independent refiners. The activity peaked in the second half of 2015, and by late December, the NDRC had issued quotas for these plants to import approximately 69 million tonnes per year of crude—roughly 1.4 million bpd, a volume equivalent to nearly 21% of China’s total crude oil imports in 2015.<sup>93</sup>

Many of the teapots run significantly-sized facilities. For instance, Dongming Petrochemical’s Shandong plant can handle 240,000 bpd of crude.<sup>94</sup> Overall, the teapots account for

<sup>93</sup> “FACTBOX-China’s new crude oil importers,” Reuters, 29 December 2015, <http://in.reuters.com/article/china-crude-imports-idINL3N14I2JN20151229>

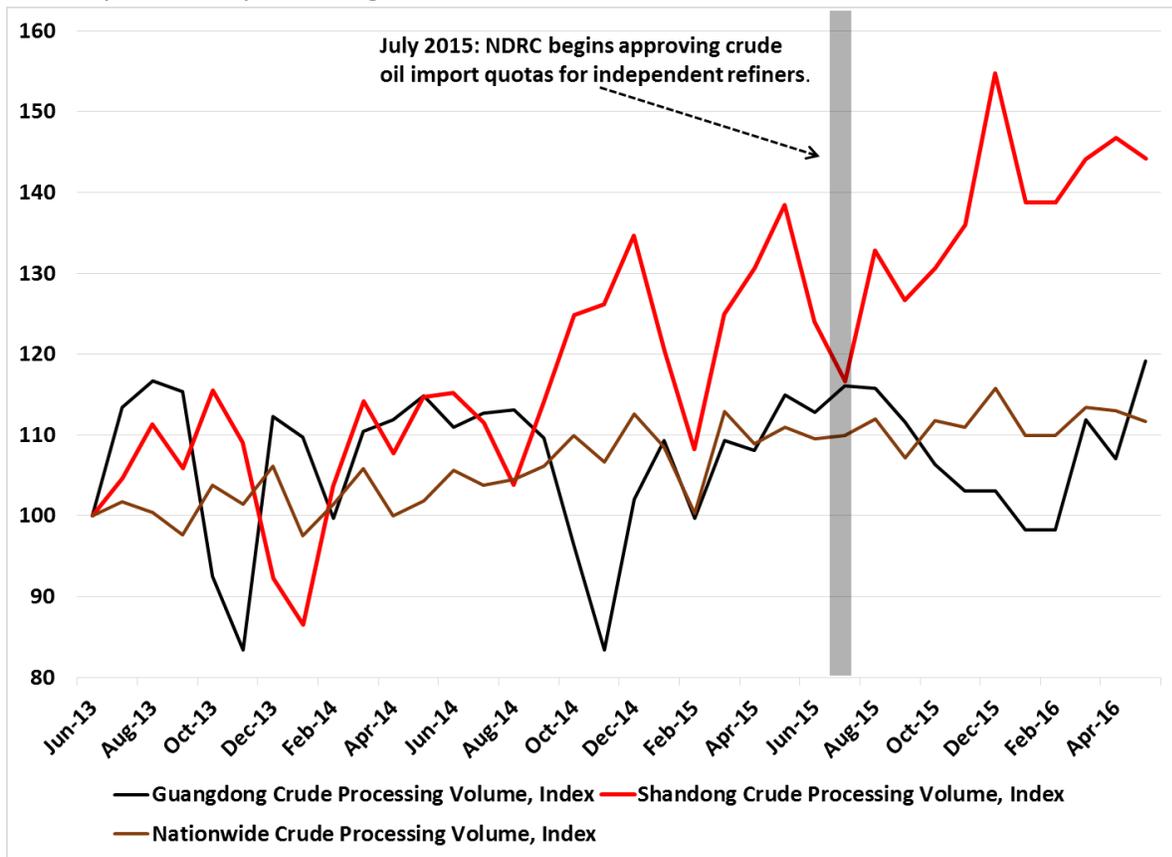
<sup>94</sup> “Enterprise Production” (集团产业), Shandong Dongming Petrochemical Group, <http://www.dms.com.cn/about/?29.html> (accessed 16 June 2016)

approximately 20% of China’s nameplate refining capacity.<sup>95</sup> As such, their switch to crude oil feedstock definitively shows up in the monthly provincial-level crude oil processing data. The author determines this by taking national monthly crude oil processing volume data and comparing it to data from Guangdong—one of China’s largest oil refining provinces—and Shandong—where the bulk of teapot capacity is located.

When the raw crude processing volume data are converted into an index with June 2013 as the start point, it becomes apparent that when the NDRC began issuing crude import quotas to independent refiners in late summer 2015, Shandong’s processing volumes grew rapidly and decisively pulled away from the pace of crude refining in Guangdong and nationwide. Here it bears noting that “crude processing” reflects actual refining activity, and gives a clearer analytical picture than other potential metrics, such as import volumes.

**Exhibit 34: Rise of the Teapots Drives Greater Crude Oil Demand**

Monthly crude oil processing volume index, June 2013=100



Source: NBS China, NDRC, Author’s Analysis

<sup>95</sup> Lucy Hornby, “China’s ‘teapot’ oil refineries pose challenge to majors,” FT, 7 April 2016, <http://www.ft.com/intl/cms/s/0/7fc95106-fc71-11e5-b5f5-070dca6d0a0d.html#axzz4BlyBRIje>

To date, Shandong's processing volumes remain elevated and local refiners have imported cargoes from Angola, Brazil, Libya, Oman, Russia, and Vietnam.<sup>96</sup> Shandong Dongming, one of the largest teapot operators by capacity, signed a long-term crude oil supply agreement with British Petroleum (BP) in November 2015.<sup>97</sup> In short, the evidence strongly reflects that China's independent refiners have become a force in the global crude market and that their demand for fuel oil as a baseline refinery feedstock has likely been permanently erased.

Changes in the intensity of waterborne freight transport—as well as policy measures aimed at cutting pollution from ship exhausts—are also chipping away at fuel in oil use in China. Historically, rail congestion led coal-fired power plants in China to source coal by sea. Coal would be mined in north-central China, transported by rail to ports on the Bohai Gulf, and then be carried by coastwise shipping to power plants in Southern China. The Daqin Railway, which links the rich coalfields at Datong with the massive Qinhuangdao coal port on the Bohai Gulf, is China's single-largest dedicated coal transport line. As such, the tonnage of coal it carries—most of which is shipped onward to power plants in South and East China—gives a sense of the health of China's coastal shipping industry, for which coal is the main cargo and fuel oil is the main power source for ship engines. Volumes stagnated over the past four years, declined slightly in 2015, and are likely to continue declining in 2016 and beyond as coastal Chinese cities strive to reduce local coal consumption (**Exhibit 35**).

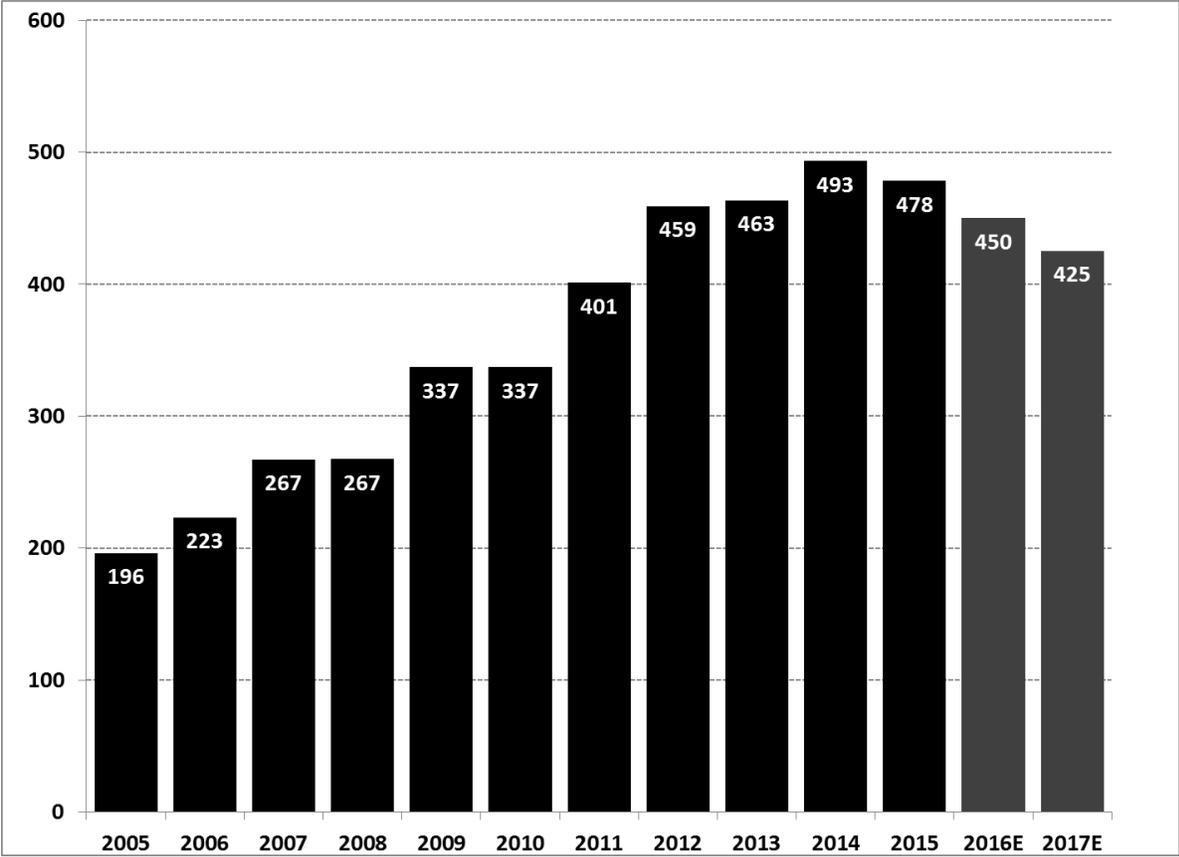
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<sup>96</sup> <http://www.platts.com/latest-news/oil/singapore/china-teapot-refineries-crude-oil-imports-continue-26337972>

<sup>97</sup> “Dongming Petrochemical Signs a Long-Term Crude Oil Supply Agreement With BP” (东明石化与BP签订原油长期供应协议), CNPC, 11 November 2015, <http://wap.cnpc.com.cn/system/2015/11/12/001566793.shtml>

**Exhibit 35: Slowing Daqin Railway Coal Shipments Suggest Less Coal Being Barged to Southern China**

Coal transported (煤炭发送量), million tonnes



Source: Daqin Railway

Second, Chinese authorities have begun cracking down on the use of high-sulfur, high pollution bunker fuels by ships in key Chinese ports. In December 2015, the Ministry of Transport designated the Bohai Gulf, Pearl River Delta, and Yangtze River Delta as Emission Control Areas (ECAs) where ships must now use bunker fuel with sulfur content of 0.50% or less.<sup>98</sup> The sulfur restrictions represent a significant departure from the traditional practice of using high-sulfur bunker fuels that can contain as much as 3.5% sulfur by mass. Ports in the ECAs are scheduled to impose restrictions as follows: by 1 January 2017, ships must use compliant fuel while berthed in key ports in the ECAs; by 1 January 2018 ships berthed in all ports in the ECAs must use compliant fuel; and by 1 January 2019 ships operating anywhere in the ECAs must use fuel with a sulfur content of 0.50% or less.<sup>99</sup>

<sup>98</sup> “Gard Alert: China introduces 0.50 per cent sulphur cap in major port regions,” Gard, <http://www.gard.no/web/updates/content/20904877/gard-alert-china-introduces-050-per-cent-sulphur-cap-in-major-port-regions>

<sup>99</sup> Id.

The new rules' bunker fuel demand effects will likely be substantial, as the 11 "key ports" that enforce the rules earliest are among the world's busiest: Guangzhou, Huanghua, Nantong, Ningbo-Zhoushan, Qinhuangdao, Shanghai, Shenzhen, Suzhou, Tangshan, Tianjin, and Zhuhai.<sup>100</sup>

It remains to be seen how stringently Chinese authorities will enforce the rules and how coastal shippers will comply with the new emissions rules. What is clear is that virtually all seaborne coal shipments from North to South China emanate from the Bohai Gulf, which is a sulfur-restricted ECA. Lower sulfur fuels such as low sulfur diesel and liquefied natural gas (LNG) are costly, as are other potential substitutes such as biodiesel and dimethyl ether. If shipowners have to exit the trade because the costs of complying with new fuel standards are too high, more coal may move south by rail as new rail corridors open between the coal fields and markets in East and Southeast China. Any of these scenarios stands to reduce marine bunker oil demand, and by extension, overall fuel oil consumption in the China market.

## **B. Jet Fuel**

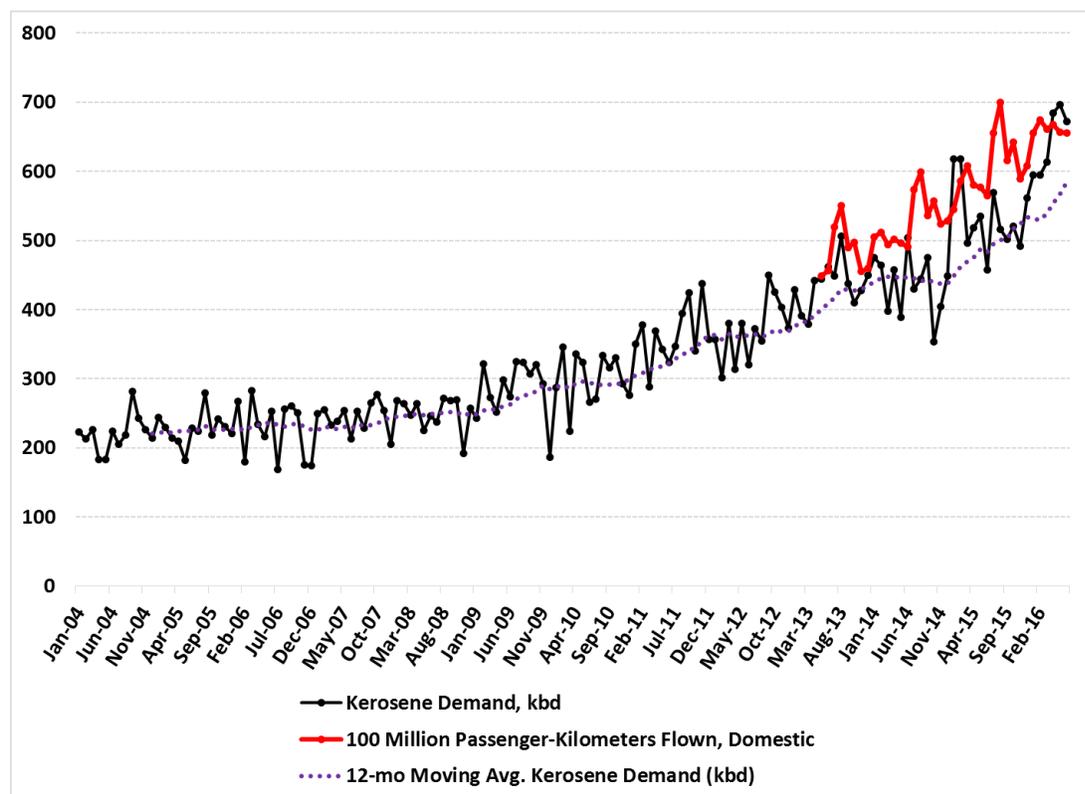
Jet fuel is a key driver of incremental oil products demand growth in China, with average annual demand growth of 11.1% between 2005 and 2012, and has been growing at approximately 10% per year since then.<sup>101</sup> China's kerosene demand is overwhelmingly driven by jet fuel demand, as evidenced in the close correlation between domestic passenger air miles travelled and kerosene consumption (**Exhibit 36**).

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<sup>100</sup> Ibid.

<sup>101</sup> "Sinopec and China Aviation Oil Work Hand-in-Hand to Deepen Cooperation" (中国石油与中国航油携手深化合作), Sinopec, 24 February 2014, [http://www.sinopecgroup.com/group/xwzx/hgzc/20140226/news\\_20140226\\_372874125527.shtml](http://www.sinopecgroup.com/group/xwzx/hgzc/20140226/news_20140226_372874125527.shtml); "CORRECTED-China's jet fuel demand growth to hold steady despite slowing economy -CAO exec," Reuters, 6 August 2014, <http://www.reuters.com/article/china-aviatn-oil-jetfuel-demand-idUSL4N0QA31V20140806>

**Exhibit 36: China’s Rising Kerosene Demand Closely Tracks Domestic Air Travel Activity**



Source: JODI, NBS China, Author’s Analysis

From a crude oil market perspective, increasing jet fuel demand plays an important role because like diesel fuel, it is a middle distillate and helps offset falling consumption of diesel fuel. As of August 2016, the IEA projects that in 2017, jet fuel demand growth in China will basically offset the loss in diesel fuel consumption.<sup>102</sup> To put the “road” versus “airways” middle distillate demand interaction in perspective, consider the following: a Boeing 737 jetliner that flies an average of 7 hours per day for 350 days of the year uses as much fuel as approximately 325 heavy diesel trucks travelling 52,000 km per year apiece.<sup>103</sup>

<sup>102</sup> IEA, Oil Market Report: 11 August 2016, <https://www.iea.org/oilmarketreport/omrpublic/currentreport/#Demand> (last accessed 15 September 2016)

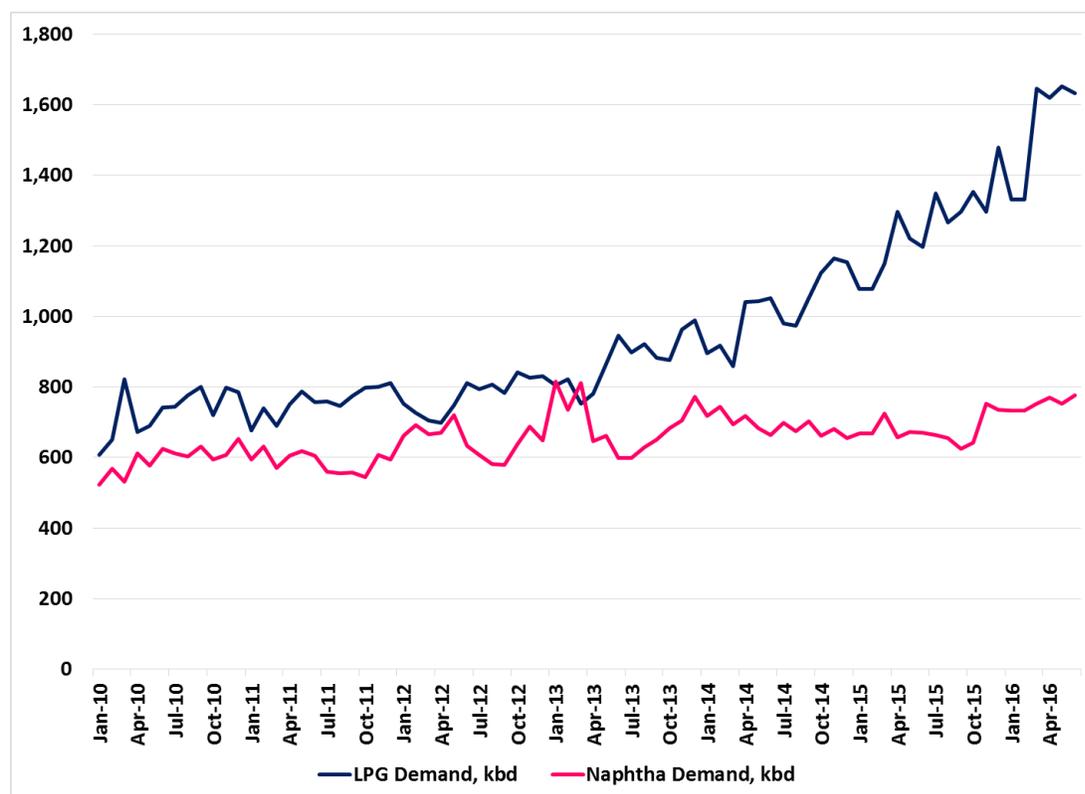
<sup>103</sup> Boeing 737 fuel use data are derived from John Cox, “Ask the Captain: Reader questions about the Boeing 737,” USA Today, 12 October 2014, <http://www.usatoday.com/story/travel/columnist/cox/2014/10/12/boeing-737/17036931/>. Boeing 737 average annual flight times are derived from the following source, but adjusted downwards: John Cox, “Ask the Captain: How far does a jet fly during its lifetime?,” USA Today, 19 November 2012, <http://www.usatoday.com/story/travel/columnist/cox/2012/11/19/ask-the-captain-how-far-does-a-jet-fly-during-its-lifetime/1712269/>. China heavy truck annual fuel use data are derived from This estimate uses the following assumptions: (1) Fuel use—Each heavy truck in China consumes 44 liters of diesel fuel per 100km (Ben Sharpe and Rachel Muncrief, “Literature Review: Real-World Fuel Consumption Of Heavy-Duty Vehicles In The United States, China, And The European Union,” The ICCT, White Paper, January 2015, [http://www.theicct.org/sites/default/files/publications/ICCT\\_HDV\\_FC\\_lit-review\\_20150209.pdf](http://www.theicct.org/sites/default/files/publications/ICCT_HDV_FC_lit-review_20150209.pdf)) while China’s

## Demand Sector 3: Crude Oil-Derived Chemical Feedstocks

### A. Naphtha and LPG

Chemical feedstocks account for a meaningful proportion of China's oil products demand. The two core products comprising the chemical feedstock stream are naphtha, which accounted for about 60% of ethylene produced in the country during 2014 and liquefied petroleum gas (LPG), which has become an important feed for polymer production (**Exhibit 37**).<sup>104</sup>

**Exhibit 37: Naphtha and Liquefied Petroleum Gas Demand in China, '000 bpd**



Source: JODI, Author's Analysis

Naphtha demand has been basically range-bound for the past six years, while LPG demand has risen sharply. Rising LPG use comes primarily from a rapid expansion in propane dehydrogenation capacity, which uses LPG (primarily propane) as a feedstock to produce propylene and ultimately, polypropylene plastics. China had an estimated 9 million tonnes per year of

passenger car fleet had an average fuel economy of 7.12 liters/100km in 2015 ("China Passenger Vehicle Fuel Consumption," 2015 Development Annual Report, The Innovation Center for Energy and Transportation, December 2015, <http://www.icet.org.cn/english/admin/upload/2015120241280305.pdf>.) (2) Annual vehicle km travelled—52,000 km per year for heavy trucks (H. Huo et al. / Energy Policy 43 (2012) 6–16 (10), [http://www.tsinghua.edu.cn/publish/ess/7835/20120719144509070242457/\[8\]%20Huo\\_EP\\_2012.pdf](http://www.tsinghua.edu.cn/publish/ess/7835/20120719144509070242457/[8]%20Huo_EP_2012.pdf))

<sup>104</sup> <http://www.platts.com/latest-news/petrochemicals/singapore/analysis-chinas-naphtha-imports-surge-amid-attractive-26103910>

propylene production capacity in 2015 and by 2020, could have as much as 20 million tonnes per year, according to IHS and Platts.<sup>105</sup>

To give a sense of how propane dehydrogenation-based propylene production drives LPG demand, consider the following example: Haiyue New Material Company's Ningbo plant can process 720 thousand tpy of propane into 600 thousand tpy of propylene.<sup>106</sup> The last several years have featured a major slug of PDH capacity additions in China. Every additional million tonnes per year of PDH capacity that are built (and actually run) in China would likely add approximately 34 kbd of propane demand, which translates into approximately 36 kbd of overall LPG demand, assuming the PDH plants run at 90% of their nameplate capacity.<sup>107</sup>

Ultimately, Chinese LPG demand will be substantially influenced by how much the new PDH plants actually run. The facilities' utilization rates will, at a fundamental level, depend on crude oil prices. In a nutshell, PDH units need propane to be cheap relative to crude oil, from which naphtha is derived. Thus, the larger the price spread between crude oil and propane, the better the economics of running PDH units and the greater that petrochemical-driven LPG demand will be in China.<sup>108</sup>

#### IV. Conclusions and Policy Insights

China's oil demand growth is now fundamentally driven by gasoline (leveraged to passenger cars) and to a lesser extent, middle distillates (basically jet fuel use driven by rising domestic air travel). As the country's oil demand becomes increasingly dependent on consumer demand, it will also likely become more volatile in the short-term. Previously, oil demand growth in China was most closely levered to large, fixed asset investment projects and other diesel-intensive activity. Yet now, rather than being tied to the 5-Year Plans, a greater share of China's oil demand will likely depend on day-to-day and week-to-week changes in consumer sentiments.

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<sup>105</sup> Jesse Tijerina, "Trends in the Polymers Market," IHS, 2015, [http://www.fullplast.cl/Descargas/Presentaciones\\_FULL\\_PLAST/IHS\\_CHEMICAL\\_Jesse\\_Tijerina.pdf](http://www.fullplast.cl/Descargas/Presentaciones_FULL_PLAST/IHS_CHEMICAL_Jesse_Tijerina.pdf); "The cyclical nature of spreads and effects on PDH propylene," Platts, 18 December 2015, <http://blogs.platts.com/2015/12/18/cyclical-nature-spreads-pdh-propylene/>

<sup>106</sup> "China's Yantai Wanhua test runs Shandong PDH plant, eyes March startup," Platts, 8 January 2015, <http://www.platts.com/latest-news/petrochemicals/singapore/chinas-yantai-wanhua-test-runs-shandong-pdh-plant-27998848>; "China Ningbo Haiyue's PDH plant to start up in July; receives first propane cargo," Platts, 1 July 2014, <http://www.platts.com/latest-news/petrochemicals/singapore/china-ningbo-haiyues-pdh-plant-to-start-up-in-21836529>

<sup>107</sup> Producing 1 tonne of propylene via PDH requires approximately 1.2 tonnes of propane feedstock (Dr. Charles Fryer, "The Impacts of Falling Crude Oil Prices on Chemical Building Blocks," Tecnon OrbiChem, 2<sup>nd</sup> International Chemical Downstream Conference, Mumbai, 29-30 January 2015.). One tonne of propane has 11.6 barrels (<https://www.extension.iastate.edu/agdm/wholefarm/html/c6-87.html>.) Platts Asia LPG spec uses Saudi Aramco's LPG export standards, which call for LPG sold into the Asian market to consist of a minimum of 95% propane by volume. ([https://www.platts.com/IM.Platts.Content/methodologyreferences/methodologyspecs/asia\\_lpg.pdf](https://www.platts.com/IM.Platts.Content/methodologyreferences/methodologyspecs/asia_lpg.pdf))

<sup>108</sup> "Charles Fryer, "After the Fall—The Impact of Oil Price Volatility on Petrochemical Markets," Tecnon OrbiChem Marketing Seminar at APIC 2015, Seoul, 7 May 2015.

Diesel demand is likely to continue gradually declining as the country works to re-balance its economy and reduce reliance on polluting heavy industries and fixed asset investment. There is some irony here, as increasing economic prosperity is stimulating a rising push by China's middle class to reduce pollution, which is also likely to trim the rate of oil demand growth. Fuel oil demand has also taken a permanent hit due to Beijing's decision to grant independent refineries license to import crude oil feedstock. At the same time, the country has added significant new net oil refining capacity. Refinery capacity additions spring from two core sources. On one hand, the "Big 3" state oil companies have built large new plants. On the other, by adopting new rules that enable the independent "teapot" refiners to import crude oil, a more competitively priced feedstock, the government has effectively induced them to run their plants at higher rates and bring capacity that had been mothballed for years back online.

Both dynamics are unfolding concurrent to a slowing industrial sector and lower demand for diesel fuel. Since Chinese refiners are geared to favor diesel production, running plants to produce more gasoline while diesel demand weakens is a recipe for surplus diesel, which is precisely why Chinese net exports of diesel fuel have risen so sharply in the past 12 months.

With those factors in mind, China's "new normal" for oil demand growth features three especially notable elements. **First**, the next five years are likely to be a period of much lower oil demand growth rates than the previous five years. A broad range of structural factors, including the cumulative effects of pollution, chronic disease, and demographic distortions that mean China will grow gray before it grows rich have begun to materially restrain the country's economic growth.<sup>109</sup> This study's base case posits oil products demand slowing to an annual expansion rate of approximately 2.8% per year over the next four years (**Exhibit 38**).

To be sure, such figures still point to significant annual increases in oil demand. Demand volume growth of 2.8% in a country that in some months now puts more than 11.5 million bpd of crude oil into its refineries could mean annual crude oil throughput increases on the order of 325 kbd. This is approximately the 2015 companywide daily liquids production of EOG Resources, one of the largest U.S. independent oil producers by volume.<sup>110</sup>

Against that contextual backdrop, it is clear that even as China moves onto a flatter oil demand trajectory, its absolute impacts on global crude oil demand will remain material. But for a world and an oil industry that had come to expect steady 5-to-8% annual demand growth from China,

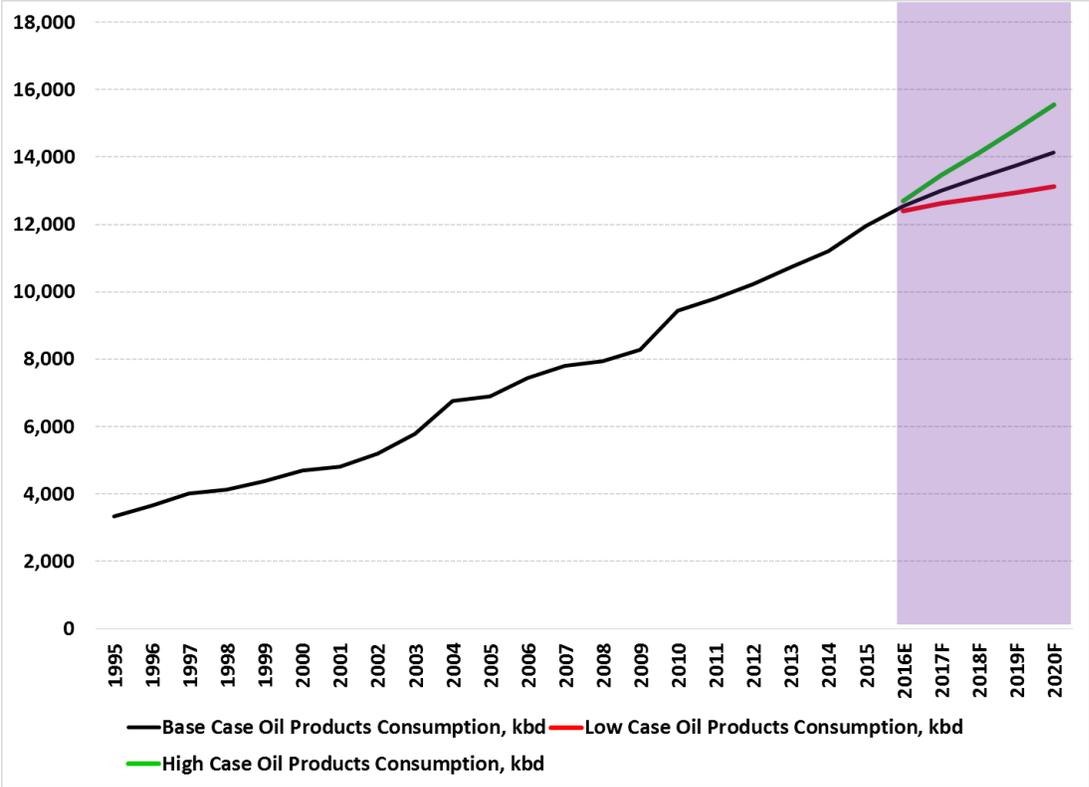
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<sup>109</sup> See, for instance, Mark Magnier, "China's Economic Growth in 2015 Is Slowest in 25 Years," The Wall Street Journal, 19 January 2016, <http://www.wsj.com/articles/china-economic-growth-slows-to-6-9-on-year-in-2015-1453169398>. For a detailed and prescient examination of the structural factors behind China's slowdown, see Gabe Collins and Andrew Erickson, "China's S-Curve Trajectory: Structural Factors Will Likely Slow the Growth of China's Economy and Comprehensive National Power," China SignPost™ (洞察中国) 44 (15 August 2011), <http://www.chinasignpost.com/2011/08/15/chinas-s-curve-trajectory-structural-factors-will-likely-slow-the-growth-of-chinas-economy-and-comprehensive-national-power/>.

<sup>110</sup> EOG Resources, 2015 Annual Report, <http://investors.eogresources.com/Annual-Reports-and-Proxy-Materials>

the shift onto the new normal path is a game changer, as the industry already sees from the current global supply demand imbalance. Moreover, there is a material risk that China in fact moves more toward this study’s low-growth case, under which oil products demand slows to an average annual growth rate of 1.9% between now and 2020. Coupled with declining oil consumption in the Euro zone and stagnant consumption in the Americas and developed Asia, such a Chinese slowdown would exert powerful downward pressure on global oil demand and could potentially push prices below \$45/bbl on a sustained basis for the next several years. Conversely, under the study’s high-growth scenario, China’s oil product demand would grow by an average of 5.4% between now and 2020, with demand reaching 15.5 million barrels per day by the end of 2020, with a resulting upward pressure on oil prices.

**Exhibit 38: China Oil Products Demand Forecast to 2020, kbd**



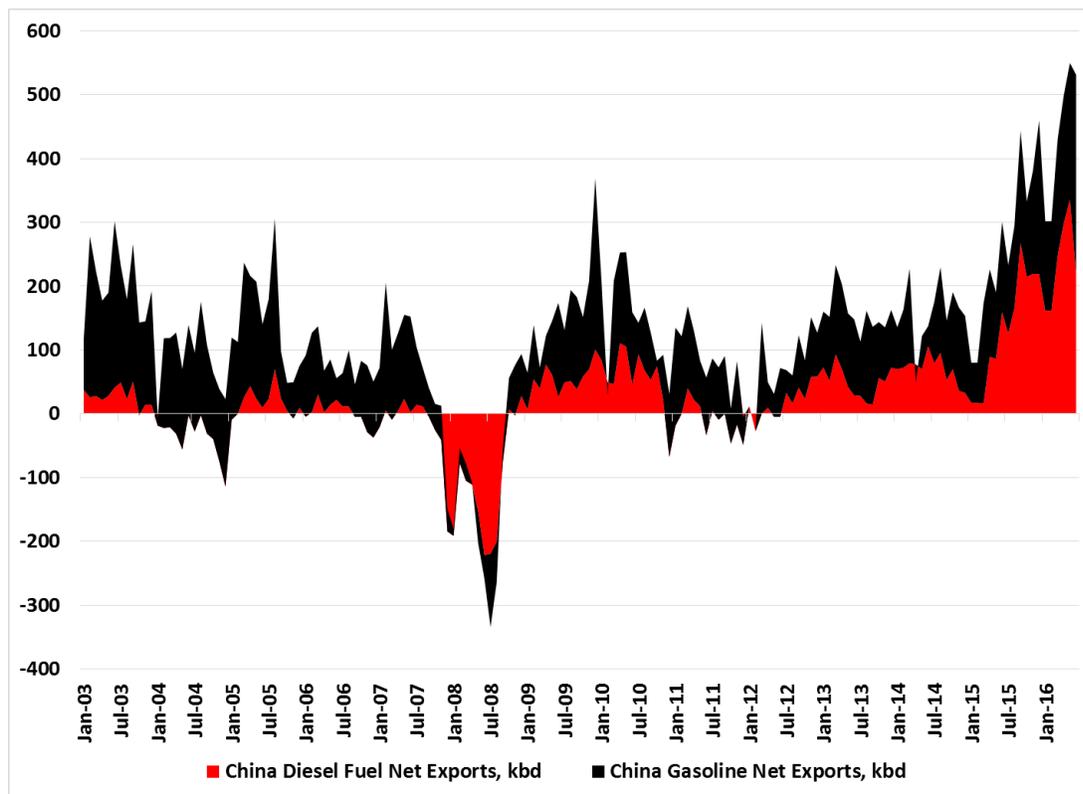
## Key Demand Model Assumptions

	Base Case GDP, Billion RMB	Base Case GDP, YoY change	Low Case GDP, YoY change	High Case GDP, YoY change	Base Case Oil Intensity, kb per billion RMB of GDP	Low Case Oil Intensity, kb per billion RMB of GDP	High Case Oil Intensity, kb per billion RMB of GDP
2010	40,890	-	-	-	84	-	-
2011	48,412	18.4%	-	-	74	-	-
2012	53,412	10.3%	-	-	70	-	-
2013	58,802	10.1%	-	-	67	-	-
2014	63,591	8.1%	-	-	64	-	-
2015	67,671	6.4%	-	-	65	-	-
2016E	71,054	5.0%	4.0%	6.0%	62	58	65
2017F	74,252	4.5%	2.0%	6.0%	59	58	65
2018F	76,851	3.5%	1.5%	5.0%	59	55	63
2019F	79,540	3.5%	1.5%	5.0%	59	55	63
2020F	82,324	3.5%	1.5%	5.0%	59	55	63

Sources: BP Statistical Review, NBS China, Author's Analysis

**Second**, the combination of slowing domestic middle distillate demand and substantial new refining capacity coming online is making China into one of the world's largest refined products exporters. In April 2016, China's net exports of gasoline and diesel fuel flirted for the first time with the 500 kbd mark—on par with the net product export numbers from Saudi Arabia (**Exhibit 39**).

**Exhibit 39: China Net Exports of Gasoline and Diesel Fuel, kbd**



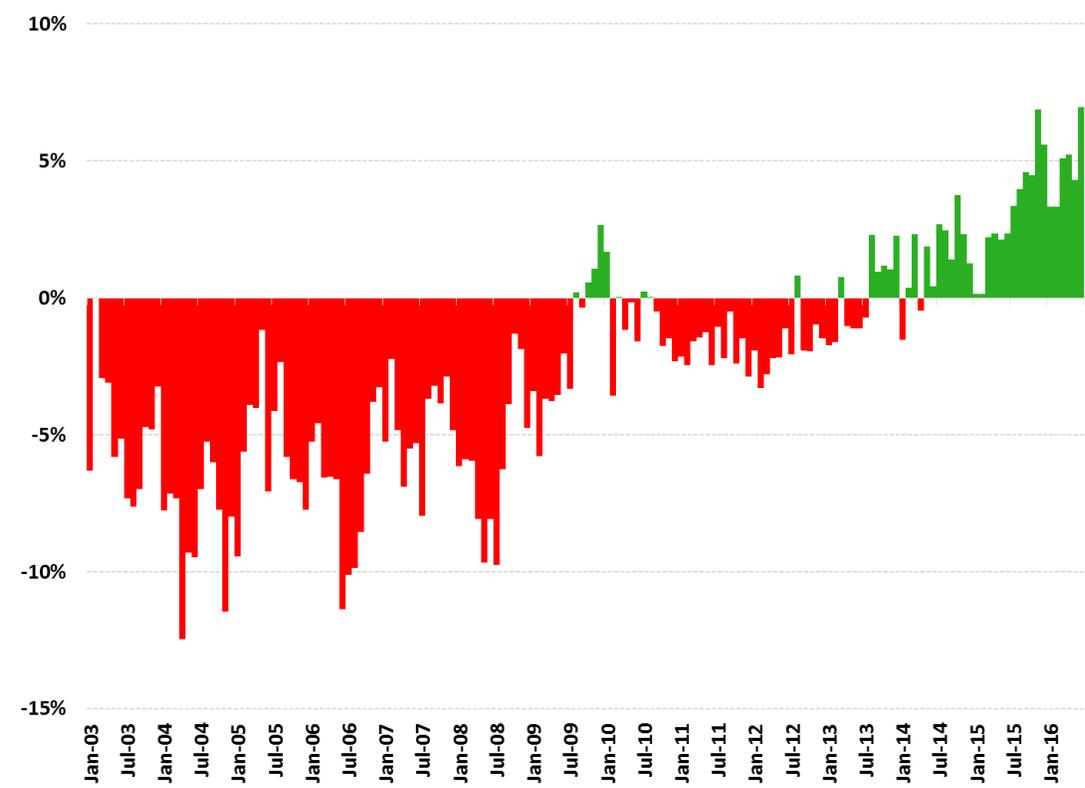
Source: JODI, Author's Analysis

The data suggest China's shift to becoming a major net exporter of oil products is one that will endure for years to come. Consider the following data points: between January 2003 and July 2013, only 10 months out of 127 saw China have positive net exports of "core" refined products: diesel, gasoline, and kerosene (i.e. jet fuel). But of the next 36 months—July 2013 to June 2016—only three months were not positive (**Exhibit 40**). To boot, the overall volume of net refined product exports grew significantly in absolute terms and as a percentage of total crude oil intake at refineries in China.

The durable shift to higher net refined product export volumes and the fact that these volumes have come to occupy a larger share of crude feedstock put into Chinese refineries suggest a watershed moment has occurred. In essence, China has almost certainly structurally overbuilt its refining system and is now effectively exporting that overcapacity to the world market in the form of gasoline, diesel, and other refined products.<sup>111</sup>

<sup>111</sup> Lucy Hornby, "China plagued by oil refining overcapacity," FT, 7 June 2016, <http://www.ft.com/cms/s/0/b1c06f2a-2965-11e6-8b18-91555f2f4fde.html#axzz4Co9HpGDa>

**Exhibit 40: Net Exports of Core Refined Products (gasoline/diesel/kero/fuel oil) as Percentage of Refinery Intake of Crude Oil**



Source: JODI, Author's Analysis

**Third**, China's political leadership has turned onto a path of nationalism and cult of leadership personality that threatens to blunt the formidable technical competence resident in the top ranks of China's leadership. The government's bungled handling of the summer 2015 stock market declines suggest it is overconfident in its ability to shape and influence market activity.<sup>112</sup> The stock market fiasco also suggests that China's economic policy is increasingly vulnerable due to over-centralization of presidential authority that slows and/or skews economic policymaking.<sup>113</sup> Of nearly equal importance, China's thousands of local officials' retain significant ability to passively resist reforms that may threaten energy-intensive local industries that are important employers while large state-owned enterprises' massive economic heft and commensurate behind-the-scenes political influence also slow reforms.<sup>114</sup> These somewhat countervailing forces

<sup>112</sup> Gabriel B. Collins and Andrew S. Erickson, "Three SignPosts to Guide You as China's Stock Market Crisis Unfolds," China SignPost™ (洞察中国) 90 (5 July 2015), <http://www.chinasignpost.com/2015/07/06/three-signposts-to-guide-you-as-chinas-stock-market-crisis-unfolds/>.

<sup>113</sup> Id.

<sup>114</sup> Andrew S. Erickson and Gabriel B. Collins, "Physician, Heal Thyself: Modest Expectations in Order for China's Reforms as Third Plenum Anniversary Approaches," China SignPost™ (洞察中国) 81 (23 October 2014),

could, at first glance, suggest continued industrial oil demand growth. But this author increasingly fears that local and corporate vested interests' resistance to central edicts aimed at re-balancing the Chinese economy could actually perpetuate further political dysfunction, reduce clarity and certainty, and ultimately deepen China's structural economic challenges in ways that depress oil demand growth.

Ultimately, these realities—combined with ongoing issues of data transparency—can magnify price volatility. For instance, announcing a stimulus package can drive up global crude oil prices, then amplify a selloff a short time later if the market realizes that the potential demand effects were overpriced due in part to lack of sufficient data to properly contextualize the measure.

The stakes are high because China has simultaneously become a core driver of global oil demand growth while also fueling this growth through the construction of a debt-based, increasingly unsustainable economic structure. Some of that risk has been priced into the global crude market, but likely to an insufficient degree. Consider for instance that in the 1997 Asian Financial Crisis, South Korea, a major industrialized economy, saw oil products demand crash by more than 14% year-on-year in 1998. To boot, South Korean oil demand took nearly five years to recover after that massive internal shock.

China's situation is different in many important ways, but in an environment of slower overall global growth, rising pressure from monetary policy distortions, and a turn to populist and nationalist politics in many key economies (arguably including China), the potential for a significant near-term demand shock should not be underestimated. The bottom line is that China was a primarily upside risk factor in the oil markets for much of the past 15 years, but now presents a complex combination of continued demand growth potential, that risks being offset by increasingly significant latent downside risks.