1. Introduction

China is the most important and most influential country in the fertilizer business. Its development has been dramatic. In the mid-1990s, fertilizer demand was on the scale of a medium sized country, albeit growing at a rapid rate. Production was relatively modest and the country was an importer of most fertilizer products. For a period it ranked among the largest importers of urea. However, as the Chinese economy has seen massive transformation, so too has its agriculture sector, and the fertilizer business whose target is primarily to support domestic crop production. It has now grown to such a scale that it is the largest producer, consumer and exporter of urea and ammoniated phosphates in the world, and one of the leading producers and consumers of potash.

In this report we provide an overview of the Chinese fertilizer industry, tracking the development of agriculture and demand, together with the supply side and its increasing international influence. We also describe our expectations for its development in the future and the impact it has on the GCC region and its fertilizer producing companies.
2. Chinese agriculture

To understand the development of the Chinese fertilizer industry it is important to understand the country’s agriculture sector, and the wider economy. China is the world’s most populous country and the third largest by area, with a range of climatic conditions, topographies and soil types. Climate ranges from monsoonal tropical in the south to near arctic in the north, alpine on the Tibetan plateau and arid in the northwest. Rainfall tends to fall off from southeast to the northwest, which is in the rain shadow of the Himalayas.

Despite the enormous changes that have taken place in China over the last few decades with the loosening of farm controls and the ever-greater exposure to the market, agriculture remains highly labor and input intensive. For the most part farms are small with overall low levels of industrialization and mechanization when compared to highly developed nations. Technical assistance tends to be limited and focuses mostly on the staple crops, while wider infrastructure services such as distribution are often poor, causing significant post-production crop losses. Further, the level of understanding of appropriate use of farm inputs such as fertilizer application is inadequate leading to inefficient application, though concerted efforts are being made to improve this.

Harvested area in China has grown consistently over the past 25 years. Between 1985 and 2010 it expanded by 25 million ha, to reach 170 million ha. Despite rapid urbanization since the 1990s, there has been no secular decline in harvested area per capita. In fact, since 2003 it has actually increased slightly. However, construction and transportation have claimed large expanses of land. As a result, between 1990 and 2009 the cultivated area declined by around seven million ha. During the same period, however, the area harvested more than once doubled from 20 million to just under 50 million ha. The growth in harvested area, therefore, has been the result of increased multiple cropping.

Around half of Chinese harvested area is under grains. A quarter of harvested area is used for fruit, vegetables and tubers which cover 43 million ha. Of these around 22 million are used for vegetables and half of that (11 million ha) for fruit, with tubers making up the remainder.

Fruits, vegetables and tubers have expanded by almost 24 million ha since 1985, when they accounted for a seventh of the total area. The harvested area under oilseeds also grew by around a fifth during the same period, reaching over 23 million ha by 2010. The area under grains has fluctuated over the past 25 years, but remains approximately the same at almost 90 million ha. However, there have been changes within the grains. Since the mid-1990s maize has increased its area at the expense of the other grain crops, generally, and wheat, in particular.

<table>
<thead>
<tr>
<th>Grains</th>
<th>Oilseeds</th>
<th>Fruit, veg and tubers</th>
<th>Pulses</th>
<th>Fiber crops</th>
<th>Sugar crops</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>95.0</td>
<td>24.5</td>
<td>47.7</td>
<td>2.9</td>
<td>4.4</td>
<td>2.0</td>
<td>5.0</td>
<td>181.5</td>
</tr>
</tbody>
</table>

The origins of the shift to fruits and vegetables lie in the social and economic reforms from the late 1970s to 1990s which saw China adapt progressively from a closed, centrally planned system to a more export oriented and market driven economy with a private sector - the commune system was abolished, farms were partially privatized, market controls for perishables were lifted and increasingly farmers were able to sell crops in the marketplace for their own profit once they had fulfilled their grain quota. In order to maximize their income, farmers thus increasingly turned to fruit and vegetables, which offered the highest returns and were farmed very intensively.
China's agriculture is spread across the country, but there is a particular concentration in the south-eastern region.

The west and north tends to be for pasture.

Wheat is grown in north/north easter regions in the spring and southern areas in the winter. Soybeans and maize also grown in the north.

Rice, cotton and fruit & vegetables are grown in the south and eastern provinces.

Source: Integer Research
3. Development of fertilizer demand

China is the biggest fertilizer producer and consumer in the world. Total fertilizer consumption represents around a third of global fertilizer use. The country is self-sufficient in N and P and exports a significant share of production, but the country imports potash, though it has been rapidly been developing its potash resources in the last decade or so in order to try and reduce its import dependence. This shortfall in K is reflected in the nutrient consumption profile, where N and P dominate (33.6 and 13.2 million tons in 2010, respectively in nutrient terms) while K is considerably smaller (4.4 million tons).

Prior to 1960 there was very little mineral fertilizer consumption in China and the majority of nutrients for crops came from organic sources. Beginning in the 1960s the government began to promote the use of mineral fertilizers as part of its drive for food security for its large population.

Production and consumption were subsidized, imports increased and prices were controlled. Consequently, mineral fertilizer use increased more than 50-fold and this is significantly responsible for the enormous intensification in Chinese agriculture, with average yields more than quadrupling over the past 50 years. Food security has been achieved - China now produces a surplus of grains and has become a major exporter of fruit and vegetables.

China’s soils are naturally phosphate deficient, which led to government policies to encourage production and use of phosphate in order to boost yield. Moreover, the store of arable land in China is limited and significant fertilizer application for high yields is required for adequate food production. Nevertheless, these application rates appear excessive and even though cereals yields are somewhat above average, ever more evidence is emerging that fertilizer is over-used and inefficiently applied, resulting in significant damage not only to soils (acidification, compaction, toxic metal leaching and phosphorous build-up), but also damage to the wider environment with significant run-off into rivers and lakes (resulting in large-scale regional eutrophication) and N escape to the atmosphere.

There is a growing awareness of the problem though, and efforts are gradually being made to improve fertilization practice at the farm level, e.g. through improved dissemination of technical information or through significantly increased levels of soil testing. Economic incentives encouraging fertilizer use are also gradually being withdrawn (e.g. reduction in production subsidies, imposition of taxation on exports and decreased price controls) and production capacity expansion is being limited. It is anticipated that these will gradually curtail significant further increases in country fertilizer consumption and application rate.

<table>
<thead>
<tr>
<th>Crop</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>N+P+K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>46%</td>
<td>43%</td>
<td>34%</td>
<td>44%</td>
</tr>
<tr>
<td>Oil Crops</td>
<td>7%</td>
<td>12%</td>
<td>9%</td>
<td>8%</td>
</tr>
<tr>
<td>Sugar Crops</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Fibers</td>
<td>3%</td>
<td>3%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>Fruit &amp; Vegetables</td>
<td>26%</td>
<td>31%</td>
<td>45%</td>
<td>29%</td>
</tr>
<tr>
<td>Pulses</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Other</td>
<td>17%</td>
<td>7%</td>
<td>7%</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Share of Consumption, %**

Source: Integer Research
4. China’s fertilizer supply and international impact

The phenomenal development of the Chinese fertilizer industry has been essential to support growing food production but growth in nitrogen and phosphate output has been so dramatic that production is now significantly in excess of domestic requirements. China has been transformed from being a significant importer of all nutrients in the mid-1990s to a major exporter today. A program to develop China’s domestic resources was implemented, and China rapidly invested in nitrogen, phosphate and more recently potash capacity.

For nitrogen, China’s industrial development has been heavily influenced by the country’s hydrocarbon resources. Outside China, including GCC countries, natural gas is the preferred fuel and feedstock. Gas is the most elegant choice as it contains the highest proportion of hydrogen, which is required to produce ammonia, the building block for all nitrogen containing products. However, China has relatively limited natural gas resources, so gas based plants account only for a quarter of total urea capacity. Instead, it has turned to its relatively abundant resources of coal, which make up three quarters of urea capacity. Initially this led to the construction of many plants based on anthracite grade coal, which now makes up about 40% of urea capacity. More recently, as demands for anthracite have increased from petrochemicals and other sectors, and its cost has also risen, China has invested in nitrogen plants which can utilize lower grade coal resources. This in turn has influenced the geography of China’s nitrogen industry, which is generally located close to the hydrocarbon source, particularly for coal which has a relatively low value per unit of weight which makes it expensive to transport. Anthracite-based plants generally are located in the center or center eastern provinces, while lower grade coal-based plants are generally located in the northern or north western provinces. Gas based plants are still in operation but tend to run at lower utilization rates due to raw material scarcity. Plants are typically near stranded gas deposits stranded, but are diminishing in importance as gas is being prioritized for consumption in other industrial sectors, pricing out gas based nitrogen manufacturers.

The corporate structure of Chinese nitrogen capacity is a mix of the major national energy companies, provincially owned, listed companies, and many companies produce nitrogen as a way of adding value to production of coal. For urea, there are around 100 different corporate entities and the industry remains relatively fragmented with a diverse age profile and scale. For urea, around a quarter of operations have capacity of less than half a million tons per year.

The chart below shows China’s development of urea production and exports. China has increased urea output to a point where it is now responsible for around 40% of world production and around 30% of world exports.
The country’s phosphate resources tend to be clustered around China’s phosphate ore containing provinces in the south and southwest. China is self-sufficient in phosphate rock and there is relatively little trade in phosphate concentrate. Ore grades vary substantially and this influences the options for producing downstream products. A significant part of China’s phosphate ore produces concentrate unsuitable to manufacture higher grade DAP which typically contains nitrogen content of around 18% and phosphate of 46% P2O5. However, the country has overcome this limitation finding an innovative technical approach and produces large volumes of lower grade MAP, typically containing 55% total nutrient content.

The structure of the Chinese phosphate industry is also quite unique. Whereas most companies producing phosphate outside China are integrated with phosphate rock, in China there are many non-integrated operations, with manufacturers buying phosphate rock on the domestic open market. In addition, there are even some companies which only mine phosphate ore, which is sold on to third parties for beneficiation. For producing finished products, again there is a range of raw materials integration. For making phosphoric acid, many companies buy sulphur on the open market, but there is a significant contingent which buy sulphuric acid, often because they are situated close to metals processing facilities which have surplus low cost sulphuric acid available. There is also a mixture of integration with ammonia - some companies make and some buy. Although there has been significant consolidation the sector remains highly fragmented, particularly for MAP. For DAP, the three largest companies by capacity account for around 40% of the country total, but for MAP the three largest operations account for less than a quarter of the total.

In the chart below we show the development of Chinese MAP and DAP production. Output has grown to a point that in recent years the country has accounted for approaching half of global DAP and MAP output.
China is still heavily dependent on potash imports, but for this nutrient also, the country has rapidly built up its domestic resources, which are centered around salt lakes in the province of Qinghai.

It is worth noting that the development of China’s fertilizer supply has been facilitated by important additional macroeconomic conditions. The country has been quick to develop its own technical approach adapting production techniques to make best use of its resources. Partly related to technical innovation is its relatively cheap capital cost, compared to international rates. Integer tracks project costs around the world and we find that Chinese plants can typically build new urea plants for anything between 10-40% less than costs in other locations. Not only is the technology and build cost generally lower, but a further stimulus to supply projects has come from the relative ease with which Chinese companies can finance projects. The government’s drive to prime the economy through fiscal stimulus has been an important catalyst to new fertilizer project construction.
5. Recent developments and outlook

The rapid growth of the Chinese fertilizer industry has not been a simple success story. The drive for self-sufficiency in nitrogen and phosphate surpassed its target several years ago, and like many areas of the Chinese economy there is now substantial spare capacity, which has resulted in rapid growth in exports. When international prices spiked in 2008, the Chinese government sought to minimize the risk of importing inflation by imposing export barriers which limited the ability of domestic fertilizer producers to export this surplus. In more recent years, as international prices have fallen, these barriers were removed and with greater freedom, exports of urea and ammoniated phosphates have rapidly expanded. For exporting producers in the Arabian Gulf region and elsewhere this led to a substantial increase in competition, which in turn has driven international prices lower still.

Not surprisingly given the growth in China’s importance, international prices of urea and ammoniated phosphates have increasingly been driven by and linked to developments in China. Furthermore, in the last year or so, as the international balance between supply and demand has lengthened with more new capacity being added in China and elsewhere, and at a rate exceeding demand growth, global prices have increasingly tracked Chinese production costs. Although China does have some relatively low cost nitrogen and phosphate production, a significant volume is medium to high cost. In 2016, with increasing supply competition, international prices have been driven down to the point at which many Chinese producers can no longer operate profitably and have been forced to close or idle capacity, or run at lower operating rates. The point at which this volume adjustment takes place has been the main mechanism for establishing an international price floor. For example, in the first five months of 2016, with urea, DAP and MAP under growing downward price pressure, Chinese export volumes of these products dropped by around 40% compared to the period a year previously, with significant volumes of Chinese capacity idled.

The floor price for urea and ammoniated phosphates is a moving target and subject to fluctuations in many variables including the Chinese supply/demand balance, exchange rates, energy costs and the international price of sulphur (for phosphates). Our research team at Integer, led by Lynn Wang in our Beijing office has modelled Chinese nitrogen, phosphate and potash production costs in detail. Using this data (illustrated below, which shows the Chinese urea cost curve), we gain greater insight into Chinese export capability and therefore underlying international price fundamentals. This gives us greater confidence about how China’s fertilizer industry position will evolve in the future.
A key question for the global fertilizer industry is to understand the extent to which China will continue to directly influence global prices, and how it will manage its domestic supply surplus in future. The growth in capacity appears to have been arrested and our expectations are that nitrogen and phosphate capacity will be relatively flat looking forward. There are new plants being constructed, but these will be balanced by closures. One outcome might be that domestic demand for nitrogen and phosphate quickly catches up with domestic supply capability, eliminating exports, but this seems unlikely. Although fertilizer demand has grown rapidly in the last few decades, fertilizers are over-used, particularly nitrogen and phosphate. The government of China is seeking to cap future growth of fertilizers in order to address this use inefficiency which in turn contributes to environmental problems. It is seeking to limit growth to 1% per year in the period to 2019 with no growth targeted thereafter.

This leaves two broad possibilities on the supply side. Capacity will be rationalized, with the least efficient producers likely forced to close, under pressure from the market and/or with direction from the Chinese government. On the other hand, we could also see continued exports on a large scale, to a point where China establishes a strong position in the global market potentially bringing about closures of capacity in other countries. It is possible that the Chinese government might seek to stimulate this development by devaluing the Renminbi (RMB) to improve international competitiveness - the RMB has already gradually depreciated over several years. Further depreciation would clearly be the least attractive outcome and a concern for competing fertilizer exporters in the GCC region and elsewhere.

So far there has been relatively little activity leading directly to the rationalization of fertilizer capacity, but there are signs from other similar sectors that the government is seeking to rationalize rather than prop up industries with structural over-capacity, particularly when some producers are small scale and inefficient. In coal for example, the government has recently introduced a policy to reduce operating days from 330 days to 276 days per year, and is seeking to bring about the closure of the least efficient producers. This coal rationalization is already starting to have an effect on the nitrogen business – as this policy brings the coal market into balance, it should bring higher coal prices, which in turn means nitrogen production costs increase, accelerating the rationing of weaker nitrogen operators.

The weakest Chinese urea producers are withdrawing products from the international market

**Urea export cost to nearest port by plant, H1 2016**

- Many Chinese urea producers cannot make money with urea prices below US$200 per ton.
- Chinese urea capacity is highly diverse in terms of ownership, scale, location, age, and fuel/ feedstock.
- Costs are not the only driver as local market prices deviate by +/- $10 per ton according to location.
- The weakest producers tend to base on:
  - Gas, or
  - Older/poorly located anthracite plants

**Source:** Integer Research

*Freight, handling and export tariff cost $/t*
Members of the Gulf Petrochemicals and Chemicals Association have established and continue to expand fertilizer businesses geared overwhelmingly toward exports, with a focus on the main commodity nitrogen and phosphate products. As such, the competitive position and the future role of China’s fertilizer sector is a key point of interest. Although China does import small volumes of specialty fertilizer products containing nitrogen and phosphate it is unlikely that China will become a destination market for GCC fertilizer products. As such, the main consideration for GPCA members is whether China can sustain its recently acquired dominant position in international nitrogen and phosphate exports. Since the main destination for Chinese exports is in Asia, its producers are competing head on with GCC sellers. The sheer scale of the Chinese supply surplus is such that even if the country moves quickly toward rationing spare capacity, export volumes will continue in volumes large enough to offer competition for GCC fertilizers sales to the key markets in India and Southeast Asia. However, although there are many uncertainties, not least the extent to which the Chinese government will support domestic producers, rationalization seems likely and this will lead to diminishing export volume. Understanding the evolution of the balance between China’s fertilizer supply and demand, and underlying production costs are therefore critical for planning of ongoing business operations for GPCA members, and perhaps most crucially, where new investment is under consideration.
Authors and acknowledgments

This publication is a collaboration between the Gulf Petrochemicals and Chemicals Association (GPCA) and Integer Research.

Integer is a specialist provider of commodity and specialty fertilizer industry research, data, analysis and consultancy services. Headquartered in London, UK, and with offices worldwide, the company offers a variety of information services: subscription products that enable benchmarking and competitor analysis, and help businesses better understand future industry developments; bespoke market research commissioned by individual clients; and industry events.

This publication was issued on the occasion of the 7th GPCA Fertilizer Convention, which took place 6-8 September 2016 in Dubai, UAE.
The Gulf Petrochemicals and Chemicals Association (GPCA) represents the downstream hydrocarbon industry in the Arabian Gulf. Established in 2006, the association voices the common interests of more than 240 member companies from the chemical and allied industries, accounting for over 95% of chemical output in the Gulf region. The industry makes up the second largest manufacturing sector in the region, producing up to US$ 102 billion’s worth of products a year.

The association supports the region’s petrochemical and chemical industry through advocacy, networking and thought leadership initiatives that help member companies to connect, to share and advance knowledge, to contribute to international dialogue, and to become prime influencers in shaping the future of the global petrochemicals industry.

Committed to providing a regional platform for stakeholders from across the industry, the GPCA manages six working committees - Plastics, Supply Chain, Fertilizers, International Trade, Research and Innovation and Responsible Care - and organizes six world-class events each year. The association also publishes an annual report, regular newsletters and reports.

For more information, please visit www.gpca.org.ae

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