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Rocks & Ores

A fertilizer primer: Potash and the need to feed more with less

Commodities Research

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We initiate coverage of potash with a positive outlook

Global population growth will add 71 million new mouths to feed each year, while rising income levels are driving an increase in the average number of calories consumed per capita. Arable land is a finite resource, so the agricultural sector will continue to meet growing demand for food by increasing the average yield per hectare, partly via greater use of chemical fertilizers. On that basis, we expect potash demand growth to average 3.1% over our forecast period and beyond, driven by higher fertilizer intensity and a rebalancing of the NPK[1] mix in non-OECD markets. This differentiates potash from other commodities that experience weaker demand after the industrialization phase.

1. Three main nutrients in a fertilizer mixture: nitrogen (N), phosphate (P), and potassium (K).

Industry structure should maintain prices well above cost support

Producer discipline has delivered consistently high margins in recent years and we believe it will sustain prices well above cost support for the remainder of our forecast period; two marketing organizations control ~65% of current production and ~60% of new production in the period to 2020. In the short term, spot prices have been impacted by a cut to Indian fertilizer subsidies and by moderate crop prices. Looking beyond the current crop cycle, we expect prices to average US$520/t over the period 2014-17, equivalent to a ~70% premium over our US$300/t estimate of marginal production costs.

Normalized prices are unlikely before 2020

In the long term, the grip of the established oligopoly should gradually weaken as new entrants expand their production capacity. Based on our analysis of 30+ growth projects across the globe, we expect the rate of production capacity additions to accelerate. We forecast production capacity to increase from 64Mtpa in 2013 to 83Mtpa in 2020, implying a modest decline in the global utilization rate towards the end of the decade. As industry concentration is gradually eroded by new entrants and as the supply side becomes more competitive, we expect prices to converge towards the inducement price level of US$475 (in 2018 US$ terms).

Contents

The authors wish to thank Amber Cai for her contribution to this report.

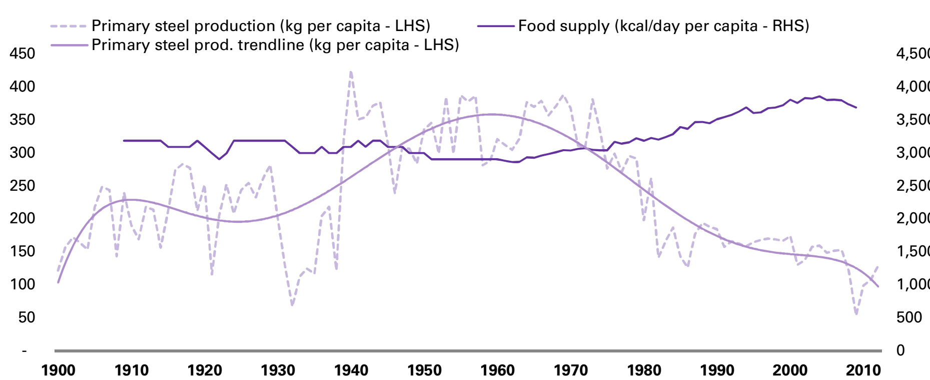
Executive Summary: oligopoly + steady growth = high margins

We add potash to our list of bulk commodities under coverage. On the demand side, agriculture is very different to steel and power generation, while the potash industry structure is admittedly unusual. However, there is also much in common on the supply side in terms of underground mining and ore beneficiation techniques, as well as in transportation and logistics.

The appeal of a late cycle commodity

We believe potash demand will be driven by the need to improve agricultural yields, particularly in emerging markets where output per hectare lags well behind the level achieved in Europe, North America and Northeast Asia. On the one hand, the world's population is set to grow at an average annual rate of 0.9% in the period to 2030 according to United Nations forecasts; this is equivalent to 71 million new mouths to feed each year. In addition to population growth, the average daily food intake per capita has increased from 2,189kcal in 1961 to 2,831kcal in 2009, equivalent to an average growth rate of 0.5% per year. On the other hand, arable land is a finite resource, so the agricultural sector must meet growing demand for food mainly by increasing the average yield per hectare. Rising food consumption is therefore a long-term trend that will outlast the demand for early cycle commodities such as steel that are driven by industrialization and urbanization. In the case of the US, primary steel production per capita rose during the first half of the 20th century before declining afterwards; current production levels are barely 30% of their level 50 years ago. Food consumption on the other hand has been increasing, and current intake per capita is approximately 30% above the level in 1962 (Exhibit 1). We view the US experience as a leading indicator for emerging markets such as China and India.

Exhibit 1: Early cycle versus late cycle commodities
Steel production and food supply per capita in the US



Source: USGS, USDA, Goldman Sachs Global ECS Research

Industry structure will maintain prices above cost support

Producer discipline has delivered consistently high margins in recent years and we believe it will sustain prices well above cost support for the remainder of our forecast period; the two marketing organizations control ~65% of current production and ~60% of new production in the period to 2020. In the short term, the upside to spot prices will be limited by a cut to Indian fertilizer subsidies and by moderate crop prices. Looking beyond the current crop cycle, we expect prices to average US$520/t over the period

2014-17, equivalent to a 73% premium over our US$300/t estimate of marginal production costs (Exhibit 2).

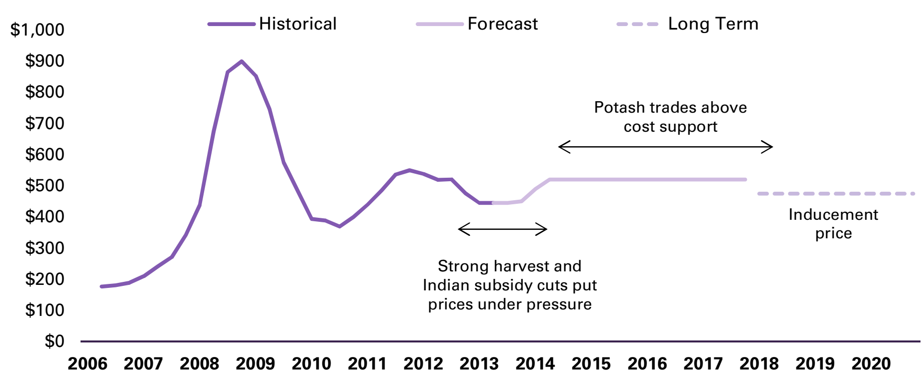
Exhibit 2: We initiate coverage of potash with a positive view
Potash price forecasts

Bulk Commodities: Price Forecast Summary nominal US$/t		Q2 2013	Q3 2013F	Q4 2013F	Q1 2014F	2012	2013F	2014F	2015F	2016F	2017F	Long Term 2018 $
Potash												
MOP - granulated	*CFR Brazil*	$ 445	$ 450	$ 490	$ 520	$ 514	$ 458	$ 520	$ 520	$ 520	$ 520	$ 475
MOP - standard	*CFR SE Asia*	$ 450	$ 460	$ 480	$ 500	$ 513	$ 457	$ 500	$ 500	$ 500	$ 500	$ 460
basin spread		$ (5)	$ (10)	$ 10	$ 20	$ 1	$ 0	$ 20	$ 20	$ 20	$ 20	$ 15

Source: Goldman Sachs Global ECS Research

In the long term, we expect the grip of the marketing oligopoly to gradually weaken as new entrants expand their production capacity. Based on our analysis of 30+ growth projects across the globe, we expect the rate of production capacity additions to increase significantly relative to the 2000-12 trend rate. We forecast production capacity to increase from 64Mtpa in 2013 to 83Mtpa in 2020, implying a modest decline in the global utilization rate towards the end of the decade. The eventual normalization of the potash industry as the supply side becomes more competitive will drive prices to converge towards the inducement price level of US$475 (in 2018 US$ terms), in our view (Exhibit 3).

Exhibit 3: We expect prices to trade above cost support
Historical and forecast potash prices – MOP granulated CFR Brazil



Source: CRU, Goldman Sachs Global ECS Research estimates

In this report we focus on our analysis on:

- The gap in **agricultural yields** between emerging and developed economies, and the challenge of rising population and rising living standards.
- The **role of fertilizers** in driving agricultural output, alongside other inputs (labor, land and capital), as well as productivity gains.
- The growth in **production capacity** and the implications for capacity utilization and prices.

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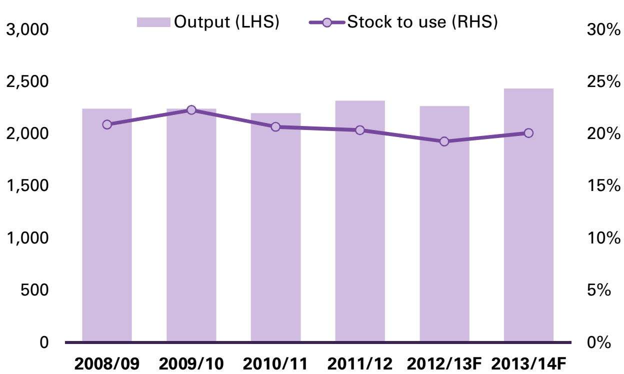
Potash prices to recover post 2014 season

In the short term, we expect the upside to potash prices to be limited by a cut to Indian fertilizer subsidies and by moderate crop prices. Looking beyond the current crop cycle, we expect prices to average US$520/t over the period 2014-17, equivalent to a ~70% premium over our US$300/t estimate of marginal production costs. In the long term, the grip of the established oligopoly will gradually weaken as new entrants expand their production capacity, driving prices to converge towards the inducement price level of US$475 (in 2018 US$ terms), in our view

Short term view: crop prices and subsidy cuts limit upside

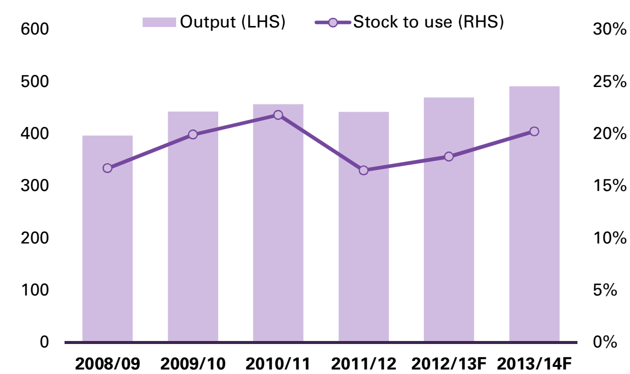
In the short term, the price upside will be mitigated by expectations of rising agricultural production and an increase in the stock-to-use ratio. According to the latest estimates from the USDA, global grain output will increase by 7.5% yoy in the 2013/14 season, lifting the stock-to-use ratio from 19% to 20% (Exhibit 4). Similarly, global oilseeds output will increase by 4.7%, lifting the stock-to-use ratio to 20% (Exhibit 5). In principle, a strong harvest will drive food prices lower and reduce the incentive of commercial farmers to increase production in the next crop cycle.

Exhibit 4: Higher volumes expected for grains…
Global grain output and stock-to-use ratio - Mt



Source: USDA

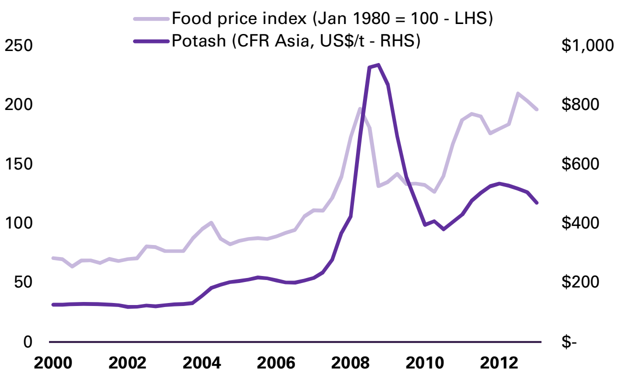
Exhibit 5: … and oilseeds will weigh on fertilizer demand
Global oilseeds output and stock-to-use ratio - Mt



Source: USDA

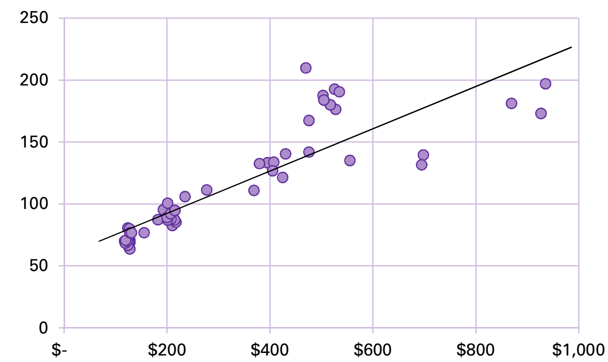
Historically, food prices have been strongly correlated with fertilizer prices. Since January 2000 the IMF Food index increased by 177%, while potash prices increased by 273%. The IMF Food Price index surged in 1H 2008, and potash prices duly followed in 2H 2008 to reach an all-time high. As demand contracted during the financial crisis, food prices declined and caused a sharp drop in potash prices (Exhibit 6). Based on average quarterly prices, the correlation between food and potash prices appears to be strongest with prices on a 6-month lag (Exhibit 7) with a coefficient of determination (R^2) of 0.58.

Exhibit 6: Food and potash prices are correlated…
Crop prices versus potash prices



Source: IMF, Goldman Sachs Global ECS Research

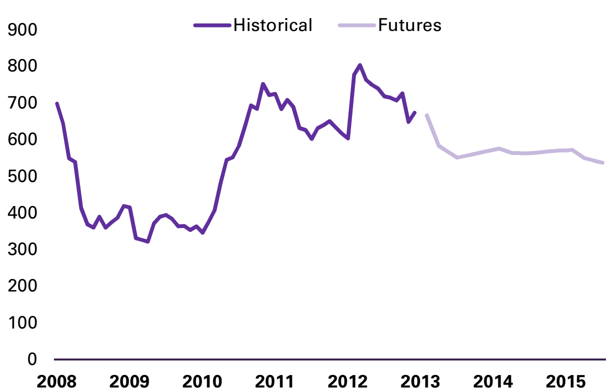
Exhibit 7: … with 6-month lag
Quarterly crop prices versus potash prices (6 month lag)



Source: IMF, Goldman Sachs Global ECS Research

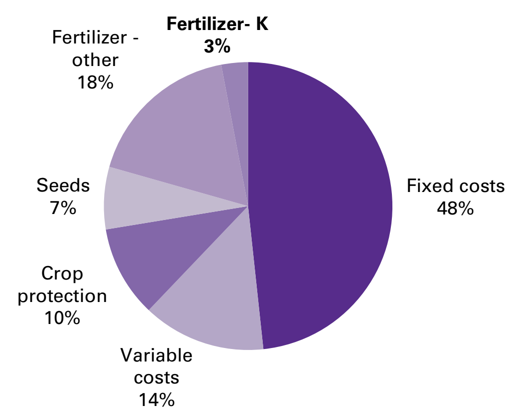
Corn futures in the US suggest a period of slightly lower crop prices (Exhibit 8). On that basis, the short term outlook for crop prices suggests a period of relatively soft demand and prices for potash. Another headwind for potash comes from recent changes to fertilizer subsidies in India. In May 2013 the Indian government announced a range of cuts to subsidies for NPK nutrients. In the case of potash, the subsidies will be reduced by 22%. Fertilizers can be a material cost to both commercial and subsistence farmers (Exhibit 9), and we therefore expect Indian demand to contract slightly in 2013.

Exhibit 8: Crop prices to soften in the short term
US corn prices – US cents per bushel



Source: CBOT

Exhibit 9: Fertilizer use contributes to variable costs
Cost analysis of wheat farming in Europe



Source: K+S Group

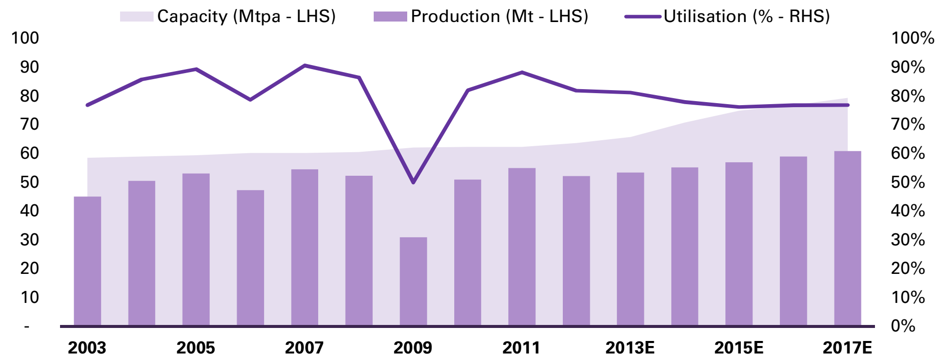
Long term view: producer discipline to hold until 2020

Producer discipline has delivered consistently high margins in recent years and we believe it will sustain prices well above cost support for the remainder of our forecast period; the two marketing organizations control ~65% of current production and ~60% of new production in the period to 2020. Our positive view on potash prices is based on the following rationale:

- The potash industry has relatively high **barriers to entry** in the form of a) high capital costs of US$1,000 per tonne of production capacity to develop new deposits and b) relative geological scarcity, with just 3 countries accounting for 60% of global production. This will limit the amount of new production capacity to be induced, in our view.

- Based on our analysis of growth projects, we expect 16Mtpa of new production capacity to be induced by 2017. This would be sufficient to meet demand growth of 3%, and we expect **capacity utilization** in the potash industry to remain near a range between 75% and 80% during that period (Exhibit 10).

Exhibit 10: Global utilization will converge towards 75% as capacity additions ramp up
Production capacity, demand and utilization rate



Source: CRU, Company data, FAO, Goldman Sachs Global ECS Research forecasts

The development of incremental production capacity outside of the marketing oligopoly should gradually erode the profitability of the potash industry. We expect the rate of capacity additions to increase relative to the historical trend rate, with global capacity rising from 64Mtpa in 2013 to 83Mtpa in 2020. This will coincide with a modest decline in the global utilization rate towards the end of the decade; as the supply side becomes more competitive, this will drive prices to converge towards the inducement price level of US$475 (in 2018 US$ terms), in our view (Exhibit 11).

Exhibit 11: In the long term, potash prices will be supported by the need to induce additional capacity
Methodology behind long term price forecasts - bulk commodities under GS coverage

	Potash	Iron Ore	Metallurgical coal	Thermal Coal
Long term price	inducement price	marginal production cost	inducement price	hybrid
Rationale	Lasting demand growth, high barriers to entry limit risk of oversupply	Excess capacity will keep the market in surplus from 2014+	Geological scarcity and industry concentration	Demand growth will slow until the need for new capacity vanishes

Source: Goldman Sachs Global ECS Research

We introduce our new potash supply & demand model

We have developed a supply and demand model for potash (Exhibit 12). On the demand side, we have based our forecasts on the historical trends in arable land and fertilizer use in each region, and we make adjustments whenever we believe there is a change in trend under way. For example, based on industry sources we believe that the K:N ratio in China will gradually increase as the agricultural sector corrects its excessive reliance on nitrogen, and we adjust our figures accordingly. We develop our demand analysis in the section titled *The quest for higher yields will drive potash demand* on page 9.

On the supply side, we have calculated the proven production capacity of the potash possible) or companies. We continue to follow the same methodology used in other bulk commodities to assess new growth projects: the inclusion of a new project into our supply forecasts is a binary decision based on a scorecard rating that reflects a project's viability and its probability of securing approvals and financing. We develop our supply analysis in the section titled *Supply growth and market structure will drive prices* on page 16.

Exhibit 12: Potash supply & demand balance

Million tonnes - KCl	2007	2008	2009	2010	2011	2012	2013E	2014E	2015E	2016E	2017E
Arable Land - million hectares											
OECD	415	418	420	416	416	420	419	418	417	416	415
non-OECD	957	958	962	967	971	975	978	982	986	990	994
Total	1,372	1,376	1,381	1,383	1,387	1,395	1,398	1,400	1,403	1,406	1,409
Fertilizer intensity - kg/ha											
OECD	85.3	71.1	75.1	80.0	80.8	81.6	82.4	83.2	84.0	84.9	85.7
non-OECD	60.4	54.9	123.7	129.0	133.5	134.2	136.6	139.1	141.6	144.1	146.7
Consumption - fertilizers											
US	6.7	4.4	6.4	6.9	7.0	7.0	7.0	7.0	7.0	7.0	7.1
EU27	5.9	3.2	3.8	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.0
Other OECD	2.9	2.0	2.2	2.4	2.4	2.5	2.5	2.5	2.6	2.6	2.6
OECD total	15.5	9.6	12.4	13.9	14.1	14.1	14.2	14.4	14.5	14.6	14.7
Brazil	6.6	5.8	5.0	6.2	7.0	7.1	7.3	7.6	7.8	8.0	8.3
China	10.3	7.4	6.8	8.2	9.4	10.1	10.5	10.9	11.3	11.7	12.1
India	4.2	5.3	5.8	5.6	4.4	4.0	3.9	4.4	4.8	5.3	5.9
Indonesia	1.5	1.5	1.3	2.0	2.4	2.4	2.5	2.6	2.7	2.8	2.9
CIS	1.6	1.8	1.8	1.8	1.9	2.0	2.0	2.1	2.2	2.3	2.4
Other non-OECD	6.4	5.2	4.5	6.2	6.5	6.8	7.1	7.4	7.7	8.0	8.4
non-OECD total	30.6	27.1	25.1	30.0	31.6	32.4	33.4	34.9	36.5	38.2	39.9
Total	**46.1**	**36.7**	**37.5**	**43.9**	**45.6**	**46.5**	**47.6**	**49.3**	**51.0**	**52.8**	**54.6**
Consumption - industrial & losses											
OECD total	3.1	6.1	0.2	1.0	2.6	2.7	2.7	2.8	2.8	2.9	2.9
Total non-OECD	2.4	2.9	2.5	2.9	2.9	2.9	3.0	3.1	3.2	3.3	3.3
Total - other sectors	5.5	9.0	2.7	3.9	5.5	5.6	5.7	5.9	6.0	6.1	6.3
Total demand	51.6	45.7	40.1	47.7	51.1	52.1	53.4	55.1	57.0	58.9	60.9
% growth		*-11.5%*	*-12.1%*	*19.0%*	*7.1%*	*1.9%*	*2.4%*	*3.4%*	*3.4%*	*3.4%*	*3.4%*
Incremental production capacity											
Canada				-	-	-	1	5	8	9	13
Others				-	-	-	0	0	1	1	4
Total incremental - unrisked				-	-	-	1	5	8	11	17
Total incremental - risked				-	-	-	2	7	11	13	16
Production											
Canada	18.1	17.3	7.2	15.6	17.7	15.3	18.1	19.1	20.7	22.2	23.5
Russia	10.6	9.9	6.1	10.2	10.8	9.4	9.9	10.3	10.4	10.5	10.5
Belarus	8.3	8.3	4.1	8.7	8.9	8.0	8.1	8.4	8.6	8.8	8.8
Israel	3.6	3.6	3.0	3.3	2.8	3.2	3.0	3.0	3.0	3.1	3.2
China	3.3	3.3	3.6	3.7	4.0	4.3	4.3	4.3	4.4	4.4	4.5
Germany	4.7	3.9	2.2	3.5	3.6	3.5	3.5	3.5	3.5	3.5	3.5
Other	6.0	6.1	4.6	6.2	7.1	7.1	6.4	6.5	6.4	6.4	6.9
Total Production	54.5	52.3	31.0	51.0	54.9	50.8	53.4	55.1	57.0	58.9	60.9
% growth		*-4.1%*	*-40.7%*	*64.4%*	*7.7%*	*-7.5%*	*5.1%*	*3.4%*	*3.4%*	*3.4%*	*3.4%*
Production capacity	60.2	60.6	62.1	62.3	62.3	63.7	65.7	70.8	74.9	76.8	79.3
utilisation rate	*91%*	*86%*	*50%*	*82%*	*88%*	*80%*	*81%*	*78%*	*76%*	*77%*	*77%*
Balancing item											
Stock changes	2.9	6.6	(9.1)	3.2	3.8	(1.3)	-	-	-	-	-
Exports											
Canada	191	16.5	6.4	15.8	16.7	14.9	15.5	18.5	20.1	21.5	22.9
Russia	112	8.9	4.5	8.3	8.8	7.0	7.5	8.6	8.6	8.7	8.7
Belarus	60	6.3	3.0	7.0	7.8	6.4	7.0	6.8	6.9	7.1	7.1
Germany	67	3.6	2.2	3.4	3.3	3.3	3.3	2.7	2.7	2.7	2.7
Israel		3.1	1.8	3.7	3.5	2.9	2.9	2.7	2.7	2.8	2.9
Other	133	2.7	2.2	4.2	4.2	4.6	4.3	9.3	9.3	9.3	9.8
Total seaborne exports	563	41.1	20.1	42.4	44.2	38.9	40.5	48.6	50.3	52.1	54.0
Imports											
US	8.1	8.0	3.3	8.0	7.4	6.8	7.0	7.1	7.1	7.1	7.2
EU27	5.9	5.4	1.7	4.8	4.8	4.6	4.7	3.7	3.7	3.7	3.8
Other OECD	2.4	2.7	1.1	2.4	2.4	2.3	2.4	4.9	6.4	7.8	9.1
OECD total	16.3	16.0	6.2	15.3	14.6	13.8	14.1	15.7	17.2	18.7	20.0
Brazil	7.1	5.9	3.7	6.8	7.2	7.3	7.4	7.7	7.9	8.1	8.4
China	9.3	5.1	1.3	5.1	6.8	6.3	6.5	6.7	7.0	7.4	7.8
India	3.9	6.0	5.4	6.2	4.7	3.2	4.0	4.5	5.0	5.5	6.0
Indonesia	1.4	1.9	0.8	2.4	3.1	2.5	2.5	2.7	2.8	2.9	3.0
Other non-OECD	6.3	6.2	2.7	6.5	7.7	5.9	6.0	9.0	9.4	9.8	10.2
non-OECD total	27.9	25.1	13.9	27.1	29.5	25.2	26.4	30.6	32.1	33.7	35.4
Total imports	44.3	41.1	20.1	42.4	44.2	38.9	40.5	46.3	49.3	52.4	55.4
% growth		*-7.1%*	*-51.1%*	*111.1%*	*4.1%*	*-11.9%*	*3.9%*	*14.4%*	*6.6%*	*6.3%*	*5.8%*

Source: CRU, IFA, World Bank, FAO, Goldman Sachs Global ECS Research estimates

The quest for higher yields will drive potash demand

Potash demand will be driven by the need to improve agricultural yields, particularly in emerging markets where output per hectare lags well behind the level achieved in developed markets. According to the United Nations, the world's population is set to grow at an average annual rate of 0.9% in the period to 2030, equivalent to 71 million new mouths to feed each year. In addition to population growth, the average daily food intake per capita has increased from 2,189kcal in 1961 to 2,831kcal in 2009, equivalent to an average growth rate of 0.5% per year. Arable land is a finite resource, so the agricultural sector will have to continue to meet growing demand for food by increase the average yield per hectare, partly via greater use of chemical fertilizers.

A framework to analyze fertilizer demand

In any given crop cycle, the incentives for farmers to increase or decrease fertilizer use in any given year will depend on factors such as the weather, crop prices and inventory levels, which are inherently difficult to forecast for any particular year. Our focus is therefore on the trend rate in potash consumption based on the following drivers:

- **Demand in OECD markets has almost peaked**: potash consumption in the OECD is dominated by large agricultural producers such as the US, the EU, Canada and Australia. In these countries the agricultural sector is mature, technologically sophisticated, and driven by profit. Current crop yields are already high, and farmers have limited upside from increased fertilizer use.
- **Emerging markets will increase fertilizer use**: for many countries outside the OECD, food security is still a key concern, and there is a strong imperative to increase yields over and above commercial considerations.
- **Some emerging markets will rebalance the N:P:K ratio**: some key markets such as China have relied on other nutrients (N in particular) well beyond the optimal level of use, and further yield improvements will require an increase in the ratio of K fertilizer in the mix.

We expect global potash demand to grow at an annual rate of 3.1% over the period 2013-17. Emerging markets account for 68% of current potash consumption (Exhibit 13) and they will be the key drivers of future demand growth (Exhibit 14). More specifically, we expect higher fertilizer intensity (in kg per hectare) and a higher K ratio (K2O as a share of NPK fertilizer use) to account for ~70% of demand growth in the period to 2017.

Exhibit 13: Emerging markets account for 68% of demand
Potash consumption by region – 2013E

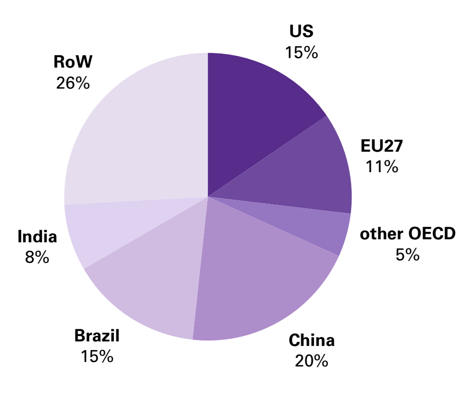
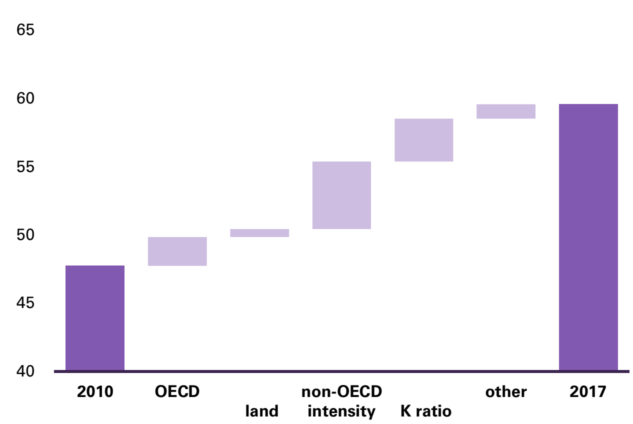


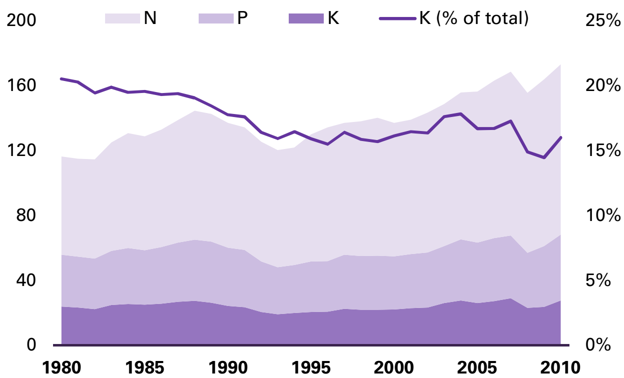
Exhibit 14: Fertilizer intensity and K ratio are key
Drivers of potash consumption in 2010-17E - Mt



We expect demand for K fertilizer to accelerate

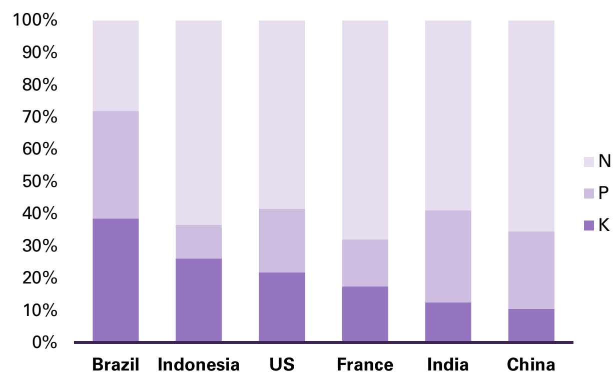
The increased use of fertilizer has been uneven across the 3 macronutrients. Global consumption over the period 1980-2010 has grown fastest for nitrogen, followed by phosphate and potash (Exhibit 15). Different types of soils and crops will require a different balance of nutrients, but we argue that in some regions the current fertilizer mix is suboptimal, explaining some of the large differences in the N:P:K ratio across countries (Exhibit 16). For instance, soils in China (the southern provinces in particular) are known to be deficient in K. At the same time, China is an important producer of vegetables (accounting for ~50% of global production) which require more potash than most other crops. In spite of these factors conducive to a relatively high use of K fertilizer, current potash consumption is low by global standards.

Exhibit 15: K has lagged N and P demand growth
Global nutrient demand (Mt – LHS) and K share (RHS)



Source: IFA

Exhibit 16: The N:P:K ratio varies greatly by country
Potash share of total nutrients – selected countries



Source: IFA

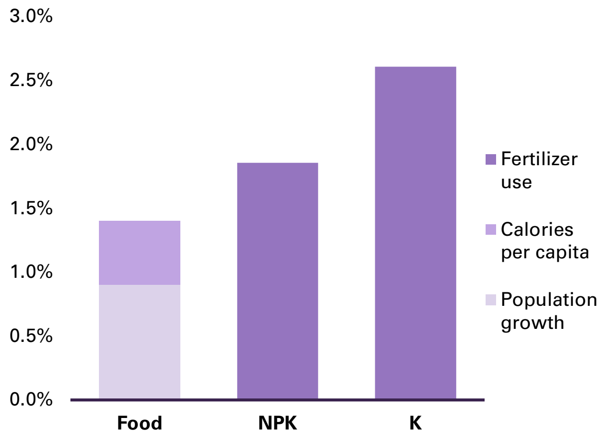
We expect global potash demand to grow at an average rate of 3.1% in the period 2012-17E. Our forecast rests on the two following assumptions:

1. **Fertilizer demand will outpace crop output**. Excluding the impacts of a change in diet and the rise of biofuels, we expect population growth and the trends towards more calorific diets to underpin a trend rate of 1.4% in global crop output. We expect fertilizer use to grow at a modest rate in the OECD, but we also expect non-OECD countries to increase their fertilizer use at an average annual rate of 2.2% over the period to 2017, lifting the global rate to 1.8% over that same period.

2. **Potash demand will outpace fertilizer demand**: We expect China and India in particular to balance their N:P:K ratio over time. In both cases the current fertilizer mix is skewed towards nitrogen, and the imperative to increase agricultural yields will require a bigger role for potash in the mix. We assume that the K ratio in other regions remains unchanged from current levels.

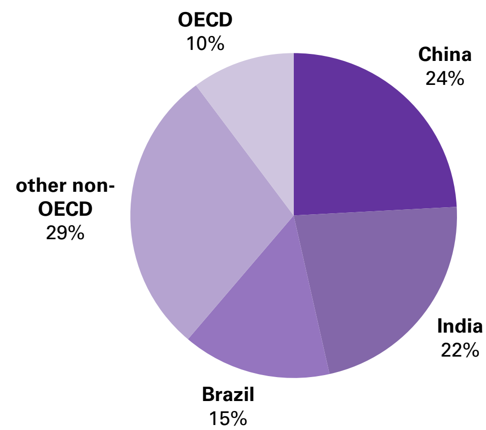
On that basis, we forecast demand for K fertilizer to outpace both N and P (Exhibit 17) and demand growth to be concentrated in the emerging markets of China, India and Brazil (Exhibit 18).

Exhibit 17: K fertilizer to outpace N and P
Average annual growth rates- 2012-17E



Source: GS Global ECS Research

Exhibit 18: Key growth markets are outside the OECD
Potash demand growth by region – 2012-17E

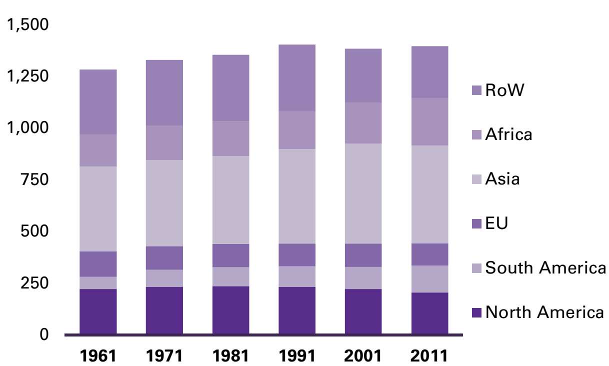


Source: Goldman Sachs Global ECS Research

Land is a finite resource but demand for food will keep growing

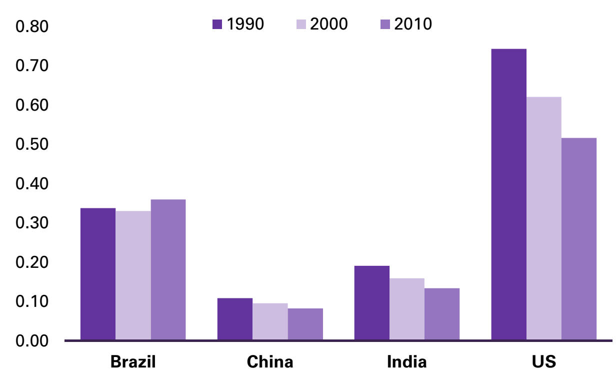
The area of arable land has largely stagnated for the past 20 years. In 2011, global arable land amounted to 1.4 billion hectares, marginally below the 1991 level and just 9% above the level 50 years ago (Exhibit 19). Over that period, arable land has actually shrunk in North America and Europe, but this has been offset by increases in South America, Africa and Asia. The challenge posed by a finite amount of land is brought into sharper focus by population growth and by the unequal distribution of land across regions. A rising population has reduced the amount of arable land per capita in most countries (Exhibit 20). With the exception of Brazil, where arable land has grown faster than population, land per capita has shrunk in China (-24%), India (-30%) and the US (-30%) over the period 1990-2010. This established trend is compounded by the unequal distribution of land. For example, China only has 16% as much arable land per person as the US.

Exhibit 19: Limited growth in arable land…
Arable land by region – million hectares



Source: FAO

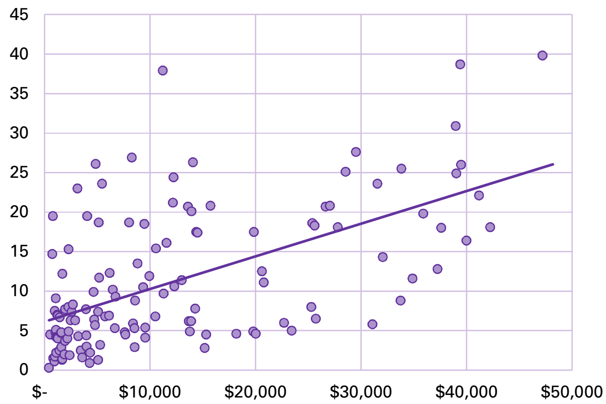
Exhibit 20: … means less land per capita
Arable land per capita – hectares



Source: FAO, World Bank

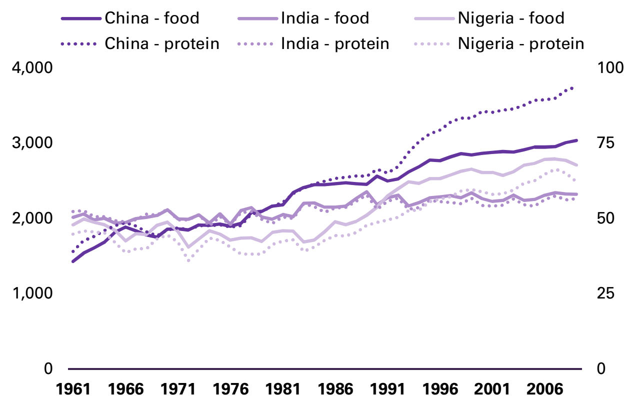
A separate trend is the impact of rising income levels on diet. For example, countries with a GDP per capita below US$10,000 tend consume 7.6kg of beef per year, whereas countries with a GDP above US$30,000 consume 21kg of beef per year on average (Exhibit 21). Of course, several factors determine the national diet, including the climate and culture; the average Argentine ate his way through 54kg of beef in 2009. More broadly, rising income levels are associated with an increase in the average intake of protein and calories (Exhibit 22).

Exhibit 21: Rising income leads to a change of diet…
Annual bovine meat consumption and GDP per capita - kg



Source: FAO, World Bank

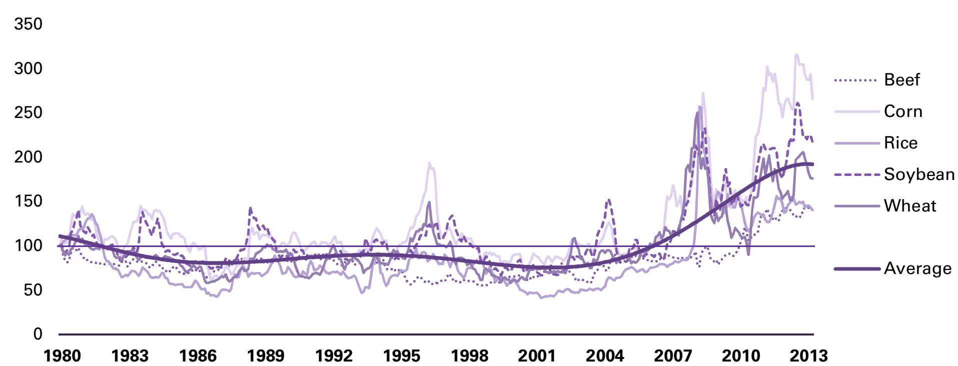
Exhibit 22: … and a higher intake of protein and calories
Average food (kcal - LHS) and protein (g – RHS) daily intake



Source: FAO

In spite of these established trends towards less arable land per capita and growing demand for food, agricultural output has increased sufficiently to keep food prices relatively stable over long periods of time. However, using a basket of key agricultural products (beef, corn, rice, soybean and wheat) we note an inflection point in 2007 when food prices started to increase (Exhibit 23). The drivers behind the recent increase in food prices include higher energy prices, higher biofuel mandates and poor weather. Importantly, oil prices have now stabilized while the increase in biofuel demand has slowed and weather patterns are due to normalize. As a result, the inflationary pressures on food prices should moderate somehow.

Exhibit 23: Food prices have passed an inflection point
Food prices – Jan 1980 = 100

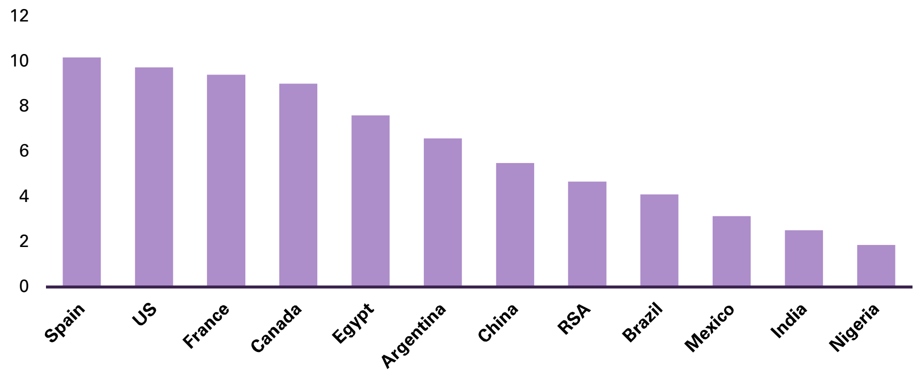


Source: IMF

The great divide: high yield versus low yield countries

The main driver of agricultural production growth has been the increase in crop yields. The deployment of better seeds, modern farming techniques, irrigation, pest control and fertilizers have all contributed to bigger harvests per hectare. However, progress has been unequal, with a clear divide between advanced farming sectors in the OECD and the rest of the world (Exhibit 24). For instance, using a selective sample of both developed and emerging markets, OECD countries achieve higher yields in corn (+85%) than non-OECD countries.

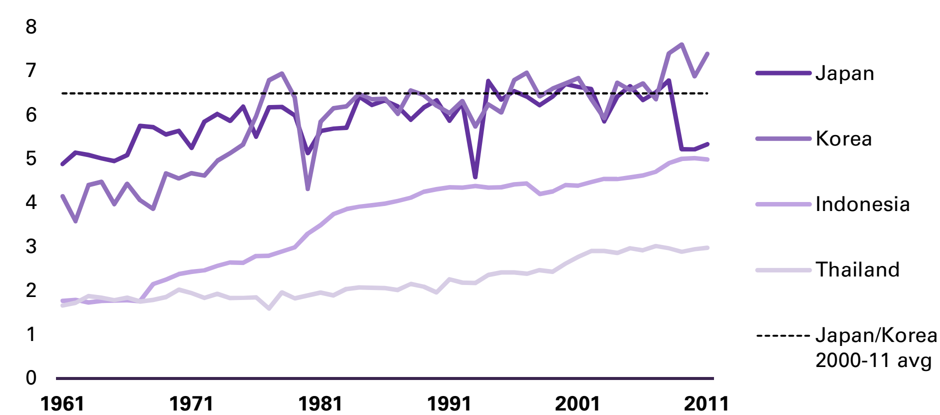
Exhibit 24: Yields tend to be higher in developed markets
Corn yields (tonnes per hectare) for selected countries – 2009-11 average



Source: FAO

Several factors can drive the variation of yields across (and within) countries. For example, South Korea adopted modern farming techniques in the 1980s, and it now achieves rice yields similar to Japan where the climate is similar (Exhibit 25). Based on historical data, it appears that both countries are now close to the full yield potential, and there is limited upside. Meanwhile, Indonesia has increased the use of irrigation and fertilizers, and yields have responded accordingly. Finally, in Thailand the soil quality is poor and irrigation is not widely used, so it may not be surprising that yields have not materially improved.

Exhibit 25: Some countries already at crop yield potential, others still have upside
Rice yields in selected countries – tonnes per hectare

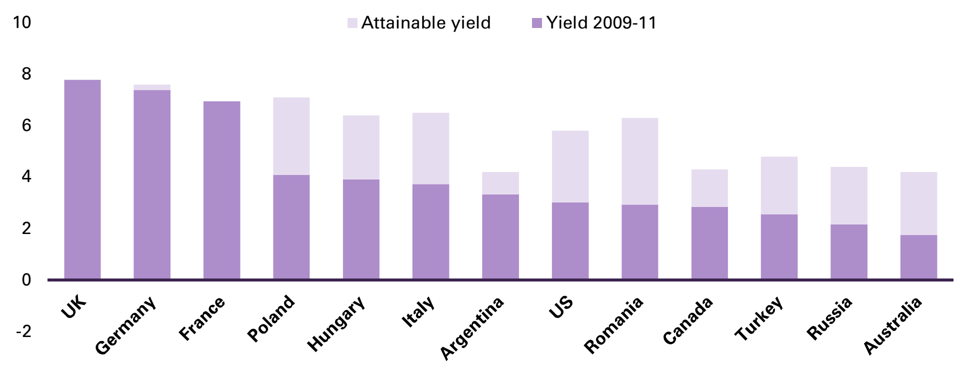


Source: FAO

How far can yields be improved? Yield growth is limited by both the physiological potential of the plant and the local environment (i.e. soil, climate). In other words, there are natural factors that determine the maximum attainable yield for a given crop on a given piece of land. The FAO has quantified the attainable yield for a range of crops, including wheat (Exhibit 26). The data suggest that several European countries have already achieved their optimal yields in wheat production given their natural endowment of soil and weather. This is arguably the result of years of efforts in R&D

fertilizers, pesticides, equipment and labor. However, countries that achieve lower yields are not necessarily less efficient. For instance, a commercial farm that is driven by profit rather than food security may achieve better returns for its owner by limiting the amount of materials, labor and capital, thereby remaining deliberately below its attainable yield. The challenge for farmers is therefore to narrow the gap between current and maximum attainable yield, partly via the better use of fertilizers.

Exhibit 26: Some countries have realized the maximum attainable yield
Wheat yield (t/ha) in selected countries – actual versus attainable

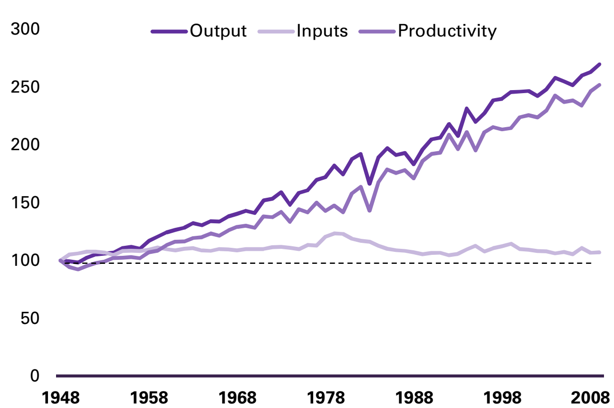


Source: FAO

The role of fertilizers in driving agricultural output

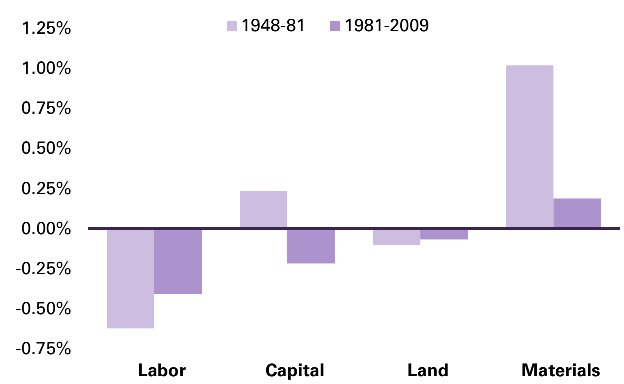
Farmers can increase yields towards the potential level by a) increasing the amount of labor, materials (fertilizers, pesticides, better seeds) and capital (machinery, irrigation, etc.) , and b) by using them more productively. If agricultural output grows faster than inputs, it implies that productivity has increased. Agricultural R&D is a big driver of productivity; in the US, productivity gains have been the main driver of agricultural production growth (Exhibit 27). Over the past 60 years, US agricultural output has increased by 170% even though the amount of inputs has declined in aggregate (Exhibit 28). In other words, farmers have been working smarter, not harder. The only type of input that has increased consistently during the period 1948-2009 is material inputs (+370%).

Exhibit 27: US agricultural output and productivity
Sources of growth in US agriculture – 1948 = 100



Source: USDA

Exhibit 28: Materials use has increased at a slowing rate
Average annual growth rates in US agricultural inputs

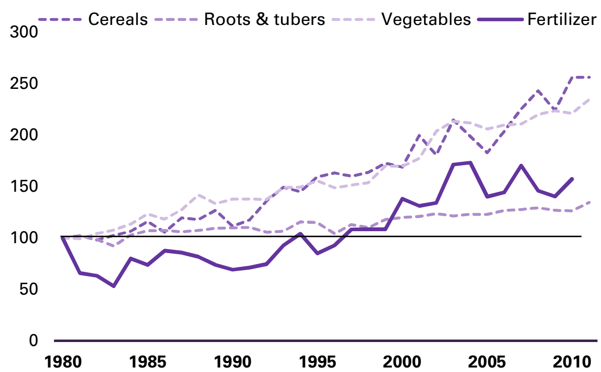


Source: USDA

What is the ideal level of fertilizer use? The answer depends on the type of crop and on local conditions such as the amount of nutrients in the soil. The answer will also depend to some degree on the crop prices of the day, which determine the desired yield. In other words, the answer is non-trivial as it depends on a large number of variables.

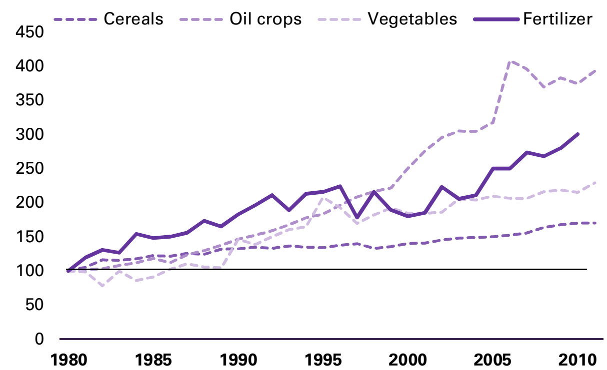
The efficiency of fertilizer use can vary greatly across countries. Based on the available data, we are able to make general observations at a country level. At one end of the spectrum, agricultural yields for cereals and vegetables in Brazil have increased in line with the rising use of fertilizer (Exhibit 29), while Indonesia has achieved remarkable growth in oil crops output (Exhibit 30). In China, the use of fertilizer appears to be less productive since its increased use exceeds the improvement in yield, probably caused by an inefficient use and an over-reliance of N-fertilizer (Exhibit 31). Finally, at the other end of the spectrum, fertilizer use in India appears to be relatively inefficient given the growth in its use relative to the growth in output (Exhibit 32).

Exhibit 29: Efficient fertilizer use in Brazil…
Agricultural yield and fertilizer (NPK) use – 1980 = 100



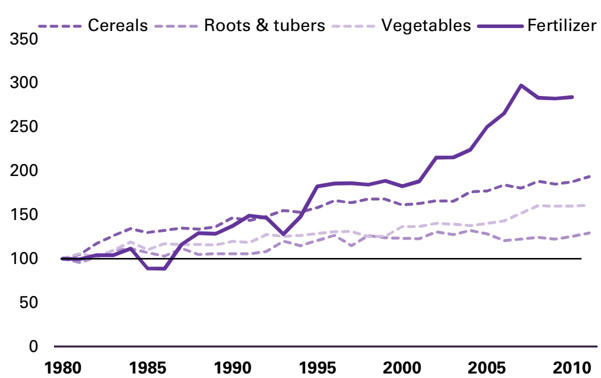
Source: FAO, IFA, Goldman Sachs Global ECS Research

Exhibit 30: … and Indonesia
Agricultural yield and fertilizer (NPK) use – 1980 = 100



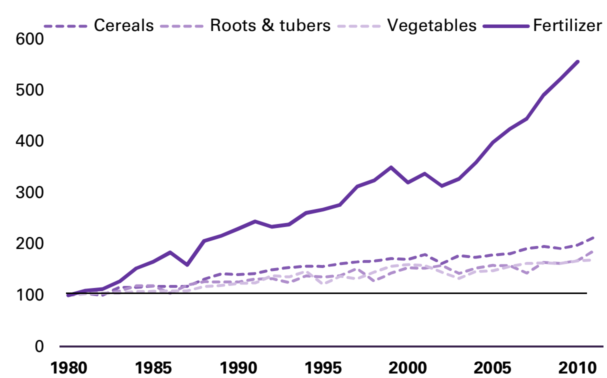
Source: FAO, IFA, Goldman Sachs Global ECS Research

Exhibit 31: Efficiency is more modest in China..
Agricultural yield and fertilizer (NPK) use – 1980 = 100



Source: FAO, IFA, Goldman Sachs Global ECS Research

Exhibit 32: … while India scores last
Agricultural yield and fertilizer (NPK) use – 1980 = 100



Source: FAO, IFA, Goldman Sachs Global ECS Research

Supply growth and market structure will drive prices

Uniquely among bulk commodities, the potash industry is characterized by two marketing organizations that collectively account for ~65% of current production and ~60% of new production in the period to 2020. Canpotex (representing PotashCorp, Mosaic and Agrium) and BPC (representing Uralkali and Belaruskali) do compete against one another, but they have also shown sufficient market discipline to deliver consistently high margins. We estimate effective production capacity at 63Mtpa and we forecast 16Mtpa of new production capacity to be induced by 2017. This will be sufficient to meet demand growth of 3%, and we expect capacity utilization in the potash industry will remain close to the 75% level during that period.

We estimate 2012 production capacity at 64Mtpa

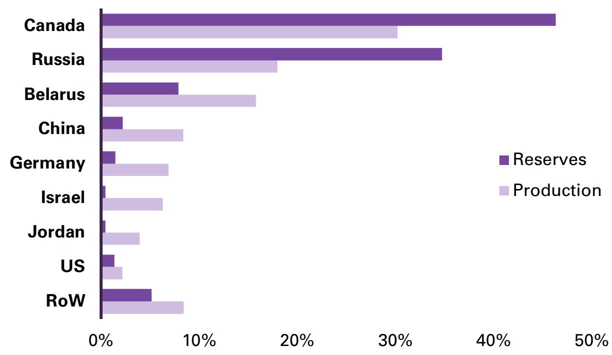
Pricing tension and capacity utilization rates are closely linked, so an adequate estimate of current and future production capacity is central to our price view. Unlike other bulk commodities where mines are usually run at full capacity (or not at all) and estimates of global capacity are relatively simple to assess, potash mines often operate at a rate below full capacity. On that basis, calculating the global production capacity requires some judgment. In particular, an estimate based on the nameplate capacity of a mine may not be a reliable indicator.

We therefore adopt a different approach based on the highest recorded annual production volume, and we adjust that figure based on any mine expansions that may have taken place after the year of peak production. This approach can underestimate the capacity of assets that have been consistently underutilized for the past decade. However, we believe that a mine that has not performed at its nameplate capacity for years may not be physically capable of achieving that higher rate without additional investment to debottleneck the mine. Conversely, our approach may overestimate production capacity in cases where peak production occurred some time ago, and as the mine matures (e.g. the mine plan moves into less productive areas) and/or sustaining capital dries up, the effective capacity falls below the historical peak level of production. We note that approximately 25% of the current production capacity achieved peak production over 8 years ago. In our view, these upside and downside risks offset each other to some degree, and we are therefore comfortable with our global production capacity estimate of 64Mtpa as of end 2012.

The potash oligopoly will remain in place until 2020 at least

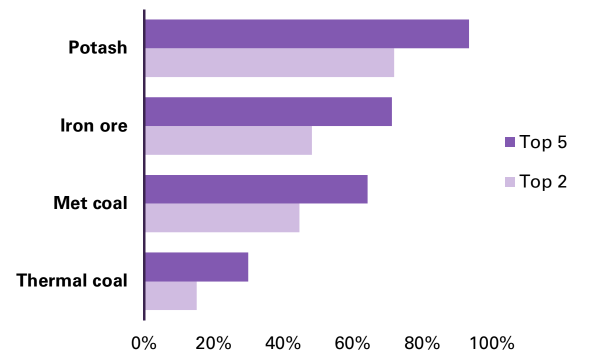
Potash reserves and production are highly concentrated, with 3 countries accounting for 89% and 64% of the global total, respectively (Exhibit 33). This geographical concentration is replicated at a company level; on a marketing basis, the top two suppliers have a much larger share of the export market in potash than in other bulk commodities, including iron ore and metallurgical coal (Exhibit 34).

Exhibit 33: Potash supply is highly concentrated
Potash reserves and production– as % of world total



Source: USGS, CRU

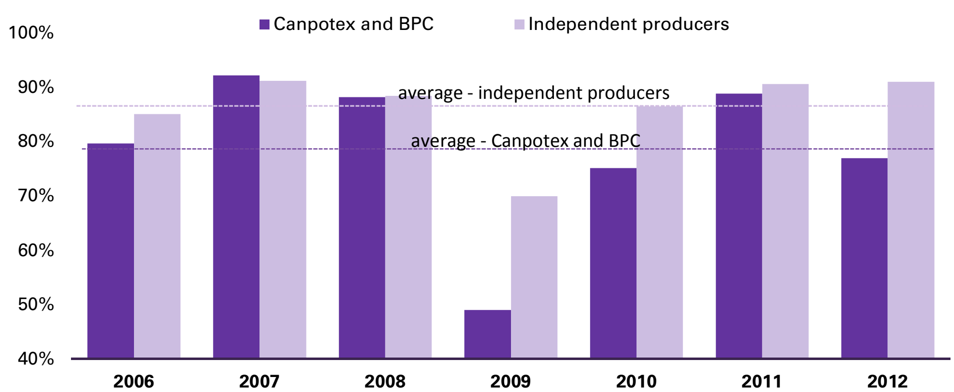
Exhibit 34: Greater concentration than other bulks
Export market share (marketing basis) - top producers



Source: Company data, Goldman Sachs Global ECS Research estimates

The two marketing organizations do compete against each other, for example by selling into the Chinese market in an uncoordinated fashion in an attempt to win market share. However, as a general rule they have shown remarkable discipline in adjusting production in a way to support prices well above the marginal cost of production. Based on our estimates of production capacity, Canpotex and BPC have operated at an average utilization rate of 79% in the period 2006-12 (Exhibit 35). Not only did they curtail production in 2009-10, but they also accepted a lower utilization rate than the independent producers who produced at an average rate of 86%. From that perspective, producers outside the oligopoly are enjoying a free ride from high potash prices but without the restraint on production volumes.

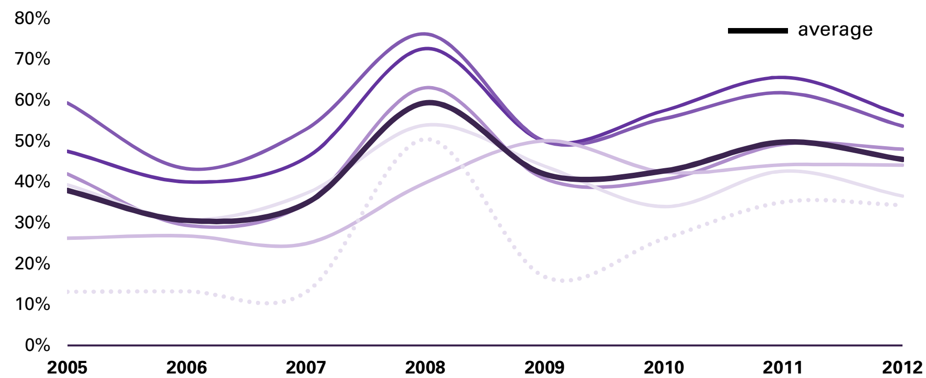
Exhibit 35: Canpotex and BPC have shown producer discipline
Capacity utilization rates by company type



Source: Company data, Goldman Sachs Global ECS Research

The impact of industry concentration is also evident on the historical level of profit margins (Exhibit 36). Over the period 2005-12, the average operating margin for potash producers accounting for 70% of current global output was 43%. The average margin peaked in 2008 at 59%. Even more remarkably, profit margins only declined marginally in 2009 when potash imports contracted by 51% yoy. These profitability levels put potash in the same league as iron ore during the period 2008-11. However, whereas iron ore margins were dependent on Chinese demand growth and high marginal production costs, margins in potash are largely the result of producer discipline and are likely to outlast the period of high iron ore margins by several years.

Exhibit 36: Producer discipline has delivered high margins for the potash industry
Operating margins for selected potash producers and global demand growth rates



Source: Company data, Goldman Sachs Global ECS Research

We estimate marginal FOB costs at US$300/t

In our view, the main drivers of production costs are (in order of importance):

- **Labor costs**: potash production is relatively labor intensive. Average labor productivity ranges from 0.5 to 2K tonnes of product per employee per year. This compares with labor productivity rates of up to 10K tonnes per employee in underground coal mining. On that basis, differences in wages and in labor productivity across countries and between individual companies will have a material impact on its position in the cost curve.
- **Mine depth**: the deeper the mine shaft, the higher the costs of hauling potash ore to the surface. By the same token, deeper mines with mining faces located far from the shaft will incur higher operating costs transporting staff and equipment to and from the mine face.
- **Ore grade**: the higher the grade in the potash deposit, the less material needs to be mined and processed in order to deliver one tonne of finished product.
- **Site-specific factors**: some sites may benefit from weather conducive to solar evaporation, which equates to lower energy costs. Conversely, some sites may incur additional costs from mine flooding which requires regular brine pumping or some other palliative measures.

We conduct a bottom-up analysis of production costs for a range of generic mine types (Exhibit 37). We apply unit cost benchmarks from the coal industry to estimate mining and processing costs, on the basis that underground mining and flotation tanks have similar costs regardless of the type of ore being produced. On similar grounds we also apply rail tariffs and port cost benchmarks from the coal industry. In our view, potash mines located in the top quartile of the FOB cost curve are located in North America and Europe. We estimate the current marginal cost of production at US$300/t.

Exhibit 37: We estimate marginal production costs at US$300/t
Indicative production costs for generic mine types – US$ per tonne, unless otherwise indicated

Region		**North America**		**Russia**	**Belarus**	**Germany**	**Israel**
Mine type		UG - low cost	UG - high cost	UG	UG	UG	EV
Mine depth	*meters*	1,000	1,000	400	400	1,000	n/a
Mining	*$ / t ROM*	$ 30	$ 45	$ 30	$ 25	$ 60	n/a
Ore grade	*% K_2O*	23%	22%	23%	23%	22%	n/a
Beneficiation	*$ / t ROM*	$ 8	$ 10	$ 7	$ 6	$ 12	n/a
Sub-total	*$ / t*	$ 104	$ 158	$ 101	$ 85	$ 206	$ 150
Sustaining capital	*$ / t*	$ 30	$ 35	$ 20	$ 15	$ 35	$ 10
Royalties (1)	*$ / t*	$ 32	$ 27	$ 4	$ 106	$ -	$ 11
Overheads	*$ / t*	$ 15	$ 15	$ 10	$ 5	$ 18	$ 10
FOR (cash cost)	*$ / t*	$ 151	$ 200	$ 115	$ 196	$ 224	$ 171
FOR (all-in)	*$ / t*	$ 181	$ 235	$ 135	$ 211	$ 259	$ 181
Distance to port	*km*	1,800	1,800	2,250	750	450	50
Transportation rate	*$ / t.km*	$ 0.020	$ 0.020	$ 0.015	$ 0.030	$ 0.045	$ 0.100
Transportation	*$ / t*	$ 36	$ 36	$ 34	$ 23	$ 20	$ 5
Port fees	*$ / t*	$ 4	$ 4	$ 4	$ 4	$ 10	$ 10
FOB	***$ / t***	**$ 221**	**$ 275**	**$ 173**	**$ 238**	**$ 290**	**$ 196**
Freight (2)	*$ / t*	$ 30	$ 30	$ 18	$ 18	$ 14	$ 18
CIF	***$ / t***	**$ 251**	**$ 305**	**$ 192**	**$ 256**	**$ 303**	**$ 215**

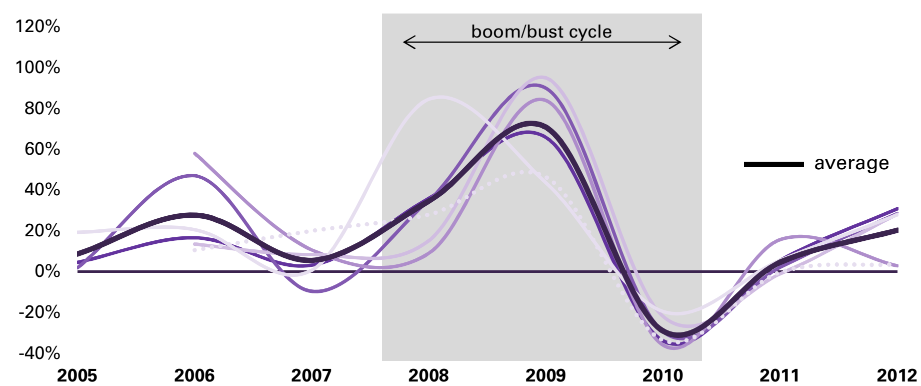
Notes: 1) includes both mining royalties and taxes but excludes corporate tax 2) estimated costs of sea freight to either Brazil or Southeast Asia (whichever is closest) on a Handysize vessel

Source: Company data, Goldman Sachs Global ECS Research estimates

Cost inflation has averaged 10%

Production costs have increased across a sample of major producers (Exhibit 38). Excluding the boom/bust period of 2008-10 when production volumes and unit costs varied significantly, the industry has experienced an average cost inflation rate of approximately 10% on average in the periods 2002-7 and 2010-12.

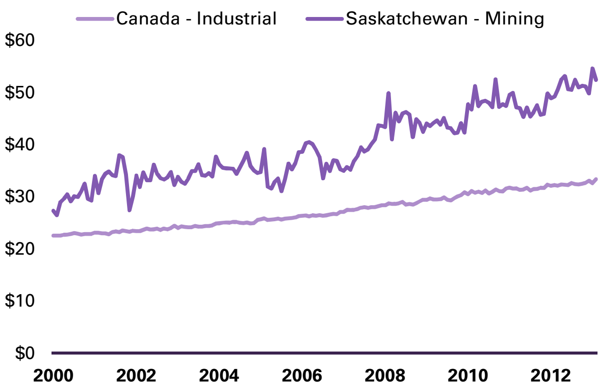
Exhibit 38: The potash industry has experienced significant cost inflation
Annual increase in potash production costs for selected producers



Source: Company data, Goldman Sachs Global ECS Research estimates

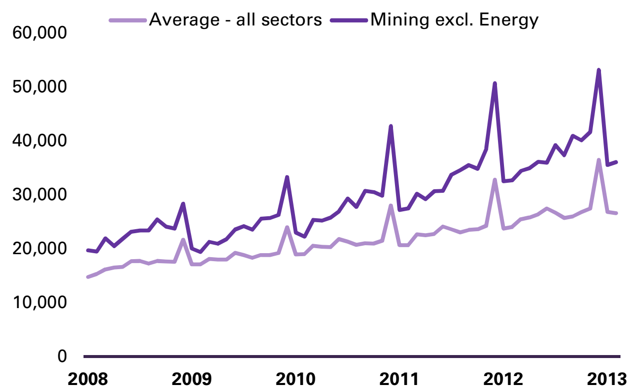
Wage inflation has been an important driver of rising costs, particularly in regions enjoying a robust mining sector and suffering from a tight labor market. In Saskatchewan, average wages in the mining sector have increased at an average annual rate of 5% over the period 2000-12, outpacing wages in the broader Canadian economy; they are now 62% higher (Exhibit 39). Employment in the mining sector will grow by 42% in the next 10 years, according to the Saskatchewan Mining Association, so this trend is likely to persist during our forecast period. Meanwhile, wages in the Russian mining sector grew at an annual rate of 24% in the period 2000-08, before slowing down to a still robust 13% over the period 2008-13; they are 42% higher than the average wage (Exhibit 40).

Exhibit 39: Mining wage inflation in Saskatchewan…
Average hourly wages by region and sector – C$



Source: Statistics Canada

Exhibit 40: … and in Russia
Average monthly wages by sector - RUB

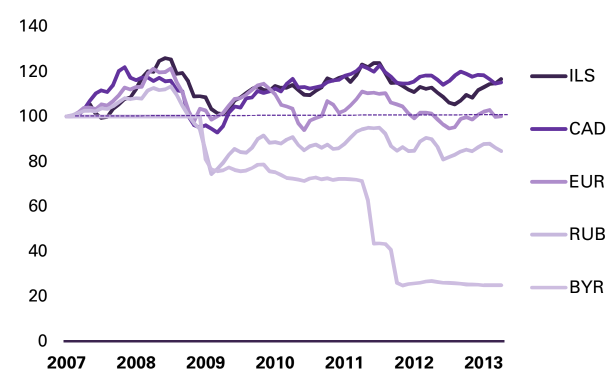


Source: Goskomstat

Taxes and royalties are another driver for cost inflation. For instance, the Jordanian government responded to the period of record prices in 2008 by increasing the royalties on potash sales to JOD125/t (US$177) with a cap set at 25% of company profits. This was followed in 2010 by an increase in the annual concession lease paid by the Arab Potash Company to JOD1.5 million.

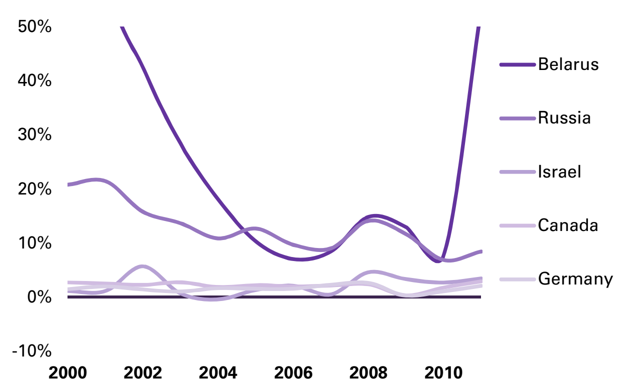
The **exchange rate** can be another driver of cost inflation. Among the key producers, only the Israeli Shekel (+17%) and the Canadian dollar (+15%) have appreciated against the US dollar while the Euro has held its value and both the Russian Ruble (-15%) and the Belarusian Ruble (-75%) have depreciated (Exhibit 41). The significant depreciation of the Belarusian Ruble has gone in hand with very high inflation rates (Exhibit 42). However, we expect cost inflation in Belarus to be moderate going forward. A reform program together with a flexible currency and a focus on price stability should bring lower inflation rates going forward. In terms of labor costs, average wages in Belarus are approximately flat in US$ terms relative to 2011.

Exhibit 41: Belarus has a weak currency…
Exchange rate against the US dollar – January 2007 = 100



Source: www.oanda.com

Exhibit 42: … combined with high inflation rates
Annual inflation – consumer prices yoy%



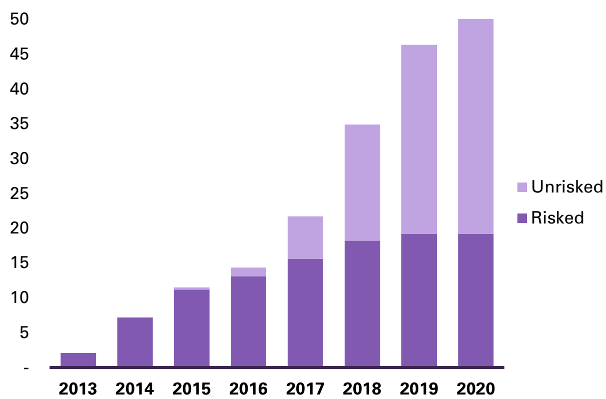
Source: World Bank

In summary, and in the absence of data on labor productivity trends, we expect the rate of cost inflation in potash production to be driven mainly by rising labor costs in Canada and Russia. Our price forecasts are based on an expected annual cost inflation rate of 2% in real terms.

Growth projects will deliver 19Mt of new capacity by 2020

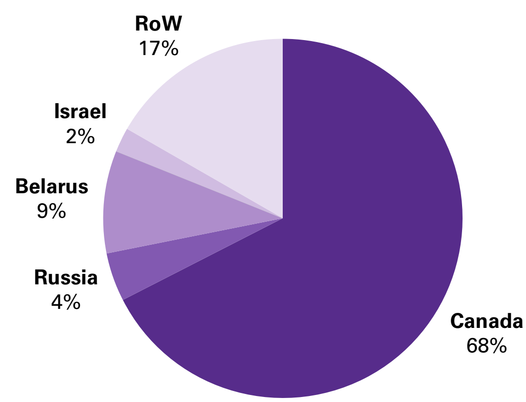
Rather than discounting the potential production of all growth projects, we have chosen instead to make a binary decision on each project on the basis of its likely position in the cost curve, its capital intensity and the company's access to finance as well as other risk factors. We exclude projects from our supply/demand forecasts, which would add an additional 19Mt of production by 2020 if approved (Exhibit 43). We expect the majority of new production to come from Canada (Exhibit 44).

Exhibit 43: We expect 19Mt in new capacity by 2020
Risked and unrisked supply growth - Mt



Source: Company data, Goldman Sachs Global ECS Research

Exhibit 44: Canada will drive future supply growth
Geographical distribution - 2020E production growth



Source: Company data, Goldman Sachs Global ECS Research

The forecast of supply growth is subject to significant uncertainty. First, a large number of potash projects are still awaiting board approval; this is particularly the case for Jansen, which at 8Mtpa is by far the largest project in the pipeline. Second, the potash industry has limited experience in developing growth projects in recent times, particularly for greenfield sites. **Whereas the global industry has added on average 0.5Mt in incremental annual capacity per year over the period 2000-12, we expect an average annual increase of 2.4Mt in the period to 2020**. This represents a five-fold increase in terms of supply growth, and we expect that it will test the project management and engineering skills of the industry. In other words, the risks of project slippage (schedule and cost) are relatively high when compared with projects in the iron ore and coal industries where such expertise is in ample supply.

We provide a sample of potash projects where first production is expected before 2020 (Exhibit 45). The list may not be exhaustive, but it is nevertheless representative of the diversity of the global project pipeline in terms of location, project type, mine type and capital intensity. Based on this sample, the average level of capital intensity is ~US$1,000/t. Assuming that the marginal project will have similar operating costs as the marginal producers in operation today, we estimate the inducement price at US$400/t in 2013 US$ terms, equivalent to US$475/t in 2018 US$ terms.

Exhibit 45: The growth pipeline suggests capital intensity for greenfield projects is in excess of US$1,000/t
A selective sample of potash projects

Country	Company	Mine	Basin	Ore Type	Mine type	Project Type	Production Capacity	Start date	Status	Capex	Capex/t
Belarus	Belaruskali	Berezovsky ph 1-3	Starobin basin	Sylvinite	Underground	bf	1.4	2013	Development	$ 540	$ 386
Belarus	Belaruskali	Krasnoslobodsky ph 3	Starobin basin	Sylvinite	Underground	bf	0.7	2013	Development	$ 270	$ 386
Canada	Mosaic	Belle Plaine ph 2	Saskatchewan		Solution Mining	bf	0.4	2013	Development	$ 102	$ 255
Canada	Mosaic	Colonsay ph 2	Saskatchewan		Underground	bf	0.5	2013	Development	$ 255	$ 510
Canada	Mosaic	Esterhazy K2	Saskatchewan	Sylvinite	Underground	bf	0.9	2013	Operation	$ 700	$ 778
Canada	Potash Corp	Allan I	Saskatchewan		Underground	bf	1.0	2013	Development	$ 785	$ 785
Canada	Potash Corp	Cory II	Saskatchewan		Underground	bf	1.0	2013	Development	$ 755	$ 755
Canada	Potash Corp	New Brunswick	New Brunswick		Underground	bf	1.2	2013	Development	$ 2,203	$ 1,836
Russia	Uralkali	Debottlenecking	Upper Kama	Mixed	Underground	bf	1.0	2013	Development	$ 192	$ 192
US	Intrepid Mining	HB Solar	Carlsbad, New Mexico	Sylvite	Solution Mining	bf	0.2	2013	Development	$ 215	$ 1,075
Canada	Agrium	Vanscoy	Saskatchewan		Underground	bf	1.0	2014	Development	$ 1,500	$ 1,500
Canada	Potash Corp	Rocanville	Saskatchewan		Underground	bf	2.7	2014	Development	$ 2,856	$ 1,058
Israel	ICL	Debottlenecking	Dead Sea	Carnallite	Surface Aquifer	bf	0.5	2015	Development	$ 188	$ 376
ROC	MagIndustries	Mengo	ROC	Carnallite	Solution Mining	gf	1.2	2015	Feasibility	$ 723	$ 603
Canada	K+S	Legacy ph 1&2	Saskatchewan		Solution Mining	gf	2.9	2016	Development	$ 3,315	$ 1,143
Turkmenistan	Turkmenkhimiya	Garlyk	Guardak/Garlyk		Underground	gf	1.4	2016	Development	$ 1,200	$ 857
Brazil	Verde Potash	Cerrado Verde ph1	Minas Gerais	Silicate	Opencast	gf	0.6	2017	PFS	$ 598	$ 997
Canada	K+S	Legacy ph 1-2	Saskatchewan		Solution Mining	gf	2.9	2017	Development	$ 4,100	$ 1,434
Canada	Mosaic	Belle Plaine ph 3	Saskatchewan		Solution Mining	bf	0.5	2017	On hold	$ 700	$ 1,400
Canada	Mosaic	Colonsay ph 3	Saskatchewan		Underground	bf	1.5	2017	On hold	$ 2,100	$ 1,400
Canada	Mosaic	Esterhazy K3	Saskatchewan	Sylvinite	Underground	bf	0.9	2017	Development	$ 1,000	$ 1,111
Canada	Western Potash	Milestone	Saskatchewan		Solution Mining	gf	2.8	2017	Feasibility	$ 2,900	$ 1,036
Russia	Acron	Talitsky	Verkhnekamsk	Mixed	Underground	gf	2.0	2017	Development	$ 2,000	$ 1,000
Russia	Eurochem	VolgaKaliy phase 1&2	Karatau basin	Mixed	Underground	gf	4.6	2017	Development	$ 3,783	$ 822
UK	Sirius Minerals	York Potash	North Yorkshire	Polyhalite	Underground	gf	5.0	2017	PFS	$ 1,700	$ 340
Argentina	Vale	Rio Colorado ph 1	Mendoza province		Solution Mining	gf	2.4	2018	On hold	$ 6,000	$ 2,500
Canada	BHP Billiton	Jansen	Saskatchewan		Underground	gf	8.0	2018	Feasibility	$ 12,000	$ 1,500
Russia	Eurochem	Usolskiy ph 1&2	Karatau basin	Mixed	Underground	gf	3.7	2018	Development	$ 2,850	$ 770
Argentina	Vale	Rio Colorado	Mendoza province		Solution Mining	gf	1.9	2020	On hold	n/a	n/a
Russia	Uralkali	Ust-Yayvinksy	Upper Kama	Mixed	Underground	gf	2.8	2021	Development	$ 1,605	$ 573
Canada	K+S	Legacy ph 3	Saskatchewan		Solution Mining	bf	1.1	2034	Feasibility	$ 700	$ 614
Total (unrisked)							**58.7**			**$ 57,835**	**$ 985**

Source: Company data, Goldman Sachs Global ECS Research estimates

Note on capital intensity: Although we have estimated the capital intensity of potash projects based on available information, we do so in the knowledge that comparisons between projects can be misleading. A low figure (in US$ per tonne of capacity) for a project may simply reflect the fact that mining equipment capex has been excluded from the balance sheet because contractors will operate the site. Conversely, a higher than average capital intensity figure may reflect the development capital for rail and port infrastructure and/or for life extensions and latent capacity for future expansions.

Risks to our views

We highlight a set of risks that have the potential to undermine our forward view of the global market and our investment thesis for potash. The key risks on the demand side are:

- **Agricultural commodity prices**: crop prices are influenced by weather variations and by changes in production volumes and stock levels. This in turn determines the incentive that farmers have in increasing fertilizer for the next harvest.
- **Fertilizer subsidies**: in certain markets such as India, fertilizer demand is highly sensitive to the level of subsidies provided by the government. Future demand growth will continue to depend in part on future policy changes.
- **Productivity and efficiency improvements**: Mature markets tend to enjoy higher returns on their use of fertilizer. This is the result of crop management practices adapted and fine-tuned to local conditions over several decades. Emerging markets on the other hand may lag behind in terms of technical knowledge, implementation of best practice, or both. This may lead to rates of potash fertilizer that may be above or below their optimal level. As farmers in emerging markets become more sophisticated, potash consumption could have upside or downside risks depending on the region and crop type.
- **Organic substitutes**: environmental concerns regarding the excess use of chemical fertilizers are likely to increase over time in certain regions. This may drive the search for substitutes in the form of manure, human/animal/industrial waste and other sources of organic nutrients.

The key risks on the supply side are:

- **Future investment in potash production**: the growth in potash production capacity, and therefore the level of capacity utilization during our forecast period, will depend on the rate of capital investment by mining companies. High barriers to entry and a large universe of investment opportunities in the resources sector (e.g. copper, iron ore, metallurgical coal, etc.) have contributed to relatively low levels of capacity growth to date. However, future capacity growth may outpace global demand growth as new entrants establish a foothold in the potash industry. Conversely, the current pipeline of growth projects may underperform relative to our estimates, leading to a tighter market and higher prices. We note that most growth projects are at a relatively early stage, and the potash industry as a whole suffers from a lack of recent experience in large project execution.

Appendix: Potash 101

Potash is a relatively unknown commodity in the natural resources sector. In this appendix we provide a brief overview of the production process, and we also provide additional background on fertilizers.

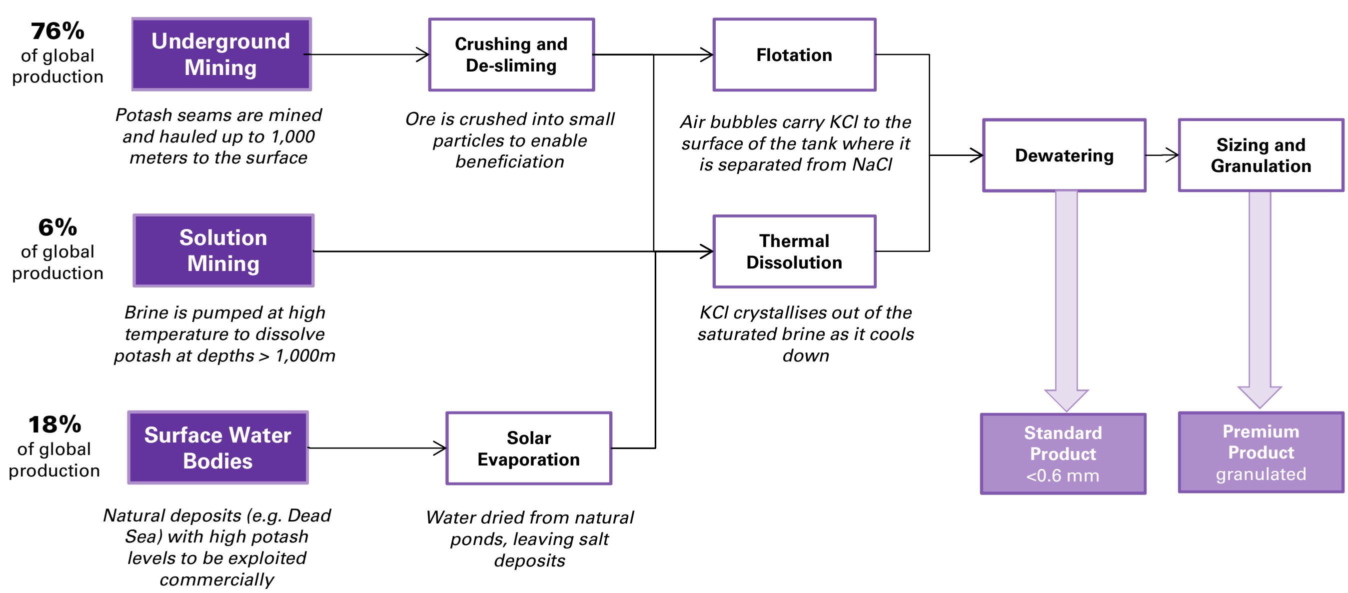
Potash mining and beneficiation

Underground mining is the primary method of extracting potash ore, accounting for 76% of 2012 production (Exhibit 46). The mine depth typically ranges between 400 and 1,000 meters, and conventional mining methods such as continuous miners and longwalls are used. The ore is transported in conveyor belts from the mine face to the bottom of the shaft, from where it is hauled to the surface for processing.

Solution mining is an alternative method used in cases where the deposit is buried at depths greater than 1,000 meters and conventional mining is not practical. Brine is injected at high temperature as a way to dissolve the potash salt. The brine is then pumped back to the surface where the potash can be recovered in ponds. Solution mining accounts for 6% of global potash production and is mainly used in Canada and the US.

In a few cases, potash deposits are accessible at ground level in the form of **surface water bodies** (e.g. saline aquifers or inland seas). In that case, the brine is pumped into evaporation ponds where the potash salts can be harvested. This production method accounts for 18% of global potash production, mainly from the Dead Sea, with smaller volumes in China, Chile and the US.

Exhibit 46: Potash production chain
Potash mining and processing flow



Source: Company data, Goldman Sachs Global ECS Research estimates

The raw potash ore typically has a KCl content of approximately 35%, and it is usually crushed into small particles to facilitate the separation of the different minerals (however, the potash industry reports ore grades in terms of K_2O content, with typical grades around 23%). There are several alternative methods to beneficiate potash ore. The most common is the flotation process, where the ore is placed in tanks where air bubbles stick to KCl particles and carry them to the surface where they can be collected, while the residues sink to the bottom. Alternatively, the ore can be dissolved in brine at high temperature (~110°C). The solubility of KCl and NaCl varies at different temperatures, and as the brine cools down the potash crystallizes and is filtered out of the solution. Other beneficiation methods include electrostatic separation and heavy media separation but their use is less widespread.

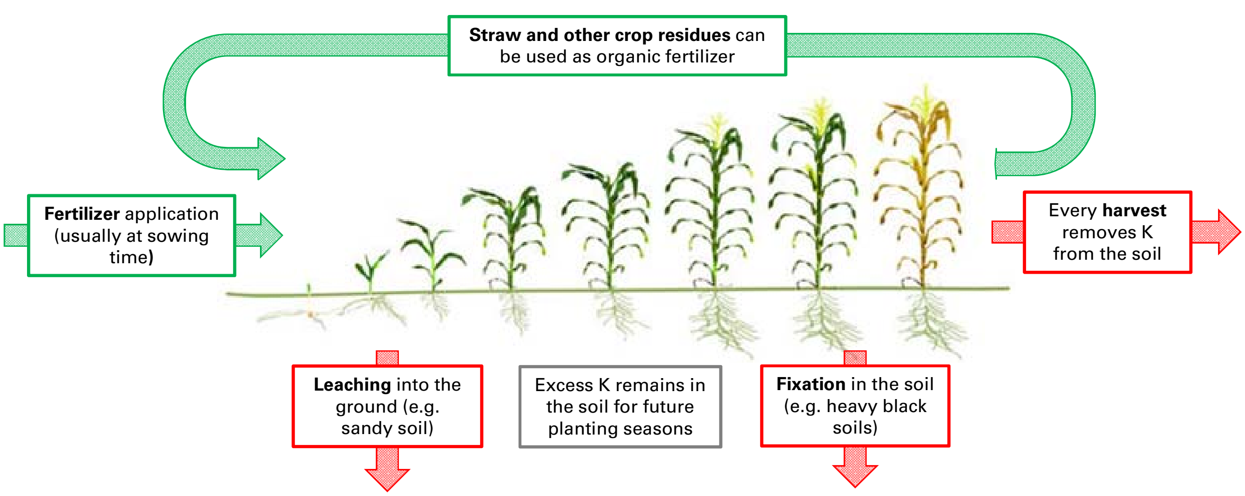
The final product is a fine powder that is either pink or white, depending on the beneficiation process. This standard product can be granulated into a premium product for ease of handling an application.

An introduction to potash fertilizers

Fertilizers are the primary end use of potash, accounting for approximately 90% of global demand. Potash fertilizer is usually applied during sowing, but in certain soil types a second application is necessary to ensure a steady supply of K to the crop. The amount of potash required depends on a range of factors, including the soil type, the amount of K already present in the soil and the amount of recycling of organic residue (Exhibit 47). Potash brings the following benefits to crops:

- **Growth**: potash helps regulate the metabolism of crops and it enhances the absorption of other nutrients, improving the efficiency of N and P fertilizers.
- **Yield**: potash increases the tolerance to drought and frost, thereby reducing potential crop losses.
- **Quality**: potash can lead to higher protein and vitamin content in crops and bigger size of fruits, thereby increasing the commercial value of the crop.

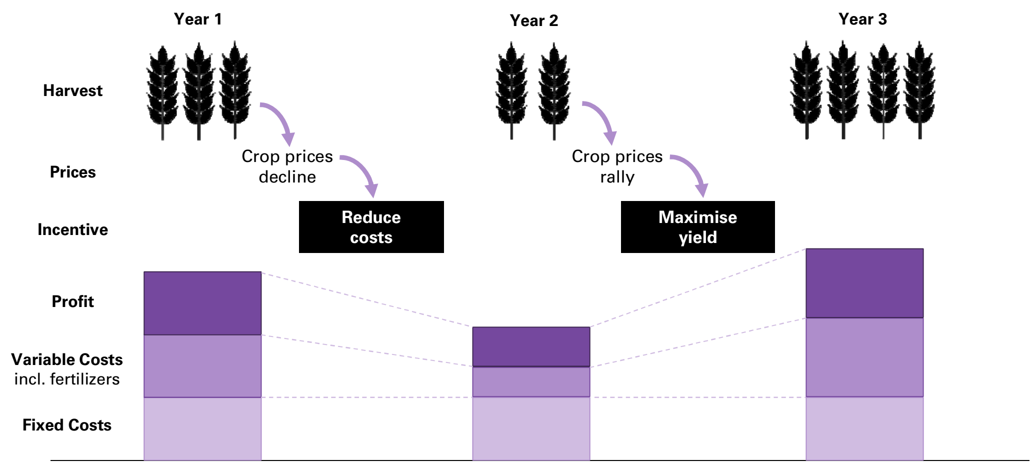
Exhibit 47: Potash use in crops
Potash balance in the crop lifecycle



Source: Goldman Sachs Global ECS Research

In the short run, fertilizer demand from commercial farms depends in part on crop prices (Exhibit 48). When crop stocks are high and prices for agricultural commodities are low, farmers will be incentivized to reduce costs. When the cycle moves and crop prices are high (e.g. following a poor harvest), farmers will be incentivized to maximize production, partly via the greater use of fertilizer.

Exhibit 48: Fertilizer demand is sensitive to crop prices
The crop cycle and its impact on farmer incentives and fertilizer use



Source: Goldman Sachs Global ECS Research

The amount of potash fertilizer also depends on the type of crop (Exhibit 49). For example, cereals tend to have a lower requirement for potash than some higher value crops such as fruits and vegetables.

Exhibit 49: Fertilizer use varies by crops
Indicative nutrient requirements by crop type – in kg of nutrient per hectare

		Nutrients - kg/ha					
	Yield	Contained in harvested crop			Required from chemical fertilizers		
	t/ha	N	P	K	N	P	K
Corn	6	120	50	120	120	60	60
Rice	5	110	34	156	120	60	60
Wheat	6	170	75	175	120	60	60
Potato	40	175	80	310	150	60	150

Source: International Potash Institute

Other end uses of potash

Industrial demand for potash accounts for approximately 10% of global demand. It comes from a wide range of applications, including: aluminium recycling, mud for oil-well drilling, water softening and several chemical compounds used in downstream applications from cement to soap manufacturing.

Disclosure Appendix

Reg AC

We, Christian Lelong, Damien Courvalin and Jeffrey Currie, hereby certify that all of the views expressed in this report accurately reflect our personal views, which have not been influenced by considerations of the firm's business or client relationships.

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