BOARD OF INVESTMENTS PHILIPPINES

DEPARTMENT OF TRADE & INDUSTRY PHILIPPINES

USAID FROM THE AMERICAN PEOPLE

RTI INTERNATIONAL

THE PHILIPPINES

CHEMICAL GLOBAL VALUE CHAIN

MAY 2016

Duke CENTER on GLOBALIZATION, GOVERNANCE & COMPETITIVENESS at the Social Science Research Institute

This research was prepared by the Duke University Center on Globalization, Governance and Competitiveness (Duke CGGC) on behalf of the USAID/Philippines, through the Science, Technology, Research and Innovation for Development (STRIDE) Program. This study is part of the Philippines Department of Trade and Industry (DTI) Board of Investment (BOI) Roadmap Initiative for the revitalization of the manufacturing industry in the Philippines. The report is based on both primary and secondary information sources. In addition to interviews with firms operating in the sector and supporting institutions, the report draws on secondary research and information sources. The project report is available at www.cggc.duke.edu.

Acknowledgements
Duke CGGC would like to thank all of the interviewees, who gave generously of their time and expertise, as well as Richard Umali of the USAID Advancing Philippine Competitiveness (COMPETE) Project for his extensive support and feedback on earlier drafts.

The Duke University Center on Globalization, Governance & Competitiveness undertakes client-sponsored research that addresses economic and social development issues for governments, foundations and international organizations. We do this principally by utilizing the global value chain (GVC) framework, created by Founding Director Gary Gereffi, and supplemented by other analytical tools. As a university-based research center, we address clients' real world questions with transparency and rigor.

www.cggc.duke.edu

The Philippines in the Chemical Global Value Chain

FINAL DRAFT FOR REVIEW

May 2016

Prepared by

Penny Bamber, Stacey Frederick and Gary Gereffi
Center on Globalization, Governance & Competitiveness,
Duke University

Prepared for

USAID/Philippines

This study is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of Duke University CGGC and do not necessarily reflect the views of USAID or the United States Government.

Table of Contents

Executive Summary iv
1. Introduction 10
2. The Chemical Global Value Chain 11
2.1. Mapping the Chemical Global Value Chain 14
2.2. Global Trade in the Chemicals GVC 19
2.3. Industrial Organization of the Chemicals GVC 25
2.4. Standards and Institutions 29
2.5. Human Capital and Workforce Development 31
2.6. Upgrading Trajectories 33
3. Lessons on Upgrading from Malaysia and Singapore 37
3.1. Malaysia: Functional Upgrading in Oleochemicals 37
3.2. Singapore Upgrading from Commodities Chemicals to Intermediate and Specialty Products 40
4. The Philippines and the Chemical Global Value Chain 43
4.1. The Development of the Chemicals Industry in the Philippines 43
4.2. Philippine Current Participation in the Chemical Global Value Chain 44
4.3. Philippine Upgrading in the Chemicals GVC 52
4.4. The Philippine Chemicals Workforce 54
4.5. Advantages and Disadvantages for GVC Participation and Upgrading 55
4.5.1. Advantages 55
4.5.2. Challenges 57
4.6. Potential Upgrading Trajectories 62
5. References 66
6. Appendix 73

List of Tables

Table E-1. Upgrading Trajectories for the Philippines in the Chemical GVC ix
Table 1. Major End Markets for Four Primary Commodity Chemical Groups 18
Table 2. World Chemical Exports by Value Chain Stage and Segment, 2007-2014 20
Table 3. Top 10 Chemicals Importers, 2007-2014 21
Table 4. Leading Chemicals Exporters, All Value Chain Stages, 2007-2014 21
Table 5. Top Ten Commodity Chemicals Exporters by Value, 2007-2014 22
Table 6. Asia Regional Chemicals Trade, 2007-2014 24
Table 7. Top 10 Specialty Chemicals & Final Products Exporters in 2014, 2007-2014 24
Table 8. Top 10 Firms in the Chemical Industry, By Revenue 2014 27
Table 9. Leading Vertically-Integrated Oleochemical Producers 28
Table 10. Employee Profile for the Chemicals GVC 32
Table 11. Upgrading Trajectories in the Chemical GVC 33
Table 12. The Philippine Chemical Exports by GVC Stage, 2007-2014 45
Table 13. The Philippine Top 10 Chemical Export Products, 2014, by Value 46
Table 14. Principal Oleochemicals Exporters in Philippines, 2014 48
Table 15. Petrochemical Firms in the Philippines, 2014 49
Table 16. Top Ten Philippine Chemical Export Destinations, All Products, 2007-2014 51
Table 17. Leading Destinations for Top Five Product Group Exports, 2014 52
Table 18. Select Examples of Upgrading in the Chemicals GVC, Philippines 53

Table 19. SWOT Analysis of the Philippines Chemical Industry........ 56
Table 20. Key Industry Stakeholders in the Philippines........ 61

List of Figures

Figure E-1. The Philippine Participation in the Chemicals GVC vii
Figure 1. Evolution of the Price of Oil & Gas, 2010-2015 13
Figure 2. The Chemical Global Value Chain 15
Figure 3. Average Price of Crude Palm Oil, Crude Palm Kernel Oil, Coconut Oil, Fatty Alcohol, Fatty Acid and Refined Glycerine, 2007-2015 35
Figure 4. The Philippines Participation in the Chemicals GVC........ 47

List of Boxes

Box 1. Activated Carbon: Growing Importance of a Green Intermediate........ 16
Box 2. End-Markets in the Chemical Global Value Chain 18
Box 3. The Changing Dynamics of the Global Polyethylene Sector........ 23
Box 4. Emery Oleochemicals: Upgrading into Specialty Chemicals........ 40
Box 5. Pacific Paint (Boysen): Functional & Product Upgrading 54
Box 6. Regional and Industry Nuances for Marketing Green Products 64

Acronyms

AOMG	ASEAN Oleochemicals Manufacturing Group
APMP	Association of Petrochemical Manufacturers of the Philippines
ASEAN	Association of Southeast Asian Nations
ASTAR	Agency for Science and Technology Research, Singapore
BCG	Boston Consulting Group
BOI	Board of Investments
CAGR	Compound Annual Growth Rate
CEFIC	European Chemical Industry Council
CHED	Commission on Higher Education
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CMP	Chemical Management Plan
DENR	Department of Environment and Natural Resources
DTI	Department of Trade and Industry
EDB	Economic Development Board, Singapore
EMB	Environmental Management Bureau
EFSA	European Food Safety Authority
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHS	Globally Harmonized System
GVC	Global Value Chains
HDPE	High Density Polyethylene
ICCA	International Council of Chemical Associations
ICES	Institute of Chemical and Engineering Sciences (Singapore)
ISO	International Standards Organization
LDPE	Low Density Polyethylene
LNG	Liquid Natural Gas
LPG	Liquid Petroleum Gas
MIDA	Malaysian Investment Development Authority
MNC	Multi-national corporation
OHSAS	Occupational Health and Safety Management Systems
P&G	Procter and Gamble
PE	Polyethylene
PEZA	Philippine Economic Zone Authority
POP	Persistent Organic Pollutants
PP	Polypropylene
PPI	Philippine Polypropylene Inc.
PS	Polystyrene
PSIC	Philippine Standard Industrial Classification
PVC	Polyvinylchloride
R&D	Research and Development
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RSPO	Roundtable on Sustainable Palm Oil
SME	Small-Medium Sized Enterprise
SOCC	Sakamoto Orient Chemicals Corporation
SPIK	Chemical Industry Association of the Philippines
STEM	Science, Technology, Engineering and Mathematics
TSCA	Toxic Substance Control Act, United States
UK	United Kingdom
US	United States

Executive Summary

This report uses the Duke CGGC global value chain (GVC) framework to examine the role of the Philippines in the global chemical industry and identify opportunities for the country to upgrade. The Philippine chemicals sector is growing rapidly alongside economic expansion and a revival in manufacturing. By 2013, the chemicals sector as a whole accounted for 6.7% of GDP. Chemicals exports reached US$2.2 billion in 2014, approximately 3.5% of the country's export basket. The sector's expansion has outpaced both global and regional trade; with a compound annual growth rate of 13% since 2007, three times as fast as global exports, and twice as fast as Asian regional exports. Participation in the export market is based primarily on commodity products in the oleochemicals and petrochemicals sub-sectors. Within these segments, exports are driven by a small number of products, with the top 10 accounting for approximately three-quarters of all exports. While the country is a small player in the global chemicals trade, accounting for just 0.2% of exports in 2014, it has generally been successful in carving out a presence in these niche products, and is one of the global leaders in most of its top product categories.

Chemicals Global Value Chain

The global chemicals market has grown rapidly over the past three decades. By 2014, it was valued at US$4.2 trillion. Trade in the sector also increased significantly during a similar time period, reaching US$1.3 trillion by 2014. The sector draws from a number of raw materials, including oil and gas, bio-based products, and minerals; applying a divergent range of manufacturing processes; and contributing to a very wide range of industries and end markets, from agriculture to construction and consumer products. Estimates suggest there are as many as 100,000 different chemicals being produced today. Key characteristics of the chemical GVC today include:

- **The chemical GVC is essentially comprised of a large number of varied and intersecting value chains**. For simplicity, this report divides the chain into five main segments: feedstock provision, breaking down of feedstock into basic chemicals together with the production of commodity chemicals, the production of intermediate chemicals, the production of specialty chemicals, followed by marketing, sales, and distribution into key end markets.

- **Demand and supply have shifted from traditional markets to emerging regions, including Asia-Pacific.** As a result of the close link between chemical consumption, manufacturing and economic growth, the sector has seen a shift in demand towards growth economies, in general, and the Asia-Pacific region, in particular. "Factory Asia", together with construction booms and a growing demand for a host of consumer products, has fostered strong demand for chemicals in the region. Faced with the need to expand capacity to meet growing global demand, together with high shipping costs, chemical producers have opted to relocate their production facilities in this region closer to the source of demand.

- **Capital intensity, technology development, and significant regulatory challenges create important barriers to entry and affect the number of firms in each stage.** Important differences in the business models required for the different stages of the chain result in a distinct power structure. While upstream segments are capital intensive and dependent on economies of scale, the technologies are generally considered to be mature and available on the market. Downstream segments are smaller, far less capital intensive, but research and development is central to success. As a result, upstream segments are affected by occasional large capacity additions, while growth in the specialties segment is more incremental.

- **Upstream chemicals have become highly commoditized and are at risk of over-capacity dampening prices.** Aggressive expansion of petrochemical feedstocks in the United States (US) as a result of the expansion of "fracking" technologies and capacity expansion of related upstream chemicals in both the US and Asia has led to the upstream stages of the chain becoming increasingly characterized by tight margins and potential over-capacity. This makes it difficult for new entrants in the short to mid-term, particularly if there is a fall in global demand. Likewise, strong expansion has been seen in the oleochemicals sector as a result of capacity growth in Malaysia and Indonesia.

- **Global lead firms are focusing on specialty chemicals where margins are higher and require more product development.** Vertically integrated lead firms such as BASF, Dow, and Dupont have been amongst the most powerful in the industry for decades. However, the growth of large, competitive commodities operators in upstream segments, focused on a very small range of related products, has contributed to a shift in strategy for these firms, which are focusing more on specialty products for specific end markets to ensure their profitability. In this segment, there is growing demand for more environmentally sustainable and non-toxic chemicals, as well as those that provide solutions to environmental challenges, such as air and water pollution. This shift towards sustainability has helped to drive the growth of the global oleochemicals market as well as provided an opportunity for increased innovation and production in the field of specialty chemicals.

The Philippines in the Chemicals Global Value Chain

The Philippines participates primarily in the oleochemicals and petrochemicals sub-sectors, with a focus on commodity products, with petrochemicals referring to chemicals derived from oil & gas products and oleochemicals describing those created from bio-based plant and animal materials. In 2014, 69% of the Philippines chemical exports were basic/commodity chemicals, compared to just 15% intermediates, and 14% in specialty chemicals and final products. Exports are driven by a small number of products, with the top 10 accounting for approximately three-quarters of all exports. These products include glycerine and fatty alcohol, based on its older coco-oleochemicals operations, as well as new products such as aromatic petrochemicals and nickel-cobalt sulphide. The oleochemical and petrochemical sub-sectors have the highest value addition, as both operate in several stages of the chain, from input supply, through to semi-processed or processed products.

Exports from the Philippines, and its participation in the chemicals GVC, have been recent, with most progress occurring since the mid-1980s. This growth can be broken down into three distinct areas: (1) oleochemicals, (2) petrochemicals and, finally (3) forays into a variety of basic, intermediate, specialty and final products.

1. The Philippines longest standing participation in the chemicals GVC has been in the oleochemicals sub-sector. Once a global leader, the industry is under threat from more competitive vertically integrated firms in Malaysia and Indonesia. Three firms have closed down their operations since 2010. Nine firms continue to produce a range of coconut-based oleochemicals, although primary exports are in glycerine.

2. The petrochemicals sector developed at the end of the 1990s, with almost all major firms focused on the production of plastic resins. The overarching goal has been to satisfy the domestic demand first before contributing to exports. The sector today comprises seven manufacturers of polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC), as well as two cracker plants (Liquid petroleum gas (LPG) and naphtha), which provide feedstock.

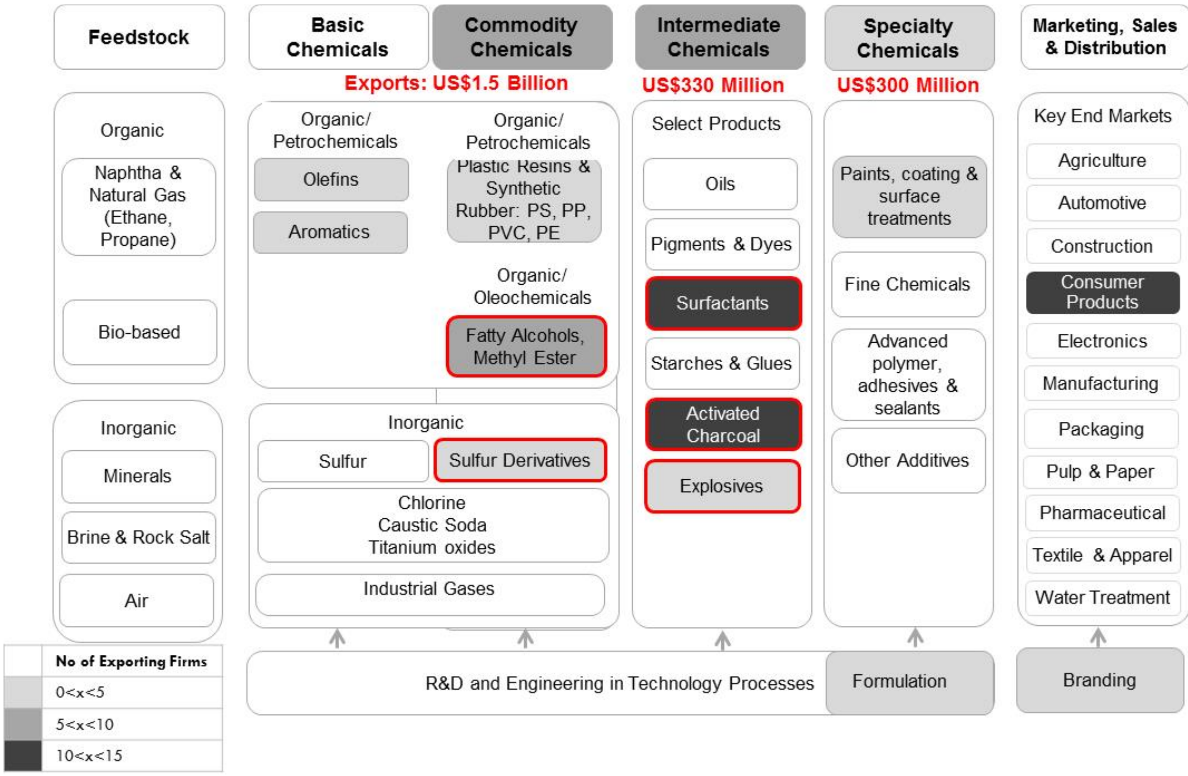
3. Very incipient entry into basic inorganic, intermediate and specialty products by a small number of firms. There is relatively little cohesiveness to this latest evolution and products fall into a range of different value chain stages and are directed to different end markets.

The composition of firms engaged in exports from the Philippines is reflective of the global sector. There are relatively few firms in the major export categories and these firms are concentrated in a small number of products, with very little overlap across segments. The specialty and final products segment is more varied, with a higher number of firms. In general, firm origin is mixed in all product categories, with numerous foreign firms investing alongside more established local firms in recent years.

The Philippine exports primarily serve regional value chains in Asia-Pacific. Export destinations are becoming more concentrated with the top 10 destinations accounting for 86% in 2014, compared to 74% in 2007. Japan continues to be the Philippines most important chemicals trading partner, although China is quickly gaining relevance. By 2014, these two markets accounted for 58% of all chemicals exports.

Figure E-1 highlights the Philippine entry into the chemical GVC to date. No shading indicates no participation in the sector. Grey shading represents the number of firms in the segment. Red/dark outlines indicate that the Philippines is a top ten global exporter in the specific product category.

Figure E-1. The Philippines Participation in the Chemical GVC



Source: Authors; Data from PSA (2007-2014), UN Comtrade (2015).

Installed capacity and past sector expertise are two key factors supporting industry competitiveness for upgrading in the chemical GVC. In addition, new initiatives regarding industrial policy formulation for the industry are also contributing to improved positioning of the country.

- **Installed Capacity in a Strategic Geographic Location**: The installed idle capacity in both oleochemicals and petrochemicals sub-sectors offers an advantage to rapidly ramp up production for local and regional markets. This can be relatively easily tapped to respond to increased demand for consumer and construction markets in the Asia-Pacific region.

- **Human Capital and Sector Expertise:** Low-cost and skilled human capital and expertise in certain segments provides the sector with an important asset. This can be focused for more knowledge-intensive roles in the industry, although turnover is high, and there are gaps between the needs of the export-oriented sub-sectors and the degree of preparation of graduates.

- **Supportive Environment for Industry Policy Development:** Recent initiatives have contributed to a more collaborative environment for industry policy development in the chemicals sector. This has been driven by a number of programs put in place by the DTI-Board of Investments through the Industry Development Program and the Manufacturing Resurgence Program. Several chemical sub-sectors were prioritized for investment incentives between 2014 and 2016, including oleochemicals and petrochemicals.

A number of entrenched constraints must be overcome in order to fully leverage these strengths, including strengthening backward linkages, streamlining regulation and standardization, including that of intellectual property protection and infrastructure services. In addition, certain global dynamics threaten specific subsectors. These threats should be considered in policy formulation.

- **Limited local feedstock supply and poor backward linkages.** The petrochemicals sub-sector must rely on foreign naphtha and LPG imports, while the oleochemicals sector has weak linkages to upstream coconut supply. Likewise in the inorganics segment, the production is entirely isolated from the rest of the chemicals industry. This lack of linkages undermines the country's potential to achieve the economies of scale that have generated success in neighboring countries.

- **Regulation and Standardization:** Efforts are underway to align chemical regulation in the Philippines with global best practices to support trade while protecting health, safety and the environment. Key problematic areas under review include a highly restrictive controlled substance regime, and the lack of local standards for chemicals allows for some degree of mislabeling, misclassification, and underreporting of imports and exports.

- **Cost and Availability of Necessary Infrastructure and Services:** Energy, transportation and storage infrastructure and related services constrain sector development and are likely to become more challenging as the economy grows. Low frequency international shipping, port congestion and high domestic shipping costs mean that logistics costs account for up to 53% of wholesale prices in the Philippines compared to less than 20% in other countries in the region, including Malaysia and Indonesia (World Bank, 2015). These constraints contribute to weak backward linkages in the sector, as raw materials tend to be located in different islands from processing capacity.

- **Intellectual Property (IP) Protection:** The Philippines has made impressive gains in improving its IP protection framework in recent years, but the country needs to overcome its poor reputation in this area before foreign companies will be willing to locate sensitive technologies and product operations within its borders. The country was only removed from the US Special 301 Watchlist in 2014 after 22 years (United States Trade Representative, 2014).

- **Substitutes in Oleochemicals**: Coconut oil is at risk of being substituted almost completely in the production of oleochemicals. Palm kernel oil fatty acids are becoming an economic alternative to coconut oil fatty acids, as the composition ranges of the fatty acids are very close. The Philippines is further losing its lead as the supplier of "sustainable" oleochemicals as vertically integrated regional producers steadily obtain Roundtable for Sustainable Palm Oil certification.

- **Global and Regional Overcapacity and Softening Demand:** Rising global and regional capacity in commodities chemicals – in both the oleochemicals and petrochemicals sub-sectors have combined with slowing economic growth to contribute to a potential overcapacity problem in the region. Nonetheless, supply continued to increase in the region in early 2016.

The potential upgrading trajectories recommended in this report focus on building upon comparative advantages in raw materials, accumulated expertise, and growing downstream demand. Trajectories do not include upgrading related specifically to the petrochemicals commodities sub-sector. In the current global context of strong, low-cost petrochemicals production in the US, the Middle East as well as other countries in the region (e.g. China, Malaysia and Singapore), it is difficult to foresee a scenario in which the Philippines can compete in the polymer export market where efforts are not incorporated into indirect exports.

Table E-1. Upgrading Trajectories for the Philippines in the Chemical GVC

Time Frame	Potential Upgrading Trajectory	Key Benefits	Philippines Challenges
Short-term	**Process Upgrading: Improving Coconut Production as a Raw Material for Coco Oleochemicals and Activated Carbon**	• Strengthen backward linkages & local value-add • Secure raw materials supply for 2 areas: oleochemicals and activated carbon • Employment creation: poverty reduction benefits in undeveloped, rural regions	• Aging (40%), diseased (14%) and hurricane-damaged (10%) trees need replacing • Limited access to finance for small producers • Lack of knowledge amongst producers about new production techniques • High transaction costs due to widely dispersed and very small coconut producers
Short to Mid-term	**Process Upgrading: Adjust plants to process palm kernel oil for oleochemicals production**	• Improve competitiveness & sustainability of oleochemicals plants • Maintain employment	• Raw materials must be imported; potential port & logistical challenges • Limited access to capital to install new capacity
Short Term	**Product & Process Upgrading for Niche Markets**	• Diversify market risk, targeting higher value markets • Increased unit value for exports	• Limited knowledge of other markets • Strict regulatory requirements
Short to Medium Term	**Product & Process Upgrading in the Activated Carbon Sub-sector**	• Additional value-add to raw materials otherwise considered waste products • Diversify product offerings with potential synergies to other industries • Increased export revenue	• High logistics costs out of Mindanao • High energy costs • Limited access to affordable finance
Short Term	**Market Upgrading for Niche Green Products**	• Generate export revenue from existing products and R&D Generate higher unit value via exporting to premium markets	• Firms lack market information • No global recognition of the Philippines as a chemicals producer, green or otherwise • Skills gaps exist between university curricula and industry needs
Medium to Long Term	**Product Diversification in Basic Inorganic Chemicals**	• Value addition in natural resource extraction • Mid-term synergies for e-vehicle manufacturing	• Uncertainty in investment environment for long term, capital-intensive operations • Heavily bureaucratic (e.g. environmental permitting & indigenous community approval) • Transportation and energy supply
	Product Upgrading into New Intermediate and Specialty Chemicals	• Additional value generation from downstream products • Opportunity to leverage low cost commodity inputs • Leverage synergies with emerging manufacturing sector • Increase indirect exports & improve competitiveness of adjacent industries	• Downstream demand must continue to grow to drive necessary economies of scale • Skills gaps exist between university curriculum & industry needs • Inefficient monitoring of intellectual property • Oleos: Upstream competitive advantages have been eroded by lower availability of raw materials

Source: Duke CGGC.

1. Introduction

The chemicals sector in the Philippines is rapidly growing alongside economic expansion and a revival in manufacturing. By 2013, the chemicals sector as a whole accounted for 6.7% of the GDP (DTI, SPIK, & BOI, 2014). Chemicals exports reached US$2.2 billion in 2014, approximately 3.5% of the country's export basket. Export growth has outpaced both global and regional trade; with a compound annual growth rate of 13% since 2007, three times as fast as global exports, and twice as fast as Asian regional exports. Participation in the export market is based primarily on oleochemicals and petrochemicals sub-sectors. Within these, exports are driven by a small number of products, with the top ten accounting for approximately three quarters of all exports. While overall the country is a very small player in the global chemicals trade, accounting for just 0.2% of exports in 2014, it has generally been successful in carving out a presence in these niche products, and is one of the global leaders in most of its top product categories.

The geographic relocation of the global chemicals industry towards the Asia-Pacific region, combined with continuous growth, provides numerous opportunities for countries in the region, such as the Philippines, to enter and/or upgrade in the industry's Global Value Chain (GVC). Raw materials requirements, economies of scale and efficient energy and logistics infrastructure, nonetheless, are all necessary for competing in upstream operations where margins have been pushed down, technology is mature and widely available, and products are treated largely as commodities by buyers. The lack of raw materials and infrastructure, in particular, constrains the Philippines entry into the higher value petrochemicals operations of this chain, while logistics and costs constrain access to the lower value inorganic commodity operations. Mid- and downstream opportunities in the manufacture of product solutions, however, offers broader access, but requires an emphasis on qualified human capital, improved intellectual property protection and a focus on sales and marketing.

This report uses the GVC framework to analyze the Philippines' current position and potential for upgrading in the chemical value chain. GVC analysis examines the full range of activities that firms and workers around the world perform to bring a product from conception through production and end use. As part of this analysis, multiple factors are considered: trade patterns, end markets, product characteristics, technology-intensity, labor, standards, and regulations, among others. This information is analyzed from a global perspective and from the viewpoint of the Philippines in order to provide a holistic picture of the situation when identifying trajectories for entry, growth, and upgrading along that chain.

This report is structured as follows: First, it analyzes the global industry, including an extended discussion on the key segments of the chain and how important stakeholders in the chain interact as well as the evolution of critical trends at the global, regional, and national levels. The report continues by analyzing the Philippines presence in the industry before concluding with potential upgrading trajectories for the country as well as recommendations to assist these efforts.

2. The Chemical Global Value Chain

The global chemicals market has grown rapidly over the past three decades. By 2014, it was valued at US$4.2 trillion (Marketline Global Chemicals, 2015). Trade in the sector has also increased significantly during a similar time period, reaching US$1.3 trillion by 2014 (UNComtrade, 2015a). The sector draws from a number of raw materials bases, applying a divergent range of manufacturing processes and contributing to a very wide range of industries and end markets (Bassett & Gardner, 2010). Estimates suggest there are as many as 100,000 different chemicals being produced today.

In order to simplify this complex industry, industry stakeholders categorize chemical products in a number of different ways. This can include classification by chemical properties, production styles, functions and intended end markets. These categorizations often overlap (Pflug, 2013). This report uses the relatively widely used categorization which divides chemicals into two broad groups: basic chemicals & commodities, and specialty chemicals (Kiriyama, 2010; Marketline, 2015a). This categorization is useful when applying the GVC analysis to the sector, as these two groups are generally dominated by different firms with distinct business models. Commodities encompass products in the upstream stages of the chain, while specialty chemicals are downstream products.

- *Basic & commodity chemicals*: These are undifferentiated chemicals, sold in bulk and generally require a limited number of processing stages to produce. Chemicals in this category include both organic chemicals, such as plastic resins and synthetic rubber, and inorganic materials such as chlor-alkli, as well as industrial gases such as hydrogen and nitrogen. This is the largest product segment by revenue.

- *Specialty chemicals*: These products are differentiated, typically requiring multiple processing stages and drawing on commodity chemicals as inputs. They are comparatively higher-value products, and their production is typically characterized by high mix/low volume business models. Many of these products, which are often referred to as product solutions by firms, are final products destined to end-users, such as paint, adhesives, and inks. Specialty chemicals as a whole accounted for 21% of the global chemical market.

These categories, of course, are dynamic and specialty chemicals can eventually become commoditized (Kiriyama, 2010) as the product cycle evolves.[1] A third category can thus be included, referred to as intermediate chemicals. Intermediate products are further processed commodities and are generally used in the production of specialty products.[2]

[1] For example, pigments and dyestuff have become increasingly commoditized, with firm size increasing and the market consolidating as volumes grew (Bamfield, 2001).

[2] In addition, two other important groups are often distinguished in industry analyses from an end market perspective: agriculture and pharmaceutical products. These are occasionally categorized together as "life sciences" products (e.g. Bayer Life Sciences). Agricultural chemicals include herbicides, pesticides and fertilizers, while pharmaceutical chemicals are active ingredients used in the production of medications. These products, which tend to be specialized and do not have a high degree of overlap with the rest of the industry, are not included in the scope of the analysis, except where they intersect with the commodities and specialties chemicals.

As a whole, the industry is cyclical and affected by upstream commodity inputs, availability of production capacity, and downstream demand. Input prices are dominated by oil and gas, and thus are subject to high degrees of volatility. Upstream stages of the industry have been characterized by capital and energy intensity and dominated by larger, centralized production driven by the need for economies of scale (Badunenko, 2008; PwC, 2011). Downstream segments vary, but specialty producers tend to be smaller and focused on a narrow range of products. As a key supplier for a broad range of manufacturing industries, chemical demand tends to follow economic cycles (Deloitte, 2011).

Although the chemicals industry is considered to be mature, several important trends have emerged over the past decade that have reshaped the industry. These include (1) the shift of demand—and thus supply—from developed countries to developing regions as global manufacturing has relocated and economic growth has boosted demand for consumer goods; (2) an increased demand for more sustainable products; (3) increased regulation as consumers and regulators alike become more aware of the impact of chemicals on health, safety and the environment; and (4) extreme changes in the price of feedstocks, resulting in the global redistribution of chemicals production. These trends are discussed in further detail below.

1. **Shift in Demand and Supply to Emerging Regions, including Asia-Pacific and the Middle East**. As a result of the close link between chemical consumption, manufacturing and economic growth, the sector has seen a shift in demand towards growth economies, in general, and the Asia-Pacific region, in particular (Marketline, 2015a). This has occurred in all major sub-sectors, including petrochemicals and oleochemicals (Intarajang, 2011; Spitz, 2003). Factory Asia, together with construction booms and a growing demand for a host of consumer products, have fostered strong demand for chemicals in the region (KPMG, 2015a, 2015b). Faced with the need to expand capacity to meet growing global demand, together with high shipping costs, chemical producers have opted to relocate their production facilities closer to the source of demand. For example, emerging market sales at BASF, the world's largest chemical producer, reached 34% of its business in 2015, and the company intends to spend 25% of its capital expenditure in those markets over the next five years (BASF, 2015). While many plants have been established in Asia, the Middle East has also benefitted from this shift given its proximity to these markets and its supply of petrochemical feedstock.[3]

2. **Increased Demand for Non-Toxic, Environmentally Sustainable Chemicals:** Over the past 10 years, there has been increased interest from consumers, firms and governments for non-toxic, environmentally friendly products (Deloitte, 2011; Intarajang, 2011; PwC, 2010; TechNavio, 2014). At the same time, there is emerging demand for products that can help to reduce the impact of pollution (Innovest, 2007; Ravenscroft, 2016). For example, water treatment chemicals have become particularly important given high levels of contamination in countries such as China (Innovest, 2007; Markets and Markets, 2014). Bioplastics, biodegradable plastics from renewable sources, are another set of products in which strong demand is being seen and is expected to reach almost 20% per annum for the next six years (Baker, 2013), as large global buyers such as Coca Cola and

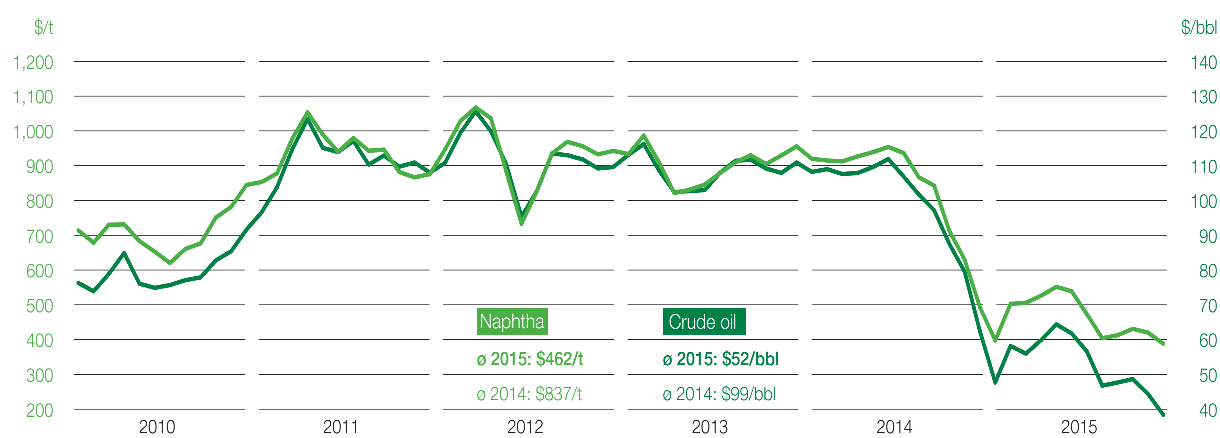
[3] This includes the Sadara joint venture between Dow Chemicals and Saudi Aramco (Baker, 2015; Dow, 2015a).

Pepsi make a shift towards more sustainable bottles (Coca-Cola, 2016; Pepsico, 2016). Similarly, green solvents derived from various agricultural sources, such as corn, sugarcane, lactic acid, refined glycerine, bio succinic acid, and vegetable oils have also seen strong growth (Coatings World, 2015a). This shift towards more environmentally sustainable goods has helped to drive the growth of the global oleochemicals market, which draws on renewable plant and animal raw materials (Frost & Sullivan, 2014).

3. **Increased Regulation:** Since 2006, there has been a significant change in the global regulatory environment of the chemicals industry (Kiriyama, 2010). While several multilateral treaties laid the groundwork for regulation in the late 1990s and early 2000s, several major markets, including Canada, China, and Japan and regional blocks such as the EU, began to implement new regulations in 2006. This has been partly driven by growing awareness of health and safety implications of exposure to chemical products (see above), and in part because of increased concerns about terrorism and the use of chemical weapons. These regulations have increased the costs of the production of new chemicals, which must be tested for their potential hazards before they can be registered for sale. Critics argue that this has slowed the development of new chemicals; findings of a recent impact assessment note that half of firms transferred their R&D budgets to compliance activities (European Commission, 2015).

4. **Volatility in the Price of Raw Material Feedstocks, Resulting in Redistribution of Global Chemical Production**: Since the mid-2000s, the US has significantly increased its production of natural gas feedstock as a result of the introduction of new technologies (i.e. fracking). The development of ethane gas supply has rapidly contributed to an overall reduction in the price of petrochemical feedstocks for the sector (Swift, 2012). The Brent oil prices in 2015 were 47% lower on average as compared to 2014 (BASF, 2015). The naphtha feedstocks (derived from oil) sold on average at US$837 per metric ton in 2014, but only US$462 in 2015, finishing the year at under US$400 (BASF, 2015). Figure 1 provides an illustration of this trend, and these prices continued to fall in early 2016.

Figure 1. Evolution of the Price of Oil & Gas, 2010-2015



Source: BASF (2015).

As process technologies for cracking natural gas are cheaper than cracking naphtha, and prices for the feedstock are lower, the US petrochemicals sector has reversed its misfortunes of the turn of the century (Spitz, 2003) to once again become a highly competitive petrochemicals producer (S&P Capital IQ, 2015; Swift, 2012). Most of the petrochemicals in the US are produced from natural gas, compared to Europe (and the Philippines) which are naphtha based (Field Research, 2016; S&P Capital IQ, 2015). The average price of gas in the US in 2015 was just 20% of the price in China (BASF, 2015). These changes have resulted in aggressive expansion plans by the leading petrochemicals producers—BASF, Chevron Phillips, Dow, Dupont, Shin-Etsu and LyondellBasel Industries, have all either brought on new ethylene operations or announced investment plans since 2015.[4]

2.1. Mapping the Chemical Global Value Chain

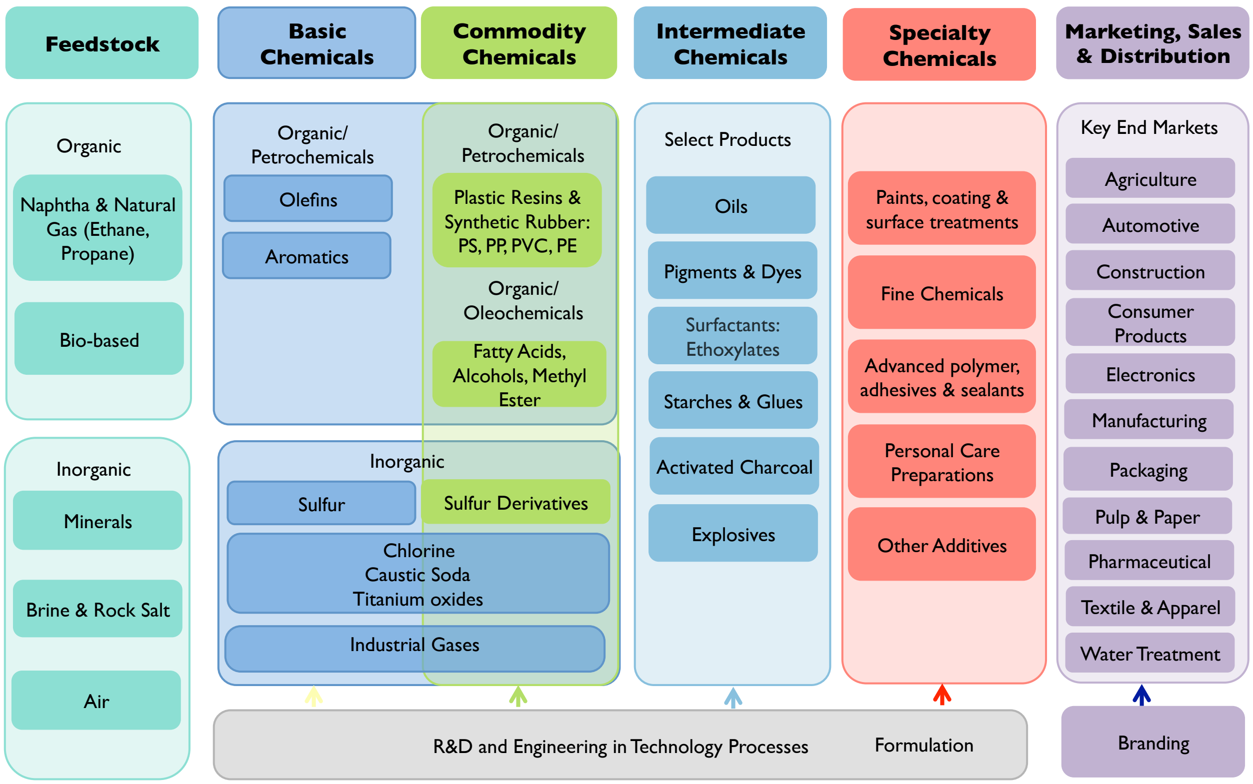
Due to the wide variety of feedstocks, processes and end markets used in the industry, the chemical GVC is essentially comprised of a large number of varied and intersecting value chains. To date, limited comprehensive GVC analyses of the industry have been undertaken[5]—this report thus provides a first approximation to understanding the complex industry using the methodology. For simplicity, the chain can be divided into five main segments: feedstock provision, breaking down of feedstock into basic chemicals together with the production of commodity chemicals,[6] the production of intermediate chemicals, the production of specialty chemicals, followed by marketing, sales, and distribution into key end markets. Figure 2 provides a simplified illustration of the overall chemicals GVC.

Feedstock: There are several sources of raw materials for the chemicals industry. *Organic chemical inputs* include oil & gas, coal and bio-based products. Of these, oil & gas account for the largest share, with 95% of all feedstocks (Innovest, 2007). Chemicals derived from oil & gas products are referred to as *petrochemicals* and those from bio-based plant and animal materials are *oleochemcials*. The leading source of oleochemical feedstock is palm kernel oil and coconut oil, although tallow (animal fat) is also used in some markets (Frost & Sullivan, 2014; Yoyo, Daryanto, Gumbira-Sa'id, & Hasan, 2014). *Inorganic inputs* are drawn primarily from minerals, atmospheric air and salt, and natural brine.

These feedstocks are generally traded commodities and their prices are subject to a variety of global economic pressures. The price volatility of many of these commodities has resulted in chemical companies strengthening their relationships with suppliers of raw materials, either through increased contracting in supply or by vertically integrating in the production of these raw materials (Kannegiesser, Gunther, van Beek, Grunow, & Habla, 2008).

[4] Based on Company Annual Reports for 2013-2015.
[5] Kiriyama (2010) and Kannegeiser (2008) refer to the chemical value chain but neither attempt to define or unpack it.
[6] Petrochemicals require six stages as the production of olefins from feedstock is a primary step before the production of commodity plastics. Whereas inorganic commodities are typically produced in one stage from feedstock.

Figure 2. The Chemical Global Value Chain



Source: Authors.

Basic & Commodity Chemicals: The first stage of processing in the industry involves breaking down the feedstock into its basic chemical components.

- In the case of the production of *petrochemicals*, natural gas and natural gas liquids (NGL) are "cracked" by heating and pressurizing the complex hydrocarbon chains to split them into smaller hydrocarbons. The most common outputs derived during this process are divided into two categories: **Olefins,** such as ethylene, propylene, and butadiene, and; **Aromatics,** including benzene, toluene, styrene and cumene. Ethylene is the largest petrochemical product by volume; it is used in the production of plastic, rubber, fibers, detergents, solvents, and anesthetics. These products then undergo further processing to produce a range of commodity chemicals, including plastic resins such as polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinylchloride (PVC).

- *Basic oleochemicals* are derived via a 'splitting' process using the hydrolysis of palm oil, palm kernel oil and coconut oil. The primary derivatives include crude fatty acids, fatty alcohols and methyl ester/glycerine (Frost & Sullivan, 2014; Yoyo et al., 2014).

- In the case of *inorganic chemicals*, a number of different processes are used to extract base chemicals from their raw materials. The chlor-alki process, for example, is used to extract chlorine and caustic soda from brine and rock salt. The most widely produced commodity chemicals, at this stage, include sulfur products, chlor-alkali products such as chlorine, caustic soda and titanium oxides and industrial gases (e.g. Hydrogen & Argon, Oxygen, Nitrogen, and Carbon Dioxide). These are either derived directly from minerals, salt/brine and atmospheric air or as by-products in the petrochemicals process.

The outputs of these processes are typically referred to as *basic, commodity, or bulk chemicals*. These upstream products are produced in high volumes and are sold at low unit value. They are used as key inputs in manufacturing or production processes, or they are directed for further processing into intermediate and specialty chemical products. For example, about 25% of the caustic soda production from chlor-alkalis is destined to pulp production in the paper GVC (S&P Capital IQ, 2015).

The cost of establishing production plants for this stage of the value chain is high compared to other stages of the chain. In the petrochemicals sector, a "steam cracker" can range in the hundreds of millions of dollars (Field Research, 2016; S&P Capital IQ, 2015), and it is not uncommon for cracking plants to be joint ventures between two or more firms. Numerous basic chemicals, particularly industrial gases and chlorine, are not well suited for shipping, and thus these products tend to be manufactured for local consumption (Spitz, 2003).

Intermediate Chemicals: At this stage of the chain, chemicals are formulated using the basic chemicals derived in the first stage of processing. These chemicals are typically not consumed directly but are used in the production of additional products, or in manufacturing processes. Examples include pigments and dyes used in the manufacture of paint, or the coloring of plastics, and surfactants used in the production of industrial and consumer detergents. Activated carbon, although still a relatively small portion of intermediate chemicals, is one product that is growing quickly in demand.

Box 1. Activated Carbon: Growing Importance of a Green Intermediate

Activated carbon has a porous structure with a wide surface area where contaminants are absorbed. It can be made from various inputs such as coal, lignite, wood, coir pitch, and coconut shell. The coconut shell is considered a superior material since it is more effective in the absorption of gas and removal of color and odor of compounds.

The activated carbon market is growing—the global value is estimated in US$2.8 billion in 2014 and it is expected to grow 12% annually during 2014-2019. Activated carbon is a powerful material used primarily to purify water and air. In liquid applications, it is commonly used for taste and odor control in water, removal of organic compounds and pollutants. In air-based applications, it is used for to absorb and remove odor and pollutants. The top exporters are China, the US, Netherlands, Belgium, India, Philippines, Sri Lanka, and Japan.

The major driver of demand is the urgency to reduce air and water pollutants, especially the mercury from coal-fired power plants in the US, Europe and Japan. Global new government regulations and civil society health concerns are pushing for pollution reduction and clean living environments. To take advantage of this global demand, producing countries are offering incentives— India in 2013 introduced a 2% export incentive for coconut-shell-based activated carbon.

Sources: Businessline (2013); Coconut Development Board (2016); PJAC (2016); PR Newswire (2014); UNComtrade (2015a).

Specialty Chemicals: This stage involves the production of specialty chemicals, including paints, coatings, surface treatments, adhesives, sealants, and inks. The products are highly specialized and diverse, designed to perform a particular function to meet the needs of the market or customers, mainly in other industry segments. These products are then sold directly for use in their end markets, including the automotive, construction, pulp, paper and printing, and textiles sector. The leading revenue source for the market is the sale of chemicals for paints and inks (S&P Capital IQ, 2015).

This stage of the chain tends to be focused on medium-low volume/high mix production models. Manufacturing plants thus tend to be smaller, with lower relative investment in capital equipment. However, due to the differentiated nature of these products, R&D and intellectual property protection are more important. Smaller investment size allows for smaller firms to operate in this segment of the chain, however, some larger diversified chemicals producers have also moved into this product segment as a result of the higher margin business.

Marketing, Sales and Distribution: This stage of the value chain involves the distribution and sales of products to final customers. Chemicals have traditionally been distributed directly by producers to their customers; however, outsourcing of distribution has increased over the last few years with a CAGR of 6.5% between 2008 and 2013, as suppliers seek to reduce transaction costs by moving smaller customers to distributors. This is particularly notable for smaller specialty producers. By 2013, distributors accounted for some US$138 billion (BCG, 2014).

Third-party chemical distributors serve greater roles than typical logistics firms as they physically take ownership of the product, and they may warehouse, mix and repackage products from a wide range of suppliers for their end-customers. Distributors may also handle transportation requirements; this accounted for 6% of the total chemical shipments of the US market in 2013 (S&P Capital IQ, 2015). These distributors have become increasingly capable as large producers have sought to rationalize their distribution lines, working with fewer, larger firms that can provide them with global coverage, including in emerging markets (BCG, 2014).

In the specialties segment, branding and engaging with customers in the end markets has become increasingly important and is a key driver of profit. Products are sold based on their performance-enhancing characteristics or their ability to solve a particular challenge for a client rather than on their basic chemical composition—as a result, they are amongst the most profitable (Deloitte, 2011). **Marketing and customer relationship management** and collaborative development thus play an essential role in bringing new products to market in this segment. An increasing number of companies—particularly in developed countries—are focused on improving their coordination with customers to enhance value creation in their firms, as commodities shift increasingly to lower cost locations (Deloitte, 2011; Roland Berger, 2015).

Chemical products are destined to a wide range of different end markets from agriculture and automotive to construction, manufacturing, packaging and the pharmaceutical industry. These end markets vary in size and volatility; the automotive and construction sectors, for example, drive demand for high volumes of both commodity and specialty chemicals; however, they are closely linked to economic cycles. Consumer products, such as detergents, soaps, and cosmetics; water treatment; and infrastructure chemicals tend to be much less cyclical than others and their growth is driven by more generalized growth, such as the rise of the middle class in emerging economies (Deloitte, 2011). Oleochemicals are primarily directed to these end markets (Yoyo et al., 2014). For example, the 2008 financial crisis saw a downturn in the demand for chemicals destined to the automotive, electronics and construction sectors, but not a downturn in those that are destined for the personal care market (oleochemicals) (Deloitte, 2011; Kiriyama, 2010). Box 2 offers further detail on the size and chemical demand in these different end markets.

Box 2. End-Markets in the Chemical Global Value Chain

Table 1. Major End Markets for Four Primary Commodity Chemical Groups

	Petrochemicals Polyethylene Polyprolylene, Polyvinyl Chloride, Polystyrene	**Industrial Gases** Oxygen, nitrogen, argon, hydrogen, acelyne, and carbon dioxide	**Inorganic Chemicals** Caustic soda, hydrochloric acid, liquid chlorine, sulfuric acid, chlorine, sodium hypochlorite, ferric chloride, titanium dioxide	**Oleochemicals** Fatty acids, fatty alcohol, methyl esters, glycerine
Agriculture		X	X	
Automotive	X			
Construction	X	X		X
Personal care & detergents		X	X	X
Electronics	X	X	X	
Food & Beverage		X	X	X
Manufacturing		X	X	
Packaging	X			X
Pulp & paper		X	X	X
Pharmaceutical				X
Textiles & apparel	X			X
Water and waste treatment		X	X	

Sources: Adapted from DTI, SPIK, et al. (2014) and IHS (2014)

The pervasiveness of chemicals in everyday life can be seen from Table 1. End markets typically source chemicals from at least two or more of the commodity chemicals sub-sectors. In turn, these sub-sectors serve multiple end markets. The vast reach of the chemical chain can be detected through a survey of the range of industries served:

- The packaging and agricultural sectors are the largest end markets for the chemicals sector, each accounting for over US$200 billion. Packaging products used for food & beverages, personal care and household products depend to a large degree on plastic resins with Polyethylene Terephthalate (PET) and polypropylene accounting for large market shares.
- The US$400 billion global personal care industry is a major buyer of oleochemicals in particular. With high consumer contact, this is one of the most profitable segments of the industry.
- The pharmaceutical industry draws heavily on fine chemical active ingredients, and accounted for over US$55 billion in 2010.
- Electronics is a rapidly growing end market (US$41 billion), drawing on over 500 different chemicals —including industrial gases such as nitrogen, oxygen, argon, helium, and hydrogen, inorganics (e.g. acetic acid, acetone, ammonium fluoride, ammonium hydroxide, hydrochloric acid, hydrofluoric acid, hydrogen peroxide, isopropyl alcohol, nitric acid, phosphoric acid, and sulfuric acid.)
- The global food additives market was valued at US$38 billion in 2014. Chemicals are used in both

the production and preservation of food and beverages. Additives can be used to extend shelf life, adjust food coloring and improve the taste.
- The pulp and paper market (US$36 billion in 2014) uses over 200 different chemicals, particularly caustic soda, soda ash, chlorine, hydrogen peroxide and titanium dioxide.
- The global textiles and apparels market was valued at US$20.5 billion in 2014. The textile industry requires various chemicals right from pretreatment to finishing of textile. Textile chemicals can be a compound, intermediates or chemicals used at any stage of textile production, from polyester fibers, to detergents and softeners used in finishing apparel products
- The automotive industry is an important growth sector for the industry, as car manufacturers seek to reduce weight, emissions and increase efficiency. It draws primarily on plastics, rubber, coolants, coatings and lubricants. Plastics now account for some 15% of materials in a mid-size car – 37% of which is polypropylene. Automotive plastics demand alone was US$19 billion in 2014. Every automobile uses over US$2,000 worth of chemical processing and products.
- Global water treatment demand in the specialty chemicals segment was valued at US$19 billion. The chemicals used depend on the particular geographic market, with organic polymers more commonly used in the US and specialty chemicals, such as aluminum sulfate, ferric sulfate, ferric chloride, and polyaluminum chloride used in Europe.
- The construction sector demanded a range of chemicals valued at approximately US$14.6 billion in 2015. Concrete admixtures, asphalt modifiers, adhesives, sealants, grout and mortar, insulation, protective coatings and other products are used to improve workability, enhance performance, add functionality and protect structures from weather and pollution.

Source: American Chemistry Council (2015); Deloitte (2011); EFSA (2016); (Global Market Insights, 2016; Grand View Research, 2015); IHS (2014); KPMG (2015a, 2015b); Zion Research (2016a, 2016b).

2.2. Global Trade in the Chemicals GVC

After growing steadily over the past three decades, global trade in chemicals surged 30% in the time period between 2007 and 2014 to reach US$1.3 trillion (see Table 2). Basic and commodities chemicals account for the largest share of trade (67% in 2014), although trade in intermediate as well as specialty chemicals and final products has risen slightly in the past five years. Within commodity chemicals, organics and plastic resins—dominated by petrochemical products— account for the largest value of chemicals trade with US$383 and US$267 billion, respectively—50% of all trade. Comparatively, inorganic chemicals made up just 7.4% of trade in 2014.

Production location in the basic & commodities stages of the chain is closely related to availability of raw materials due to economies of proximity and scale. This keeps production in a relatively small number of locations. Intermediate chemicals production tends to be more widespread—it is either co-located with upstream production or dependent on downstream uses. Specialty production is more diverse, owing to lower capital barriers to entry.

Table 2. World Chemical Exports by Value Chain Stage and Segment, 2007-2014

Value Chain Stages and Selected Sectors	Value (US$, billions)				Value Chain Stage or Sector Share of World Total (%)			
	2007	2010	2012	2014	2007	2010	2012	2014
Total	**989.3**	**1,115.3**	**1,307.5**	**1,303.2**				
Basic & Commodity Chemicals	**695.1**	**772.0**	**910.9**	**874.8**	**70.3**	**69.2**	**69.7**	**67.1**
Organic	323.3	347.7	415.7	391.2	32.7	31.2	31.8	30.0
Petrochemicals	220.2	234.5	265.0	268.6	22.3	21.0	20.3	20.6
Inorganic	75.2	88.3	99.0	96.1	7.6	7.9	7.6	7.4
Other	76.3	101.5	131.2	118.9	7.7	9.1	10.0	9.1
Intermediate Chemicals	**155.2**	**181.5**	**207.1**	**217.9**	**15.7**	**16.3**	**15.8**	**16.7**
Oils	18.1	20.9	24.9	27.2	1.8	1.9	1.9	2.1
Coatings	13.7	15.0	18.7	16.8	1.4	1.3	1.4	1.3
Surfactants	11.1	13.0	15.2	16.2	1.1	1.2	1.2	1.2
Activated Carbon	1.4	1.8	2.3	2.8	0.1	0.2	0.2	0.2
Other	110.9	130.8	145.9	154.9	11.2	11.7	11.2	11.9
Specialty Chemicals & Final Products	**138.9**	**161.8**	**189.4**	**210.5**	**14.0**	**14.5**	**14.5**	**16.2**
Coatings	34.2	37.6	43.7	47.2	3.5	3.4	3.3	3.6
Pesticides	17.9	22.9	28.7	34.4	1.8	2.1	2.2	2.6
Personal Care	50.5	60.5	69.1	77.9	5.1	5.4	5.3	6.0
Other	36.4	40.8	47.9	51.1	3.7	3.7	3.7	3.9

Source: UNComtrade, HS02 4D, all reporters imports from the world. Retrieved on October 31, 2015.

Global Demand

On the demand side, as a result of the close link between chemical consumption, manufacturing and economic growth, the sector has seen a shift in demand towards growth economies in general, and the Asia-Pacific region, in particular. While production is expanding in the region, imports have also grown. Although as a group the EU15 remains the largest importer, individual country imports are lower than those of China and the US. Chinese demand has increased by 70% since 2007, surpassing the US as the largest single market, while India has also emerged as a leading importer. Although South Korea is no longer a top 10 buyer, its imports have also expanded. China's leading position holds for both basic and commodity chemicals and intermediate goods (see Table A-3 and Table A-4 in the Appendix).

Table 3. Top 10 Chemicals Importers, 2007-2014

Reporters	Value (US$, billions)				World Share (%)			
	2007	2010	2012	2014	2007	2010	2012	2014
World	**1,055**	**1,183**	**1,378**	**1,392**				
China	103	136	163	171	10%	11%	12%	12%
USA	101	102	120	124	10%	9%	9%	9%
Germany	81	83	95	102	8%	7%	7%	7%
Belgium	59	57	65	67	6%	5%	5%	5%
France	56	53	61	59	5%	5%	4%	4%
Italy	47	45	48	48	4%	4%	4%	3%
Netherlands	36	36	47	47	3%	3%	3%	3%
India	—	—	43	46	—	—	3%	3%
United Kingdom	52	42	44	43	5%	4%	3%	3%
Japan	35	41	47	41	3%	3%	3%	3%
Rep. of Korea	28	34	—	—	—	3%	—	—
Spain	29	—	—	—	3%	—	—	—
Top Ten	**628**	**629**	**733**	**748**	**57%**	**54%**	**53%**	**52%**

Source: UNComtrade, HS02 4D, all reporters imports from the world. Retrieved on October 31, 2015.

Global Supply

Exports in the chemical industry, on the other hand, are concentrated in a smaller number of countries, with the top ten exporters accounting for approximately 64% of all exports (UNComtrade, 2015a). The main exporters of chemicals in all stages of the value chain are primarily developed countries. In 2014, the EU15, driven by Germany, maintained its position as the leading exporter, closely followed by the US (US$157 billion), China (US$117 billion), and Japan (US$65 billion).

Table 4. Leading Chemicals Exporters, All Value Chain Stages, 2007-2014

Reporters	Value (US$, billions)				World Share (%)			
	2007	2010	2012	2014	2007	2010	2012	2014
World	**989**	**1,115**	**1,307**	**1,303**				
USA	119	141	157	157	12%	13%	12%	12%
Germany	116	109	123	131	12%	10%	9%	10%
China	55	78	100	117	6%	7%	8%	9%
Belgium	74	73	81	83	7%	7%	6%	6%
Netherlands	55	56	71	72	6%	5%	5%	6%
Japan	60	67	68	65	6%	6%	5%	5%
Rep. of Korea	—	45	56	62	—	4%	4%	5%
France	55	52	58	61	6%	5%	4%	5%
Singapore	29	—	—	46	3%	—	—	4%
Ireland	40	38	41	41	4%	3%	3%	3%
United Kingdom	42	38	43	—	4%	3%	3%	—
Top Ten	**645**	**698**	**799**	**834**	**65%**	**63%**	**61%**	**64%**

Source: UNComtrade, HS02 4D, all reporters exports to the world. Retrieved on October 31, 2015.

Note: The discrepancy in world totals between imports and exports is based on small differences in reporting processes by individual countries.

While there has been little change in recent years amongst the top 10 leading exporters in each stage of the chain, there have been considerable changes with respect to capacity distribution in the commodities chemicals segment. For example, in petrochemicals, cracker capacity in Europe has been reduced in recent years, compared to increased capacity development in Asia and the Middle East (Germany Trade and Invest, 2014). Capacity changes in China and the US in particular are important to highlight. Significant capacity development in upstream stages of commodities has allowed China to steadily increase its export market share from 6.3% in 2007 to 10.3% in 2014 (see Table 4) (KPMG, 2011). Meanwhile, the US has rapidly ramped up its petrochemicals capacity since 2010, as a result of cheap and available ethane from shale gas (see Box 3). It is estimated that excess PE production for export from the US will be between 2.7 and 4.1 million MT/year through 2020 (Petrochemical Update, 2016). Trade statistics are yet to reflect this recent trend, but this is set to have major repercussions for global manufacturing of these petrochemicals.

Table 5. Top Ten Commodity Chemicals Exporters by Value, 2007-2014

Reporter	Value (US$, billions)				World Share (%)				% Change
	2007	2010	2012	2014	2007	2010	2012	2014	2007-14
World	**695.1**	**772.0**	**910.9**	**874.8**					26%
EU-15	301.4	282.5	320.2	319.9	43.4	36.6	35.2	36.6	6%
USA	80.4	95.6	105.4	101.3	11.6	12.4	11.6	11.6	26%
China	43.9	61.0	78.3	89.8	6.3	7.9	8.6	10.3	105%
Rep. of Korea	31.3	39.3	49.2	53.3	4.5	5.1	5.4	6.1	70%
Japan	38.5	42.6	43.6	42.7	5.5	5.5	4.8	4.9	11%
Singapore	22.3	25.9	35.7	34.2	3.2	3.4	3.9	3.9	53%
Canada	18.6	18.8	22.2	21.1	2.7	2.4	2.4	2.4	13%
Russian Federation	12.9	14.7	22.4	21.0	1.9	1.9	2.5	2.4	62%
Switzerland	17.2	18.8	20.5	20.9	2.5	2.4	2.2	2.4	21%
India	10.4	15.1	19.7	19.8	1.5	2.0	2.2	2.3	90%
Top 10 (2014)	**576.9**	**614.4**	**717.1**	**724.0**	**83.0**	**79.6**	**78.7**	**82.8**	**25%**
Saudi Arabia	13.1	20.3	31.4	—	1.9	2.6	3.4	—	

Source: UNComtrade, HS02 4D and 6D (6D only for HS Chapters 34, 35 and 37), all reporters exports to the world. Retrieved on October 31, 2015.

Note: Saudi Arabia was in the top 10 in 2010, but otherwise top exporters are the same except variations within the EU15

Box 3. The Changing Dynamics of the Global Polyethylene Sector

The shale gas revolution in the United States is changing the global ethylene and polyethylene industry. Although naphtha has been more commonly used in the production of PE in the past, the lower costs of gas extraction compared to naphtha will equalize the use of these two feedstocks by 2020 in the production of ethane and ethylene. In 2014, ethylene polymers were the 29th most traded product in the world. In 2014, the top exporters of ethylene polymers were Saudi Arabia (US$11.6 billion), the United States (US$8.04 billion), and Belgium-Luxembourg, while the top importers were China (US$14.1billion), Germany (US$4.64 billion) and the US (US$4.36 billion). While the Middle East leads the production, this is likely to change in the coming decades and the US will likely dominate exports.

The excess of ethane supply in the US has led to the construction of more processing and export infrastructure. The boom of US exports of ethane-ethylene in the last 2 years has been significant; from no exports in the last two decades to 38 thousand barrels per day in 2014 and 65 barrels per day in 2015. The ethylene capacity in the country continues to expand rapidly. All major companies have announced expansions in Texas and California. The largest investments include Dow Chemical in Taft & Freeport, Texas with a capacity of 1.9 million MT, Chevron Phillips in Cedar Bayou, Texas with a capacity of 1.5 million MT and Exxon Mobil in Baytown, Texas with a capacity of 1.5 million MT. In total, it is calculated that through 2020 the ethylene capacity in North America will increase by around 12 million MT.

Source: Eramo (2016); IHS (2015); MIT (2014); U.S. EIA (2016)

While industrialized nations have historically been the largest exporters of chemical products, developing economies have begun to play a more important role in recent years. This can be partially attributed to economic development and the global relocation of many manufacturing operations to the Asia-Pacific region. While chemicals are widely traded, high transportation costs as well as safety and security challenges, particularly of commodity chemicals, favor geographic proximity of production and consumption (Field Research, 2016). Many producers have thus responded to the changing patterns of demand by installing new capacity closer to key emerging markets. Regional trade within Asia, for example, has grown twice as fast as the global growth rate during the past eight years, at 62% compared to 32% (see Table 6). These regional exports, nonetheless, are consolidated with the top four exporters accounting for 75% of all trade. Japan no longer leads the region; between 2010 and 2012, China surpassed Japan as the biggest regional exporter, accounting for 25% of all regional exports by 2014.

While new capacity is being developed in emerging markets in upstream products, chemical producers generally have retained production capacity for specialty chemicals within their traditional manufacturing bases (CEFIC, 2014; Germany Trade and Invest, 2014). These include the EU, US and Japan. Specialties have both a higher value-to-volume ratio than commodity chemicals as well as larger margins, which allows for farther-reaching global trade.

Table 6. Asia Regional Chemicals Trade, 2007-2014

Reporters/ Exporters	Value of Inter-Asian Trade (US$, billions)				Share of Inter-Asian Trade (%)			
	2007	2010	2012	2014	2007	2010	2012	2014
Inter-Asia	**155.3**	**202.7**	**242.3**	**252.3**				
China	28.5	40.5	51.1	59.4	18%	20%	21%	24%
Japan	43.1	50.1	51.1	47.9	28%	25%	21%	19%
Rep. of Korea	26.4	34.9	42.8	45.1	17%	17%	18%	18%
Singapore	19.4	25.3	31.9	35.4	12%	12%	13%	14%
Thailand	8.6	12.3	18.1	19.1	6%	6%	7%	8%
Malaysia	8.3	10.2	12.1	12.7	5%	5%	5%	5%
China, Hong Kong SAR	14.4	14.4	14.7	13.1	9%	7%	6%	5%
Indonesia	0.0	5.5	7.1	8.4	0%	3%	3%	3%
India	4.6	6.1	8.2	8.1	3%	3%	3%	3%
Philippines	0.7	1.4	1.5	1.8	0%	1%	1%	1%
New Zealand	0.7	0.6	0.8	0.8	0%	0%	0%	0%
Viet Nam	0.5	1.0	2.1	0.0	0%	1%	1%	0%

Source: UNComtrade, HS02 4D, all reporters exports to the world. Retrieved on October 31, 2015. Asia-Pacific countries excluding the Americas.

These higher value products are dependent on R&D and IP protection. The leading four exporters of specialty products spent considerably in this category; the EU spent US$8.1 billion, the US US$7.9 billion and Japan US$6.0 billion in R&D in 2014. The only emerging economy that competes in R&D spending is China, which invested US$7.6 billion in 2013. The EU is by far the largest supplier of these chemicals and has a growing trade surplus in specialty products (CEFIC, 2014). Table 7 details the leading specialty chemical exporters. There is considerable overlap with commodities exporters, with eight of the top 10 in both categories. This reflects the consolidation of the industry in a small number of countries. Notably, however, three of the Asian countries more than doubled their exports of specialty and final products during this period.

Table 7. Top 10 Specialty Chemicals & Final Products Exporters in 2014, 2007-2014

Reporter	Value (US$, billions)				World Share (%)				% Change
	2007	2010	2012	2014	2007	2010	2012	2014	2007-14
World	**138.9**	**161.8**	**189.4**	**210.5**					52%
EU-15	79.5	82.6	93.6	105.3	57.2	51.1	49.4	50.0	33%
USA	15.4	18.5	21.2	23.4	11.1	11.4	11.2	11.1	52%
China	5.9	7.8	10.9	13.8	4.3	4.8	5.7	6.5	133%
Japan	5.0	6.7	7.3	6.8	3.6	4.1	3.9	3.2	37%
Poland	2.6	3.8	4.4	5.2	1.9	2.4	2.3	2.5	100%
Singapore	2.6	3.4	4.1	5.1	1.9	2.1	2.2	2.4	96%
Rep. of Korea	1.2	2.2	2.9	4.0	0.9	1.4	1.5	1.9	221%
Switzerland	2.5	3.0	3.2	3.5	1.8	1.9	1.7	1.7	41%
Mexico	2.1	2.5	3.2	3.4	1.5	1.6	1.7	1.6	66%
India	1.3	2.0	2.7	3.1	0.9	1.2	1.4	1.5	138%
Top 10 (2014)	**118.1**	**132.6**	**153.4**	**173.6**	**85.0**	**81.9**	**81.0**	**82.5**	**47%**

Source: UN Comtrade, HS02 4D and 6D (6D only for HS Chapters 34, 35 and 37), all reporters exports to the world. Retrieved on October 31, 2015.

Oleochemicals Supply: Oleochemicals trade differs from these broader categories, although it is comparatively much smaller, and thus has little impact on global trade statistics. Global supply has increased by approximately 40-45% over the past five years (Brunskill, 2015). Asia is the world's leading and fastest growing region in oleochemical production and exports. In 2012, Asia accounted for over 42% and 33%, respectively, of the 6.4-million ton and 2.2-million ton global markets of fatty acids and fatty alcohols. Southeast Asia, in particular, has become the key production center for vegetable-oil based oleochemicals primarily because of its unique raw material advantages (Frost & Sullivan, 2014). After Malaysia and Indonesia (palm oil), Thailand and the Philippines (coconut oil) are the main producer countries of basic oleochemicals (fatty acids, fatty alcohols and refined glycerine). China and India are also the other two rising producers in Asia—China's share of fatty acid output is estimated to account for more than 25% of global production by 2020 to meet its domestic demand.

The shift to Southeast Asia has also been cost and quality driven. Raw material costs are about 80-90% of the cost of the production of natural fatty acids and fatty alcohols. Oleochemical production in mature markets has depended on tallow—animal fat renderings and operations are generally old. Health, price and quality concerns have reduced demand for animal fat products in favor of vegetable based ones. The new operations in Southeast Asia are modern, efficient operations—more productive, with lower cost labor and close to raw materials (Frost & Sullivan, 2014).

2.3. Industrial Organization of the Chemicals GVC[7]

The chemical sector as a whole is characterized by capital intensity, technology development, and significant regulatory challenges that create important barriers to entry and limit the number of firms operating in the sector (S&P Capital IQ, 2015). However, important differences in the business models required for the different stages of the chain result in a distinct power structure. While upstream segments are capital intensive and dependent on economies of scale, the technologies are generally considered to be mature and available on the market. Downstream segments are smaller, far less capital intensive, but R&D is central to success. As a result, upstream segments are affected by occasional large capacity additions, while growth in the specialties segment is more incremental.

While the competitive landscape varies by the particular product and segment of the chain, firms in the chemicals industry can generally be divided into four types of companies based on their primary activities: (1) Commodities producers; (2) Specialty producers; (3) Oleochemical producers; and, (4) Diversified producers engaged in all aspects of the chain. Some overlap exists across these categories due to the benefits of vertical integration in the industry. Diversified players have been amongst the most powerful in the industry for decades. However, the growth of large, competitive firms that focus on a very small range of related products ("pure-play" firms) in each of these segments has led to a shift in strategies amongst diversified firms, which in turn has resulted in a reduced emphasis on commodity products and an increased focus on specific end markets. Furthermore, new players have emerged in the

[7] Where not specifically cited, firm information in this section is based on company websites, annual reports and firm interviews.

oleochemicals sector as larger consumer products operations have divested from oleochemicals, and plantation owners have gained market power.

1. **Commodity Chemicals & Industrial Gases:** As competitiveness in this undifferentiated segment of the chain is based on volumes and price, these firms are typically very large, pure-play firms focused on a small number of products in which they have significant economies of scale.[8] The largest firms in this sector are oil & gas producers, which have leveraged their petroleum operations to upgrade into petrochemicals production (e.g. Sinopec, ExxonMobil and Chevron Phillips) or petrochemicals makers that have backward integrated into oil & gas (e.g. Shin Etsu) (Deloitte, 2015; Marketline, 2015b). This has been partly the outcome of high energy prices, as firms have sought to manage their exposure to fluctuations in the price of key raw materials (Kannegiesser et al., 2008). Petrochemical companies primarily produce polyethylene and polypropylene and fertilizers, while participation in the specialties market is limited to a small number of specific and related products (e.g. lubricants).

   The inorganic segment produces primarily chlor-alkali, titanium, sulphur products, and industrial gases. Due to their production of chlorine products, chlor-alkali producers may also operate in the production of polyvinylchloride (PVC)[9] and vice versa, thus spanning both petrochemicals and inorganics. Shin Etsu, for example, is one of the world's largest PVC manufacturers, with an annual capacity of 3.5 million tons (Shin-Etsu Chemcial Co, 2015). PraxAir is the dominant firm in the production of industrial gases. Commodities production—in both the organic and inorganic products—is becoming increasingly consolidated on a global scale, with a few lead firms in each specific product category. Nonetheless, new players are emerging in some developing countries where they have been able to leverage lower costs and proximity to clients to gain market share (BCG, 2015; PwC, 2011; S&P Capital IQ, 2015). For example, Tata Chemicals, headquartered in India, has become the world's second largest soda ash company (S&P Capital IQ, 2015).

   Due to the high volumes that must be produced in this segment of the chain to be profitable, commodity chemicals tend to be oriented into a wide number of uses, and the number of buyers is generally high. These buyers tend to be larger companies who make large-scale purchases of chemicals, and these chemicals are essential to their supply chains. These buyers may also require their suppliers to have global capabilities to meet their needs (S&P Capital IQ, 2015; Spitz, 2003). As a result, even though commodity chemicals are largely undifferentiated, purchasing tends to be through long-term contracts (Marketline, 2015a), while in other cases, long-term relationships are concreted in geographical clustering.

   Due to the high costs involved in the production of commodities chemicals, it is not uncommon for producers to seek out offtake agreements prior to the construction of operations. These offtake agreements commit buyers to purchase a certain portion of

[8] Three of the largest Japanese firms, Shin-Etsu, Mitsui Chemicals and LG Chem are commodities players, however, they have also established strong electronics chemicals operations.
[9] Chlorine accounts for approximately 60% of the raw material inputs in the production of PVC.

the plant output for an extended period of time (Spitz, 2003). This reduces production for producers, and locks the buyer and the producer into a hierarchical governance structure.

2. **Specialty Chemical Producers:** On the other hand, the specialty market is highly fragmented with a large number of products and firms. Leading companies include AkzoNobel, Degussa, Ecolab Ciba, Rohm & Haas, and Clariant, though together they account for just 5% of global sales (S&P Capital IQ, 2015). Within the specialty chemical sector, a company's strength is largely based upon IP and R&D capabilities. Volumes are typically low (as compared to commodities production), technological innovation heightens the potential for the development of substitutes and there are lower barriers to entry making the segment highly competitive. Development of new products is crucial, and a constantly updated portfolio of patents is important for maintaining high margins. The introduction of new regulations about chemicals use is raising the costs of participation and lowering the value proposition of the segment (see following section). These trends are driving consolidation amongst specialty producers; this has been a major trend, and is expected to continue (S&P Capital IQ, 2015). Due to the significant amount of R&D and innovation required, and the relative value-to-volume ratio, specialty firms tend to be based in developed countries (BCG, 2015). Buyers draw from a wide-range of industries including manufacturers of consumer products, automotive manufacturers, and textile producers. In some cases, specialty chemicals form a vital part of their product and cannot be replaced, reducing their power vis-à-vis producers (Marketline, 2015).

Table 8. Top 10 Firms in the Chemical Industry, By Revenue 2014

	Name	Revenue (US$, millions)	Employees	HQ	Firm Category
1	BASF	90,011	112,206	Germany	Diversified
2	Sinopec	68,875	NA	China	Commodity
3	Dow Chemical Company	58,167	52,731	USA, MI	Diversified
4	Exxon Mobil Chemicals	56,373	75,000	USA, TX	Commodity
5	Saudi Basic Industries Corporation	50,122	33,000	Saudi Arabia	Commodity
6	Lyondellbassel Industries	45,608	45,608	USA, TX	Commodity
7	Dupont	34,723	64,000	USA, DE	Diversified
8	Mitsui Chemicals	30,478	14,363	Japan	Diversified
9	INEOS	27,003	17,000	UK	Commodity
10	Bayer	26,962	116,700	Germany	Diversified [a]

Source: Company Annual Reports and ICIS (2015b)

Note: In 2015, Bayer rebranded itself as a Life Sciences company focused on the pharmaceuticals and agricultural segments and divested its material sciences group (Bayer, 2016).

3. **Oleochemical producers:** The oleochemicals sector, which serves primarily consumer markets such as food and beverages, household products and cosmetics, in addition to a growing number of applications in the agriculture, construction and

automotive sector, has already undergone important restructuring. Prior to the 1990s, the sector was dominated by the European and North American firms; since then, lead buyers in the sector such as Unilever and Proctor & Gamble have been pulling out of the basic oleochemicals production and focusing on their core activities in the production and marketing of consumer products—although they do continue to maintain some presence upstream (Marketline, 2015). The restructuring has resulted in the emergence of vertically integrated firms upstream in the chain after the large palm plantation owners upgraded into oleochemicals production. The sector has already become relatively consolidated with fewer than 25 firms operating in the region (Frost & Sullivan, 2014). Major firms in this segment now include Emery Oleochemicals, Wilmar International, KLK Oleochemicals and IOI Oleochemicals (Frost & Sullivan, 2014). Many of these firms are headquartered in Malaysia and Indonesia (see Table 9), and are pushing to upgrade further up the chain to become intermediate and specialty providers (Intarajang, 2011). Furthermore, in certain product categories, these firms have gained advantage over producers of petrochemical substitutes for the consumer markets as awareness of how products are produced and the ingredients they contain have pushed lead firms towards more sustainable, non-toxic and environmentally friendly inputs (Field Research, 2016; Frost & Sullivan, 2014; Kiriyama, 2010).

Table 9. Leading Vertically-Integrated Oleochemical Producers

Company	Country	Oil Palms (ha)	Oleochemicals Revenue (2013, US$ millions)	Highest Stage of GVC
Emery Oleochemicals (Sime Darby)	Malaysia	1,000,000	1,000	Specialty chemicals
KLK	Malaysia	270,000	233.8	Oleochemicals, Biodiesel
IOI Corporation	Malaysia	175,000	231.0	Specialty chemicals,
Wilmar International	Singapore	238,000	202.6	Oleochemicals, Biodiesel
PT Musim Mas	Singapore	26,000	180.6	Oleochemicals, Biodiesel, Consumer products
PT Bakrine Sumatera	Indonesia	73,000	111.6	Oleochemicals

Source: Company websites; Frost & Sullivan (2014)

Globally, the markets into which oleochemical producers supply are quite concentrated, with a small number of powerful lead firms controlling a high share of the market. Procter & Gamble (P&G), Unilever, Johnson & Johnson, and Colgate all have strong market shares—more than 5% each in the personal care and household products markets (Marketline, 2015c, 2015d). These firms have been influential in shaping the behavior of upstream suppliers. This has been particularly relevant regarding issues of sustainable sourcing in the face of widespread concern of deforestation in the palm oil sector. These firms have been responding in part to consumer awareness, but also as a result of pressures from major retailers, such as Aldi, Carrefour and Walmart who have also committed to improving supply chain responsibility (RSPO, 2016).

4. **Diversified:** Firms in this category generally operate in most segments of the chemicals GVC and include three of the world's largest chemicals manufacturers—BASF, Dow

Chemicals, and Dupont. These firms draw on both organic (petroleum and bio-based) and inorganic feedstocks, and compete in multiple downstream markets, including agriculture, electronics, plastics, and pharmaceuticals with both commodity and specialty chemical products. They are typically vertically integrated, including some into feedstock provision in the oil & gas segment, and some, such as BASF have developed a competitive advantage by establishing fully integrated plants that use by-products of the production of one chemical for the development of another (BASF, 2015). However, this long-standing tradition of large, diversified chemicals firms is potentially heading for a change as diversified firms seek to minimize risk to fluctuating feedstock prices by reducing their participation in low-value commodities-driven businesses while also increasing their competitiveness in specific end markets.[10]

2.4. Standards and Institutions

As chemical products that have significant impact on health, safety and the environment, the industry has become heavily regulated, both domestically and internationally. Accidents, terrorism and growing consumer awareness in recent years have driven changes in most of the major markets during the past two decades (Kiriyama, 2010). The new global regulatory environment covers not only approval for sale of the chemicals, but it also covers transportation requirements for hazardous products, disposal, and security concerns. These changes have included public regulations, and private standards as well as certifications by NGOs seeking to raise consumer awareness of the toxicity and environmental impact of products. Public and private standards have been the most important changes in petrochemical and basic chemicals and their derivatives, while social standards have mainly been associated with consumer products. This complex mix of regulations has made it increasingly challenging for firms to engage in international trade.

Public Regulation

With the exception of the US, all major markets have implemented new chemical regulation systems over the past ten years. These include the implementation of the Chemicals Management Plan (CMP) in Canada in 2006, Registration, Evaluation, Authorisation and Restriction of Chemicals system (REACH) in 2007 in the EU, reforms in Japan in 2003 and 2009, and recent changes in China in 2010 and 2013 (Kiriyama, 2010; Motaal, 2009; Naiki, 2010). The US Congress only recently began the process of reform of the 1976 Toxic Substances Control Act (American Chemistry Council, 2016; Denison, 2015), [11] although they have been more proactive in areas of security. In 2007, new legislation was introduced in the US regarding security standards for chemicals that pose a high risk for terrorism. These Chemical Facility Anti-Terrorism Standards were further extended in 2014.[12] While public regulations remain disparate, with regulation occurring at state, national and international levels

[10] For example, Dow and Dupont recently announced a major merger (December 2015), which is set to create three pure-play independent companies in the agriculture, material sciences and specialty chemicals (Bunge & Feintzeig, 2016; Dow, 2015b).

[11] The major federal laws affecting the US chemicals industry are the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act, the Comprehensive Environmental Response Compensation and Liability Act (CERCLA, also known as the Superfund program), and the Toxic Substances Control Act (S&P Capital IQ, 2015).

[12] The Protecting and Securing Chemical Facilities from Terrorist Attacks Act 2014.

(Selin, 2013), the CMP and REACH programs have been highly influential in shaping global regulations leading to some degree of harmonization (Abelkop & Graham, 2015), and globally raising the bar for producers.

The changes brought about by these new systems have largely increased manufacturer responsibility for the health, safety and environmental impact of their products and the processes by which they are produced (Kiriyama, 2010; S&P Capital IQ, 2015). The REACH regulations, in particular, have shifted the burden of proof from the regulator to the chemical manufacturer or importer (Motaal, 2009).[13] This system requires registration for harmless chemicals, evaluation for chemicals that may be harmful and authorization for chemicals that are known to be harmful (Motaal, 2009). The registration requirements to meet these standards, which were rolled out in 2010 and expected to be completed by 2018, create a barrier to market entry, as companies must undertake testing and auditing of their products and processes before a product can be registered for sale. Recent studies have demonstrated that small and medium sized firms—mostly in the specialty segment of the chain—are having difficulties keeping up with the regulations both financially and technically (European Commission, 2013; Scruggs, Ortolano, Wilson, & Schwarzman, 2015). In addition, in order to ensure compliance in supply chains, there has been less switching between suppliers abroad, resulting in reduced supply chain flexibility (European Commission, 2015). Companies have also revised their product portfolios, eliminating low-value, low volume products and those at the end of their product life cycle (European Commission, 2015).

In addition to national regulation, three key multilateral agreements shape the flows of chemicals trade at the global and regional level. These include the 1998 Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (145 country members in 2012); and the 2001 Stockholm Convention on Persistent Organic Pollutants (POPs) and1998 regional Protocol on Persistent Organic Pollutants to the Convention on Long-Range Transboundary Air Pollution (CLRTAP).[14] These agreements cover different but partially overlapping parts of the chemicals life cycle of production, use, emissions, trade, and disposal. The Rotterdam Convention provides countries with discretionary power to accept or reject, or establish the specific conditions for importing certain hazardous chemicals; by 2012, this convention covered 43 different chemical substances. The Stockholm Convention sets global controls on the production, use, emissions, trade, and disposal of POPs. By 2012, 175 countries and the EU had ratified the Stockholm Convention (Selin, 2013) and are strongly influenced by the CLRTAP agreement which regulates the production and use of 22 chemicals different chemicals which are recognized as harmful and demonstrated to pose significant risks. More substances are likely to be added in the future.

Finally, the Globally Harmonized System for the Classification and Labelling of Chemicals, launched in 2003, has been adopted by a growing number of countries in an attempt to make it

[13] The proposed changes to the TSCA in the US maintain the burden for regulation with the Environmental Protection Agency, however, they shift the cost of the testing to the individual companies, which would be required to pay a fee for testing (Denison, 2015).
[14] In addition, 1998 Basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and Their Disposal. However, since this addresses end-of-life management of chemicals it is beyond the scope of this report.

easier to identify specific chemicals transported between two countries, in turn reducing technical barriers to trade (Kiriyama, 2010).

Private Standards

While ISO 9000, ISO 14000 and OHSAS 1800 are all integral and accepted standards at the global level in this industry, the most wide reaching and long standing private chemical industry standard is Responsible Care managed by the International Council of Chemical Associations, established in the 1980s as a private sector standard towards self-regulation and improving sustainability of processes and products. Under the program, member companies voluntarily commit to continuous improvement of health, safety, and environmental performance. The program establishes codes for management practices in six areas: community awareness and emergency response, pollution prevention, process safety, distribution, employee health and safety, and product stewardship (S&P Capital IQ, 2015). Today, 60 national chemical associations participate in this program, including China, India, Indonesia, Japan, Mexico, Philippines, Singapore, Thailand, and the US, (ICCA, 2016). Critics highlight that the lack of third-party mandatory audits prior to 2005 undermined Responsible Care's credibility, effectiveness and relevance. The updated standard was modeled after the ISO14000 environmental standard, and firms can opt for dual certification to avoid duplication. This is likely to grow in importance as green chemicals grow in popularity.

Consumer-awareness has also driven the adoption of increased private standards from buyers in the household cleaners, food and beverages and cosmetic range of chemicals. In these consumer products markets, standards have focused on sustainable production as well as organic, non-toxic chemical derivatives. This is not surprising as it is the segment in which consumers are most directly exposed and they have more control through buyer power. One of the most important applications of these standards has been with respect to sustainability in the palm oil industry. This was of particular importance for environmental sustainability as these products were being produced through deforestation. In 2004, large lead buyers, including Unilever and P&G launched the Roundtable on Sustainable Palm Oil (RSPO, 2016). These firms have committed to 100% sourcing of raw materials for their oleochemical based products from certified sustainable plantations by 2020. Several firms have also committed to requiring the involvement of more and more small farmers in their supply chains to increase the inclusiveness of their supply chains (P&G, 2014; Unilever, 2016). Other standards in the cosmetics industry include the Cosmos and NaTrue social standards that set out requirements for products to qualify as natural and/or organic products.

2.5. Human Capital and Workforce Development

Although the chemicals GVC is very capital intensive, it also depends on a small but highly skilled workforce (Lewis, 2013). The US chemicals workforce, for example, employs 125,000 chemists and chemical engineers, and a further 173,000 qualified technicians (O*Net Online, 2016). In the UK chemicals industry, technicians accounted for just under 40% of the workforce (Lewis, 2013).

The global chemicals industry has traditionally been a long-term employer, recruiting new workers at the beginning of their careers, and then training them in-house, either through on the job training models (e.g. US) or apprenticeship style programs (e.g. Germany) (Deloitte, 2015; Lewis, 2013). Only occasionally did firms hire mid-career professionals.

Over the past few decades, however, this traditional model has become inadequate. In particular, it has become increasingly difficult to attract new and qualified workers to the industry and firms in many traditional hubs, including Germany, France, the UK and the US, are challenged by an aging workforce (Deloitte, 2015; Lewis, 2013; Royal Society of Chemistry, 2015). In labor markets such as the US, firms have faced a shrinking number of STEM graduates with the skills sets required by the industry, and of these, even fewer that are attracted to work in the industry (Deloitte, 2015; KPMG, 2015c). As a result, firms have to focus on global rather than local recruiting of not just entry-level, but also mid-career professionals, complemented with the development of retention strategies. This is all occurring in parallel with global growth in the chemicals industry. Table 10 highlights the employment profile for the chemical GVC.

Table 10. Employee Profile for the Chemicals GVC

Value Chain Position	Firm Types	Positions	Principal Formal Education Attainment & Training Requirements	Experience
Upstream	Commodities Producers	Chemical Engineers Industrial Engineers Manufacturing Engineers Mechanical Engineers Technical operators	Formal education (Bachelors & Masters Degrees) 2/3 year Technical training (post-high school)	On the job & apprenticeship training (up to several years in length)
Vertically integrated	Diversified Firms	Chemists Engineers (chemical, industrial, manufacturing, mechanical). Chemical technicians Finance Procurement specialists Product management Technical operators		
Downstream	Specialty Firms	Chemists, Chemical Engineers, Chemical technicians Business Strategy Procurement specialist Marketing Client Managers R&D managers Technical operators		

Source: Authors based on Deloitte, 2015, Lewis, 2013 and Field Research, 2016.

Human capital needs differ according to the type of business model pursued by firms and their corresponding stages in the value chains. The commodities segment, in which low margins require efficient and large operations, depend mostly on industrial, chemical, and mechanical engineers. As products are undifferentiated and prices generally drive sales, the role for sales and marketing staff is limited. Diversified firms require financial and product management skills, together with R&D, to support new product development. Specialty providers, which are essentially solutions providers, must focus heavily on R&D, branding and sales positions (Deloitte, 2015). With new regulations, those firms targeting key markets such as the EU and Japan must also rely on technicians and experts to navigate the increasingly complex regulatory environment (Lewis, 2013).

2.6. Upgrading Trajectories

The development of a robust, high value chemical industry can be an important driver of a country's manufacturing sector, as well as a contributor to overall economic growth. Availability of raw materials, economies of scale, and an integrated approach all drive successful upgrading in basic chemicals and commodities. Downstream specialty and final product segments rely more on human capital requirements, with strong capabilities in formulation, client relationships and innovation. This section discusses the upgrading trajectories that have been pursued by different countries in the chemicals GVC.

Table 11. Upgrading Trajectories in the Chemical GVC

	Upgrading Type	Description	
Basic & Commodity Chemicals	**Functional Upgrading:** From Feedstock to Building Blocks	Moving from provision of feedstock to the production of commodity chemicals.	• Singapore Petrochemicals • Malaysia Oleochemicals
	Functional Upgrading: Development of Fully Integrated Chemical Complexes	Becoming a fully integrated chemicals producer, including upstream feedstock, commodities and specialty products.	• Sadara, Saudi Arabia • Jurong Island, Singapore • Kuantan, Malaysia
Specialty Chemicals	**Functional Upgrading:** Production of Specialty Chemicals	Moving from the production of commodity or intermediate chemicals into the production of specialty products.	• China
	Functional Upgrading: Formulation of Specialty Chemicals	Performing R&D to develop new specialty chemicals.	• Shanghai's emerging innovation hub
	Process Upgrading: Improving Productivity of Raw Materials Production for Oleochemicals	Application of higher levels of technology or processes to increase productivity in the production of palm kernel oil. One method is through increases in economies of scale for plantation operations.	• Malaysia and Indonesia
	Product Upgrading: Green Chemicals	Upgrading into the production of bio-degradable and eco-friendly chemicals. Mature markets are willing to pay a price premium for these products.	• Thailand

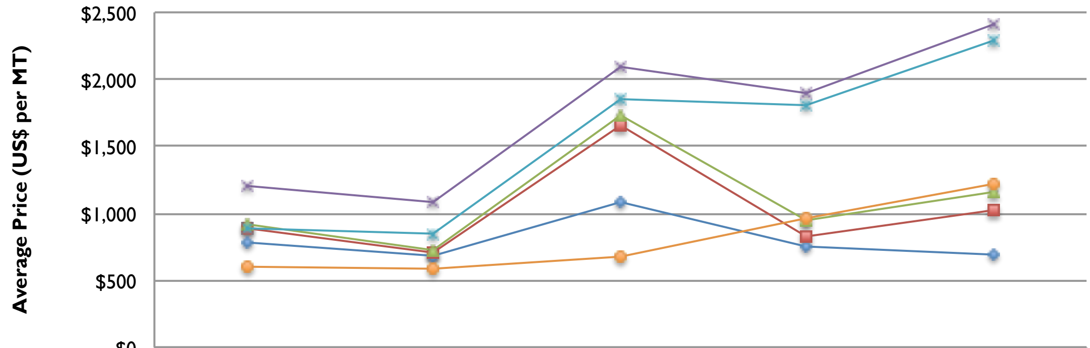
Source: Authors.

1. Entry into the Chemicals GVC: From Feedstock Provision to Chemical Building Blocks

Functional Upgrading from Oil & Gas Refining into Petrochemicals: This trajectory, which can be observed in the evolution of both Singapore and Malaysia's chemical sector development, provides a classic example of functional upgrading. Singapore leveraged its experience as an oil & gas refinery to enter the petrochemicals commodities segment, establishing a fully integrated petrochemicals complex on Jurong Island that connected chemicals producers directly with feedstock from the country's refineries (Hing & Lee, 2009). This hub draws largely on the country's high naphtha output; the 1984 establishment of the first naphtha cracker was a key driver of growth for the petrochemicals sector (Singaporean-German Chamber of Industry and Commerce, 2014). Four additional crackers in 1997 (PCS), 2000 (Exxonmobil), 2010 (Shell) and 2014 (ExxonMobil) have further increased the capacity in the country to 3.6 million MT/Y of ethylene. These crackers were complemented with a supply of natural gas from Indonesia (via pipeline) and a LNG plant (Singaporean-German Chamber of Industry and Commerce, 2014). With a relatively small domestic market, the Singaporean industry is export-oriented, although with a degree of indirect exports as the sector supports manufacturing located in the country. Malaysia also leveraged its oil & gas operations to enter into the petrochemicals sector, beginning in the 1990s. By 2015, the country has 1.2 million MT/Y of ethylene production in addition to propylene and benzene production. Like Singapore, the country has invested heavily in the creation of a fully integrated site, Pengerang Integrated Petroleum Complex (PIPC), announced in 2011 to improve its competitiveness in the petrochemicals sector (Foo, 2015).

Functional Upgrading from Bio-Based Oils into Oleochemicals: The current price of key oleochemicals, such as fatty acids and fatty alcohols can net twice the prices of inputs such as crude palm and coconut oil (see Figure 3). With raw materials making up 80-90% of the cost of production of oleochemicals, this makes upgrading into the production of oleochemicals an attractive proposition. Malaysia, which is the second largest producer of palm oil in the world (Emerging Markets Direct, 2015), has undergone rapid upgrading into the production stage of basic oleochemicals. The expansion of palm plantations significantly increased the availability of raw materials, while the government provided incentives for investment in processing capacity, together with taxing unprocessed oil to increase the competitiveness of locally produced oleochemicals. By 2015, there were 15 oleochemical plants operating in Malaysia (Foo, 2015). The major oleochemical exports are fatty acids (32% of all exports), methyl ester (20%), fatty alcohol (19%), soap noodles (15%), and glycerine (12%). Malaysia is now one of the top producers of oleochemicals in the world, accounting for 20% of global capacity as of 2013 (Frost & Sullivan, 2014; MIDA, 2013).

Figure 3. Average Price of Crude Palm Oil, Crude Palm Kernel Oil, Coconut Oil, Fatty Alcohol, Fatty Acid and Refined Glycerine, 2007-2015



	2007	2009	2011	2013	2015
Crude Palm Oil	$780	$683	$1,077	$745	$688
Crude Palm Kernel Oil	$889	$702	$1,649	$829	$1,023
Coconut Oil	$919	$725	$1,732	$943	$1,159
Fatty Alcohol	$1,205	$1,080	$2,100	$1,900	$2,413
Fatty Acid	$881	$848	$1,850	$1,800	$2,286
Refined Glycerin	$600	$580	$670	$965	$1,217

Source: Frost & Sullivan (2014)

2. Functional Upgrading: Development of Fully Integrated Chemical Complexes

These chemical complexes are fully integrated units in which the outputs or by-products of the production of one chemical can be used to produce another chemical. This saves significantly on transportation and infrastructure costs and allows operations to extract maximum value from raw materials. Known as the "Verbund" approach, this chemicals production method originated in Germany in the 1960s at BASF (The Economist, 2006), and has subsequently driven the development of production complexes in a number of different locations around the world.[15] These sites have generally developed close to the initial source of raw materials. One of the largest and most recent efforts to upgrade in this manner is the Sadara project between Dow and Saudia Aramco in Saudi Arabia. This US$20 billion investment will leverage Saudi Arabia's naphtha and ethane feedstock with the region's first mixed feed cracker plant to produce a number of commodity and intermediate chemicals. The planned exports include 45% to Asia, 10 % to Europe and 25% to the Middle East. This fully integrated complex seeks to help diversify the country's production into specialties as well as commodities. The latter currently account for 99% of chemicals capacity (Baker, 2015; ICIS Chemical Business, 2015).

3. Functional Upgrading into the Production and Formulation of Specialty Chemicals

Upgrading into the Production of Specialty Chemicals: This is the upgrading into the production of specialty chemicals, which is generally characterized by higher mix/low volume

[15] Examples include Freeport, Texas; Jurong Island, Singapore; Kuantan, Malaysia; and Nanjing, China.

production and depends on IP protection. As developing countries gain capabilities in the chemical sector, and demand for specialty products in developing regions grows, several countries, including China and Singapore have upgraded into the production of specialty chemicals (Bathelt & Zeng, 2012). China began targeting specialties growth in the mid-1990s with a five-year plan and initiatives to remove binding constraints for the industry (Young, 1996). This upgrading has been facilitated by the shift of manufacturing chains to the Asia-Pacific (PwC, 2011). By 2012, specialty chemicals sales in Singapore accounted for almost US$10 billion, which represented 25% of chemicals exports (Singaporean-German Chamber of Industry and Commerce, 2014). In early 2016, German firm Bertshi, inaugurated a logistics facility specifically for specialty chemicals in Jurong Island (Bantillo, 2016). This upgrading into specialty chemicals with a focus on increased relationships with end customers is a trend also being reflected at a company level. Several of the diversified firms have begun to focus more on specialties, leaving aside the commodities business that has become highly competitive as a result of the entry from firms in developing countries (BASF, 2015; PwC, 2011).

Functional Upgrading into R&D for Specialties: This involves the development and formulation of new specialty chemicals. Formulation is typically carried out by chemists or chemical engineers with significant expertise in the industry. This upgrading trajectory has been less common for developing countries, as leading firms have maintained their capabilities in developed markets. Nonetheless, one example is Shanghai, China, which has been successful at upgrading into specialties R&D operations. As firms seek to provide solutions for the Chinese and broader Asian markets, these development activities are beginning to shift fast (PwC, 2011). Several leading specialty and diversified chemicals producers, including AkzoNobel, Degussa, Dow and DuPont have established innovation centers in the Shanghai-Pundong region in recent years (BCG, 2015; ICIS, 2004; PwC, 2011). Likewise, Singapore set its goals of upgrading into R&D for chemicals with the establishment of the Institute of Chemical and Engineering Sciences (ICES) on Jurong Island in 2002. The institute has hosted laboratories for numerous leading specialty providers, including Dystar and Ciba Specialties (now BASF). ICES provided a stepping stone for these firms to establish their own R&D centers in the country (Carpenter & Kiong Ng, 2013) .

4. Innovation in the Chemicals GVC: Product and Process Upgrading

Process Upgrading: Given the lack of product differentiation in the commodities sector, firms seek to improve their competitiveness by introducing process improvements and new technologies to improve the efficiency and productivity of their operations. However, due to the plant size and cost of introducing new technologies, this usually occurs with the development and design of a new plant rather than changing an existing operation (BCG, 2015; Kiriyama, 2010). Indeed, in the commodities chemicals sector, process technology in and of itself is the key driver of competitive advantage and can be sold or licensed. Technology driven process upgrading is more common in the smaller specialty chemicals plants where they are more flexible and new technologies can be introduced more easily (Burgess, Hwarng, Shaw, & de Matteos, 2002; Guinsinger & Ghorashi, 2004).

Product Upgrading: One of the most prominent product upgrading trends in recent years is the shift into the production of more efficient, less wasteful and non-toxic products (Kiriyama, 2010). "Green chemicals" are produced from bio-based feedstock and can be substituted for many petrochemical products, offering sustainable, biodegradable alternatives. Thailand has been encouraging firms to invest in the production of biodegradable and compostable bioplastics primarily for packaging in the food and beverage and consumer product segments (Thailand Board of Investment, 2014).[16] The Thai bioplastics segment is generally composed of firms previously only focused on petrochemicals production.

3. Lessons on Upgrading from Malaysia and Singapore

In order to help define the potential upgrading of the Philippines in the chemicals sector, the upgrading experiences of two countries in the region, Malaysia and Singapore, are examined. These cases focus on specific stages and sub-sectors of the industry to provide greater insights. Malaysia was chosen for analysis due to its strong functional upgrading trajectory in the oleochemicals sub-sector over the past thirty years, during which the country has successfully strengthened linkages between raw materials production, basic oleochemicals production and downstream final products. Growth has been driven by a combination of local and foreign firms, ensuring access to key technologies, but also retaining significant value-added within the country. Its graduated approach to R&D investment also provides a strong lesson—first focused on productivity in raw materials, then followed by technologies for developing basic oleochemicals, finally advancing into R&D for final products. Singapore offers an example of upgrading into intermediate and specialty chemicals stages of the chain. Although Singapore's competitive advantage in the chemicals industry is derived from upstream production of commodities chemicals, which distinguishes it somewhat from the Philippines experience, the country's approach to developing a supportive institutional environment for upgrading into the R&D intensive segments of the chain offers rich examples for policy formulation, including building collaborative R&D operations and human capital development to support R&D growth.

3.1. Malaysia: Functional Upgrading in Oleochemicals

Malaysia is the world's largest oleochemicals exporter, accounting for some 20% of global capacity (Frost & Sullivan, 2014; MIDA, 2014). A long time palm oil producer, the largest ahead of Indonesia until 2005, the industry was born in the 1980s out of initiatives to upgrade into higher value-added products, and a desire from key consumers of oleochemicals to produce in lower cost locations. By 2015, the Malaysian oleochemicals industry had upgraded further into the production and export of oleo derivatives, as well as developing a range of final consumer products for the local market. In 2014, the major export products are fatty acids (32%), methyl ester (20%), fatty alcohol (19%), soap noodles (15%) and glycerine (12.3%). These products are destined for a growing range of end markets, including the food and beverage sectors, personal care, consumer and industrial uses as well as high value pharmaceutical products (Emerging Markets Direct, 2015).

The oleochemicals industry, today, is comprised of both local and foreign investors, with approximately 22 firms, the majority of which are vertically integrated into the supply of raw

[16] As this market segment emerges, definitions as to what constitutes a "bioplastic" are still emerging. For example, not all bioplastics are biodegradable, and not all biodegradable plastics are sourced from renewable resources.

materials (Emerging Markets Direct, 2015; European Union Delegation to Malaysia, 2012). Local firms such as KLK Oleochemicals and Wilmer International are global leaders (Emerging Markets Direct, 2015; Frost & Sullivan, 2014); foreign firms include Belgian Oleon and IFFCO from the United Arab Emirates (BFTA, 2014). Early investments were driven, on one hand, by palm oil plantation owners seeking to add further value to their basic oil products, and on the other, by joint ventures from foreign firms seeking to tap into the abundant supply of raw materials available. These foreign firms, such as P&G and Kao Corporation (MIDA, 2014), were important partners in the transfer of key technologies to the country. Investment by both local and foreign firms in expanding capacity continues with oleochemicals accounting for 20% of the total palm oil industry investments (RM482 million in 2013); including the KIL fatty alcohol plant (100,000MT) and the Emery Oleochemicals fatty acid plant (300,000MT) which were brought online between 2014 and 2015 (Frost & Sullivan, 2014; MIDA, 2014). Capabilities have been increasing in final product categories by serving the local market, particularly in personal care and food additives. This has paid off; the Turkish soap producer Evyap's US$200 million investment in a fully integrated oleochemicals-personal care complex in Johor. With a capacity of 400,000 MT this is set to be Malaysia's largest oleochemicals plant (MIDA, 2014).

The new plants established in the region were highly competitive with those operating in traditional markets, such as Europe and US. With state of the art technologies, these plants were more productive, and the readily available supply of raw materials meant that many could run at close to full capacity. The sector is notably almost entirely served by local raw material supply (Frost & Sullivan, 2014). In 2014, oleochemical producers were running at an average capacity of close to 80%; meanwhile, efficiency at the mill level had helped to increase the oil extraction rate from palm seeds and kernels (Emerging Markets Direct, 2015). Furthermore, with growing health concerns about the use of tallow-based (i.e. animal fats) oleochemicals following the Bovine Spongiform Encephalopathy[17] outbreaks of the early 1990s, demand increased for vegetable-based products.

A series of government policies and programs have helped to support the development of the sector. These have applied to both the upstream stages of developing raw materials supply, as well as in the mid and downstream stages of basic oleochemicals, derivatives and final products. These initiatives have generally been driven by central policy goals laid out in the numerous industrial plans set out by government since the early 1980s. While the first industrial plan focused on building competitiveness amongst palm oil refiners, the second plan (1995-2005) focused on functional upgrading into oleochemicals with some 17 separate tax incentives regarding partial or total exemption from import duties, sales taxes and excise duties for companies in the oleochemicals industry included in the SMIP (European Union Delegation to Malaysia, 2012; ICIS, 2005). Similarly, the Economic Transformation Plan (2011-2020) also included palm oil as one of its 12 key sectors (European Union Delegation to Malaysia, 2012).

A central tenet of policies for driving functional upgrading through the oleochemicals value chain in Malaysia has been the implementation of the crude palm oil tax. This was first implemented in the 1960s; between 1974 and 2013, this export duty charged a sliding scale of taxes on crude palm oil exports between 10 and 30% depending on market price. Over the

[17] Commonly referred to as "mad cow disease."

period, this averaged around 22-23% (European Union Delegation to Malaysia, 2012). As the world's largest producer of palm oil until it was overtaken by Indonesia in 2006, this tax was an important stimulus for driving both local palm oil producers and foreign buyers of palm oil to establish processing plants in the country. This tax was readjusted in 2013 to between 4.5 and 8.5% to improve the country's competitiveness vis-à-vis Indonesia which only imposed a US$50/ton fixed price tax on exports (Emerging Markets Direct, 2015). Controlling over 85% of the supply of palm oil, this has provided both countries with a significant advantage over other oleoproducers and helped to stimulate production in the region (Frost & Sullivan, 2014).[18] In addition, the government has used this as an instrument to avoid the accumulation of excessive stockpiles, by temporarily suspending the tax as it did between September 2014 and March 2015 (Emerging Markets Direct, 2015; Pakiam, 2014) .

This disincentive to export crude products was supported by additional measures to stimulate upgrading. These included direct tax incentives and credits from the import of equipment, support for R&D, and favorable conditions for foreign direct investment. In addition, the government sought to stimulate local demand for palm oil products, through the 2006 Biofuels policy, which similar to the Philippines initiative mandated a 5% methyl ester content and provided R&D incentives for upgrading into biodiesel and biomass projects (Emerging Markets Direct, 2015).

In addition to driving downstream initiatives, the government has focused on ensuring continued growth and supply of raw materials, which continue to be the key source of its competitive advantage. The Ministry of Plantation Industries and Commodities offers replanting incentives and support to small producers (<40ha) (European Union Delegation to Malaysia, 2012). For example, in 2013, they launched another scheme to replace some 100,000 ha of trees that were over 25 years old (some 2% of the local crop) (Emerging Markets Direct, 2015). Credit is also available for the purchase of improved seed varieties for replanting to incentivize the switch towards more resistant and productive varieties.

The government created a set of core institutions to support the development of the sector. Amongst the earliest of these initiatives was the Palm Oil Research Institute of Malaysia established in 1979, focusing on identifying opportunities to introduce new technologies, increase productivity, and add value to palm oil products. This later became the Malaysian Palm Oil Board in 2000. The Advanced Oleochemical Technology Division was set up in 2004 to research potential for downstream oleochemical applications. Research undertaken by the Board is financed by both the public and the private sectors. The Malaysian Palm Oil Council was established in 1990 to drive branding and marketing of the country's products, with offices in most major markets, including China, the EU, India, Turkey and the US (European Union Delegation to Malaysia, 2012). In addition, a tri-partite council, the Chemical Industry Council of Malaysia was established in 1978. Although a private entity, it plays a proactive role in bringing together the private and public sectors and academia to focus on key issues for developing the industry. Oleochemicals producers are represented as a product group by the Malaysian Oleochemical Manufacturers Group (AOMG, 2016a).

---

[18] Indonesia accounts for 49% of global production and has also put in place an export tariff to drive investment in downstream processing (MIDA, 2014).

Box 4. Emery Oleochemicals: Upgrading into Specialty Chemicals

To successfully upgrade into higher stages of the oleochemicals value chain, Malaysian plantation owner, Golden Hope Plantation (now Sime Darby) established a joint venture with Cognis (a subsidiary of Henkel) in 2006. In 2008, Thai PTT Chemicals acquired Cognis's stake, making the company a fully-owned South Asian firm. With full control over its entire supply chain, the rebranded Emery Oleochemicals, continued to strengthen its legacy presence in developed country markets, where it has established additional research centers and pilot plants in innovative new oleo derivatives and specialty chemicals. The goal was to shift from a dependence on basic oleochemicals to generate 50% of its revenues from specialty sales (Beacham, 2012a).

Recent investments in capabilities higher in the value chain include a US$25 million oleo-based polymer additive plant in Germany, an ethoxylation plant in the Netherlands, and a bio-based polyols facility in Cincinnati to serve the automotive, furniture and major appliances demand for eco-friendly coatings. These investments have allowed the firm to tap into sources of expertise in leading chemical countries, and, importantly, position themselves close to key clients. With Europe and the US continuing to lead the demand for green chemicals, proximity to these clients for the development of new solutions is essential. In the medium term, Emery will be able to leverage its expertise to serve the growing demand for eco-products in its Asia-Pacific home base.

Source: Beacham (2015); de Guzman (2013); Emery Oleochemicals (2016a, 2016b)

3.2. Singapore Upgrading from Commodities Chemicals to Intermediate and Specialty Products

The chemical industry in Singapore is one of the largest contributors to GDP in the country, accounting for some 37% of GDP in 2014 with over 100 chemicals producers manufacturing products. Cumulative investments in the industry are close to US$47 billion (Lim, 2016). Despite no competitive advantages in feedstock availability, the country built its chemicals business based on highly productive and well-located petrochemicals refining operations and the strategic development of the integrated petrochemicals complex in Jurong Island; a result of significant infrastructure development and coordination by the Economic Development Board (EDB) (Carpenter & Kiong Ng, 2013), which included not only reclaiming of land, but also construction of roads and facilities.

However, in the face of rising regional capacity in commodity chemicals over the past decade, the country has switched from actively seeking additional upstream capacity to a strategy focused on upgrading into the production and formulation of the specialty chemicals stage of the value chain, in addition to focusing on improving its environmental efficiency by attracting energy efficient and 'green chemicals' producers with Jurong Island 2.0 (EDB, 2016a; Yep, 2013). The Asian market for specialty chemicals has been valued as high as US$350 billion in recent years (Marketline, 2015e; McElligott, 2012), and Singapore's proximity to this strong and growing market provides it with a key competitive advantage over traditional European, US and even Japanese supply for the region.

Initial growth in intermediate and specialty chemicals was concentrated on those for the export-oriented electronics sector in the country. Today, this has diversified into numerous different industrial end markets, both for direct and indirect exports. Progress has occurred with respect to engaging in the production of specialty chemicals as well as their formulation. Between 2013 and 2015, more than six new production facilities and three new R&D laboratories were opened. Output reached US$9.6 billion in 2013, having doubled from 2003 and accounting for 10% of the country's chemical production and close to ¼ of exports (Seow, 2015; Singaporean-German Chamber of Industry and Commerce, 2014).

With a growing number of R&D centers in the country for a range of different industries from aerospace and electronics to medical devices (EDB, 2016b), the country has become a good location for collaboration on specialty chemical solutions for these industries. Growth has been helped by investments from multinationals seeking to establish operations to serve the growing Asian market. The country is now host to a growing number of intermediate and specialty producers, including large global players such as Clariant, Evonik, Degussa, Dupont, Lanxess and Solvay Novecare (Beacham, 2012b; Channel NewsAsia, 2015; ICIS, 2015a; Solvay, 2016). Clariant have a production facility for polymer colors as well as a platform for collaborative product formulation to work with buyers in a wide range of industries. Solvey Novecare also established an R&D laboratory to complement its new intermediate alkoxylation plant. Evonik has a new R&D center for coating additives. These R&D centers have created highly skilled—and high paying - job opportunities in recent years.

Singapore's EDB was instrumental in driving the initial development of the industry and ensuring the success of the Jurong Island complex, particularly by providing market access through trade agreements, hard infrastructure and logistics operations. An integrated chemical logistics park, Banyan LogisPark, sits on 80 ha adjacent to chemical operations (Hing & Lee, 2009). As the country has sought to upgrade, additional 'soft' factors including a strong commitment to human capital development, intellectual property protection, and an institutionalized approach to public-private research collaboration have become just as important.

Human capital initiatives are focused on both developing professionals to work at the R&D level, as well as ensuring a supply of operationally-ready technicians for plant work. The Workforce Development Agency (WDA) offers four certificate programs for the industry, from foundational courses for technicians through to an advanced diploma level course of managers in chemicals production (WDA, 2016). The Chemicals Process Technology Center, established by Nanyang Polytechnic together with EDB provides pre-employment training for up to 800 students per year, and training for 8,000 employed workers in true scale operations. These training initiatives to a large degree can be financed by incentives provided by the WDA—particularly for smaller firms. In addition, through the Agency for Science, Technology and Research (ASTAR), scholarships are available for both local and foreign students to pursue their doctorate degrees at the country's two leading universities while pursuing research at an ASTAR facility of their choice (ICES, 2016b). This approach has paid off and some three quarters of the 26,000 employees in the chemicals sector are either Singapore citizens or permanent residents (EDB, 2014). The growing competition for skilled workers has also encouraged companies to establish training programs. Clariant, for example, has launched a 24-

month graduate program including 6 months working abroad to gain exposure to the company's operations (Seow, 2015).

Singapore has leveraged its ASTAR research institutions to drive collaborative R&D with the private sector, while its strong intellectual property protection laws—it ranked 4th globally for intellectual property protection in 2015 (World Economic Forum, 2016) - provide additional institutional advantages for upgrading. The primary ASTAR research institute in the chemicals sector is the Institute of Chemicals and Engineering Sciences (ICES) that was established on Jurong Island to operate as an autonomous R&D center working directly with firms to help them develop new solutions, as well as process optimization and run pilot-scale operations. Sustainable and Innovative Processes for Specialty Chemicals is one of the Center's key research programs (ICES, 2016a). Companies can either directly collaborate with the center, or they can hire ICES staff to work directly on their projects. For smaller sized firms, under US$100 million or 200 workers, with local ownership, these benefits can be partially funded (up to 70%) by the government through SPRING's Capabilities Development Program. These grants can be used for innovative product, process or even market upgrading (SPRING, 2016). Larger foreign firms can also access financial benefits for R&D, although funding and incentives vary (Deloitte, 2014). Finally, the Ministry of Trade and Industry set up the Intellectual Property Intermediary to facilitate commercialization of innovative technologies through licensing at matching events, such as the Techinnovation conference held annually since 2011.

Infrastructure, nonetheless, remains an important competitive advantage of the country's upgrading into the intermediate and specialty segments of the chain as it did in the commodities stages. The economies of scale and scope achieved through the geographic clustering in Jurong help lower overall costs for specialty chemicals producers. Jurong Town Corporation Chemical Hubs at Tuas View, for example, is set up to host multiple firms in shared facilities with safety and security compliant features and ready access to a wide supply of commodity and intermediate chemical inputs. This makes it both easier and cheaper for smaller specialty firms to set up operations (Lim, 2016).

4. The Philippines and the Chemical Global Value Chain

The chemicals sector in the Philippines is rapidly growing alongside economic expansion and a revival in manufacturing. By 2013, the chemicals sector as a whole accounted for 6.7% of the GDP (DTI, SPIK, et al., 2014). Sector employment is just under 50,000 (Philippines NSO, TBD). Chemicals exports reached US$2.2 billion in 2014, approximately 3.5% of the country's export basket. Export growth has outpaced both global and regional trade; with a compound annual growth rate of 13% since 2007, three times as fast as global exports (4%), and twice as fast as Asian regional exports (7.2%).

The Philippines participates primarily in the oleochemicals and petrochemicals chemicals markets. Within these segments, exports are driven by a small number of products, with the top 10 accounting for approximately three-quarters of all exports. While overall the country is a very small player in global chemicals trade, accounting for just 0.2% of global exports in 2014, it has generally been successful in carving out a presence in its niche products and is one of the global leaders in most of its top product categories. These products include more traditional products, including glycerine and fatty alcohol based on its older oleochemicals operations, as well as new products such as aromatic petrochemicals and nickel-cobalt sulphide. The petrochemical and oleochemical sectors have the highest value addition, as both sectors operate in several stages of the chain, from input supply, through to semi-processed or processed products.

Growth has been stronger in certain sub sectors than others. Competitiveness is constrained by a range of factors, including a lack of raw materials, poor economies of scale, and binding constraints such as logistics and energy costs. As a whole, it has been more cost-effective for firms to manufacture abroad and import to the Philippines. Several firms in the oleochemicals sector have been non-operational for much of the past five years, unable to compete against more efficient and lower cost producers in neighboring Indonesia and Malaysia. Meanwhile petrochemicals firms, which had shut down operations for much of the early 2000s, reinitiated operations towards the end of the last decade.

4.1. The Development of the Chemicals Industry in the Philippines

The chemicals manufacturing sector has developed traditionally as a home-based industry serving the domestic market, although capacity is far short of demand, forcing the country to rely on imports. Today, there are approximately 516 firms operating in the chemicals sector in the Philippines (DTI, SPIK, et al., 2014).[19] Large global players including BASF, Dow, Dupont and Bayer are all present in the country, primarily in a sales and marketing capacity importing from regional production hubs, such as Thailand, Malaysia, and Indonesia.

Exports from the Philippines, and its participation in the chemicals GVC, have been more recent, with most progress occurring since the mid-1980s. This growth can be broken down into three distinct areas: (1) oleochemicals, (2) petrochemicals and, finally (3) forays into a

[19] 92 of these are engaged in the production of basic chemicals, 8 in refined petroleum products, 67 in pharmaceuticals, and 147 in other chemicals (Philippines NSO, TBD).

variety of basic, intermediate, specialty and final products. Each grouping is discussed below.

1. The Philippines longest standing participation in the chemicals GVC has been in the oleochemicals segment. The oleochemicals industry, which is built on the local coconut sector, emerged in the 1970s as a result of both domestic and Japanese investments. During the next two decades, the export-oriented industry grew significantly, becoming a leading exporter by the mid-1990s of fatty acids, fatty alcohols, crude and refined glycerine and soap noodles. By 1996, there were 12 firms producing oleochemicals (Frost & Sullivan, 2014; ICIS, 1996). Competition in the region was minimal. However, since then, Indonesia and Malaysia have made a dramatic entry into the market, developing palm-based oleochemical products. Built on largely under-funded, small-scale coconut farming production, the Philippines has not been able to maintain its competitiveness with the vertically integrated plantations and state-of-the-art processing facilities in neighboring countries. These regional developments have damaged the Philippine position and prompted a reconfiguration of the local industry. A small number of firms have continued to aggressively upgrade their capacities, processes and products, including producing specialty surfactants. Others have shifted focus towards the production of biofuels, while several large firms (Cocochemicals, Unistar Oleochemicals Corporation, and Lina Holdings) have closed their operations since 2010 (Field Research, 2016; Pazzibugan, 2013). Today, there are nine firms that continue to operate.

2. The petrochemicals sector developed at the end of the 1990s, with almost all major firms making investments within a two-year period that centered on the production of plastic resins. These efforts were in part thanks to joint public-private initiatives to support the development of a sector, including the drafting of a master plan for the industry in the mid-1990s. The sector's establishment, however, was far from smooth. Although plants were established in the 1990s, trade liberalization brought challenges and both PE and PP plants in Bataan closed their operations for several years before being re-commissioned in the later 2000s (DTI, APMP, & BOI, 2014). The overarching goal has been to satisfy the domestic demand first before contributing to exports. The sector today comprises seven manufacturers of PE, PP and PVC, as well as two cracker plants (JG Summit and Petron). These firms are almost entirely focused on serving the domestic market, although the growing local capacity also serves some regional demand for commodity chemicals, with aromatics exports to China and Vietnam.

3. Very incipient entry into basic inorganic, intermediate and specialty products by a small number of firms. Within the past decade or so, a number of firms have entered into the export of a wide range of products. There is relatively little cohesiveness to this latest evolution and products fall into a range of different value chain stages and are directed to different end markets.

4.2. Philippine Current Participation in the Chemical Global Value Chain

Currently, the Philippines is primarily an exporter of basic and commodity chemicals rather than intermediates and specialty chemicals or final products. In 2014, 69% of the Philippines chemical exports were basic/commodity chemicals stage, compared to just 15% intermediates, and 14% in specialty chemicals and final products (see Table 12 below).[20] Within the basic/commodity chemicals stage, the largest sector is organic chemicals, followed by inorganic chemicals, and petrochemicals. Within intermediates, surfactants are the largest sector, while personal care items (including toiletries, hair care, and shaving cream, etc.) are the largest sector within the final products stage. The highest value addition, as expected, comes from finished products in the consumer product range, while lowest is derived from mature basic chemicals (DTI, SPIK, et al., 2014).

Table 12. The Philippine Chemical Exports by GVC Stage, 2007-2014

Value Chain Stages & Selected Sectors	Value (US$, billions)				Philippines Share of World (%)				Share of Philippines Chemical Exports (%)			
	2007	2010	2012	2014	2007	2010	2012	2014	2007	2010	2012	2014
Total	**0.9**	**1.6**	**1.9**	**2.2**	**0.1**	**0.1**	**0.1**	**0.2**				
Basic & Commodity Chemicals	**0.7**	**1.2**	**1.2**	**1.6**	**0.1**	**0.2**	**0.1**	**0.2**	**75.3**	**77.0**	**64.2**	**70.8**
Organic			0.5	0.9	0.0	0.0	0.1	0.2	0.0	0.0	25.7	41.5
Petrochemicals			0.2	0.2	0.0	0.0	0.1	0.1	0.0	0.0	12.8	7.8
Inorganic			0.3	0.3	0.0	0.0	0.3	0.4	0.0	0.0	16.0	15.9
Other			0.2	0.1	0.0	0.0	0.1	0.1			9.7	5.7
Intermediate Chemicals	**0.1**	**0.2**	**0.4**	**0.3**	**0.1**	**0.1**	**0.2**	**0.2**	**13.4**	**12.0**	**19.8**	**15.1**
Oils			0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.4	0.3
Coatings			0.0	0.0		0.0	0.0	0.0	0.0		0.2	0.3
Surfactants			0.2	0.2		0.0	1.0	1.0	0.0		8.2	7.0
Activated Carbon			0.1	0.1		0.0	4.6	3.7	0.0		5.6	4.7
Other			0.1	0.1		0.0	0.1	0.0	0.0		5.4	2.8
Specialty Chemicals & Final Products	**0.1**	**0.2**	**0.3**	**0.3**	**0.1**	**0.1**	**0.2**	**0.1**	**11.3**	**11.0**	**15.9**	**14.1**
Coatings	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	4.2	2.3
Pesticides			0.0	0.0		0.0	0.0	0.0	0.0		0.2	0.0
Personal Care	0.0	0.0	0.1	0.2		0.0	0.2	0.2	0.0		7.7	8.2
Other	0.0	0.0	0.1	0.1		0.0	0.2	0.2	0.0		3.8	3.5

Source: UN Comtrade, HS02 4D and 6D (6D only for HS Chapters 34, 35 and 37), Philippine exports to the world. Retrieved on October 31, 2015.

All major export categories draw directly on the country's raw materials supply in coconuts, minerals and the emerging petrochemicals sector. The top 10 exports in 2014 accounted for US$1.6 billion, which represented almost 75% of all chemical exports (see Tables 12 and 13). These included: (1) glycerine/glycerol, (2) nickel-cobalt sulphide, (3) aromatic hydrocarbons, (4) fatty alcohol in the commodity chemicals segment and (5) activated carbon and (6) surfactants in the intermediates segment. Glycerine/glycerol and fatty alcohol, the two leading oleochemicals exports together with activated carbon and surfactants draw directly on the country's coconut production. Nickel cobalt-sulphide is derived from the extraction of nickel and is used for the production of electrolytic nickel and cobalt for batteries, and magnets. Key

[20] This is similar to global trends in which commodity products, by sheer volume, account for the largest share of global trade (see Global Trade in the Chemicals GVC).

aromatic hydrocarbons exports are mixed isomers, benzene and toluene (UNComtrade, 2015a). Overall, participation globally is low, although the Philippines is a top ten exporter globally in oleochemcials, nickel-cobalt sulphide and activated carbon product categories (UNComtrade, 2015a).

Table 13. The Philippine Top 10 Chemical Export Products, 2014, by Value

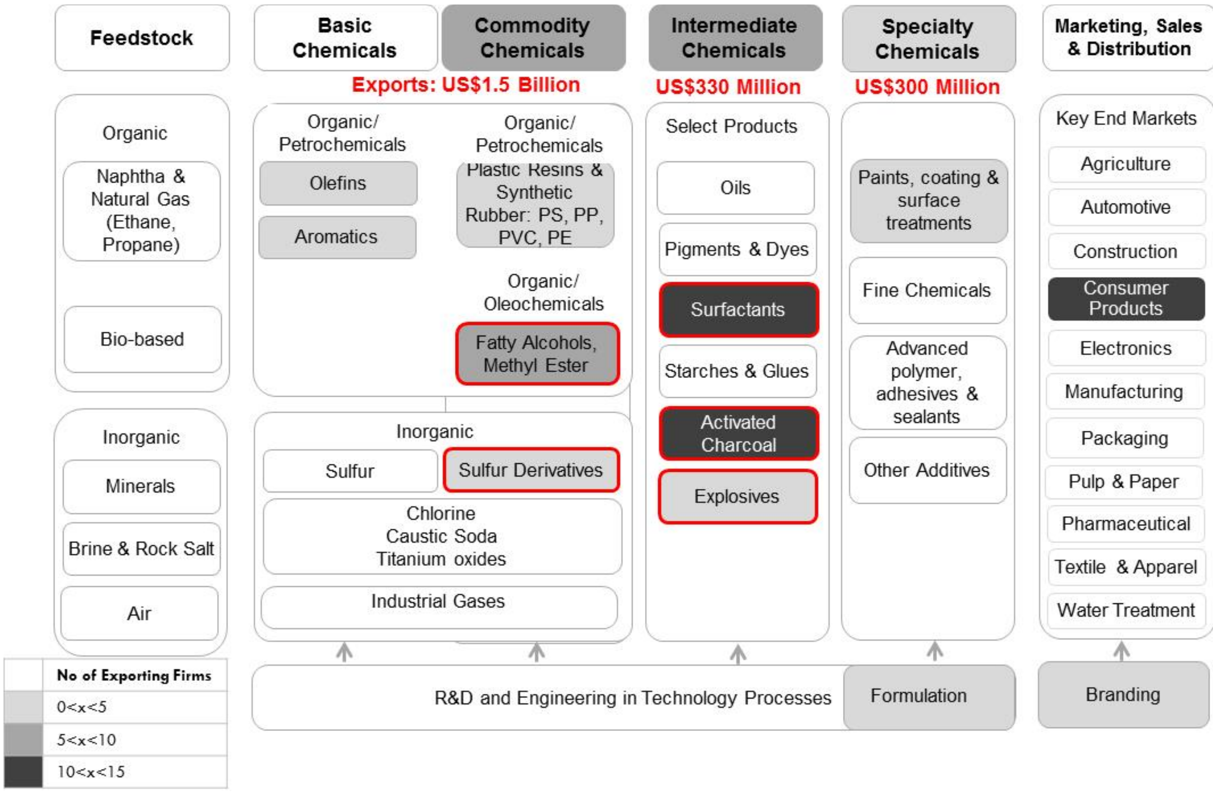
HS Code	Product Description	Value (US$, millions)	Share of Philippines Chemical Exports	Share of Global Exports (%)
Total		**2,192**		
290545	Glycerine/Glycerol	418.6	19.1	27
283090	Nickel-cobalt sulphide	282.1	12.9	100
2902	Aromatic Hydrocarbons	222.2	10.1	0.4
290517	Fatty Alcohols (coco)	202.5	9.2	38
3402*	Surfactants	154,2	7.0	1
3307	Personal Care Preparations	129.1	5.9	1
3802	Activated Carbon	102.5	4.7	3.7
3105	Fertilizers	47.8	2.2	0.2
3602	Prepared Explosives	46.2	2.1	3.1
3215	Ink	29.0	1.3	0.2
Total Top Ten		**1,605**	**73.2**	

Source: UNComtrade, HS02 4&6D, Philippines exports to the world, retrieved on October 31, 2015.

Note: Excludes raw feedstock; HS4D-3402 excludes 340220 retail preparations

Figure 4 illustrates the position of the Philippines in the chemicals GVC. Shaded segments represent participation in the GVC; the degree of shading, from lighter to darker, denotes the number of firms in each segment. Firms with exports over US$1 million in 2014 were considered. Segments outlined in red/dark lines indicate that the Philippines is a top 10 global exporter of the particular product.

Figure 4. The Philippines Participation in the Chemicals GVC



Source: Authors; Data from PSA (2007-2014), UN Comtrade (2015).

Note: The number of firms in each stage of the chain corresponds to firms with US$1 million in exports in 2014. Segments outlined in red/dark lines indicate that the Philippines is a top 10 global exporter of the particular product.

The composition of firms engaged in exports from the Philippines is reflective of the global sector. There are relatively few firms in the major export categories and these firms are concentrated in a small number of products, with very little overlap across segments.[21] Although leading diversified chemicals producers Dow, Dupont and BASF all have sales offices in the Philippines, these firms do not manufacture locally and there is only one export-oriented semi-diversified firm, Chemrez. The specialty and final products segment is more varied, with a higher number of firms. In general, firm origin is mixed in all product categories, with numerous foreign firms investing alongside more established local firms in recent years.

Oleochemicals: Oleochemicals continue to lead the country's chemicals exports, but the sector has shrunk over the past five years with a number of firms exiting the industry, including one of the oldest and largest operations, Cocochem (Field Research, 2016). The remaining companies include Chemrez, Kao Chemicals, Pan Century Surfactants, Sakamoto Orient Chemicals Corporation (SOCC) and Stepan. These firms include both domestic and foreign investors; Kao is a global leader in the oleochemicals sector - the fourth largest global supplier of detergent

[21] This is based on the analysis of firm-level exports for each of the HS-6 Digit product codes for the country's major products PSA (2007-2014).

alcohols (de Guzman, 2013). Each respective product segment of the oleochemicals industry is highly concentrated. For example, in the case of glycerol, the country's largest export, the leading firm has accounted for over 90% of exports since 2007 (PSA, 2007-2014). There are currently no fatty acid plants operational in the Philippines, although two plants, Cocochem and Pan Century, have fatty acid production capacity (DTI, SPIK, et al., 2014).

Table 14. Principal Oleochemicals Exporters in Philippines, 2014

Firm	Origin	Key Oleochemical Products	Year Est.
Chemrez Technologies	Philippines	Methyl Esther	1982
JNJ Oleochemicals	Philippines	Methyl esters, crude glycerine, amides	2010
Kao Chemicals	Japan	Fatty Alcohol, Fatty Amines, Glycerine	1977
Pan Century Surfactants*	India	Glycerine; fatty alcohols	(1994) 2015
PEPMACO	Philippines	Surfactants	2004
Sakamoto (SOCC)	Japan	Refined glycerine	1988
Stepan Philippines Inc	US	Surfactants	1995

Source: Field Research (2016); PEZA (2015).

Note: Pan Century Surfactants was originally Prime Oleochemicals. The operations was shuttered for several years until Pan Century acquired the operations and re-registered as an export firm in 2015.

Competitiveness in recent years has been affected by higher costs of raw materials and less efficient manufacturing processes compared to other producers, Malaysia and Indonesia. The core input for the oleochemicals sector is coconut oil. In addition to strong demand for oleochemicals in personal care, and household cleaners, there has been a general increase in demand for coconut inputs in the food sector both as an alternative vegetable oil, as well as a 'sports drink'. However, the increase in demand has coincided with falling production in the Philippines. With a pervasive small-scale farming structure, supply of coconuts has been declining due to underinvestment in coconut plantations, aging trees, and falling productivity. From a total plantation area of nearly 3 million hectares, concentrated in Mindanao province, 1.24 million hectares, or 40% of the plantation area, are senile and nutrient-deficient trees (CPBRD, 2012). The average productivity is down to 38-40 nuts per tree per year from the ideal 75 nuts per tree per year (CPBRD, 2012). This combination of supply fluctuations and increased demand has made coconut oil in the Philippines approximately 20% more expensive than alternative palm kernel oil over the past two years (Frost & Sullivan, 2014). This has made it difficult for firms to compete.

Surviving firms have invested in expansion and upgrading of their operations to remain competitive, particularly in the production of crude and refined glycerine (Field Research, 2016; PEZA, 2015). Glycerine is a by-product in the production of bio-fuels (Bauer & Hulteberg, 2013); several sources attributed this shift to the 2006 Biofuels Act, which mandates blending coco methyl ester with the country's diesel supply (AOMG, 2016b; Field Research, 2016; GAIN, 2014). Others have also diversified into the production of virgin coconut oil and related products for the food industry (Field Research, 2016). Although there is R&D occurring at the coconut production level, only two oleochemical firms reported engaging in any R&D activity at the processing level (Kao Chemicals), and processing technologies are generally imported (Field Research, 2016; PEZA, 2015).

Petrochemicals: The petrochemicals segment is even more concentrated than oleochemicals and currently only operates in polymer production, with no derivatives being manufactured in the country. Two firms are active per product segment (see Table 15). JG Summit and Petron operate cracking facilities (naphtha and LPG, respectively), producing primarily olefins (ethylene and propylene) and aromatics (benzene and toluene). Exports in these segments began in 2009 (PSA, 2007-2014; UNComtrade, 2015a), when Petron's cracker plant came online (DTI, APMP, et al., 2014), and will likely increase as a result of JG Summit's operations in 2014 (Field Research, 2016). These firms, however, are principally oriented towards the local market, and total aromatic and olefins exports amounted to just US$250 million in 2014. (UNComtrade, 2015a). Both investors are domestic firms—this is indicative of the weaker competitiveness of the Philippines as a location in the petrochemicals sector. With no local raw materials,[22] and only a medium-sized downstream market,[23] there is limited incentive for foreign firms to set up operations in the country when there are significant benefits of operating in other locations to serve the region such as Singapore, Malaysia or even the US as discussed earlier in the report.

Table 15. Petrochemical Firms in the Philippines, 2014

Firm	Origin	Primary Products & Capacity (MT/Y)	Investment (US$, millions)	Launch Year
Petron Corporation	Philippines (Public)	Propylene: 140,000 Benzene: 20,000 Toulene: 150,000 Mixed Xylene: 220,000	300	2009
JG Summit Olefins Corporation (JGSOC)	Philippines	Ethylene: 320,000 Propylene: 190,000 Pyrolysis gasoline, Mixed C4	800	2014
Chemrez/Chemrez Technologies Inc. (affiliate of D&L)	Philippines	Polystyrene (PS): 30,000 Polymer Emulsions: 14,000 Unsaturated Polyester (UPR)	37	1982
JG Summit Petrochemical Corporation (JGSPC)	Philippines	Polyethylene (PE): 169,000 Polypropylene (PP): 175,000	350	1998
NPC Alliance Corp.	Iran	Polyethylene (PE): 250,000	330	2005
Philippine Resins Industry, Inc. (PRII)	Japan	Polyvinyl Chloride (PVC) resins: 100,000	61	1999
Philippine Polypropylene Inc.	Philippines	Polypropylene (PP)	180	1998
Tosoh Polyvin Corporation	Japan	Polyvinyl Chloride (PVC) compounds		1998

Source: (DTI, APMP, et al., 2014; Field Research, 2016)

Each of the respective polymer categories, PE, PE and PVC have a total capacity of 419,000 MT/Y, 335,000 MT/Y, and 200,000 MT/Y (DTI, APMP, et al., 2014). Comparatively, Malaysia produces 1,170,0000 MT/Y in PE, 373,000 MT/Y in PP and 110,000 MT/Y and Singapore produces 1,270,000 MT/Y in PE and 370,000 MT/Y in PP (APIC, 2016; Malaysian Petrochemicals Association, 2015), making Philippines a small regional producer of PE. In addition, Chemrez,

[22] The Philippines currently has one natural gas reserve in operation, however, there are no cracker facilities adapted for ethane.
[23] At 11kg/capita consumption of petrochemicals in the Philippines is well below the regional average of 56.5kg/capita (DTI, APMP, et al., 2014).

primarily an oleochemicals producer, produces polystyrene (Field Research, 2016), as do PPI and SMPI (DTI, APMP, et al., 2014). Again, these products are oriented to the domestic market and despite close to US$1 billion in investments between the mid-1990s and 2014, they accounted for just US$170 million in exports in 2014 (UNComtrade, 2015a). The petrochemical sector, nonetheless, aims to contribute to downstream export competitiveness for intermediate and specialty producers rather than compete in direct exports (Field Research, 2016). Foreign investors are from Iran and Japan. Japanese investments have been concentrated in PVC production. Geographic clustering as seen around global hubs such as Freeport, Jurong Island, and Kuantan is not strong, but there are two emerging poles, one in Baatan and the other in Batangas. The firms sell downstream to the plastics industry; there are approximately 485 plastics producers in the Philippines (Philippines NSO, 2013),[24] which are mainly clustered in the Metro Manila region (Field Research, 2016). Tosoh Polyvin Corporation supplies PVC to the country's booming automotive wire harness sector (Tosoh Polyvin Corp, 2016), and is co-located in Batangas.

Basic and Commodity Chemicals (Excluding Petrochemicals): This segment essentially consists of firms exporting nickel-cobalt sulphide. There are just two large producers of nickel-cobalt sulphide in the Philippines: Coral Bay (Sumitomo, Mitsui, Rio Tuba) and Tagalito (Coral Bay Nickel Corporation, 2016; Nickel Asia Corporation, 2016). Coral Bay entered production in 2005 and expanded in 2009, and Tagalito was commissioned in 2013 (Nickel Asia Corporation, 2016; Sumitomo Metal Mining Co, 2016). These firms include both domestic and foreign participation, however, almost all exports are destined for Japan (PSA, 2007-2014; UNComtrade, 2015a), where investor Sumitomo undertakes further processing. While prices were lower as a result of the decline in overall commodities prices globally in 2014, export volumes remained fairly constant.

Activated Carbon: In 2014, there were 10 firms in this product segment with exports over US$1 million, with a further 20 with exports over US$100,000 (PSA, 2007-2014). Several of the firms in the industry have operated since the 1990s; however, recent investments from Donau Carbon, Visayas Activated Carbon, and the expansion of PAACOI have helped to boost the industry's exports, which doubled between 2010 and 2014.[25] Exports are likely to continue to grow as the Japanese firm Jacobi Carbons site in Mindanao is brought online.[26] According to Jacobi, this 20,000 MT/Y plant is the world's largest activated carbon production facility and makes the company the largest in the world (Francisco, 2015; Jacobi, 2016a). These firms also draw on coconut value chain for shells and have tended to cluster close to the source in Mindanao. Activated carbon is used in the production of other specialty chemicals as well as for air filters, purification in the production of food and beverages and in the pharmaceutical industry. High purity activated carbon is also being used in the manufacture of supercapacitors (Jacobi, 2016b), which is likely to drive future demand for the product.

[24] The Petrochemical Industry Roadmap estimates there are approximately 100 plastics producers supplied by their operations (DTI, APMP, et al., 2014).
[25] Exports reached US$100 million in 2014, accounting for 4.7% of the country's chemical exports and making the country the 8th largest exporter of activated carbon globally (UN Comtrade, 2015).
[26] Jacobi Carbons is originally a Swedish firm. The company was acquired by Osaka Gas Chemicals from Japan in 2014.

Specialties & Final Products: Exports in the Philippine specialty chemicals sector were US$308 million in 2014. Personal care preparations and products account for over half of this, while coatings—dominated by paints—accounted for a further US$50 million. The Philippines participation in the personal care product segment has been driven in part by strong domestic demand, which has helped to drive capability development in the country.[27] In 2014, there were 12 firms with exports over US$1 million; although the bulk of exports are dominated by two companies that together produce deodorants and antiperspirants, bath products, and room perfuming preparations. The coatings segment consists of various smaller participants. There is only one exporter with over US$1 million in exports in 2014 (PSO, 2007-2014). India, Vietnam and Saudi Arabia accounted for over half of these exports in 2014. Nonetheless, the 29 local paint manufacturers (Field Research, 2016) have developed a strong position in the Asian market through domestic sales, thanks to stronger relative consumption of premium paint in the Philippines. One firm is even ranked in the top 100 firms, globally (Coatings World, 2015b).

End Markets

Overall, Philippine exports serve regional value chain destinations. As shown in Table 16, of the top ten export destinations between 2007 and 2014, only the US and Belgium are outside of the Asia-Pacific region. In addition, export destinations are becoming more concentrated with the top 10 destinations accounting for 86% in 2014, compared to 74% in 2007.

Table 16. Top Ten Philippine Chemical Export Destinations, All Products, 2007-2014

	Export Value (US$, millions)				Share of Philippines Exports (%)			
	2007	**2010**	**2012**	**2014**	**2007**	**2010**	**2012**	**2014**
World	**944**	**1,598**	**1,911**	**2,192**				
Japan	346	425	318	824	37%	27%	17%	38%
China	76	251	246	428	8%	16%	13%	20%
Other Asia, NES	—	203	214	137	--	13%	11%	6%
USA	61	88	146	111	6%	6%	8%	5%
Indonesia	48	38	85	88	5%	2%	4%	4%
Rep. of Korea	33	91	153	84	3%	6%	8%	4%
Malaysia	25	—	44	57	--	3%	2%	3%
Australia	27	—	--	44	3%	--	--	2%
Thailand	31	41	132	43	3%	3%	7%	2%
Viet Nam	52	129	136	40	6%	8%	7%	2%
China, Hong Kong SAR	—	—	75	23	—	—	4%	1%
India	—	54	—	—	—	—	—	—
Belgium	25	—	—	—	3%	—	—	—

Source: UNComtrade, HS02 4D and 6D (6D only for HS Chapters 34, 35 and 37), Philippines exports to the world. Retrieved on October 31, 2015.

Note: NES refers to "Not elsewhere specified"

These top 10 destinations have also consolidated over the past decade, with just 13 countries participating during this time. Japan continues to be the Philippines most important chemicals

[27] Domestic demand was valued at around US$3 billion in 2015 (Euromonitor, 2015).

trading partner, although China is quickly gaining relevance. By 2014, these two markets accounted for 58% of all chemicals exports.

Product-level analysis for the leading five product groups provides a somewhat more varied picture. Certain product categories show strong linkages with specific end markets; for example, nickel-cobalt sulphide, as highlighted earlier, is destined almost exclusively for Japan, as a result of strong value chain links between the key Japanese buyer, which has majority stakes in the two processing plants in the Philippines. Oleochemical exports show slightly divergent patterns: Glycerine is also closely linked to Japan—which accounted for 98% of exports in 2014—through SOCC and Kao Chemicals; other oleo derivatives are directed to a more diverse number of markets (PSA 2007-2014).

Table 17. Leading Destinations for Top Five Product Group Exports, 2014

Product Group	Top Three Destinations	Share of Group Exports
Acylic Hydrocarbons (incl. glycerine)	Japan, Netherlands, Republic of Korea	91%
Nickel Cobalt Sulphide	Japan, China	100%
Aromatics	China, Other Asia (nes)	97%
Personal Care	China, Australia, US	73%
Activated Carbon	Germany, Japan, China	57%

Source: UNComtrade, HS02 4D and 6D (6D only for HS Chapters 34, 35 and 37), Philippine exports to the world. Retrieved on October 31, 2015.

The end market for activated carbon has also seen strong participation from the top 10 destinations, which have accounted for over 80% of exports during the 2007-2014 period. However, the mix and relevance of countries has changed. In particular, Germany has rapidly emerged as a destination for the products—with exports doubling between 2010 and 2012 and then again between 2012 and 2014. One possibility for this increase could be the commissioning of the Donau Carbon plant in 2011. Aromatic petrochemicals are very new export commodities for the Philippines; the movement in their end markets reflects the volatility of spot global petrochemicals trade. Nonetheless, China is emerging as a strong market destination for these products. Similarly, trade in final product categories, such as toiletries building on the country's oleochemical businesses, was more varied, with China, Australia and the US featuring as top destinations for the 2007-2014 period.

4.3. Philippine Upgrading in the Chemicals GVC

While the Philippines continues to export primarily commodities, several examples of upgrading can be identified within the industry. These are highlighted in Table 18. In addition, although the paint segment remains a small contributor to exports, at a firm level, significant upgrading has occurred serving the local market, which positions the Philippines well for exports in this category. Box 5 highlights the experience of leading paint producer, Pacific Paint (Boysen).

Table 18. Select Examples of Upgrading in the Chemicals GVC, Philippines

Value Chain Segment	Value Chain Sub-segment	Type of Upgrading	Description
Basic Chemicals & Commodities	**Basic Chemicals**	**Entry:** Production of Nickel-Cobalt Sulphide	• Strong entry into nickel-cobalt sulphide exports • Grown to US$282 million since 2003. • Plants apply cutting edge HPAL process technology
	Petrochemicals	**Functional Upgrading:** Backward Linkages	• Backward linkages forged with two cracker plants • Ethylene production for PE increases from 0 to 320,000MT.
		Functional Upgrading: Forward Linkages	• A PVC plastics manufacturer is directly drawing on local production to support the automotive wire harness sector for export.
	Oleochemicals	**Process & Product Upgrading**	• Basic oleochemical production upgraded to include refined glycerine, high purity fatty alcohol, tertiary amine, monoalkyl phosphate. The production of refined glycerine, for example, requires significant investment in equipment and technical expertise.
Intermediate Chemicals	**Activated Carbon**	**Process & Product Upgrading**	• Installation of two new large, state of art processing facilities since 2011 improves productivity. • Number of exporters increased: 10 firms export +US$1 million. • Exports double 2010-2014 to US$100 million.
	Oleochemicals	**Functional Upgrading:** Production of Surfactant products	• Exports increased: US$27 million (2007) to US$162 million (2014). • Number of exporters increased: 10 firms now export +US$1 million in 2014.[28] • This step moved from the export of fatty alcohols to local processing into higher stage of the chain. Predominantly anionic surfactants,[29] high and stable foaming agents most widely used in the production of liquid washing soaps, shampoos and laundry detergent.
Specialty Chemicals	**Coatings & Paint**	**Product Upgrading:** Export of Green Paint	• Leveraged paint expertise to export higher value environmental paints; value of Knox-Out is 2-3 times substitutes.

Source: Authors.

Note: Export statistics based on UN Comtrade analysis, downloaded 10/312015. Firm level exports based on PSA, 2007-2010.

[28] The top five firms account for 93% of these exports (PAS 2007-2010).
[29] Based on analysis HS-6D level export codes from UN Comtrade and PAS 2007-2010.

Box 5. Pacific Paint (Boysen): Functional & Product Upgrading

Founded in 1953 as a solvent repacker, this family-owned Philippine business has since made considerable strides in upgrading. Today, it is ranked 59th globally amongst paint and coatings firms and has begun to innovate in the production of environmental solutions.

The company first began by moving into the manufacture of solvent-based paints for the Philippines market. At the time, the market was dominated by American based paint products, which made entry difficult. As a result, they licensed an American-brand—Boysen. Success followed, and they continued to upgrade their product base, next producing water-based paints, followed by zero-VOC (non-toxic) paints. Each development during this time was based on leveraging existing global technology, but they did require a certain degree of product formulation. In addition, in 2000, the firm started a new fully integrated production facility that included emulsion and resin production to increase their competitiveness. The company now owns three production facilities, including two large, low mix/high volume plants in Cavite and one smaller, high mix/low volume operation in Quezon City.

More recently, driven by the growing demand for environmental chemical solutions—and the poor air quality in Manila, the firm has undertaken even further functional upgrading with the development of KNOxOUT, a photocatalytic paint which helps remove pollutants from the air. This is an innovative product on the global market which the firm developed together with a foreign partner, Cristal, the world's largest producer of ultrafine and photocatalytic titanium dioxide, produced under the CristalActiv brand. Working together, the teams have combined their technologies to deliver a brand new product to the market.

Source: Boysen (2016); Field Research (2016).

4.4. The Philippine Chemicals Workforce

Globally, the chemicals sector is primarily a capital-intensive rather than labor-intensive industry, providing few direct employment opportunities. This is true also for the Philippines—in 2012, the total chemical sector in the Philippines employed close to 50,000 people (Philippines NSO, 2013),[30] while employment in the export sector engaged in GVC trade was considerably smaller.

Nonetheless, it relies heavily on a small but well-qualified labor pool. Employees in the sector typically have a minimum of post-secondary technical training (approximately 50% of the workforce), with a large portion (20%) of chemical and mechanical engineers and chemists. Firms highlight that technician training, along with government certification, is provided by Technical Education and Skills Development Authority (TESDA), while the professional staff draw from primarily local universities including of the University of the Philippines, University of Sto. Tomas, and Mapua Institute of Technology among others (Field Research, 2016). These courses are generalist, with limited customization towards the chemical industries operating in

[30] This includes three categories, basic chemicals, other chemicals n.e.s., and refined petroleum products. This third category is included to account for the provision of feedstock in the petrochemicals sector, however, it has little impact on the total figures as it accounts for just 1,827 workers.

the country, such as specific courses on oleochemicals, petrochemicals or paint production. Firms suggested that staff thus require both additional formal and on-the-job training of up to two years once they join the workforce. In an effort to resolve this challenge, the industry association, SPIK, is engaged in the development of training regulation with TESDA (Field Research, 2016).

According to firm interviews, the availability of qualified chemical engineers and chemists is relatively low, making recruitment difficult. Approximately 705 chemical engineers passed the board exams in 2015. While this is a generalized increase from 2010, when just 531 students passed, it was down from the 2014 levels of over 800 (Professional Regulation Commission (Philippines), 2016). The number of board certified chemists is approximately half of that—414 in 2015; this number has steadily increased from 378 in 2010.

In contrast to the broader manufacturing industry, in addition to a small supply of qualified staff, turn-over has been a challenge for the industry as a result of brain-drain, particularly in the petrochemicals sector, where firms have faced high personnel turnover to firms abroad such as those in the Middle East. Locally based firms have found it difficult to compete with foreign job offers; one large petrochemical provider noted that at one point their turnover was as high as 35-40%. To respond to this challenge, firms have adopted a range of strategies, including hiring more female chemical engineers, who they claim have a lower attrition rate.

4.5. Advantages and Disadvantages for GVC Participation and Upgrading

The chemicals industry in the Philippines has developed organically in recent years, with limited direct government intervention contributing to its growth with the exception of the petrochemicals sector (DTI, SPIK, et al., 2014). Comparative advantage in raw materials, combined with the growing local market, and its geographic location have been key drivers of the industry to date. Within the past five years, however, new initiatives regarding industrial policy formulation for the industry have sought to improve the competitiveness of the Philippines in the chemicals sector. Table 19 highlights the key strengths and challenges facing the industry for future growth, and this is followed by a discussion of these key elements.

4.5.1. Advantages

Installed Capacity in a Strategic Geographic Location: Both the oleochemicals and the petrochemicals segments offer an advantage of installed capacity to ramp up production for the local and regional markets. According to industry associations, both segments are currently operating with underutilized capacity, which offers the country a strong advantage in serving growing demand—particularly for consumer and construction markets in the Asia-Pacific region. Strong economic growth within the country provides an impetus for investments to serve both the domestic and foreign markets from Philippine manufacturing centers.

Table 19. SWOT Analysis of the Philippines Chemical Industry

Strengths	Weaknesses
• Installed capacity in a geographic location proximate to major markets • Availability of qualified human capital • Improving environment for supportive sector development • Oleochemical and petrochemicals included as priority sectors in 2014-2016 IPP • Expertise in oleochemicals • Existing production of coconuts (activated carbon & oleochemicals) • Just-in-time and flexible delivery to domestic market (petrochemicals)	• Limited feedstock supply, and poor backward linkages to existing supply • High turnover of personnel • Lack of national standards and/or harmonization with global standards • Porous borders, lack of technical expertise in customs offices and smuggling • Cost and availability of energy, transportation and storage infrastructure and services (including domestic) • Lack of long-term strategic industry development plan • Inefficient monitoring of IP protection
Opportunities	**Threats**
• Continued growth (albeit slower) of the Asia-Pacific market, especially in consumer and construction products • Growing export-oriented manufacturing hub in Philippines • Increased global demand for key environmentally sustainable and non-toxic products	• Weakening global markets • Price volatility of inputs • Substitutes • Global overcapacity (esp. China) and cheap polyolefins from US driving down prices • Global and regional environment for tariff liberalization, implementation, and subsidies

Source: Authors based on DTI, APMP, et al. (2014); DTI, SPIK, et al. (2014); Field Research (2016).

Human Capital and Sector Expertise: Low-cost and skilled human capital provides the sector with an important asset. In certain segments such as the oleochemicals and paint sectors, the country's established presence in the industry has helped to develop a strong base of technical expertise in the country. However, as highlighted earlier, turnover is high, and there are gaps between the needs of the export-oriented sub-sectors and the degree of preparation of graduates (Field Research, 2016; USAID, 2014). In addition, the industry attracts few people. The poor perception of the industry amongst younger generations has been cited as one of the reasons it has failed to attract a larger supply (DTI, SPIK, et al., 2014), together with a perceived overall decline in interest in non-tech STEM careers (USAID, 2014).

Collaborative Environment for Industry Policy Development: Over the past five years, there have been strong initiatives to develop a supportive and collaborative environment for industry policy development in the manufacturing sector. This has been driven by a number of programs put in place by the Department of Trade and Industry Board of Investments (DTI-BOI), which focus on identifying and prioritizing the development of high potential sectors in order to revitalize manufacturing in the country. The collaborative implementation of the Industry Development Program and the Manufacturing Resurgence Program (DTI, 2016c; DTI-BOI, 2014)— between and among the private sector, academe and government agencies has played a central role in coalescing industry stakeholders into a more cohesive group and has clearly helped to establish strong lines of communication between the public and private sectors.

The Industry Roadmapping Project, which was launched in 2012 and focused on developing industry "roadmaps" for growth, in particular, has been critical in articulating the needs and wishes of industry. Two roadmaps were prepared for the chemicals sector: a broader industry strategy, as well as one specifically for the petrochemicals sector (DTI, APMP, et al., 2014; DTI, SPIK, et al., 2014). Two of the chemicals industry associations, SPIK and APMP were highly proactive in pursuing this initiative to develop an industry plan for growth (DTI, SPIK, et al., 2014; Field Research, 2016).These various industry associations represent both domestic and foreign actors, large and small. This strong buy-in from the private sector in policy development can help to provide continuity across governments and contribute to the institutionalization of sector development.[31]

Furthermore, efforts are underway to improve inter-departmental coordination to ensure that policies can be effectively implemented through the Industry Development Council (IDC)[32] led by the Secretary of the DTI which is tasked with bringing together working groups— including one on chemicals at the government level (DTI, 2016b; DTI, SPIK, et al., 2014; Field Research, 2016). Despite this progress, long term planning has yet to be adopted for the chemicals industry. Comparatively, other countries in the region, including China and Singapore, have implemented long-term visions for industry development of the chemicals sector.

4.5.2. Challenges

Overall, two major supply chain gaps undermine development in the industry: **limited local feedstock supply and poor backward linkages.** In the petrochemicals segment, weak supply of oil & gas means that the country has to depend on imports for its petrochemicals plants, either at the cracker level or at the polyolefin level. Offshore natural gas resources suggest potential for long-term backward linkages in the petrochemicals value chain. Industry players, however, suggest that leveraging these resources effectively is not yet viable for their operations—there are weak linkages with this supply,[33] and petrochemical players continue to rely mostly on global feedstock supply. This is likely to continue in the short-to-medium term as a result of depressed global oil and gas prices. The size of the local petrochemical commodities production is also relatively small; with high energy costs (discussed below) it will be difficult for these firms to remain competitive to imports from abroad.

In the oleochemicals sector, the coconut industry has been struggling in recent years, yet it remains an arms-length operation between coconut producers, mills, and chemicals manufacturers. With a pervasive small-scale farming structure, the supply of coconuts has been declining due to underinvestment in plantations and aging trees. The processing industry thus faces a continued tightness in the supply of coconuts as their raw material.[34] Comparatively,

[31] These efforts have been recognized with the Philippines moving up in different international competitiveness rankings between 2010 and 2015. The country rose from 85th to 47th in the World Economic Competitiveness Global Competitiveness Ranking from 2010/11 to 2015/16 (World Economic Forum, 2016), and up 31 places in the World Bank's Doing Business rankings during that same period (The World Bank, 2016).
[32] Established by virtue of Executive Order 380, series of 1996, the IDC has been re-convened in April and October 2014, aiming to amend E.O. 380 to reflect the new institutional needs of the IDC, as well as respond to current realities and challenges of industry development in the country.
[33] For instance, the cracker plants are set up for naphtha and LPG, not natural gas.

oleochemicals producers in Malaysia and Indonesia are aggressively vertically integrating (Emerging Markets Direct, 2015; Yoyo et al., 2014). This lack of integration through the supply chain has constrained the industry's response to challenges with raw material supply in the country. It also has the potential to affect the growing activated carbon sector, albeit to a smaller degree. Similarly, in inorganics, production is entirely isolated from the rest of the sector. This undermines the country's potential to achieve the types of economies of scale that have generated success in neighboring countries.

Regulation and Standardization: Efforts are underway to align chemical regulation in the Philippines with global best practices, which are designed to both improve health, safety and environmental impacts of chemicals, while at the same time alleviating technical trade barriers and facilitating increased trade.

- Chemicals in the Philippines are technically managed under a similar registration system as some of the prevailing global systems, requiring registration and clearance before products can be introduced to the market, manufactured or exported with the Philippines Inventory of Chemicals and Chemical Substances (DENR, 2016).[35]
- Since the mid-2000s, the Priority Chemicals List of controlled substances has been developed to govern the import, manufacture and use of certain chemicals (Republic of the Philippines, 2005).
- Chemical regulation follows the American Chemical Society Chemical Abstract Services for aligning chemical labeling. This is one of the two acceptable labeling systems under the UN Globally Harmonized System (GHS) of Classification and Labeling (OSHA, 2005). The country has committed to several GHS deadlines between 2015 and 2019 to implement further controls.
- The Philippine Bureau of Product Standards (BPS) is developing national standards together with industry working groups, of which the paint sector has already made significant progress (DTI BPS, 2016; Field Research, 2016). Third party laboratories, such as SGS are available to certify chemicals according to a range of international standards, including REACH and volatile organic compounds (VOC) compliance (SGS, 2016).

Regulatory gaps and challenges remain a problem for the industry, increasing costs of compliance and undermining competitiveness both in the short and mid-term. First, controlled substances regulation has been considered unnecessarily restrictive and not aligned with findings in leading markets and that compliance requires multiple bureaucratic procedures.[36] This requirement combines with additional permitting by a number of other agencies, including the Food and Drug Administration in some cases, which can extend permitting time to three to six months (DTI, SPIK, et al., 2014). Second, the lack of local standards for chemicals allows for some degree of mislabeling, misclassification, and underreporting of imports and exports. So far, only a small number of products account for mandatory certification under the BPS and

[34] The industry output declined 4.4% in 2013 (Narvaez, Basilio, & Fernandez, 2015).
[35] The National Chemical Database will be a platform that will list all pertinent information and regulations pertaining to specific chemical substances.
[36] Comparative analysis with restricted, banned and candidate substance lists in the EU system reveal that only half of the 41 substances listed in the controlled substances list in March 2016 were regulated by what is considered a highly restrictive European system (ECHA, 2016; Republic of the Philippines, 2005).

relatively weak industry expertise in the customs authority undermine the control of correct labeling—and thus tariff coverage of products. Some industry estimates suggest that this 'technical smuggling' accounts for as much as 50% undervaluation of products (DTI, APMP, et al., 2014; Field Research, 2016).

These regulatory constraints have broadly been recognized by DTI and efforts are underway to reduce this burden. The Department of Environment and Natural Resources (DENR) issued an Exemption of Certain Chemical Mixtures from the Priorities list in an effort to facilitate industry transactions and new implementing rules and regulations are being developed through a multi-stakeholder initiative based on workshops and forums (Business World Online, 2016; DTI, 2016a). Paints Standards are among BPS' current priorities. Since the start of this initiative, standards for Paints and Varnishes—Semi-gloss latex paint (white and light tints for exterior and interior use) has been promulgated in 2015. The development and upgrading of standards aims to make the paints industry more competitive worldwide (Field Research, 2016).

Cost and Availability of Necessary Infrastructure and Services: The chemical GVC depends heavily on energy, transportation and storage infrastructure. This is heightened in the upstream and mid-stream segments of the chain, where volumes are high and margins are low. All three of these infrastructure elements and their related services have been problematic to date for the development of the industry in the Philippines and are likely to become more challenging as the economy grows. Most of the large petrochemical firms claim to have developed their own power plants to support their operations (Field Research, 2016); this increased the cost of initial investment and constrains expansion (DTI, APMP, et al., 2014).[37] In transportation, in addition to low frequency international shipping and port congestion, which is a transversal challenge for the manufacturing sector, domestic shipping costs are extremely high; logistics costs account for up to 53% of wholesale prices in the Philippines compared to less than 20% in other countries in the region, including Malaysia and Indonesia which also face archipelago challenges (World Bank, 2015).

These constraints appear to be prohibiting backward linkage development in the production of nickel-cobalt sulphide. This process draws on sulphuric acid inputs; the two plants have a combined need of 1.4 million tons of acid, much of which has been supplied through imports from Japan. In 2014, these totaled US$175 million (UNComtrade, 2015a). Sulphuric acid production in the Philippines by the Philippines Associated Smelter and Refining Corporation (PASAR) has typically been absorbed by the Philippine Phosphate Fertilizer Corporation (Philphos). However, the plant's shut down since typhoon Haiyan, combined with PASAR's capacity expansion from 600,000MT to 1.2 Million MT in 2015, has increased local supply (Wilcock, 2015). This offers the opportunity for increased backward linkages and indirect exports of sulphuric acid. Domestic shipping costs, however, may prove to make this unfeasible. Coral Bay is located in Palawan Island, Taganito in Mindanao, while PASAR is on a separate island in the archipelago in Leyte.

In the oleochemicals sector, coconut oil must be shipped from a number of different islands to

[37] The plastics industry is also undertaking energy audits to help improve energy efficiency in their operations (Field Research, 2016).

Luzon processing plants, adding extra costs to the already premium prices of coconut raw materials. While recent investments have been made in chemical storage facilities, these are inadequate, and global MNCs present in the Philippines do not consider these to meet global standards (Field Research, 2016).

Intellectual Property Protection: The Philippines has made impressive gains in improving its IP protection framework in recent years,[38] but the country needs to overcome its poor reputation in this area before foreign companies will be willing to locate sensitive technologies and product operations within its borders. In 2015, it was ranked 71st out of 140 countries by the World Economic Forum's Global Competitiveness Ranking for IP protection, up some 29 places since 2011 (World Economic Forum, 2016). The country was only removed from the US Special 301 Watchlist in 2014 after 22 years (United States Trade Representative, 2014).

Substitutes: Coconut oil is at risk of being substituted almost completely in the production of oleochemicals. Although coconut oil has specific advantages in the production of certain oleochemical compounds,[39] palm kernel oil fatty acids are becoming an economic alternative to coconut oil fatty acids, as the composition ranges of the fatty acids are very close (Frost & Sullivan, 2014). While coconut oil produced from the Philippines continues to offer a 'sustainable' alternative to Indonesia and Malaysia's poor reputation for clearing natural forests for palm plantations, this advantage is quickly eroding. The majority of the leading vertically integrated palm-based oleochemicals producers in these neighboring countries have already obtained sustainable certifications for most of their crops. This allows them to continue to supply cheaper palm oleos to lead consumer product firms such as L'Oreal and Unilever that have committed to sustainable sourcing (RSPO, 2016).

Global and Regional Overcapacity and Softening Demand: Rising global capacity in commodities chemicals – in both the oleochemicals and petrochemicals sub-sectors have combined with slowing economic growth to contribute to a potential overcapacity problem in the region in the short term (BMI, 2016). In the polyolefin market, in 2014, Malaysia had already begun to cut back capacity both in its PP and PVC manufacturing as plants were unable to remain competitive (Larionova, 2012; Malaysian Petrochemicals Association, 2015). In the oleochemicals sector, some analysts suggest that no additional fatty acid capacity will be required for another 6-8 years (Brunskill, 2015).

The continued low volumes of the Philippines market, combined with other challenges listed above, do not justify the risk of investing in long-term, expensive production plants in the country (Field Research, 2016).

---

[38] These include a new code which came into effect in 1998 covering copyrights, and enforcement, the creation of an inter-agency taskforce for enforcing these rules, the National Committee on Intellectual Property Rights, in 2008, and the formation of an Intellectual Property Office in 2013.
[39] Coconut oil has a higher composition of short chains (C-8 caprilic and C-10 capric) acids used in agriculture, food and beverages and health care sectors and lubricants than palm kernel oil. The inputs are similar in composition of medium chain C12 (Lauric acid), C14 (Myrisitc) and C16 (Palmitic acid) with coconut oil exhibiting only a slight advantage in these acids.

Table 20. Key Industry Stakeholders in the Philippines

Institution	Role	Influence
Private Sector Actors		
Chemical Industry Association of the Philippines (SPIK)	Represents the entire chemicals industry in the Philippines. Allied with the ICCA and advocates Responsible Care, an international program for environment, health and safety. 57 members.	Developed the chemicals roadmap; proactive organization.
Association of Petrochemical Manufacturers of the Philippines (APMP)	Represents six petrochemical firms operating in the Philippines.	Developed the petrochemicals roadmap.
Philippine Oleochemical Manufacturer Association (POMA)	Represents five oleochemical manufacturers in the Philippines; also represents the Philippine interests at the Asian oleochemicals Manufacturers Group (AOMG).	Did not participate in the roadmap exercise; appears to be relatively disconnected from policy formulation as the industry struggles to survive.
Philippine Activated Carbon Manufacturers Association, Inc. (PACMA)	Represents eight activated carbon manufacturers in the Philippines.	
Public Sector Actors		
Department of Environment and Natural Resources (DENR), Environmental Management Bureau (EMB)	Responsible for registration of all chemicals used, traded, stored or produced in the Philippines. First published in 1995, the 2011 list already contained 46,000 chemicals. Non-listed chemicals must be registered and obtain security clearance. Only controlled substances must obtain clearance once registered.	The Prioritized Chemicals List covers 48 chemicals; including benzene, vinyl chloride (used in PVC), and formaldehyde, amongst others.
Philippine Drug Enforcement Agency (PDEA)	Responsible for regulating the use and distribution of dangerous drugs, precursor chemicals and essential chemicals in the Philippines.	Affects the movement and availability of inputs, specifically basic chemicals, for the formulation of intermediate and specialty chemical products.
Philippine Coconut Authority	This is the government agency with the responsibility of developing the coconut industry. The organization also has legal mandate over the palm oil industry in the country.	The organization is mandated to develop and implement a plan to revive the coconut industry in the Philippines.
Bureau of Product Standards, DTI	The BPS is the National Standards Body of the Philippines and is responsible for developing/ adopting, implementing and promoting Philippine National Standards (PNS).	The list of incoming chemical products supported is minimal, and probably not adequate to protect against poor quality chemical inputs/etc.
Department of Trade and Industry	Tasked with coordinating with the private sector to grow the manufacturing sector in the country; launched the roadmaps initiative in 2012.	The Board of Investments (BOI), an attached agency of DTI, approves investment incentives applications for the industry. DTI-BOI coordinates public-private sector working groups introduced to overcome binding constraints.

Educational Institutions		
Commission on Higher Education (CHED)	CHED is responsible for overseeing higher education in the country. Responsibilities include formulation of policy and programming such as foreign scholarships and training and accreditation of tertiary educational institutions.	There are a number of scholarship and study abroad programs coordinated by CHED which are applicable to the industry.
University of the Philippines, University of Sto. Tomas, and Mapua Institute of Technology	Leading chemistry and engineering universities providing human capital for the manufacturing sector	UP considered to graduate the best students in the country.

Source: Authors.

4.6. Potential Upgrading Trajectories

The potential upgrading trajectories recommended focus on building upon comparative advantages in raw materials, accumulated expertise and growing downstream demand. Trajectories discussed in this section include few upgrading paths related specifically to the petrochemicals commodities sub-sector. In the current global context of strong, low cost petrochemicals production in the US, the Middle East as well as other countries in the region (e.g. China, Malaysia and Singapore), it is difficult to foresee a scenario in the short to medium term in which the Philippines can compete in the polymer export market where efforts are not incorporated into indirect exports.

1. **Process upgrading and strengthening of backward linkages in the coco oleochemicals segments (Short Term):** Process upgrading is required in coconut production, which has been affected by low productivity. Coconut production in the Philippines is undertaken by small, underfinanced farmers, and has been subject to several environmental challenges in recent years which have reduced production. Trees need to be rejuvenated and/or replaced and new production techniques incorporated. This will require strengthening of supply chain relationships between oleochemicals producers and agricultural producers to ensure adequate supply, helping to develop more integrated business models to compete with the vertical integration of the Malaysian and Indonesian operations. While this is a necessary upgrading initiative to remain in the production of basic oleochemicals, this may not result in sufficient gains to remain competitive vis-à-vis palm based products. This strategy should be combined with chain upgrading strategies, at the country level, of moving into the more profitable, although lower volume, food products sector.

2. **Process upgrading: Adjust oleochemical plants to process palm kernel oil (Short to Medium Term):** Currently, oleochemicals production relies exclusively on coconut oil; the increased cost of this means that plants are operating under capacity. In the short to medium term, in order to operate cost effectively, local plants should diversify for both palm kernel oil and coconut oil inputs to manage risk. Palm kernel oil can be sourced abroad. Currently, at least one firm – Pan Century Surfactants, has the capacity to operate with either palm kernel oil or coconut oil feedstock (Aditya Birla, 2016). Indeed, flexibility in feedstock use should be a central strategy, allowing oleochemical producers to adjust

feedstocks based on the price of raw materials helping them to remain competitive. Given the large scale expansion of palm oil plantations in Southeast Asia, the change in the export duty in Malaysia, and Indonesia's relatively low export tariff, there is a strong supply of this substitute raw material at lower prices than coconut oil. The differences in feedstock costs would be subject mostly to transportation and logistics challenges, although general growing regional trade could help to reduce those costs. While the Philippines could seek to develop its own palm oil industry, a key challenge would be the overall dependence on smallholder land ownership, which lacks the two factors that have made palm oil so competitive in Indonesia and Malaysia: economies of scale and access to finance and technology. In addition, controversies around its impact on the environment and the wide range of higher value opportunities available to smallholders in the agribusiness sector would make this a further challenge.

3. **Product & process upgrading for niche markets for coco oleochemicals (Short Term):** Currently, the majority of oleochemical production is oriented to the commodities market. However, given the price competitiveness in that sector, the coco oleochemicals production that does continue should be directed to higher value niche markets. There are several possible niche markets that can be accessed through certification which generate higher margins per product. These include organic, sustainable and 'religious' markets. For example, the Halaal personal care market, estimated to be growing at 12% per annum, was valued at US$13 billion in 2013. Over half of the world's Muslim population lives in the Asia Pacific region. This market requires all ingredients to be certified Halaal. Several oleochemicals producers have identified this as a potential niche, including global firms Evonik and P&G, and Malaysian firm, Pacific Oleochemicals, have certified their operations. Halaal certifications are also being seen as synonymous with organic and environmentally friendly products in more traditional markets (Islamic Bankers Association, 2013). Other environmental certifications include the USDA Organic, EU Organic, Rainforest Alliance, Cosmos and NaTrue. Furthermore, certifications for specific industry end markets, such as the food and beverage and pharmaceutical industry can help secure access to higher paying clients.

4. **Product and functional upgrading in activated carbon (Short Term):** The global demand for activated carbon is going to increase as the demand and regulatory pressures for purification of water and air sources rises (see Box 1), as well as a rapidly expanding number of end-use applications in the aerospace, automotive, electronics and electrical industries. In addition to expanding and improving current production, short-term product upgrading opportunities exist for the Philippines, including fiber type, chemically impregnated, specially molded (e.g. honeycomb filters and sheets) and electrodes (Freedonia, 2014). There are also potential opportunities to develop synergies with other manufacturing sectors in the country. Electrochemical double facing capacitors (ultra or supercapacitors), for example, made using activated carbon electrodes have entered commercial operations to store and release energy in hybrid cars, in uninterrupted power supplies in hand-held and portable electronics and as backup systems in case of power supply for opening aircraft doors (Jacobi, 2016b). The market for supercapacitors alone is forecast to grow at 27% CAGR between 2014 and 2020, to reach US$1 billion (Markets & Markets, 2014). These final products continue to be manufactured in developed countries

but offer medium-term potential for offshoring given the rapid projected increase in demand. The Philippines could potentially offer lower overall cost competitiveness.

5. **Market upgrading for niche green chemicals cluster (Short Term):** There are numerous emerging environmental solutions and sustainable products being developed in the Philippines chemicals sector. These include Knox-Out paint by Boysen, industrial cleaners such as Spill-Care developed by Chemrez and sustainable, organic oleochemicals for the cosmetics industry. No strong pattern towards the export of these products has yet emerged—with the possible exception of activated carbon, many of these products are being directed to the local market or an irregular mix of regional markets. The Philippines has an opportunity to push market upgrading for these niche green chemicals and their related final products into higher value end markets. Although still in their infancy, these markets have continued to grow over the past five years and are predicted to remain strong. For example, the Asian market is becoming an increasingly important one for premium, sustainable products in the personal care segment. The region's premium skin-care market grew by close to US$1 billion between 2014-2015 (Micallef, 2016), buoyed by demand in China and India (Frost & Sullivan, 2014).

Box 6. Regional and Industry Nuances for Marketing Green Products

A 2012 industry survey on green chemicals by McKinsey uncovered important nuances in marketing and branding green products. Strategies to launch products into new markets must take these differences into account.

- **Defining "green":** This incorporates more than bio-based products; recyclability, low toxicity and biodegradability are key characteristics that are valued by both industry and end consumers. The importance of these differences by industry end market; for example, recyclability is most important in sectors with high use of disposals.
- **Willingness to pay a premium:** Three out of four consumers are willing to pay 5% more for a green product over its non-green alternative, while half would still pay a 10% premium. In sourcing practices, overall, buyers are willing to pay between an average of 10% more for green ingredients.
- **Regional differences**: European B2B buyers most consistently purchase green chemicals (38%), followed by Asia (28%); the US market, interestingly, is less inclined to spend more on green products.

Source: Kaiser, Miremadi, Musso, and Weihe (2012)

6. **Product diversification in basic inorganic chemicals (Medium to Long Term):** As a highly mineralized country, the Philippines has the potential to leverage its natural resources to produce additional basic inorganic chemicals for the commodities segment. The success of the nickel-cobalt sulphide production provides precedent for the Philippines to explore other channels for leveraging its natural resources. Given the importance of raw materials in driving exports of commodity chemicals, new products will need to be based on comparative advantages of the Philippines in minerals, such as nickel, copper and gold. As the largest nickel producer globally in 2015 (USGS, 2015), contributing close to one fifth of

the global supply (Moss, 2015),[40] nickel-based products offer a logical alternative for further analysis. Other nickel-based chemical products could include nickel-hydroxide, which is currently used in the manufacture of rechargeable batteries such as all of Toyota's hybrid cars (non-plug in) (The Nickel Institute, 2010). British firm ENK, has successfully run a pilot project for the production of nickel-hydroxide in the Philippines (Swanepoel, 2012; USGS, 2013). Although new technologies such as lithium-ion have been introduced, nickel-hydroxide batteries continue to be used commercially.

7. **Entry into production of intermediate and specialty chemicals (Medium to Long Term)**: In general, the Philippines first needs to develop capabilities in production and sales of intermediate and specialty products before functionally upgrading into formulation of new chemicals. Entry into the production of intermediate and specialty chemicals to support the emerging export-oriented manufacturing sectors as well as growing regional and domestic demand.[41] Estimates of the size of the Asian specialty chemical market range from US$100 billion to US$350 billion (McElligott, 2012; Yep, 2013); sales for specialty chemicals are only likely to rise in Asia, and there are opportunities to develop and produce solutions to meet the needs of the local market. This can exploit synergies for growth via indirect exports and reduce the cost for firms operating export plants in the Philippines. For example, Chemrez produces plastic colors used in PVC manufacturing for automotive wire harnesses (D&L Polymers and Colors, 2016). Due to the lack of raw materials, this is more difficult to achieve for the upstream commodities production; however, the lower volumes required for intermediates and specialties can facilitate local production of these chemicals. These could include petrochemical derivatives if economies of scale generated can provide competitively priced outputs. For example, ethylene oxide is used in the production surfactants. Key challenges will be growing interest amongst other players in the region, such as Singapore and Thailand, to deepen their participation in the intermediates and specialties market.

   This could be particularly important for oleochemials. Given the rising regional capacity in basic palm-based oleochemicals, profit margins in these categories will continue to tighten, making it more difficult for coco-oleos to successfully compete. The oleochemicals firms in the Philippines that have survived the first wave of closures have done so by upgrading into higher value added products, such as biofuels and surfactants. The scope for upgrading into derivatives and specialty chemicals is broad, as the number of downstream applications for oleochemicals continues to rise. This next stage of the value chain allows firms to leverage the lower cost supply of basic oleochemicals – be it from coconut or palm oil feedstock. Malaysian firms are aggressively trying to upgrade into this stage of the chain, in order to remain relevant in the face of rising basics capacity in Indonesia. Upgrading into this stage of the chain will require clear drivers of either the supply of competitive raw material highlighted in points 1 and 2, or a strong connection with downstream markets in the region, combined with efficient import and export logistics for chemical inputs and outputs.

[40] The Philippines also ranks in the top ten for total nickel reserves.
[41] In doing so, the country would need to facilitate achieving 'logistical' economies of scale (Spitz, 2003), by building logistics systems that allow the country to sell to the region and not just to the domestic economy.

5. References

Abelkop, A., & Graham, J. (2015). Regulation of Chemical Risks: Lessons for Reform of the Toxic Substances Control Act from Canada and the European Union. *Pace Environmental Law Review, 32*, 108-224.

Aditya Birla. (2016). Pan Century Surfactants Inc. Retrieved from http://www.adityabirla.com/businesses/Profile/Pan-Century-Surfactants-Inc-(PCSI)

American Chemistry Council. (2015). *Plastics and Polymer Composites in Light Vehicles*. Retrieved from https://plastics-car.com/Todays-Automobiles/Latest-Trends/Chemistry-and-Light-Vehicles-Annual-Report-.pdf

American Chemistry Council. (2016). TSCA Modernization. Retrieved from https://www.americanchemistry.com/TSCA

AOMG. (2016a). Malaysian Oleochemical Manufacturers Group. Retrieved from http://www.aomg.org.my/index.php/2014-03-22-08-56-09/malaysia-section - activities

AOMG. (2016b). Philippines Oleochemical Manufacturers Assocation (POMA). Retrieved from http://gain.fas.usda.gov/Recent GAIN Publications/Biofuels Annual_Manila_Philippines_10-22-2014.pdf

APIC. (2016). Market Data: Singapore. Retrieved from http://www.apic-online.org/countrydata_singapore.htm

Badunenko, O. (2008). Downsizing in the German chemical manufacturing industry during the 1990s. Why is small beautiful? *Small Business Economics, 34*(4), 413-431. doi:10.1007/s11187-008-9142-x

Baker, J. (2013). Bioplastics set for growth phase. *ICIS Chemical Business, 284*(19), 2-2.

Baker, J. (2015). Laying the foundations for success. *ICIS Chemical Business*, 1-2.

Bamfield, P. (2001). The restructuring of the colorant manufacturing industry. *Review of Progress in Coloration and Related Topics, 31*(1), 1-14. doi:10.1111/j.1478-4408.2001.tb00132.x

Bantillo, P. (2016). Bertschi plans significant growth in China, MalaysiaBertschi eyes China, Malaysia. *ICIS Chemical Business*, 2-2.

BASF. (2015). *BASF Report 2015: Economic, Environmental and Social Performance*. Retrieved from Ludwigshafen:

Bassett, M., & Gardner, L. (2010). Optimizing the design of global supply chains at Dow AgroSciences. *Computers & Chemical Engineering, 34*(2), 254-265. doi:http://dx.doi.org/10.1016/j.compchemeng.2009.08.002

Bathelt, H., & Zeng, G. (2012). Strong growth in weakly-developed networks: Producer–user interaction and knowledge brokers in the Greater Shanghai chemical industry. *Applied Geography, 32*(1), 158-170. doi:http://dx.doi.org/10.1016/j.apgeog.2010.11.015

Bauer, F., & Hulteberg, C. (2013). Is there a future in glycerol as a feedstock in the production of biofuels and biochemicals? *Biofuels, Bioproducts and Biorefining, 7*(1), 43-51. doi:10.1002/bbb.1370

Bayer. (2016). *Annual Report 2015*. Retrieved from Leverkusen:

BCG. (2014). *Special Chemical Distribution - Market Update*. Retrieved from http://www.bcg.com

BCG. (2015). How the Global Chemical Industry Became a Battle of Equals. *BCG.Perspectives*.

Beacham, W. (2012a). Emery boosts specialties. *ICIS Chemical Business, 282*(8), 10-10.

Beacham, W. (2012b). LANXESS drives green mobility. *ICIS Chemical Business, 282*(9), 37-37.

Beacham, W. (2015). Emery sells Europe oleochem site. *ICIS Chemical Business*(3536), 18-18.

BFTA. (2014). *Major Chemical Players*. Retrieved from Brussels:

BMI. (2016). *BMI Industry View - Thailand Petrochemicals Q2 2016*. Retrieved from

Boysen. (2016). Boysen KnoxOut: Air Cleaning Paint. Retrieved from http://www.knoxoutpaints.com/home2.do

Brunskill, A. (2015, March 3). *An Outsider's View of the Oleochemicals Market.* Paper presented at the POC 2015: Palm & Lauric Oils Price Outlook Conference, Kuala Lumpur.

Bunge, J., & Feintzeig, R. (2016, January 12, 2016). Dow and DuPont Strive to Find the Right Chemistry *The Wall Street Journal*

Burgess, T., Hwarng, B., Shaw, N., & de Matteos, C. (2002). Enhancing Value Stream Agility: The UK Specialty Chemical Industry. *European Management Journal, 20*(2), 199-212.

Business World Online. (2016, April 7). Comments Sought on PNP Proposals for Chemical Imports. *Business World Online*. Retrieved from http://www.bworldonline.com/content.php?section=Economy&title=comments-sought-on-pnp-proposals-for-chemical-imports&id=125622

Businessline. (2013). Incentive for Coconut-Shell-based Activated carbon. Retrieved from http://www.thehindubusinessline.com/economy/agri-business/2-export-incentive-for-coconutshellbased-activated-carbon/article4272277.ece

Cargill. (2015). Partnership of GIZ, BASF and Cargill promotes the world's first production of copra certified by Rainforest Alliance. Retrieved from http://www.cargill.com/news/releases/2015/NA31845855.jsp

Carpenter, K., & Kiong Ng, W. (2013). Singapore's Chemicals Industry: Engineering an Island. *CEP*.

CEFIC. (2014). *The European Chemical Industry: Facts and Figures 2014*. Retrieved from

Channel NewsAsia. (2015, July 10). Solvay Opens New Manufacturing Plant in Singpore. *Channel NewsAsia*.

Coatings World. (2015a). Green Solvents Market is Expected to Reach US$13 Billion Globally by 2020. *Coatings World*.

Coatings World. (2015b, July 23). Top Companies Report.

Coca-Cola. (2016). Plantbottle. Retrieved from http://www.coca-colacompany.com/plantbottle-technology/

Coconut Development Board. (2016). Activated Carbon. Retrieved from http://coconutboard.nic.in/activatd.htm

Coral Bay Nickel Corporation. (2016). About Us. Retrieved from http://www.coralbaynickel.com/index_files/Page350.htm

CPBRD. (2012). Coco Levy Funds: A Fiscal Stimulus to the Coconut Industry? Retrieved from http://cpbrd.congress.gov.ph

D&L Polymers and Colors. (2016). Markets We Serve: Key Accounts Served Directly or Indirectly. Retrieved from http://dlpc.com.ph/our-markets/markets-we-serve

de Guzman, D. (2013). Oleochemicals Updates. Retrieved from http://greenchemicalsblog.com/2013/01/28/oleochemical-updates/

Deloitte. (2011). *End Market Alchemy: Expanding Perspectives to Drive Growth In the Global Chemical Indsutry*. Retrieved from

Deloitte. (2014). *Applying for Government Incentives in Singapore: See What We See*. Retrieved from

Deloitte. (2015). *The Talent Imperative in the Global Chemical Industry*. Retrieved from London: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx-mfg-talent-imperative-global-chemicals-industry.pdf

Denison, R. (2015). Comparing the Senate and House TSCA Reforma Legislation: A Side by Side [Press release]. Retrieved from http://blogs.edf.org/health/2015/06/29/comparing-the-senate-and-house-tsca-reform-legislation-a-side-by-side/

DENR. (2016). Philippine Inventory of Chemicals and Chemical Substances. Retrieved from http://119.92.161.2/embgovph/chemical/PICCS.aspx

Dow. (2015a). *2014 Annual Report*. Retrieved from Midland, MI:

Dow. (2015b). DuPont and Dow to Combine in Merger of Equals [Press release]. Retrieved from http://www.dow.com/news/press-releases/dupont and dow to combine in merger of equals

DTI. (2016a). BOI Facilitates Stakeholder Consultation on Draft IRR on Controlled Chemicals [Press release]. Retrieved from http://www.dti.gov.ph/dti/index.php/news/562-boi-facilitates-stakeholder-consultation-on-draft-irr-on-controlled-chemicals-improved-rules-seen-to-enhance-competitiveness-of-chemicals-manufacturing-industries

DTI. (2016b). Industry Development Council. Retrieved from http://industry.gov.ph/industry-development-council/

DTI. (2016c). Manufacturing Resurgence Program. Retrieved from http://industry.gov.ph/manufacturing-resurgence-program/

DTI, APMP, & BOI. (2014). *Philippines Petrochemical Industry Roadmap*. Retrieved from Manila:

DTI, SPIK, & BOI. (2014). *Philippine Chemicals Industry Roadmap*. Retrieved from Maniila:
DTI BPS. (2016). The Standards and Conformance Portal. Retrieved from ttp://http://www.bps.dti.gov.ph/
DTI-BOI. (2014). *2014 Investment Priorities Plan (IPP)*. Retrieved from Manila, Philippines: http://industry.gov.ph/investment-priorities-plan-ipp-2014-2016/
ECHA. (2016). Candidate List of Substances of Very High Concern for Authoritisation. Retrieved from http://echa.europa.eu/web/guest/candidate-list-table
EDB. (2014, November 19). A Growing Chemical Center in Asia. *CHEManager International*, .
EDB. (2016a). Chemicals Industry in Singapore. Retrieved from https://www.edb.gov.sg/content/edb/en/industries/industries/chemicals.html
EDB. (2016b). Industries in Sinagpore. Retrieved from https://www.edb.gov.sg/content/edb/en/industries.html
EFSA. (2016). Chemicals in Food. Retrieved from http://www.efsa.europa.eu/en/topics/topic/chemicalsinfood
Emerging Markets Direct. (2015). *Malaysia Industry Research: Palm Oil Industry* Retrieved from
Emery Oleochemicals. (2016a). Emery Oleochemicals Announces US$50 Million Expansion Works in Cincinnati, USA. Retrieved from http://www.emeryoleo.com/individual_news.php?g=58
Emery Oleochemicals. (2016b). History. Retrieved from http://www.emeryoleo.com/History.php
Eramo, M. (2016). *Global Ethylene Market Outlook*. Retrieved from http://media.corporate-ir.net/media_files/IROL/11/110877/05_Global_Ethylene_Market_Outlook_Eramo.pdf
European Commission. (2013). *The Consequences of REACH for SMEs*. Retrieved from Brussels: http://www.eesc.europa.eu/resources/docs/the-consequences-of-reach-for-smes.pdf
European Commission. (2015). *Monitoring the Impacts of REACH on Innovation, Competitiveness and SMEs*. Retrieved from Brussels:
European Union Delegation to Malaysia. (2012). *The Malaysian Palm Oil Sector*. Retrieved from Rome: http://www.ice.gov.it/paesi/asia/malaysia/upload/173/Palm Oil_overview_2012.pdf
Field Research (2016). [Philippines Field Research].
Foo, D. (2015). The Malaysian Chemicals Industry: From Commodities to Manufacturing. *CEP Magazine*.
Francisco, M. (2015, September 24). Big Mindanao Coco Charcoal Plant Opens. *Business World*.
Freedonia. (2014). *Activated Carbon: United States*. Retrieved from
Frost & Sullivan. (2014). *Southeast Asia Oleochemicals Market: New End-User Applications are Expected to Drive the Market*. Retrieved from
GAIN. (2014). *Philippines Biofules Situation and Outlook*. Retrieved from Washington, D.C.: http://gain.fas.usda.gov/Recent GAIN Publications/Biofuels Annual_Manila_Philippines_10-22-2014.pdf
Germany Trade and Invest. (2014). *The Chemical Industry in Germany*. Retrieved from Berlin:
Global Market Insights. (2016). *Global Automoative Plastics Market*. Retrieved from
Grand View Research. (2015). *Global Food Additives Market*. Retrieved from San Francisco:
Guinsinger, A., & Ghorashi, B. (2004). Agile Manufacturing Practices in the Specialty Chemical Industry: An Overview of the Trends and Results of a Specific Case Study. *International Journal of Operations and Production Management, 24*(6).
Hing, A. Y., & Lee, K. J. (2009). Evolution of the Petrochemical Industry in Singapore. *Journal of the Asia Pacific Economy, 14*(2), 116-122. doi:http://www.tandfonline.com/loi/rjap20
ICCA. (2016). Responsible Care. Retrieved from http://www.icca-chem.org/en/Home/Responsible-care/
ICES. (2016a). Institute of Chemical and Engineering Sciences. Retrieved from https://www.a-star.edu.sg/ices/Corporate-Profile/About-Us.aspx
ICES. (2016b). Institute of Chemical and Engineering Sciences: A*STAR Scholarships. Retrieved from https://www.a-star.edu.sg/ices/Students-Programme/A-STAR-Scholarships/A-STAR-Scholarships.aspx They.aspx
ICIS. (1996). Sunrise for the Philippines. *ICIS Chemical Business*.

ICIS. (2004). Degussa Opens Euro10M R&D Center in China. Retrieved March 2016, from ICIS http://www.icis.com/resources/news/2004/04/23/575180/degussa-opens-euro10m-r-d-centre-in-china/
ICIS. (2005). Malaysia to Launch New Industrial Master Plan in December. *ICIS Chemical Business*.
ICIS. (2015a). Clariant inaugurates new Center. *ICIS Chemical Business*(3663), 22-22.
ICIS. (2015b). Top 100 Chemical Companies. *ICIS Chemical Business*.
ICIS Chemical Business. (2015). Sadara: A Game Changer. *ICIS Chemical Business*, 4-5.
IHS. (2014). *Water Management Chemicals*. Retrieved from Englewood, CO:
IHS. (2015). *Chemical Economics Handbook: Ethane*. Retrieved from https://www.ihs.com/products/ethane-chemical-economics-handbook.html
Innovest. (2007). *Overview of the Chemicals Industry: Overview for Coming Clean*. Retrieved from New York:
Intarajang, K. (2011). Sustainable future for Asia-Pacific. *ICIS Chemical Business, 280*(17), 38-39.
Islamic Bankers Association. (2013). The Global Halal Industry: An Overview *Global Islamic Finance Report*: Ebiz Consulting.
Jacobi. (2016a). About Us. Retrieved from http://jacobi.net
Jacobi. (2016b). Supercapacitors. Retrieved from http://jacobi.net/supercapacitors/
Kaiser, H. M., Miremadi, M., Musso, C., & Weihe, U. (2012, Spring 2012). The Growing Demand for Green *McKinsey on Chemicals*.
Kannegiesser, M., Gunther, H., van Beek, P., Grunow, M., & Habla, C. (2008). Value Chain Management for Commodities: A Case Study from the Chemicals Industry. *OR Spectrum, 31*(1), 63-93.
Kawesqar. (2016). Cobertura, Diversificacion e Innovacion: Pilares de la Gestion Exportadora Chilena. *Revista Kawesqar*.
Kiriyama, N. (2010). *Trade and Innovation: Report on the Chemicals Sector*. Retrieved from Paris:
KPMG. (2011). *China's Chemical Industry: The New Forces Driving Change*. Retrieved from https://www.kpmg.de/docs/China-Chemical-Industry-201109.pdf
KPMG. (2015a, March). Building the 21st Century: Chemicals and the Global Construction Industry.
KPMG. (2015b, March). Global Automotive Industry Growth Driving Demand for Chemical Products. *Reaction*.
KPMG. (2015c). The US Chemicals Industry in 2015. *Reaction*.
Larionova, A. (2012). Petronas Exit can Affect PVC Supply in Malasya. Retrieved from http://www.mrcplast.com/news-news_open-218297.html
Lewis, P. (2013). *Technical Roles, Skills and Training in the UK Chemical Industry: An Analysis*. Retrieved from London:
Lim, L. (2016). *Singapore's Economic Development: Retrospection and Reflections*: World Scientific Publishing Company Incorporated.
Malaysian Petrochemicals Association. (2015). *Malaysia Petrochemcial Country Report 2014*. Paper presented at the APIC: Asia Petrochemical Industry Conference, Seoul, Korea. http://cpmaindia.com/pdf/apic-country-2015/Malaysia-Petrochemical-Industry-2015.pdf
Marketline. (2015a). *Global Chemicals 2015*. Retrieved from London, UK:
Marketline. (2015b). *Global Commodity Chemicals 2015*. Retrieved from London, UK:
Marketline. (2015c). *Global Household Products 2015*. Retrieved from London, UK:
Marketline. (2015d). *Global Personal Care Products 2015*. Retrieved from London, UK:
Marketline. (2015e). *Global Specialty Chemicals 2015*. Retrieved from London, UK:
Markets and Markets. (2014). *Water Treatment Chemicals Market By Type, By Application - General Trends and Forecasst to 2019*. Retrieved from
McElligott, S. (2012). Specialty Chemicals: Agents of Change. Retrieved from https://www.edb.gov.sg/content/edb/en/resources/downloads/articles/specialty-chemicals.html
Micallef, N. (2016). Beauty and Personal Care Latest Research Highlights: Discretionary and Premium in the Limelight. Retrieved 14 April, from Euromonitor International
MIDA. (2013). *Malaysia Chemicals Report*. Retrieved from Kuala Lumpur:
MIDA. (2014, August). Tapping Global Growth in Oleochemicals. *InvestByte*.
MIT (Producer). (2014, April 4, 2016). The Observatory of Economic Complexity. Retrieved from http://atlas.media.mit.edu/en/profile/hs92/3901/

Moss, T. (2015, May 12). Mining Companies in Philippines Face Many Travails. *The Wall Street Journal*. Retrieved from http://www.wsj.com/articles/mining-companies-in-philippines-face-many-travails-1431467078
Motaal, D. A. (2009). Reaching REACH: The Challenge for Chemicals Entering International Trade. *Journal of International Economic Law, 12*(3), 643-662.
Naiki, Y. (2010). Assessing Policy Reach: Japan's Chemical Policy Reform in Response to the EU's REACH Regulation. *Journal of Environmental Law, 22*(2), 171-195.
Nickel Asia Corporation. (2016). Coral Bay Nickel Corporation, . Retrieved from http://www.nickelasia.com/our-business/downstream-processing.php
O*Net Online. (2016). Retrieved from http://www.onetonline.org/find/stem?t=4&g=Go
OSHA. (2005). *A Guide to the Globally Harmonized System of Classification and Labeling of Chemiclas (GHS_*. Retrieved from Washington, D.C.:
P&G. (2014). P&G Sets New Sustainability Goal: No Deforestation in the Palm Supply Chain [Press release]. Retrieved from http://news.pg.com/press-release/pg-corporate-announcements/pg-sets-new-sustainability-goal-no-deforestation-its-palm-s
Pakiam, R. (2014, September 5). Malaysia Scraps Palm Export Tax for Two Months to Help Sales. *Bloomberg*. Retrieved from http://www.bloomberg.com/news/articles/2014-09-04/malaysia-scraps-palm-oil-export-tax-for-two-months-to-help-sales
Pazzibugan, D. (2013, June 12). PCGG Looking for a Few Good Investors to Help Reopen Shuttered Coco Firm. *Philippines Daily Inquirer*. Retrieved from http://business.inquirer.net/126615/pcgg-looking-for-few-good-investors-to-help-reopen-shuttered-coco-firm
Pepsico. (2016). Packaging, Recycling and Waste. Retrieved from http://www.pepsico.cl/Purpose/Environmental-Sustainability/Packaging-and-Waste
Petrochemical Update. (2016). US Ethane Boom to Double Polyethylene Exports by 2020. Retrieved from http://analysis.petchem-update.com/supply-chain-logistics/us-ethane-boom-double-polyethylene-exports-2020
PEZA. (2015). Firm-Level PEZA Investment Data (through Sept. 30, 2015). Manila: Philippine Economic Zone Authority (PEZA).
Pflug, K. (2013). Classification of chemicals in the commercial area. *Journal of Business Chemistry, 10*(3), 151-160.
Philippines NSO. (2013). *2010 Annual Survey of Philippine Business and Industry (ASPBI) - Manufacturing Sector: Final Results, Volume III-A*. Retrieved from: https://psa.gov.ph/content/2010-annual-survey-philippine-business-and-industry-aspbi-manufacturing-sector-final-results
Philippines NSO. (TBD). *2013 Annual Survey of Philippine Business and Industry (ASPBI)*. Retrieved from: https://psa.gov.ph/content/primer-2013-survey-philippine-business-and-industry
PJAC. (2016). Applications. Retrieved from http://www.pjac-corp.com/applications.htm
PR Newswire. (2014). Global Activated Carbon Market. Retrieved from http://search.proquest.com.proxy.lib.duke.edu/abicomplete/docview/1637991946/CD4375BD2DB84577PQ/22?accountid=10598
Prochile. (2016). Prochile. Retrieved from http://www.prochile.gob.cl/
Professional Regulation Commission (Philippines). (2016). Exam Results: Chemical Engineer Data. Retrieved from http://www.prc.gov.ph/licensure/?id=27
PSA. (2007-2014). Firm-Level Trade Data. Manila: Philippines Statistics Authority (PSA).
PwC. (2010). *Green Products: Using Sustainable Attributes to Drive Growth and Value*. Retrieved from Washington, D.C.:
PwC. (2011). *New Opportunities in China for the Chemicals Industry: What Foreign Investors Need to Know*. Retrieved from
Ravenscroft, M. (2016). Emerging markets to grow fastest. *Chemical Week, 178*(1), 23.
Republic of the Philippines. (2005). *DENR Administrative Order No 2005-27: Revised Priority Chemical List*. Retrieved from Quezon City:
Roland Berger. (2015). *Think Act: Chemicals 2035 - Gearing Up for Growth. How Europe's Chemical Industry Can Gain Traction in a Tougher World*. Retrieved from Munich:

Royal Society of Chemistry. (2015). *Skills for the Chemical Industry - Training the Teachers*. Retrieved from London:
RSPO. (2016). Members. Retrieved from http://www.rspo.org/members
S&P Capital IQ. (2015). *Chemicals Industry Survey June 2015*. Retrieved from New York:
Scruggs, C. E., Ortolano, L., Wilson, M. P., & Schwarzman, M. R. (2015). Effect of company size on potential for REACH compliance and selection of safer chemicals. *Environmental Science & Policy, 45*, 79-91. doi:http://dx.doi.org/10.1016/j.envsci.2014.10.001
Selin, H. (2013). Global Chemicals Politics and Policy. In R. Falkner (Ed.), *The Handbook of Global Climate and Environment Policy*. Oxford: John Wiley & Sons, Lt.
Seow, J. (2015, September 15). Science Sells in Field of Specialty Chemicals. *The Strait Times*. Retrieved from http://www.straitstimes.com/singapore/science-sells-in-field-of-speciality-chemicals
SGS. (2016). Industrial Manufacturing: Chemical Testing. Retrieved from http://www.sgs.ph/en/Industrial-Manufacturing/Services-Related-to-Production-and-Products/Materials-Testing/Analytical-Services/Chemical-Testing.aspx
Shin-Etsu Chemcial Co. (2015). *Annual Report 2015*. Retrieved from Tokyo:
Singaporean-German Chamber of Industry and Commerce. (2014). *Singapore Oil & Petrochemical Industry*. Retrieved from Singapore: http://www.sgc.org.sg/fileadmin/ahk_singapur/DEinternational/IR/diffIR/Oil_Petrochemicals_2014.pdf)
Solvay. (2016). Solvay in Jurong Island, Singapore. Retrieved from http://www.solvay.sg/en/solvay-in/solvay-in-jurong-island-singapore.html
Spitz, P. (2003). The Global Industry. In P. Spitz (Ed.), *The Chemical Industry at the Millenium: Maturity, Restructuring and Globalization*. Philadelphia: Chemical Heritage Foundation.
SPRING. (2016). *Capability Development Grant*. Retrieved from Singapore, : http://www.spring.gov.sg/Resources/Documents/Brochure_Capability_Development_Grant.pdf
Sumitomo Metal Mining Co. (2016). Our Businsses. Retrieved from http://www.smm.co.jp/E/business/refining/domestic/nickel/kyoten.html
Swanepoel, E. (2012, 26 July). ENK Searches for Strategic Offtake Partner for Philippines Nickel Project. *Mining Weekly*.
Swift, T. K. (2012). Looking for Growth in the Chemicals Industry. *CEP*(January), 12-15.
TechNavio. (2014). *Global Green Chemicals Market 2014-2018*. Retrieved from
Thailand Board of Investment. (2014). *Thailand Bio-Plastics Industry*. Retrieved from Bangkok: http://www.boi.go.th/index.php?page=pdf_page&menu_id=348
The Economist. (2006, November 2). Molecular Weight. *The Economist*.
The Nickel Institute. (2010, June). Enabling Essential Battery Technologies. *Nickel, 25,* 16-17.
The World Bank. (2016). *Doing Business 2016- Economic Profile Philippines*. Retrieved from http://www.doingbusiness.org/data/exploreeconomies/~/media/giawb/doing business/documents/profiles/country/PHL.pdf?ver=3
Tosoh Polyvin Corp. (2016). About Us. Retrieved from http://tosohpolyvin.weebly.com/
U.S. EIA. (2016). Petroleum & Other Liquids. Retrieved April 4, 2016, from U.S. Energy Information Administration https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=METEXUS2&f=A
UNComtrade. (2015a). World Chemicals Exports by All Reporters and Partners, 2005-2014 (based on HS-2002) *Retrieved October 31, 2015 from UNComtrade*. New York: United Nations Statistics Division (UNSD).
UNComtrade. (2015b). World Wine Exports by Chile, 2004-2014 (based on HS-2002) *Retrieved April 27, 2016 from UNComtrade*. New York: United Nations Statistics Division (UNSD).
Unilever. (2016). *Unilever Annual Report and Accounts 2015*. Retrieved from https://www.unilever.com/Images/annual_report_and_accounts_ar15_tcm244-478426_en.pdf

United States Trade Representative. (2014). US Removes the Philippines from the Special 301 Watchlist [Press release]. Retrieved from https://ustr.gov/about-us/policy-offices/press-office/press-releases/2014/April/US-Removes-the-Philippines-from-the-Special-301-Watch-List
USAID. (2014). *Science, Technology, Research and Innovation for Development (STRIDE): Philippines Innovation Ecosystem Assessment*. Retrieved from Manila:
USGS. (2013). The Mineral Industry of the Philippines *2011 Minerals Yearbook*. Washington, D.C.: United States Geological Survey.
USGS. (2015). *Minerals Commodities Summary*. Retrieved from Washington, D.C.: http://minerals.usgs.gov/minerals/pubs/mcs/2015/mcs2015.pdf
WDA. (2016). Singapore Workforce Skills Qualifications: Chemicals.
Wilcock, K. (2015). Philippines is key to sulphuric acid. *ICIS Chemical Business*(3537), 3-3.
World Bank. (2015). *Philippine Economic Update: Making Growth Work for the Poor*. Retrieved from Washington, D.C.:
World Economic Forum. (2016). *Global Competitiveness Report- Philippines*. Retrieved from http://reports.weforum.org/global-competitiveness-report-2015-2016/economies/ -indexId=GCI&economy=PHL
Yep, E. (2013). Singapore Seeks to Profit from Specialty Chemicals. *The Wall Street Journal*.
Young, I. (1996). China's ambitious specialties strategy. *Chemical Week, 158*(39), 38.
Yoyo, T., Daryanto, A., Gumbira-Sa'id, E., & Hasan, M. F. (2014). Competitiveness Model and Gap Analysis of Indonesian Palm Oil-Based Fatty Acid and Fatty Alcohol Industry. *International Journal of Economics and Finance, 6*(2), 218-225.
Zion Research. (2016a). *Global Plastic Packaging Market*. Retrieved from Deerfield Beach, FL:
Zion Research. (2016b). *Global Textile Chemicals Market*. Retrieved from Deerfield Beach:

6. Appendix

Table A-1: Chemical Industry Definition by HS Codes

VC Stage	VC Sector	HS Code 2002	Description Notes
Raw Materials	Inorganic	28	Basic inorganic chemicals, except HS 2844
	Organic[42]	29 3823	Basic organic chemicals
	Plastic resins/ Petrochemicals[43]	3901-3915	Polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), polyester, and others
	Other	2503, 2707-08 31 3201-3206 3507 3803-3807 , 4402	Includes minerals (2503, 2707-08), fertilizers/nitrogen compounds (31*) coating precursors (3201-06), enzymes (3507), and miscellaneous (3803-07, 4402)
Intermediates	Coatings	3207, 3211, 3212; 3214; 3814	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
	Oils	3301-3302	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
	Surfactants	34021-9; 340290	
	Other	3503-04, 350190, 350220, 350290 3601, 3603 3707, 3701, 3703 3802 3809-3813, 3815, 3817-3822, 3824-3825	Includes starches & glues (3503-3504, 350190, 350220, 350290), explosives (3601, 3603), photography (3707, 3701, 3703), activated carbon (3802), and other chemical intermediates (3809-3813, 3815, 3817-3822, 3824-3825)
Final Products	Coatings	3208-3210, 3213-14 350520, 3506	Includes paint, art sets, ink and starches/glues (350520, 3506)
	Pesticides	3808	Pesticides and other agrochemical products
	Personal Care	3304-3307 3401	Includes haircare, toiletries, cosmetics & make-up, dental hygiene, and soap
	Other	3602, 3604, 3605 370251-54; 370291, 3 3403-05, 3407 3303 340220	Includes explosives (3602, 3604, 3605), photography (370251-54; 370291, 3), lubricants/waxes/polishes/pastes (3403-05, 3407), perfumes/fragrances (3303), surfactants (340220)

Notes: Rubber (HS4002) and pharmaceuticals (HS30) are not included in the trade analysis to match the definitions used in the Philippines' roadmaps.

[42] All codes in HS Chapter 29 are included, however the following codes would NOT be included if the PSIC09/ISICRev4 to ISICRev3.1/HS02 is used: 291821, 291822, 291823, 292241, 292242, 2923, 2924 (except 292421), 29331, 293321, 29335, 293369, 293430, and 2935-2941. These are designated as being related to pharmaceuticals.

[43] The Petrochemical Roadmap appears to only include HS3901-3905.

Table A-2. Top 10 Basic and Commodity Chemicals Importers, 2007-2014

Reporters	Value (US$ billions)				World Share (%)			
	2007	2010	2012	2014	2007	2010	2012	2014
World	**765.9**	**848.4**	**997.6**	**991.5**				
China	88.0	114.0	136.5	141.2	11%	13%	14%	14%
USA	77.9	79.1	92.3	93.0	10%	9%	9%	9%
Germany	58.3	57.1	65.4	69.2	8%	7%	7%	7%
Belgium	48.1	46.5	53.5	54.6	6%	5%	5%	6%
India	--	29.3	38.1	40.6	--	3%	4%	4%
France	37.3	35.4	40.9	37.6	5%	4%	4%	4%
Italy	35.9	32.7	35.7	35.7	5%	4%	4%	4%
Netherlands	26.7	25.5	34.9	34.0	3%	3%	4%	3%
Japan	25.8	31.0	35.2	30.7	3%	4%	4%	3%
Rep. of Korea	19.7	--	28.9	29.6	3%	--	3%	3%
Brazil	--	--	--	28.6	--	--	--	3%
United Kingdom	37.2	26.4	--	25.0	5%	3%	--	3%

Source: UNComtrade, HS02 4D, all reporters imports, retrieved 10/31/15.

Table A-3. Top 10 Intermediate Chemical Importers, 2007-2014

Reporters	Value (US$, billions)				World Share (%)			
	2007	2010	2012	2014	2007	2010	2012	2014
World	**152.6**	**175.7**	**198.8**	**201.4**				
China	10.5	15.4	18.3	20.0	7%	9%	9%	10%
USA	13.4	13.3	15.9	17.5	9%	8%	8%	9%
Germany	12.9	14.6	15.8	17.0	8%	8%	8%	8%
France	9.8	9.3	10.6	10.9	6%	5%	5%	5%
United Kingdom	6.7	7.0	7.1	7.8	4%	4%	4%	4%
Rep. of Korea	7.0	7.8	8.1	7.5	5%	4%	4%	4%
Italy	6.6	7.0	7.6	6.8	4%	4%	4%	3%
Mexico	--	4.8	--	6.7	--	3%	--	3%
Netherlands	4.9	--	6.7	6.7	3%	--	3%	3%
Belgium	5.8	5.9	6.4	6.5	4%	3%	3%	3%
Japan	6.0	6.4	7.0	--	4%	4%	4%	--

Source: UNComtrade, HS02 4D, all reporters imports, retrieved 10/31/15.

Table A-4. Top 10 Specialty Chemicals and Final Product Importers, 2007-2014

Reporters	Value (US$, billions)				World Share (%)			
	2007	2010	2012	2014	2007	2010	2012	2014
World	**136.3**	**158.5**	**182.1**	**198.7**				
Germany	9.8	11.2	13.7	15.5	6%	6%	7%	8%
USA	9.6	9.6	11.7	13.7	6%	5%	6%	7%
France	8.6	8.8	9.4	10.5	6%	5%	5%	5%
United Kingdom	8.5	8.3	8.8	10.1	6%	5%	4%	5%
China	4.3	6.5	8.2	9.5	3%	4%	4%	5%
Canada	5.6	6.6	7.2	7.8	4%	4%	4%	4%
Netherlands	4.5	4.8	5.8	6.7	3%	3%	3%	3%
Russian Federation	--	5.2	6.6	6.6	--	3%	--	3%
Belgium	4.6	4.7	5.1	5.9	3%	--	3%	3%
Italy	4.9	5.0	5.2	5.6	3%	3%	3%	3%
Spain	4.5	--	--	--	3%	--	--	--

Source: UNComtrade, HS02 4D, all reporters imports, retrieved 10/31/15.