

LEVELS OF ADVANCEMENT IN SUPPLY CHAIN PLANNING BY LARGE-SCALE PETROCHEMICAL COMPANIES IN SOUTH AFRICA

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Abstract

The adoption of a full supply chain approach in the chemical industry is still relatively slow compared to other industries. Although the awareness has been kindled, very few petrochemical companies have advanced to a point where supply chain considerations and influences are proactively taken into account and incorporated in the formulation of corporate- and unit-specific business strategies/tactics, and formally structured and applied. Conventional supply chain integration concepts focus primarily on the internal and external integration of individual supply chains. Due to the highly integrated nature of petrochemical value chains, the related supply chains should also be integrated by taking account of enterprise/industry-wide synergies and interdependencies. Since not much research has been done to indicate the level of advancement in terms of supply chain planning in large-scale, South African-based petrochemical companies, this empirical research is the first of its kind. This research provides useful information regarding an understanding of the petrochemical industry, appropriate supply chain planning practices and the level of advancement in a number of related planning dimensions.

Keywords: petrochemical industry, strategic planning, supply chain planning, value chain

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INTRODUCTION

Effective supply chain planning is one of the critical ingredients for thorough supply chain management. Following a supply chain approach, companies can use integrated planning processes to proactively align the channel partners (internal and external) towards common objectives. Supply chain planning processes support long-, medium- and short-term decision making across the different segments and stages in the supply chain. Seeking a global optimum, and translating these decisions into feasible tactical and operational supply chain plans, assures that the stage is set for world-class supply chain execution. Large-scale integrated petrochemical companies face very specific supply chain planning challenges, and there are opportunities to make improvements in their supply chain integration. These challenges relate to interdependencies within and between related supply chains.

Petrochemical companies and their products

The macro petrochemical value chain is characterised by a number of linked and successive interdependent transformation stages and processes. Starting with a

relatively small number of raw materials, a large variety of liquid fuel and chemical products (organic and inorganic) are produced in subsequent refining processes [2, 7]. Some products are made intentionally; others are the result of the processing technology used (i.e. co-products). The products are then either distributed and sold locally or exported. Along the various stages of feed and derivative transformation, opportunities exist to either sell/trade the *petroleum* and *chemical* products, or to further process them into higher-value products (in so doing progressing closer to the end consumer). The various stages of the macro petrochemical supply chain typically deal with raw materials (e.g. coal, oil, gas); petroleum distillates and chemical feed streams (e.g. naphtha, ethylene); liquid fuels and bulk chemicals (e.g. petrol, diesel, methanol, ammonia); fine chemicals (e.g. reagents, surfactants, explosives, polymers and resins); and specialty chemicals (e.g. adhesives, films and fibres, paints and additives).

Chemical industry products are inputs to nearly all other sectors of the manufacturing economies [1]. Holistically, the chemical industry comprises two primary groups: bulk/commodity chemicals and specialty chemicals. These two primary groups differ in several ways, such as in supply and demand complexity, manufacturing, transportation and

profitability. The South African chemical industry sector focuses principally on the production of base chemicals and petroleum, which accounts for 60% of the total production value. The remainder focuses on downstream, higher-value chemical production [3].

OBJECTIVE, METHOD AND SCOPE OF RESEARCH

There is limited literature currently available on supply chain and supply chain planning that specifically focuses on applicable practices in the petrochemical industry (the literature relating to large-scale petrochemical companies in South Africa is even more limited). An empirical research study was conducted to gain better insight into the applicable supply chain decision integration practices applied by large-scale petrochemical companies in South Africa. The empirical research included the following:

- *Semi-structured interviews* with identified stakeholders were conducted to clarify best practice, concepts and approaches, followed by

key industry leaders, consulting practices, academia and technology providers.

- A *questionnaire* was used (and completed in the interviews) to assess the level of advancement in supply chain integration along relevant supply chain dimensions.

Because of the relatively small population size of large petrochemical companies in South Africa related to this study topic (refer to Table 1), key stakeholders to this industry were identified and used as a mechanism to support the findings and recommendations [6]. Applicable criteria were used for screening and selecting credible experts and participants from industry, consultancy, enabling technology suppliers and academia. In total, 21 ‘one-on-one’ interviews were conducted either through appointments or telephonically. The experience base of the participants to this empirical study covered most of the major industry players in each of the chemical industry’s sub-sectors.

Table 1. Major players in each of the chemical industry’s sub-sectors

Sub-sector	Major players
Liquid fuels	BP, Caltex, Sasol, Shell, Total,
Basic organic chemicals	AECI, African Products, Degussa, Dow, Sasol
Basic polymers and rubbers	Dow, Sasol
Basic inorganic	AECI, Bayer, Dow, IOF, NECSA
Fine chemicals	AECI, Dow, FCC
Specialty and functional	AECI, Aventis, Bayer, Chemserve, Plascon, Resinkem
Bulk formulated	AECI, Bayer, Omnia, Sasol
Pharmaceuticals	Adcock Ingram, Aspen Phamacare, GSK, MSD, Novartis, Pfizer
Consumer formulated	Colgate Palmolive, Dulux, Plascon, Unilever
Plastics	Dancor, Fenner SA, Goodyear, SA Leisure
Rubber	Bridgestone/Firestone; Goodyear
Synthetic fibres (textiles)	SANS Fibers

Source: [4]

Given that the number of potential participants to this empirical research was relatively small (due to the field, scope and context of this study), the stakeholder (participants) approach coupled with the Delphi technique was used to obtain general agreement on the findings among an informed audience. The range of perspectives from the participants to this research provided a balanced contribution, means for validation and assurance of consistency (triangulation principle). The empirical research was completed in the period July 2005 to January 2006.

FINDINGS

The interview and questionnaire findings are presented separately in the following sections. Companies or divisions focusing upstream in the

macro petrochemical ‘pipeline’ follow different supply chain approaches and are faced with different decisions from those downstream. Thus, where applicable, the interpretations of results were separated and aggregated into the *liquid fuels* and *chemical businesses* paragraphs.

Interview findings

Nature of petrochemical businesses

Liquid fuels businesses: All crude oil feed for the South African-based refineries is imported. From the large variety of crude oil grades imported, petroleum refineries produce a wide range of products from those with a very light, low boiling point, to the heavy, high boiling temperature ones. These petroleum products are mainly supplied to the South

African local markets (with some exports to African countries in the region). Oil companies tend not to have more than one or two refineries in a country and use supply agreements with the other oil companies to make up for their shortfall (product exchanges and swaps are commonly used). Refineries are capital-intensive and require vast numbers of utilities for production.

The cost of crude oil has a major impact on the value chain cost for liquid fuels businesses. From the figures provided by the participants, crude oil costs amount to 80–90% of revenue. Up to 80% of oil companies' profits depend on the profitability of crude oil trading (larger margins made upstream in the value chain). The direct supply chain cost as a proportion of sales typically amounts to 90%; and total direct inventory value as a percentage of turnover roughly amounts to 15%.

Chemical businesses predominantly rely on seven fundamental types of feedstock for the production of higher-value chemical products (agricultural and inorganic inputs also play a significant role). These seven types are ethylene, propylene, C4 olefins (mixed butenes), benzene, toluene, xylenes and methane. Chemical feedstock is sourced almost exclusively from the energy sector (oil, naphtha, gas or coal). Most feedstock is available locally and it is necessary only for certain process chemicals to be imported. The manufacturing facilities are predominantly located close to the major feedstock sources. Since chemical plants are relatively small compared to refineries, there may be multiple plants in a single country for the manufacturing of a specific chemical. The use of toll manufacturing and market swap are not as common as in the liquid fuels industry.

Although the feedstock cost for chemical businesses is a lower percentage (i.e. 20–40% of cost) than that of liquid fuels businesses, it still has a major impact on the chemical value chain cost. Since there is a substantial growth in chemical exports and foreign revenue, the outbound logistics cost represents a higher percentage than that of liquid fuels businesses. The direct supply chain cost as a percentage of sales typically amounts to 70%; total direct inventory value as a percentage of turnover amounts to 12–30%.

Petrochemical supply chain approach

Most participants agreed that only a relatively small number of petrochemical companies have adopted a full supply chain approach in managing their businesses along horizontal, cross-functional processes, which reaches across upstream, refining and downstream supply chain stages. In cases where a full supply chain approach has been adopted, it is still in the early stages of development (i.e. two to three years in existence). The following categories were

confirmed to be a practical approach to categorising the supply chain process:

- Physical and inventory flow processes (across the physical supply chain network)
- Transactional processes (workflow clearly defined; tasks in succession)
- Information processes (for sharing, exchanging information and collaboration)
- Planning and decision-making processes (to support and enable supply chain decisions)

Supply chain planning and decision-making processes aim to reach across multiple internal functional areas, as well as externally across the upstream and downstream supply chain stages [6, 7]. These processes were found to be distributed among the business units and functions and not necessarily totally integrated with single accountability assigned. Therefore, this is still an area that requires major development to achieve the intended benefits. The supply chain functions are not regarded as highly within these businesses as other functional disciplines (e.g. marketing, finance, etc.), with the result that the critical influences of supply chain activities on the business's strategies/scenarios are not always taken into account.

Key supply chain decisions

Most participants highlighted the fact that long-, medium- and short-term decisions are typically iterative by nature and involve many parties along the supply chain to reach consensus (i.e. a number of reviews are required before a final answer is produced). Long- and medium-term decisions relate to planning, while short-term decisions relate more to scheduling (typically linked to crude and petrochemical feed, production plants and units, products and logistics).

Most supply chain decisions revolve around matching demand and supply. Participants agreed that supply chain decisions need to be taken well in advance to keep actual supply chain operations running uninterruptedly (mostly on a 24-hour basis) and meet consumer requirements. Most manufacturing technology in the process industry is product-specific, making manufacturing processes less versatile. There is a trend for petrochemical supply chains to become more demand- and pull-oriented. However, in the process industries it is more difficult to foresee real end user demand for final products compared to the discrete industries (e.g. point of sale information).

For *liquid fuels* (petrol, diesel, jet fuel, fuel oil, etc.), typical supply chain decisions were found to cover all the supply chain stages from crude supply from the various sources right through to final products for end consumers. However, for non-fuels and *chemicals* (lubes, solvents, bitumen, etc.), typical supply chain decisions only start at downstream feedstock from refineries for chemical plants and

extend to product supply for end customers. Higher upstream, the supply chains are influenced by profitable and feasible allocation decisions concerning bulk streams of scarce chemicals to downstream producers of intermediate and derivative products (based on value-adding potential and yield optimisation). Further downstream decisions are more related to market/region allocation, and based on margin enhancement potential.

It is critical to understand the different cycles of supply chain decision making and their applicable time windows. If possible, decisions should not be taken too far in advance, but should be taken at the latest time that is feasible. One major outcome of decisions should always be to determine the value of relaxing some constraints to supply chain throughput

(e.g. by using advanced analytical processes). Constraints are typically related to feed material, markets, manufacturing and policies. Time horizon (forward looking), time buckets (granularity of data) and frequency of review (based on time buckets) are important parameters of supply chain decision making.

Tables 2 to 5 indicate the major long- (i.e. enterprise-wide and business unit-specific), medium- and short-term supply chain decisions that need to be taken in petrochemical companies, which were determined in the interviews. An indication is also given of the scope of and interdependencies between these major long-, medium- and short-term supply chain decisions.

Table 2. Typical long-term decisions taken across multiple supply chains

Decisions	Scope and dependency
Long-term: External to enterprise with other industry players	
<p><i>Macro logistics network:</i></p> <ul style="list-style-type: none"> - Structural synergistic opportunities - Joint infrastructure investment - Cooperation with government <p><i>Upstream feed supply clusters:</i></p> <ul style="list-style-type: none"> - Feed supply sources and agreements - Possible feed exchange agreements - Joint supply agreements <p><i>Downstream product supply clusters:</i></p> <ul style="list-style-type: none"> - Possible product exchange agreements - 'Supply pipeline' inventory sharing - Possible hospitality arrangements 	<p>Across multiple enterprises' supply chains, within and across relevant industries</p> <p><i>These decisions typically determine the boundaries internal to enterprise but across multiple business units; long-term plans in terms of strategic objectives, investment, policies, directives, guidelines, etc. Investment decisions: 3 to 10 years</i></p>
Long-term: Internal to enterprise – across multiple business units	
<p><i>Macro logistics network:</i></p> <ul style="list-style-type: none"> - Cross-enterprise corridor synergies - Commercial synergistic agreements - Consolidated logistics network risk <p><i>Upstream feed supply clusters:</i></p> <ul style="list-style-type: none"> - Feed supply sources and agreements - Aggregate feed supply priorities and directives - Group optimisation management <p><i>Downstream product supply clusters:</i></p> <ul style="list-style-type: none"> - Determine interdependent product supply clusters - Business cluster optimisation management - Directives on competition for the scarce products 	<p>Across multiple business units' supply chains, within an enterprise</p> <p><i>These decisions typically determine the boundaries for business unit-specific long-term plans in terms of strategic objectives, investment, policies, directives, guidelines, etc. Investment decisions: 3 to 10 years.</i></p>

Table 3. Typical long-term supply chain decisions for a business unit

Long-term: Per business unit supply chain	
Marketing scenarios to consider	For a business unit's supply chains, across all supply chain partners
Consensus target market, product range and specification	Decision taken under the umbrella of the corporate strategic decisions. Long-term decisions determine the SC network through which production, assembly and distribution serve the marketplace.
Production technology and capacity	
Available crude wells/chemical sources	
Energy supply choices (generate own/source external)	
Supply chain network structure and configuration and capacity requirements (options and choices)	
Ownership/contract strategy	
Exchange and supply agreements	
Supply chain risk tolerance and contingencies	<i>Looking 1 to 5 years ahead with monthly, quarterly, yearly time buckets used. Periods to cover at least multiple seasons and cycles.</i>
Inventory policy	
Supply chain strategic plan and directives; supply chain goals	
Planning and execution practices to follow, broad policies, performance measures and enabling of supply chain processes	

Table 4. Typical medium-term supply chain decisions for a business unit

Medium-term: Per business unit supply chain	
Consensus demand and sales plan to use	For a business unit's supply chains, across all supply chain partners
Supply and demand balancing (define supply operations plans)	<i>Decision taken under the umbrella of the long-term decisions.</i>
Cost and lead time trade-offs	<i>Working according to the SC network; prescribes material flow management policies, including production levels at all plants, inventory levels and lot sizes. Optimised utilisation of resources.</i>
Inventory deployment, allocation and control plans	
Primary and secondary transport requirements	
Shipment nominations and commitments	
Feed stream allocation to manufacturing operation	
Assignment of production capacity	
Workforce requirements	<i>Looking 3 to 6 months ahead with weekly and monthly time buckets.</i>
Supply scheduling of longer lead time materials	
Commitment to exchange and supply agreements	
Contract call-offs from term agreements	

Table 5. Typical short-term supply chain decisions for a business unit

Short-term: Per business unit supply chain	
Allocate demand/orders to delivery opportunities	For a business unit's supply chains, across all supply chain partners. <i>Decisions taken under the umbrella of the medium-term decisions and conscious of the medium-term economics (e.g. product slate, crude slate).</i> <i>Prime focus on when operations should be performed within constraints; looking for feasible execution plan.</i> <i>Looking 1 to 4 weeks ahead in hourly, daily and weekly time buckets.</i>
Order processing and scheduling	
Consolidated logistics schedules	
Short-term inventory balancing and reconciliation	
Inventory replenishment	
Feed, refinery, plant campaign and unit scheduling	
Final refinery, plant and unit allocation and operations sequencing	
Process yield optimisation	
Workforce schedules	
Firm commitments to supplier and service provider	

Supply chain planning to support supply chain decision making

Participants supported the principle that supply chain planning processes should be used to translate the supply chain strategy into plans that direct the supply chain operations (i.e. to manage the flow of material, products, information and funds). Although not yet applied to its fullest extent, planning processes are utilised to explore, evaluate and make supply chain decisions. These processes span long-, medium- and short-term time horizons. They provide the means to balance the market demand requirements with supply resources (taking into account agreements, capacity, availability, efficiency, service level and profitability) and to establish and communicate plans for the whole supply chain. Supply chain planning also supports the drive for internal cross-functional cooperation (breaking the 'silo mentality'), as well as external decision integration (i.e. working with supply chain partners).

The use of planning processes (involving the relevant internal and external stakeholders), supported by appropriate analytical techniques, was found to be still fragmented along the various stages and sections of petrochemical businesses' supply chains. In some cases, decisions are still made on the basis of judgement (or bogged down on time-consuming procedures), as opposed to using integrated planning processes and an iterative analytical approach. Very limited formal processes exist on the strategic level to explore, evaluate and make supply chain decisions. (This applies to the corporate level, as well as individual divisions and business units.) Medium- and short-term planning processes are more structured, but still rely heavily on people's roles and the relationships that have been established over time. People are still learning how to orient themselves to the hierarchy of constraints and follow an analytical approach. The evaluation of interdependencies is crucial in the process of developing feasible and optimal plans.

Strategic and long-term supply chain network design and configuration are still mostly done on an ad hoc (as opposed to by regular review), informal and unsophisticated basis, with the result that supply chains evolve over time rather than being established and optimised by intent. The following were found to be the applicable *long-term* supply chain planning processes – *company-wide* (cross-divisional) and across *multiple enterprises*:

- Planning of chemical feed clusters (inventory flow dependencies)
- Evaluation of consolidated supply chain scenarios (aggregate growth impact evaluation)
- Evaluation of macro logistics network synergies (logistics synergies and interdependencies)
- Sourcing consolidation (commercial synergies)
- Evaluation of consolidated risk (aggregate risk effect)
- Governance of company-wide technology (standardising systems and data models)
- Planning company-wide manpower (planning of critical jobs and succession)

The following were found to be the typical *long-term* supply chain planning processes used by *business unit* structures:

- Supply chain scenario and strategic planning
- Supply chain network design
- Supply chain configuration and functional design
- Alliance and trading partner strategic planning
- Long-term sales and operations planning (quarterly, yearly – three to ten years)

Medium-term planning processes are now getting a lot of attention and are becoming a bit more formalised. The sales and operations planning (S & OP) process is found to currently receive most attention. Although some have already utilised S & OP for a number of years, several petrochemical businesses are only just starting, or are still busy embedding these processes to support decision making. This overarching S&OP process typically includes the following processes:

- Demand planning and forecasting,

- Supply planning
- Supply chain balancing
- Formalising supply chain plans

The supply planning process then incorporates the following sub-processes:

- Inventory planning
- Distribution planning
- Manufacturing planning
- Feed, component – external sourcing and exchange supply planning
- Procurement planning

Short-term planning was found, in many cases, to be done informally at each facility. It includes distribution scheduling, feed procurement scheduling and production scheduling. Closed loop scheduling is becoming more important (i.e. updating the status of schedules continuously and alerting relevant parties proactively as to the extent and impact of changes; this relates to supply chain event management). The following were found to be the applicable short-term supply chain planning processes:

- Order fulfilment scheduling
- Distribution scheduling
- Production scheduling
- Feed scheduling
- Procurement scheduling
- Supply chain event management

Analytical techniques used to support supply chain planning processes

There is a huge lack of knowledge concerning the use of advanced analytical techniques for supply chain decision support. Simple mathematical calculation is primarily used for analysis (typically with spreadsheets). Furthermore, decision makers still rely on their own brainpower, cognitive models and experience for taking judgemental decisions.

In some cases, companies have developed to a level where more advanced analytical techniques are used. Analytical techniques are then used to construct models representing the real-world supply chains and indicate the effect of changes to certain parameters. Sophisticated models (using mathematical programming techniques) are also used to indicate the optimal solution to a specific problem. Long-term and strategic analysis typically utilises LP, MIP and comparative economics analysis to provide decision support. For medium-term tactical decisions, LPs are predominantly used for sequencing and capacity balancing. Operational scheduling predominantly uses heuristics.

Participants agreed that more advanced mathematical tools and techniques should in future be utilised to prove that supply chain strategic and practice levers could have a positive impact on the company's financial objectives. Until now, too much

focus has been placed on cost and local optimisation, as opposed to profit and global optimisation. It is, however, important to realise that the approach and techniques used will determine the quality of the results achieved (i.e. it is important to use the right technique to solve the right problem).

Opportunities and potential value-adding benefits through advance planning

Companies with mature supply chain planning processes are far more profitable, hold much less inventory and have superior delivery performance than their less advanced competitors. Most participants indicated that substantial supply chain improvements are still possible in the petrochemical industry (20–40%). There still exist huge opportunities to advance and improve the industry's business conduct by applying appropriate supply chain practices. Due to huge volume throughputs, small improvements can make a big contribution. To justify any supply chain planning intervention and get the attention and interest of senior managers, supply chain levers should be linked (as far as possible) to financial benefits and key company performance measures. Advanced supply chain planning processes can help provide a better understanding (mental model) of the interrelationships between the key supply chain operational activities.

Questionnaire findings (level of advancement)

Petrochemical businesses are still aspiring to advance to a point where the firm's strategic/competitive advantages are associated with the way it can leverage its integrated supply chain activities.

Supply chain focus/approach followed

Table 6 provides an aggregate view of the differences in the supply chain approach followed by petrochemical companies. From the responses, it is clear that most liquid fuel and chemical businesses have advanced to a stage where they have adopted a market focus/orientation. Since more than half of the commodity products are traded between the major players in the petrochemical value chain, a strong cost focus is maintained related to direct supply chain expenditure (to support cost containment/leadership strategies). Not many businesses have advanced to the stage where customer and market differentiation strategies are followed. In these cases, the supply chain design, configuration and management practices were geared to differentiate the business from its competitors.

Table 6. Supply chain approach followed by petrochemical companies

Focus	Indicators	Approach	
Cost focus	Supply chain is only viewed as an area for cost control.	Liquid fuels	○
		Chemicals	○
Market focus	The company recognises that adopting a supply chain approach could have a revenue-enhancing impact on sales.	Liquid fuels	●
		Chemicals	●
Customer and market differentiating focus	A supply chain approach is one of the key aspects in which a firm can differentiate itself from its competitors.	Liquid fuels	○
		Chemicals	○
Strategic focus	One of the firm's strategic/competitive advantages is centred on its integrated supply chain activities.	Liquid fuels	
		Chemicals	

Legend: Most replies ● Some replies ○

Some supply chain approaches might not be applicable to certain businesses, purely because of the specific business drivers, state regulation of commodities, the company's market capitalisation and the scope of the extended supply chain. Upstream and wholesale/industrial market players are further away from end-user customers and have a strong focus on supply, throughput and asset utilisation. Downstream and retail-focused players have a much closer interaction with end consumers, requiring a focus on customer satisfaction, service and segmentation. However, a market focus might be a competitive necessity. Where a customer-differentiating focus may provide superior customer service, a price premium may enhance margins (and may also lead to pricing and revenue optimisation).

Advancement in supply chain decision integration

Four dimensions of supply chain integration were assessed to get an indication of the level of advancement reached in petrochemical companies. These dimensions are:

- Horizontal integration (partners involved along the supply chain stages)
- Hierarchical integration (decision level involved, impact and time scale)
- Petrochemical value chain cluster and supply chain decision integration
- Logistics network integration (cross-business unit, cross-company, cross-industry)

Advancement in horizontal and hierarchical integration

Table 7 indicates the current extent of internal and external integration of petrochemical business units (supply chain partners involved along the supply chain stages upstream and downstream). This is cross-mapped with the level of supply chain decision integrations achieved.

Although many petrochemical companies are actively busy with external supply chain integration, there is great scope for bedding down internal integration within each business unit (within individual functions as well as cross-functionally, or departmentally). Unfortunately, however, many companies still find it easier to integrate externally as opposed to integrating internally across functions. Some business units still need to reach functional excellence before being able to step up to supply chain integration. The decision-making levels involved (hierarchical decision integration) still need to extend properly to medium- and long-term integration. The decision integration for short-term supply chain operations in liquid fuel businesses has advanced further than that of chemical businesses. Upstream supply chain integration has also advanced further than downstream supply chain integration (based on feed stream dependencies).

Table 7. Horizontal integration and advancement in supply chain decision integration

Horizontal supply chain integration		Hierarchical decision integration		
		Short term	Medium term	Long term
Internal integration: (<i>within an internal function</i>)	Liquid fuels	●	⊙	⊙
	Chemicals	●	⊙	⊙
Internal Integration: (<i>across internal functions</i>)	Liquid fuels	⊙	⊙	⊙
	Chemicals	⊙	⊙	⊙
External integration: (<i>with upstream partners</i>)	Liquid fuels	●	⊙	⊙
	Chemicals	⊙	⊙	⊙
External integration: (<i>with downstream partners</i>)	Liquid fuels	●	⊙	⊙
	Chemicals	⊙	⊙	⊙
External integration: (<i>upstream and downstream</i>)	Liquid fuels	⊙	○	
	Chemicals	⊙	○	

Legend: ● Mastered ⊙ Maturing ○ Still developing

Advancement in value chain cluster and the integration of supply chain decisions

Individual petrochemical value chains exist around a specific product or product family and form the basis for business unit structures in this industry. Tightly interdependent value chains form value chain clusters. These value chain clusters then closely cooperate in balancing their interrelationships, collaboratively allocating scarce chemicals and reaching shared

objectives. Value chain business decisions should also incorporate long-, medium- and short-term supply chain decisions.

Table 8 indicates what progress has been made in petrochemical companies in terms of integrating value chain and supply chain decisions in the long, medium and short term. This is an indication of what level of supply chain decision considerations is being incorporated when taking chemical value chain and value chain cluster decisions.

Table 8. Progress in integrating value chain and supply chain decisions

Decision integration in petrochemical value chain clusters		Supply chain decisions considered		
		Short term	Medium term	Long term
Single value chain integration with first upstream chemical feed sources	Liquid fuels	●	⊙	⊙
	Chemicals	●	⊙	⊙
Single business unit integration with feed source(s) and consumer(s)	Liquid fuels	●	⊙	
	Chemicals	●	⊙	
Multiple business units collaborate around a specific feedstock's supply	Liquid fuels	●	⊙	
	Chemicals	●	⊙	⊙
Multiple business units collaborate around many feedstocks and products	Liquid fuels	⊙	○	
	Chemicals	⊙	⊙	○

Legend: ● Mastered ⊙ Maturing ○ Still developing

It is clear that the advancement of petrochemical value chain cluster and supply chain decision integration has not moved beyond short-term decisions. Only some of the petrochemical companies with many successive value chains and multi-stage supply chains are starting to advance in terms of their integration of value chain and supply chain decisions.

Only a few *liquid fuels businesses* have established organisational entities for the total supply chain alignment for a specific product and cluster of related products (feed supply, manufacturing and product supply to consumer). Value chain segments are managed within functional domains and only certain areas are managed cross-functionally (e.g.

joint-venture partners managing their share in a refinery via manufacturing, supply and trading groups). However, not enough interaction exists between these functions, and this typically results in deep silos of specialisation and isolation. This is partly the reason why very limited long- and medium-term supply chain decision influences are considered in collaboration across feedstock value chains.

Chemical businesses deal with a large variety of feed streams (from on-site refineries or overland/international sources) and interrelated successive chemical transformation processes requiring closer collaboration (*upstream chemical process streams, mid-stream chemical feedstock and derivatives, to downstream polymers, commodity chemicals, fine chemicals, and specialty and functional chemicals*). Production planning and scheduling need close interaction with the outbound supply chain segments, marketing and sales. A number of internal chemical value chain clusters have formed in the industry, which are sometimes formally structured (e.g. polymer and nitrogenous businesses).

The petrochemical supply chain practitioners are still developing in terms of achieving a total understanding of the fully integrated nature of petrochemical businesses. They form part of the

macro oil and gas and chemical value chains, individual value chain decision domains (value chain structures), as well as possible petroleum and chemical clusters that closely relate to one another and have the potential for increased cooperation (chemical dependency). Many value chain decisions are thus made without taking the required supply chain considerations into account. Ultimately, these decisions result in operational inefficiencies and sometimes in not meeting consumer requirements. Consequently, huge profit-enhancing opportunities are lost.

Integration processes to conduct objective trade-off analysis between the decision domains of asset/production managers (managing shared assets), business unit managers (managing product value chains), supply chain managers and cluster and group optimisation managers are still in their infancy.

Advancement in the integration of logistics network decisions

Table 9 indicates what progress has been made in terms of logistics network integration for large-scale petrochemical companies (cross-business unit, cross-company and cross- industry).

Table 9. Progress in the integration of logistics network decisions

Logistics network integration		Supply chain decisions considered		
		Short term	Medium term	Long term
Enterprise: corporate unity (upstream integration)	Liquid fuels	●	◎	◎
	Chemicals	●	◎	○
Enterprise: corporate unity (downstream integration)	Liquid fuels	●	◎	○
	Chemicals	◎	◎	○
Enterprise: corporate unity (up- and downstream)	Liquid fuels	◎	◎	○
	Chemicals	◎	○	○
Petrochemical industry: (upstream integration)	Liquid fuels	●	◎	◎
	Chemicals	◎	◎	○
Petrochemical industry: (downstream integration)	Liquid fuels	●	◎	○
	Chemicals	◎	◎	○
Petrochemical industry: (upstream and downstream)	Liquid fuels	●	◎	○
	Chemicals	◎	○	○
Multiple industry: (upstream and downstream)	Liquid fuels	○	○	○
	Chemicals	○	○	○

Legend: ● Mastered ◎ Maturing ○ Still developing

Liquid fuel companies have matured as an industry and have a long history of cooperation and exchange agreements. They also share some of their operations and logistics infrastructure. With competition becoming fierce, collaboration between supply managers has reduced, but is still present among shipping managers.

Chemical businesses have not yet reached the same level of logistics cooperation as liquid fuel companies. In South Africa, the logistics activities of chemical businesses are still relatively independent from one another, with limited sharing and co-management of infrastructure (e.g. ammonia imports). Some advancement is also evident in Europe where

multiple enterprises draw from a network of propylene pipelines. Opportunities do exist for multiple industries to cooperate. The South African agricultural industry is in the early stages of such operational development.

There are also possible opportunities for cooperation with the motor manufacturing industry (containers) on rail along certain trade corridors. However, huge opportunities exist for the chemical companies to work more closely within the industry itself, as well as with related industries (e.g. chemicals, paper and pulp, and paints). Closer collaboration and gradual sharing of increasing relevant supply information is the key. There is also a gradual move in the chemical industry to outsource the logistics operations further, and to allow fourth party logistics (4PL) to leverage synergistic opportunities with other related players across the types of logistics networks that exist.

DEDUCTION

The nature, practices followed and level of advancement related to advanced supply chain planning processes differ between the liquid fuels and chemical domains. Companies or divisions focusing upstream in the macro petrochemical 'pipeline' follow different supply chain approaches and are faced with different decisions from those downstream.

A relatively small number of petrochemical companies have adopted a full supply chain approach (including planning) in managing their businesses along horizontal cross-functional processes reaching across upstream, refining and downstream supply chain stages. Value chain and supply chain planning processes provide the main mechanism to integrate and align the enterprise cross-functionally, cross-divisionally and with all related external parties directly involved in the applicable segments of the macro petrochemical value chain. Petrochemical businesses are still aspiring to advance to a point where the firm's strategic/competitive advantages are associated with the way in which it can leverage its integrated supply chain activities.

Supply chain decisions must be taken well in advance to keep actual supply chain operations running uninterruptedly and to meet consumer requirements. Brief indications of the typical interdependencies found for the different time horizons for supply chain decisions are as follows:

- **Long-term corporate/industry decisions** (Mindset: Focus and alignment): These decisions have a long-lasting effect and typically determine the boundaries for a business or business unit's specific long-term plans in terms of strategic objectives, investment, policies, directives, guidelines, etc. Corporate priorities, enterprise-wide functional strategies and business charters are established. Long-term financing and

aggregate capital investment decisions are also determined.

Investment decisions typically are taken three to ten years in advance.

- **Long-term business unit supply chain decisions** (Mindset: Strategise and prepare): These decisions work under the umbrella of the corporate/industry strategy decisions (also having a long-lasting effect). The business strategy is translated into a supply chain strategy. Long-term supply chain decisions determine the supply chain network that provide the configuration and inventory flow capacity for feed supply, production conversion of feed into value-added products and distribution to the marketplace. Strategic supply chain objectives and targets are also determined.

Looking one to five years ahead in monthly, quarterly and yearly time buckets.

- **Medium-term supply chain decisions** (Mindset: Structure and organise): These decisions work under the umbrella of the long-term decisions and work according to the supply chain network, prescribed material flow management policies, production levels set at all plants, inventory levels and lot sizes. The prime focus is on converting the supply chain strategy into supply chain operation plans. Medium-term decisions also focus on optimising supply to the market within the supply chain resource capability.

Looking three to six months ahead in weekly and monthly time buckets.

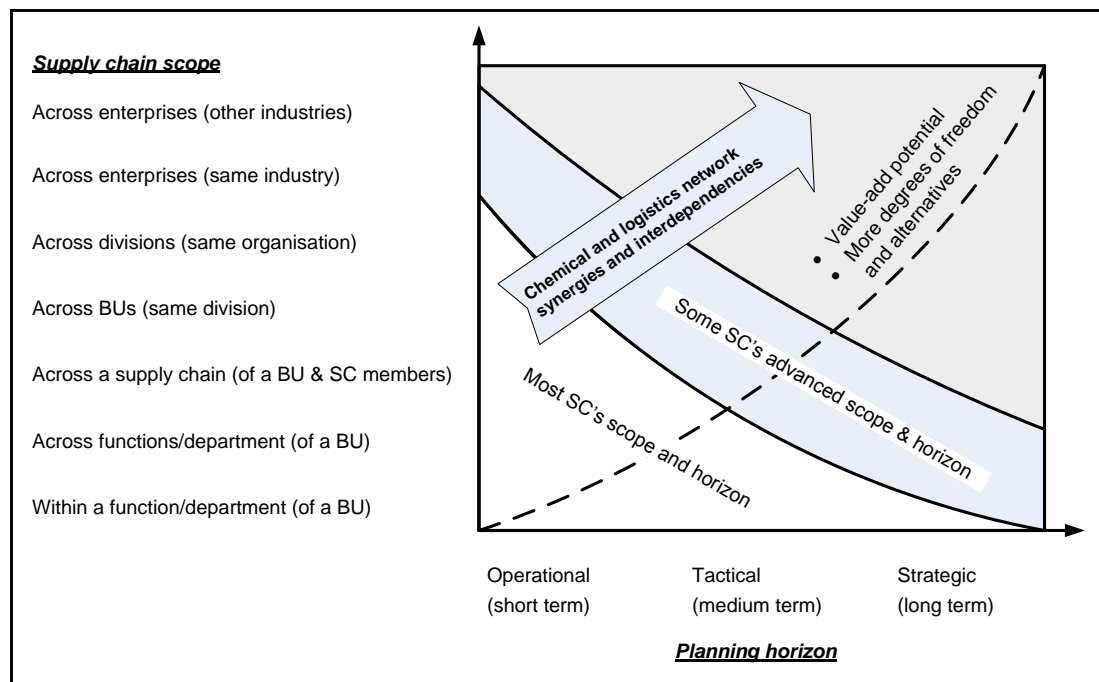
- **Short-term supply chain decisions** (Mindset: Commit and control): These decisions are conscious of the medium-term economics (e.g. profitable product allocations, crude slate decisions already taken) and work under the umbrella of the medium-term decisions. The prime focus is on converting the supply chain operation plans into supply chain operation schedules. Monitoring processes for execution control are also utilised.

Looking one to four weeks ahead in hourly, daily and weekly time buckets.

Given the current level of advancement, there exists an opportunity to expand the chemical supply chain scope and planning horizon, as indicated in Figure 1 (to support supply chain decisions). There are few petrochemical companies that have expanded their supply chain thinking to include additional value-add dimensions of supply chain scope and supply chain planning in their interdependent chemical supply chains and logistics networks. Firms can expand their supply chain scope by harnessing both internal and external benefits by leveraging synergies and interdependencies found between chemical supply chains and logistics network. This calls for network management of the related interdependencies. Huge opportunities exist for the chemical companies to work more closely within the

industry, as well as with related industries to leverage logistics network synergies for mutual benefit (e.g. the chemical, paper and pulp, and paints industries).

Figure 1. Potential expanded chemical supply chain scope and planning horizon



CONCLUSION

Supply chain planning processes can provide a logical and structured approach for supply chain decision making. The use of planning processes (involving the relevant internal and external stakeholders), supported by appropriate analytical techniques, are still fragmented along the various stages and segments of petrochemical businesses' supply chains. Very limited formal processes exist on the strategic level to explore, evaluate and make supply chain decisions (this applies to both the corporate level and within divisions and business units). Medium- and short-term planning processes are more structured, but still rely heavily on people's roles and the relationships that have been established over time. Supply chain planning supports the drive for internal cross-functional cooperation (breaking the 'silo mentality'), as well as external decision integration with supply chain partners.

Although there seems to be a fair degree of advancement in the level of analytical techniques used, the knowledge, understanding and experience in the application of management science and operations research are still lacking among end users. In many cases, people still rely on their own brainpower and cognitive models (i.e. experience and judgement) for taking 'gut feel' decisions (or they are fixated on following time-consuming procedures).

Although many petrochemical companies are actively busy with external supply chain integration, huge scope still exists for internal integration for each

business unit (within functions as well as cross-functionally/departmentally). Unfortunately, many companies still find it easier to integrate externally, as opposed to integrating internally across functions. Some petrochemical business units still need to reach functional excellence and stability in their supply chain operations before being able to step up to supply chain integration (internal and external). The decision-making levels involved (hierarchical decision integration) still need to extend properly to medium- and long-term integration.

Albeit slowly, the petrochemical industry has started to believe in the potential of using advanced supply chain planning processes, as well as employing modelling to enhance its decision making. There are also some positive signs in organisational development to assist in the change process. Supply chain management is becoming the leading strategic concern in the petrochemical industry, with many companies planning or implementing major supply chain planning initiatives.

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