TRADE SUSTAINABILITY IMPACT ASSESSMENT FOR THE NEGOTIATIONS OF A PARTNERSHIP AND COOPERATION AGREEMENT BETWEEN THE EU AND CHINA

Sectoral Study 4 of 5: Chemicals

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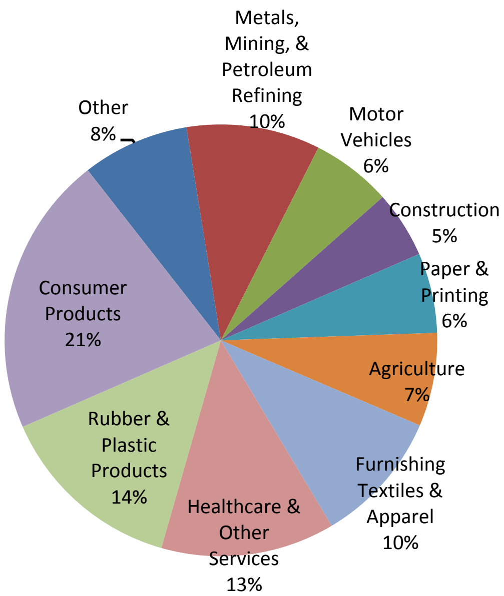
1. Background

With over 70,000 different products the global chemical industry is one of the most broad, complex industries in the world. Chemical products range from basic commodity chemicals, derived from initial processing of organic and inorganic raw materials, to specialty and fine chemicals that are characterised by consumer products such as pharmaceuticals, soaps, cosmetics, toothpaste and other basic household goods. In terms of absolute output the chemical industry is dominated by commodity and related intermediate chemicals that are crucial inputs into a vast array of other industries such as electronics, machinery, and the aforementioned consumer goods. Despite the chemical industry's crucial role in a number of other industries the general public is more or less unaware of its products besides final consumer goods.

The chemicals industry can be roughly characterised as a series of subsectors classified by their linkages to other industrial sectors such as agriculture, construction or electronics, wherein chemical products are inputs such as fertilizers, pesticides, sealants, protective coatings, etc. The chemical industries' huge range of products as well as broad field of consuming industries make it particularly sensitive to the health of the overall economy (see **Figure 1**).

Figure 1: Chemical Output by Linked Industry Segment



Source: EMG 2007

Chemical goods are frequently intermediate goods inputs into a variety of other sector's production processes. As a result, innovation is a key attribute of successful companies to adapt to changing market dynamics in downstream industries. The chemicals industry is also heavily capital intensive, which has historically led to its geographic concentration in developed economies. Recent growth in capital mobility, however, has lead to a shift towards commodity manufacturing in Asian economies.[1]

As a rule, commodity manufacturing in Asia is only for the regional Asian market and the huge investments in Asia are driven by the strong growth of the customer markets in Asia. Therefore, Asia's imports from Europe and other regions with decrease with the new production facilities going onstream in Asia.

In that context it is important to know that the chemical industry has a distinctly multiregional character in the sense that there are limited trade flows between the three main manufacturing regions of North America, Europe and Asia. Only about 10 percent of total output is shipped between these three regions. Not surprisingly, interregional trade is particularly limited for volume/commodity products which are relatively expensive to transport. The limited interregional trade has not, however, decoupled prices and industry cycles in the different regions. The prices of commodity plastics, for example, moved in remarkably close harmony in all three regions. Unlike interregional trade, trade within the regions is very strong.

The relative dominance of upstream chemicals, i.e. commodity or petrochemicals, in a number of other sectors, has raised concerns in recent years. Currently approximately 30 million barrels of oil are used daily for industrial purposes worldwide, of which a large majority is used in the

[1] Sector Futures: Chemicals, European Foundation for the Improvement of Living and Working Conditions

chemicals industry. This figure is expected to reach 50 million barrels per day in 2030.[2] As oil prices have risen concerns about knock-on-effects in downstream industries are increasingly raised.

The global petrochemical industry is a dynamic one which has been undergoing significant changes since the 1990s. The Middle East still maintains a significant advantage over other regions because of its readily accessible feedstock. However, India and China are major competitors with the rapid industrialisation and commercialisation of their industries; while Russia retains its potential, despite regulatory inconsistencies. Eastern Europe is also fast emerging as a competitor, boasting major refineries, MOL, ORLEN and Pompetrol, while Western Europe and North America maintain a competitive edge in advanced, value added sectors.[3]

While viewing the chemicals industry by its linkages to other sectors of the economy is illustrative of its relationship to the overall economy and its operations, more intuitive means of classification exist that allow for more general analysis. These categories are commodity chemicals, specialty chemicals, and fine chemicals. **Commodity chemicals** are comprised of upstream products that are generic in nature and produced in large scales for input into other industrial processes, requiring significant economies of scale as well as a large dependence on petroleum.[4] **Specialty chemicals** are intermediate chemicals that again are not end products but rather inputs into other industrial processes. Specialty chemicals differ from commodity chemicals in that they are generally of higher value and have specific applications as both intermediate and end use products, for example in the electronics manufacturing and construction materials industries, although generally still not as specialised as fine chemicals. Additionally, specialty chemicals also constitute consumer products, such as household chemicals and cosmetics. The final category, **fine chemicals**, represents the highest value-added segment of the chemicals industry, with unique performance characteristics playing a much more important role than bulk production or price, as in commodity chemicals. The fine chemicals market includes examples such as pharmaceuticals, special coatings, inks and photographic chemicals. Each subsector follows significantly different business models and as such it is important to differentiate the three (see **Table 1**).

Table 1: Chemicals Industry - Factors for Success by Subsector

Commodity	Specialty	Fine
Lowest cost of production (economy of scale and economy of scope) Capacity utilisation (plant and site) Number of competitors Oil price and price of derivatives (naphtha etc.) Long-term access to technology Long-term access to feedstock (petrol and gas)	Product differentiation and innovation Logistical issues such as distribution capacity Broader range of services including: Research Problem solving Bespoke product development Storage solutions	Customer intimacy, service-oriented approach Technology tool box Reputation and size Development and scale-up capability Efficient use of R&D, sales force, etc.

[2] Chemicals, Coatings & Plastics Industry Overview. Plunkett Research, Ltd.

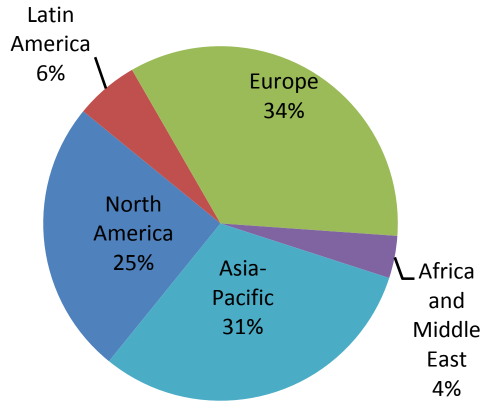
[3] World Refining Association, 2008

[4] In addition to organic and inorganic basic chemicals, commodity chemicals in this study will include generic rubber and plastic, as these products are primarily manufactured by companies specialising in the commodity chemicals sector.

1.1 Global Competitive Sector Context

The global chemical sector has shown modest growth in recent years, with output reaching €1.86 trillion in 2006, up 9.4% from 2004.[5] Of this developed economies have held their historical strength, with the EU leading with approximately a third of global output (see **Figure 2**). While major players are still based heavily in developed nations (Japan claimed the lion's share of Asia-Pacific output in 2006), a rising competitive environment globally has prompted massive industry restructuring since the early 1990s.

Figure 2: Share of Global Chemical Output 2006



Source: American Chemistry Council

During the 1990s the then agglomerated chemical industry split into three distinct sub-industries in a bid to improve financial viability. The oil industry took over low margin, high output petrochemicals (or commodity chemicals) as well as downstream plastics and rubber industries, while pharmaceuticals (i.e. fine chemicals) and core chemical companies (dealing in both specialty and fine chemicals) focused on their higher value added markets. As a result of industry consolidation that occurred throughout this period, multi-billion dollar specialty and fine chemical companies were formed, particularly in Western Europe, to focus on core competencies as well as bolster global competitiveness.[6]

This restructuring and consolidation saw historical industry leaders such as Hoechst, Rhộne-Poulenc, Sandoz American Cyanamid and Union Carbide no longer existing through mergers into companies such as Novartis, AstraZeneca and Aventis (later merged with Sanofi to form Sanofi-Aventis) or spin-offs into companies such as Clariant, Syngenta, Avecia and Cognis (see **Table 2**).

Table 2: Transformation of the European chemicals industry

Source: FESTEL CAPITAL

[5] Global Industry Profile. American Chemistry Council

[6] Study on the Future Opportunities and Challenges of EU-China Trade and Investment Relations: Chemicals. DEVELOPMENT Solutions, 15 February 2007.

Initially, merger strategies favoured more diversified holdings that blended pharmaceuticals and agrochemicals in a “Life Sciences” approach in companies such as Novartis and Aventis, however, recently the mergers have focused on a pure, single subsector approach.. In the coming years analysts expect further consolidation through mergers between medium sized enterprises or their acquisition by subsector leaders.[7]

Within this environment of adaptation **commodity chemical producers** have seen their geographic positions shift more closely to their resource bases, primarily in the Middle East. This has occurred as oil and gas companies has solidified their position in the chemicals industry, leveraging their cost advantages as resource producers to gain a competitive edge against more distant rivals. These advantages include secure access to feedstock, the ability to combine refining and chemical production facilities to achieve greater economies of scale, thus achieving significant capital expenditure reductions in a capital intensive industry, and finally existing connections to the marine shipping industry as well as close proximity to existing deep-sea ports, greatly reducing transport costs. As a result, companies in the Middle East have expanded their market positions rapidly in recent years, taking advantage of previously stranded natural gas reserves and exporting derived, higher value derivatives. Meanwhile, chemical companies from the Middle East are buying assets on a large scale in Europe (e.g. the purchase of the commodity business of DSM by Sabic). In some cases Western producers have entered in joint ventures to gain access to resources, while in Asia backward integration has taken place, with chemicals, refining, and oil producing companies undergoing vertical integration to ensure feedstock access.

Prior to the 1990s **specialty chemicals** had been regarded as a low volume, high earnings sector with a large degree of predictability, bolstering investment greatly. During the industry reconfiguration a new model emerged. Prior growth dependence on industries such as automotive, home goods and electronics was perceived as a weakness, with these and other markets maturing and reaching saturation. Simultaneously a number of previously performance based specialty chemicals began being mass-produced by companies outside of the traditional developed countries, shifting their market dynamic towards a price based focus and these goods towards the commodity chemicals market. Finally, major purchasing industries of specialty chemicals themselves began to consolidate, seeking larger single vendors from whom to make their price-based purchases.

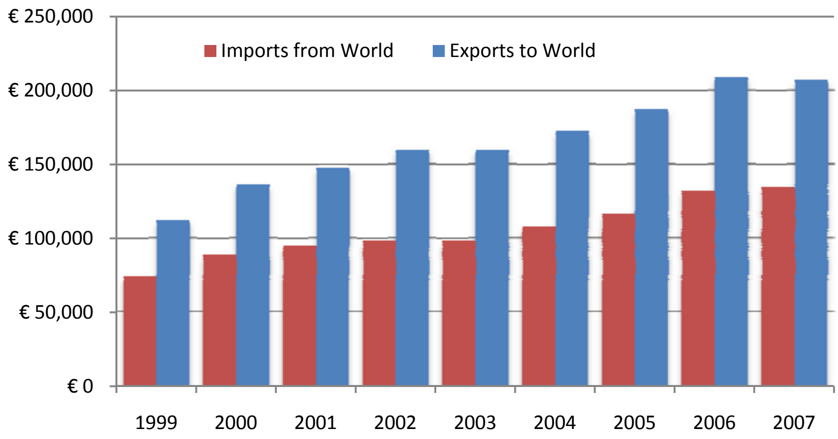
Today, specialty chemical producers are facing the challenges raised by their recent history of consolidation. With competition still based heavily on product differentiation but drifting towards commoditisation, companies are doing their best to differentiate their products through service offerings. These are seen as *de facto* barriers to market entry as larger incumbents are able to expand their service portfolios and tailor their offers to specific customer needs, with offerings such as on-site technical support, customised product development, training activities and supply chain management. Through this, service costs are presumably reduced while new market players face high

[7] Study on the Future Opportunities and Challenges of EU-China Trade and Investment Relations: Chemicals. DEVELOPMENT Solutions, 15 February 2007.

standards in order to carve out their own niche. Meanwhile, new market entrants also face difficulty in matching larger incumbents' ability to take on high-risk markets by leveraging extensive financial reserves.

In the **fine chemicals** market the United States has long be the region of highest demand, thus driving market growth, however, the European Union remains one of the key producers. Despite these geographic concentrations the fine chemicals market is in fact highly fragmented, with the top 10 producers accounting for less than 20% of market share.[8] This situation is not necessarily stable, however, with many fine chemicals producers facing an environment of consolidation similar to that recently experienced by the specialty chemicals sector.[9]

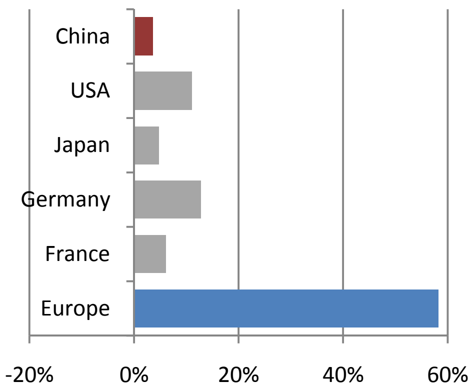
Figure 3: EU27-World Trade in Chemical Goods (millions)



Source: Eurostat

Despite a chaotic period of consolidation and reconfiguration the EU experienced sustained output and export growth throughout the last decade, with exports growing at an average rate of 8% per annum (see **Figure 3**). In absolute terms this growth has resulted in total EU trade in chemicals reaching €342 billion in 2007, with its surplus having grown from €38 billion in 1999 to €72 billion in 2007. **Although global output of chemicals is relatively dispersed geographically, in terms of trade the EU is unquestionably dominant, claiming over 58% of global chemical exports in 2006** (see **Figure 3**, **Figure 4**). While other economies, such as Japan and the US, closely follow the EU in terms of raw output, a larger proportion of their production is geared strictly for domestic consumption, resulting in a lower world trade ranking.

Figure 4: Share of Global Chemical Exports 2006



Source: United Nations Comtrade

Within its surplus growth the EU's restructuring strategy has focused on the evolution of its export composition, where commodity chemicals and specialty chemicals combined share of exports has dropped from 68% in 1999 to 63% in 2007, corresponding with a rise in fine chemicals share of exports from 31% to 37% over the same period.[10] The rise of fine chemicals has been led by

[8] Yu, D., Trends in the Chinese Fine Chemicals Market. In: The Chemical and Pharmaceutical Industry in China. Eds.: Festel, G., Kreimeyer, A., Oels U., v. Zedtwitz, M.. Springer, Berlin, Heidelberg, 2005.
[9] Personal communication with Dr Gunter Festel, FESTEL Capital
[10] Eurostat

Europe's pharmaceuticals industry, which accounted for over 83% of fine chemical exports in 2007. **The rising prominence of fine chemicals, including pharmaceuticals, in the EU's export composition highlights both the global competitive environment in the relatively lower value, high quantity commodity chemicals as well as Europe's innovative strengths in higher value, knowledge and service based markets.**

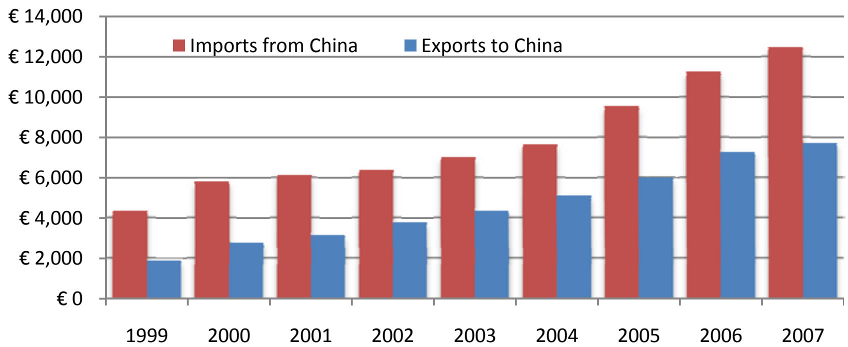
Fine chemicals also represent a sector of rising strategic importance globally. While commodity chemicals are volatile in their close link to the rising cost of oil, a requisite input, they are also highly energy dependent relative to other chemical sectors. In developed economies chemical industry activities are estimated to account for up to 30% of industrial energy consumption, largely due to the mass processing operations of commodity chemicals.[11]

1.2 EU-China Sector Specific Context

Following accession in to the World Trade Organisation in late 2001 China's trade with the world has expanded at an incredible pace. Within this EU-China trade growth has been equally impressive, if unbalanced. In 2006 bilateral trade between the EU and China reached €254 billion, with imports from China at €191 billion, a year-on-year rise of 21%, while exports to China reached €63 billion, a year-on-year rise of 22.5%.[12]

Trade between the EU and China in chemical goods has had a similar experience over the past decade. In 2007 bilateral trade in the sector reached €20 billion, with an average annual growth rate of just 15.7% since 1999 (see **Figure 5**). Within this bilateral trade China has held a long running surplus with the EU, which reached €4.7 billion in 2007. While the EU deficit has continued to grow over this period at a rate of 8.4%, EU exports to China have risen from €1 billion in 1999 to approximately €5 billion in 2007, growing at 19% annually.

Figure 5: EU27-China Trade in Chemical Goods (millions



Source: Eurostat

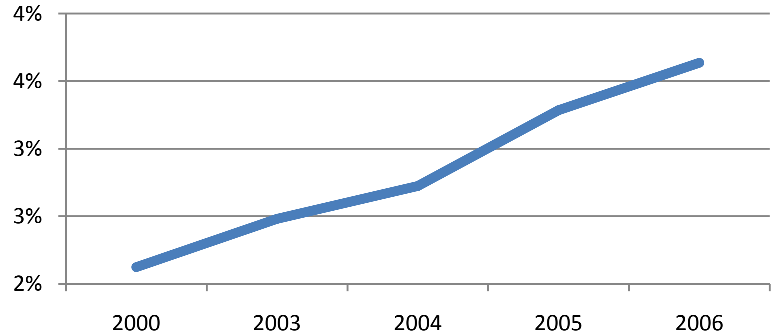
While the trade balance is not a desirable position for Europe, the fact that the Chinese surplus as a fraction of the overall trade balance has declined significantly over the past 8 years, from 39% to 23% (despite its absolute growth), is indicative of both European strengths as well as the reform process

[11] Chemicals Industry of the Future. US Department of Energy, 4 March 2007. Available at: http://www1.eere.energy.gov/industry/chemicals/

[12] Bilateral Trade Relations – China. European Commission – External Trade. Available at: http://ec.europa.eu/trade/issues/bilateral/countries/china/index_en.htm

China underwent following its WTO accession. As a signatory to the Chemical Tariff Harmonisation Agreement, China reduced its average tariffs on chemicals from a pre-WTO level of 14.7% to 6.9% by 2005.[13] Within this new tariff regime all basic chemicals (i.e. commodity chemicals) face zero tariffs upon entry into China. Notably, however, until December 2006 (marking China's 5 year ascension anniversary) distribution of chemical fertilizers and processed petrochemical products, accounting for 32% of 2007 EU commodity chemical exports to China, faced high barriers to market entry and in-country distribution.[14] Besides strong growth in exports to the EU, China's chemical industry has shown high growth in recent years, particularly in exports where its share of global exports has grown from 2.12% in 2000 to 3.64% in 2006, or in absolute terms reaching €28.9 billion in 2006 (see **Figure 7**).

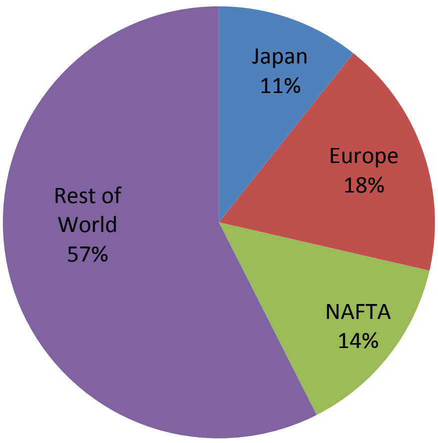
Figure 7: Chinese Share of Global Chemical Exports 2000-2006



Source: United Nations Comtrade

Simultaneously with its chemicals export absolute growth, China has also diversified its client base since 2000 (see **Figure 6**). While Europe accounted for approximately 21% of China's chemical exports in 2000, by 2006 this figure had dropped to 18%. The US and Japanese proportion of exports dropped similarly over this period, while developing countries, particular the Commonwealth of Independent States, saw their shares grow by as much as a factor of three.

Figure 6: Destination of Chinese Chemical Exports 2006



Source: United Nations Comtrade

[13] Walton, Julie. WTO: China enters year three. The China Business Review,
[14] Ibid

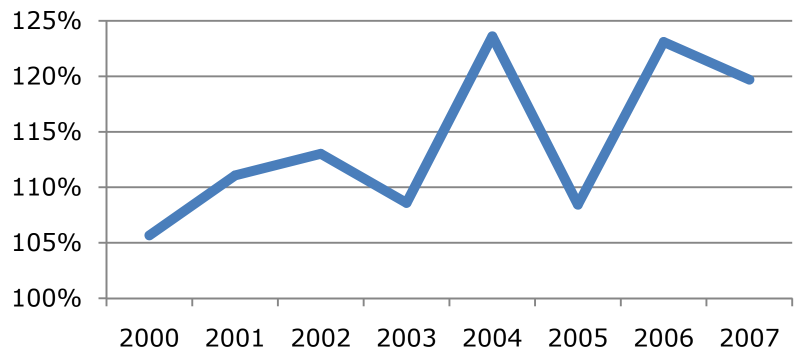
2. Baseline Scenario

As part of the European Commission's Sustainable Impact Assessment methodology a baseline scenario between the EU and China in the chemicals sector must be established. This baseline aims to elaborate the economic, social, and environmental conditions which are related to bilateral trade in the chemicals sector, not only to serve as a baseline of comparison against shifting trends under the proposed PCA scenarios, but also to establish already sensitive areas wherein significant impacts may undermine the long term sustainability of more robust and liberalised bilateral relations. These sensitive areas not only serve to steer the PCA scenarios towards more realistic parameters but also input into policy recommendations which will endeavour to mitigate the possible negative impacts associated with increased trade while also bolstering positive welfare gains.

2.1 Economic

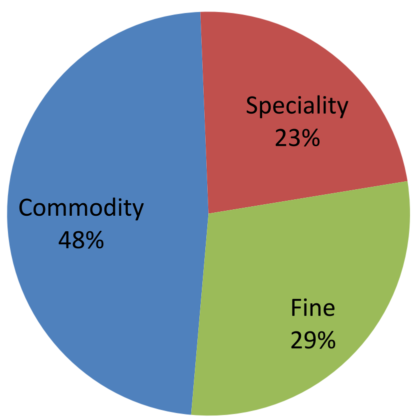
As a whole the chemicals industry is of strategic importance to most developed economies other industries, due to the complex inter-industry interactions discussed in **Section 1.1**. It comes as no surprise that as China's overall economy and industry output have grown by over 10% for several years its chemicals industry has also experienced rapid growth. In fact China's chemical sector has experienced growth in excess of national growth during this period, with annual growth in output of major chemical goods as high as 23% since 2000 (see **Figure 9**).

Figure 9: China Chemical Sector Year-on-Year Output Growth



Source: China Statistical Yearbook 2006; American Chemistry Council Global Production Index

Figure 8: Chinese Chemicals Production 2006



Source: China Yearly Industrial Data, China Data Center

In absolute terms, Chinese production of chemical goods reached US$ 372 billion in 2006, cementing its high importance to the domestic economy. Among this domestic production approximately half resulted from the commodity chemicals sector, composed of crucial upstream inputs into other industrial sectors, while fine and specialty chemicals split the remaining half (see **Figure 8**).[15] Please note that absolute production value does not necessary imply a correspondingly high level of trade, as some sectors (commodity chemicals) may be more focused on relocating to reduce transport costs to downstream consumers.

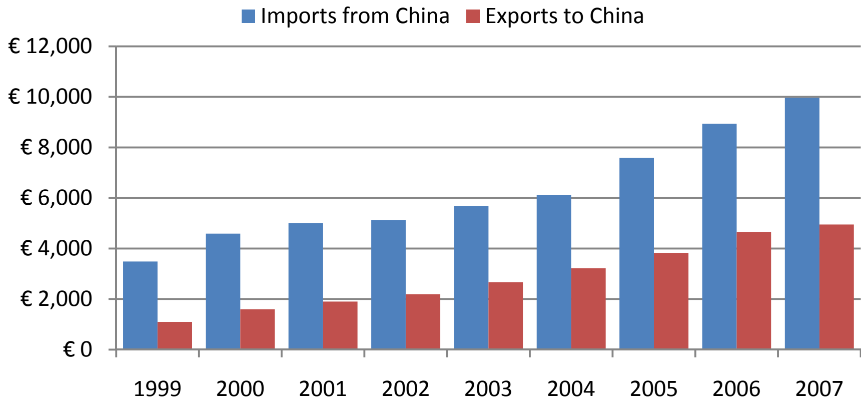
[15] For additional information on base data, sources, methodology, and analysis, please see **Chapter 6**.

2.1.1 Commodity Chemicals

EU-China trade in commodity chemicals accounted for over €14 billion in 2007, growing at approximately 16% annually since 1999 (see **Figure 9**). The EU has maintained a deficit in the sector throughout this period, reaching €5 billion in 2007. As a portion of total sector trade, however, the EU's deficit has declined from 52% in 1999 to 33% in 2007, signifying growing competitive strength or increasing market access for EU companies, or both.

The EU's continued deficit in the sector is not surprising, given its restructuring towards fine chemicals in recent years. This has provided a niche for new, relatively inexperienced producers such as those in China to fill. Furthermore, China's reputation as a low cost labour centre as well as the 'world's factory' for basic manufactured goods has made close placement of petrochemical plants, along with related downstream plastics and rubber manufacturing, an ideal choice, thus reducing transport costs for primary and intermediate inputs into China's many manufacturing industries. As a result, commodity chemicals accounted for 79% of Chinese chemical exports to Europe in 2007, essentially the same proportion as in 1999.

Figure 10: EU27-China Trade in Commodity Chemicals (millions)

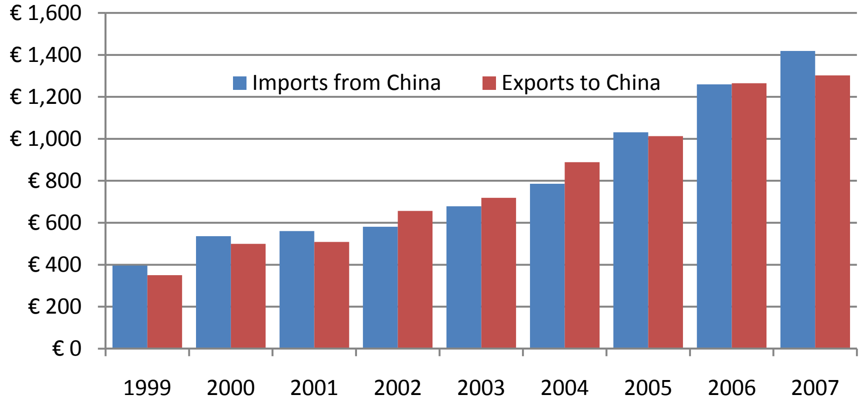


Source: Eurostat

2.1.2 Specialty Chemicals

In 2007 EU-China trade in specialty chemicals reached €2.7 billion, growing strongly at 17.5% since 1999 (see **Figure 10**). Prior to China's WTO ascension, when tariffs on chemical exports averaged 14.7%, the EU held a slight deficit to China in specialty chemicals, amounting to less than €52 million, or 4.8% of total trade, at its peak in 2001. Following WTO ascension and the corresponding tariff declines the EU's sector trade balance improved marginally, reaching €102 million in 2004 after three years of 16% annual export growth. In 2005, however, China reached its obligations for tariff reductions in the sector, and with the Yuan declining vis-à-vis the Euro (due it it's managed float vis-à-vis the declining US dollar) European chemical exports faced increasingly difficult price competitiveness from Chinese producers. Nonetheless, European exports remained more or less on par with Chinese imports, resulting in a relatively minor Chinese surplus of €116 million in 2007, representative of less than 4.2% of bilateral trade in the sector.

Figure 11: EU27-China Trade in Specialty Chemicals (millions)



Source: Eurostat

As noted, China's chemical industry's focus has been on high quantity commodity goods, further exemplified by specialty goods small 11.35% of total Chinese chemical exports to Europe in 2007, which also showed only marginal growth over the prior decade. For Europe, specialty chemicals play a comparatively larger role, accounting for 17% of total chemical exports to the world and over 19% of total chemical exports to China, highlighting Europe's strength in this mid-value sector.

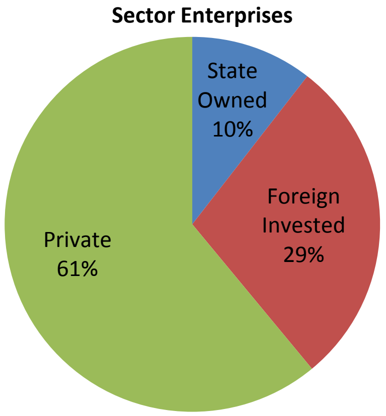
Within the EU deficit in specialty chemicals in recent years there has been an overwhelming dominance by generic household chemicals such as detergents, waxes, and soaps as well as cosmetics. While cosmetics feature several luxury lines, on the whole goods in this category are generic in nature and competition is highly based on price as opposed to product performance.

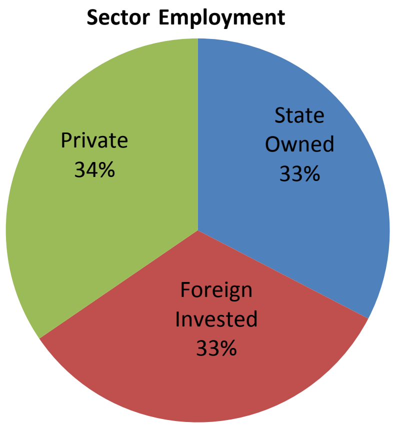
2.1.3 Fine Chemicals

In 2007 EU-China trade in fine chemicals reached €2.6 billion, following average annual growth of 13.6% since 1999 (see **Figure 11**). European producers have been particularly strong in the subsector since increased market access following China's WTO ascension in 2001, maintaining a growing trade surplus which reached €382 billion in 2007. The EU's strength has been primarily driven by robust pharmaceuticals exports, which constituted 50% of bilateral trade and, when considered a subsector to their own, a €602 million trade surplus for the EU in 2007. Although only in the fine chemicals market for just over a decade, by 2004 China had reached 13.1% market share in the pharmaceuticals market.[16] European producers have also performed well in fertilizers, although to the lesser extent than pharmaceuticals, with that group of goods experiencing a minor EU surplus of €31 million in 2007.

[16] Chemical Engineering News, October 10, 2006

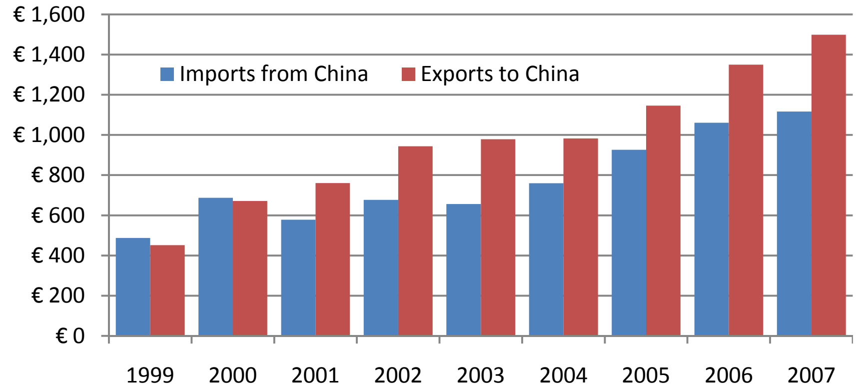
Figure 12: China Chemical Sector Enterprises and Employment by Ownership





Source: China Statistical Yearbook 2006

Figure 13: EU27-China Trade in Fine Chemicals (millions)



Source: Eurostat

The EU's sustained strength in fine chemicals trade with China is not surprising, given its global position as the leading pharmaceuticals exporter worldwide. In 2006 the EU exported approximately 69% of total pharmaceuticals; if Switzerland is included its share exceeds 79%.[17] Despite the EU's strength in this subsector, reports have indicated that barriers are faced by European suppliers in China in the segment of active-pharmaceutical ingredients. A host of registration, documentation, and customs procedures which are not WTO compatible have been noted as posing a potentially significant trade barrier.[18]

2.2 Social

Employment

In addition to the significant economic weight of the chemicals sector in China is its large effect of the sector on Chinese society. With over 10 million employees in 2004 the chemical industry accounted for 10.98% of total employment in China's industrial sector.[19] Despite this high level, reports indicate that many local governments in China are keen to further encourage investment and expansion in the chemicals sector (among others) as a means to bolster overall employment numbers.[20] Employment numbers may cause Chinese officials to hesitate when considering increased market liberalisation, as state owned industries account for a relatively large share of employment in the sector, despite constituting only one-tenth of total enterprises (see **Figure 12**). State-owned enterprises on average employ 601 employees each, compared to 223 in foreign invested enterprises or just 109 in private invested enterprises. These significantly different employment dynamics across varying forms of enterprise ownership imply the possibility that while China's state owned enterprises may be a source of significant employment, they possibly are also less efficient and less streamlined compared to their private counterparts.

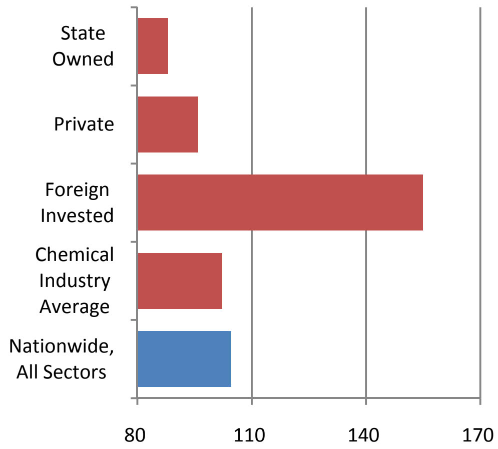
[17] Hamilton, Daniel and Quinlan, Joseph. Globalisation in Europe: Prospering in the New Whirled Order. Center for Transatlantic Relations, John Hopkins University, 2008.

[18] Market Access Database. http://mkaccdb.eu.int/madb_barriers/barriers_details.htm?barrier_id=020085

[19] Main economic indicators of all industrial sectors (2004). China Statistical Yearbook 2006, National Bureau of Statistics.

[20] China Insight – Chemicals. Broadwin China Strategy Consulting. Available at: http://www.chinastrategy.com.cn/industry_insight_chemical.htm

Figure 14: Chemical Industry Labour Productivity by Ownership (RMB thousands)

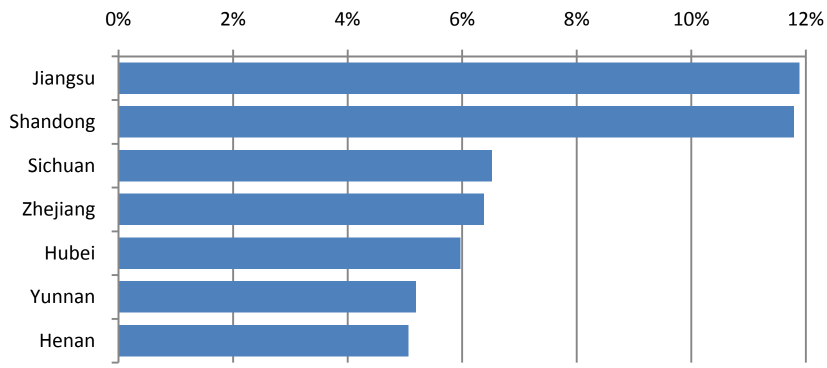


Source: China Statistical Yearbook 2006

The inefficiencies of China's state owned chemicals companies is cemented when viewed in terms of overall labour productivity (see **Figure 13**). On average, throughout all of China's industries, labour productivity in 2005 was approximately RMB 104,000 per worker annually. Conversely, the chemical industry average was approximately RMB 102,000 per worker annually, implying a minor misallocation of labour, because labour productivity within the chemical industry in Europe is much higher compared to other industries. Within the chemical industry, however, vast disparities exist in labour productivity between enterprises of different ownership schemes. Within enterprises with foreign investment, worker productivity is approximately 50% greater than the industry-wide average, at RMB 154,000 per employee. In the state-owned and domestic private enterprises, however, labour productivity is well below the national average at RMB 88,000 and RMB 95,000 per worker, respectively. This inefficiency has been anecdotally confirmed through industry surveys that indicate that chemical engineers in China experience significantly lower job satisfaction in chemical sectors than in other areas of the world.[21]

Risk of unemployment through elimination of inefficient or redundant enterprises in the chemical sector is further exacerbated by the high concentration of China's chemical industry. The seven provinces of Jiangsu, Shandong, Sichuan, Zhejiang, Hubei, Yunnan and Henan account for approximately 53% of China's chemical goods output (see **Figure 14**).

Figure 15: Provincial Contributions to Chinese Chemical Sector Output



Source: China Statistical Yearbook 2006

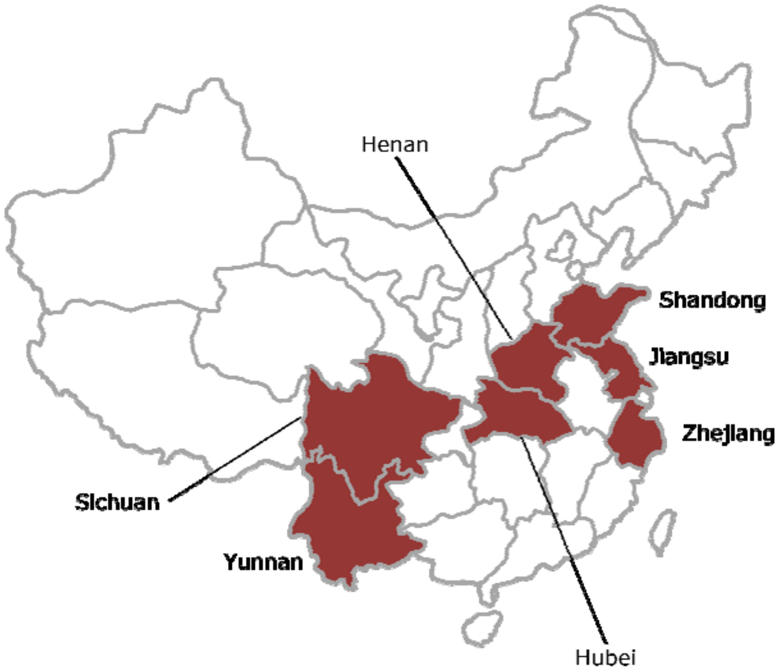
This concentration occurs due to strategic considerations, such as Zhejiang's historical development of oil processing facilities and accompanying infrastructure, or many of the other provinces close proximity to manufacturing bases along the east and south coasts (see **Figure 15**).[22, 23]

[21] How does chemical engineering education meet the requirements of employment?. World Chemical Engineering Council, September 2004

[22] Economic Development. The People's Government of Zhejiang Province. Available at: http://www.zhejiang.gov.cn

[23] Note: Hong Kong Special Administrative Region, Macao Special Administrative Region and Chinese Taipei not included in this analysis.

Figure 16: Map of Key Provinces in China's Chemical Sector Output



Source: China Statistical Yearbook 2006

Sustained employment is also a concern in Europe, with chemicals ranked the 4th most affected sector by globalisation between 2003 and 2006. During that period, overall sector employment declined by 7.9%, with Ireland experiencing the most drastic sector-employment decline of 14.5%.[24] Within this European wide employment declines, approximately 12.1% are estimated to have been jobs which were relocated to Asian production facilities.[25]

Human Health

In addition to its significant social impact through employment, China's chemical industry also has a more notorious social impact. In 2006 SEPA acknowledged that the environmental accidents had reached alarming levels, occurring at a rate of every other day in 2005, with 76 major incidents, and causing over 510,000 social 'disputes'.[26] Due to China's high population densities in areas of commerce it is inevitable that industrial facilities and residential neighbourhoods overlap. In recent years social awareness of the risks posed by large industrial facilities, particularly chemical processing plants, has risen, leading to grassroots movements and organised protests against new plant construction, in a similar essence to the 'not in my back yard' movement surrounding the heavy industry construction in developed countries.

Most recently this has materialised in Fujian province, where thousands of Chinese citizens have protested on multiple occasions to halt a US$1.4 billion chemicals plant (funded by Taiwanese investors) from being constructed two

[24] Hamilton, Daniel and Quinlan, Joseph. Globalisation in Europe: Prospering in the New Whirled Order. Center for Transatlantic Relations, John Hopkins University, 2008.
[25] Ibid
[26] China sees environmental accident every other day: SEPA. Gov.cn, 19 April 2006. Available at: http://english.gov.cn/2006-04/19/content_257882.htm

miles offshore from the island village of Dongshan.[27] The plant had originally been planned to be built in the nearby city of Xiamen, however protests there had prompted its relocation.[28] Dongshan's economy is largely based around fishing and aquaculture, while highly publicised environmental disasters in the chemical industry in recent years have raised citizen awareness of the impacts that a new plant may have on local commerce, environment and health.

A US$8 billion project in a suburb of Guangzhou, Guangdong, has also been put on hold in early 2008. The Kuwaiti funded project received approval from the National Reform and Development Commission in late 2007, however 14 provincial legislators have voiced concerns about the project's environmental impact at the behest of citizens living near the target site. Citizens had complained about possible health risks, while legislators have noted that the project has to yet to conduct an environmental impact assessment as required by law.[29]

In the recent past there are numerous other instances of social tension over chemical spills caused by both producers and consumers. In early 2008 some 20 tons of fish were killed in an aquaculture farm in Yunnan province when 120 tons of phosphate residues were improperly used on a nearby farm. The incident also stopped water resources to 9,000 local residents.[30]

Along with long term human and environmental health concerns, negligence in chemicals production has also caused several high profile fatal disasters. In late 2005 a benzene plant in Jinlin province killed 5 and injured over 70 workers, along with depriving 3.5 million residents of a source of clean water.[31] In 2006 in Tianjin an ammonia pipeline burst at a cosmetics factory killing 7 workers.[32] Just two months prior in Anhui province an explosives factory fire resulted in the death of 16 workers, while a bleaching and antiseptics factory explosion in Zhejiang province killed 3 the same week.[33] In the summer of 2006 an explosion at a chlorine factory in Jinagsu province released a noxious gas which killed 22 and forced the evacuation of over 7,000 local residents.[34] In May 2007 a Hebei province toluene diisocyanate factory exploded, killing 5, injuring 18, prompting the evacuation of 2,000 local residents and damaging a majority of houses in nearby Dazidian village, home to 4,000.[35]

In addition to the impacts felt by negligence in production and transport of chemicals within China, there are a number of other risks. As recently as

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[27] Coastal projects face opposition from local residents. Chemical & Engineering News, 10 March 2008. Available at: http://pubs.acs.org/cen/news/86/i10/8610notw9.html

[28] Public opposes Xiamen chemical plant. China Daily, 30 May 2007. Available at: http://english.peopledaily.com.cn/200705/30/eng20070530_379187.html

[29] Coastal projects face opposition from local residents. Chemical & Engineering News, 10 March 2008.

[30] China water supplies resume along China's algae-affected Hanjiang river. Xinhua, 27 February 2008. Available at: http://news.xinhuanet.com/english/2008-02/27/content_7681968.htm

[31] Death toll rises to 5 in chemical plant blasts. Xinhua, 14 November 2005. Available at: http://www.chinadaily.com.cn/english/doc/2005-11/14/content_494543.htm

Chinese river contamination resulting from a petrochemical explosion and toxic spill. United Nations Environmental Programme, 24 November 2005. Available at: http://www.uneptie.org/pc/apell/disasters/china_harbin/info.htm

[32] Death toll of N China chemical plant blast rises to 7. NewsGD.com, 8 August 2006. Available at: http://newsgd.com/news/china1/200608080007.htm

[33] Death toll in Eastern China chemical plant explosion rises to 14. Associated Press, 17 June 2006.

Chemical plant blast kills 16 in Anhui. China Daily, 19 June 2006.

[34] Death toll from East China chemical plant blast rises to 22. Xinhua, 30 July 2006.

[35] Death toll rises to five in China chemical plant blast. Xinhua, 12 May 2007.

February 2008 suspicion has been raised regarding the quality of China's pharmaceutical production, prompted by allegations that Chinese produced heparin caused 4 deaths in the US in addition to over a dozen in China.[36] Heparin, a blood thinner, is chemically derived from pig intestines, with approximately 70% of Chinese production taking place in small factories in rural villages, primarily located in Jiangsu province north of Shanghai.[37] In 2006 an estimated 300 Panamanians died due to consumption of Chinese produced cough syrup which was contaminated with diethylene glycol, also known as antifreeze, presumably used in error due its name's similarity to glycerine, which is used to sweeten cough syrup.[38] In total up to 300,000 Chinese deaths annually may be attributable to contaminated or counterfeit pharmaceuticals.[39]

While a number of concerning social impacts exist with regards to China's chemicals industry, the situation has begun to improve significantly in recent years. Since 2002 the China Petroleum and Chemical Corporation (Sinopec), among China's largest commodity chemicals producers, has worked with the International Labour Organisation and the China Employment Forum to implement a responsible system of safety management. As a result, Sinopec has seen a relative decline in workplace accidents at their facilities of 25%.[40] More broadly the Chinese government has also ratified the ILO convention concerning Safety in the use of Chemicals at Work (C170) and Guidelines on Occupational Safety and Health Management Systems (ILO-OSH).[41]

2.3 Environmental

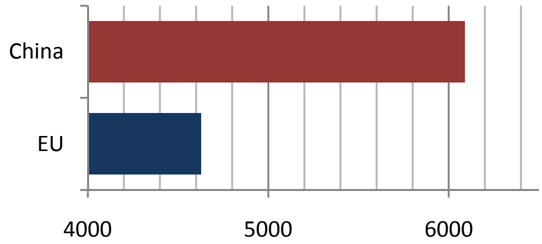
The effect of the chemical industry on China's environment has been an area of rising concern in recent years, especially considering the breadth of its impact in the case of large spills on waterways. Even without concerns of water pollution, China is one of the most water-deficient countries in the world. The total volume of water resources in China is substantial, although water is unevenly distributed and scarce given the size of its population. The country can be divided into two distinct regions: the "dry North", referring to all areas north of the Yangtze River basin, and the "humid South", which includes the Yangtze River basin and the provinces south.

The per capita volume of water resources at 2,170 cubic meters is small, equivalent to less than 28 percent of the world average. By the time China's population is expected to reach 1.6 billion by 2030, per-capita water resources will drop to 1,760 cubic meters, close to the internationally recognised water-shortage benchmark of 1,700 cubic meters.[42] By comparison water resources per capita for the Euro zone stands at 2,942 cubic meters per capita. Water

[36] Blood Thinner Heparin Linked to Deaths. KMBC-TV, 22 February 2008. Available at: http://www.kmbc.com/health/15371130/detail.html
[37] Barboza, David and Bogdanich, Walt. Twists in Chinese chain of raw supplies for blood drug. Chicago Tribune, 28 February 2008. Available at: http://www.chicagotribune.com/news/nationworld/chi-china-heparin-feb28,1,2190663.story
[38] Panama relatives say hundreds poisoned. Associated Press, 14 February 2008. Available at: http://ap.google.com/article/ALeqM5jOEkPzu0V4zbAV8zPHb2NOvBSfdwD8UQBTS80
[39] Blood Thinner Heparin Linked to Deaths. KMBC-TV, 22 February 2008. Available at: http://www.kmbc.com/health/15371130/detail.html
[40] China Employment Forum, Beijing. Ministry of Labour and Social Security & International Labour Organisation, 28 April 2004
[41] The ILO in China. International Labour Organisation. Available at: http://ilo.law.cornell.edu/public/english/region/asro/beijing/inchina.htm
[42] People's Daily (5 June 2002) 'Water Resources Set to Reach Critical Levels'

resources are much more equally distributed in the EU than in China, making water availability in Europe a less pressing concern.

Figure 17: Emissions of Organic Water Pollutants 2003 (1000 kg/day)



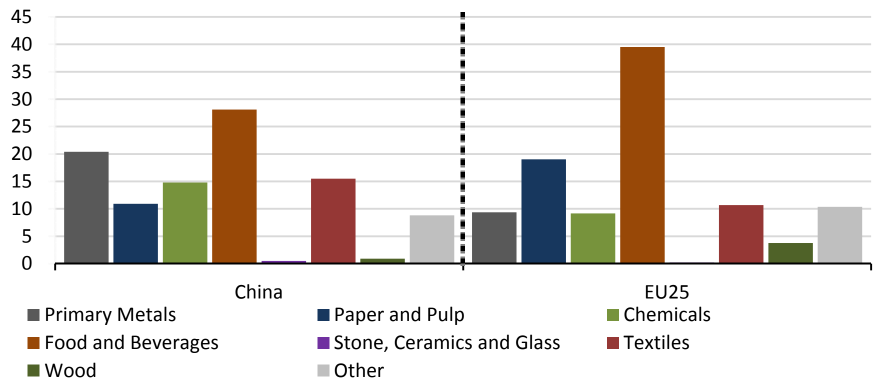
Source: World Bank 2006

Due to water pollution, China's water shortage is getting worse every year. In 2003, over six million kilograms of organic water pollutants per day were released (see **Figure 16**).[43] This has led to approximately 38% of China's rivers and 75% of its lakes to be severely polluted, while only 20% of waste water is treated in China, compared to 80% in most developed countries. Around 700 million Chinese do not have access to drinking water that meets minimum purity standards; hence cholera and other waterborne diseases have a high prevalence rate. The result has been water shortages across most of northern China, estimated at 30 billion cubic meters.[44]

Agriculture, including the use of agrochemicals, is by far the most important user for water, accounting for over two-thirds of water used in China. Despite shortages, water is used wastefully in China. Water pollution in China is mainly a consequence of pollution from the agricultural sector such as agrochemicals and wastes from intensive livestock farming.

Within all industries, approximately 90% of organic water pollutants from industry originate from the food and beverages, primary metals, chemicals, textiles, and paper and pulp sectors (see **Figure 17**). **The chemicals industry is estimated to account for 14.8% of total emissions in China, compared to 9.1% in Europe. Concurrently the chemicals industry in China was accountable for approximately 20.1% of total industrial waste water emissions nationwide in 2005.**[45] Further exacerbating the chemical sector's contributions towards emission of pollutants is the fact that in 2005 it accounted for 21.5% of industrial energy demand, and 12.3% of total energy demand in China.[46]

Figure 18: Industry shares of emissions of organic water pollutants (2003)



Source: World Bank 2006

In recent years environmental damage due to domestic chemical production has received attention from both Chinese government and media. A July 2006 SEPA report found that of 7,555 chemical factories nationwide, 1,354 were located along sources of water while 2,489 were located near major

[43] Emissions of organic water pollutants are measured in terms of biochemical oxygen demand, which refers to the amount of oxygen that bacteria in water will consume in breaking down waste (World Bank 2006).

[44] DG Trade (2007) Future Opportunities and Challenges in EU-China Trade and Investment Relations – Study 10: Sustainable Technologies and Services

[45] China Statistical Yearbook 2006. China National Bureau of Statistics

[46] China Statistical Yearbook 2006. China National Bureau of Statistics

population centres. In all, approximately 45% posed a major environmental or public health risk in the event of a spill. Following the report, SEPA ordered 3,745 chemical and petro-chemical plants to improve their preventative safety measures, at a cost of over RMB 14.05 billion, or €1.32 bn.[47]

In November 2005, 3.8 million residents of Harbin went without access to tap water for over a week following a spill of over 100 tons of benzene, nitrobenzene and aniline on the Songhua River. Furthermore, citizens of the Russian cities of Khabarovsk and Komsomolsk, which lie on the Songhua's Russian extension, the Amur River, were also affected. A United Nations disaster response team estimated that while aniline and nitrobenzene would dissipate or degrade within several days, benzene may remain at harmful levels in groundwater for several months.[48]

In August 2006 ten tons of mixed toxic chemicals were dumped in a tributary to the Songhua, the Mangniu River, by truck drivers for Changbaishan Jingxi Chemical.[49] Just 2 months prior an overloaded cargo truck carrying tar crashed into the Dasha River in Shanxi province, requiring the emergency construction of 51 dams to prevent water contamination to the nearby Wangkuai reservoir used by 10 million local residents.[50] Later in 2006 over 20,000 Hubei residents were evacuated following a leak of over 10 tons of ammonia, a chemical which aggravates asthma in low levels and may cause death in high concentrations.[51]

In May 2007 in Jiangsu Province, a major centre for chemicals production, China's third largest freshwater lake suffered from a massive algae bloom which turned waters florescent green, killed fish, and endangered the drinking water of neighbouring Wuxi's 2.8 million residents. Prior to the incident, Lake Tai had over 2,800 chemical factories surrounding it, however increased scrutiny in the months following the incidents and new regulatory fees have reduced that number by 1,000. The central and Jiangsu governments are expected to spend of RMB 108.5 billion (€9.9 billion) in 2007 on cleanup efforts.[52]

2.4 Future Directions

Within China attitudes towards the environment and its stewardship have shifted rapidly in recent years, partly driven by the aforementioned rise in environmental disasters including at the hands of China's chemicals industry. As a result, a significant amount of new legislation has arisen that directly or indirectly affects the operations of future chemical producers and consumers in the country.

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[47] "Half of China's chemical plants endanger environment" http://news.xinhuanet.com/english/2006-07/11/content_4818672.htm

[48] The Songhua River Spill China. United Nations Environmental Programme, December 2005. Available at: http://www.unep.org/PDF/China_Songhua_River_Spill_draft_7_301205.pdf

[49] China to clean up polluters along Songhua River. Embassy of the PRC in the USA, 9 May 2006. Available at: http://www.china-embassy.org/eng/gyzg/t270405.htm

[50] Death toll in Eastern China chemical plant explosion rises to 14. Associated Press, 17 June 2006.

[51] Ammonia leak results in safety overhaul in Hubei. China.org.cn, 4 November 2006. Available at: http://www.china.org.cn/environment/2006-11/04/content_1187704.htm

[52] China to spend billions cleaning up polluted Lake Tai. International Herald Tribune, 26 Oct 2007. Available at: http://www.iht.com/articles/2007/10/26/asia/26china.php

The 11th Five Year Plan

Although lacking extensive provisions regarding the chemicals industry, China's 11th Five Year Plan does include much legislation is relevant to the chemicals industry. Between 2006 and 2010 emissions of total pollutants are planned to decrease by 10%, while energy consumption per unit of GDP is planned to decrease by 20%, particularly relevant given the chemical industries' 30% contribution to total industrial power consumption.[53] The plan also calls for a structural adjustment to the layout of the chemicals industry, although no specific goals are described. Also specified is a goal of improving technological competiveness in a number of sectors, including new materials and electronics, both of which have intrinsic ties to the chemicals industry. Finally, the plan calls for promotion of China's biopharmaceuticals industry and revitalisation of ethylene production industry, despite the fact that national ethylene production grew by 9.6% annually between 1999 and 2005.[54]

Catalogue for the Guidance of Foreign Investment Industries

In late 2007 the National Development and Reform Commission's catalogue which classifies different types of encouraged, restricted and prohibited investment was updated. In the revision a number of polluting industries were removed from the encouraged category and in some cases restricted or prohibited, however the chemical industry still largely benefits from its inclusion on the encouraged list (see **Annex 1**). With over 30 specific goods market for encouraged investment in the chemicals market and over 15 in the pharmaceuticals market, investment is likely to continue to grow significantly in the coming years. Notably, a number of 'green' goods are included on the list, including at least nine goods with environmentally sustainable production processes or end-use applications (see **Table 3**). In addition to emphasis on environmentally sustainable chemicals production, the pharmaceutical industry will enjoy encouraged investment in a number of growing high value, R&D intensive fields such as AIDS research, cancer treatments and new time release methods using bioengineering (see **Annex 1**).

Table 3: Encouraged Investment in Environmental Chemicals in China

Production of environment-friendly printing ink and environment-friendly arene-oil
Development and production of new technology and products for the forestry chemicals
Development and production of inorganic, organic and biologic films for environment protection
Development and production of new varieties of effective, safe agriculture chemicals and pesticides
Comprehensive utilisation and disposal of exhaust gas, discharge liquid, waste residue
Production of Environmental Protection chemical fiber of New Solvent cellulose fiber
Production of new style fiber material made use of renewable resources, biomass technology: PLA, PDO
Digestion and recycle of waste plastics
Exploitation and production of new technology and new production of plastic soft package (high barrier, multi-function film and material)

Source: Catalogue for the Guidance of Foreign Investment Industries 2007

Measures for Administration of the Pollution Control of Electronic Information Products (China RoHS)

[53] The Outline of the 11th Five Year Plan. National Reform and Development Commission. Available at: http://en.ndrc.gov.cn/hot/t20060529_71334.htm

[54] China Statistical Yearbook 2006. China National Bureau of Statistics

Beijing's 11th Five Year Plan. Beijing Association of Enterprises with Foreign Investment, 29 March 2006.

On 1 March 2007, the Ministry of Information Industry of China began its new hazardous waste restriction program, often referred to as China RoHS for its conceptual similarities to the EU Restriction on Hazardous Substances directive. While not specifically targeting the chemicals industry, because of its effects on downstream producers, China RoHS has a high relevance to both EU and Chinese chemicals producers. Similar to the original EU RoHS, the regulation is designed to reduce hazardous wastes through elimination of pollutants in consumer products and packaging as well as enforced recycling programs. [55] The program takes a 'cradle-to-grave' approach, placing requirements on input producers (such as commodity chemicals producers) down to final sellers. These requirements include: the use of non-toxic, biodegradable or recyclable packaging; labelling which indicates the environmental friendliness of a product throughout its supply chain and its recyclability; listing of potentially harmful substances involved in its production; and the dates for which its chemical ingredients are active (i.e. not degraded). Producers of these products are also required to contract with local recyclers and waste management facilities to ensure these products are recovered and disposed of safely, and notably must finance recycling costs. Similar to EU RoHS, the six hazardous substances polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE), lead (Pb), mercury (Hg), cadmium (Cd) and hexavalent chromium (Cr) are banned from general production. Notably, in addition to these agreed upon hazardous substances, the Chinese RoHS also mentioned the banning of "other toxic and harmful substances" without qualification, placing a degree of uncertainty on the chemical industries and their downstream purchasers.[56] Also differing from the EU RoHS, all producers along a supply chain are legally responsible for compliance, including for products which are not on the market.[57]

EU REACH

In addition to a changing regulatory environment in China, new regulations in Europe have raised concerns among Chinese chemical producers. The European Union began enforcement of the **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emical substances (REACH) regulation on 1 June 2007. The goal of the legislation is to improve environmental stewardship as well as reduce risks to human health by placing increasing responsibility on chemical producers and users to manage risks as well as provide safety information to downstream consumers. REACH has been designed to accommodate to the historical legacies of the chemical industry, with a staggered phase-in period through 2018 to help producers in meeting compliance while still remaining competitive.[58] REACH is designed to improve environment and safety in the chemical industry in Europe.

[55] China RoHS Answers to Frequently Asked Questions. Design Chain Associates, 27 February 2007. Available at: http://www.chinarohs.com/faq.html

[56] Franklin, Ray. China RoHS and China WEEE. RoHSwell.com, 28 October 2008. Available at: http://www.rohswell.com/News/Genl006.php

[57] In the EU RoHS goods are only required to comply when they are 'put on the market', i.e. available for sale. Within China RoHS a subtle difference is that goods must comply once they have left production facilities. While this definition is only slightly different it has raised concern among suppliers about ambiguity as to when one must comply, particularly in intermediate goods whose toxicity may vary significantly from the final, end use product.

[58] What is REACH?. European Commission. Available at: http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

Producers in both the EU and abroad have raised concerns to the new law, which is scheduled to be actively enforced from 1 June 2008. In China the Chinese Chamber of Commerce of Metals, Minerals and Chemicals of Importers and Exporters (CCCMC) has noted a high level of concern with Chinese producers, who may face certification and licensing fees as expensive as US$399,558, with total registration costs expected to add 5% to overall business operating costs.[59] These cost pressures are expected to hit small and medium enterprises whom operate on thin margins, with a decline in overall chemical industry employment of up to 200,000 workers predicted by the CCCMC. Furthermore, manufacturers who utilise downstream chemicals in their production processes are expected to also be negatively affected, as chemical producers based in Europe will experience rising compliance costs that will be reflected in overall commodity prices.

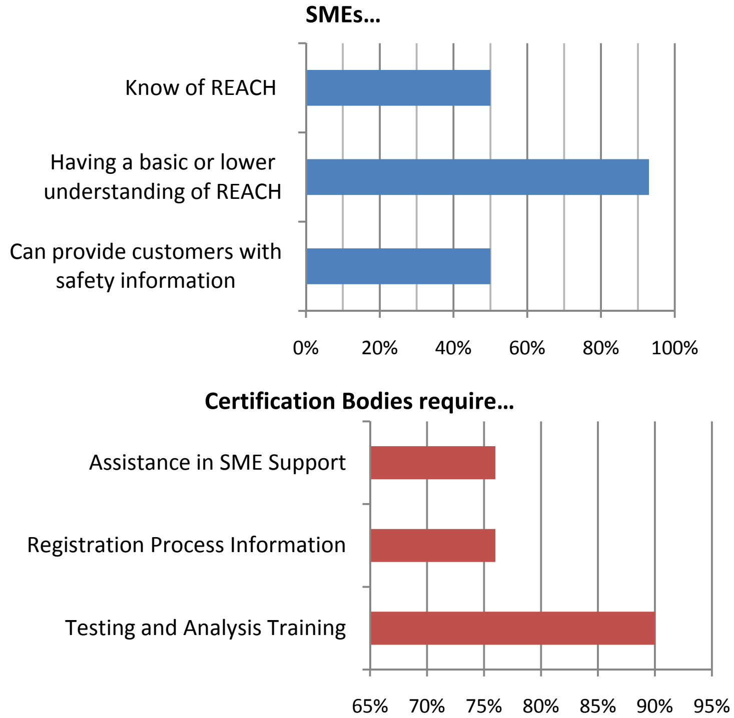
Chinese compliance is partly complicated by the multiplicity of government agencies with involvement in REACH compliance. The National Standards Commission of the State General Administration for the People's Republic of China for Quality Supervision, Inspection and Quarantine (AQSIQ) is responsible for monitoring environmental and health standards of chemicals exports. The Chinese Academy of Inspection and Quarantine, also part of AQSIQ, provides technical support to policy formation as well as training for SMEs from their Beijing office. The World Trade Organisation Technical Barriers to Trade (WTO-TBT) Entry Point, again under AQSIQ, is responsible for raising general awareness of regulations, directives and other possible barriers to trade. SEPA has established a Chemicals Registration Centre (CRC-SEPA) to support Chinese enterprises in REACH compliance, and also mandates environmental impact assessment and registration of chemicals based on their environmental properties. The Ministry of Commerce (MOFCOM) is responsible for chemical export regulations compliance in their role as overseer of foreign trade. In the past MOFCOM have also organized REACH compliance workshops. The National Reform and Development Commission (NDRC) is responsible for national policy formation of economic and social importance, and also oversees the SME business environment and would be expected to provide assistance in the event that REACH adversely affected a large portion of the SME sector. While it is clear that numerous resources exist in raising awareness, ensuring testing and compliance, or in providing SME's with assistance, the overlap of various ministries' and agencies' responsibilities can convolute a chemicals company's best path to compliance.

In late 2007 a EuropeAid project under Asia Invest titled REACH Capacity Building in China and South-East Asia conducted a needs assessment survey regarding the impact of REACH on China SMEs, testing and administrative bodies and government officials (see **Figure 18**). It found that 93% of 257 Chinese SMEs had only basic, limited or an unfamiliar understanding of REACH, while only 50% had even a basic familiarity with the concept of REACH. Results also revealed that 50.8% had difficulty in providing information to consumers on safe use and management of their chemical products. Furthermore, over 63% of SMEs polled indicated a desire to further learn about the scope and

[59] Reach to severely impact China's chemical industry. PlasticNews, 22 October 2007. Available at: http://www.plastemart.com/plasticnews_desc.asp?news_id=11083&P=P

impact of REACH, potential registration costs and the registration process. The same needs assessment found that of over 20 testing and certification bodies in China, over 90% would like additional testing and analysis capabilities, over 76% would like a greater understanding of registration and relation costs, and 76% expressed interest in assistance in establishing a SME support facility.

Figure 19: REACH Needs in China – SME and Certification Bodies



Source: http://www.reachcapacity.org/

Table 4: Impacts Summary Table Legend

(⇧)⇧	(Strong) positive impact
▫	Negligible impact
(⇩)⇩	(Strong) negative impact
⇩⇧	Mixed impacts
(+)+	(Strongly) positive existing conditions
0	Neutral existing conditions
(-)-	(Strongly) negative conditions
⌖	Localised impacts
⊙	Moderately diffuse impacts
◎	Highly diffuse impacts
L	Low capacity to change via policy
M	Moderate capacity to change via policy
H	High capacity to change via policy

Table 5: Sector Scenario Parameters

	Tariffs and NTBs reductions	Exchange Rate
	Multilateral	
Baseline with DDA	10%	-
DDA Modest	25%	-
DDA Ambitious	75%	-
Structural Change only	-	-
DDA Modest with Structural Change	25%	10%
DDA Ambitious with Structural Change	75%	10%

Table 6: Chinese Structural Change used in Projection Scenarios

Chemicals	Supply	Demand
Commodity	43%	48%
Specialty	28%	30%
Fine	33%	34%

3. PCA Scenarios

The studies in this section utilise quantitative modelling results, which are then used to qualitatively assess the impacts of a PCA between the EU and China within the themes of economics, society and environment. Finally, summary tables are provided which provide a visual guide to the overall economic, social, and environmental impacts of liberalisation specific to each sector and should be read using the legend provided in **Table 4**. These impacts are addressed in the **Final Report** with an early provision of possible flanking measures, i.e. policy recommendations, which provide negotiators and stakeholders alike with a number of potential options to address both positive and negative impacts.

Liberalisation Scenarios

While the PCA is not designed to be a means of traditional trade liberalisation, i.e. of bilateral or multilateral tariff reductions, it is possible that it may include provisions which assist with the reduction of behind the border barriers, with benefits accruing multilaterally similar to the possibility of a successful Doha Development Agenda. To simulate the impacts of this liberalisation six scenarios have been devised and applied to each sector.

Three types of medium-run experiments were run. Medium-run is taken to be a three year period during which the assumed structural changes take place and the effects of changes in the policy environment on protection and the real exchange rate apply. The first three experiments relate to shallow integration under the DDA with an unchanged real exchange rate. The three experiments shown in **Table 5** were DDA Baseline (10% cut), DDA Modest (25% cut), and DDA Ambitious (75% cut). Second, and more speculatively, a set of medium run projections of domestic demand growth and possible supply curve shift for import competing production and export production were run to obtain a consistent set of projections of imports, domestic production and domestic demand. The same supply curve shifts were applied on the export side.

PCA Impacts

Economic Impacts

Within the policy only scenarios the economic impacts are expected to be mixed. Within China's **Economic Structure**, low export growth coupled with significantly high (41% from the EU) import growth will lead to an overall balancing of China's current account surplus. Notably, while Chinese production will decline absolutely, Chinese exports will expand marginally, implying that the economic performance of sector actors will become more competitive and efficient in an environment of reduced trade barriers. With production declining it is also possible that material consumption will be reduced marginally, however significance of this reduction is difficult to assess without further analysis into upstream supply chain affects.

China's **Consumption and Production Patterns** are also expected to experience a positive effect, with declining chemicals production leading to both a decline in energy use and waste generation, although these factors may be offset by the transport costs of higher trade flows between the EU and China under more ambitious scenarios. As the chemical sector is estimated to account for over 30% of industrial energy use in China, a production decline of 3% may mean significant shifts in overall energy use. A decline in production may also lead to a decline in hazardous wastes, where the chemical sector produces approximately 14% of Chinese total output.

Social Impacts

The social impacts of a PCA between the EU and China are mixed, with both positive and negative effects felt across different social themes. Within the theme of **Equity**, a decline in overall production in China may lead to unemployment and an aggravation of existing poverty conditions.

Within the theme of **Health**, declining water pollution from domestic sources as a result of reduced chemicals production in China will likely lead to better access to safe water, and also reduce the occurrence of chemical disasters which contaminate major water sources for extended period of time, such as in the case of the eutrophication of Lake Tai. Growth in fine chemicals, inclusive of pharmaceuticals, will also reduce the cost of medicines to Chinese consumers.

Housing may expect to benefit, as actors in the market narrow in the face of declining chemicals production. Chemical plants located on the suburban fringes, a source of serious social unrest in recent years, will in future be fewer.

Labour is an area of significant likely impact. With production declining, a rise in unemployment appears likely in China, although the opposite would occur in Europe. This may aggravate China's already inequitable income distribution. As a result employment opportunities within China may decline, leading to increases in unacceptable work practices and a decline in job stability during the period of analysis. A decline in chemicals production, however, may also lead to a decline of industrial accidents, with the overall growth or decline in industrial accidents difficult to accurately assess.

Environmental Impacts

The environmental baseline for the chemicals sector presents a variety of problems to China. With regards to the **Atmosphere**, with the chemicals sector accounting for over 12% of total energy demand in China it is also understood to be a significant contributor to the country's currently rising CO_2 emissions. A decline in production under the trade policy only scenarios would presumably lead to marginal declines in energy demand as well, thus reducing CO_2 emissions from the sector.

Within the **Land** and **Freshwater** themes, increased access to chemicals from abroad may lead to high levels of pollution by domestic consumers, in spite of reduced emissions from domestic production. In particular, greater access to agrochemicals may allow farmers to use these vital inputs in an even less environmentally sound manner than in the past. Chemicals runoff previously has lead to eutrophication of major bodies of water, such as rivers, lakes, and coastal areas, where abnormally high levels of chemical nutrients from fertilizers leads to an explosion in certain types of algal growth, which subsequently unbalances the overall ecosystem and also makes water unfit for human consumption. The conflicting impacts of reduced domestic output and increased use of foreign agrochemicals makes it difficult to determine a definite outcome, making this a key area for attention in the period following a PCA. Impacts of potential pollution would also impact on **Oceans, Seas, and Coasts** as well as **Biodiversity**, although the impacts again are uncertain.

A summary of impacts are provided below. Please note that impacts are derived from policy only scenarios, while projections scenarios help determine the feasible reversibility and capacity to change within a sustainable development theme.

Table 7: PCA Summary Impacts Table – Chemicals (China)

Indicator	Existing Conditions	Scenario Impacts		Policy Options	
		Overall Direction Magnitude	Equity	Reversibility	Capacity to change
Economic					
Economic Structure	+	⇧	◎	N	L
Consumption and Production Patterns	--	⇧	◎	Y	H
Social					
Equity	0	⇩	⌖	Y	H
Health	--	⇧	⊙	Y	M
Housing	-	⇧	⌖	Y	H
Labour	-	⇩	⌖	Y	M
Environmental					
Atmosphere	--	⇧	◎	Y	H
Land	-	⇧⇩	⊙	Y	M
Fresh Water	--	⇧⇩	◎	Y	H
Oceans, Seas, and Coasts	--	⇧⇩	⊙	Y	M
Biodiversity	--	⇧⇩	⌖	N	M

Table 8: PCA Summary Impacts Table – Chemicals (EU)

Indicator	Existing Conditions	Scenario Impacts		Policy Options	
		Overall Direction Magnitude	Equity	Reversibility	Capacity to change
Economic					
Production & Exports	-	⇧	◎	N	L
Social					
Labour	-	⇩	⌖	Y	M

Bibliography

Ammonia leak results in safety overhaul in Hubei. China.org.cn, 4 November 2006. Available at: http://www.china.org.cn/environment/2006-11/04/content_1187704.htm

Barboza, David and Bogdanich, Walt. Twists in Chinese chain of raw supplies for blood drug. Chicago Tribune, 28 February 2008. Available at: http://www.chicagotribune.com/news/nationworld/chi-china-heparin-feb28,1,2190663.story

Beijing's 11th Five Year Plan. Beijing Association of Enterprises with Foreign Investment, 29 March 2006.

Bilateral Trade Relations – China. European Commission – External Trade. Available at: http://ec.europa.eu/trade/issues/bilateral/countries/china/index_en.htm

Blood Thinner Heparin Linked to Deaths. KMBC-TV, 22 February 2008. Available at: http://www.kmbc.com/health/15371130/detail.html

Blood Thinner Heparin Linked to Deaths. KMBC-TV, 22 February 2008. Available at: http://www.kmbc.com/health/15371130/detail.html

Chemical Engineering News, October 10, 2006

Chemical plant blast kills 16 in Anhui. China Daily, 19 June 2006.

Chemicals Industry of the Future. US Department of Energy, 4 March 2007. Available at: http://www1.eere.energy.gov/industry/chemicals/

Chemicals, Coatings & Plastics Industry Overview. Plunkett Research, Ltd.

China Employment Forum, Beijing. Ministry of Labour and Social Security & International Labour Organisation, 28 April 2004

China Insight – Chemicals. Broadwin China Strategy Consulting. Available at: http://www.chinastrategy.com.cn/industry_insight_chemical.htm

China RoHS Answers to Frequently Asked Questions. Design Chain Associates, 27 February 2007. Available at: http://www.chinarohs.com/faq.html

China sees environmental accident every other day: SEPA. Gov.cn, 19 April 2006. Available at: http://english.gov.cn/2006-04/19/content_257882.htm

China Statistical Yearbook 2006, National Bureau of Statistics.

China Statistical Yearbook 2006. China National Bureau of Statistics

China Statistical Yearbook 2006. China National Bureau of Statistics

China to clean up polluters along Songhua River. Embassy of the PRC in the USA, 9 May 2006. Available at: http://www.china-embassy.org/eng/gyzg/t270405.htm

China to spend billions cleaning up polluted Lake Tai. International Herald Tribune, 26 Oct 2007. Available at: http://www.iht.com/articles/2007/10/26/asia/26china.php

China water supplies resume along China's algae-affected Hanjiang river. Xinhua, 27 February 2008. Available at: http://news.xinhuanet.com/english/2008-02/27/content_7681968.htm

Chinese river contamination resulting from a petrochemical explosion and toxic spill. United Nations Environmental Programme, 24 November 2005. Available at: http://www.uneptie.org/pc/apell/disasters/china_harbin/info.htm

Coastal projects face opposition from local residents. Chemical & Engineering News, 10 March 2008.

Coastal projects face opposition from local residents. Chemical & Engineering News, 10 March 2008. Available at: http://pubs.acs.org/cen/news/86/i10/8610notw9.html

Death toll from East China chemical plant blast rises to 22. Xinhua, 30 July 2006.

Death toll in Eastern China chemical plant explosion rises to 14. Associated Press, 17 June 2006.

Death toll of N China chemical plant blast rises to 7. NewsGD.com, 8 August 2006. Available at: http://newsgd.com/news/china1/200608080007.htm

Death toll rises to 5 in chemical plant blasts. Xinhua, 14 November 2005. Available at: http://www.chinadaily.com.cn/english/doc/2005-11/14/content_494543.htm

Death toll rises to five in China chemical plant blast. Xinhua, 12 May 2007.

DG Trade (2007) Future Opportunities and Challenges in EU-China Trade and Investment Relations – Chemicals

DG Trade (2007) Future Opportunities and Challenges in EU-China Trade and Investment Relations – Sustainable Technologies and Services

Economic Development. The People's Government of Zhejiang Province. Available at: http://www.zhejiang.gov.cn

Eurostat

Franklin, Ray. China RoHS and China WEEE. RoHSwell.com, 28 October 2008. Available at: http://www.rohswell.com/News/Genl006.php

Global Industry Profile. American Chemistry Council

Half of China's chemical plants endanger environment. Available at: http://news.xinhuanet.com/english/2006-07/11/content_4818672.htm

Hamilton, Daniel and Quinlan, Joseph. Globalisation in Europe: Prospering in the New Whirled Order. Center for Transatlantic Relations, John Hopkins University, 2008.

Heidelberg, 2005.

How does chemical engineering education meet the requirements of employment?. World Chemical Engineering Council, September 2004

Industry in China. Eds.: Festel, G., Kreimeyer, A., Oels U., v. Zedtwitz, M.. Springer, Berlin,

Panama relatives say hundreds poisoned. Associated Press, 14 February 2008. Available at: http://ap.google.com/article/ALeqM5jOEkPzu0V4zbAV8zPHb2NOvBSfdwD8UQBTS80

People's Daily (5 June 2002) 'Water Resources Set to Reach Critical Levels'

Personal communication with Dr Gunter Festel, FESTEL Capital

Public opposes Xiamen chemical plant. China Daily, 30 May 2007. Available at: http://english.peopledaily.com.cn/200705/30/eng20070530_379187.html

Reach to severely impact China's chemical industry. PlasticNews, 22 October 2007. Available at: http://www.plastemart.com/plasticnews_desc.asp?news_id=11083&P=P

Sector Futures: Chemicals, European Foundation for the Improvement of Living and Working Conditions

The ILO in China. International Labour Organisation. Available at: http://ilo.law.cornell.edu/public/english/region/asro/beijing/inchina.htm

The Outline of the 11th Five Year Plan. National Reform and Development Commission. Available at: http://en.ndrc.gov.cn/hot/t20060529_71334.htm

The Songhua River Spill China. United Nations Environmental Programme, December 2005. Available at: http:// www.unep.org/PDF/China_Songhua_River_Spill_draft_7_301205.pdf

Walton, Julie. WTO: China enters year three. The China Business Review,

What is REACH?. European Commission. Available at: http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

World Refining Association, 2008

Yu, D., Trends in the Chinese Fine Chemicals Market. In: The Chemical and Pharmaceutical

Annex 1 – Encouraged Investment in China's Chemical's Industry

In the 2007 Catalogue for the Guidance of Foreign Investment Industries 25 subsectors of the chemicals industry are marked as encouraged for foreign investment (see **Table 8**).

Table 9: Encouraged Investment in China's Chemical's Industry 2007

Chemical
Production of ethylene with an annual production capacity of 600,000 tons or over (The Chinese party shall hold relative majority of shares)
Processing and manufacturing of derivatives of downstream products of ethylene and comprehensive utilization of ethylene side-products such as C4-C9
Production of ethylene with an annual production capacity of 200,000 tons or over Polyvinyl chloride resin (in the way of ethylene)
Production of further processed products of sodium-process bleaching powder, polyvinyl chloride and organosilicon
Production of basic organic chemical industrial raw materials such as the of benzene, methylbenzenc, dimethylobenzene, etc. and its derivatives
Production of supporting raw materials for synthesized materials: bisphenol-A production and production of propylene oxide in the way of oxidizing propylene with hydrogen peroxide
Production of synthetic fibre raw materials: precision terephthalic acid, vinyl cyanide, caprolactam, nylon 66 salt and polyurethane elastic fiber
Production of synthetic rubber: liquid butadiene styrene rubber by butadiene method(excluding styrene-butadiene rubber), butyl rubber, isoamyl rubber, polyurethane rubber, acrylic rubber, chlorophydrin rubber, ethylene-propylene-rubber, fluororubber, silicon rubber and other special rubber production)
Production of engineering plastics and plastic alloys: PPO, engineering plastic nylon of 11 and 12, polyurethane, polysulfone, PAR, liquid crystal polymer and other products
Fine chemistry industry: new products and technology for catalytic agent, auxiliary and addictive; processing technology for the commercialization of dye (pigment); production of high-tech chemicals for electronics and paper-making, food additives, feed additives, leather chemical products (excluding N,N-dimethylformamide), oil-well auxiliaries, surface active agent, water treatment agent, adhesivcs, inorganic fibre, inorganic nano material production and deep processing of pigment encapsulation.
Production of low hysteresis and high abrasion carbon black
Production of environment-friendly printing ink and environment-friendly arene-oil
Production of nature spices, synthetic spices and single ion spices
Production of high capability coatings, water automotive coatings and assorted water resin (15) Production of chlorofluorocarbon substitution
Production of organic fluorine chemical products(excluding CFC/HCFC and tetrafluoroethylene)
Production of fluorine recycling from phosphorus chemicals and aluminum smelting
Production of mass coal chemical industrial products(The Chinese party shall hold the majority of shares)
Development and production of new technology and products for the forestry chemicals
Production of ion film for caustic soda, abio-filtration membrane and function membrane
Development and production of inorganic, organic and biologic films for environment protection
Development and production of new-type fertilizer: biologic fertilizer, high-density fertilizer, compound fertilizer, controlled release fertilizer, compound microbial inoculant, Compound microbial manure, degradation agent for stalks and garbage and microbial preparation of special functions
Development and production of new varieties of effective, safe agriculture chemicals and pesticides
Development and production of biopesticide and bio-control products: microbial insecticide, microbial fungicide, agricultural antibiotic, insect pheromone, enemy insect and microbial herbicide
Comprehensive utilization and disposal of exhaust gas, discharge liquid, waste residue
Production of organic polymer material: organic silicone modified coatings for ship shell, covering film for plane, rare earth cerium sulphide red dye, lead-free in electronic packages, serials of special sizing agent by photoetching for color Plasma Display Panel, small diameter and large specific surface area superfine fibre, high precision fuel filter paper, Li-ion battery membrane, multi-function compound accessory ingredient for plastic processing, citric acid diglyceride, fludioxonil, cyazofamid
Production of hi-tech chemical fiber of differential chemical fiber, aramid, carbon fiber, polyethylene of high-strength and high-mode, polyphenylene sulfide(PPS) and so on
Production of Environmental Protection chemical fiber of New Solvent cellulose fiber
Production of new style of fiber and non-fiber polyester: PTT, PEN, PBT
Production of new style fiber material made use of renewable resources, biomass technology: PLA, PDO
Production of polyamide, single line production capacity of 100 ton a day
Production of meridian tyre aramid fiber and tyre cord
Exploitation and production of new technology and new production of agricultural film(photodegradable film and multi-function film)
Digestion and recycle of waste plastics
Exploitation and production of new technology and new production of plastic soft package (high barrier, multi-function film and material)
Pharmaceutical
Production of new type compound medication of active composition medication (including bulk drug and preparation)
Production of amino acids: serine, tryptophan, hstidine, methionine for feed
Production of new anti cancer medication, new cardio-cerebrovascular medication and new nervous system using medication
New type, high effective and economical contraception medication and instrument
Production of new type medication using bioengineering technology
Production of high physillogical active medication heterocyclic fluoride containing fluorine, like heterocyclic fluoride, and intermediate
Production of genetic engineering bacterin (AIDS bacterin, third bacterin, contraception bacterin)
Production of biology bacterin
Production of bcg vaccine and poliomyelitis vaccine

Exploitation and production of marine drug
Drug preparation: production of new formulation using new technologies of sustained-release, release, targeting and percutaneous absorption
Exploitation and production of new type of pharmaceutic adjuavant
Production of biomedicine material and ware(except flesh body, sample, human organ tissue and sample processing)
Production of animal using antibacterial raw material drug
Exploitation and production of animal using antibacterial drug, insect repellent, pesticide, anticoccidial drug and new formulation
Production of new diagnosis reagent