

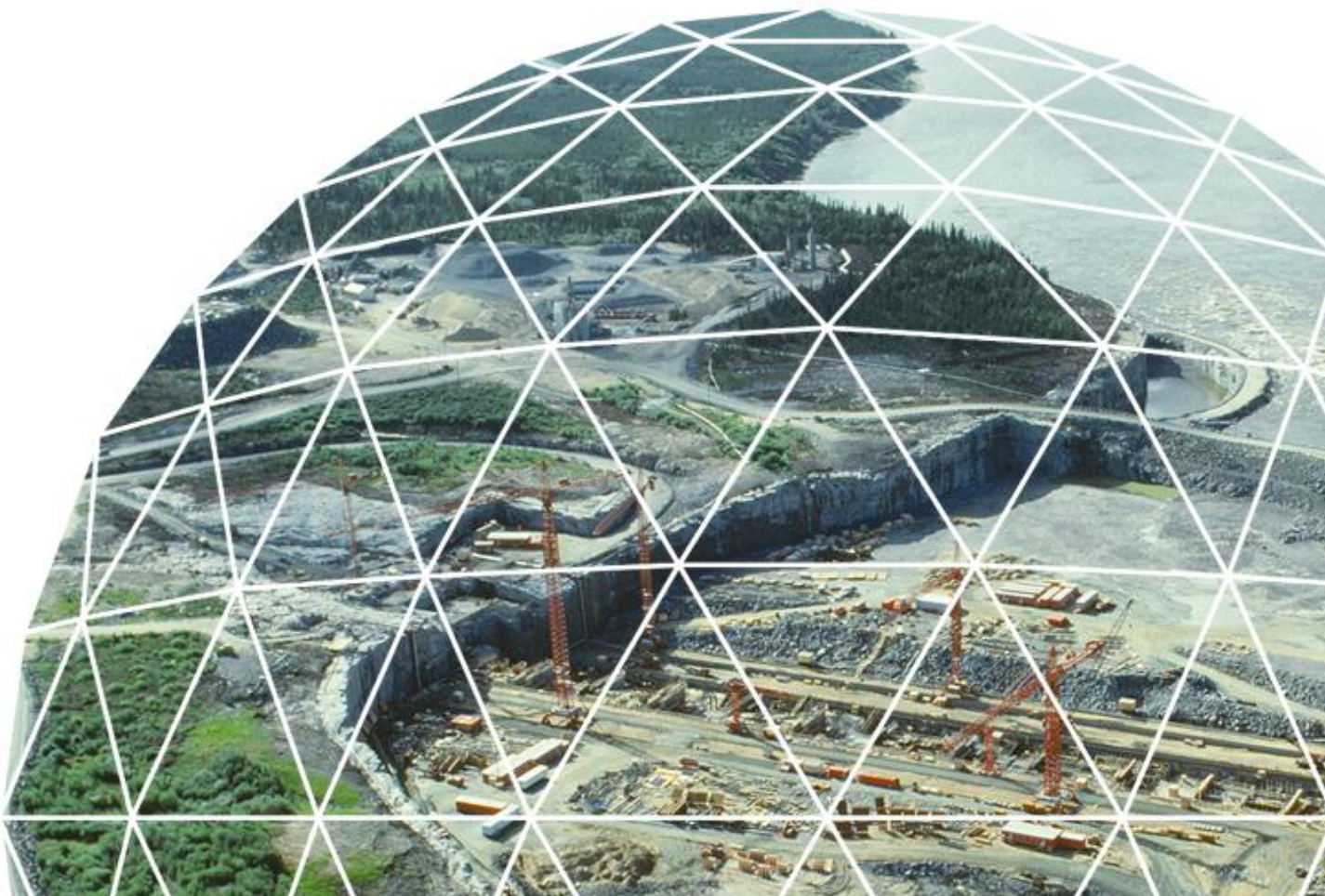


# Mapping resource prices: the past and the future

Summary Report – Final Report

Client: European Commission - DG Environment

Rotterdam, 25 October 2012





# Mapping resource prices: the past and the future

Summary Report

Final Report

Client: European Commission - DG Environment

Henri L.F. de Groot (Ecorys)  
Koen Rademaekers (Ecorys)  
Katarina Svatikova (Ecorys)  
Matthew Smith (Ecorys)  
Oscar Widerberg (Ecorys)  
Michael Obersteiner (IIASA)  
Abel Marcarini (IIASA)  
Gaspard Dumollard (IIASA)  
Pierre Strosser (Acteon)  
Gloria de Paoli (Acteon)  
Wietze Lise (Ecorys)  
Erik Klaassens (Ecorys)

Rotterdam, 25<sup>th</sup> October 2012

**Disclaimer:**

The sole responsibility for the content of this report lies with the authors. It does not necessarily reflect the opinion of the European Communities. The European Commission is not responsible for any use that may be made of the information contained therein.



# About Ecorys

At Ecorys we aim to deliver real benefit to society through the work we do. We offer research, consultancy and project management, specialising in economic, social and spatial development. Focusing on complex market, policy and management issues we provide our clients in the public, private and not-for-profit sectors worldwide with a unique perspective and high-value solutions. Ecorys' remarkable history spans more than 80 years. Our expertise covers economy and competitiveness; regions, cities and real estate; energy and water; transport and mobility; social policy, education, health and governance. We value our independence, integrity and partnerships. Our staff are dedicated experts from academia and consultancy, who share best practices both within our company and with our partners internationally.

Ecorys Netherlands has an active CSR policy and is ISO14001 certified (the international standard for environmental management systems). Our sustainability goals translate into our company policy and practical measures for people, planet and profit, such as using a 100% green electricity tariff, purchasing carbon offsets for all our flights, incentivising staff to use public transport and printing on FSC or PEFC certified paper. Our actions have reduced our carbon footprint by an estimated 80% since 2007.

ECORYS Nederland BV  
Watermanweg 44  
3067 GG Rotterdam

P.O. Box 4175  
3006 AD Rotterdam  
The Netherlands

T +31 (0)10 453 88 00  
F +31 (0)10 453 07 68  
E [netherlands@ecorys.com](mailto:netherlands@ecorys.com)  
Registration no. 24316726

**[www.ecorys.nl](http://www.ecorys.nl)**



# Table of contents

Summary Report	1
Key findings	1
Summary overview	2
Background	4
Historic evolution of resource prices	4
Key drivers of prices	12
Future trends in resources prices & scenarios	14
Competitiveness analysis	17
Price signals and resource use	22





# Summary Report

## Key findings

- **Historic trends:** Resource prices for metals, minerals, fuels, fish, timber and biomass generally decreased until 1998 (an overall decrease of 55% in real prices during 1980-1998), after which they have been steadily increasing. Our aggregated price index shows that on average real prices increased by more than 300% between 1998 and 2011. A big jump occurred between 1998 and 2000 when prices more than doubled (i.e. a 125% increase in real prices), but even after 2000 prices have increased further by almost 6% per annum in real terms;
- **Volatility:** Real prices of individual resources vary greatly in terms of their volatility. On average, resource price volatility has increased in the last 10 years, however, similarly high (or even higher) price volatility has occurred in the past for some resources;
- **Key drivers:** The key drivers of price changes are supply and demand factors (production capacity, industry demand, recycling and substitutability), market structures (competitive, oligopolistic or local markets), government interventions (export restrictions, subsidies or other trade policies), energy prices and environmental changes (drought, floods, deforestation, climate change);
- **Future trends:** Over most of the twentieth century, resource prices fell as production became more efficient, but this trend has reversed. In general, the prices of commodities are expected to rise due to increased population growth, demand from emerging economies such as China and India, and potentially from increased political risk in producing countries for critical materials. For example, on average metal prices are expected to rise by around 13% between 2010 and 2020, and graphite or fluorspar by around 20%. However, stagnation or even a decrease in prices is expected for some other resources. The price of oil is forecast to increase, but the price of renewable energy is forecast to decrease;
- **Competitiveness:** Europe is highly dependent on imports of metals, minerals and oil as domestic mining/production of these resources within the EU is limited, and the rents from resource production increasingly are earned outside the EU. The EU self-sufficiency ratio measured as the extent to which EU production satisfies EU consumption is very low. It is close to 0 for critical metal and minerals, around 25% for iron ore and 14% for crude oil. This demonstrates that the risk of supply is a major concern for Europe for some resources. In contrast, the EU is a net exporter of wheat, potatoes, sawnwood, and wind energy products and services (measured by trade value). China has become a crucial source of many resources of economic value. Recycling and finding substitutes for critical resources can help Europe to mitigate the supply risk and avoid high prices. Improved energy efficiency, as resource prices often have a high energy cost component, can also help;
- **Completeness of price message:** In general the prices of resources do not fully take into account environmental costs (externalities) and scarcities, which leave resources underpriced against their 'true' value. However, this is partly offset for some metals, fuels, and minerals by oligopolistic market structures (e.g. 75% of iron ore is produced by three producers), financial speculation or export restrictions (Chinese export quotas on rare earth or fluorspar), which force prices higher than otherwise. Overall, higher resource prices only give a partial signal to the market, and socially inefficient production/extraction, and then use, of resources continues.

## Summary overview

Table 1 shows an overview of key figures since 2000 for aspects covered in this summary report:

**Table 1 Summary overview table**

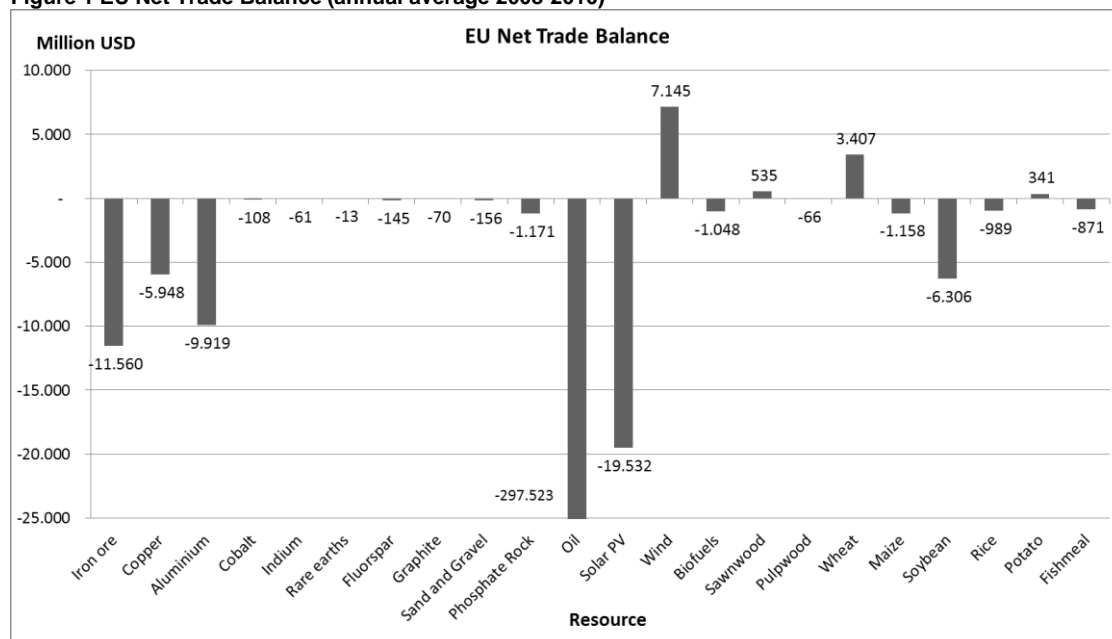
Resource	Past trend (2000- 2011)	Volatility (2001- 2011)	Future expected trend (2010-2020)	2011 EU import value in MEUR	Criticality	2010 EU Self- sufficiency ratio
<b>Metals</b>						
iron ore	175.5%	0.64	53.1%	11 674	Low	25%
copper	165.1%	0.41	-4.7%	6 528	Medium	52.7%
aluminium	-21.3%	0.18	1.2%	10 715	Low	50.4%
cobalt	-26.9%	0.26	5.6%	48	Medium	0%
indium	107.6%	0.58	14.1%	128	High	0%
rare earths	-4.5% <sup>1</sup>	0.33	11.7%	17	High	0%
<b>Average for metals</b>	<b>59.2%</b>	<b>0.40</b>	<b>13.5%</b>	<b>4 852</b>	-	<b>21%</b>
<b>Weighted aver. metals</b>	<b>117.9%</b>	<b>0.38</b>	-	-	-	-
<b>Minerals</b>						
graphite	0%	0.17	21.1%	71	High	13.2%
fluorspar	-9.0%	0.11	21.1%	372	Medium	28.5%
sand and gravel	-23.6%	0.16	2.7%	224	Low	N/A
phosphate rock	108.9%	0.81	-44.5%	1 011	Low	10.2%
<b>Av. minerals</b>	<b>19.08%</b>	<b>0.31</b>	<b>0.1%</b>	<b>420</b>	-	-
<b>Weighted av. minerals</b>	<b>19.5%</b>	<b>0.58</b>	-	-	-	-
<b>Fuels</b>						
crude oil	114.6%	0.29	1.7%	332 764	Medium	14.1%
solar	-67.9%	0.39	-54.7%	22 723	Medium	N/A
wind	33.3%	0.15	-42.5%	3 444	Medium	146.4%
biofuel	12.7%	0.11	9.4%	969	Medium	75.8%
<b>Av. fuels</b>	<b>23.18%</b>	<b>0.24</b>	<b>-21.5%</b>	<b>89 975</b>	-	-
<b>Weighted av. fuels</b>	<b>84.8%</b>	<b>0.26</b>	-	-	-	-
<b>Fish</b>						
fish meal	49.4%	0.25	6.8%	936	Medium	N/A
<b>Timber</b>						
sawn wood	-17.5%	0.15	15.9% <sup>3</sup>	2 821	Medium	112%
wood pulp	21.1%	0.33	7.8% <sup>3</sup>	78	Medium	88%
<b>Av. timber</b>	<b>1.8%</b>	<b>0.24</b>	<b>11.85%</b>	<b>1 450</b>	-	100%
<b>Weighted av. timber</b>	<b>-29.5%</b>	<b>0.16</b>	-	-	-	-
<b>Biomass</b>						
wheat	22%	0.23	-5.3% <sup>3</sup>	1 723	Medium	270%
maize	54.6%	0.22	-6.1% <sup>3</sup>	1 868	Medium	1 432%
potato	-33% <sup>2</sup>	0.28	-3% <sup>3</sup>	185	Medium	170%

Resource	Past trend (2000-2011)	Volatility (2001-2011)	Future expected trend (2010-2020)	2011 EU import value in MEUR	Criticality	2010 EU Self-sufficiency ratio
soybean	36.9%	0.19	-9.6% <sup>3</sup>	5 363	High	755%
rice	50%	0.24	-3.8% <sup>3</sup>	1 009	Low	76%
<b>Av. biomass</b>	<b>40.9%</b>	<b>0.23</b>	<b>-5.6%</b>	<b>2 030</b>	-	-
<b>Weighted av. biomass</b>	<b>38.5%</b>	<b>0.15</b>	-	-	-	-
<b>Overall price index</b>						
<b>Weighted incl. oil</b>	<b>84%</b>	<b>0.26</b>				
<b>Weighted excl. oil</b>	<b>34%</b>	<b>0.18</b>				
<b>Simple average</b>	<b>33%</b>	<b>0.17</b>				
<b>Land and water</b>						
Land <sup>4</sup>	30%-230%	0.13-0.36	(-1)%-13%	-	High	n.a.
Water	-	-	-	-	High	n.a.

Note: The trend is defined as % price change during a certain period (negative values in red), the future expected trend is defined as the base scenario prediction of % price change during 2011-2020; Volatility is measured by the coefficient of variation; the EU self-sufficiency ratio is defined as the extent to which EU production satisfies EU consumption needs (for biomass, the values are distorted as they relate only to direct human consumption, hence does not take into account needs for feeding livestock and for making biofuels); 2011 EU import value in MEUR is defined as the value of imports of a certain resource into EU27 in million Euros based on UN Comtrade statistics; criticality is defined as the criticality of a resource for the EU taking into account scarcity, distribution of reserves, production concentration and political stability, as well as recycling opportunities and substitutability (based on Consultant's judgment); <sup>1</sup> due to data limitations, this figure does not take into account the recent price explosion of rare earths; <sup>2</sup> the period covered by the data series is 2006-2011 and trend estimations are highly uncertain; <sup>3</sup> European prices incl. exogenous yields increases based on historical trends scenario; <sup>4</sup> land prices vary per region, a possible range is given.

Figure 1 shows the EU net trade balance for the different resources:

**Figure 1 EU Net Trade Balance (annual average 2008-2010)**



Source: UN Comtrade, Ecorys own calculations.

## Background

Enhancing resource efficiency is one of the most important challenges the European Union and the world is facing. Economic development, globalisation and population growth have all contributed to increased resource consumption. The increased demand for resources, further enhanced by rapid developments in emerging economies, has resulted in increased competition for resources and pressure on supplies and prices. The finite nature of many mineral and energy resources has increased fears of resource scarcity and aggravated volatility of commodity prices. Many renewable resources have also come under growing pressure as demand for food, land, soil and water has increased substantially. Moreover, Europe is highly dependent on the rest of the world for many resources that it consumes. Therefore scarcity and volatile commodity prices will affect European production and consumption of these resources and will have a potentially substantial impact on the competitiveness of European industries.

Resource price increases can pose a threat to growth and jobs in Europe. Most of the rents (excess profits) from such increases will accrue to overseas producers. At the same time, those resource price increases will still leave resources underpriced against their 'true' value, leading to overconsumption compared to the situation where their potential scarcity and the environmental impacts associated with them are properly reflected in prices. One of the barriers identified that hold back resource efficiency has been this incompleteness of resource price messages, i.e. prices do not reflect all environmental and social costs. As stated in the Roadmap to a Resource Efficient Europe, removing these barriers and transforming the economy could be helped by "getting the prices right", for example by adjusting environmental taxation, subsidies or regulations. Better price signals would create the right set of incentives for production and consumption decisions. This study should be understood within this policy context and was commissioned to better understand the price signals of resources and how this could be used to promote resource efficiency for businesses.

This study analyses eight resource categories covering 24 resource sub-categories. The assessment includes:

- an analysis of historic resource prices in real terms in the EU (resource-by-resource);
- an analysis of volatility in prices;
- aggregation into price indices for several resource categories;
- forecasts of resource prices over the medium-term;
- an assessment of the accuracy of price messages in reflecting externalities and scarcity;
- an analysis of the impact of future resource prices on the competitiveness of Europe and key sectors.

## Historic evolution of resource prices

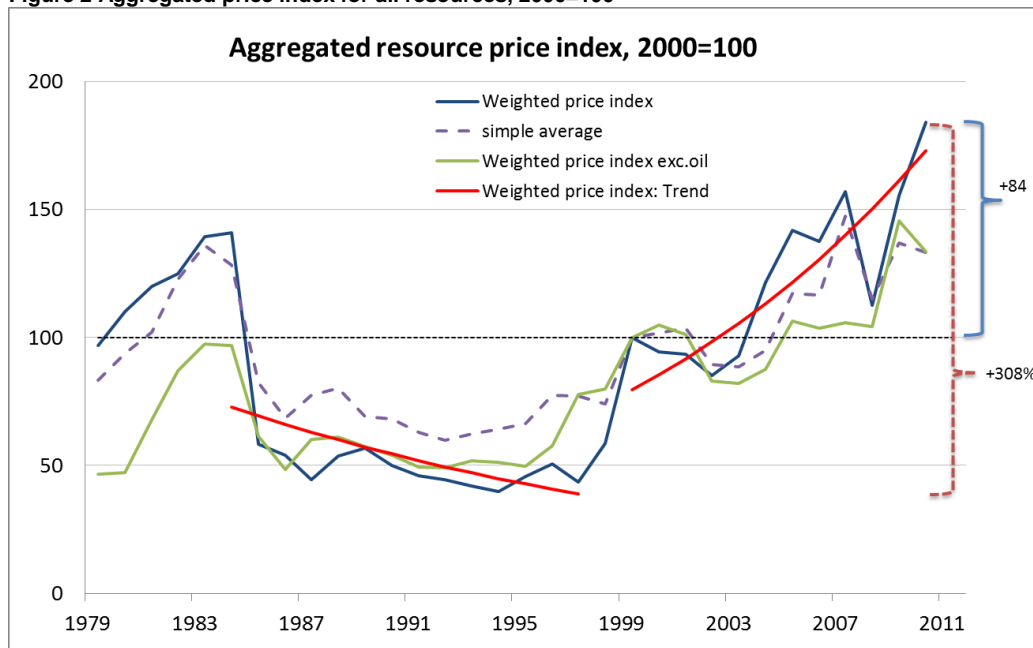
Using historic time series of resource prices corrected for inflation, trend and volatility analysis was performed using statistical techniques resource-by-resource. The magnitude of price volatility is visible by looking at price fluctuations and how prices deviate from the trend line. The greater the fluctuations in distance from the trend line (i.e. the greater the deviation from the mean), the greater the volatility. Volatility for the different time periods has also been calculated. The key findings are the following:

*Resource prices generally decreased until the late 1990s, but since then have increased significantly, more than tripling on average on 1998 levels by 2011.*

The evolution of historic prices in constant 2011 Euros per unit of resource since 1971 is shown in figure 2. Aggregated price indices (2000=100) for metals, minerals, fuels, timber, fish and biomass weighted by EU 27 import values (average 2008-2010) show a decreasing trend up until 1998 and an increasing trend since then.

The main weighted price index is dominated by crude oil prices (80% weight in the index), however both a weighted index excluding oil, and a simple index with all resource categories given equal weight show very similar trends in price developments.

**Figure 2 Aggregated price index for all resources, 2000=100**



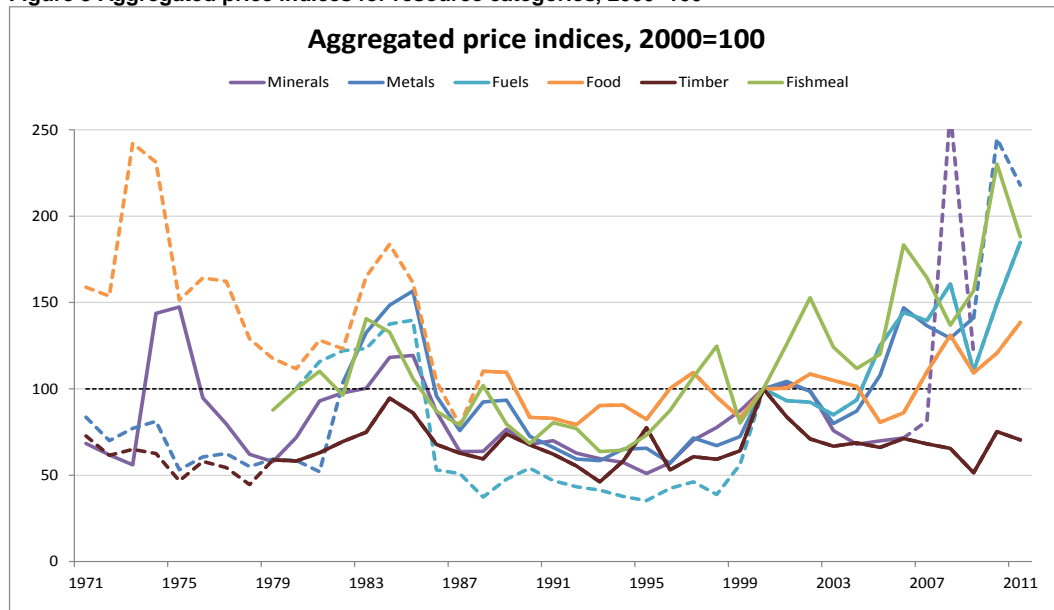
Source: Ecorys own calculations.

Note: minerals excluded from indexes 2010-2011 as full price data unavailable, weights=0.5% weighted price index, 16.7% simple average, 2.6% weighted price excluding oil.

Figure 3 portrays the price development of aggregated price indices for the resource categories<sup>1</sup>, based on weights determined by average EU27 import values for 2008-2010.

<sup>1</sup> The 8 resource categories and 24 resources were selected to highlight the most important resource categories in economic and scarcity terms. The selections are all representative of the trends in the whole resource category, i.e. the 6 metal resources account for a significant proportion of all EU imports of metals. Land and water are excluded from the aggregated index due to data limitations.

Figure 3 Aggregated price indices for resource categories, 2000=100



Source: Ecorys own calculations, dotted lines signify only partially complete price series.

Figure 3 shows that the prices of resource categories have a similar trend to the aggregate, i.e. decreasing up until around 1998 and increasing since then.

- **Despite this apparent trend the six resource category price indices do not move in tandem:** by considering the compound price indices of metals, food, timber, fuels, fish and minerals together in a so-called co-integration test<sup>2</sup>, in 4 of 10 tests no co-integrating factor could be found. This means that prices of different resources together do not have a common movement in the long run, since some are related to the price of oil while others are not. It does not provide any conclusions on causality between price movements, neither on the relationship between two resource categories;
- Historic real prices of the four minerals investigated in this study (graphite, fluorspar, sand and gravel and phosphate rock) do not have a joint movement as a whole (no co-integration) and have been relatively stable between 1971-2007. In 2008 there was a sharp increase in mineral prices caused by phosphate rock prices (index weight=59%) more than quadrupling in a year (2007-8). Based on a rough estimate, these four minerals cover approximately 32% of all mineral resources by trade value;
- Historic real prices of the six metals investigated in this study move in tandem (are co-integrated) as a whole and have a generally increasing trend over the last 30 years. The metal price index increased by 250% between 2000 and 2010. The index is largely driven by the price of iron ore (40%), aluminium (33%) and copper (26%). The critical metals (cobalt, indium, rare earths) have a negligible weight (each <0.5%) in the metal price index as their traded value is very low relative to the other metals. These six metals cover around 88% of all metal resources, hence the metal index provides a good representation of the general price movement of metals;
- Historic real prices of the four fuels investigated in this study (oil, solar PV, wind and biofuels) do have a joint price movement (are co-integrated). The relationship is an inverse one for oil and wind, and oil and solar PV, i.e. as the oil price increases, wind and solar PV prices decrease. Oil dominates the index (weight=92%) and prices have increased substantially since 1998. Trends for wind and solar are also somewhat similar to each other and both exhibit

<sup>2</sup> A co-integration test statistically analyses the movement of several time series together, in our case prices of several resource categories, and determines whether these price series follow a long run common trend (note, prices do not have to move in tandem in the short term).

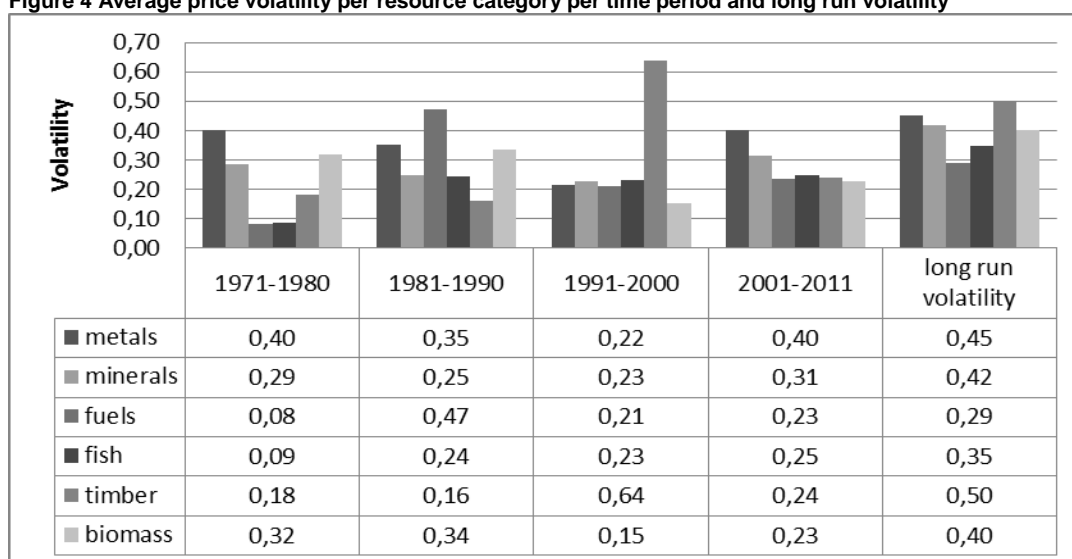
decreasing price trends. Crude oil covers approximately 85% of all energy raw materials by value, hence the index is representative of all fuels;

- Historic real prices of the five food resources investigated in this study (wheat, rice, potatoes, soybean and maize) appear to move in tandem. However, by considering the price indices of wheat, maize, soybeans, and rice together in a co-integration test, it turned out that in 2 of the 10 test results, no common co-integrating factor was found. They exhibited a joint decreasing trend until around 1992, since then prices have slowly increased again. Soybean (index weight=57.5%) is the most important determinant of this index. These five crops commodities represent around 68% of their respective food families;
- Historic real prices of the two timber resources investigated in this study (sawnwood and woodpulp) exhibit quite different price trends to each other and are not co-integrated. Woodpulp has been more volatile over time, and sawnwood much more stable. As sawnwood dominates the timber index (weight=97%) the aggregate price trend is also relatively stable. This is the only price index to be lower than its 2000 value, 2000 representing a price peak. These two commodities represent around 26% of the trade value of all forest products;
- Historic real fishmeal (industrial fish, relevant for businesses) prices have exhibited similar trends to other indices, and since around 2000 have experienced a significant, but volatile, increase, linked to increased fuel costs and declining fish stocks. Increased demand for fish by consumers in developing countries, has not led to increased production or consumption of fishmeal for aquaculture as efficiency in use has improved and alternative feed ingredients (i.e. vegetable derived) are increasingly used.

*On average resource price volatility has increased in the last 10 years, however similarly high (or even higher) price volatility has been present in the past for some resources*

The study used the coefficient of variation as a simple but informative measure for volatility (values range between 0 and 1, with 0= no volatility and 1=extreme volatility). For example, a volatility of 0.4 means that the standard deviation (or 'variation') of real prices for a given period is 40% of the mean value. Volatility greatly varies per resource sub-category and time. Figure 4 shows calculated average volatility per resource category per time period as well as the long run volatility taking into account the entire period for analysis.

**Figure 4 Average price volatility per resource category per time period and long run volatility**



Note: Simple averages were used to calculate average volatility per resource category.

- In the long run all resources have an average volatility in the range of 0.3-0.5 which is considered as moderate to high volatility;
- In the last 10 years, metals were the most volatile commodities, driven namely by iron ore (0.64) and indium (0.58). Phosphate rock (fertilizer) had at 0.81, the highest volatility during this period among all the selected resources;
- Overall, over the longest time series available per resource, the least volatile resource prices were aluminium (0.23), sawn wood (0.2), wind (0.19) and biofuels (0.11), however, limited data was available for the two latter resources. The least volatile period for the majority of resources, except for timber, was the period 1991-2000. Critical metals and minerals also had relatively low volatility however, the analysis does not cover data after 2009 where substantial price volatility (increases) are understood to have occurred.

Resource prices are expected to be more volatile in the future, mainly due to increased speculation on the market (globally traded resources), and the supply risk from emerging economics such as China and India (increased consumption of resources, export restrictions) and from politically unstable countries (Congo, Zambia). This will be a problem for European businesses.

---

*There is substantial variation in real price dynamics both across and within resource categories.*

---

The aggregated price index presented above shows a trend break in 1998 mainly due to dominance of crude oil prices in the price index. Examining price developments of the different individual resources, historic time series of real prices show substantial variation, with price trends differing even within a resource sub-category. For example, the price of aluminium has a general downward long-term trend, while the price of other metals such as iron ore or copper have an increasing trend over the same period. Trends for each resource are remarkably consistent over time, with clear, statistically significant trend breaks visible for only a few specific resources: oil, fish meal, woodpulp, and potentially iron ore (too recent to derive any conclusions). Note that the following figures show real price trends in 2011 constant EUR, with prices corrected for inflation using MUV index as deflator.

#### **Metals:**

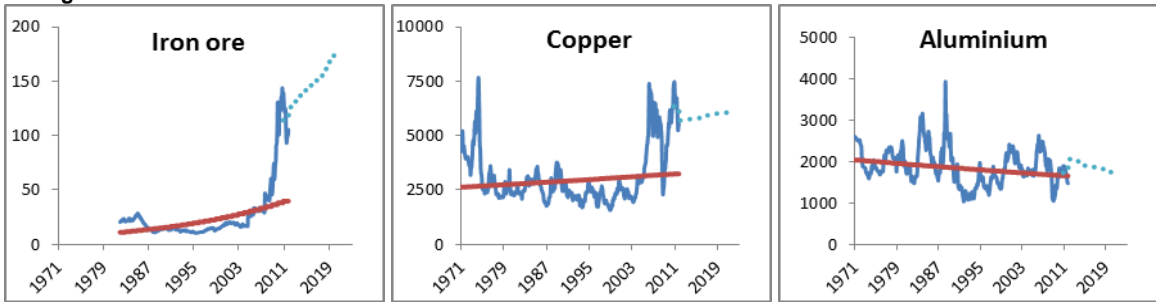
- The price of **iron ore** and **copper** has increased over time, particularly in the last 5-10 years. These increasing trends are expected to continue through to 2020 as represented by the dotted line<sup>3</sup>. In contrast to these increasing trends the price of primary **aluminium** has shown a consistent slow decline over time.

---

<sup>3</sup> The dotted line represents our base case price forecast scenario. High, low and model-fit scenarios are also examined in the main report.

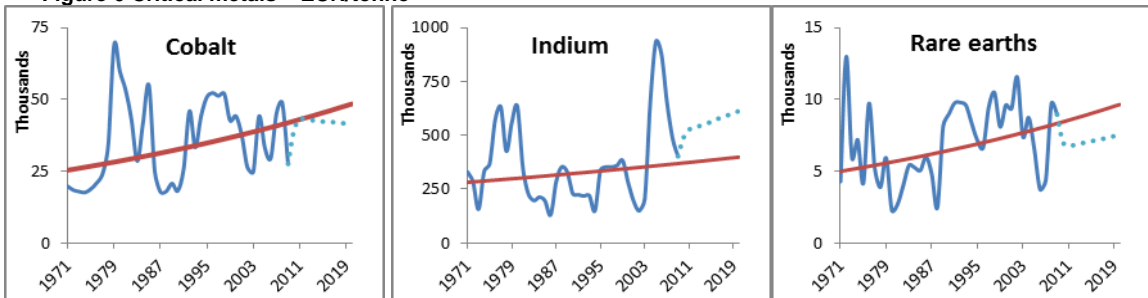


Figure 5 Base metals - EUR/tonne



- The prices of **critical raw metals** have also increased and fluctuated greatly over time demonstrating relatively high volatility.

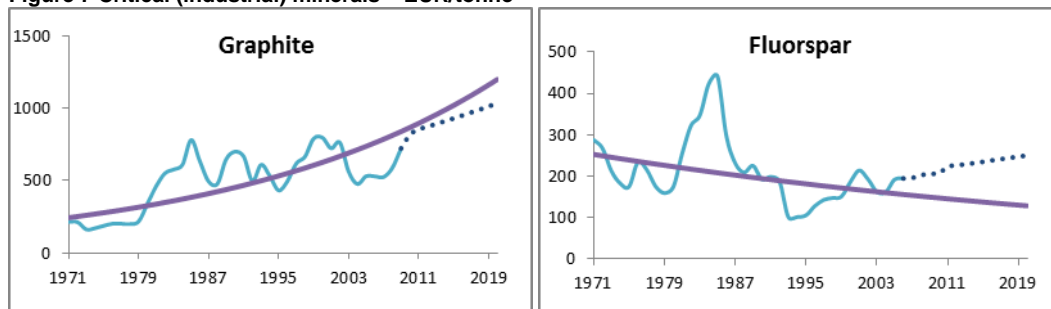
Figure 6 Critical metals – EUR/tonne



**Minerals:**

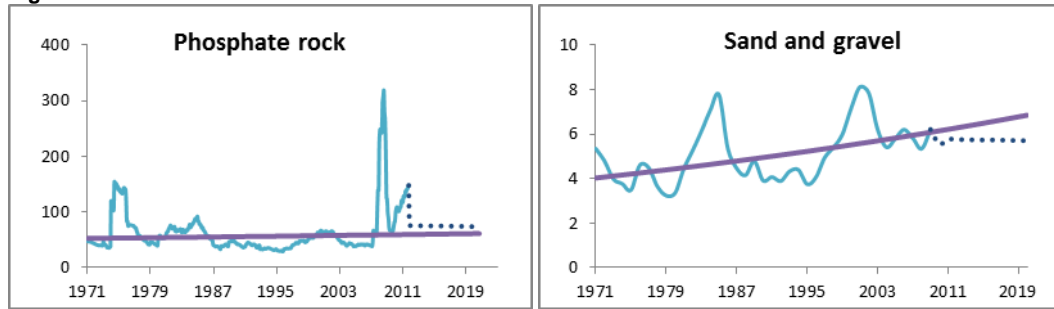
- The price development of **critical minerals** has had a diverging historical trend – graphite (increasing) and fluorspar (decreasing).

Figure 7 Critical (industrial) minerals – EUR/tonne



- **Phosphate rock (fertilizer)** prices have been relatively stable over time with the exception of two significant price spikes, the first a result of Morocco and other producers tripling tariffs (prices) in the mid-1970's, the second since 2007 with prices jumping from under 40 €/tonne to over 300 €/tonne in the space of 18 months, and then back down again;
- **Sand and gravel (construction mineral)** prices have shown a slow increasing trend over time.

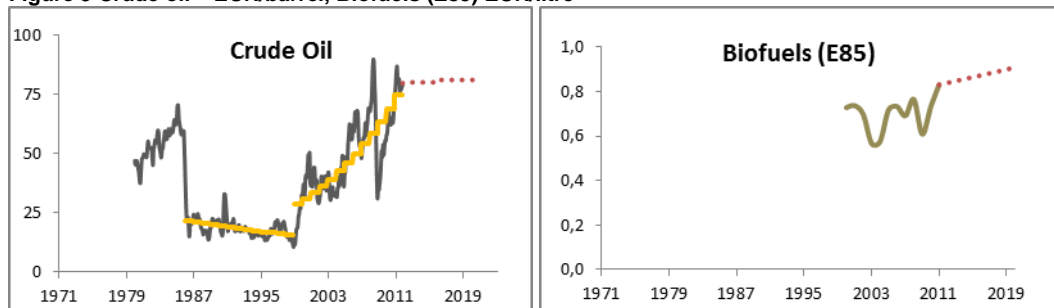
**Figure 8 Fertilizer and construction mineral – EUR/tonne**



**Fuels:**

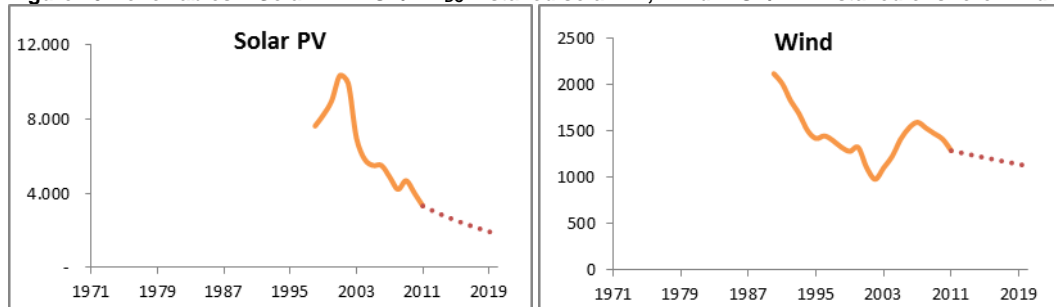
- **Crude oil** prices have fluctuated considerably and a trend break can be observed in 1985 and 1998. The prices reached peaks in 2007 and 2011. The price of **biofuels (E85)** fluctuates in a similar pattern to oil, and the price has moved in a relatively small, stable range since 2000.

**Figure 9 Crude oil – EUR/barrel, Biofuels (E85) EUR/litre**



- **Renewables:** Solar PV and wind energy prices have seen prices decline significantly over the last 20 years, though both experienced a short period of price increases along the way. Price decline is driven by technological advances, learning and significant public financial support through subsidies.

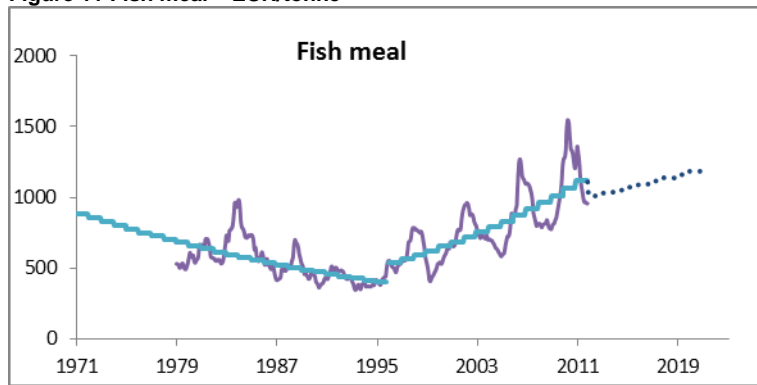
**Figure 10 Renewables – Solar PV: EUR/KW<sub>DC</sub> installed solar PV, Wind: EUR/KW installed onshore wind**



**Fish:**

- The development of **fish meal** prices was characterized by a declining trend until 1995 and a rising trend afterwards. Fishmeal prices have risen by 55% since 2005. Fishmeal prices are increasing as fish stocks decline and fuel costs increase.

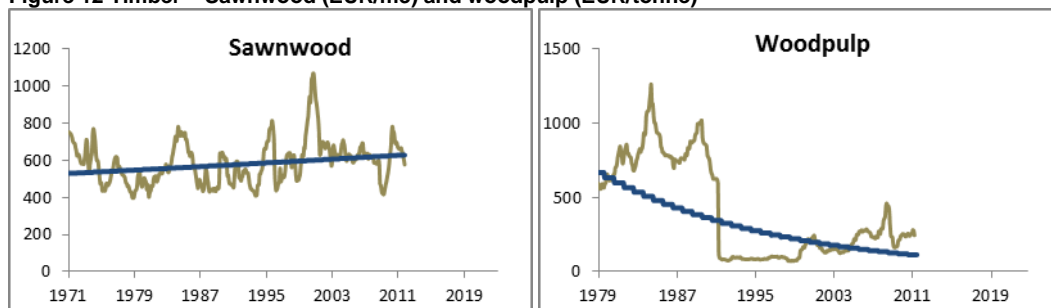
Figure 11 Fish meal – EUR/tonne



**Timber:**

- The price of **sawn wood** has remained relatively constant over the past 40 years (slightly increasing trend). On the other hand, the price of **wood pulp** had a period of high prices until 1991, after which the price dropped considerably and is now slowly increasing.

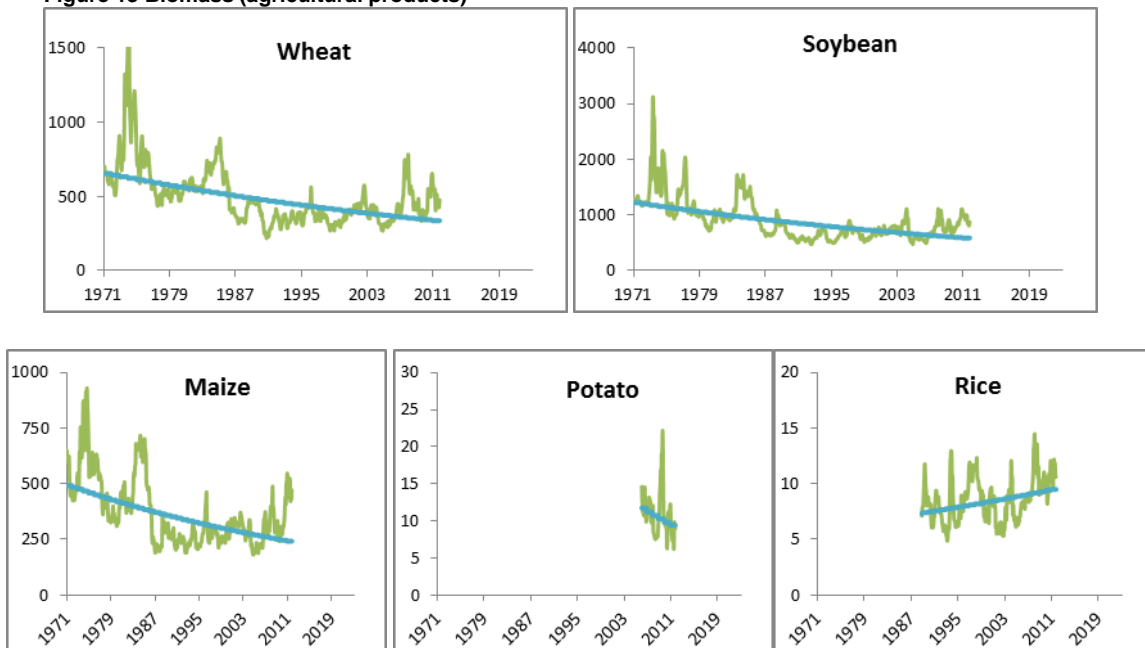
Figure 12 Timber – Sawnwood (EUR/m3) and woodpulp (EUR/tonne)



**Biomass (agricultural products):**

- The price of **agricultural products (biomass)** has had a generally decreasing trend over the past 40 years except for rice, which has increased.

Figure 13 Biomass (agricultural products)



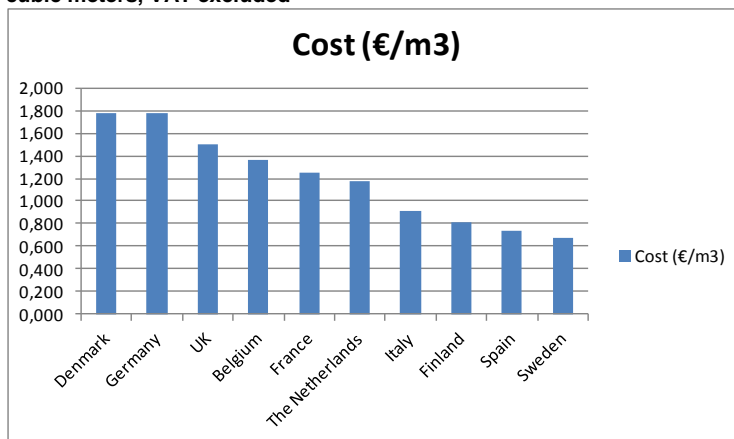
### Land:

- There has been a generally increasing trend for **land prices** in Europe since 2000 but with substantial differences across countries and regions.

### Water:

- **Water** is a “special” resource of strong “general interest”. Water prices are generally determined by specific water pricing policies and vary by country and client (private individuals, industries, agriculture, etc.). In the absence of sufficiently good data on water prices, a water cost comparison for selected EU countries shows significant variation in water cost (prices) across the EU. A divide exists between those that pay higher water prices, close to full cost recovery, and those, mainly in Southern Europe, that do not.

**Figure 14** Data are based on prices as of July 2006 for an organization with an annual usage of 10000 cubic meters, VAT excluded



### Key drivers of prices

The study extensively reviewed existing relevant literature on key drivers of resource prices (resource-by-resource) to explain price peaks and low points, trends and trend breaks.

*Resource prices are primarily driven by supply and demand, market structures, government intervention (export quotas, export taxes, subsidies), energy prices, financial speculation and new technologies.*

### Key drivers of prices are:

- *General macro-economic developments* – economic crises, economic growth, development and business cycles all influence resource prices - usually long term volatility effects (oil prices, metals, minerals all depend economic growth and market demand);
- *Change of pricing structure* – for example from negotiated prices to spot or exchange-based prices (aluminium, iron ore);
- *Financial market considerations* – speculation and hedging activity, “warehousing” – usually short term volatility effects (aluminium, copper, iron ore);
- *Market fundamentals* – refer to the underlying availability, supply and demand, usually lags in production (mining activity related to metals and minerals);

- *Natural and corporate disasters* – storms, fire, floods, etc. have an impact on the price of crops and wood; corporate disasters can have an influence on prices, e.g. Deepwater Horizon and oil;
- *Politics and market power* - export restrictions (related to critical metals and minerals where only a few countries produce these raw material), market manipulation – i.e. dumping to price out competitors and ensure long-term market share, oligopolistic market structure (oil, iron ore); politically unstable countries also create uncertainty on resource prices, e.g. Democratic Republic of Congo and cobalt) or in OPEC countries (oil);
- *Government policies and subsidies* – markets and prices that are dependent on public subsidies, quotas, regulation or are publicly owned. (biofuels, renewable energy, water, fishing);
- *New technologies* - can have dramatic price effects through their costs implications for production or consumption (renewable energy, food [green revolution], oil [unconventional sources]);
- *Extraction methods* – more efficient and less costly means of extraction have been the main driver over the last century.

Interesting resource specific drivers include:

- **Metals** - futures trading and warehousing is a specific factor pushing aluminium prices higher than otherwise; an oligopolistic market - three key producers covering 75% of production – has a major impact on iron ore prices; export restrictions and dumping by China and others can have an influence on the supply and price of rare earths and indium;
- **Minerals** – Chinese domestic consumption of fluor spar and export restriction on graphite influence their price; the price of phosphate rock is driven by its low substitutability;
- **Oil** – geopolitical events, speculation, market power of major producers (e.g. OPEC) all play a major role. Fears over scarcity, production peaking and a structural imbalance between production and consumption also plays an important role;
- **Renewable energy** – Solar PV and wind energy prices strongly driven by technological advance and learning, and by the financial incentives (e.g. public subsidies) that drive demand. ‘Dumping’ of products sold at, or below, cost by state-owned/funded East Asian firms is an issue forcing prices down;
- **Food commodities** – strong inter-linkages with prices of other resources, such as oil prices and fertilizers (minerals). Change in diets in emerging economies, investment in the agricultural sector and trade policies as well as environmental change and degradation all have an impact on the price of food commodities in the long run. In the short run, climatic variations (drought, heat waves), pests and diseases and biofuels demand have an impact on prices. Food prices are usually determined locally or nationally (e.g. potato and rice);
- **Water** – the determination of water prices is generally not left to the market, but it is the object of specific water pricing policies and water prices are highly distorted in many Member States by public policy and subsidies. Prices often also vary by sector (households, agriculture, industry), with many Member States cross-subsidising to provide much lower prices for agriculture;
- **Fish meal** – the price of fish meal has been determined by capture fisheries production which is stable over time; prices also driven by increases in fuel prices and use of sea freight, strong population and economic growth, changing diets, and growth in aquaculture –the major user of fishmeal. The efficiency of fishmeal use in aquaculture and the suitability and success of substitute fish-feed ingredients also play a role in prices;
- **Land and timber** - climate change and all environmental change (such as land degradation) that affect land resources also affect forestry products such as timber. Concerns about global warming mitigation, ecosystems conservation and the need for recreational services have pushed for the adoption of forests protection policies (at least in some regions) to limit or forbid logging in certain areas. This can affect wood prices.

## Future trends in resources prices & scenarios

Projections of future resource price developments were made for three different scenarios (high-end, base, low-end) based on existing literature, historical resource prices as well as a simple forecast models and the Globiom model. Figures 5-11 include these price projections. The summary table (Table 1) reports on the base scenario forecasts for 2020 for individual resources. The direction and scale of change, along with the key factors underpinning them, are summarised below and future trends in metals, minerals, fuels and food are profiled in more detail.

---

*In general, resource prices are expected to rise in the future. However, stagnation or even a decrease in real prices by 2020 is expected for a handful of resources.*

---

### Land:

- **Land** prices are expected to continue to rise slowly until 2050 with some regional variations.

### Water:

- **Water** prices are expected to increase as water stress becomes a bigger issue and prices rise to enable cost recovery in those Member States where this is not yet the case.

### Timber:

- The price of **sawn wood** is expected to rise slightly until 2020 and then stabilize until 2050;
- Similarly, the price of **wood pulp** is expected to increase steadily until 2050.

### Fish:

- **Fish meal** prices are expected to continue to increase through to 2020 as demand for fish continues to increase and stocks are unsustainably depleted.

Global population growth and climate change will primarily affect fish, water, land, food and agricultural raw materials such as timber. As a result, worsened water scarcity is expected to drive up water prices, increased demand due to population growth fish meal, food and land prices.

---

*For several metals and minerals supply risk is more important to the EU than increasing prices*

---

### Metals:

- The prices of **iron ore** and **copper** are expected to continue to increase through to 2020;
- In contrast, the price of primary **aluminium** is expected to decrease on 2011 values by 2020;
- The prices of **indium** and **rare earths** are expected to increase over time, but the price of **cobalt** is forecast to experience a slow decline to 2020.

### Minerals:

- Prices of **graphite** and **fluorspar** are expected to increase in the future;
- **Phosphate rock** prices are forecast to slowly decline to 2020;
- **Sand and gravel** (construction mineral) prices are forecast to remain relatively stable to 2020.

The key producers of the most economically important metals and minerals lie outside Europe, often in China, therefore supply risk is one of the principal risk factors for European industries. This is the case for all the metals and minerals investigated, except for aluminium and copper, where Europe is less sensitive due to its high efficiency of use and good recycling rates, and sand and gravel, which is relatively abundant.

The majority of metals are traded on global metal exchanges, such as the London Metal Exchange (e.g. aluminium, copper, etc.), or on spot markets (iron ore), hence there is a single price for buyers on these markets. The price of minerals is usually determined by negotiated contracts but phosphate rock and graphite have globally determined prices. The increasing prices of metals and minerals result in increased costs for the end users but the impact is offset by factors such as:

- Increased supply, even if this lags as new mines are opened (aluminium, copper);
- Energy efficiency and recycling (aluminium, copper, steel);
- Small quantities needed by client industries (usually high-tech) due to increased efficiency, leading to a smaller weight in the cost structure (cobalt, indium, rare earths, graphite), hardly influencing the price of the end product.

Therefore, for these metals and minerals, it is supply risks rather than increasing prices which pose the greatest threat to European industries as some materials have unique properties and thus limited substitutability. The production of some of the raw materials is highly concentrated and political or natural events can have serious consequences for supply (wars, export restrictions, storms). Securing supplies therefore becomes an important concern for EU industry.

One solution is outsourcing part of production, and hence part of profits, to the countries producing these materials to secure access. As demand for many of these resources has only just started to increase, recycling markets are also not yet well developed. In most of the 'critical' markets, expansion activities are expected to diversify supply and thus decrease supply risk in the coming years. Price peaks, in addition to making some previously uneconomic sources economically viable, have also sparked intensified research into recycling and substitutes, which will in some cases reduce the supply risk and thus price volatility. One of the main reasons for the recent decline of indium prices for instance, is increased recycling, which accounted for a greater share of indium production than primary production by 2007.

---

*Oil prices are expected to remain high but stable, while renewable energy prices continue to decline as the technology improves.*

---

#### **Fuels:**

- **Crude oil** prices are expected to remain around peak 2007 and 2011 values by 2020. Some feel this is overly optimistic and the oil price will rather keep on rising arguing that the oil peak has been passed, others argue that current prices are higher than is justified by demand-supply fundamentals, even though the current trend of a stable high oil price tends to contradict this;
- The price of **biofuels (E85)** fluctuates in a similar pattern to oil, although it is a relatively minor part of the blend. Prices are forecast to slowly increase to 2020;
- The prices of **solar PV** and **wind** are forecast to continue to decline to 2020, due to high learning rates and technological development.

There are strong distinctions between future price scenarios for oil and the renewable fuels. Oil prices are among the most closely followed of any commodity in the world and a variety of forecasts

exist: the authoritative forecast of the International Energy Agency (IEA) projects that oil prices will remain at a level of around €80 per barrel through to 2020, with only a minor increase experienced on today's levels (assuming constant Euros, in current values the oil price will certainly continue to rise). Consistent with the volatility of oil prices and the 'peak oil' theory there are also a variety of studies that predict much higher oil prices as demand increases faster than supply and scarcity begins to play a major role, this is represented in a high price scenario. In a low scenario oil prices are forecast to decline, partly reflecting the view that oil is over-priced, or that the expected boom in oil demand will not materialise, which would lead to over-supply production capacity.

In the case of renewable energy, biofuels are not expected to exhibit any strong upwards or downwards trends through to 2020. This contrasts with solar PV and wind energy, which are forecast to continue to decline in price in all scenarios. Solar PV is forecast to exhibit the strongest price declines as the scope for technological progress and learning is greater than for wind, which is a more mature technology and also with greater physical limitations.

*Prices of agricultural products are expected to decline by 2020 and even further by 2050.*

#### Biomass:

- The price of **agricultural products (biomass)** is expected to show a stagnating trend until around 2030 after which the prices are projected to decrease by 2050 (depending on the scenario).

Price projections based on the GLOBIOM model show three different scenarios more or less optimistic with regard to crop yield increases – no yield growth, yield growth based on past data (from FAOSTAT) and yield growth based on the IMPACT model (maintained by the IFPRI) projections. Assuming there will be future yield growth, for example due to technological improvements and/or agricultural intensification in general (intensification of the use of production inputs and factors other than land), the prices of five investigated biomass resources (wheat, maize, potato, soybean and rice) are expected to decline by 2020 (compared to 2010) and further decline by 2050. This holds for global as well as EU27 prices. On the other hand, assuming there is no yield growth in the future, global and EU27 prices are expected to increase by 2020 but slightly stagnate after that till 2050. In any case, price projections generated by GLOBIOM consist of long-term trends, i.e. the model is not designed to predict short-term variations such as the 2007 food crisis, which could still happen. Crises are indeed due to a conjunction of short-term phenomena, in particular extreme climate events (drought, flooding, etc.) that are not taken into account in GLOBIOM.

**Table 2 EU27 projected periodic price changes for agricultural products**

% price change	No yield growth		Yield growth past data		Yield growth GLOBIOM	
	2010-2020	2020-2050	2010-2020	2020-2050	2010-2020	2020-2050
Corn	5.3%	-0.9%	-6.1%	-20.5%	-3.9%	-15.4%
Potato	1.8%	2.2%	-3.0%	-6.5%	0.7%	-4.7%
Rice	4.4%	2.1%	-3.8%	-7.2%	-5.4%	-40.4%
Soyabeans	7.4%	-4.3%	-9.6%	-26.9%	-10.1%	-36.5%
Wheat	9.2%	-3.2%	-5.3%	-25.3%	-6.2%	-23.0%

Source: FAOSTAT, GLOBIOM, IIASA own calculations.



Moreover, it should be noted that these projections do not take into account long-term shifts such as climate change impacts, change in agricultural policies or trade policies.

## Competitiveness analysis

---

*The key risks for competitiveness and future resource prices are political instability, export restrictions, scarcity, oligopolistic markets, low recycling and substitutability rates, and climate change.*

---

The competitiveness impacts of changes in resource prices will be the results of many factors, with the source of resources an important consideration. Europe is only a minor producer for many resources and has to import to meet its needs. This does not create a problem for resources freely available on global markets, where the main disadvantages are the additional transport costs and the transfer of wealth (the economic rents) to producer countries, only some of which is recouped in exports of finished products. Where global markets do not work as well, this confronts the EU with a range of potential supply and price risks.

Since the majority of raw materials – metals, minerals and fuels – are produced in politically unstable or trade-restricting countries (China, Congo, Middle East), the prices of these materials depend heavily on their political situation. Nevertheless the international community has some influence over it, for example China dropped export restrictions on bauxite, magnesium or rare earths on request of WTO<sup>4</sup> or by trying to secure political stability in resource rich countries. The WTO and trade actions are also used to deal with dumping, which although it reduces prices in the short term, can deliver market control and price-setting power in the long term.

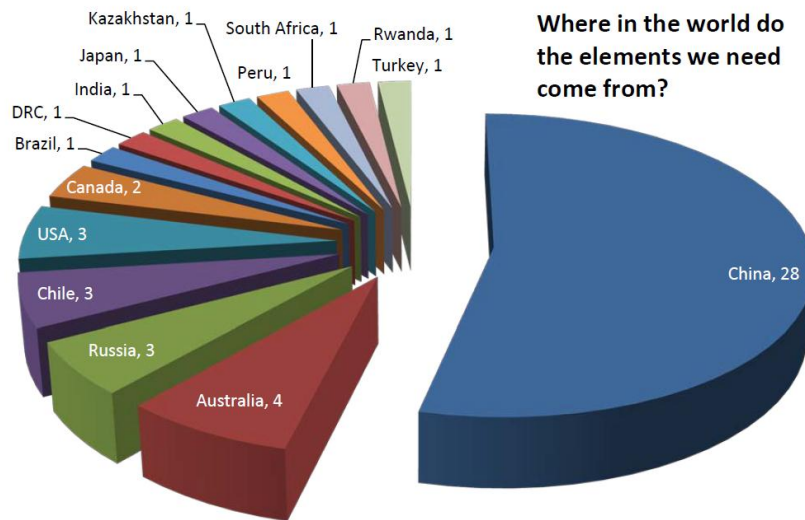
The British Geological Survey made a list of 52 chemical elements (resources) that society needs to “maintain our economy and lifestyle”<sup>5</sup> and indicated, which country is the leading producer. The figure below shows that the world depends on China for most of these resources (28 out of 52). Notable examples of commodity markets dominated by Chinese exports are rare earths, indium, graphite and fluorspar.

---

<sup>4</sup> <http://www.reuters.com/article/2012/01/30/china-wto-exports-idUSL5E8CU3QA20120130>.

<sup>5</sup> BGS, 2011, Raw materials Risk list 2011, British Geological Survey, September 12, 2011.

**Figure 15 Leading producers of 52 essential chemical elements of economic value**



Source: BGS, 2011.

---

*Europe is highly dependent on the rest of the world for the majority of resources, and this is reflected in our trade balance.*

---

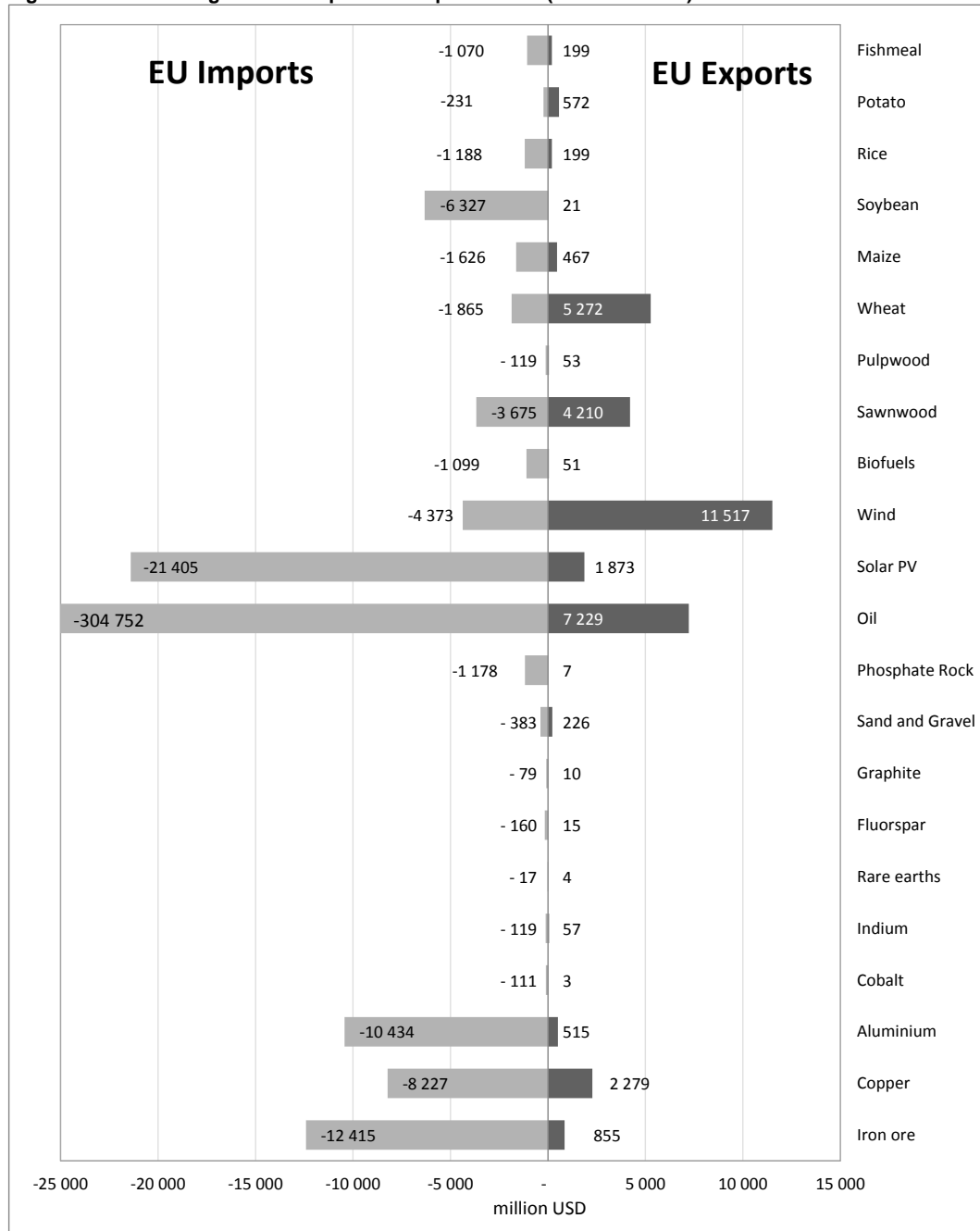
The trade balance of the EU27 for the selected resources shows strong reliance on imports (see also figure 1). The EU27 is a net importer of all resources (the exceptions are potatoes, wheat, sawn wood and wind energy). Figure 16 portrays the EU27 trade balance.

It shows Europe's great dependence on imports of crude oil, aluminium, copper and iron ore as important resources driving European industries (in terms of value). Soybeans are the most important imported agricultural resource but rice and maize are also major imports. Solar PV is the second biggest total import, with rapid expansion of solar PV being fed by imports from China, Japan and others. In the long term this may help reduce imports of other energy sources such as oil, coal and gas.

Wind energy is by far the biggest export success for the EU from the selected resources, with EU-based firms, particularly Danish, German and Spanish firms, successfully building on expansion of wind energy in Europe to export the technology around the globe.

Regarding timber, it is expected that the EU27 trade balance for sawn wood will improve in the future but deteriorate for wood pulp. The share of EU in global production for these resources has remained constant during 2002 and 2009.

Figure 16 EU27 average annual import and export values (in million USD) for 2008-2010



Source: UN Comtrade, Ecorys own calculations.

*Recycling and substitutability of materials becomes increasingly important for security of supply and the competitiveness of European sectors.*

Increased competition as a result of recycling and substitutability releases some pressure on raw materials demand. Since the extraction and refining of most raw materials is a highly energy intensive process, improvements in the energy efficiency of production processes will be key to keeping production costs down. R&D in recycling and the substitutability of materials will also be a driving factor of future prices of many materials. Recycling is already a key driver of competitiveness and security of supply for several resources, particularly metals, where it is an

established secondary material source. For many other materials, recycling is still in its infancy and is likely to become much more important in the (near) future. Some of the findings include:

- Recycling of scrap metal is essential to maintain the competitiveness of the EU non-ferrous metals industry, particularly for **aluminium** and **copper**. In recent years, the majority of metal scrap is exported to developing and emerging economies, for example to China. Nearly 60% of aluminium and more than 40% of copper production stems from scrap. Recycling of **steel** (more than 67% of steel scrap is recycled) reduces the need for iron ore, energy and landfill space;
- For resources like **graphite** or **cobalt**, recycling rates are still low and may become important in the future in order to decrease import dependency and make European industries less vulnerable to supply fluctuations. On the **indium** market, increased recycling has already caused prices to drop from the 2005 price peak back to previous levels;
- Recycling and re-use is often less energy intensive than mining materials. For example, around 30% of primary aluminium production consists of energy costs. Recycling of aluminium scrap uses only 5% of the energy;
- Since the production of many materials significantly depends on the use of energy, improvements in energy efficiency are crucial for the competitiveness of EU sectors;
- For **rare earths**, **fluorspar** and **graphite** recycling rates and substitutability are currently very limited (recycling rate less than 1%).

---

*Water prices will increase – particularly in countries where prices are currently well below the level needed for cost recovery.*

---

The competitiveness impacts of expected water price increases would be felt in industry and agriculture. In agriculture, the Mediterranean Member States with high water use in irrigation but currently low prices (i.e. below those needed for cost recovery) would see the biggest impact, as these farmers costs would increase. This is likely to spur some water efficiency investments, but many irrigators are understood to already employ efficient technologies. On the other hand, increasing prices may lead to a better allocation of water rights, and positively affect the competitiveness of other farmers. Overall, the impact might be to negatively affect EU agricultural producers more than other EU producers but it is not a uniform effect.

In the long term, water availability in Europe is thought to be better than in many other regions. As climate change is expected to reduce water availability globally the relative competitiveness effects for the EU could be positive.

The EU is reliant on imports of fishmeal to supply its high-value aquaculture sector. The competitiveness effects of the expected increase in prices are unclear, it is likely to impose additional costs, but these are balanced against savings from improved efficiency in the use of fish in fishmeal and the use of substitute ingredients. Relatively larger competitiveness impacts are expected in Asia due to their more rapid aquaculture growth and switching to higher-value fish.

---

*We estimate that rare earths, graphite, indium, soybeans, water and land are the most critical resources to the EU.*

---

Criticality for the EU takes into account scarcity, distribution of reserves, production concentration and political stability, as well as recycling opportunities and substitutability. The EU Raw Materials initiative has identified a list of 14 economically important raw materials which are subject to a higher risk of supply interruption, among which are five (cobalt, indium, rare earths, fluorspar and graphite) also analysed in this report. The British Geological Survey (BGS) also carried out a supply risk assessment and ranks all minerals and metals on a criticality scale. Table 3 shows the results for our metals and minerals.

**Table 3 Criticality of metals and minerals for the EU**

Resource	BGS score	Criticality
Rare earths	8	High
Graphite	7	High
Indium	6.5	High
Cobalt	5.5	Medium
Copper	4.5	Medium
Fluorspar	4.5	Medium
Iron ore	3.5	Low
Aluminium	3.5	Low

Although it is very difficult to design an objective method to assess the criticality of other resources and compare them with each other, since fuels, water, fish, wood, land and food are all very different in nature, some general observations can be made based on which resources can be classified according to their criticality into “high”, “medium” and “low”.

**Fuels** – there is no absolute shortage of energy today. Known oil reserves can cover at least 45 years of expected average demand between 2010 and 2030 and there is still untapped potential in unconventional sources.<sup>6</sup> Coal is abundant, and the share of renewables is also expected to increase. However, it can become more and more expensive to tap marginal sources of energy, with production costs increasing as the best fossil fuel and uranium deposits are extracted. Of course, doing so would have climate change impacts and also have impacts through potential fuel poverty increases. The criticality is hence assumed ‘*medium*’.

**Timber and food** – in general these resources are currently abundant and no significant shortages are perceived in Europe. However, the increasing demand from emerging economies, such as China and India, and their dietary change (i.e. more meat consumption) will increase demand for food, this is compounded by increased demand for biofuels. This is likely to put pressure on supplies and prices. The problem of water scarcity in some producing regions (e.g. the American Midwest) might limit future increases in maize production. Based on this, a first assessment would classify timber, potato and maize as ‘*medium*’ criticality resources. With regard to soybean, EU production is not close to meeting its own demand. This resource could be classified as ‘*high*’ criticality resource. With wheat and rice, the criticality is assessed ‘*low*’ since there is no shortage of supply of this resource and Europe is increasing its production.

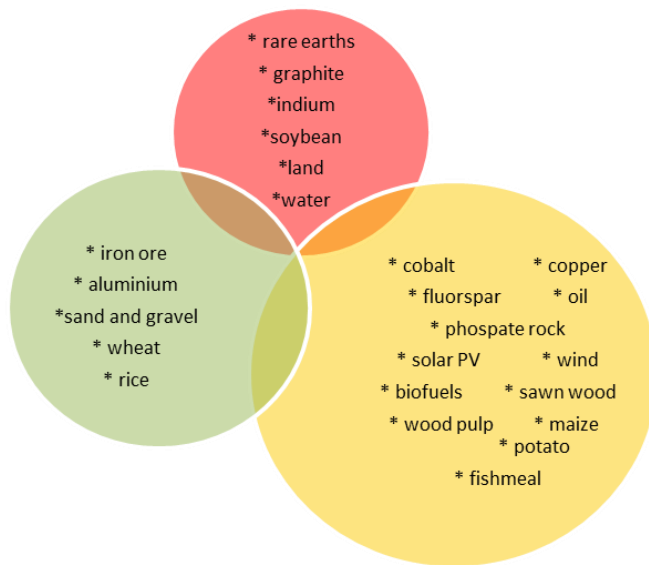
**Fish** – concerns over fish populations are widespread, as is evidence of over-fishing and a decline in stocks. As a renewable resource it is necessary to manage in a sustainable way, and sustainable fish produce is an increasing trend in the EU, driven largely by retailers and consumers. While EU stocks have gained some protection, many global fisheries are poorly policed and over-exploited, with EU boats among those over-exploiting. Specifically for fishmeal, Asian use of aquaculture is

<sup>6</sup> McKinsey study (2011).

increasing, but actual global fishmeal production and consumption is in decline as efficiency in use improves. Substitutability for other food – protein – sources also makes it less critical overall. Therefore while fish as a whole is a resource with high supply risk, fishmeal is ranked as *medium* criticality.

**Land and water** – the overall growth in demand for agricultural products will require more land and water. These resources are estimated to need a 250% and 140% increases in supply, respectively over the next 20 years compared to the past 20 years.<sup>7</sup> Increasing supply is becoming more and more costly for these resources as more land is urbanised, climate change makes more land marginal for agricultural production and forest areas gain greater protection. The economic criticality and supply risk of water varies significantly by location, generally speaking it could be said that it is of low-medium criticality in Northern and Central Europe, but is of high criticality in Southern Europe. For land the criticality is classified as ‘*high*’.

**Figure 17 A first step into classifying resources according to their criticality**



Source: Ecorys assessment.

## Price signals and resource use

*Resource prices often take little account of scarcity and environmental externalities, offering incomplete price signals and leading to socially inefficient resource use.*

Assessment of the completeness of the price message – whether resource prices fully reflect externalities, scarcities and other factors – shows that there are two opposite forces at hand. On the one hand, resource-by-resource analysis demonstrated that scarcity and environmental costs of resource production are usually not included in the price signals. Part of the reason is that it is very difficult to judge a ‘complete’ or ‘true’ price of a resource as there is typically great uncertainty regarding the lifetime of reserves, substitutability, ‘right’ level for subsidies, maximum sustainable yields, environmental impacts and such factors. The difficulties, uncertainties and unclear

<sup>7</sup> McKinsey study (2011).

responsibilities lead to these factors being marginalised in prices, and resources being underpriced. This can then lead to over consumption and is most clearly evident for the timber, fish, land, water and agricultural commodities investigated.

On the other hand, market failures such as government interventions (export restrictions); instability in producing countries, oligopolistic markets and financial speculation can keep resource prices artificially high. The recent oil peaks are considered by some experts as an example of significant overpricing of the resource due to these factors, given that marginal production costs for major producers such as Saudi Arabia are only a small fraction of the current price, pointing to excess profits and over-pricing. The oil price is especially important to all resource prices due to its role in their transport. The forecasting models have shown that the oil price is highly correlated one-to-one with metal prices, for this reason, since the oil price has been argued to be overpriced, makes the metal prices similarly overpriced. Restriction of supply and financial speculation also distorts the prices of metals and minerals.

On balance these two sets of factors can be seen to, at least partially, offset each other in most cases, i.e. that market imperfections partially result in the higher prices that would be required for scarcity and externalities to be taken into account. It seems unlikely that market imperfections fully reflect such issues though for all resources, especially since for some resources global markets work fairly freely. However, the bottom line is that these price increases are not a reflection of healthy market forces and the effect for the EU is typically a simple shift of rents outside Europe rather than decreased consumption. As such, currently it cannot be said that market signals deliver an appropriate response and socially efficient use of resources.

A few examples of the incompleteness of the price message are illustrated below.

### Scarcity

For most resources, there is a lot of uncertainty about the lifetime of the reserves. Projections are often adjusted due to progressing technology and on-going exploration activities. Two examples from the estimated reserves of *indium* and *phosphate rock* show that these adjustments can be quite dramatic and illustrate the high degree of uncertainty. Around 2005-2006 the estimated lifetime of indium reserves was around 10 years, currently the reserves are expected to last at least 100 years, due to improved recycling and recovery techniques of indium contained in zinc sludge. In 2010, the USGS estimated that phosphate rock reserves would be depleted in 100 years, the most recent projections extended the anticipated time-frame of availability of phosphate reserves to between 300 and 400 years.

Even if there is adequate information on the reserves and/or reserve bases, market participants often have little incentive to include it in their pricing, as higher prices, when few substitutes are available, increases income at least in the short-term. The producers of the resources are typically commercial parties that do not incorporate time horizons of several decades in their investment plans and cost calculations. Production costs will be set at a price that is required to recoup the investment costs within a certain time period. This time period will rarely exceed 30 years and will almost always be below the expected lifetime of the reserves. This is a particular problem for 'free' natural resources such as fish and water, where there can be strong short-term economic rationales for over-exploiting the resource.

Nevertheless, prices do tend to go up when a resource becomes more scarce due to higher production costs. The low hanging fruit is already picked; for instance declining ore grades make remaining resources more expensive to produce.

An interesting case is *wood* as wood production can be made from managed forests or from the deforestation of natural forests. In the first case, the production can be compared to crop production and wood is seen as a renewable resource. In the second case, wood production is comparable to the extraction of a non-renewable resource. In this case, production costs often consist only of extraction and transformation costs and the scarcity of the resource is not taken into account (or possibly at a low price).

Rising prices also carry a mitigating factor for supply risks and scarcity as they enable a wider range of supplies to be produced y, expanding the known economically recoverable reserves. This can help diversify suppliers, although the economic gains from these new sources are more marginal and often the environmental disruption of these sources is much greater, e.g. unconventional oil – Alberta tar sands require oil prices of US\$50-70 barrel to be viable, but cause major water and environmental pollution. This is an important environmental danger in wishing for higher resource prices, in that scarcity is less a physical issue than an economic one, and increasing prices most often lead to reduced scarcity.

### Externalities (environmental costs)

An adequate assessment of the real costs needs to take environmental externalities into account, such as air pollution or biodiversity loss due to resource production. Externalities are often referred to as hidden costs because it is usually unclear what the costs for society or the environment are as a result of the production of a certain resource. Even if there are estimates of these hidden costs, these are rarely incorporated in the price of the resource. The European CO<sub>2</sub> market (EU ETS) is an example of an attempt to incorporate the environmental costs of energy use (i.e. global warming caused by CO<sub>2</sub> emissions) into prices. A few examples of externalities include:

- **Metals** - the environmental external costs for industrial metals & mining sector of the top 3,000 companies by market capitalisation in Trucost's database were estimated to be around USD 220 bn in 2008, 77.3% of which relate to greenhouse gases. For iron ore, if carbon prices would rise to a level of \$30/tonne, iron ore costs would increase by 3.3% across the industry. An adequate incorporation of the water costs of iron ore mining would result in a 2.5% cost increase. Combined carbon and water costs, this could mean increased costs of up to 16% for some operators in water-scarce regions;<sup>8</sup>
- **Minerals** –as well as being responsible for greenhouse gases in their extraction, there are often localised pollution issues (e.g. close to mines);
- **Food commodities** - agricultural activities emit CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O that are partly responsible for global warming, are responsible for water pollution, biodiversity loss and chemical pollution;
- **Timber** - another example is deforestation in case of using timber as a resource. Forests removal can also provoke landslides that can cause terrible human and economic damages. These considerations are not reflected in the price of wood;
- **Fish and water** - Similarly the cost of removing apex predators from marine ecosystems (e.g. over-fishing), overabstractions of water reducing ecologically sustainable river flows and conversion of agricultural or waste land to built land.

### Other market failures

---

*Some 'under-pricing' of resources is mitigated by market distortions (oligopoly, export restrictions, financial speculation) rather than pricing in externalities or scarcity.*

---

<sup>8</sup> McKinsey Resource Revolution: Meeting the world's energy, materials, food, and water needs (2011).



Besides the aforementioned issues, there are other factors that can distort price signals. Most notably the structure of the market and government intervention through for example exports restrictions, subsidies or pricing policies. The primary failures include:

- **Oligopolistic market structure** - too much dependency on too few suppliers causes uncertainty in the market and gives market players significant price setting power and incentives to collude. When only a few producers supply the market, this oligopolistic structure tends to distort the market and prices rise. For example, the *iron ore* market is dominated by three key producers covering around 75% of global production and has seen significant price increases in the last 5 years. This distortion is accentuated when the country that dominates the market imposes export restrictions, such as for example China in its production of *rare earths, graphite, and indium*. OPEC in oil markets is a further classic example of oligopolistic / cartel-type behaviour;
- **Export restrictions** - Export taxes and especially export quotas can have huge impacts on the market and cause rapid price changes. Chinese export quotas on *fluorspar* and *rare earths* for instance, have caused considerable price increases of up to 700% in just a few months in the case of rare earths. India increased its export tax on iron ore from 20% to 30% in January 2012, causing a price increase. Imposition of such restrictions cannot be predicted and causes uncertainty in the market. For example, a recent WTO ruling challenged Chinese rights to impose export restrictions on several key resources. China cited an exemption in WTO rules that allowed it to restrict exports for environmental reasons but lost the appeal<sup>9</sup>. Related to this is the warehousing practice in the aluminium industry which also imposes a supply restriction to the market - almost 75% of LME aluminium stocks are locked into so-called financing transactions and unavailable to consumers,<sup>10</sup> hence prices do not directly reflect real demand;
- **Subsidies and other pricing policies** – subsidies are an example of market distortions keeping resource prices artificially low. This applies particularly to water and energy, but also to industries such as fishing and agriculture where subsidies enable over-production or exploitation of a resource. Agricultural policies in a broad sense also include tariffs on food commodities as well as non-tariff barriers to trade, direct and indirect subsidies to the agricultural sector, and bioenergy policies. All these measures have an impact on prices and affect the allocation of resources (e.g. the Common Agricultural Policy (CAP) to support the European agricultural sector). There can often be sound strategic and long-term efficiency reasons for such subsidies, such as to stimulate renewable energy technologies against well-funded and entrenched fossil-fuel competition, or to maintain production of strategic resources and land husbandry (food and agriculture).

Clearly, most resource markets function far from perfectly and the price signals do not completely communicate the various factors at play. Careful consideration will need to be given to how policy can impact this to target price or other changes that will resolve the resource efficiency problem in a more socially beneficial way.

---

<sup>9</sup> <http://www.reuters.com/article/2012/01/30/china-wto-exports-idUSL5E8CU3QA20120130>.

<sup>10</sup> <http://www.businessweek.com/news/2012-04-16/aluminum-warehouse-orders-premiums-signal-scarcity-of-metal>.



P.O. Box 4175  
3006 AD Rotterdam  
The Netherlands

Watermanweg 44  
3067 GG Rotterdam  
The Netherlands

T +31 (0)10 453 88 00  
F +31 (0)10 453 07 68  
E [netherlands@ecorys.com](mailto:netherlands@ecorys.com)

**W** [www.ecorys.nl](http://www.ecorys.nl)

***Sound analysis, inspiring ideas***