

# Assessing the global determinants of virgin and recovered plastics prices, for WRAP

October 2008

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# Assessing the global determinants of virgin and recovered plastics prices

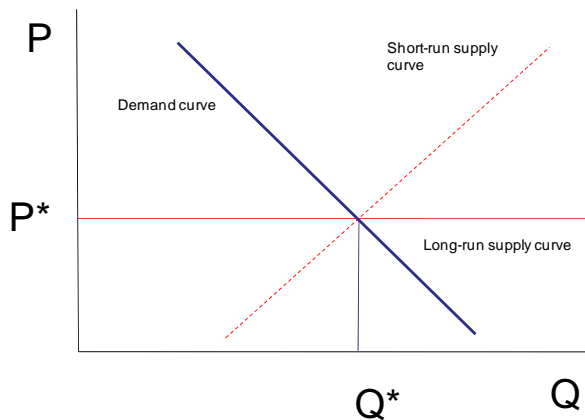
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## Executive Summary

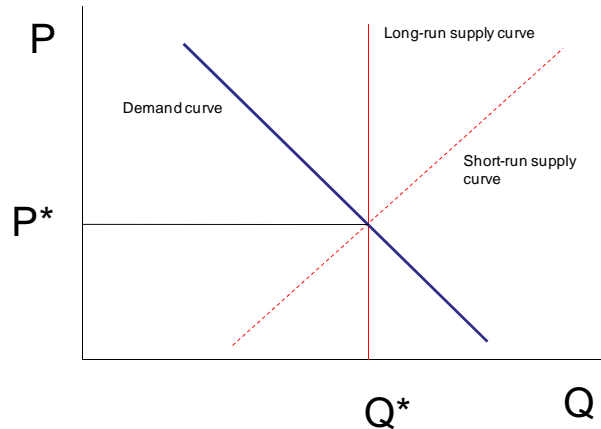
- Virgin plastics are a globally traded commodity. That means that the price of virgin plastics is determined by their cost of production in the long run.
- The main influence on that cost is the price of raw materials, which are derivatives of crude oil. So, if the price of crude oil increases, in the end the price of virgin plastics will increase in proportion as crude oil contributes to the costs of producing virgin plastics.
- Being a global commodity means that the level of demand for virgin plastics does not affect their price in the long run. But shifts in demand can cause the price to rise or fall for a period. But such demand-led price changes eventually cause the capacity of the global virgin plastics industry to change, via new investment or plant closures, so that profits are restored to their normal levels.
- The market for recovered plastics, by contrast, is still immature. It is small relative to the market for virgin plastics. As a result, recovered plastics prices are not determined by the costs of production. Instead, they are pegged to the price of virgin plastics in the long run.
- An increase in oil prices, for example, will drive up the cost of producing virgin plastics. That will force up the price of virgin plastics. Higher prices for virgin material will cause consumers of plastics to increase the quantity of recovered plastics that they use. That will force up the price of recovered plastics, until they stand in the same ratio to virgin plastics prices as before the oil price shock. Producers of recovered plastics will benefit with higher profits. But any subsequent change in the capacity of the recovered plastics industry will not (at least until now) have been large enough to materially affect the price of virgin or recovered plastics.

- The charts below show a stylised representation of the global market for virgin and recovered plastics. The long-run supply curve is horizontal for virgin plastics: in the end, suppliers will produce as much or as little as the market wants at the prevailing price, determined by cost. The long-run supply curve is vertical for recovered plastics: in the end, the quantity produced is fixed by the amount of material that is recycled, so shifts in demand just cause the price to increase or decrease.

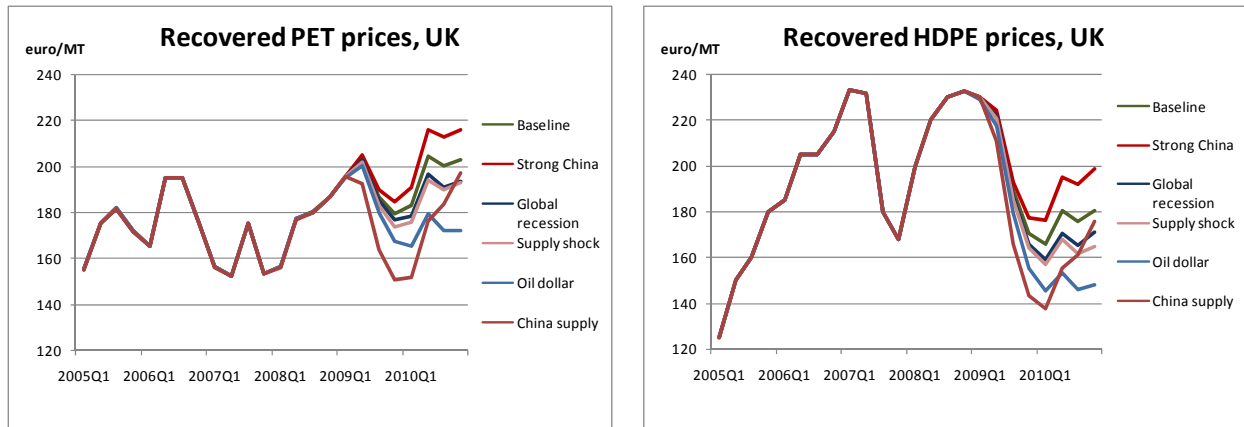
Virgin plastics market structure



Recovered plastics market structure



- In this paper, we estimate and build a model of virgin and recovered plastics prices which captures the relationships in the charts above. The model identifies virgin and recovered PET and HDPE prices in the US and Europe, and recovered PET and HDPE prices in the UK.
- We use the model to explore the impact on virgin and recovered plastic prices of a range of macroeconomic scenarios. These scenarios include a global recession, a positive shock to China, a range of outcomes for oil prices, a shock to the global supply of plastics, and a collapse in Chinese demand for UK recovered plastics.
- The charts below show the impact of these scenarios on UK recovered plastics prices, according to our model. The spread between the various scenarios over the forecast period is wide, reflecting the volatility of these data and the relatively short time series that have informed the estimates in our model.



- We find that the prospects for recovered plastics prices in the UK depend upon:
  - The outlook for crude oil prices, and their impact on virgin prices
  - The outlook for the global economy, and its impact on global demand for plastics
  - The outlook for the Chinese economy, and the growth of its industries that make intensive use of plastics in their production process
  - The outlook for the regulation of the waste plastic industry in the UK

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# Assessing the global determinants of recovered plastics prices, for WRAP

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## 1 Introduction

The purpose of this study is to develop a framework to help understand the factors that influence the prospects for the recovered plastics market in the UK. Some of those influences are global in origin, relating to the global market for virgin plastic. Some are specific to the UK: changes in the regulatory environment in the UK, or changes in the weather. Some are a mixture of both – such as the growth in demand for UK recovered plastics coming from China. And others are specific to the UK recovered plastics industry itself: changes in the availability or quality of UK recycled plastic.

We disentangle this complex web of influences on recovered plastics prices in the context of a clear analytical framework, consistent with the best and most recent advances in the literature in this area. And we go on to develop a range of future scenarios setting out the central prospects and key risks for recovered plastics prices in the UK over the coming few years. We outline our central forecast, and assess three scenarios around that: a global recession; even stronger growth in China; and an increase in the supply of recovered plastics in the UK.

There are many different types of recovered plastics, the market for each of which has its idiosyncrasies. In this paper, we focus on two plastic types: PET and HDPE. Even within those categories, there is a spectrum of prices across the different stages of the supply chain. Our choice of the price indicators that we assess in this paper has been guided by the availability of data: we choose those recovered plastics prices for which we can find the longest consistent time series, the better to facilitate our econometric analysis.

The rest of this paper is organised as follows:

Section 2 describes recent trends in the global plastics market

Section 3 describes the structure of the UK recovered plastics market

Section 4 sets out the structure of the model that we have employed, and summarises our estimation results

Section 5 goes through our central forecast and the scenarios around that

Section 6 offers some conclusions

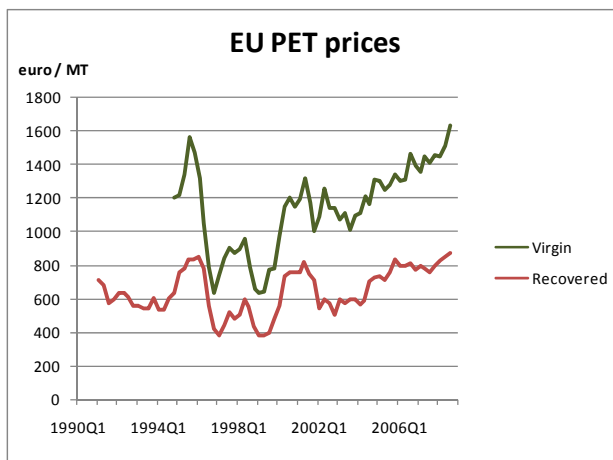
## 2 Recent trends in the global plastics market

Most commodity prices have risen sharply in recent years, driven by the most pronounced global economic boom on record. The recent economic slowdown in some developed economies has not yet put a dent in growth in emerging markets, especially China, where the new demand for all commodities is growing most rapidly.

### 2.1 Virgin prices and recovered prices on a rising trend

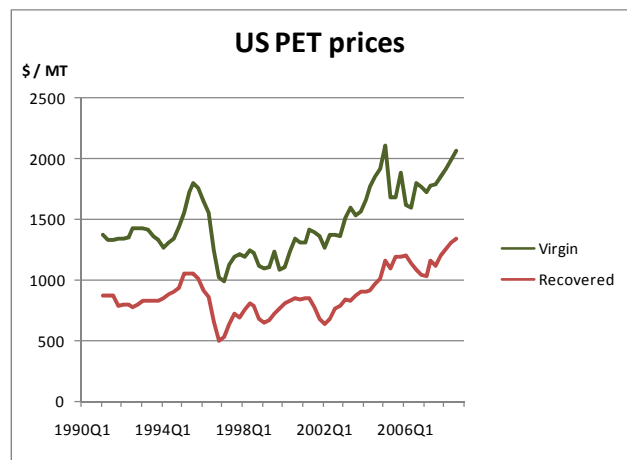
The charts below show virgin and recovered PET and HDPE prices fluctuating around a rising trend since 1999.

Chart 2.1



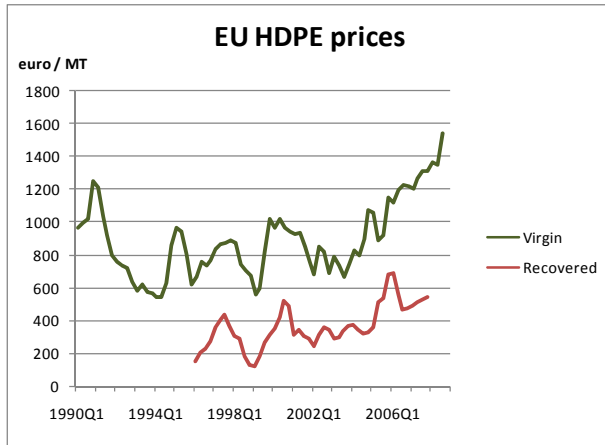
Source: letsrecycle.com

Chart 2.2



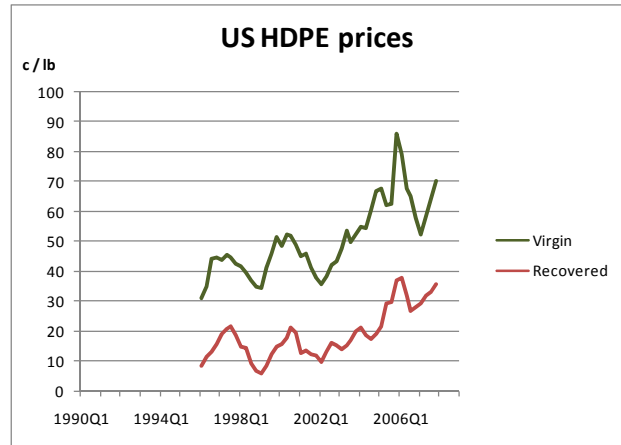
Source: letsrecycle.com

Chart 2.3



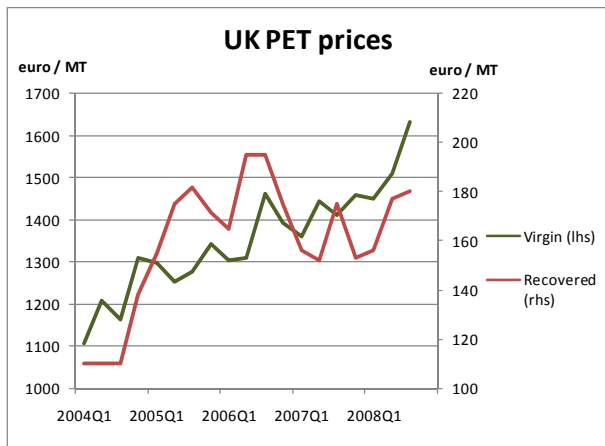
Source: letsrecycle.com

Chart 2.4



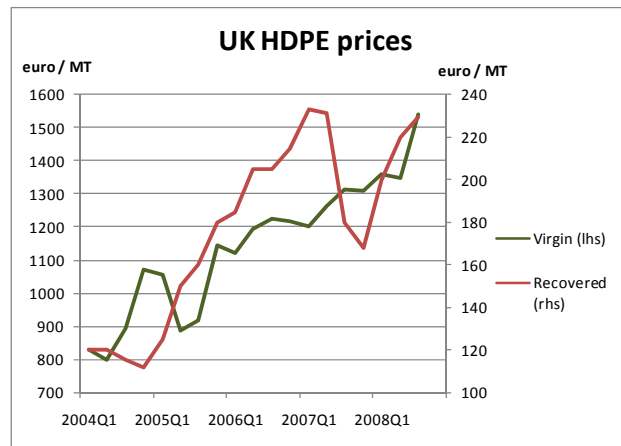
Source: letsrecycle.com

Chart 2.5



Source: letsrecycle.com

Chart 2.6



Source: letsrecycle.com

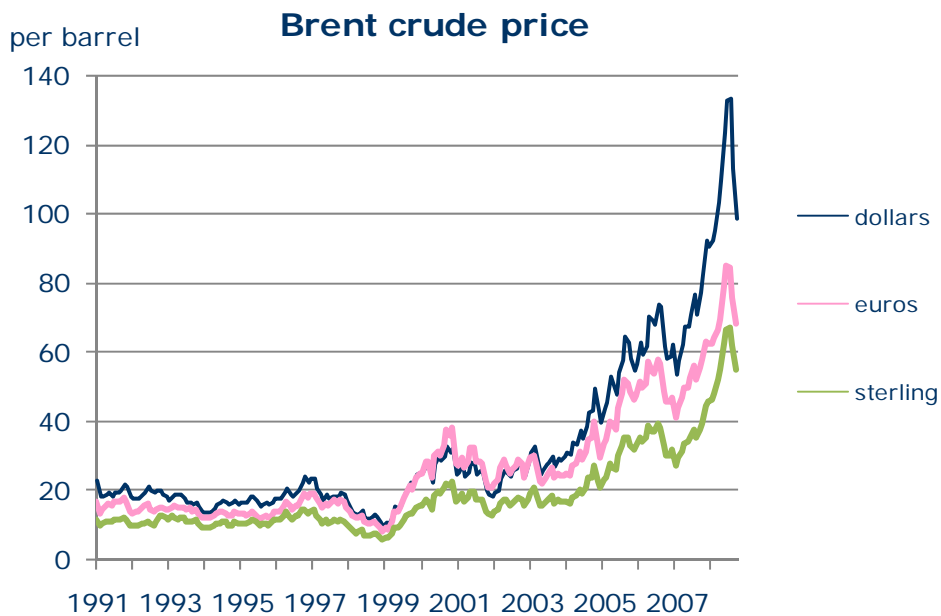
The charts above suggest that there is a reasonably well-defined relationship between virgin and recovered plastics prices across all plastics types and in all regions. The relationship is not perfect: for example, recovered PET and HDPE prices in Europe have not recovered since the middle of 2006 to the same degree as have virgin PET and HDPE prices in Europe; recovered HDPE prices fell in the UK in the first half of 2007 where virgin HDPE prices continued to increase. But as a rule, a change in virgin prices tends to be associated with a change of a similar proportion in recovered prices.

Another way of putting this is that virgin plastic prices trade at a premium over recovered plastic prices and, while that premium fluctuates over time, it tends to

come back to a constant or equilibrium proportion of the virgin price. Note that the recovered prices in the UK are at a different point in the supply chain to the recovered prices reported for Europe and the US, and the margin between those prices and virgin prices is accordingly much higher than in Europe or the US.

## 2.2 Price growth accounted for in part by crude prices

Chart 2.7



The upwards trend in virgin prices partly reflects an upswing in the price of crude oil, which is the original feedstock for the raw materials that are used in the production of virgin plastic. Oil prices have more than quintupled since the start of 1999 (with some variation across currencies). Plastics prices have been influenced by that trend, but the growth in plastics prices over the same period has been much less pronounced, with plastics prices broadly doubling since the start of 1999.

## 2.3 Crude prices affect raw materials prices

Virgin PET and HDPE are produced by combining the raw materials PTA, DMT and MEG. The costs of those raw materials are heavily influenced by changes in crude oil prices.

Chart 2.8

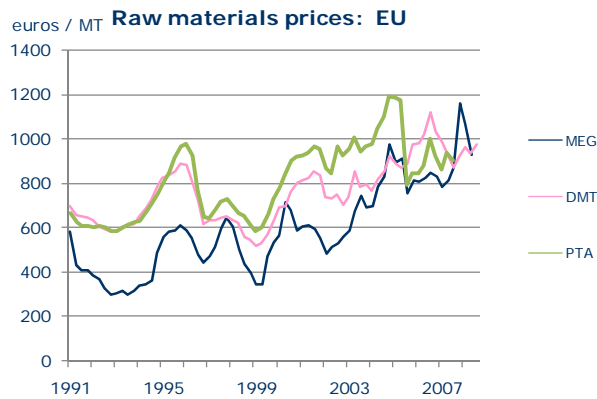
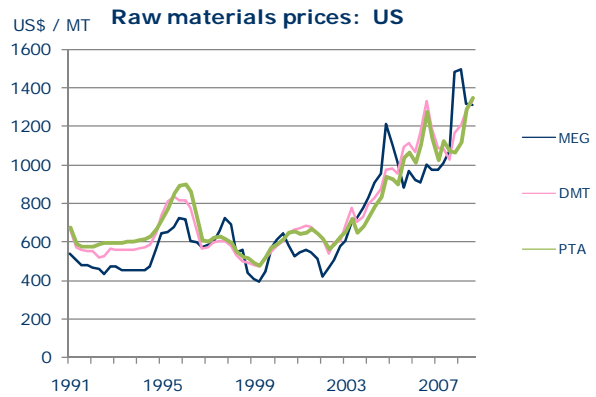


Chart 2.9



Our analysis suggests that the most important raw materials prices (PTA and MEG) are both influenced, though in different degrees, by crude oil prices. In general:

- The influence of crude prices on raw materials costs appears to be greater in the US than in Europe, perhaps because there is a larger tax wedge between crude and raw materials prices in Europe than in the US, and that wedge is a specific rather than an ad valorem tax, implying that it does not change in euro terms when the price of crude changes. However, these cross-country differences are not statistically significant, so we should be cautious in placing too much weight on them
- The influence of crude prices appears to be more pronounced on PTA than on MEG – and this difference is statistically significant.

Overall our analysis suggests that PTA prices increase by around 4% for a 10% increase in crude oil prices, while MEG prices increase by around 5.5%.

## 2.4 Production of virgin plastics is also growing

The upswing in virgin plastic prices has resulted in increased production capacity in most plastics producing countries. The production increase is particularly pronounced in the oil-producing countries. Charts 2.10 and 2.11 show the production of plastic resins in Europe and the US, while Chart 2.12 compares the production of rubber and plastics of all types across a number of countries.

Chart 2.10

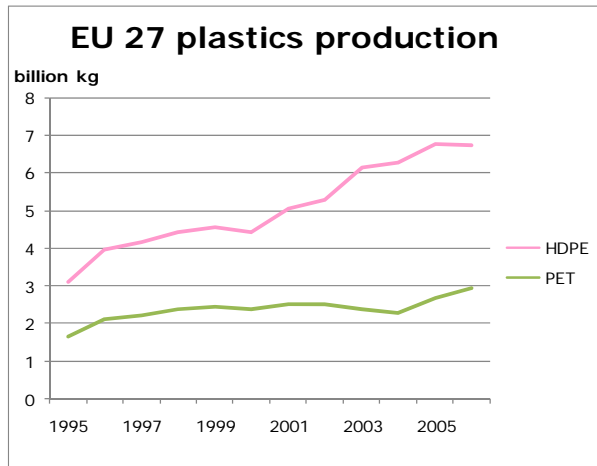


Chart 2.11

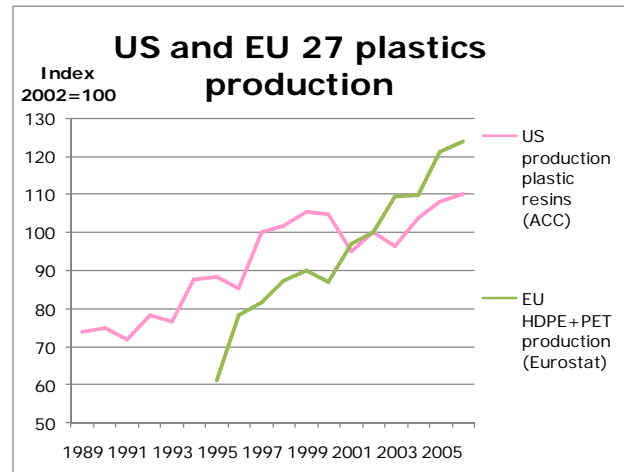
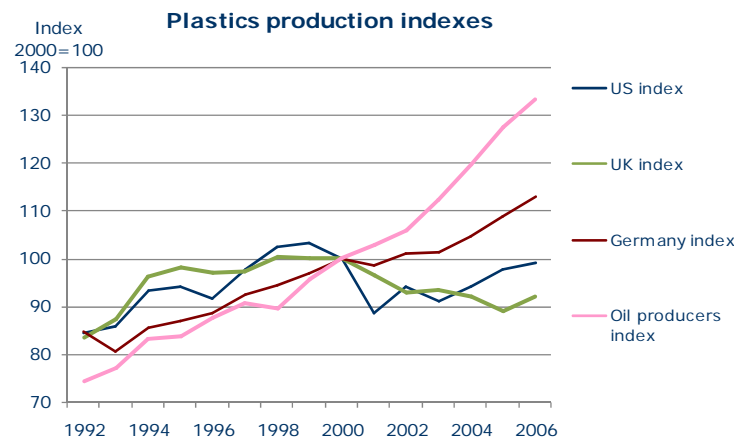


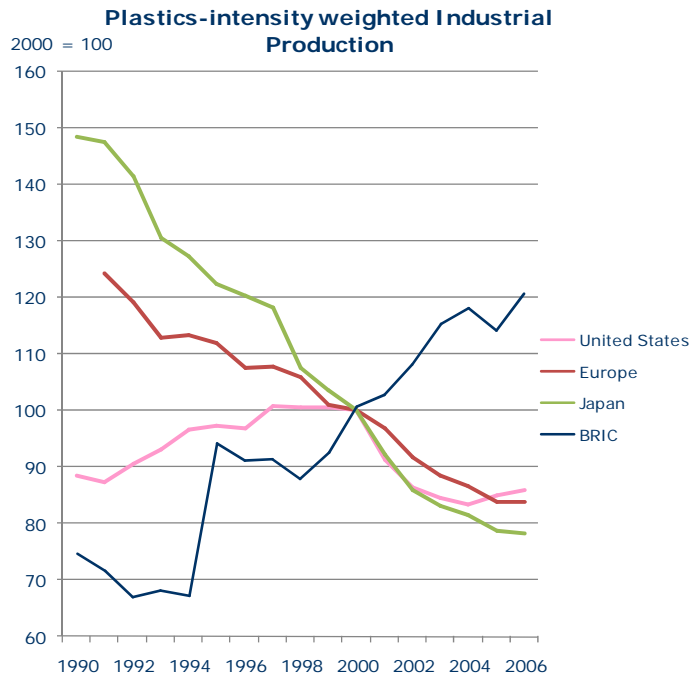
Chart 2.12



## 2.4 Global supply follows global demand

Intermediate demand for plastics is falling in developed economies but rising rapidly in emerging economies. This pattern is consistent with the ‘hollowing out’ of manufacturing industry from developed to developing economies across the board. Chart 2.13 illustrates this point. Each of the lines in this chart is a weighted average of industrial production in the ten industrial sectors that make the most intensive use of plastic in their production technology, where the weights correspond to that ‘plastics-intensity’.

Chart 2.13



The blue line in Chart 2.13 shows industrial production in plastics-intense industries growing rapidly in 'BRIC' (Brazil, Russia, India, China), but the other lines show it falling sharply in the US, Europe and Japan. Globally, the growth in plastic-intensive production in developing economies more than offsets the reduction in developed economies – a global increase in industrial demand for plastics, reflected in the increase in the global supply of plastics described above.

### 3 UK recovered plastics industry

#### 3.1 UK produces recovered plastic mainly for export to China / HK

In the UK, production of both plastic products and recycled plastics has increased in recent years. Almost all UK produced recycled plastic is ultimately destined for China, either directly or via Hong Kong, although exports of plastic products to China and Hong Kong account for only a very small share of total UK exports of plastics products, as the charts below illustrate.

Chart 3.1

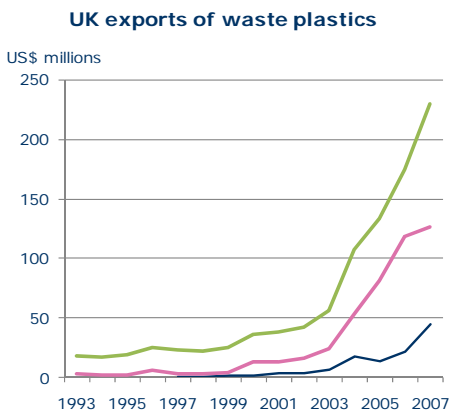
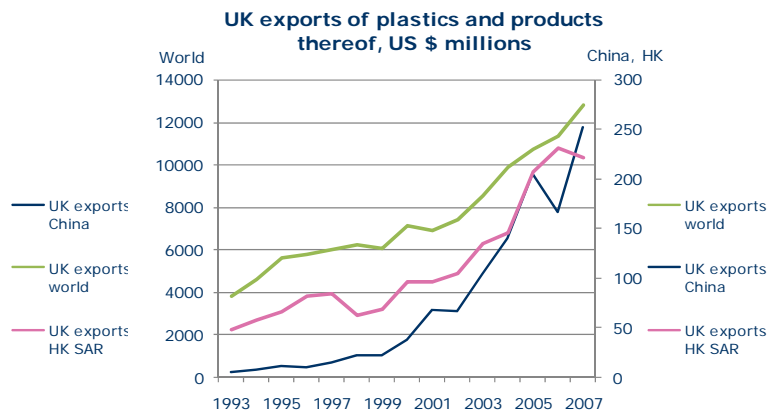


Chart 3.2



The overwhelming importance of the Chinese market in driving demand for recycled plastics produced in the UK suggests that any threat to the prospects for growth in China will represent a key risk for the UK recycled plastic industry. Other risks relate to changes in the price of virgin plastics, growth in global supply of virgin and recovered plastics, changes in the regulatory regime relating to plastics recycling in the UK and elsewhere, among others. The best way to disentangle each of these different influences is in the context of a clear analytical framework, or model. The next section sets out the analytical framework that we have employed.

## 4 Model structure

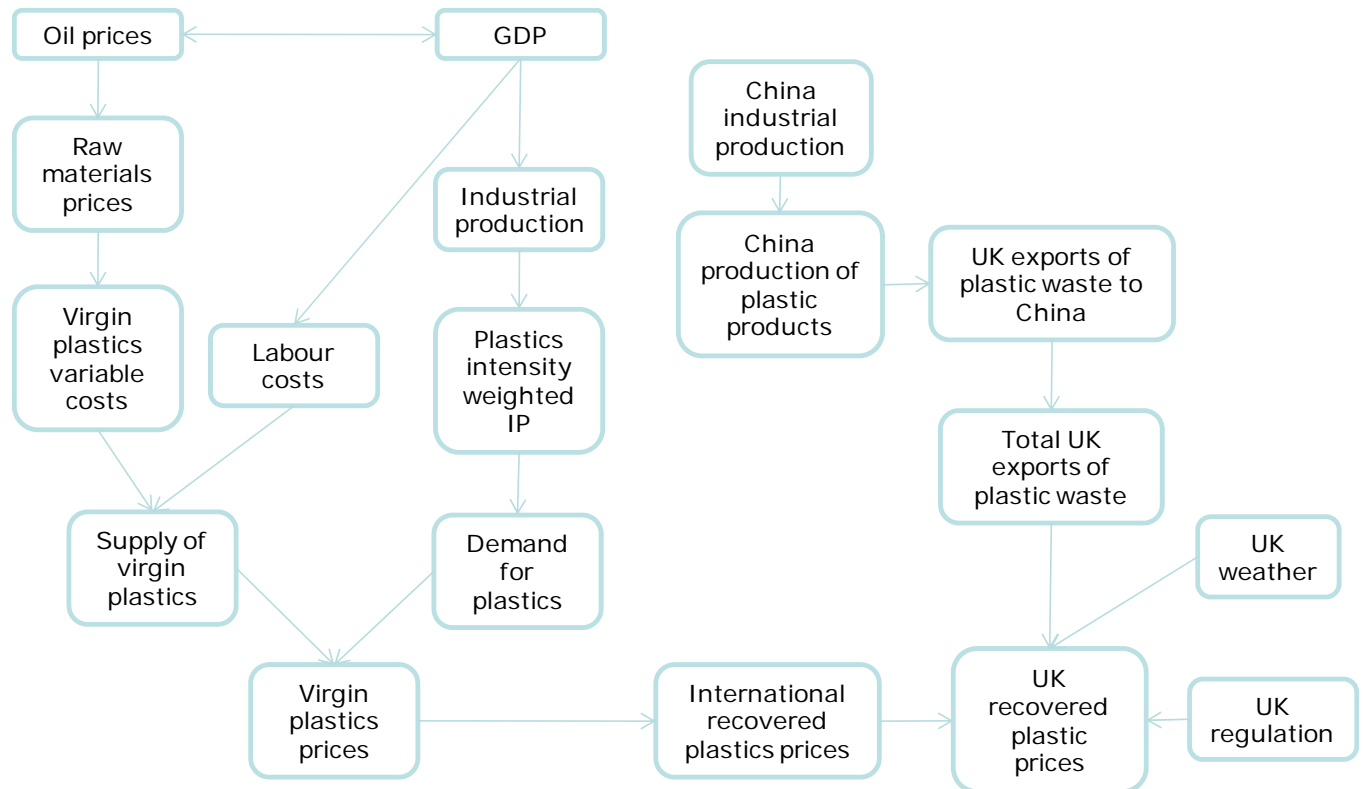
The model that underlies our scenario analysis is a fairly simple representation of the market for virgin and recovered plastics. But we have tested and rejected a variety of important variants on the simple structure that we outline below. Very broadly:

- Virgin plastics behave like a global commodity in the long run
- Recovered plastic prices are pegged to the price of virgin plastics in the long run
- Other country-specific or market-specific factors can influence the prices of both virgin and recovered plastics, but usually only for a short period

Below, we set out our analytical framework in more detail, though we do not present any of our econometric results in this paper – those can be found in our technical report.

### 4.1 Schematic

The diagram below shows the key channels of influence on plastics prices that our analytical framework is designed to capture.



Starting from the top left corner, oil prices flow into raw materials prices and thence into the variable cost element of virgin plastic production. Along with labour costs, these determine the total cost of production of virgin plastic. Oil prices also influence global GDP and industrial production, which drives the growth in output of those industries that make intensive use of plastics in their production process. That influences the global demand for plastics. The price of virgin plastics then reflects the interaction between global supply and global demand.

Reading towards the right, the price of virgin plastics is the benchmark for the price of recovered plastics on international markets, which is itself the benchmark for UK recovered plastics at all stages in the supply chain. But UK recovered plastics prices also pick up influences from China, via the growth in demand for UK recovered plastics exports; from the UK weather, where an increase in the mean temperature could be associated with a reduction in the price of recovered plastic; and the regulatory environment in the UK as regards the plastics recycling industry,

which could lead to big changes in the quantity of recovered plastics that are produced.

#### 4.2 Stylised representation of our econometric results

Charts 4.1 and 4.2 below summarise our econometric analysis, in a stylised description of the virgin and recovered plastics markets.

Chart 4.1: virgin plastics market structure

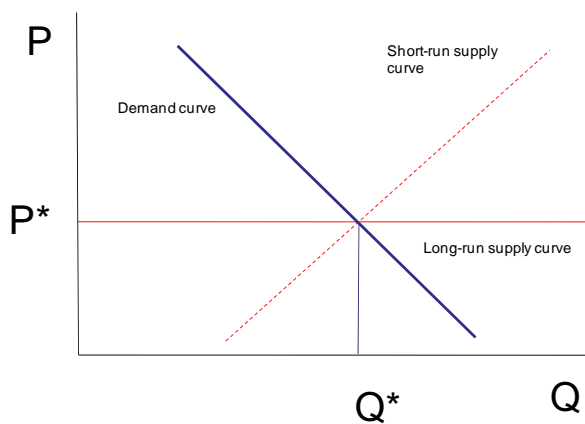
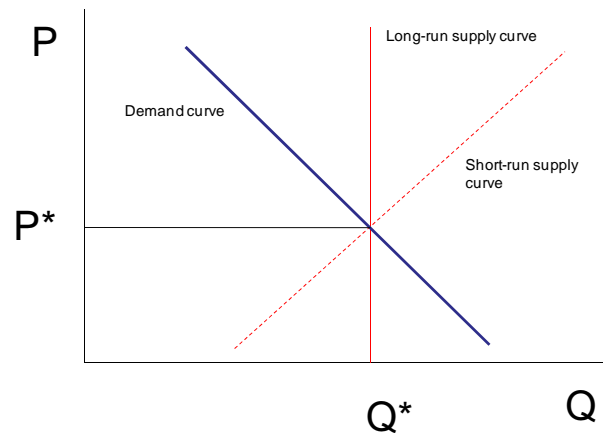


Chart 4.2: recovered plastics market structure



On the virgin side, we find that virgin plastics behave like a global commodity in the long run, with prices determined by costs of labour and raw materials. An increase in demand causes prices and quantities to increase for a period, but higher profits encourage more investment. So, in the long run, higher demand leads to higher supply capacity but an unchanged price. By contrast, an increase in the cost of raw materials and/or labour will cause prices of virgin plastics to rise, and that will cause demand to fall in the long run, as consumers of virgin plastics switch into other, cheaper substitutes.

On the recovered side, the price is pegged to the price of virgin plastics rather than to the cost of producing recovered plastic, and the quantity produced shifts around to reflect shifts in the capacity of the recovered plastics industry, driven by factors like the regulatory regime in each country.

In the case of the UK, the main demand shifter for recovered plastics is demand from China, emphasising the vulnerability of the UK industry to risks to the Chinese economy.

Globally, the main demand shifter is shocks to the price of virgin plastics: since recovered plastics are a substitute (albeit an imperfect substitute) for virgin plastics, an increase in the price of virgin plastics will cause demand for recovered plastics to increase. In the long run, that will drive up the price of recovered plastics to restore the normal ratio between virgin and recovered plastics prices, consistent with the recovered plastics industry producing to full capacity.

In the next section, we develop a set of scenarios in the framework of the model described above, to assess the prospects and risks for virgin and recovered plastics prices in the UK and globally.

## 5 Scenarios

In this section, we assess the prospects for plastics prices under six scenarios:

- **Baseline:** this scenario assumes that oil prices and exchange rates remain at their current levels throughout the forecast period, while global growth rates in industrial production and GDP remain close to trend. These are simplistic assumptions, but nevertheless represent a plausible central case: growth is slowing in developed economies, but it remains extremely fast in developing economies, so the global average right now and for the next year or so is close to trend, in the central case at least. Oil prices and exchange rates are notoriously hard to predict, and many studies show that – at least over a two to three year horizon, which we assess here – it is not possible to improve on the most recent level as a forecast.
- **Strong China:** This scenario sees Chinese demand for plastics increase by 10% relative to the (already strong) growth in the baseline scenario. At the same time, consistent with a wider Chinese boom, global oil prices increase by 20% relative to the baseline scenario and stay higher throughout the forecast period. Because of that, US and European industrial production and GDP growth slow relative to the baseline case.
- **Global recession:** This scenario sees US and EU growth slowing sharply (with industrial production down by 2% relative to the baseline scenario). Because of that slowdown, global oil prices fall by 10%, while Chinese GDP growth also slows thanks to weaker demand for Chinese exports.
- **Oil price fall:** This scenario sees oil prices fall rapidly back to around \$70pb, as the speculative bubble bursts. At the same time, the dollar strengthens against the euro, recovering to around \$1.20. GDP growth benefits in all economies, but particularly in oil-intensive economies like China. Strong demand combined with falling costs pushes demand for plastics up. But quantities increase while prices fall on the virgin side: bad news for the recovered plastics industry.
- **Global plastics supply shock:** This scenario sees the global production of plastics increase by 5% relative to the baseline forecast – and that increase is also reflected in the production of recovered plastics in the UK.
- **China plastic supply shock:** This scenario sees demand for UK recovered plastics from China fall, either because China as a whole slows or, more

likely, because China shifts to sourcing more of its recovered plastic domestically. The impact of this shock is felt only by the UK recovered plastics industry: in the charts below, we do not separately identify this scenario except in the case of UK recovered plastics prices.

Below, we set out the results of these scenarios for plastic prices, going through each plastic type in turn.

### 5.1 Results: virgin PET

The charts below show how virgin PET prices evolve under the five different scenarios over the forecast period (to the end of 2010).

Chart 5.1

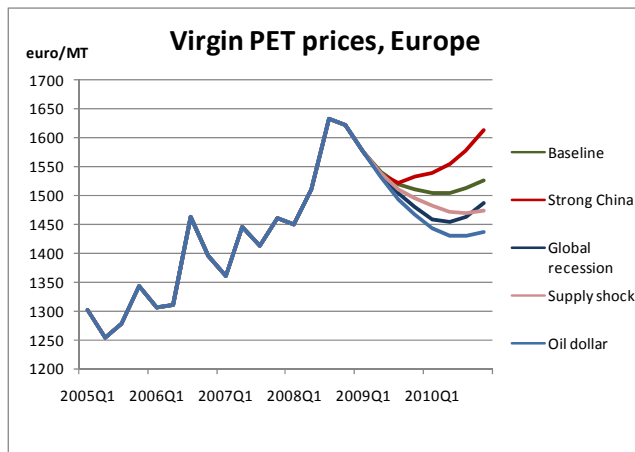
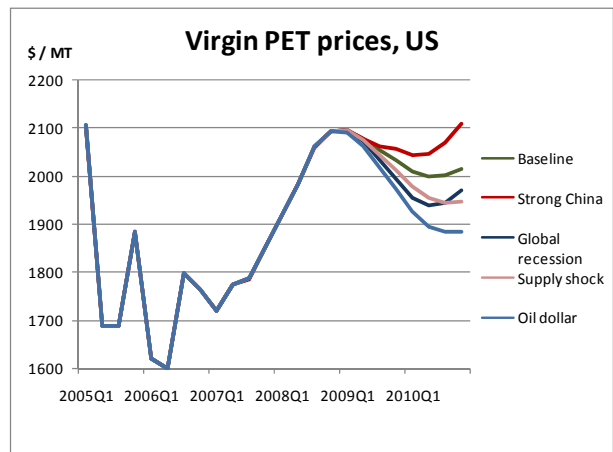


Chart 5.2



The baseline scenario (green line) shows virgin PET prices in Europe continuing their recent upwards trend until the end of 2009, while in the US they peak in early 2009, before easing off into 2010.

The reason for these slightly different profiles is that, according to our model, US virgin PET prices become overvalued during the course of this year, though their recent momentum persists for a few quarters, making that overvaluation even more pronounced. European virgin PET prices, by contrast, are slightly below their 'fair' value according to our model, and the growth they see in the baseline scenario unwinds that undervaluation.

Two of the three downside scenarios – global recession and supply shock– have a similar impact by the end of the forecast period, but a different profile along the way. The global recession scenario sees prices fall further relative to the baseline scenario, but in this case, the fall is only temporary. Eventually (after the end of

our forecast period) the global economy will recover, and oil prices and virgin PET prices will follow. But the supply shock is permanent, seeing a permanent increase in the global supply of both virgin and recovered plastics, which results in a permanent fall in virgin plastics prices relative to the baseline scenario.

The third downside scenario – oil dollar – sees virgin PET prices slide along with the price of oil. That decline is more pronounced in the US than in Europe, thanks to the appreciation of the dollar in this scenario: with the euro weakening, oil prices expressed in euros do not decline as far as oil prices expressed in dollars, so the impact on virgin PET prices is also more muted.

The upside scenario – strong China – sees virgin PET prices continuing to rise as oil prices pick up further and global demand growth increases.

## 5.2 Results: virgin HDPE

It is a very similar story for virgin HDPE as for virgin PET prices, with prices rising significantly during 2008, as recent momentum and the lagged effects of higher oil prices work through. Prices fall back in 2009, as by then they have overshot their 'fair' value according to our model.

Chart 5.3

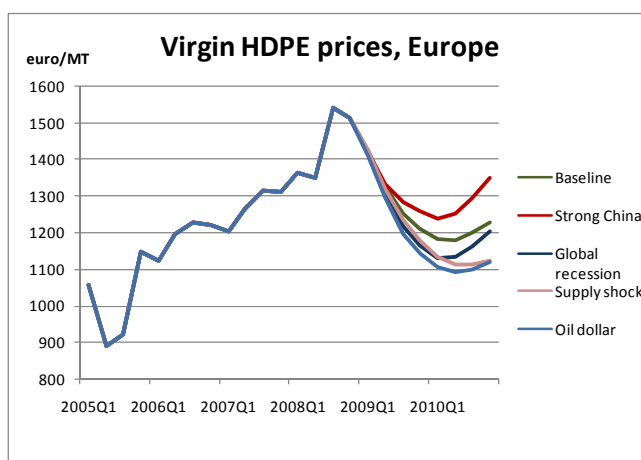
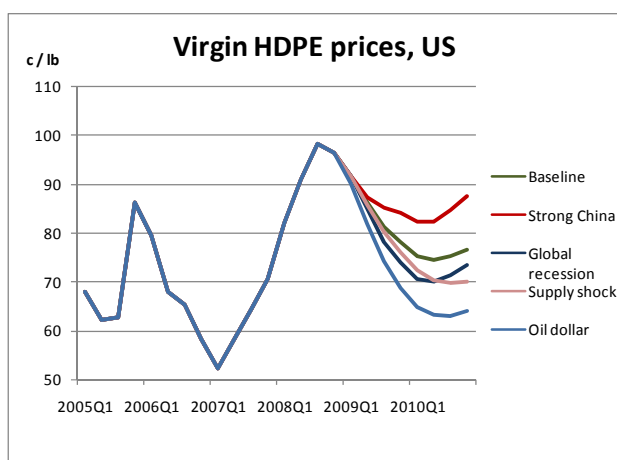


Chart 5.4



The spread around our baseline scenario is similar to that for PET prices, with the distinction between the two downside scenarios also repeated. Note, however, that even in the upside scenario, virgin HDPE prices do not hold their level, thanks to the overvaluation they achieve during 2009. Of course, there are a range of other scenarios one could explore, such as oil prices going to \$200 per barrel and staying

there throughout the forecast period. That would inevitably mean substantially higher virgin PET and HDPE prices, too.

### 5.3 International recovered plastics prices

Recovered prices in our model are driven primarily by the price of their virgin counterparts, shown above. So recovered prices of PET and HDPE in Europe and the US broadly follow the spread across the different scenarios described for the virgin prices.

Chart 5.4

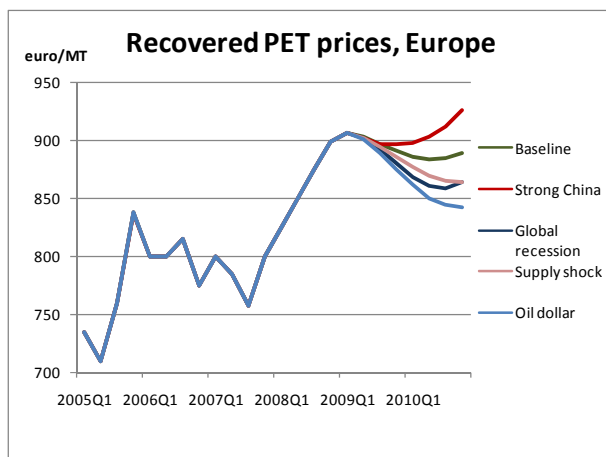


Chart 5.5

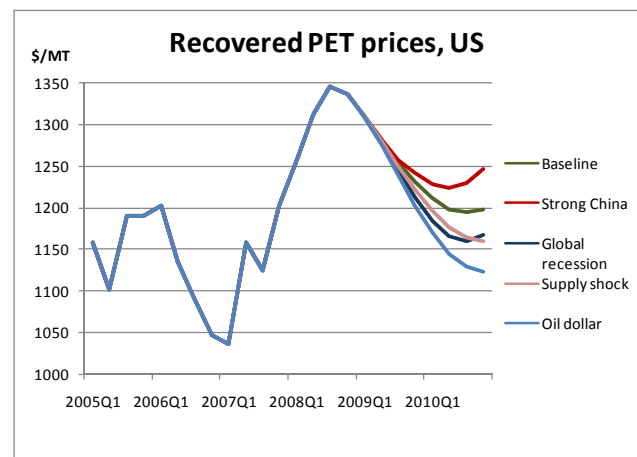


Chart 5.6

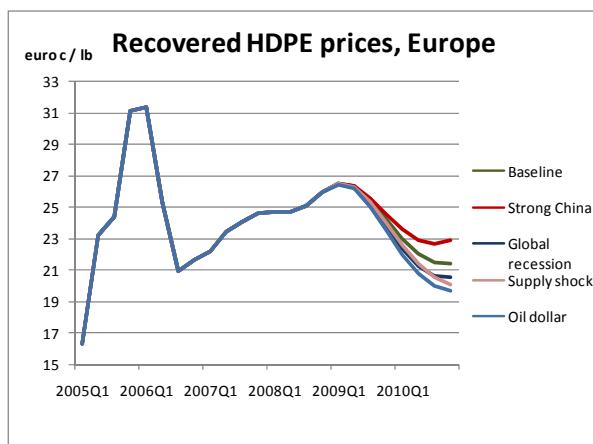
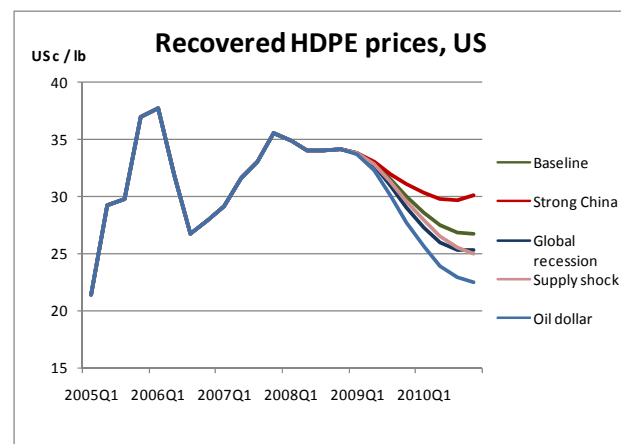


Chart 5.7



The charts above capture the impact on international recovered plastic prices of a range of macro scenarios. The spread between the different scenarios is relatively small. That is probably because the factors that cause most of the noise in these series are not identified in our model (they are in the 'residual'). These will be

factors that are specific to the markets for recovered plastics in the US and Europe. The scenarios pick up the influence of the global determinants of recovered plastics prices, but not the market-specific determinants.

## 5.6 Results: UK recovered plastics prices

By contrast, our model of UK recovered plastics prices does pick up some factors specific to the UK market. UK recovered plastics prices are driven by the European price of their virgin counterparts (expressed in sterling) and by short-term influences from Chinese demand, from UK supply, and from the weather.

Chart 5.8

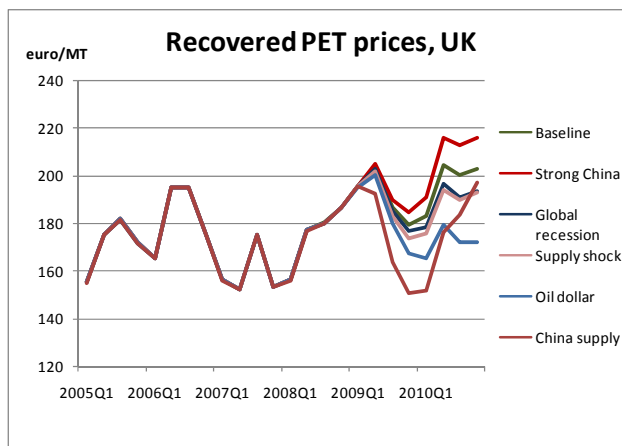
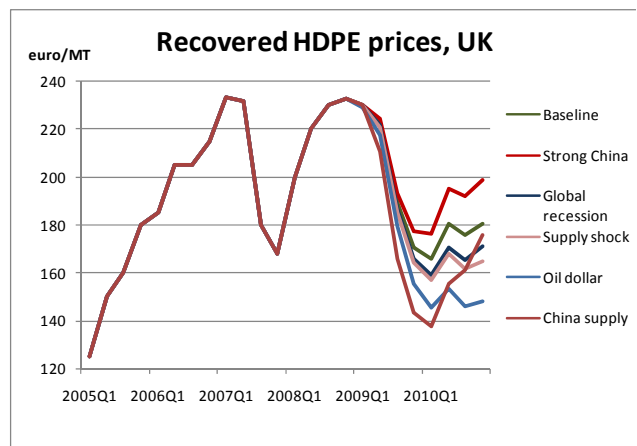


Chart 5.9



Our baseline scenario for recovered PET prices sees them easing back as oil prices and virgin plastic prices fall, with some 'normal' seasonal variation layered on top of that. Contrast that with recovered HDPE prices, which rise slightly in our central case, reflecting a slight undervaluation right now according to our model. The strong China scenario sees recovered PET and HDPE prices around 8% higher than in our baseline scenario by the end of the forecast period.

We report the results of four downside scenarios – global recession, supply shock and oil dollar, as above, and China supply, which impacts directly on demand for UK recovered plastics. The impact of the global recession and the supply shock scenarios is similar in magnitude to their impact on virgin plastic prices. But note that the distinction between the two is not so marked as in the case of virgin prices. That is for two reasons:

1. The impact of the global recession scenario is much slower to come through to recovered prices than it is to virgin prices: virgin prices move first, in

response to weaker demand and lower oil prices; recovered prices catch up with that move later on.

2. The supply shock has a permanent effect on virgin prices and, therefore, indirectly on recovered prices. But there is a short-term influence on recovered prices as well from this source, which has gone away by the end of the forecast period.

The combination of these factors means that these two downside scenarios are much more similar to each other for recovered prices than for virgin prices.

The other two downside scenarios have a much larger impact on UK recovered plastic prices. The oil dollar scenario sees sterling maintain its value against the dollar (strengthening against the euro). Therefore the sterling price of oil falls sharply, and the impact on sterling virgin prices is pronounced, and passes through eventually to their recovered counterparts. The China supply scenario sees Chinese demand for UK recovered plastics fall by half, forcing UK recovered plastics producers to accept a much lower price for a period. By the end of the forecast period, UK recovered plastics find other markets outside China in which they are competitive, and prices start to recover.

That is a property of our model – shifts in demand for recovered plastics from any individual country cannot have a permanent impact on their price, which is like saying that the market is deep enough to support a certain ratio of recovered to virgin plastic prices irrespective of what happens to China or any other individual source of demand. However, given the shortage of data, it is difficult to be sure that this property of our model is correct. There is at least a serious risk that a collapse in demand from China would result in a permanent fall in UK recovered plastics prices, perhaps threatening the industry's long-run prospects.

## 6 Conclusions

Our analysis suggests the following structure for the global plastics market:

- Virgin plastics are global commodities. Their prices are driven by costs of production – related to costs of raw materials which depend in turn on crude oil, and on labour costs. Shifts in demand for virgin plastics can drive the price up or down in the short term, but in the end that will result in a change in the capacity of the plastics industry, so that all producers end up making ‘normal’ profits.
- Recovered plastics prices are pegged to virgin plastics prices in the long run, reflecting the immaturity of this market. As the market matures and deepens, we would expect recovered plastics prices to be increasingly driven by the costs of production, like their virgin counterparts. But that transition could take years or even decades to complete, and will depend on the regulatory regime relating to waste plastic in a number of different countries. For now, recovered plastic prices go with virgin prices in the long run, with short-term movements arising from shifts in demand, changes in regulation and supply, and changes in the weather.
- The prospects for recovered plastics prices in the UK therefore depend upon:
  - The outlook for crude oil prices, and their impact on virgin prices
  - The outlook for the Chinese economy, and the growth of its industries that make intensive use of plastics in their production process
  - The outlook for the regulation of the waste plastic industry in the UK