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| NESA Identified Issues: Strait of Hormuz | |
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| An economic assessment of a disruption to shipping in the Strait of Hormuz on the Australian economy | |
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| Prepared for the Department of Resources, Energy and Tourism | |
| 25 July 2012 | |
|  | Description: ACIL Tas logo 25-100 | |

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Contents

[Executive summary iii](#_Toc340240734)

[1 Introduction 3](#_Toc340240735)

[2 Methodology and approach 3](#_Toc340240736)

[2.1 Overall approach 3](#_Toc340240737)

[2.2 Estimation of elasticities 3](#_Toc340240738)

[2.3 Estimation of price impacts 3](#_Toc340240739)

[2.4 Economic modelling 3](#_Toc340240740)

[3 Significance of Middle East production 3](#_Toc340240741)

[3.1 The Strait of Hormuz 3](#_Toc340240742)

[3.2 Production and exports 3](#_Toc340240743)

[3.3 Australia’s dependence on Middle East petroleum 3](#_Toc340240744)

[3.4 Alternative routes to the Strait of Hormuz 3](#_Toc340240745)

[3.5 Conditions leading up to closure 3](#_Toc340240746)

[3.6 Conditions during closure 3](#_Toc340240747)

[3.7 Policy responses 3](#_Toc340240748)

[3.7.1 International cooperation 3](#_Toc340240749)

[3.7.2 Liquid Fuels Emergency Act 1984 3](#_Toc340240750)

[3.8 Impact of different oil refinery scenarios 3](#_Toc340240751)

[3.9 Overall impact and aftermath 3](#_Toc340240752)

[4 The shock sequence 3](#_Toc340240753)

[4.1 The shock 3](#_Toc340240754)

[4.2 Elasticities 3](#_Toc340240755)

[4.3 The shock effects – elasticities and prices 3](#_Toc340240756)

[4.3.1 Weeks 1 to 4 3](#_Toc340240757)

[4.3.2 Week 5 3](#_Toc340240758)

[4.3.3 Week 6 3](#_Toc340240759)

[4.3.4 Week 7 3](#_Toc340240760)

[4.3.5 Week 8 and beyond 3](#_Toc340240761)

[4.4 Summary of effects 3](#_Toc340240762)

[4.5 Other possible scenarios 3](#_Toc340240763)

[4.5.1 Other analysts views 3](#_Toc340240764)

[5 Economic impacts 3](#_Toc340240765)

[5.1 Measures of macroeconomic impacts 3](#_Toc340240766)

[5.2 Results 3](#_Toc340240767)

[5.2.1 Impacts for Australia 3](#_Toc340240768)

[5.2.2 Impacts on other countries 3](#_Toc340240769)

[5.2.3 Liquid fuel consumption 3](#_Toc340240770)

[5.3 Comparison with Singapore product supply shock 3](#_Toc340240771)

[5.4 Implications of IEA collective action 3](#_Toc340240772)

[5.5 Implications of departure from the assumed scenario 3](#_Toc340240773)

[6 Key findings and conclusions 3](#_Toc340240774)

[A Terms of reference A-3](#_Toc340240775)

[B Methodology B-3](#_Toc340240776)

[C Analysis of Oil Shocks C-3](#_Toc340240777)

[D Bibliography D-3](#_Toc340240778)

List of boxes

[Box 1 Price elasticities of demand and supply 3](#_Toc340240779)

[Box2 Role of speculative demand and taxes in ‘first oil crisis’ C-3](#_Toc340240780)

[Box 3 Katrina and Rita Supply Shocks and Market Forces C-3](#_Toc340240781)

List of figures

[Figure 1 Economic assessment sequence 3](#_Toc340240782)

[Figure 2 Illustrative scenario analysis using Tasman Global 3](#_Toc340240783)

[Figure 3 The Strait of Hormuz 3](#_Toc340240784)

[Figure 4 Oil shipments and the Strait of Hormuz 3](#_Toc340240785)

[Figure 5 Oil pipelines 3](#_Toc340240786)

[Figure 6 Movements in physical crude prices and crude futures ($/bbl) 3](#_Toc340240787)

[Figure 7 Singapore Export Petrol Price Movements Compared with Crude Oil Price Movements in 2005-06, Highlighting Effects of Hurricane Katrina and Rita and IEA Stock Releases 3](#_Toc340240788)

[Figure 8 Shock scenario 3](#_Toc340240789)

[Figure 9 Movements in crude oil and product prices – Case A (low elasticities) 3](#_Toc340240790)

[Figure 10 Movements in crude oil and product prices – Case B (high elasticities) 3](#_Toc340240791)

[Figure 11 Percentage decline in liquid fuel consumption relative to the base case 3](#_Toc340240792)

[Figure 12 Product price rises for Strait of Hormuz compared to Singapore 3](#_Toc340240793)

[Figure B13 Illustrative scenario analysis using Tasman Global B-3](#_Toc340240794)

[Figure C1 Singapore Export Petrol Price Movements Compared with Crude Oil Price Movements in 2005-06, Highlighting Effects of Hurricane Katrina and Rita and IEA Stock Releases C-3](#_Toc340240795)

List of tables

[Table 1 Tasman Global commodity and region aggregation 3](#_Toc340240796)

[Table 2 Middle East liquid petroleum production, 2009 3](#_Toc340240797)

[Table 3 Liquid petroleum exports from Gulf producers, 2009 3](#_Toc340240798)

[Table 4 Australian imports of petroleum 3](#_Toc340240799)

[Table 5 Imports of petroleum products 2010-11 3](#_Toc340240800)

[Table 6 Volume of crude oil and product on the water 3](#_Toc340240801)

[Table 7 Capacity of alternative oil transport routes in the Middle East 3](#_Toc340240802)

[Table 8 Stocks of crude oil and petroleum product held on land by IEA member countries 3](#_Toc340240803)

[Table 9 Australian refinery production with seven and four refineries operating (ML per annum) 3](#_Toc340240804)

[Table 10 Net imports of crude oil and product 2012-13 3](#_Toc340240805)

[Table 11 OECD industry stocks during and after Hurricane Katrina 3](#_Toc340240806)

[Table 12 Elasticities and price impacts for Case A (low elasticities), relative to the reference case 3](#_Toc340240807)

[Table 13 Elasticities and price increases for Case B (high elasticities), relative to the reference case 3](#_Toc340240808)

[Table 14 Elasticities and price changes for week 5 in Case A (low elasticities) 3](#_Toc340240809)

[Table 15 Elasticities and price changes for week 5 in Case B (high elasticities) 3](#_Toc340240810)

[Table 16 Elasticities and price changes for week 6 in Cases A and B 3](#_Toc340240811)

[Table 17 Elasticities and price changes for week 8 and beyond in Cases A and B 3](#_Toc340240812)

[Table 18 Price Shock Derivation 3](#_Toc340240813)

[Table 19 Results from Week 1 to Week 23, relative to the reference case 3](#_Toc340240814)

[Table 20 Average change in Australian bilateral real exchange rates (Week 1 to 23), relative to the reference case 3](#_Toc340240815)

[Table 21 Changes in real industry output for selected industries (Week 1 to 23), relative to the reference case 3](#_Toc340240816)

[Table 22 Assumed elasticities and resultant price changes in Singapore disruption scenario 3](#_Toc340240817)

[Table 23 Results for week 5 – the first week of the closure, relative to the reference case 3](#_Toc340240818)

[Table 24 Average weekly prices (real as at Jan 2011) 3](#_Toc340240819)

[Table B1 Regional and commodity aggregation B-3](#_Toc340240820)

Executive summary

ACIL Tasman was commissioned by the Department of Resources, Energy and Tourism to undertake an analysis of the economic impacts of a temporary closure of the Strait of Hormuz using our computable general equilibrium (CGE) model, Tasman Global.

Background

The 2011 National Energy Security Assessment concluded that the reliability of liquid fuels supply in Australia is likely to be high in the medium term, falling to moderate in the longer term. This assessment drew on an analysis of a 30-day closure of the Port of Singapore to assess the implications of a supply disruption on the Australian economy. The assessment noted that there could be more severe disruptions than that represented by the Singapore scenario and identified domestic refinery rationalisation and geopolitical tensions in production centres as future liquid fuel security watch points.

The 2011 NESA drew on an analysis of a 30-day closure of the Port of Singapore to assess the implications of a supply disruption on the Australian economy. The assessment noted that there could be more severe disruptions than that represented by the closure of Singapore

The objective of this report was to assess the economic impacts of a more severe disruption to world oil supplies. The terms of reference (which are provided in an attachment to this report) require modelling of the economic impact of a major physical supply disruption represented by a blockage of the Strait of Hormuz. This scenario would represent a major crude oil supply shock, as opposed to the product supply shock examined in the Singapore scenario. The scope also required examination of the potential closure of Australian refineries on the magnitude of the economic impact.

The three key questions that this report seeks to answer are:

* whether the scenario posed would result in a physical disruption to Australia’s liquid fuel supply
* whether economic outcomes would be affected by possible closure of refineries in Australia
* how the economic impacts of the posed scenario would differ from the economic impacts of the supply disruption represented by the Singapore disruption.

The hypothetical disruption scenario

The Strait of Hormuz is located between Oman and Iran. It connects the Persian Gulf with the Gulf of Oman and the Arabian Sea. Around 15 per cent of crude oil and around 5 per cent of petroleum products imported by Australia is sourced from the Middle East. In addition, Asian refineries on which Australia depend for at least 64 per cent of its imports of petroleum products, source around 70 per cent of their refinery feedstock from the Middle East.

ACIL Tasman’s modelling assumed a full closure of the Strait for one week, with a partial restoration of 25 per cent of shipping flows in the second week and a full resumption of shipping in the third week

Sailing times from the Middle East to Australia are around 3 to 4 weeks and sailing times from Asian refineries are around 2 to 3 weeks. At any one time, there are therefore stocks of crude oil and product on the water sufficient to meet Australia’s import needs for at least two weeks.

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It was also assumed that the International Energy Agency (IEA) would announce, in the first week, a collective action to release stocks of up to 15 million barrels per day, and that these stocks would have reached the market by the end of the second week. This release of stocks effectively negates the supply shortfall from closure of the Strait by the end of the second week.

The modelling scenario was developed in conjunction with the Department and the IEA, and was based on advice from a range of credible sources to represent an outcome that is considered among the most plausible, noting that any scenario would involve a wide range of political, military and economic interests from a number of countries. Appendix C provides background to past oil shocks and analysis of their impacts which informed our analysis.

The economic impacts were estimated under two alternative assumptions for the elasticities of demand and supply for crude oil (‘Case A’ with higher assumed elasticities and ‘Case B’ with lower assumed elasticities) and under two alternative assumptions about the domestic production of petroleum products – one where the current 7 refineries were operating (‘Scenario 1’), the other with only 4 refineries operating after the closure of the Shell refinery at Clyde in Sydney and the Caltex refineries at Kurnell in Sydney and Lytton in Brisbane (‘Scenario 2’).

In addition, the supply shock was assumed to be preceded by a speculative demand shock – a build-up of precautionary and other speculative buying due to increasing uncertainty that rising political tension and fear of closure would generate. At the conclusion of the incident, it was assumed that IEA member countries rebuilt stocks over a 16-week period. The event therefore occurs over a 23-week period and commences four weeks before the actual closure. The shock sequence is summarised in Figure ES 1.

Figure ES 1Shock scenario

|  |
| --- |
|  |

Source: Department of Resources, Energy and Tourism and ACIL Tasman.

Effect of the disruption on oil prices

The effects of the disruption on crude oil prices under the alternative assumptions on demand and supply elasticities are shown in Table ES 1. After an analysis of movements in oil prices in the period leading up to the shock, it was concluded that the price in February 2012 of around $110 per barrel for dated Brent represented the base price from which price movements were estimated.

Table ES 1 **Effect of disruption on crude oil price**

| Timeframe | Occurrence | Price elasticities Case A (low elasticities) | Accumulated price outcome from start of Week 1 – Case A (low elasticities) | Price elasticities Case B (high elasticities) | Accumulated price outcome from start of Week 1 – Case B (high elasticities) |
| --- | --- | --- | --- | --- | --- |
| Weeks 1-2 | Speculative demand shock (+0.05%) | Ed = –0.04  Es = 0.015 | +9% | Ed = –0.06  Es = 0.0225 | +6% |
| Week 3-4 | Speculative demand shock (+1%) | Ed = –0.075  Es = 0.025 | +20% from start Week 1 | Ed = –0.15  Es = 0.05 | +11% from start Week 1 |
| Week 5 early | Supply shock –15 m b/d (–16.67%) plus speculative demand effect, 2.33% | Ed = –0.18  Es = 0.06 | +116% from start Week 1 | Ed = –0.35  Es = 0.12 | + 37% from Week 4  + 60% from start week 1 |
| Week 5 mid-late | IEA stock release announcement +15 m b/d | Ed = –0.18  Es = 0.06 | +82% from start Week 1 | Ed = –0.35  Es = 0.12 | +46% from start Week 1 |
| Week 5 average |  |  | +98.8% average for the week from start Week 1 |  | +53.0% average for the week from start Week 1 |
| Week 6 | Restoration of 25% of shipments | Ed = –0.18  Es = 0.06 | Oil price returns to that at end of week 4 | Ed = –0.35  Es = 0.12 | Oil price returns to that at end of week 4 |
| Week 7 | Restoration of 100% shipments | Ed = –0.18  Es = 0.06 | +20% from start week 1 | Ed = –0.35  Es = 0.12 | +11% from start week 1 |
| Week 8-23 | Unwinding speculative demand and re-building government and mandated stocks | Ed = –0.18  Es = 0.06 | +23.6% from start week 1 | Ed = –0.35  Es = 0.12 | +13% from start week 1 |
| Week 24 on | Completion of stock adjustments | Ed = –0.04  Es = 0.015 | Decline to price at start week 1 | Ed = –0.06  Es = 0.0225 | Decline to price at start week 1 |

*Data source*: ACIL Tasman

**Over the entire period from week 1 to week 23, there is no net shortage of supply to markets (including Australia) as the IEA coordinated stock release schedule, when combined with the availability of oil on the water, ensures sufficient supplies in the weeks following closure, to compensate for the loss of around 183 million barrels arising in the two-week period of the disruption.** The principal impact would be on the price of crude oil and petroleum products in all markets over this period.

During the four weeks leading up to closure, petrol and diesel prices rise as the price of crude oil on world markets rises due to speculative buying and stock building. Petrol and diesel prices rise in the first halve of week five (the week of the closure) then fall back in the second half as speculative demand falls and IEA and other stocks are released into the market.

The average prices of petrol and diesel during week 5 are 44 per cent and 57 per cent higher respectively than the prices in week zero under the low elasticity of demand case. In week 6, prices fall again as more stocks reach the market and 25 per cent of shipments through the Strait recommence. Prices remain elevated in weeks 8 to 23 as IEA countries rebuild stocks. Prices fall back to the original price that prevailed in week zero once the stock rebuild has concluded.

Economic modelling

The economic impacts were estimated using Tasman Global, ACIL Tasman’s CGE model. Price movements and elasticity assumptions were fed into the CGE model to determine the aggregate impacts of the price rises on the Australian and world economies.

The data bases were converted to allow model runs in weekly time increments for the various scenarios. The economic impacts for the shock scenarios were then compared with the relevant reference or base cases.

The cumulative impacts of the disruption (from week 1 to week 23) on Australian GDP and real income are shown in Table ES 2.

Table ES 2 **Economic impact from Week 1 to Week 23, relative to the reference case**

|  |  | Scenario 1 (7 refineries) | | Scenario 2 (4 refineries) | |
| --- | --- | --- | --- | --- | --- |
|  |  | Case A (Low elasticities) | Case B (High elasticities) | Case A (Low elasticities) | Case B (High elasticities) |
| Australian real GDP | 2012 A$m | **-556** | **-465** | **-561** | **-470** |
| Per cent over 23 week period | **%** | **-0.087** | **-0.073** | **-0.088** | **-0.074** |
| Australian real income | 2012 A$m | **-3,118** | **-2,148** | **-3,108** | **-2,141** |
| Per cent over 23 week period | **%** | **-0.46** | **-0.32** | **-0.46** | **-0.32** |

Data source: ACIL Tasman modelling.

Real GDP

The results show that for Scenario 1, Australia’s GDP is $556 million lower over the 23 weeks under the low elasticities case (case A) and $465 million lower under the high elasticities case (case B). These losses represent –0.087 per cent and –0.073 per cent of GDP that would be produced over the 23 week period respectively.

The results for Scenario 2 are *not* significantly different. This is because firstly, the shock is affecting the crude oil price rather than refinery margins because the price impact is passed through to petroleum products. Secondly, the impacts are estimated relative to a reference case where only 4 refineries are operating. The scenarios are therefore compared to different reference cases. This removes the economic impact of differences in the number of operating refineries on the results.

Real income

Although changes in real GDP are useful measures for estimating how much the output of the relevant economies may change, change in the real income of a region is a more relevant measure of the change in economic welfare of the residents of a region.

Real income is equivalent to real economic output plus net foreign income transfers, while the change in real income is equivalent to the change in real GDP, plus the change in net foreign income transfers, plus the change in terms of trade, which measures changes in the purchasing power of a region’s exports relative to its imports.

Under scenario 1, real income is reduced by $3,118 million over the 23 weeks under the low elasticity case and $2,148 under the high elasticity case. Under scenario 2, real income loss over the 23 weeks is $3,108 million under the low elasticity case compared with $2,141 million under the high elasticity case. These losses represent –0.46 per cent and –0.32 per cent of the real income that would be produced over the 23 week period respectively.

The larger projected loss in Australia’s real income compared to the change in real GDP can be attributed to the change in terms of trade arising from the increase in the price of crude oil and petroleum products.[[1]](#footnote-1)

The larger difference in real incomes under the low and high elasticity cases than arose for GDP can be attributed mainly to the fact that under the low elasticity case, Australia pays higher prices for more crude oil and petroleum products than under the high elasticity case. As a significant proportion of the crude oil and product is imported, the income transfers abroad (via the terms of trade loss) are higher which reduces real incomes.

**In summary, the operation of four refineries rather than seven will have a negligible effect on the fall in GDP and in real incomes resulting from the oil supply shock.** The impact on real incomes is more significant than the impact on GDP because Australia is a net importer of crude oil and petroleum products and the higher prices paid increases income transfers abroad. This is not offset by higher prices for petroleum exports in the short term.

Liquid fuel consumption

The temporary closure of the Strait causes liquid fuel consumption in Australia to decline relative to the base case over the 23-week period. The decline is most pronounced in week 5 (coinciding with the price spike in that week), when the decline ranges from 7.08 per cent to 7.90 per cent depending on the case and scenario. Liquid fuel consumption remains below the baseline level during the stock rebuilding phase (weeks 8 to 23).

Comparison with Singapore product supply shock

In 2011, as part of an overall assessment of Australia’s liquid fuels vulnerability, ACIL Tasman modelled the economic impacts of a 30-day interruption of shipping of crude oil and petroleum products into and out of Singapore.

After allowing for the time it takes to ship crude oil to Singapore, refine crude oil, store and blend sufficient oil products, break-up cargos, and ship crude oil and refined products to Australia, it was estimated that the interruption of supply from Singapore to Australia could last for 45 to 60 days. The incident would temporarily remove around 1.72 per cent of world refinery capacity from the market.

ACIL Tasman’s modelling of the Singapore scenario indicated that the total loss in GDP over 4 months would be $1,382 million if the shock occurred in the short term (2011). This is significantly higher than the loss of GDP estimated for closure of the Strait of Hormuz which was calculated to be around $556 million.

The total loss in real income in the Singapore case was estimated at $2,145 million if the disruption occurred in 2011. This compares with the real income loss of $2,148 – $3,118 million over 23 weeks for the Strait of Hormuz disruption.

The Strait of Hormuz event involves a much larger initial disruption than the extended disruption in the Singapore case (15 million barrels per day compared to 1.3 million barrels per day). However its economic impact, as modelled by ACIL Tasman, is mitigated by a number of factors.

While the price spike in week 5 of the case of the Strait of Hormuz is significantly higher than the price increase in the Singapore case, it is a transient event. Most of the time, the elevated prices in the Strait of Hormuz incident are caused by speculative buying before the event and restocking by IEA countries after the event. For most of these weeks, the product price rise is less than that for the Singapore incident. In the absence of the release of IEA stocks in the Strait of Hormuz case, the economic impact would be much higher.

A further important difference in the modelling of the economic impacts between the two incidents is the assumption about unemployment. In the Singapore incident, it was assumed that unemployment effects should be taken into account because it extended for sufficient time to allow reduced economic activity to lead to layoffs.

By comparison, in the Strait of Hormuz incident it was assumed that there would be no unemployment effects as the duration of the incident was so short and that, in aggregate, the supply of oil was not lost (rather the sources of supply and speculative/precautionary demand changed resulting in short term price effects). Tasman Global was therefore constrained so that the level of employment could not change. If the incident were significantly prolonged, the impact on employment would need to be taken into account. This would be achieved in Tasman Global by removing this constraint. Under such circumstances, the projected loss in Australian real GDP could be expected to be five to ten times greater than the impacts reported in this analysis. Similarly, the change in real incomes could be expected to be two to three times greater.

There are other more technical differences in the modelling. ACIL Tasman refined the Tasman Global data base and modelling approach to better simulate the very short term dynamics of the supply shock for the Strait of Hormuz, including the integration of the assumed elasticities in global oil markets and specifying how the oil is supplied (i.e. from standard production or from stock releases).

In summary

The report found that the scenario analysed for this report would not result in a physical disruption to Australia’s liquid fuel supplies. This arises for two main reasons:

* full supplies through the Strait are restored within two weeks.
* the release of stocks by IEA member countries in the first two weeks negates the supply shortfall effectively reversing the shock before the shortfall reaches markets recognising that ships already on the water could provide cover at least two weeks.

Prices rise in the weeks leading up to the closure, spike when the closure occurs and remain elevated for a period as countries rebuild stocks after the event.

The reported economic impact arises from the price increases for petroleum fuels and not from a break in the supply chain. Economic outcomes are not significantly different for the seven or four refinery cases because the shock affects the crude oil price not refinery margins.

While the estimated impact on GDP of the closure of the Strait is lower to that estimated for the Singapore disruption, the anatomy, of the two events is quite different.

A major difference between the two scenarios is the assumption of a coordinated release of stocks by IEA member countries in the Strait of Hormuz scenario. By effectively reversing the shock, the IEA release avoids any supply disruption and minimises the duration of elevated oil prices.

Knowledge that IEA would release stocks in the event of a major disruption could create some disincentive to suppliers and consumers to hold stocks for their own insurance value. If this were the case it would reduce the level of speculative and precautionary buying.

In addition a different approach was taken to modelling the two cases. In the Singapore case it was assumed that unemployment could occur as a result of the oil shock. In the case of closure of the Strait of Hormuz it was assumed that the duration of the actual disruption was too short to incur unemployment effects.

The findings in this report are consistent with the conclusions on liquid fuels vulnerability drawn in the report based on the Singapore disruption.

# Introduction

This report has been prepared for the Department of Resources, Energy and Tourism. (the Department). It addresses the economic impacts of temporary closure of the Strait of Hormuz.

The terms of reference are provided at Attachment A. This project arose against a backdrop of threats to closure of the Strait of Hormuz arising from political developments in the Middle East. These developments have coincided with a potential shift in Australia’s imports from crude oil to refined petroleum products because of consideration being given to closure of one and potentially three of Australia’s oil refineries.

The 2011 National Energy Security Assessment (NESA) concluded that the reliability of liquid fuels supply is likely to be high in the medium term, falling to moderate in the longer term. It found that Australia’s current liquid fuels supply security was underpinned by access to well-functioning regional and global petroleum markets. Increasing net imports of crude oil and petroleum products over the past decade has resulted in Australia not always complying with its obligations under International Energy Agency (IEA) treaty obligations. However, the NESA found that this did not constitute a decline in Australia’s liquid fuels supply security because of the depth and resilience of the Asian oil refinery supply chain network.

The 2011 NESA drew on an analysis of a 30-day closure of the Port of Singapore to assess the implications of a supply disruption on the Australian economy. The assessment noted that there could be more severe disruptions than that represented by the closure of Singapore.

The implications of a major disruption to Middle East supplies, and the possibility that up to three oil refineries could close in the near term, justifies a closer examination of the potential impact on liquid fuel security, particularly in the light of the uncertainties that are emerging in relation to shipping through the Strait of Hormuz.

This project is to assess the likely economic impacts of a major physical supply disruption from a temporary blockage of the Strait of Hormuz. The economic impact is assessed for two scenarios: one with seven oil refineries operating in Australia; and one with four oil refineries operating. The refineries to be assumed to have closed are the Shell oil refinery at Clyde in Sydney and the Caltex refineries at Kurnell in Sydney and Lytton in Brisbane. It was also assumed that each oil refinery would be converted to a product import terminal.

The deliverables for the project were:

1. A quantitative assessment of the economic impact of the temporary closure of the Strait of Hormuz assuming that the current seven refineries continue to operate.
2. A quantitative assessment of the economic impact of the partial closure of the Strait of Hormuz assuming the Clyde, Lytton and Kurnell refineries are closed and converted to import terminals.

Each assessment of the economic impact was to take into account:

* the likely duration of any closure taking into account the most likely responses from the international community and actions to address the closure
* the likely impact on the global oil market, including the impact of price increases on global and regional supply and demand
* policy responses from governments, including collective action by IEA member countries;
* the impact on Australian imports of crude oil
  + the impact on Australian imports of petroleum products, including qualitative discussion on impacts on availability
  + the economic impact on Australia including:
    - impact on Australian trading partners
    - impact on Australian real gross domestic product and real income
    - impact on Australian domestic retail fuel prices
    - impact by sector on the Australian economy (e.g. agriculture, mining).

In the course of consultations with the Department in the course of undertaking this project, three key questions arose that ACIL Tasman was asked to consider. These questions were:

* whether the scenario posed would result in a physical disruption to Australia’s liquid fuel supply
* whether the economic outcomes would be affected by the possible closure of refineries in Australia
* how the economic impacts of the posed scenario would differ from the economic impacts of the supply disruption represented by the Singapore disruption.

The report was also to include the following information:

* modelling and analysis methodologies, including a description of the modelling tools used
* basis of the modelling
* description of the reference case
* assumptions made
* conclusions.

In consultation with the Department and in order to contain project costs, the Department agreed to provide the following information:

1. a profile of the nature of the shock including
   1. the quantities of crude and product that will be taken off the market
   2. the duration of the time taken for the market to recover
   3. the amount and nature of petroleum that might be supplied through pipeline to alleviate the closure of the Strait of Hormuz
   4. assumptions on IEA cooperative action including the quantities and timing of release of stocks and any other actions including demand management.
   5. assumptions regarding actions that Asian nations might make, particularly with respect to China and India
2. an assumed date for the closure of the Strait of Hormuz, 1 March 2012
3. an assumption that an oil supplies emergency is not declared under the Liquid Fuels Emergency Act 1984.

To leverage existing work being done by other consultants, the Department was also to provide information on the likely changes to the supply chain that would arise as a result of domestic rationalisation of refining.

# Methodology and approach

The methodology and approach was agreed with the Department at the end of the second week of the project. Full details of the methodology are set out in detail at Attachment B. This section summarises the methodology and approach adopted for this project.

## Overall approach

The overall approach to modelling the economic impacts involves the following sequence of analysis and modelling:

* estimation of global price responses to a defined reduction in supplies of crude oil and petroleum products resulting from partial closure of the Strait of Hormuz commencing on 1 March 2012 (DRET provided assumptions regarding the extent and duration of reductions in supply of crude oil and petroleum products, including the timing and quantities involved in ramping-up supply after partial closure, and the timing, quantum and mix of internationally coordinated releases from stockpiles)
* estimation by ACIL Tasman of speculative demand changes and price elasticities of supply and demand for crude oil and for petroleum products before, during and following the period of interruption to full recovery of supply
* modification of the supply and demand elasticities in Tasman Global for the rest of the world and for Australia
* application of shocks to the model reflecting price increases in crude oil and petroleum products globally and to Australia and based on two scenarios tested against a reference case
* tabulation and reporting of results in terms of aggregate economic impacts for Australia
* a qualitative analysis of the likely impact of declaration of a liquid fuels emergency.

## Estimation of elasticities

ACIL Tasman undertook extensive desktop research into the most recent literature on short- and long-run price elasticities globally and in Australia. Elasticities for this report differ from those used by ACIL Tasman in 2011 to estimate price changes for disruption of supply of refined products from Singapore. The differences reflect important differences in circumstances, including shock size, type of shipments disrupted, sources of uncertainty, and expectations regarding IEA responses. Representative events involving a number of other important reductions in supply were reviewed to facilitate refinement estimates of demand and supply elasticities for crude oil and petroleum products, as well as speculative demand responses.

Through the Department, ACIL Tasman consulted with the IEA and other organisations to probe further into supply and demand responses that are likely and the feedback mechanisms that might change demand/supply responses in the months after the initial closure.

An explanation of the concepts of price elasticities of demand and supply and the implications of their interaction is provided in Box 1 below.

|  |
| --- |
| Box 1 Price elasticities of demand and supply |
| The analysis for this report drew on price elasticities of supply and demand to estimate the price impacts of the supply shock. The price elasticity of demand is the percentage change in quantity demanded by consumers divided by the percentage change in the price. This is illustrated in the chart on the left of the diagram below. The chart shows a downwards sloping demand curve. As the price rises by Δp the quantity demanded by consumers falls by Δq. The price elasticity of demand is shown in the diagram.  Similarly the price elasticity of supply is the percentage change in quantity supplied divided by the percentage change in price. This is illustrated in the chart on the right of the diagram below. The chart shows an upwards sloping supply curve. As the price rises by Δp the quantity producers are willing to supply to the market increases by Δq. The equation for the price elasticity of supply is also shown in the diagram.    A hypothetical supply shock removing and amount of (Δq/q) percent of global oil production would require a proportionate increase in the price of (Δp/p) to clear the market. This market clearing process would result in an initial price increase which would cause a decrease in the quantity demanded. The market clearing process would be accomplished by a combination of proportionate change in quantity demanded of (Δp/p) x Ed and a proportionate change in quantity supplied of (Δp/p) x Ed.  The proportionate supply shock therefore would be equal to the proportionate change in demand from consumers less the proportionate change in supply by producers = [ (Δp/p) x Ed ] – [ (Δp/p) x Es ] = (Δp/p) x (Ed-Es)  Taken another way percentage increase in price (Δp/p) that would arise in the short term as a result of a percentage change in quantity supplied (Δq/q) can be expressed algebraically as  (Δp/p)= (Δq/q)/( (Ed-Es).  This formula has been used to calculate the percentage price increase that would arise in each week of the shock event in response to changes in supply.  Source: ACIL Tasman based on research summarised in Attachment C. |
|  |

## Estimation of price impacts

The nature of the shock was provided to ACIL Tasman by the Department of Resources Energy and Tourism. This included the date of the shock (1 March 2012), its duration and the timing and extent of IEA coordinated response mechanisms.

ACIL Tasman took this shock profile, allowed for changes in speculative demand in the context of uncertainty, and using the price elasticities of demand and supply, calculated movements in crude oil prices prior to, during and after the closure. The amount of refine products passing through the Strait is small compared with crude oil and not material for calculation of Australian economic impacts.

The price impacts for were estimated for two scenarios and two elasticity cases:

* **Scenario 1** assumes seven refineries operating
  + relatively low elasticity case (Case A)
  + higher elasticity case (Case B)
* **Scenario 2** assumes four refineries operating
  + relatively low elasticity case (Case A)
  + higher elasticity case (Case B).

Scenario 1, case A and case B were compared with a reference or base case scenario including Australia’s seven existing refineries. Scenario 2, case A and B were compared with a base case involving only four Australian refineries. The reference case scenarios assumed price movements estimated to apply in the absence of concern regarding closure of the Strait of Hormuz.

## Economic modelling

This report examines the economic impacts of the shock scenarios at the aggregate level for the Australian economy. An assessment of the regional impacts is beyond the scope of this project. The scenarios were divided into weekly segments. The research undertaken for this report revealed the importance of speculative (including precautionary) demand and its impact on the oil price in the weeks leading up to and after the disruption (see Appendix C).

ACIL Tasman used its computable general equilibrium (CGE) model of the Australian and world economies, *Tasman Global*, to estimate the economic impacts of the proposed supply shock. CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, using a ‘bottom-up approach’ – starting with individual markets, producers and consumers and building up the system via demands and production from each component.

When an economic shock or change to economic conditions, such as different rates of mining industry growth, is applied to the model, each of the markets adjusts to a new equilibrium according to the set of behavioural parameters which are underpinned by economic theory.

The current *Tasman Global* database is based on the GTAP v8 database and contains 128 international regions plus a detailed regional representation of the Australian economy. The database was aggregated to the 39 commodities and 11 regions presented in Table 1.

Table 1Tasman Global commodity and region aggregation

|  |  |  |  |
| --- | --- | --- | --- |
|  | Commodities |  |  |
| 1 | Crops | 21 | Textiles, clothing, footwear |
| 2 | Livestock | 22 | Wood, pulp and paper |
| 3 | Forestry | 23 | Fabricated metal products |
| 4 | Fishing | 24 | Transport equipment and parts |
| 5 | Processed food | 25 | Electronic equipment |
| 6 | Coal | 26 | Machinery and equipment nec |
| 7 | Oil | 27 | Other Manufacturing |
| 8 | Gas | 28 | Water |
| 9 | Electricity | 29 | Construction |
| 10 | Petroleum & coal products | 30 | Trade services |
| 11 | Iron & steel | 31 | Other transport |
| 12 | Liquefied natural gas (LNG) | 32 | Water transport |
| 13 | Iron ore | 33 | Communication |
| 14 | Bauxite | 34 | Financial services nec |
| 15 | Other mining | 35 | Insurance |
| 16 | Alumina | 36 | Other business services |
| 17 | Primary aluminium | 37 | Recreational and other services |
| 18 | Nonferrous metals | 38 | Government services |
| 19 | Nonmetallic minerals | 39 | Dwellings |
| 20 | Chemicals, rubber, plastics |  |  |
|  | Regions |  |  |
| 1 | Australia | 7 | Middle East c |
| 2 | China | 8 | European Union 27 a |
| 3 | India | 9 | United States and Canada |
| 4 | Japan | 10 | Rest of Asia |
| 5 | Korea, Republic of | 11 | Rest of World |
| 6 | Other ASEAN b |  |  |

a European Union 27 comprises Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Republic of Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

b Other Association of South East Asian Nations comprises Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. Timor Leste is also included as it is not separately identified in the GTAP database.

c Bahrain, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kuwait, Lebanon, Palestinian Territory, Occupied, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen.

Note: nec = not elsewhere classified.

Data source: ACIL Tasman

The database was updated to 2 February 2012 using the model, ensuring that energy demand by fuel by industry by region closely matched the most recent available annualised production, consumption, trade and price data. Two alternative representations of the Australian and world economies were created: one with seven oil refineries operating in Australia and one with only four refineries operating.

The sequence of converting the supply shock scenarios into economic effects involved four steps as illustrated in Figure 1. The first step was to estimate the supply shock for each week of the shock period. The second step was to estimate the percentage impact on crude oil prices using the elasticity estimates for each week. The third step was to shock the reference cases in the CGE model with the estimated crude oil price increases and report the effects as changes in economic aggregates such as GDP or aggregate income.

Figure 1Economic assessment sequence

|  |
| --- |
|  |

Source: ACIL Tasman.

Under this process the model had to run in weekly rather than annual periods. The databases were therefore converted to allow model runs in weekly time increments for the various scenarios.

The economic impacts for the shock scenarios were then compared with the relevant reference or base cases. The comparison is illustrated in Figure 2.

Figure 2 **Illustrative scenario analysis using Tasman Global**

|  |
| --- |
|  |

Source: ACIL Tasman

# Significance of Middle East production

## The Strait of Hormuz

The Strait of Hormuz is located between Oman and Iran. It connects the Persian Gulf with the Gulf of Oman and the Arabian Sea Figure 3).

Figure 3The Strait of Hormuz

|  |
| --- |
|  |

According to the U.S. Energy Information Administration, on an average day in 2011, about 14 tankers carrying 17 million barrels of crude oil passed out of the Persian Gulf through the Strait. This was said to represent 35 per cent of the world's seaborne oil shipments, and 20 per cent of oil traded worldwide (Figure 4).

Figure 4Oil shipments and the Strait of Hormuz

|  |
| --- |
| Hormuz is the largest gateway to oil, controlling access to one fifth of the world's oil supply |

Data source: (Vanderbrook, February 2012).

It is estimated that more than 85 per cent of these crude oil exports went to Asian markets, with Japan, India, South Korea and China the largest destinations (75 per cent of Japan’s oil passes through the Strait) (EIA, 2012).

## Production and exports

The volumes of crude oil and petroleum products produced in countries surrounding the Strait of Hormuz in 2009, based on IEA data, are shown in Table 2 and Table 3 below.

Table 2Middle East liquid petroleum production, 2009

|  | **Production in 2009 ('000 tonnes)** | | | | Barrels/day |
| --- | --- | --- | --- | --- | --- |
|  | Crude oil | Petrol | Diesel | Jet fuel | Crude oil |
| Iran | 205,637 | 12,070 | 27,294 | 1,212 | 4,129,257 |
| Iraq | 114,760 | 2,822 | 6,373 | 522 | 2,304,418 |
| Kuwait | 114,651 | 2,745 | 10,639 | 2,491 | 2,302,229 |
| Saudi Arabia | 407,930 | 15,196 | 30,521 | 3,030 | 8,191,365 |
| Bahrain | 9,102 | 764 | 4,555 | 2,205 | 182,771 |
| Qatar | 35,673 | 1,633 | 1,078 | 877 | 716,325 |
| UAE | 107,712 | 2,392 | 4,364 | 5,141 | 2,162,892 |
| Total | 1,038,162 | 39,779 | 86,619 | 16,227 | 20,846,627 |

Source: International Energy Agency.

In 2009, a total of around 20.8 million barrels per day (Mb/d) of crude oil was produced by countries in the Gulf region, of which 15 Mb/d were exported by ship through the Strait of Hormuz. At the same time, around 579,677 tonnes of petroleum products were exported through the Strait. This is equivalent to around 0.14 Mb/d of crude oil.

Table 3 **Liquid petroleum** exports from Gulf producers, 2009

|  | **Exports in 2009 ('000 tonnes)** | | | | Barrels/day |
| --- | --- | --- | --- | --- | --- |
|  | Crude oil | Petrol | Diesel | Jet fuel | Crude oil |
| Iran | 114,754 | 0 | 0 | 0 | 2,304,297 |
| Iraq | 93,514 | 0 | 0 | 0 | 1,877,791 |
| Kuwait | 68,274 | 28 | 7,478 | 1,729 | 1,370,964 |
| Saudi Arabia | 312,394 | 2,909 | 5,766 | 450 | 6,272,972 |
| Bahrain | 0 | 210 | 3,560 | 1,605 | 0 |
| Qatar | 29,255 | 688 | 689 | 2 | 587,450 |
| UAE | 99,828 | 0 | 0 | 2,263 | 2,004,578 |
| Total | 753,097 | 4,319 | 17,777 | 6,351 | 15,122,430 |

Source: International Energy Agency.

It is estimated that more than 85 per cent of these crude oil exports went to Asian markets, with Japan, India, South Korea and China the largest destinations (75 per cent of Japan’s oil passes through the Strait).

## Australia’s dependence on Middle East petroleum

According to the Bureau of Resources and Energy Economics (BREE), in 2010-11, Australia imported 156 megalitres (ML) of crude oil from Saudi Arabia and 4,683 ML from the UAE (out of a total 31,766 ML from around the world or 15.2 per cent of Australia’s crude oil imports as shown in Table 4).

Middle Eastern crudes generally are heavier than and complement light crudes produced from Australian oil fields. This applies principally to the refineries in Victoria that draw on domestic supplies of crude oil from the producing fields in the Gippsland Basin. Shipping times from the Middle East are around 2 to 3 weeks. Australian refineries would be able to rely on crude oil on the water for about this period before closure of the Strait would begin having a physical impact on supplies.

Australia also imported 897 ML of products from the Middle East (5.4 per cent of total product imports), compared with 9,471 ML from Singapore and 2,013 ML from the Republic of Korea, out of a total of 18,771 ML (see Table 4). Of course, a significant proportion of the products produced in the Republic of Korea and Singapore are refined from crude oil from the Middle East.

Table 4Australian imports of petroleum

|  | 2006-07 ML | 2007-08 ML | 2008-09 ML | 2009-10 ML | 2010-11 ML |
| --- | --- | --- | --- | --- | --- |
| Crude oil and other refinery feedstock |  |  |  |  |  |
| Indonesia | 3,391 | 3,289 | 3,666 | 4,178 | 4,805 |
| Malaysia | 3,730 | 4,103 | 4,461 | 5,319 | 5,930 |
| New Zealand | 635 | 1,974 | 2,313 | 2,569 | 2,565 |
| Other Middle East | 118 | 43 | 40 | 43 | 0 |
| Papua New Guinea | 2,059 | 2,190 | 1,349 | 1,580 | 1,612 |
| Qatar | 106 | 0 | 0 | 0 | 42 |
| Saudi Arabia | 1,151 | 573 | 775 | 478 | 156 |
| Singapore | 841 | 713 | 555 | 605 | 497 |
| United Arab Emirates | 2,971 | 3,660 | 2,918 | 3,846 | 4,683 |
| Viet Nam | 6,677 | 6,318 | 5,277 | 3,904 | 2,554 |
| Other | 3,665 | 3,360 | 2,947 | 4,762 | 8,923 |
| **Total** | **25,345** | **26,223** | **24,302** | **27,284** | **31,766** |
| Refined products |  |  |  |  |  |
| Indonesia | 17 | 11 | 45 | 95 | 259 |
| Korea, Rep. of | 821 | 785 | 1,704 | 1,960 | 2,013 |
| Malaysia | 8 | 316 | 184 | 249 | 263 |
| Middle East | 642 | 1,044 | 1,050 | 1,070 | 897 |
| New Zealand | 96 | 40 | 215 | 4 | 9 |
| Singapore | 7,681 | 10,215 | 10,217 | 10,249 | 9,471 |
| United States | 378 | 421 | 473 | 301 | 400 |
| Other | 4,375 | 5,149 | 5,808 | 6,039 | 5,459 |
| **Total** | **14,018** | **17,982** | **19,697** | **19,967** | **18,771** |

Data source: BREE – Australian Commodity Statistics.

A reduction in exports of crude oil from the Gulf would also have implications for Asian refineries that supply Australia with petroleum products. A list of countries and their current consumption of crude oil shipped through the Strait follows (Lloyds, 2011):

* Japan -- takes 26 per cent of crude oil moving through the Strait (meets 85 per cent of this country's oil needs)
* Republic of Korea -- 14 per cent (meets 72 per cent of this country’s crude oil needs)
* United States -- 14 per cent (meets 18 per cent of this country’s crude oil needs)
* India -- 12 per cent (meets 65 per cent of this country’s crude oil needs)
* Egypt -- 8 per cent (most transhipped to other countries)
* China -- 8 per cent (meets 34 per cent of this country’s crude oil needs)
* Singapore – 6 per cent (meets 70 per cent of this country’s crude oil needs).

Importantly for Australian imports, oil refineries in Singapore and South Korea derive 70 per cent of their crude oil from shipments through the Strait. Oil refineries in India are also similarly dependent on shipments through the Strait, while oil refineries in China are only 34 per cent dependent on such crude oil. Around 50 per cent of Australia’s imports of petroleum products come from Singapore.

There is insufficient evidence to make an accurate calculation of the proportion of petroleum products imported into Australia that are dependent on crude oil shipped through the Strait of Hormuz. However, based on data from Table 4 and dependence figures in Table 5, ACIL Tasman estimated that around 60 per cent of the products imported would come from oil refineries in Asia and elsewhere that depend to varying degrees on crude oil imported from the Middle East.

Table 5 **Imports of petroleum products 2010-11**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Imports of petroleum products | Dependence on Middle East Crude | Imports dependent on Middle East Crude |
|  | ML | ML | ML |
| Indonesia | 259 |  | 0 |
| Korea, Rep. of | 2013 | 72% | 1449 |
| Malaysia | 263 |  | 0 |
| Middle East | 897 | 100% | 897 |
| New Zealand | 9 |  | 0 |
| Singapore | 9471 | 70% | 6629 |
| United States | 400 | 18% | 72 |
| Other | 5459 | 50% | 2729 |
| Total | 18771 | 63% | 11777 |

*Note:* Dependence percentages are based on ACIL Tasman estimates for Indonesia, Malaysia and other.

Data source: BREE – Australian Commodity Statistics.

Shipping times for crude oil is around 3 to 4 weeks from the Middle East, 4 to 5 weeks from West Africa and 2 to 3 weeks from Asia respectively (Australian Institute of Petroleum, 2008). Average shipping times would be around 17 days.

Shipping times for product from Asia is from around 10 to 14 days to the major east and west coast import terminals. As the major proportion of imported product is sourced from Asia, the average shipping time for product might be around 12 days.

Taking these shipping times as a guide, an estimate of the volumes of crude oil and product on the water at any one time is provided in Table 6. The table shows that the estimated volume of crude oil on the water is around 1,480 ML. Total stocks of crude oil in Australia and on the water were 4292 ML as at January 2012 (Australian Petroleum Statistics, 2012). This means that stocks of crude oil on the water represent around 34.5 per cent of the total of crude oil in storage in Australia and in ships destined for Australia.

Using a similar calculation for petroleum products, the estimated 617 ML of petroleum product on the water bound for Australia represents around 15 per cent of the total of 4136 ML of petroleum product in storage in Australia and in ships destined for Australia.

This estimate should only be regarded as a general guide the volume of crude and product that might be in the pipeline as the data is not detailed enough to draw precise conclusions.

Table 6 **Volume of crude oil and product on the water**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Total imports  20010-11 | Average sailing time to Australia | Stocks on the water | End of months stocks as at January 2012 | Total stocks on land and on water | Proportion of stocks on water to total stocks on land and water |
|  | ML | Days | ML | ML | ML |  |
| Crude oil | 31,766 | 17 | 1,480 | 2,812 | 4,292 | 34% |
| Product | 18,771 | 12 | 617 | 3,519 | 4,136 | 15% |

*Note:* Calculations provide only an approximate indication of petroleum on the water.

Data source: Australian Petroleum Statistics.

## Alternative routes to the Strait of Hormuz

Currently, there are limited alternative routes to the Strait of Hormuz for exporting Persian Gulf oil (see Figure 5). Some of the options described below need repairs and upgrades or are closed due to political, economic, or geopolitical issues in the area.

Figure 5Oil pipelines

|  |
| --- |
| http://www.consumerenergyreport.com/wp-content/uploads/2010/10/oil-pipelines-middle-east.jpg |

Source: www.consumerenergyreport.com.

The potential capacity of the alternative transport routes is indicated in Table 7. The pipeline from Abqaiq to Yanbu (East-West or Petroline) has a nameplate capacity of 5 Mb/d and consists of two lines. It has been reported that only one of the lines remains in service for oil. The other line has been converted to natural gas and would not be readily available for oil transport. The estimated capacity of the line in use is between 2.5 Mb/d and 3 Mb/d. As utilisation on this line is estimated at 1.5 to 2 Mb/d, our working assumption is a spare capacity on this line of 1 Mb/d. If the closure of the Strait were to occur today, the other pipelines would not be available for use, for the reasons indicated in the footnote to Table 7. In addition, shipments from Yanbu add up to five days roundtrip travel time for tankers through the Bab al-Mandab Strait to major customers in Asia

Table 7Capacity of alternative oil transport routes in the Middle East

|  |  |
| --- | --- |
| Alternative transport routes | Barrels/day |
| Iraq-Turkey pipeline1 and Strategic Pipeline2 | 2,300,000 |
| Iraq-Syria-Lebanon Pipeline (ISLP)3 | 700,000 |
| Iraqi Pipeline through Saudi Arabia (IPSA)4 | 1,650,000 |
| Saudi Arabia East-West pipeline (Petroline) to Yanbu on Red Sea | 5,000,000 |
| Trans-Arabalalian Pipeline (Tapline) from Saudi Arabia to Zahrani on Lebanese coast5 | 500,000 |

Notes:

1Usable capacity in 2007 believed to be 300,000 b/d.  
2 System needs rehabilitation.

3 Flows stopped in 2003 due to war.  
4 Needs to be reactivated; currently carrying natural gas.  
5 Capacity in 2007 was 50,000 b/d.

Source: <http://www.marcon.com/marcon2c.cfm?SectionListsID=93&PageID=771>.

According to advice from the IEA, around 2 Mb/d of crude oil could be shipped through the East West Pipeline if a disruption had occurred on 1 March 2012 resulting in a loss of 15 Mb/d, after allowing for additional production from the region.

## Conditions leading up to closure

An important influence on the economic impact of a hypothetical closure of the Strait on 1 March 2012, is the impact on precautionary and other speculative buying in anticipation of the event. The IEA reported an almost relentless tightening in the crude oil market in the ten quarters leading up to the first quarter of 2012 (IEA, April 2012). This was driven by supply disruptions in Syria, South Sudan and Yemen, which were exacerbated in late-2011 by concerns about conflict with Iran leading to sanctions on that country. In addition, reasonably strong economic growth in Asia contributed to further tightening of crude oil markets over this period.

Changes to speculative demand for crude oil refer to buying or selling of oil in response to “expectations shifts”. These shifts involve changes to perceptions of uncertainties relating to future supply and demand and consequential prices. Changes in speculative demand cause oil price changes.

A major issue is that speculative demand derives from precautionary, hedging, investment and pure speculative activities, which are now focussed mainly in futures or derivative markets, not spot markets. Oil futures were first traded in 1983. Activity in futures market has increased greatly over the past decade, particularly from 2005 (Hamilton, Wu, 2011).

The causes and consequences of precautionary buying and other speculative demand are discussed at length in Section C.6 of Appendix C. If the futures market is in contango (futures prices exceed current spot prices) and the spread is large enough to exceed crude oil holding costs (storage and interest cost) – a case of strong contango – there would an incentive to sell oil forward and to purchase crude oil on the spot market and hold it for delivery under the forward contract. Alternatively, a producer could slow production, which means higher remaining underground reserves (a form of inventories). Therefore, arbitrage activity could be expected to lower futures prices and increase spot oil prices, moderating the spread.

This strong link between futures and spot markets does not exist if the futures market is in backwardation (current spot prices exceed futures prices) or weak contango (futures prices exceed current spot prices, but not sufficiently to cover crude oil holding costs). It is not possible to buy crude oil in the futures market and then sell at an earlier time in the spot market (Tilton, Humphreys, Radetzki, 2011).

However, there is a weaker mechanism through which the futures market can still influence the spot market during periods of backwardation and weak contango. Users of crude oil are prepared to bear costs of holding inventories of crude oil up to some level because having stocks on hand reduces risks of supply disruption and delays in acquiring additional supply to respond to a demand surge.

In the lead up to 1 March 2012, the futures market was in slight backwardation. However, despite this, there appeared to be a strong incentive for users to build inventories to reduce risk of supply disruption.

These factors created an environment for precautionary buying in the crude oil market by refineries in Europe searching for replacement grades for the heavier Iranian crudes and by stock building by Chinese oil refineries[[2]](#footnote-2). This, reinforced by increased demand for Brent crudes from Asian oil refineries, led to a gradual rise in Brent and Dubai crude prices. Price rises in West Texas Intermediate were less marked owing to high inventory levels at Cushing Oklahoma storage depot, that were expected to be drawn down for technical reasons in the following months.

The trend of increasing in crude oil prices accelerated in the first quarter of 2012, as shown in Figure 6. The prices of Dated Brent and Dubai crude oil increased by around 13 per cent during this period[[3]](#footnote-3). The percentage increase in West Texas Intermediate crude oil was of a similar order, although for the above mentioned reasons, its price was lower.

Figure 6Movements in physical crude prices and crude futures ($/bbl)

|  |  |
| --- | --- |
|  |  |

Data: IEA, April 2012.

Not all of this price increase can be attributed to concerns about the potential supply shortfalls associated with a disruption to shipments through the Strait of Hormuz. However the IEA reported that prices fell in March by around $5 per barrel “on cautious optimism that the stalled talks with Iran over its nuclear program would resume” (IEA, April 2012). This suggests that speculative buying driven by concerns over a possible incident with Iran may have pushed the price of crude by up to $5 per barrel in February. Precautionary buying appears to have contributed to a further increase bringing the total increase to around $9 per barrel over the period from the beginning of February to the beginning of March. This can be seen in Figure 6.

As discussed above concerns over supply disruptions in Syria, South Sudan and Yemen had been a factor in the elevated oil prices over the previous eleven months. Concerns over conflict with Iran had also been a factor but it is not known how much of a factor they had been. Spot prices for dated Brent had been moving in a narrow range around $110 per barrel since October 2011. The Brent price began a steady rise in early February. This is more likely to reflect concern building in the market over the Iranian situation and the growing concern about shipments through the Strait of Hormuz. While there were some concerns over Iran prior to the beginning of February 2012, ACIL Tasman has assumed for the purpose of economic modelling for this report, that the price rises attributable to speculative buying in contemplation of closure of the Strait of Hormuz began in February.

Global oil demand hit a peak in February of 91.1 million barrels per day (Mb/d) compared to an average demand of 89.1 Mb/d for 2011. Global supply fell by 0.2 Mb/d to 90.4 Mb/d in February 2012 with rising OPEC natural gas liquids production only partially offsetting a 0.5 Mb/d decline in production from non-OPEC countries.

Production from Iran declined by 50 kilo barrels per day (kbd) to 3.38 Mb/d compared with a sustainable production capacity of 3.51 Mb/d. A number of European countries had reportedly halted imports from Iran but this was reported to be offset by increased purchases from Asian countries including India and South Korea (IEA, April 2012).

OPECs spare capacity declined to around 2.54 Mb/d from 2.75 Mb/d in February 2012 reflecting in part the removal of Iranian spare production capacity on the basis that sanctions would progressively cap the ability of the country to raise output. Overall it appears that there was a supply shortfall in February equivalent to around 700 kbd, which was met from stocks. This was predominantly at the expense of OPEC stocks as OECD and some Asian refineries increased stocks over the period.

Concerns over closure of the Strait appeared to abate in late February and early March. If closure had occurred on 1 March it is likely that market concerns would have increased in late February leading to more precautionary buying which would have increased the price above the $9 per barrel cited above. Further discussion of the magnitude of the price rise in the period leading up to a closure is discussed in Section 4.3.

## Conditions during closure

Closure of the Strait of Hormuz would immediately remove a net amount of around 15 Mb/d of crude oil and around 0.14 Mb/d of product from world oil supplies. From Australia’s perspective, the dependence of Asian refineries on crude shipped through the Strait would have serious consequences for supplies of imported petroleum product. However, there would be a lag of between two to three weeks while crude and product on the water was processed by Asian and Australian refineries.

In the short term therefore, the main impact would be significant price spikes for crude oil and products globally. This would be driven initially by precautionary and other speculative demand in the lead up to and during the period of closure, the supply shortfall itself, the release of speculative holdings, rebuilding of government and government-mandated stock positions, and restoration of confidence in the period after resolution of the closure.

The loss of 15 Mb/d would drive prices higher than earlier speculative demand. As discussed in Section 4.2, the price elasticities of demand and supply for both crude oil and product are low, and particularly so in the short-term. Recent research also suggests that these elasticities are even lower today than they were during the 1990s and early 2000s. A full discussion of recent research into elasticities of demand and supply is also provided in Appendix C. In Section 4.3.2, ACIL Tasman’s analysis suggests the price rise could be above 100 per cent under certain assumptions.

The economic impact for Australia however would depend on the duration of the closure and the possible policy responses of the IEA member countries as well as countries such as China and India to the closure. As discussed above, the availability of oil on the water would provide a physical supply buffer to oil refineries for 2 to 3 weeks. The most prominent impact during this period would be on the price of crude oil and product. The world oil market is highly integrated and such price movements would now be reflected in crude oil and product markets around the world almost immediately. Price differentials may still exist between regions depending on levels of inventory and transport and oil refinery logistics, but the relative price movements would be similar. This is also discussed at length in Appendix C.

An important factor in the duration of the price spike would be the draw on stocks by both industry and government following closure. The release of crude oil stocks by the U.S. Government and additional collective action by IEA countries involving crude oil and refined products had a significant impact on prices of crude oil and refined products in the aftermath of Hurricane Katrina in the Gulf of Mexico in 2005.

The supply disruption caused by Hurricane Katrina resulted in an increase in United States petrol prices of about 18 per cent over the next few days. Because there is an integrated international market for refined petroleum products, as well as crude oil, this substantial supply loss affected prices globally. This is illustrated by Figure 7, which shows export petrol price movements from the refining and trading hub of Singapore, the benchmark for Australian retail prices. Retail petrol prices in Europe behaved similarly. Obviously, the integrated market moderated the effect that the supply disruption would have caused in the United States if that economy had not been open to imports from the rest of the world.

Figure 7Singapore Export Petrol Price Movements Compared with Crude Oil Price Movements in 2005-06, Highlighting Effects of Hurricane Katrina and Rita and IEA Stock Releases

|  |
| --- |
|  |

a Acpl – Australian cents per litre.

*Data source:* Caltex Australia, 2006.

A striking feature of Figure 7 is that petrol prices (before taxes, transport costs, and wholesale and retail margins) rose substantially relative to crude oil prices. This could be attributed to the structure of U.S. Government and IEA action, which moderated crude oil prices much more than refined product prices.

On 31 August 2005, the U.S. Government announced a decision to release Strategic Petroleum Reserve crude oil to provide loans totalling more than 13 million barrels to refiners. On 2 September 2005, all 26 IEA members agreed to a package of emergency response measures, including use of emergency stocks, increased production, and demand restraint totalling 60 million barrels (2 million barrels per day for a period of 30 days). Emergency stocks of 52 million barrels of oil and refined products were to be made available by releases from government stocks (29 million barrels) and reduction of private sector stockholding obligations (23 million barrels), with almost half of the emergency stock releases being in the form of refined products. The crude oil releases were to be made from the U.S. Strategic Petroleum Reserve. (IEA, 2008). Crude oil production increases were to provide about 6.6 million barrels.

For a full discussion of price responses to the Hurricane Katrina supply shock and earlier oil supply disruptions see Appendix C.

## Policy responses

### International cooperation

There would likely to be much uncertainty and confusion in the immediate aftermath of a closure of the Strait of Hormuz. There would be considerable speculation as to the likely duration of the closure. Meanwhile, the IEA would face considerable pressure to make a decision in the first week. Market participants would expect the IEA to call for collective action by member counties under the Coordinated Emergency Response Mechanism (CERM), as closure of the Strait is the biggest single disruption conceivable.

To calm markets, the IEA would probably call for a massive action along the lines of 15 million barrels per day (17 million barrels per day disrupted minus 2 million barrels per day redirected and OPEC spare). While this is an extremely large volume, it would likely be achievable with a technical maximum drawdown of 14 million barrels per day from public stocks and the lowering of industry stock obligations. Drawdown has to commence within 15 days, but many countries could move more quickly and in addition a proportion of the amounts of obligated stocks are already in the hands of the industry. Due to the magnitude of the disruption, countries are likely to be more committed than they were during Katrina. While the initial collective action would likely focus on stocks, countries would very quickly be considering possible demand restraint programs to enact.

With collective action, no direct shortages would be expected. IEA stocks are close to markets and sailing time from the Strait of Hormuz to markets is 2-3 weeks, so the release would be timely given our assumptions about the duration of the disruption.

IEA collective action would likely be reviewed at 30 days and adjusted or cancelled, depending on circumstances at the time. The IEA would likely allow member countries to replenish their required stockholdings that were drawn down in the collective action over the course of a year, although we assume in our modelling that member countries will restock over 16 weeks as they would likely want to reduce their vulnerability to future disruptions. This would likely cause oil prices to be slightly elevated compared with what they otherwise would be over this time period.

It should also be noted that non-IEA countries, including OPEC, also hold stocks that might be made available to the market. Saudi Arabia for example holds stocks in and outside the Middle East. According to the IEA Oil Market Report in May 2012, Saudi Arabia held stocks of around 80 Mb in inventories. Approximately 10 Mb barrels are stored near consumer markets in Okinawa, north-western Europe, and Sidi Kerir, with the remainder inside the Kingdom. According to the IEA’s *Oil Market Update* for June 22, 2012, stocks in OECD countries averaged 1,376 million barrels for products and 2,653 million barrels for crude over the last 5 years. The same report shows that stocks on land held in IEA countries were around 4,067 million barrels as at 31 December 2011 (see Table 8).

Table 8 **Stocks of crude oil and petroleum product held on land by IEA member countries**

|  |  |
| --- | --- |
|  | Stocks |
|  | Million barrels |
| Australia | 40.0 |
| Austria | 19.4 |
| Belgium | 36.4 |
| Canada | 190.5 |
| Czech Republic | 20.7 |
| Denmark | 22.4 |
| Finland | 29.2 |
| France | 165.0 |
| Germany | 278.6 |
| Greece | 27.9 |
| Hungary | 15.4 |
| Ireland | 10.7 |
| Italy | 128.3 |
| Japan | 588.5 |
| Republic of Korea | 166.8 |
| Luxembourg | 0.6 |
| Netherlands | 101.4 |
| New Zealand | 8.3 |
| Norway | 25.9 |
| Portugal | 21.9 |
| Poland | 64.5 |
| Slovak Republic | 8.5 |
| Spain | 132.8 |
| Sweden | 31.5 |
| Switzerland | 35.7 |
| Turkey | 55.8 |
| United Kingdom | 87.8 |
| United States | 1752.1 |
| **Total** | **4066.6** |

Data source: (IEA, May 2012)

### Liquid Fuels Emergency Act 1984

Australian government energy policy acknowledges the responsibility to prepare contingency arrangements against a possible liquid fuel emergency.

In the unlikely event of a severe global fuel shortage affecting Australia, the Liquid Fuels Emergency Act 1984 allows the Governor General, on the advice of the Minister, to declare a liquid fuels emergency. If such a declaration is made, the Government has powers to intervene in wholesale and retail markets to manage fuel supply shortfalls. A national plan administered jointly by Government in consultation with the petroleum industry reinforces market strategies for returning Australia to normal fuel supply levels and includes a public communication plan[[4]](#footnote-4).

The Liquid Fuel Emergency Act has never been invoked. The economic analysis discussed in Section 5 assumed that a liquid fuels emergency is not declared and that demand and supply decisions in Australia for both crude oil and petroleum products was determined by the decisions of oil industry participants and consumers.

## Impact of different oil refinery scenarios

Closure of three Australian refineries prior to the hypothetical crude oil supply shock would result in different crude oil and product import figures. Closure would reduce the level of imports of crude oil for refining in Australia and increase the level of imports of petroleum products to replace the products formerly produced by the refineries that are assumed to have closed

Table 9 shows the production of various petroleum products with all seven refineries operating and with only four refineries operating (assuming the Clyde, Kurnell and Lytton refineries are shutdown).

Table 9 **Australian r**efinery production with seven and four refineries operating (ML per annum)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario | LPG | Avgas | Petrol | Jet | Diesel | Fuel oil | Bitumen | Lubes | Other | Total |
| Seven refineries | 1,467.4 | 98.3 | 16,642.8 | 5,463.7 | 12,858.7 | 951.7 | 476.0 | 170.3 | 377.1 | 38,506.0 |
| Four refineries | 894.6 | 98.3 | 9,734.5 | 2,972.3 | 8,858.0 | 597.4 | 322.8 | 0.0 | 186.9 | 23,664.8 |

Data source: DRET.

Prior closure of three Australian refineries would have several impacts on the economic modelling. However, the same changes in crude oil product prices would apply to both refinery scenarios. This is because crude and product prices in Australia are based on international prices. There may be transient departures from this for products in certain regions but overall import parity pricing would apply.

The key difference from the economic impact perspective is the fact that the relativities between imports of crude oil and product differ between the two refining capacity scenarios. The relative level of imports of crude oil and petroleum product for the two scenarios are summarised in (see Table 10).[[5]](#footnote-5) With less refineries Australia would import more product and less crude oil. However under both scenarios total net imports of crude oil and petroleum products expressed in volume terms remain approximately the same even after allowing for crude oil used in the refining process.

Table 10 **Net imports of crude oil and product 2012-13**

|  |  |  |  |
| --- | --- | --- | --- |
| Imports | Petroleum products | Crude oil | Total |
|  | ML/a | ML/a | ML/a |
| Scenario 1 - Seven refineries | 15,704 | 17,939 | 33,642 |
| Scenario 2 - Four refineries | 30,545 | 2,568 | 33,113 |

Data source: Hale and Twomey, 2012.

The bigger impact in economic terms is therefore likely to be on changes in the structure of the manufacturing sector. There will also be different exposures to sources of product between the scenarios.

According to ABS data the petroleum refining industry accounted for 0.2 per cent of GDP and directly employed around 2500 people in 2008[[6]](#footnote-6). The Shell oil refinery at Clyde employs around 310 people directly and the two Caltex refineries are understood to employ a total of 900 people directly and 550 contractors[[7]](#footnote-7).

The closure of these refineries would therefore represent a contraction of the oil refinery component of the manufacturing sector. There would be regional impacts on employment and incomes as a result of closure. However, because oil refinery margins are relatively low in Australia, closure in economic terms could have a positive economic impact for Australia as a whole if resources (labour and capital) are redeployed to higher margin areas of the economy. In any case, these transitional effects associated with the rationalisation of the oil refining sector are assumed to have already occurred prior to the disruption assumed to occur on 1 March 2012.

To model Scenario 2, *Tasman Global* was modified to reduce the size of the oil refining sector in Australia. The above-mentioned changes in the sector were incorporated into the reference for this scenario.

It is likely that the closure of Australian refineries would make Australia more dependent on products produced in Asian refineries some of which are more dependent on crude oil supplied from the Middle East than were the Australian refineries that closed. For example, refineries in Singapore and the Republic of Korea (two major suppliers of petroleum products to Australia) are heavily dependent on Middle Eastern feedstock.

On the other hand, Australian refineries import significant amounts of crude from non-Middle Eastern countries, particularly from Indonesia, Malaysia and Vietnam. Overall the closure of the three Australian refineries could increase Australia’s dependence on petroleum products refined from crude oil that passes through the Strait of Hormuz.

This does not mean however that the economic impact of closure of the Strait will be significantly different for the two scenarios. As discussed in Sections 4 and 5, the two week duration of the assumed shock, combined with prompt action by IEA countries to release stocks, means that the only impact is a rise in the price of crude oil and petroleum products worldwide, not a disruption in supplies in end markets.

## Overall impact and aftermath

The overall impact of closure would depend on the length of time that the Strait remained closed, the nature and duration of government policy responses, and the impact on oil prices after the event as industry and governments rebuild stocks.

While closure of the Strait would result in an immediate loss of 15 million barrels per day, the ability of the industry to draw initially on stocks built up in the period prior to the event, on surge production from countries outside of the Middle East, and on stocks released under policy measures such as IEA collective action, would limit the total shortfall and potentially remove the shortfall altogether in the initial weeks. If shipping could be reinstated within two to three weeks, there would be no net impact on supply to world refineries. The main impact would be on price increases in the market in the weeks leading up to the closure, a significant price spike in the week of the closure, a fall in the price as strategic stock draws occurred and an elevated price for a period after the event while countries rebuild stocks (see Appendix C for a full discussion of these points).

The IEA allows member countries to rebuild stocks over a 12 month period. In reality, it is possible that stocks would be rebuilt in less time than this. Table 11 shows that both industry and government drew down stocks during the fourth quarter of 2005 partly in response after Hurricane Katrina. However, stock levels had fully recovered by the second quarter of 2006.

Table 11 **OECD industry stocks during and after Hurricane Katrina**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2Q2005 | 3Q2005 | 4Q2005 | 1Q2006 | 2Q2006 | 3Q2006 | 4Q2006 |
|  |  |  |  |  |  |  |  |
| Industry stocks | 2,604 | 2,618 | 2,576 | 2,575 | 2,637 | 2,749 | 2,655 |
| Government stocks | 1,494 | 1,494 | 1,487 | 1,487 | 1,493 | 1,495 | 1,499 |
| Total | 4,098 | 4,112 | 4,063 | 4,062 | 4,130 | 4,244 | 4,154 |
| Stock change |  | 14 | -50 | -1 | 68 | 113 | -90 |

*Note:* Data are closing stock levels.

Data source: IEA Monthly Oil Market Reports.

Factors that affect the rate of stock rebuild include the production response to the higher prices generated by the closure, the duration and extent of the price rise, and the general political and industry climate following the closure. Industry participants will be discouraged from building stocks while prices remain elevated. However, some producers would have been able to benefit from the higher prices during the event and replenish them at a lower price after the event. Expectations of the risk of further disruption of supplies would also influence the rate of stock replenishment in the months following conclusion of the event. In order to balance these factors, it has been assumed that IEA stocks would be rebuilt over a period of 16 weeks.

# The shock sequence

The Department of Resources, Energy and Tourism provided ACIL Tasman with a scenario defining the nature and duration of the hypothetical event that was assumed to occur on 1 March 2012.

There are a range of possible scenarios that could have been chosen to assess the impact of a blockage of the Strait of Hormuz. Any scenario would involve a range of political, military and economic interests from a number of countries. It would be impossible to accurately and definitively determine the manner in which a particular scenario would play out. Predicting geopolitical events, military strategy and the military capabilities of individual nations was outside the scope of this project.

The scenario that was provided by the Department represents one plausible case. It was based on advice from a range of credible sources to represent an outcome that, while unlikely, is nevertheless considered among the most plausible. An assumption regarding the nature and extent of collective action by IEA countries was developed in consultation with the IEA. It recognises that full knowledge of the duration and scope for the blockage would not be known at the time of announcing collective action.

The economic impacts have been estimated by comparing two price elasticity cases under each of two Australian refining scenarios with a relevant reference or base case scenario. The reference case is assumed to be the outcomes that would have arisen if the concerns over blockage of the Strait of Hormuz had not arisen. Under this case, it has been assumed that crude oil prices would have remained broadly at the levels that had arisen at the end of January 2012. At this time, dated Brent crude oil prices were around $110 per barrel.

As discussed elsewhere the Brent crude had been trading around $110 since November 2011 but had been elevated since around March 2011 over concerns over supply disruptions elsewhere. While there may have been some impact on the price associated with concerns over Iran, the price did not commence a consistent upward trend until around the beginning of February. ACIL Tasman has assumed therefore that the price of $110 per barrel in January reflected concerns over supply disruptions other than the threat to passage of oil through the Strait of Hormuz. For the purpose of modelling therefore, ACIL Tasman has assumed that the event envelope for the disruption commenced on 1 February when the price began a steady rise from around $110 per barrel.

It has also been assumed that total oil demand would have been around 88.9 Mb/d as projected by the IEA in its oil market outlook for March (IEA, March 2012).

While other factors such as inventory rebuilding, international oil refinery closures and demand changes might have led to different outcomes, it has been assumed that these price and production assumptions would have applied under the reference case.

## The shock

The supply shock selected by the Department involves complete cessation of shipping through the Strait of Hormuz commencing on 1 March and persisting for one week. Some shipping was assumed to be recommenced in the following week. Specifically, around 25 per cent of normal oil shipments was assumed to pass through the Strait during that week.

It was also assumed that the IEA announces collective action in the form of a stock release in the middle of the first week of up to 15 million barrels per day, as necessary. It was assumed that the IEA stock release reaches the market by the end of two weeks from the closure (the end of week 6). Full resumption of shipping is assumed to be realised in the following week (week 7). The supply shock would be preceded by a speculative demand shock – a build-up of precautionary and other speculative buying in the light of the increasing uncertainty that rising political and tension fear of closure would generate. At the conclusion of the incident it was assumed that IEA member countries rebuilt stocks over a 16 week period.

In summary, therefore, the event transpires over a 23 week period and commences four weeks before the actual closure. The shock sequence is summarised in Figure 8.

Figure 8Shock scenario

|  |
| --- |
| IEA announces collective action  Stocks released reach markets by end of week |

Source: Department of Resources, Energy and Tourism and ACIL Tasman.

The detailed responses to this shock are discussed in the following sections.

## Elasticities

Large scale disruptions to supply of crude oil or products tend to cause proportionate increases in prices that are much higher than proportionate reductions in supply. Conversely, large supply increases tend to cause price reductions that are proportionately much larger. Shifts in crude oil supply lead to disproportionately large price changes because responsiveness of demand and supply to price movements (price elasticity of demand and supply, respectively) tends to be extremely low (or inelastic) in the short-term. Even in the long-term, this responsiveness tends to be very low compared to most other goods and services.

In the economics literature, responsiveness of quantity demanded to price changes is measured by price elasticity of demand, which is defined as the proportionate change in quantity demanded divided by the proportionate change in price (a negative number). Responsiveness of supply to price changes is measured by price elasticity of supply, which is calculated as the proportionate change in quantity supplied divided by the proportionate change in price (a positive number).

The importance of very low price elasticities of demand and supply is illustrated by the following. A hypothetical supply shock removing (or adding) **Ss** per cent of global crude oil production would require a proportionate increase (or reduction) in price of **∆** to clear the market, eliminating a shortage or surplus caused by the supply shock at the price applying before the shock. This market-clearing process would be accomplished by a combination of a proportionate change in quantity demanded of **∆** x **Ed** and a proportionate change in quantity supplied of **∆** x **Es**, where **Ed** and **Es** represent short-term price elasticity of demand and short-term price elasticity of supply, respectively. The changes in quantity demanded and quantity supplied in response to a market clearing price increase are in opposite directions, but will add to the amount of the initial shock (a price increase reduces quantity demanded and increases quantity supplied, and a price reduction does the opposite, as reflected in the signs of **Ed** and **Es**). Therefore, the supply shock, **Ss** = (**∆** x **Ed**)– (**∆** x **Es**), and the proportionate change in price, **∆** = **Ss/**(**Ed** – **Es**).

If the supply shock, **Ss** = –0.05 (5 per cent reduction in supply) when **Ed** is –0.05 and **Es** is 0.05, the proportionate change in price, **∆** = 0.5. So, a 5 per cent reduction in supply leads to a 50 per cent increase in price. Conversely, a supply increase of 5 per cent, with the same values of **Ed** and **Es** leads to a reduction in price of 50 per cent. Smith (2009a, p. 155) observed that values of –0.05 and +0.05 for short-term price elasticities of demand and supply for crude oil, respectively were indicative of estimates in the economics literature on the crude oil market.

Revising the calculation with the values of **Ed** and **Es** suggested by Kilian and Murphy (2010), –0.26 and 0.02, respectively, indicates a 5 per cent reduction in supply would cause a price increase of nearly 18 per cent in the short-term. Using median values of **Ed** and **Es** for the last few years of around –0.15 and 0.02, respectively, as estimated by Baumeister and Peersman (2012), a reduction in supply of 5 per cent would cause a price increase of more than 29 per cent in the short-term.

Using similar reasoning, a demand shock, **Ds** = (∆ x **Es**) – (∆ x **Ed)**, and the proportionate change in price, **∆** = **Ds/**(**Es** – **Ed**). Assuming a positive demand shock of 2 per cent (+0.02), and inserting the values of **Ed** and **Es** suggested by Baumeister and Peersman (2012), the resulting price change would be an increase of nearly 12 per cent.

A full discussion of recent research and literature on elasticities of demand and supply for crude oil and petroleum products, and interaction of supply shocks and speculative demand shocks is provided in Appendix C. The following sub-sections discuss these influences over the weeks leading up to and during the hypothetical supply disruption.

## The shock effects – elasticities and prices

The shock sequence assumed below was based on a detailed review of the available literature on oil shocks and price elasticities of demand and supply for crude oil in short-term time-frames. The review included analysis of the causes and effects of oil shocks, including the implications of the coincidence and interaction of causes of shocks. The causes included shifts in oil supply, refined product supply, speculative demand, and aggregate demand. The review also studied several examples of historical oil shocks, analysing potential causes and contextual influences. The aim was to draw out lessons from the mechanisms and effects of those shocks. The results of this review have been set out in Appendix C.

For the economic analysis, ACIL Tasman developed two scenarios and two elasticity cases:

* **Scenario 1** assumes seven refineries operating
  + relatively low elasticity case (Case A)
  + higher elasticity case (Case B)
* **Scenario 2** assumes four refineries operating
  + relatively low elasticity case (Case A)
  + higher elasticity case (Case B).

### Weeks 1 to 4

At the beginning of week 1 (1 February), the price of dated Brent crude was assumed to be around $110 per barrel. This was considered to be representative of a price free of precautionary and other speculative buying attributable to concerns over potential closure of the Strait.

For indicative purposes, it has been assumed that the speculative demand would be triggered in the first week in February 2012, and would strengthen over the next three weeks to reach 1.5 per cent of the previous world daily production rate.

#### Case A (relatively low elasticities)

For case A, it has been assumed, based on analysis in Appendix C, that very short-term global price elasticity of demand and supply for crude oil in early February was –0.04 and 0.015 respectively, rising to –0.075 and 0.025 in the second half of the month, as elapsed time facilitated adjustments to higher prices caused by speculative demand for crude oil. The assumed elasticities are towards the lower end of the range of estimates in the literature to allow for the very short-time frame (less than one month) relative to typical practice of basing estimates on monthly or quarterly data. This would result in a price increase of around 20 per cent. This is summarised in Table 12.

Table 12 **Elasticities and price impacts for Case A (low elasticities), relative to the reference case**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Week |  | Week prior | Weeks 1 and 2 | Weeks 3 and 4 |
| Demand shock | Proportion |  | +0.005 | +0.010 |
| Elasticity of demand | Proportion |  | –0.040 | –0.075 |
| Elasticity of supply | Proportion |  | 0.015 | 0.025 |
| Increase in price | Proportion |  | 0.091 | 0.100 |
| Index increase in crude oil price | Cumulative index |  | 1.091 | 1.2 |
| Dated Brent Marker price | $US/bbl | 110 | 120 | 132 |

Data source*: ACIL Tasman.*

#### Case B (high elasticities)

For the more conservative case B, it has been assumed that global price elasticities of demand and supply for crude oil are initially –0.06 and 0.0225, rising to –0.15 and 0.05. This would result in a price increase of around 11 per cent during February. This is summarised in Table 13.

Table 13 **Elasticities and price increases for Case B (high elasticities), relative to the reference case**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Week |  | Week prior | Weeks 1 and 2 | Weeks 3 and 4 |
| Demand shock | Percentage |  | +0.005 | +0.010 |
| Elasticity of demand | Percentage |  | -0.060 | -0.150 |
| Elasticity of supply | Percentage |  | 0.023 | 0.050 |
| Increase in price | Percentage |  | -0.083 | -0.200 |
| Index increase in crude oil price | Cumulative index |  | 1.061 | 1.114 |
| Dated Brent Marker price | $US/bbl | 110 | 117 | 123 |

Data source: ACIL Tasman

### Week 5

In the disruption scenario modelled by ACIL Tasman, the closure of the Strait is assumed to be triggered by an event leading to an immediate cessation of shipping.

While it is assumed that the Strait would be completely closed, the supply of crude oil and petroleum products from the region to customers worldwide would not immediately cease due to shipments already underway. There would be potential for a very significant oil price spike in the immediate aftermath of the closure.

Within 24-48 hours, the IEA would make a declaration of collective action, assumed to match the amount of oil taken off the market of approximately 15 Mb/d (see Section 3.7). The declaration, and even its anticipation, should help to calm panicked markets and moderate the oil price rise pending the market’s judgement on progress in the implementation of the collective action and the severity of the supply disruption.

#### Case A

Closure of the Strait of Hormuz would be a severe negative supply shock, which would trigger an additional speculative demand shock. The supply shock would be approximately one sixth of world production. While we assumed that the additional speculative demand would have been triggered in February in the context of rising tensions in the Persian Gulf region, the reality of closure of the Strait would add to this form of demand, pending responses from the international community. However, it could reasonably be assumed that speculative demand would be less than if the closure had been completely unexpected. Speculative demand in February would have increased stocks in anticipation of a potential supply shock. We have assumed a combined supply and additional speculative demand shock. The speculative demand shock is estimated to be around 2.25 million barrels per day or around 2.5 per cent of demand. This leads to a total supply/demand shock of around 19 per cent or 17.3 million barrels per day (excluding the previous speculative demand in February).

Because price increases in February would already have induced processes to adjust consumption and production, it could be expected that price elasticities of supply and demand would have been rising. For case A (low price elasticities), it has been assumed that price elasticities of demand and supply of -0.18 and 0.06, respectively, would apply in the first week of the supply shock with its associated additional speculative demand shock. In case A, there would be would be an indicative price spike of nearly 80 per cent, early in the first week of March. Consequently, the potential price increase from the beginning of February to early in the first week in March could be of the order of 116 per cent raising the oil price to $238 per barrel.

However, because of substantial International Energy Agency (IEA) stock releases following Hurricane Katrina in the Gulf of Mexico in August-September 2005, and disruption of Libyan oil supplies in 2011, a reasonable case could be made that market participants would anticipate large stock releases co-ordinated by the IEA in response to closure of the Strait of Hormuz. This anticipation would substantially moderate the indicative crude oil price increases suggested above. However, it would not completely pre-empt large price increases, because of uncertainty regarding various aspects of potential IEA releases. Further complicating the likely outcome is the effect that an IEA announcement would have in the presence of the Strait actually being closed, with large uncertainties and speculation no doubt occurring during the initial days of the first week in March.

On the one hand, the announcement of a substantial release that effectively negates the supply loss (see Section 5.4 below) would be expected to return prices back to those prevailing during week 4. Under this possibility the average price increase in week 5 compared to week 4 would be approximately 20 per cent, implying an average price of around $135 per barrel.

Of course, if a substantial portion of the market participants are of the view that there is a high risk of the supply disruption being prolonged, the IEA announcement may only reduce speculative demand, with the price reversal happening in week 6 (see Section 0).

The authors view either outcome as plausible given the terms of the disruption. However, for the purposes of the economic modelling we have opted for the latter outcome. Under this situation, the announcement by the IEA will reverse just the speculative demand element resulting in an average case A price increase over week 5 of 98.8 per cent, relative to the start of week 1. This implies an average week 5 price of $219 per barrel under case A (low elasticities). The proportional movements in supply/demand, price and elasticities are summarised in Table 14.

Table 14 **Elasticities and price changes for week 5 in Case A (low elasticities)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Week |  |  | 1st half of Week 5 | 2nd half of Week 5 | Average Week 5 |
| Supply/demand shock | Proportion |  | –0.191 | 0.038 |  |
| Elasticity of demand | Proportion |  | –0.18 | –0.18 |  |
| Elasticity of supply | Proportion |  | 0.06 | 0.06 |  |
| Change in price | Proportion |  | 0.800 | –0.160 |  |
| Index increase in crude oil price | Cumulative index |  | 2.160 | 1.815 | 1.988 |
| Dated Brent Marker price | $US/bbl | 110 | 238 | 200 | 219 |

*Data source*: ACIL Tasman

#### Case B

For case B (high elasticities), price elasticities of demand and supply of –0.35 and 0.12, respectively, have been assumed. The case B elasticities are at the high end of the range of estimated elasticities reported in the relevant literature.

In case B (high elasticities), the price of crude oil would increase by nearly 40 per cent in the first week of March, and by 60 per cent from early February to early March.

ACIL Tasman has assumed that the announcement of the stock release a relaxation of speculative demand would occur similar in percentage terms for demand/supply balance as adopted for case A. The impacts of the closure for week 5 are summarised in Table 15.

Table 15 **Elasticities and price changes for week 5 in Case B (high elasticities)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Week |  |  | 1st half of Week 5 | 2nd half of Week 5 | Average Week 5 |
| Supply/demand shock | Proportion |  | –0.191 | 0.038 |  |
| Elasticity of demand | Proportion |  | –0.32 | –0.32 |  |
| Elasticity of supply | Proportion |  | 0.12 | 0.12 |  |
| Increase in price | Proportion |  | 0.436 | –0.087 |  |
| Index increase in crude oil price | Cumulative index |  | 1.60 | 1.460 | 1.530 |
| Dated Brent Marker price | $US/bbl | 110 | 176.0 | 160.6 | 168.3 |

*Data source*: ACIL Tasman.

As with case A, ACIL Tasman has adopted the average price for the week as shown in the last column of Table 15.

### Week 6

Shipping is assumed to have recommended by Week 2, with at least 25 per cent of shipping being activated in practice. The IEA stock release would be completed towards the middle to the end of the second week.

In the context of the focus of this report, the IEA has advised the Department that it expects IEA members would authorise stock releases of the order of 15 million barrels. Presumably, such releases would be linked to a tentative time-frame of 30 days, as for the responses to supply disruptions linked to Hurricane Katrina and the Libyan conflict. The IEA indicated that such a response would be announced about 24 to 48 hours after closure of the Strait of Hormuz.

The indicative response suggested by the IEA would completely offset the supply shock, with a lag, for the duration of the period of stock releases. Inventories, including oil on the water, would cover the lag, which would be short, because government stocks and mandatory industry stockholdings are close to markets, particularly major markets. It could reasonably expected that the price effects of the supply shock would be completely reversed by the end of the second week in March, making the price spike short in duration.

It is important to recognise that there is a risk of IEA and other nations’ release of stocks could send the oil price to levels lower than at the commencement of the shock. For the purpose of this exercise, it has been assumed that coordinated action for stock release by IEA member countries would be targeted to the shortfall that the shock creates and would not overshoot the target driving the oil price down to this degree.

For modelling purposes the elasticities of demand and supply that applied in Week 5 are assumed to continue in the following weeks. This recognises the fact that the market would have been fundamentally changed by the event and low elasticities of demand are likely to continue for many months after the event in the light of perceived risks in the market.

The assumptions for the two scenarios are summarised in Table 16. The tables take into account the return of 25 per cent of supply through the Strait of Hormuz.

Table 16 **Elasticities and price changes for week 6 in Cases A and B**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Week 6 |  |  | Case A (low elasticities) | Case B (high elasticities) |
| Supply shock | Proportion |  | +0.169 | +0.169 |
| Elasticity of demand | Proportion |  | –0.18 | –0.32 |
| Elasticity of supply | Proportion |  | 0.06 | 0.12 |
| Change in price | Proportion |  | –0.451 | –0.307 |
| Index increase in crude oil price | Cumulative index |  | 1.2 | 1.11 |
| Dated Brent Marker price | $US/bbl | 110 | 132 | 123 |

Data source: ACIL Tasman.

The implications on the economic impact of the IEA release are discussed in Sections 0 and 5.5.

### Week 7

By the beginning of the seventh week, it is assumed that shipping would have returned to normal. The bulk of the IEA stock release would have reached the market during this week, covering the delayed shortfall caused by the initial closure of the Strait. There would thus be no material shortage of crude oil at any point during the disruption. The oil price would continue to decline towards pre-disruption levels. However the return would not be complete as IEA member countries and non-member countries seek to rebuild and restore their stocks to pre incident levels. ACIL Tasman understands that IEA member countries are allowed one year to replenish stocks.

However for this work ACIL Tasman assumed that stock rebuilding would not occur in this week. The oil price would remain the same as in week 6 for both elasticity cases.

### Week 8 and beyond

In the weeks and months following the ending of the disruption, IEA member countries would slowly rebuild their stock holdings to pre-disruption levels. With countries given 52 weeks by the IEA to replace stocks released (equal to 1.75 weeks of supply) during the disruption, the oil price is likely to be slightly elevated compared with the no-disruption case.

A total of 183 million barrels would have been withdrawn from stocks between week 5 and week 6. ACIL Tasman has assumed that the stocks would be replenished over a period of about four months, representing around 1.5 Mb/d or around 1.7 per cent of demand.

The impact on price for week 8 and beyond is summarised in Table 17.

Table 17 **Elasticities and price changes for week 8 and beyond in Cases A and B**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Week 8 and beyond |  |  | Case A (low elasticities) | Case B (high elasticities) |
| Demand shock | Proportion |  | 0.0173 | 0.0173 |
| Elasticity of demand | Proportion |  | –0.18 | –0.32 |
| Elasticity of supply | Proportion |  | 0.06 | 0.12 |
| Change in price | Proportion |  | 3.040 | 1.660 |
| Index increase in crude oil price |  |  | 1.124 | 1.078 |
| Dated Brent Marker price | $US/bbl | 110 | 124 | 119 |

Data source: ACIL Tasman

## Summary of effects

The price and shock effects are summarised in Table 18.

Over the period from week 1 to week 23, there is no net shortage of supply to markets as the IEA coordinated stock release fully compensates for the loss of around 183 million barrels during the two week period of the disruption. The principal impact would be on the price of crude oil and products in the market over this period. Movements in the dated Brent crude oil price and in Australian average prices for diesel and petrol are shown in Figure 9 for Case A and Figure 10 for Case B.

Table 18 **Price Shock Derivation**

| Timeframe | Occurrence | Price elasticities Case A (low elasticities) | Accumulated price outcome from start of Week 1 – Case A (low elasticities) | Price elasticities Case B (high elasticities) | Accumulated price outcome from start of Week 1 – Case B (high elasticities) |
| --- | --- | --- | --- | --- | --- |
| Weeks 1-2 | Speculative demand shock (+0.05%) | Ed = –0.04  Es = 0.015 | +9% | Ed = –0.06  Es = 0.0225 | +6% |
| Week 3-4 | Speculative demand shock (+1%) | Ed = –0.075  Es = 0.025 | +20% from start Week 1 | Ed = –0.15  Es = 0.05 | +11% from start Week 1 |
| Week 5 early | Supply shock –15 m b/d (–16.67%) plus speculative demand effect, 2.33% | Ed = –0.18  Es = 0.06 | +116% from start Week 1 | Ed = –0.35  Es = 0.12 | + 37% from Week 4  + 60% from start week 1 |
| Week 5 mid-late | IEA stock release announcement +15 m b/d | Ed = –0.18  Es = 0.06 | +82% from start Week 1 | Ed = –0.35  Es = 0.12 | +46% from start Week 1 |
| Week 5 average |  |  | +98.8% average for the week from start Week 1 |  | +53.0% average for the week from start Week 1 |
| Week 6 | Restoration of 25% of shipments | Ed = –0.18  Es = 0.06 | Oil price returns to that at end of week 4 | Ed = –0.35  Es = 0.12 | Oil price returns to that at end of week 4 |
| Week 7 | Restoration of 100% shipments | Ed = –0.18  Es = 0.06 | +20% from start week 1 | Ed = –0.35  Es = 0.12 | +11% from start week 1 |
| Week 8-23 | Unwinding speculative demand and re-building government and mandated stocks | Ed = –0.18  Es = 0.06 | +23.6% from start week 1 | Ed = –0.35  Es = 0.12 | +13% from start week 1 |
| Week 24 on | Completion of stock adjustments | Ed = –0.04  Es = 0.015 | Decline to price at start week 1 | Ed = –0.06  Es = 0.0225 | Decline to price at start week 1 |

*Data source*: ACIL Tasman

Figure 9Movements in crude oil and product prices – Case A (low elasticities)

|  |
| --- |
|  |

*Note:* Crude oil is represented by the dated Brent benchmark price. Product prices are approximate Australian averages based on South Australian price movements.

Source: *ACIL Tasman*

Figure 10Movements in crude oil and product prices – Case B (high elasticities)

|  |
| --- |
|  |

*Note:* Crude oil is represented by the dated Brent benchmark price. Product prices are approximate Australian averages based on South Australian price movements.

Source: ACIL Tasman

The figures show the oil price rising in the weeks prior to the shock due to speculative buying and stock build followed by a peak in the first half of week 5 (the first week of closure of the Strait) and falling back in the second half of week 5 as speculative demand falls and stocks begin being released into the market to take advantage of the high prices. In week 6, the price in both cases falls again as IEA stocks plus 25 per cent of shipments through the Strait recommence.

Prices remain elevated in week 8 as IEA countries begin rebuilding stocks. This lasts for the remainder of the period to week 23. Prices fall back to the original price in week zero once the stock rebuild is concluded.

## Other possible scenarios

### Other analysts views

There are some oil industry analysts who consider that a closure would persist for more than that assumed in this scenario. For example according to Michael Singh, managing director of the Washington Institute and a former senior director for Middle East affairs at the National Security Council,

“It is unlikely that Iran could close the Strait for a meaningful period of time. Any Iranian effort to seize control of the Strait would meet swift and determined resistance from the U.S. Navy, with the support of U.S. allies in the region and beyond. Iran’s regular navy and air force are no match for their U.S. counterparts; both would almost certainly be dispatched quickly in any outright confrontation. Recognizing this, Iran is more likely to use the asymmetric warfare capabilities of the elite Islamic Revolutionary Guard Corps Navy to disrupt shipping through the Strait and to harass U.S. forces. The Revolutionary Guards could use small boats (either individually or in “swarms”); influence mines (which do not require that a ship run into them); midget submarines; anti-ship cruise missiles; and even divers. These tactics could be a nuisance, but they are also unlikely to shut the Strait. Yet they would probably provoke a strong U.S. response.”[[8]](#footnote-8)

According to a New York Times article published on January 13,

“Estimates by naval analysts of how long it could take for American forces to reopen the strait range from a day to several months, but the consensus is that while Iran’s naval forces could inflict damage, they would ultimately be destroyed.”[[9]](#footnote-9)

A Reuters report from 5 January 2012 asserted that:

“Should Iran's rulers ever make good their threats to block the Strait of Hormuz, they could almost certainly achieve their aim within a matter of hours. But they could also find themselves sparking a punishing – if perhaps short-lived – regional conflict from which they could emerge the primary losers. ..... Few believe Tehran could keep the strait closed for long – perhaps no more than a handful of days....”[[10]](#footnote-10)

Mark Thompson, in “Can Iran Close The Strait of Hormuz” Battleland.Blogs.Time.com, December 28, 2011, quotes a 2008 Naval War College study by Navy Commander Rodney Mills as stating:

"There is consensus among the analysts that the U.S. military would ultimately prevail over Iranian forces if Iran sought to close the strait. The various scenarios and assumptions used in the analyses produce a range of potential timelines for this action, from the optimistic assessment that the strait would be open in a few days to the more pessimistic assessment that it would take five weeks to three months to restore the full flow of maritime traffic."

A September 2011 report from CNA (Centre for Naval Analyses) stated:

"A detailed analysis of this question was conducted by [Caitlin] Talmadge using a scenario in which Iran was able to lay several hundred mines in the Strait and the Persian Gulf. In her analysis, Talmadge assumes the U.S. considers its mine countermeasure (MCM) forces too vulnerable and scarce to use in a hostile environment, and so would instead wait to use them until it had essentially eliminated the threat from [antiship cruise missiles] ASCMs. Using a technical analysis of U.S. air and Iranian ASCM and air-defence capabilities, she concluded it could take between 9 and 72 days for the U.S. to do so. Using mine-clearance rates based on previous efforts in the Persian Gulf (e.g., Operation Candid Hammer), she concluded it would take between 28 and 40 days to adequately clear the minefields. Putting these two timelines together, she concluded overall that it could take 37 to 112 days for the U.S. to reopen the Strait under such a scenario. Many of her assumptions regarding Iranian capabilities were subsequently disputed as giving the Iranians too much credit, but the disputer did not rule out completely the capability of Iran to threaten the Strait."[[11]](#footnote-11)

The assumptions behind the chosen scenario are not intended to be interpreted as a prediction of the likely progression of a closure. However, some discussion is provided of their implications for the results reported in this report in Section 5.

# Economic impacts

The approach taken to modelling the economic impacts of the scenarios has been discussed in Section 2 and in Appendix B.

For the economic analysis, ACIL Tasman developed two scenarios and two elasticity cases:

* **Scenario 1** assumes seven refineries operating
  + relatively low elasticity case (Case A)
  + higher elasticity case (Case B)
* **Scenario 2** assumes four refineries operating
  + relatively low elasticity case (Case A)
  + higher elasticity case (Case B).

The economic impacts reported below are based on the difference between each scenario and its respective reference case. As discussed in Section 2.4, the reference scenarios already take into account the resource impacts of closing three refineries.

## Measures of macroeconomic impacts

One of the most commonly quoted macroeconomic variables at a national level is GDP which is a measure of the aggregate output generated by an economy over a period of time (typically a year). From the expenditure side, GDP is calculated by summing total private and government consumption, investment and net trade.[[12]](#footnote-12)

Although changes in real GDP are useful measures for estimating how much the output of the relevant economies may change, change in the **real income** of a region is a more relevant measure of the change in economic welfare of the residents of a region. Indeed, it is possible that real GDP can increase with no, or possibly negative, changes in real income. In *Tasman Global*, a change in real income at the national level is synonymous with change in real gross national disposable income (RGNDI) reported by the ABS.

Real income is equivalent to real economic output plus net foreign income transfers, while the change in real income is equivalent to the change in real GDP, plus the change in net foreign income transfers, plus the change in terms of trade, which measures changes in the purchasing power of a region’s exports relative to its imports[[13]](#footnote-13). As Australians have experienced first-hand in recent years, changes in terms of trade can have a substantial impact on people’s welfare independently of changes in real GDP. Change in real income (as projected by *Tasman Global*) is ACIL Tasman’s preferred measure of the change in economic welfare of residents.

## Results

The results from week 1 to week 23 are shown in Table 19.

Table 19 **Results from Week 1 to Week 23, relative to the reference case**

|  | Scenario 1 – 7 refineries | | Scenario 2- 4 refineries | |
| --- | --- | --- | --- | --- |
|  | Case A (Low elasticities) | Case B (High elasticities) | Case A (Low elasticities) | Case B (High elasticities) |
|  | 2012 A$m | 2012 A$m | 2012 A$m | 2012 A$m |
| **Real GDP** |  |  |  |  |
| Australia | -556 | -465 | -561 | -470 |
| China | -3,933 | -2,673 | -3,861 | -2,681 |
| India | -1,657 | -1,917 | -1,653 | -1,912 |
| Japan | 5,158 | 2,122 | 5,157 | 2,116 |
| South Korea | 237 | 86 | 340 | 89 |
| ASEAN | -3,541 | -1,898 | -3,334 | -1,901 |
| Middle East | -88,421 | -65,883 | -88,558 | -65,722 |
| EU 27 | -4,577 | -6,602 | -4,579 | -6,612 |
| USA and Canada | 21,030 | 12,974 | 20,999 | 12,920 |
| Rest of Asia and Oceania | -1,201 | -874 | -1,152 | -870 |
| Rest of World | -7,120 | -5,658 | -7,109 | -5,644 |
| **World** | **-84,580** | **-70,787** | **-84,312** | **-70,687** |
| **Real income** |  |  |  |  |
| Australia | -3,118 | -2,148 | -3,108 | -2,141 |
| China | -35,973 | -20,059 | -35,840 | -20,042 |
| India | -14,335 | -8,588 | -14,313 | -8,573 |
| Japan | -19,470 | -11,159 | -19,388 | -11,119 |
| South Korea | -9,518 | -5,025 | -9,356 | -5,003 |
| ASEAN | -12,945 | -6,926 | -12,672 | -6,916 |
| Middle East | 21,869 | -8,463 | 21,373 | -8,455 |
| EU 27 | -68,665 | -41,858 | -68,567 | -41,807 |
| USA and Canada | -35,386 | -17,340 | -35,325 | -17,344 |
| Rest of Asia and Oceania | -4,753 | -2,777 | -4,687 | -2,770 |
| Rest of World | 97,715 | 53,554 | 97,570 | 53,482 |
| **World** | **-84,580** | **-70,787** | **-84,312** | **-70,687** |

Note: ‘Rest of World’ includes the rest of OPEC plus other large oil producers  
Data source: ACIL Tasman modelling.

### Impacts for Australia

#### Real GDP

The results show that for Scenario 1, Australia’s GDP is $556 million lower over the 23 weeks under the low elasticities case (case A) and $465 million lower under the high elasticities case (case B). These losses represent –0.087 per cent and –0.073 per cent of GDP that would be produced over the 23 week period respectively.

The results for Scenario 2 are not significantly different. The reason is first, the nature of the shock (as characterised in Chapter 4) is affecting crude oil margins rather than refinery margins and second, that the impacts are estimated relative to a reference case where only 4 refineries are operating. As discussed earlier, the scenarios are compared to different reference cases, which removes the economic impact of differences in the number of operating refineries.

#### Real income

Under scenario 1 real income is reduced by $3,118 million over the 23 weeks under the low elasticity case and $2,148 under the high elasticity case. Under scenario 2 real income loss over the 23 weeks is $3,108 million under the low elasticity case compared to $2,141 million under the high elasticity case. In each scenario, these losses represent just under 0.5 per cent and just over 0.3 per cent of the real income that would be produced over the 23 week period respectively.

The larger projected loss in Australia’s real income compared to the change in real GDP can be attributed to the change in terms of trade arising from the increase in the price of crude oil and petroleum products.[[14]](#footnote-14)

The larger difference in real incomes under the low and high elasticity cases than arose for GDP can be attributed mainly to the fact that under the low elasticity case, Australia pays higher prices for more crude oil and petroleum products than under the high elasticity case. As a significant proportion of the crude oil and product is imported, the income transfers abroad (via the terms of trade loss) are higher which reduces real incomes.

In summary, for the two reasons noted above, the operation of four refineries rather than seven will have a negligible impact on the fall in GDP and in real incomes resulting from the oil supply shock. The impact on real incomes is more significant than the impact on GDP because Australia is a net importer of crude oil and petroleum products and the higher prices paid increases income transfers abroad. This is not offset by higher prices for petroleum exports in the short term.

#### Exchange rate and trade

In *Tasman Global*, it can be shown from the macroeconomic accounting identities that the change in the capital account (namely, savings less investment) equals the change in the trade account (namely, exports minus imports). Change in the real exchange rate is the mechanism by which this identity is achieved in the model. There is a range of ways to describe what the real exchange rate in CGE models such as *Tasman Global* represents. At heart though, a declining real exchange rate implies a reduction in purchasing power of the regional output bundle relative to the global average. Similarly, an appreciation of the real exchange rate is akin to an increase in terms of trade where the purchasing power of the region’s output increases.

As discussed previously, the primary impact of the supply disruption is not a change in output but a change in the cost of imported crude oil and petroleum products. This is equivalent to a net wealth transfer from regions that are net importers of crude oil and petroleum products to those that are net exporters. In the case of Australia, the net wealth transfer results in lower real income which results in lower savings, relative to the reference case. In the model closure used for this analysis, (to the first order) investment moves with real GDP. Consequently, there is a net decline in Australia’s capital account (that is, savings fall relative to investment). Countries that are more exposed to the increase in crude oil and product prices will have a bigger loss in their trade account which needs to be balanced by bigger changes in their capital account[[15]](#footnote-15).

To balance the macroeconomic identities, the real exchange rate therefore needs to move to create a net decline in the trade account (that is, to reduce the value of exports relative to imports). This happens simultaneously across all regions to solve for the suite of bilateral real exchange rates to clear global physical and financial traded markets.

The projected changes in Australia’s bilateral exchange rates are presented in Table 20. As can be seen, over the 23 weeks Australia’s real exchange rate is projected to depreciate relative to the major oil exporting regions but is projected to appreciate relative to most of our major trading partners, including for example European Union countries that are particularly vulnerable to interruptions. In particular, under Scenario 1, Australia’s real exchange rate (on a trade-weighted basis) is projected to appreciate by an average of 0.69 and 0.29 per cent relative to the reference case under the low and high elasticities cases, respectively. Similar changes are projected under Scenario 2.

Table 20 **Average change in Australian bilateral real exchange rates (Week 1 to 23), relative to the reference case**

|  | Scenario 1 – 7 refineries | | Scenario 2 – 4 refineries | |
| --- | --- | --- | --- | --- |
|  | Case A (Low elasticities) | Case B (High elasticities) | Case A (Low elasticities) | Case B (High elasticities) |
|  | Per cent | Per cent | Per cent | Per cent |
| China | 0.41 | 0.11 | 0.41 | 0.11 |
| India | 0.31 | 0.04 | 0.32 | 0.04 |
| Japan | –0.15 | 0.02 | –0.16 | 0.02 |
| South Korea | 0.54 | 0.24 | 0.53 | 0.24 |
| ASEAN | –0.90 | –0.43 | –0.90 | –0.43 |
| Middle East | –9.36 | –4.34 | –9.32 | –4.33 |
| EU 27 | 9.21 | 4.30 | 9.17 | 4.29 |
| USA and Canada | 0.01 | –0.07 | 0.01 | –0.07 |
| Rest of Asia and Oceania | 0.51 | 0.30 | 0.50 | 0.30 |
| Rest of World | –4.00 | –2.21 | –3.98 | –2.21 |
| **World** | **0.69** | **0.29** | **0.69** | **0.29** |

Data source: ACIL Tasman modelling

#### Impact on selected industry sectors

The impact on real industry output for selected industry sectors is shown in Table 21. In interpreting these results it is important to note as a result of the characterisation of the disruption event that the impacts are small relative to the size of the sectors.

This shows that the biggest impact on output occurs in the services sector. The change in real output over this period is –0.08 per cent (–$706 million) for case A (low elasticities) and –0.08 per cent (–$679 million) under case B (high elasticities) under Scenario 1. The results for Scenario 2 are not significantly different. It is important to note that the services sector comprises around three quarters of the Australian economy and final demand for services is the most sensitive to changes in real income.

The manufacturing sector gains 0.08 per cent ($171 million) under case A (low elasticities) and 0.08 per cent ($156 million) under case B (high elasticities) under Scenario 1. The results for Scenario 2 are not significantly different. This arises primarily through a slight switching toward domestically manufactured goods away from imported goods as a result of the lower proportionate increase in the retail prices.

For both scenarios, agriculture is projected to lose real output of 0.21 per cent ($64 million) and 0.07 per cent ($22 million) under case A (low elasticities) and case B (high elasticities), respectively. Agriculture is a relatively high user of diesel fuel (as a share of their total costs) and the higher prices for diesel are the main cause of the loss of real income.

Mining output increases by around 0.06 per cent ($57 million) under case A (low elasticities) and falls by 0.08 per cent ($76 million) under case B (high elasticities) in each Scenario. While diesel fuels are important in mining operations and in transport services, fuel costs are not a significant component of the total cost structure in the mining industry (particularly at current commodity prices). The projected impacts on the mining industry are mixed, however, indicating that the direction of the impact is quite sensitive to the assumptions used in the modelling.

Transport sector output falls by 0.21 per cent ($109 million) and 0.12 per cent ($60 million) under case A (low elasticities) and case B (high elasticities), respectively under Scenario 1. The results for Scenario 2 are not significantly different.

Table 21 **Changes in real industry output for selected industries (Week 1 to 23), relative to the reference case**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Scenario 1 – 7 refineries | | | | Scenario 2- 4 refineries | | | |
|  | Case A (Low elasticities) | | Case B (High elasticities) | | Case A (Low elasticities) | | Case B (High elasticities) | |
|  | 2012 A$m | Per cent | 2012 A$m | Per cent | 2012 A$m | Per cent | 2012 A$m | Per cent |
| Agriculture | –63.9 | –0.21 | –21.9 | –0.07 | –63.4 | –0.21 | –21.7 | –0.07 |
| Mining | 57.4 | 0.06 | –75.9 | –0.08 | 54.3 | 0.05 | –77.2 | –0.08 |
| Manufacturing | 170.6 | 0.08 | 156.4 | 0.08 | 173.2 | 0.09 | 157.8 | 0.08 |
| Air/road/rail transport | –108.6 | –0.21 | –60.5 | –0.12 | –105.7 | –0.20 | –58.6 | –0.11 |
| Other services | –706.0 | –0.08 | –679.0 | –0.08 | –703.6 | –0.08 | –674.6 | –0.08 |

Note: Mining includes petroleum, gas, coal and other minerals extraction.

Data source: ACIL Tasman modelling

### Impacts on other countries

The Countries that experience the largest impact on real GDP are the Middle East, the European Union, Japan, South Korea, North America and India. However, when the impact on real incomes is considered the countries that are the higher losers include the European Union, United States and Canada, China and Japan.

The Middle East experiences a fall in GDP ($88,421 million) but a rise in real income ($21,869 million) under Scenario 1, because it can export at higher prices in the weeks prior to week 5 as well as during the months after the reopening of the Strait as IEA countries rebuild their stocks. Given the assumed inelastic nature of demand and supply, the benefit of the higher prices is projected to offset the large income losses that occur in weeks 5 and 6 (when the Strait were closed). Excluding the impact of the stock rebuilding phase, the Middle East is projected to lose a total of $9.7 billion of real income in weeks 1 to 7 under Scenario 1 (and a loss of $17.2 billion under Scenario 2). It is likely that if the stock rebuilding phase occurred over a longer time frame than assumed in this analysis the projected aggregate benefit to the Middle East under Scenario 1 would be less or even negative.

The Rest of World (which includes the rest of OPEC plus other large oil producers) is projected to experience a net increase in real incomes under all scenarios.

### Liquid fuel consumption

The temporary closure of the Strait causes liquid fuel consumption in Australia to decline relative to the base case over the 23-week period. As can be seen in Figure 11, the decline is most pronounced in week 5 (coinciding with the price spike in that week shown previously in Figure 9 and Figure 10), when the decline ranges from 7.08 per cent to 7.90 per cent (78.3 ML to 87.4 ML) depending on the case and scenario. Liquid fuel consumption remains below the baseline level during the stock rebuilding phase (weeks 8 to 23).

Figure 11Percentage decline in liquid fuel consumption relative to the base case

|  |
| --- |
|  |

Note: Liquid fuels include LPG, petrol, jet fuel, diesel, fuel oil, bitumen and lubes  
Source: ACIL Tasman

## Comparison with Singapore product supply shock

In 2011, as part of an overall assessment of Australia’s liquid fuels vulnerability, ACIL Tasman modelled the economic impacts of a 30-day interruption of shipping of crude oil and petroleum products into and out of Singapore.

After allowing for the time it takes to ship crude oil to Singapore, refine crude oil, store and blend sufficient oil products, break-up cargos, and ship crude oil and refined products to Australia, it was estimated that the interruption of supply from Singapore to Australia could last for 45 to 60 days. The incident would temporarily remove around 1.72 per cent of world refinery capacity from the market (around 1.3 million barrels per day of refined product).

Key differences between the Singapore disruption and the Strait of Hormuz disruption scenarios include:

1. The Singapore scenario represented a disruption in the supply of petroleum products to Australia compared with a disruption in the supply of crude oil represented in the Strait of Hormuz scenarios.
2. The Singapore interruption was for one month as opposed to two weeks for the Strait of Hormuz interruption.
3. The Singapore shock involved a loss of around 90 million barrels of product in total from the market over a period of around two months after allowing for start up and recovery times for Singapore refineries.
4. The Singapore scenario did not assume a month-long build-up of stocks prior to the disruption nor a coordinated release of stocks by IEA member countries.
5. The economic modelling for the Singapore shock was undertaken on a month-by-month basis over a period of 4 months whereas the Strait of Hormuz modelling was based on week-by-week modelling over a period of 23 weeks.
6. The Singapore modelling assumed that unemployment arose over the period whereas the Strait of Hormuz modelling did not.

The demand and supply elasticities assumed in the modelling of the Singapore disruption and the resultant month-by-month price changes are shown in Table 22.

Table 22Assumed elasticities and resultant price changes in Singapore disruption scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Disruption occurring in 2011** | | | **Disruption occurring in 2015** | | |
|  | Month 1 | Month 2 | Month 3 | Month 1 | Month 2 | Month 3 |
| Elasticity of demand | –0.10 | –0.15 | na | –0.10 | –0.15 | na |
| Elasticity of supply | 0.04 | 0.10 | na | 0.02 | 0.05 | na |
| Percentage change in quantity | –1.72 | –1.72 | 0.00 | –1.72 | –1.72 | 0.00 |
| Percentage change in price | 12.3 | 6.9 | 0.00 | 14.3 | 8.6 | 0.00 |
| Assumed impact of precautionary demand | 5.7 | 3.7 | 2.00 | 6.7 | 5.4 | 3.5 |
| Percentage change in price | 18.00 | 10.6 | 2.00 | 21 | 14 | 3.5 |

Data source: ACIL Tasman, Liquid Fuels Vulnerability Assessment, October 2011

ACIL Tasman’s modelling of the Singapore scenario indicated that the total loss in GDP over 4 months would be $1,382 million if the shock occurred in the short term (2011). This is significantly higher than the loss of GDP estimated for closure of the Strait of Hormuz which was calculated to be around $556 million.

The total loss in real income in the Singapore case was estimated at $2,145 million if the disruption occurred in 2011. This compares with the real income loss of $2,148 – $3,118 million over 23 weeks for the Strait of Hormuz disruption.

The Strait of Hormuz event involves a much larger disruption than the Singapore event (15 million barrels per day compared to 1.3 million barrels per day). However, its economic impacts as modelled by ACIL Tasman are mitigated by a number of factors discussed below.

While the price spike in week 5 of the case of the Strait of Hormuz is significantly higher than the price increase in the Singapore case, it is a transient event. Most of the time, the elevated prices in the Strait of Hormuz incident are caused by speculative buying before the event and restocking by IEA countries after the event. For most of these weeks, the product price rise from the closure of the Strait of Hormuz incident is less than that for the Singapore incident (see Figure 12).

Figure 12Product price rises for Strait of Hormuz compared to Singapore

|  |
| --- |
|  |

Source: ACIL Tasman

In the absence of the release of IEA stocks in the Strait of Hormuz case, the economic impact would be much higher.

A further important difference in the modelling of the economic impacts between the two incidents is the assumption about unemployment. In the Singapore incident, it was assumed that unemployment effects should be taken into account because it extended for sufficient time to allow reduced economic activity to lead to layoffs.

In the Strait of Hormuz incident it was assumed that there would be no unemployment effects as the duration of the incident was so short and that, in aggregate, the supply of oil was not lost (rather the sources of supply and speculative/precautionary demand changed resulting in short term price effects). If the labour market were made more responsive the projected loss in Australian real GDP would be expected to be five to ten times greater than the impacts reported in this analysis. Similarly, the change in real incomes would be expected to be two to three times greater.

There are other more technical differences in the modelling. ACIL Tasman refined the Tasman Global data base and modelling approach to better simulate the very short term dynamics of the supply shock for the Strait of Hormuz, including the integration of the assumed elasticities in global oil markets and specifying how the oil is supplied (i.e. from standard production or from stock releases).

## Implications of IEA collective action

In the 2011 *Liquid Fuels Vulnerability Assessment*, ACIL Tasman indicated that

The effect of IEA collective action, particularly a stock draw, could be highly significant if undertaken promptly and if the response is commensurate with the supply shock. There is no question that IEA collective action to release refined product stocks can significantly calm the market and hence reduce the likelihood of extreme price outcomes in the event of a refined products supply shock. (p.97)

This assertion has been borne out by the modelling results for the Strait of Hormuz disruption, even though this disruption affects supplies of both crude and product to Australia (the latter via its impact on the supply of feedstock of Asian refineries from which Australia imports products). The early intervention by IEA member countries announcing the release of stocks in the first week of the closure has a very important effect on the economic impact of the closure. The release of 184 million barrels of crude oil equivalent stocks would effectively offset completely the loss from the crude oil and product traditionally shipped through the Strait (105 million barrels in week 5 and 78.75 million barrels in week 6). The stocks released by IEA member countries represents less than 5 per cent of the total stocks of crude oil and petroleum product held on land by IEA countries as at end December 2012 (around 4,000 million barrels).

The IEA stock release would also be augmented by release of stocks previously built-up from speculative buying in the month leading up to the closure of the Strait. The price increase caused by the speculative demand would also induce an increase in production and supply prior to the shock.

The release of stocks under IEA collective action would have a very important effect on the oil market. It would quickly reverse the price effect of the supply shock caused by closure of the Strait and the associated speculative demand shock. However, it would not cause a complete unwinding of precautionary and other speculative stock build-up, because of lingering uncertainty regarding the length and severity of the closure and possible additional conflict-related oil supply disruptions in the region.

The source of the economic impact is not limited to the two weeks of complete or partial closure of the Strait. It commences around four weeks before the closure with increased uncertainty and tensions prompting precautionary buying which increases demand and increases the price by up to 20 per cent under the low elasticity scenario. The price spikes to 116 per cent above the 1 February price under the assumed supply shock and associated speculative demand shock in the first few days, but this is reduced to around 80 per cent after the IEA announcement of collective action.

By week 8 the price increase has fallen back to around 12 per cent above the 1 February price under the low elasticity scenario which continues for another 16 weeks while stocks are replenished.

The greatest weekly impact for Australia and the rest of the word occurs in week 5 – the first week of the closure. The economic impact for this week is shown in Table 23.

Comparing the economic impacts for Australia for Scenario 1 – Case A (low elasticities) the relative impacts for week 5 are:

* a loss of $70 million in GDP (compared with a loss of $556 million over the full 23 weeks)
* a loss of $462 million in real income (compared with a loss of $3,118 million over the full 23 weeks).

This means that around 13-15 per cent of the economic impact occurs in the first week of the closure (week 5). Truncation of the price spike by the IEA announcement and subsequent stock release significantly reduces the cost of the closure to Australia as well as to the rest of the world.

Table 23 **Results for week 5 – the first week of the closure, relative to the reference case**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Scenario 1 – 7 refineries | | Scenario 2 – 4 refineries | |
|  | Case A (Low elasticities) | Case B (High elasticities) | Case A (Low elasticities) | Case B (High elasticities) |
|  | 2012 A$m | 2012 A$m | 2012 A$m | 2012 A$m |
| **Real GDP** |  |  |  |  |
| Australia | -70 | -59 | -70 | -59 |
| China | -310 | -219 | -313 | -220 |
| India | -386 | -412 | -386 | -411 |
| Japan | -791 | -714 | -790 | -713 |
| South Korea | -384 | -325 | -384 | -325 |
| ASEAN | -139 | -90 | -139 | -90 |
| Middle East | -7,545 | -6,448 | -7,528 | -6,432 |
| EU 27 | -4,431 | -3,407 | -4,425 | -3,402 |
| USA and Canada | -1,114 | -887 | -1,113 | -886 |
| Rest of Asia and Oceania | -80 | -63 | -79 | -63 |
| Rest of World | -31 | -237 | -31 | -236 |
| World | **-15,282** | **-12,861** | **-15,257** | **-12,838** |
| **Real income** |  |  |  |  |
| Australia | -462 | -311 | -459 | -310 |
| China | -5,483 | -2,884 | -5,479 | -2,881 |
| India | -2,480 | -1,460 | -2,476 | -1,458 |
| Japan | -3,817 | -2,305 | -3,806 | -2,298 |
| South Korea | -1,685 | -998 | -1,680 | -996 |
| ASEAN | -1,552 | -814 | -1,548 | -812 |
| Middle East | 1,694 | -1,997 | 1,692 | -1,991 |
| EU 27 | -12,365 | -7,656 | -12,350 | -7,645 |
| USA and Canada | -6,570 | -3,771 | -6,566 | -3,768 |
| Rest of Asia and Oceania | -625 | -343 | -624 | -342 |
| Rest of World | 18,063 | 9,677 | 18,040 | 9,663 |
| World | **-15,282** | **-12,861** | **-15,257** | **-12,838** |

Data source: ACIL Tasman

There is a corollary to this, however. The fact that the oil industry participants know that the IEA stocks are available also serves as a disincentive for suppliers and consumers to hold stocks for their own insurance value against disruption. That said, there are geopolitical and strategic benefits and other non-priced spillovers that are not captured in the economics of commercial stocks.

## Implications of departure from the assumed scenario

The supply shock analysed in this report does not lead to a shortage in supply of crude oil or petroleum product to markets anywhere in the world. The return of shipping through the Strait of Hormuz within two weeks falls within the shipping time from the Strait to most Asian refineries. In addition, the coordinated release of stocks by IEA countries is capable of meeting any shortfalls in Asia, Europe and the Americas. It was also noted that other countries, including Saudi Arabia and China, hold stocks close to markets that would also act to moderate the impact.

The shipping time to Australian refineries is sufficient to permit continuous supply through both oil on the water and oil from the global stock draw by IEA countries. At any one time, there is over 14 day’s supply (or 65,000 ML) of crude oil in tankers destined for Australia and over 14 day’s supply (or 157,000 ML) of petroleum product from Asian refineries that is refined from crude oil from the Middle East. The analysis assumes that Australia does not participate in a pre-event stock build nor in a draw of stocks from Australian based supplies. There is therefore theoretically a total of between 14 to perhaps 21 days of supply of crude oil and product on the water to supply Australia.

The sole impact of the closure is to increase the price of crude oil and petroleum product over the 23 week period of the event envelope and especially in weeks 5 and 6 when the Strait is affected. It is the price increase that reduces consumption in Australia and causes the economic loss both globally and in Australia.

The economic cost would increase significantly, however, if the closure extended beyond two weeks and the IEA collective action were not implemented. If these two assumptions were changed, physical shortages would extend through to markets around the world and in Australia. This would have two important effects relevant to the size of the economic impact. In the first instance, the initial price spike would persist, reducing consumption and rationing and reallocating scarce supply, and causing much greater economic contraction. With more time the price elasticity of demand and supply would also increase, meaning greater responsiveness of quantity demanded and supplied to price.

It would be expected, however, that the elevated price would also induce a larger draw on commercial stocks and strategic stocks held around the world by individual countries, such as the United States, China and Saudi Arabia. This uncoordinated action, combined with increased production from other suppliers, would moderate the price rise, with the role of increased production elsewhere increasing over time and the role of stock releases diminishing with time as stocks are run down.

Despite these moderating responses, the economic costs would rise substantially without IEA collective action and with prolongation of closure of Strait of Hormuz. These two matters are not independent. It is likely that the potential of IEA collective action would impede action leading to prolonged closure of the Strait. ACIL Tasman has not modelled these impacts, and therefore, is not in a position to opine on the magnitude of the economic impacts.

However, our qualitative analysis underscores the role that IEA collective action and other stock draw strategies play in reducing the duration of the price rise resulting from extended disruption of oil and industry supply chains that would result in substantially higher economic loss resulting from closure of the Strait.

# Key findings and conclusions

This study examined the economic impact of a hypothetical closure of the Strait of Hormuz occurring on 1 March 2012. The closure was assumed to result in a complete blockage of shipping for the first week in March followed by resumption of 25 per cent of shipping in the second week and 100 per cent resumption in the third week. The net impact on supplies of crude oil of total closure would have been around 15 million barrels per day allowing redirection for around 2 million barrels per day via pipeline. The quantity of petroleum product disrupted is by comparison relatively small – less than 0.14 million barrels per day in crude oil equivalent.

The study found that the economic impacts would commence well before the actual event as a result of precautionary and other speculative demand increasing demand by up to 1.3 million barrels per day in the month before the event. This could increase prices before the event by up to 20 per cent over the prices that would have occurred in the absence of fears regarding disruption of supply through the Strait. For this study it was assumed that the economic impacts begin four weeks prior to 1 March and continue until week 23. This represents the event envelope for the purposes of this study.

Once the event occurs (week 5 of the event envelope) prices are projected to initially spike by up to around 116 per cent over prices at the beginning of February, as the oil market adjusts to the loss of around 20 per cent of crude oil supplies.

However the study also found that an announcement by the IEA in the first week of the disruption (week 5) of release of up to 15 million barrels per day of stocks effectively neutralises the supply shock and partly reverses the cumulative speculative demand shock, moderating the price surge to around 80 per cent. As a result, the average price during the week of the supply disruption could be nearly double that of if the disruption event did not happen. However, depending on the state of anxiety and information available at the time, it was found that the IEA announcement could very quickly return prices back to those prevailing before the disruption with the average price of oil during the first week of the disruption being only $135 per barrel. Both outcomes were deemed plausible by the authors, but only the first was used for the purposes of the economic impact modelling.

Resumption of 25 per cent of the shipments in the second week (the sixth week of the event envelope) and commencement of delivery of stocks under the IEA collective action effectively returns supplies to pre-closure levels and returns prices to around 20 per cent above what they would have been if the blockage and prior speculative demand had not occurred. It was assumed that, under the collective action, the release of stocks would be timed in such a way as to prevent any physical shortages.

Stock rebuilding by IEA member countries was projected to occur between week 8 and week 23 of the event envelope. During this time oil prices were projected to be up to 24 per cent higher than they would otherwise have been.

The release of IEA member country stocks in the first two weeks of the event (weeks 5 and 6) pre-empts any oil supply shortfall as stocks on the water are sufficient to continue supplying refineries until the IEA stocks reach their markets. The principal impact therefore is a rise in oil prices over the 23 week period

The economic impacts therefore occur from week 1 at the beginning of February to week 23.

The economic impact arises because of the rise in the price of crude oil globally. The estimated price rises are summarised in Table 24. The table summarises the price rises for the low and high elasticity cases. Recent research reviewed for this report suggests that short term elasticities of supply and demand are now lower than they were in past decades, meaning that price effects of supply and demand shock are likely to be greater now than historically. The impact on prices is not affected by the number of refineries operating in Australia as petroleum product prices are set to import parity levels.

Table 24Average weekly prices (real as at Jan 2011)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Week |  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 - 23 | 24 + |
| **Case A** | Crude oil price | $US/bb Dated Brent | 110 | 120 | 120 | 132 | 132 | 219 | 132 | 132 | 124 | 110 |
|  | Petrol price in Australia | c/l | 148 | 154 | 154 | 161 | 161 | 213 | 161 | 161 | 164 | 148 |
|  | Diesel price in Australia | c/l | 157 | 165 | 165 | 175 | 175 | 247 | 175 | 175 | 178 | 157 |
| **Case B** | Crude oil price | $US/bb Dated Brent | 110 | 117 | 117 | 123 | 123 | 168 | 123 | 123 | 119 | 110 |
|  | Petrol price in Australia | c/l | 148 | 152 | 152 | 156 | 156 | 183 | 156 | 156 | 157 | 148 |
|  | Diesel price in Australia | c/l | 157 | 163 | 163 | 167 | 167 | 205 | 168 | 168 | 169 | 157 |

*Note:*. Prices assume US/AUS dollar exchange rate at parity

Source: ACIL Tasman

The principal economic impact on Australia of the closure of the Strait of Hormuz for two weeks is on real income which falls by between $2,148 million (high elasticity case) and $3,118 million (lower elasticity case) over the 23 weeks of the event envelope under Scenario 1. Slightly over 50 per cent of this arises in week 5 – the first week of the closure. This illustrates the importance of the IEA collective action being announced and implemented in the first two weeks of closure and its effect on the supply and speculative demand shocks.

These impacts are not significantly different for the 7 oil refinery (Scenario 1) or 4 oil refinery (Scenario 2) configurations. This arises for two reasons. First, the characterisation of the supply disruption scenario impacts the price of crude oil and (unlike other potential disruptions) not refinery margins. The increase in the price of crude oil is passed through to petroleum product prices. Accordingly the returns to the refining industry are not affected.

Second, the consequences of closure of refineries was included in each reference case and the employment and regional impacts of the closures in themselves are not shown in the difference between each Scenario and its corresponding reference case.

The industry effects are small but varied. The Services Sector experiences a loss of real output of approximately –0.08 per cent relative to the reference case under all cases. The transport sector loses output of between –0.21 per cent to –0.12 per cent in the low and high elasticity cases, respectively under Scenario 1 (and between –0.20 per cent and –0.11 per cent under Scenario 2).The agriculture sector loses real industry output of between –0.21 per cent to –0.07 per cent for the low and high elasticity cases under both Scenarios.

Manufacturing is projected to have a small benefit with an increase in output of approximately 0.08 per cent under all cases. The results for the mining sector are mixed showing an increase in output of approximately 0.06 per cent under the low elasticity cases and a fall in output of –0.08 per cent under the high elasticity cases. These changes are small relative to the size of the sectors and do not reflect material impacts.

The results reflect the fact that the disruption event results in a short price shock and not a long term net shortfall in supplies in any market including Australia. Demand is reduced in Australia because of the price effect with a negative price elasticity of demand. A key factor in this finding is the fact that within two days the IEA is assumed to have announced the release of enough stocks into the market to completely reverse the supply shock from the closure of the Strait by the end of the second week. With two to three weeks sailing times for crudes to Australia and around two weeks sailing times for shipment of petroleum products to Australia from Singapore and most of Asia, there is sufficient crude oil and product on the water to keep supplies flowing to Australia. This reflects the importance of the release of stocks by the IEA in containing the economic damage for both Australia and the world.

The modelling results are therefore consistent with the following key findings from the 2011 *Liquid Fuels Vulnerability Assessment* (p. xxvi):

Australia’s growing dependency on oil and petroleum product imports will have limited affordability, reliability and security implications for liquid fuels supply.

The market would respond and readjust the supply lines to replace supplies lost in the event of a disruption. Prices would rise and there would be a cost to the economy. However, the impact could be reduced in size and duration in the event of a coordinated response by IEA members designed to increase available supply.

The IEA stock release is augmented by the build-up of stocks from speculative buying that preceded the closure of the Strait. The price increase caused by the speculative demand would also have induced an increase in production and supply prior to the shock.

However, it should be noted that oil industry participants’ knowledge that the IEA stocks could be made available might serve as a disincentive for suppliers and consumers to hold stocks for their own insurance value against disruption.

In conclusion, the Strait of Hormuz closure scenario considered by ACIL Tasman does not result in a physical disruption to Australia’s liquid fuel supply. Over the entire modelling period of 23 weeks, there is no net shortage of supply to markets (including Australia) as the IEA coordinated stock release, combined with the availability of oil on the water, fully compensates for the loss of around 183 million barrels during the two-week period of the disruption. In addition, the closure of three Australian refineries was found to have little effect on the magnitude of the economic impact of the disruption.

The total loss in Australian real income as a result of the Strait of Hormuz disruption, estimated to be between $2.15 billion and $3.12 billion, compares with the estimated loss of $2.15 billion to $3.70 billion for the Singapore disruption. While the Strait of Hormuz disruption is a much larger-scale event compared with the Singapore disruption, its effects (as modelled by ACIL Tasman) were mitigated to a considerable extent by the IEA collective action and by the relative brevity of the disruption recognising that the availability of stocks on the water which would provide cover for at least two weeks.

Terms of reference

RFQ Number 2012/018

Background

Beginning in December 2009, Australia has regularly been in breach of its International Energy Agency (IEA) International Energy Program (IEP) 90-day oil stockholding obligation. This treaty level commitment requires IEA member countries to establish a common emergency self-sufficiency in oil supplies, with each country maintaining emergency reserves equivalent to at least 90 days of daily net imports.

A significant increase in Australia’s net imports over the last decade is a key factor which has led to non-compliance with the stockholding obligation. This is being driven by increasing imports to meet rising demand with declining domestic production of crude oil. These trends are forecast to continue over the long term and Australia is predicted to fall into structural non-compliance with the IEP Treaty.

In 2011, evaluation of the issue was undertaken as part of the Draft Energy White Paper 2011, National Energy Security Assessment 2011 (NESA) and Liquid Fuel Vulnerability Assessment 2011 (LFVA). The Australian Government concluded that this issue was one of compliance with an important international treaty, rather than an issue of liquid fuel security.

The NESA found that non-compliance did not constitute a decline in energy security due to Australia’s continued access to well functioning regional and global markets for liquid fuels which enabled a high diversity of supply of refinery feedstocks and/or petroleum products from a wide variety of international sources. Furthermore, investment in new import infrastructure and storage was found to be keeping pace with increasing consumption facilitating the import of these feedstocks and products.

In July 2011 Shell announced that it intended to cease oil refinery operations at Sydney’s Clyde oil refinery and convert the facility into a fuel import facility before mid 2013. This decision recognised that the oil refinery was no longer competitive against Asian mega-refineries. Caltex Australia is currently undertaking a review of its oil refinery operations with an anticipated conclusion date of August 2012. A possible outcome of the review would be that the Kurnell and Lytton refineries could close, resulting in 4 remaining Australian refineries. The NESA identified continuing competitive pressures on refineries as a long term watch point for consideration in future NESA and LFVA assessments.

Recent geo-political events in the Middle East have highlighted the potential for major physical supply disruptions. These events have culminated in Iranian threats to close the Strait of Hormuz, which would prevent the movement of up to 15.54 Mb/d of crude exports, equal to approximately 20% of global oil consumption. While there is some capacity to bypass the Strait, any blockage would constitute a major physical supply disruption. Disruptions of this scale have not previously been taken into account in assessments of Australia’s energy security.

The combination of potential major supply disruptions and domestic oil refinery closures are of sufficient scale to warrant a closer examination of their potential impact on energy security and the Australian economy.

Project Description

This project will model likely economic impacts of a major physical supply disruption shock scenario. The shock scenario in this case will represent the partial blockage of the Strait of Hormuz. The project will model the economic impact of the scenario in situations with current and reduced levels of domestic refining.

Objective

The 2011 National Energy Security Assessment concluded that reliability of liquid fuels supply is likely to be high in the medium term; falling to moderate in the longer term. This assessment drew on an analysis of a 30 day closure of the Port of Singapore to assess the implications of a disruption to supply of petroleum fuels on the Australian economy.

The assessment found that Australia’s vulnerability is primarily related to logistical considerations. As long as the global oil refinery sector has surplus capacity, price movements work to ensure that refined products reach users. It is a question of how long it takes to arrange for and then physically transport those alternative supplies to users in Australia.

The potential for a partial closure of the Strait of Hormuz presents a different shock scenario to that of Singapore – one that would result in a loss of crude oil supply as well as product. Loss of crude supply to world markets was not a feature of the Singapore disruption scenario which was based primarily on a loss of petroleum product supplies. Given the current tensions in the Gulf, an assessment of the impact of a partial closure of the Strait of Hormuz on Australia’s economy is timely.

The objective of this project is to assess the economic impact on the Australian economy of partial closure of the Strait of Hormuz and the consequences for the supply of liquid petroleum fuels for two scenarios – a situation with the current 7 refineries continuing to operate in Australia and a situation where the Clyde, Lytton and Kurnell refineries are closed and converted to import terminals.

Deliverables

The deliverables for the project will include a final report with:

1. A quantitative assessment of the economic impact of the partial closure of the Strait of Hormuz assuming that the current seven refineries continue to operate; and
2. A quantitative assessment of the economic impact of the partial closure of the Strait of Hormuz assuming the Clyde, Lytton and Kurnell refineries are closed and converted to import terminals.

Each assessment of economic impact is to take into account:

1. the likely duration of any closure taking into account the most likely responses from the international community and actions to address the closure;
2. the likely impact on the global oil market, including the impact of price increases on global and regional supply and demand;
3. policy responses from governments, including collective action by IEA member countries;
4. the impact on Australian imports of crude oil;
5. the impact on Australian imports of petroleum products, including qualitative discussion on impacts on availability; and
6. the economic impact on Australia including:
   * impact on Australian trading partners;
   * impact on Australian real gross domestic product and real income;
   * impact on Australian domestic retail fuel prices; and
   * impact by sector of the Australian economy (e.g. agriculture, mining).

The report shall also include the following information:

* modelling and analysis methodologies, including a description of the modelling tools used;
* basis of the modelling;
* description of the reference case;
* assumptions made;
* conclusions.

Additional deliverables for this part of the project include:

* an executive summary of the final report;
* an initial project plan including the draft contents page of the report; and
* a presentation made to RET staff outlining the modelling and analysis methodology to be done and assumptions to be made.

Weekly project update meetings are required. Given that the schedule allows for only one draft being provided for comment, provision of draft sections of the report is expected at each meeting. These sections are to be provided on the basis that they are indicative only and are to assist in ensuring that the final report is aligned with the Department’s expectations.

Shock Scenario

The scenario to be modelled is the partial blockage of the Strait of Hormuz affecting the ability to trade oil and petroleum products through the waterway.

The partial blockage of the Strait is to be modelled to last for a period of 7-14 days, and impacts would be assessed under present conditions, i.e. a reference case, as well as under a hypothetical situation in which the Clyde, Lytton and Kurnell refineries are closed and converted to import terminals. In each case the full range of impacts on the Australian economy are to be analysed with the only differentiating factor being the number of refineries. The volume of Middle Eastern oil transit disrupted by the scenario is to be equivalent to 25% of business-as-usual Middle Eastern oil exports. This would have a significant impact on global oil markets and the Australian economy.

This scenario takes into account:

* Effects of efforts to mitigate a supply disruption through:
  + Redirection of some Gulf oil supplies through alternate export routes such as pipelines;
  + Ability of some net oil exporting nations to increase production; and
  + Use of government and industry held stocks (both strategic and commercial).
* Changes in Australian demand for refined petroleum products and prices of refined petroleum products over several months following the disruption.

Milestone Dates and Payment Schedule

The following milestone dates and payment schedule for delivery of the services shall apply:

| Milestone | Due Date | Payment Amount |
| --- | --- | --- |
| Signing of Contract | 17 April 2012 (tentative date) |  |
| Provision of Project Plan,  including draft Table of Contents | 20 April 2012 |  |
| Presentation made to RET staff outlining the modelling and analysis methodology to be done and assumptions to be made | 26 April 2012 |  |
| Draft report submitted for review by RET | 1 June 2012 | 50% of contract value |
| Comments on draft report from RET to consultant | 8 June 2012 |  |
| Delivery of final report, with comments to the draft report addressed to the satisfaction of the Project Officer. | 22 June 2012 | 50% of contract value |

Methodology

Introduction

This document provides the proposed methodology for modelling the impact of a temporary closure of the Strait of Hormuz on the Australian economy. The impacts will be assessed for two scenarios – one with the current 7 refineries and one with only 4 refineries operating.

The terms of reference provide the overall outputs that are required. The main outputs are as follows:

The output from the CGE modelling will include:

* Impact on macroeconomic aggregates including GDP, GNP and trade.
* Impact on economic activity in key sectors
  + Noting the impact of trade effects on these sectors
* Impact on consumption of petroleum fuels by important sectors
* Impact on imports of crude oil and petroleum products
* General comments on the extent of the rise in price of petroleum products.

The report is also to provide qualitative commentary on the likely impact of declaration of a liquid fuels emergency on the economic and price impacts.

Overall approach

The overall approach to modelling the economic impacts follows the following sequence of analysis and modelling:

* Estimation of global price responses to a defined reduction in supplies of crude oil and petroleum products arising as a result of the partial a closure of the Strait of Hormuz commencing on 1 March 2012.
  + DRET is to provide assumptions regarding the extent and duration of reductions in supply of crude oil and petroleum products, including the timing and quantities involved in ramping-up supply after partial closure, and the timing, quantum and mix of internationally coordinated releases from stockpiles
* Estimation by ACIL Tasman of price elasticities of supply and demand for crude oil and for petroleum products during the period of interruption and for the duration to full recovery of supply
* Modification of the supply and demand elasticities in Tasman Global for the rest of the world and for Australia
* Applying a shock to the model that reflects the price increases in crude oil and petroleum products globally and to Australia
* Reporting the results outlined above.
* A qualitative analysis will then be undertaken of the likely impact of declaration of a liquid fuels emergency
  + DRET is to provide an outline of the actions that might be taken in terms of reallocation of wholesale supplies and of demand restraint measures that might be implemented.

International and domestic elasticities

Estimation of international elasticities

The impact of oil supply shocks can be expected to vary in accordance with the nature and size of the of the shock, the products (types of crude oil and refined products), the degree of capacity utilisation, the location of any excess capacity, and international macroeconomic conditions at the time of the shock. Closure of the Strait of Hormuz would be a major supply shock. This shock would interact with aggregate demand conditions and precautionary demand effects could be expected to have exacerbating effects.

Precautionary buying could be undertaken by private and government entities. To some extent, this could offset the effects of an IEA coordinated release of stocks, but stock releases would also moderate precautionary buying.

ACIL Tasman will aim to estimate price elasticities of demand for crude oil and petroleum products in each of three world regions (plus Australia) for the purposes of the CGE modelling. However, the final regional breakup will depend on the information that comes to light during the initial research.

Petroleum products and different grades of crude oil will be treated as generic products as elasticity data are not available for specific refined products and crude oil types.

We will start with a review of published price elasticities of demand. However, it will be necessary to allow for the effect of the magnitude of the shock on these elasticities. In addition, we will have to be made for the further effect of precautionary buying. Adjustments will be made to take into account normal increases in (negative) elasticities over time as consumers adjust to price changes.

We will also start with available information on supply elasticities. These will have to be adjusted to allow for normal increases in elasticities over time as alternative suppliers are able to adjust production.

Estimates of elasticities will be different to those used by ACIL Tasman in 2011 to estimate price changes for disruption of supply of refined products from Singapore. For the Singapore disruption scenario, it was possible to use the benchmark of disruptions that arose during Hurricanes Katrina and Rita that swept through the Gulf of Mexico in 2005. The Strait of Hormuz disruption will be very much larger and could trigger a much larger precautionary demand shock. It is proposed to review representative events involving a number of comparable reductions in supply to refine estimates of demand and supply elasticities for both crude oil and petroleum products. Through the Department, ACIL Tasman will consult with the IEA and other organisations to probe further into supply and demand responses that are likely and the feedback mechanisms that might change demand/supply responses in the months after the initial closure.

Another complication is that partial closure of the Strait of Hormuz is also likely to result in swift action by the international community to both address the cause and mitigate the consequences of such closure. Stock releases would effectively increase short term supply elasticities and modify precautionary buying and short term demand elasticities.

The changing demand and supply elasticities will then be used to estimate price movements over time following the initial supply shock, the reinforcing precautionary demand shock, and moderating stock release program. The Asian region elasticities will determine the price shocks applied to Australia. Other elasticities will determine price shocks elsewhere.

The results of this analysis will be a matrix of supply and demand elasticities for crude oil and petroleum products by region. These elasticities will be incorporated into Tasman Global’s data base, ensuring consistency between the bases for estimation of initial supply shocks and the bases for estimation of general equilibrium feedbacks internationally.

Estimation of Australian elasticities

In order to model the impact on the Australian economy it will be necessary to review elasticities of demand for crude oil and refined petroleum products in Australia. Elasticities will need to be adjusted to account for the magnitude of the internationally transmitted refined product price shock. These adjusted elasticities will be applied in the Tasman Global CGE model.

Definition of the oil refinery scenarios

This will largely be provided by DRET. The key factors for consideration are the impact on crude oil and petroleum product imports. The later will be dealt with as a generic group for the purposes of modeling.

ACIL Tasman will take the advice from DRET and convert it into two scenarios – one with seven refineries and one with four.

This output will then be used to amend the CGE model, Tasman Global to set up the work to model the impacts for seven and for four refineries.

CGE modelling

ACIL Tasman will use its CGE model of the Australian and world economies, *Tasman Global*, to estimate the economic impacts of the proposed supply shock. The current *Tasman Global* database is based on the GTAP v7 database and contains 112 international regions plus a detailed regional representation of the Australian economy. The database will be aggregated to the proposed 39 commodities and 11 regions presented in Table B1. This aggregation has been proposed to enable a detailed representation of fossil fuel and energy intensive sectors as wells as a good representation of Australia’s major trading partners. The final regional breakup will, however, depend on the information that comes to light from the initial research.

The database will be updated to the 2012-13 financial year ensuring that energy demand by fuel by industry by region closely matches the most recent available annualised production, consumption, trade and price data and using the model to project out to 2012-13. This is an involved task. Two alternative representations of the Australian and world economies will be created: one with seven refineries operating in Australia and one with only four refineries operating.

Once the two 2012-13 databases have been estimated, we will convert the databases and model to run in monthly time increments as per our previous analysis of the 30-day closure of the port of Singapore. This will enable the short term dynamics associated with the temporary closure of the Strait of Hormuz to be implemented more faithfully and informatively than if the standard annualised database and model were used.

A range of key parameters will then be calibrated to replicate the supply and demand elasticities for crude oil and petroleum products estimated separately as part of this analysis. The difficulty with the calibration is that much of the demand for oil and petroleum products is ‘derived demand’ or ‘joint demand’. That is, the demand for these products occurs as a result of demand for other goods and services. Consequently, there isn’t a single demand elasticity that can be calibrated; rather there are a suite of elasticities that, in aggregate, imply a demand elasticity. Further complicating the calibration process is the interrelationships between all sectors within an economy together with the interrelationships between regions. Typically this is a core strength of CGE models but, in this instance, complicates the calibration process since all elasticities need to be changed as a group rather than individually (for example, it is not possible to calibrate the Australian elasticities and then calibrate the Chinese elasticities since changes to the Chinese parameters will affect the Australian economy – thereby requiring different parameterisation).

Table B1 **Regional and commodity aggregation**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Commodities |  |  |
| 1 | Crops | 21 | Textiles, clothing, footwear |
| 2 | Livestock | 22 | Wood, pulp and paper |
| 3 | Forestry | 23 | Fabricated metal products |
| 4 | Fishing | 24 | Transport equipment and parts |
| 5 | Processed food | 25 | Electronic equipment |
| 6 | Coal | 26 | Machinery and equipment nec |
| 7 | Oil | 27 | Other Manufacturing |
| 8 | Gas | 28 | Water |
| 9 | Electricity | 29 | Construction |
| 10 | Petroleum & coal products | 30 | Trade services |
| 11 | Iron & steel | 31 | Other transport |
| 12 | Liquefied natural gas (LNG) | 32 | Water transport |
| 13 | Iron ore | 33 | Communication |
| 14 | Bauxite | 34 | Financial services nec |
| 15 | Other mining | 35 | Insurance |
| 16 | Alumina | 36 | Other business services |
| 17 | Primary aluminium | 37 | Recreational and other services |
| 18 | Nonferrous metals | 38 | Government services |
| 19 | Nonmetallic minerals | 39 | Dwellings |
| 20 | Chemicals, rubber, plastics |  |  |
|  | Regions |  |  |
| 1 | Australia | 7 | Middle East c |
| 2 | China | 8 | European Union 27 a |
| 3 | India | 9 | United States and Canada |
| 4 | Japan | 10 | Rest of Asia |
| 5 | Korea, Republic of | 11 | Rest of World |
| 6 | Other ASEAN b |  |  |

a European Union 27 comprises Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Republic of Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

b Other Association of South East Asian Nations comprises Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. Timor Leste is also included as it is not separately identified in the GTAP database.

c Bahrain, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kuwait, Lebanon, Palestinian Territory, Occupied, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen.

Note: nec = not elsewhere classified.

Data source: ACIL Tasman

In light of the greater complexity and uncertainty that this project carries, we expect that the impacts will be analysed and reported as ranges rather than as single point estimates. Consequently, we envisage that it will be necessary to model an upper and a lower bound range for the expected price outcomes (as well as sensitivity to the economic impacts on Australia’s major trading partners).

A potential difficulty that may need to be addressed once the project has commenced is whether there is a need to alter key functional forms for energy demand in order to best replicate the likely response in the event that of a temporary closure of the Strait of Hormuz.

Once the calibration process has been finalised, a reference case and policy simulations will be run. In applications of the *Tasman Global* model, a reference case simulation forms a ‘business-as-usual’ basis with which to compare the results of various simulations. The reference case provides projections of growth in the absence of the changes to be examined. The impact of the change to be examined is then simulated and the results interpreted as deviations from the reference case (see Figure B13). In this case the policy shock will be the projected oil and product price changes (by region) resulting from a temporary closure of the Strait of Hormuz. As mentioned earlier, the policy will be modelled against two alternative reference cases: one with seven refineries operating in Australia and one with only four refineries operating. The projected economic impact of the closure of three Australian refineries will not be reported as it is beyond the scope of this project.

Figure B13 **Illustrative scenario analysis using Tasman Global**

|  |
| --- |
|  |

Source: ACIL Tasman

Qualitative discussion

The report will present the results assuming that a liquid fuels emergency is not declared. However the terms of reference require some qualitative discussion of how declaration might affect the findings on economic impact.

In order to undertake this part of the analysis ACIL Tasman will require advice from the Department on the likely actions that might be taken in the event that a liquid fuels emergency is called. This would include the nature of the intervention contemplated at the bulk and retail level. It will not be possible to model these impacts as they override the operation of the market. However we would examine each contemplated action in terms of the likely impact on specific industry sectors and provide comment on the impacts that intervention could have on outcomes for each industry with observations on how that might affect the broader economic conclusions.

Analysis of Oil Shocks

Introduction

The terms of reference required an assessment of the economic impact on Australia of a major supply shock in respect of crude oil and refined products. The hypothetical supply shock to be considered for illustrative purposes was temporary disruption of shipments of crude oil and refined products through the Strait of Hormuz linking the Persian Gulf with the Arabian Sea and Indian Ocean. This disruption was to be assumed to involve a period of complete blockage of shipments followed by a phased return to normal shipments.

This chapter provides a qualitative analysis of considerations relevant to a quantitative assessment of the hypothetical supply shock. The analysis provides a foundation for estimation of the first round crude oil and refined product price effects of the hypothetical shock. These first round effects do not take into account the feedback into prices of macroeconomic effects of the shock.

Shocks, Shortages and Market Forces

A large scale interruption of supply of crude oil and refined oil products would create fear of shortages. This fear would induce market responses. They would be global in scope, because crude oil and refined products are traded in highly integrated global markets.

A major interruption of supply would induce normal recipients of crude oil and refined products from the supply source to seek to purchase supplies from alternative sources of supply, thereby bidding up prices in integrated international markets. Existing purchasers from these alternative sources would compete to retain supply. Sellers would require higher prices for their scarcer supply. Higher prices would reduce quantities demanded, effectively rationing available supply. Higher prices would also call forth some additional supply quantities from sources with spare capacity. Crude oil and refined products made available in these ways would be reallocated to those prepared to pay higher prices.

If fears of shortages were caused by a major demand surge, rather than a supply interruption, the responses of market participants would again push up prices. Higher prices again would ration existing supply, call forth some additional supply, and reallocate existing and new supply in accordance with willingness to pay.

If price increases resulting from a supply shock or demand surge were exacerbated by precautionary or speculative buying in anticipation of higher prices or persistence of high prices, the additional price increases would ration supply more strictly, increase the inducement to produce additional quantities and further reallocate supply.

Consistent with this analysis, the history of oil shocks over the past 40 years has not provided any evidence to suggest that crude oil and refined product markets would not swiftly ration and reallocate supply efficiently to avoid shortages. However, the characteristics of these markets are such that the scale of the price change that is required to clear the market following a shock to supply or demand is likely to be proportionately much larger than the change in quantity, as discussed in the next sub-section.

The position would change in the event of government intervention to constrain prices of crude oil inputs to refineries or prices chargeable by refiners or importers for products. Then, shortages would persist. Scarce supply would have to be rationed by queuing or some administrative device or some combination of the two.

Market-determined prices are far superior at rationing supply and allocating resources efficiently, than queuing and administrative allocation. The market system allocates resources to their highest valued uses. Queuing and administrative allocation do not. Queuing is biased towards users with lower time values. Administrative allocation is inefficient because the information requirements for efficient centralised allocation are extremely demanding and arbitrariness is inevitable.

Disproportionate Price Effects of Oil Shocks – Implications of Low Responsiveness of Demand and Supply to Price Changes

Crude Oil

Large scale disruptions to supply of crude oil tend to cause proportionate increases in prices that are much higher than proportionate reductions in supply. Conversely, large supply increases tend to cause price reductions that are proportionately much larger. Shifts in crude oil supply lead to disproportionately large price changes because responsiveness of demand and supply to price movements (price elasticity of demand and supply, respectively) tends to be extremely low (or inelastic) in the short-term. Even in the long-term, this responsiveness tends to be very low compared to most other goods and services.

In the economics literature, responsiveness of quantity demanded to price changes is measured by price elasticity of demand, which is defined as the proportionate change in quantity demanded divided by the proportionate change in price (a negative number). Responsiveness of supply to price changes is measured by price elasticity of supply, which is calculated as the proportionate change in quantity supplied divided by the proportionate change in price (a positive number).

The importance of very low price elasticities of demand and supply is illustrated by the following. A hypothetical supply shock removing (or adding) **Ss** per cent of global crude oil production would require a proportionate increase (or reduction) in price of **∆** to clear the market, eliminating a shortage or surplus caused by the supply shock at the price applying before the shock. This market-clearing process would be accomplished by a combination of a proportionate change in quantity demanded of **∆** x **Ed** and a proportionate change in quantity supplied of **∆** x **Es**, where **Ed** and **Es** represent short-term price elasticity of demand and short-term price elasticity of supply, respectively. The changes in quantity demanded and quantity supplied in response to a market clearing price increase are in opposite directions, but will add to the amount of the initial shock (a price increase reduces quantity demanded and increases quantity supplied, and a price reduction does the opposite, as reflected in the signs of **Ed** and **Es**). Therefore, the supply shock, **Ss** = (**∆** x **Ed**)– (**∆** x **Es**), and the proportionate change in price, **∆** = **Ss/**(**Ed** – **Es**).

If the supply shock, **Ss** = –0.05 (5 per cent reduction in supply) when **Ed** is –0.05 and **Es** is 0.05, the proportionate change in price, **∆** = 0.5. So, a 5 per cent reduction in supply leads to a 50 per cent increase in price. Conversely, a supply increase of 5 per cent, with the same values of **Ed** and **Es** leads to a reduction in price of 50 per cent. Smith (2009a, p. 155) observed that values of –0.05 and +0.05 for short-term price elasticities of demand and supply for crude oil, respectively were indicative of estimates in the economics literature on the crude oil market.

Revising the calculation with the values of **Ed** and **Es** suggested by Kilian and Murphy (2010), –0.26 and 0.02, respectively, indicates a 5 per cent reduction in supply would cause a price increase of nearly 18 per cent in the short-term. Using median values of **Ed** and **Es** for the last few years of around –0.15 and 0.02, respectively, as estimated by Baumeister and Peersman (2012), a reduction in supply of 5 per cent would cause a price increase of more than 29 per cent in the short-term.

Using similar reasoning, a demand shock, **Ds** = (∆ x **Es**) – (∆ x **Ed)**, and the proportionate change in price, **∆** = **Ds/**(**Es** – **Ed**). Assuming a positive demand shock of 2 per cent (+0.02), and inserting the values of **Ed** and **Es** suggested by Baumeister and Peersman (2012), the resulting price change would be an increase of nearly 12 per cent.

Price elasticities of demand and supply tend to rise (ignoring the negative sign of price elasticity of demand) with elapsed time after a price or quantity change as adjustment opportunities become increasingly accessible by economic entities. With time, entities could change consumption, production, exploration, investment, research and development activities to reduce fuel-use, increase recovery from petroleum reservoirs, expand exploration programs, and develop and deploy new technologies and techniques.

Demand for crude oil derives from demand for products (principally for transport use) produced from crude oil. If the demand for products rises, demand for crude oil rises. In the absence of offsetting increases in supply, product and crude oil prices rise. If the supply of crude is cut, prices of crude oil and products rise, in the absence of an offsetting reduction in demand.

In response to a large fuel price increase, car owners might switch to public transport for trips to and from work and/or reduce discretionary driving in the very short-term. Of course, some individuals will respond sooner and to a greater extent than others. The longer the fuel price increase persists, the greater such responses would be in aggregate.

If the large fuel price increase persists, individuals and businesses might switch to vehicles with lower fuel consumption, when vehicles are scheduled for replacement or perhaps sooner. They may even seek information and participate in educational programmes showing how fuel can be saved by changing driving and maintenance practices. Manufacturers might increase emphasis on improving fuel economy in planning for their new models. They may accelerate research and development activities focused on better fuel consumption through improvements to internal combustion engines, transmissions, tyres and vehicle mass without loss of safety. In addition, they may accelerate research and development activities in respect of petrol-electric and diesel-electric hybrids, electric vehicles, and hydrogen fuelled vehicles.

The longer the large price increase persists, the greater would be the accessible range of opportunities to reduce consumption of liquid petroleum fuels. Therefore, with the elapse of time, price elasticity of demand (ignoring the negative sign) increases. That is, demand becomes more elastic.

In both the short-term and long-term, price elasticity of demand for refined oil products is low compared to price elasticity of demand for other goods and services in the same time-frame. This has resulted from the relatively high costs associated with switching to alternatives.

Price elasticity of demand for products ex-refinery is higher (ignoring the negative sign) than for crude oil, because the crude oil price accounts for only part of the ex-refinery price of refined products. Price elasticity of demand for products is higher again at the point of use because of taxes and distribution and retailing costs and margins.

On the supply side, crude oil production can be increased in the short-term in response to a large price increase only if there is excess production capacity. In addition, there would have to be no effective constraints on utilisation of that excess capacity. Such constraints have been applied in OPEC countries, particularly in the largest producing country, Saudi Arabia, for lengthy periods during the past 40 years (Smith, 2009a). This has resulted in crude oil producers elsewhere operating close to capacity.

It takes time and investment to activate spare crude oil production capacity and much more time to increase capacity. With time, various investments can be made to increase the production rate and extent of extraction from producing reservoirs. With more time, other known deposits, which were previously sub-marginal, can be brought into production. In longer time-frames, new deposits can be discovered, assessed, and brought into production, but this could take a decade or more because of various lags in the investment process, even if increased exploration activity yields to relatively early, positive outcomes. Of course, exploration may not produce positive results relatively quickly, because better-than-marginal deposits are scarce and the degree of scarcity increases with the economic surpluses they can yield.

The various lags in the investment process that delay commissioning of new production capacity include lags in (Radetski, others, 2008):

* perceiving trends and opportunities and deciding to respond
* planning and undertaking exploration programmes
* assessment and investment decision processes
* planning and design activities
* government regulatory processes
* arrangement of funding
* construction and commissioning of projects.

For reasons outlined above, the long-term can be a long time coming, and long-term price elasticity of supply can be expected to be very low. Of course, the long-term price elasticity of supply is still substantially higher than in the short-term.

Extremely low price elasticities of demand (ignoring the sign) and supply in the short-term, and elasticities that are still very low relative to most other goods and services in the long-term are important explanatory factors for pronounced price effects of oil shocks that seem proportionately much larger than the shock to supply or demand.

Refined Oil Products

The phenomenon of very low price elasticity of demand for refined petroleum products in the short-term, a rising elasticity with the elapse of time, and a relatively low elasticity in the long-term compared to most other goods and services have been described above. It has also been explained that these elasticities are greater at the point of use than ex-refinery, and the price elasticity of demand for crude is even lower.

Price elasticity of supply for refined products in the short-term depends on the existence of spare production capacity. This in turn depends on the level of global economic activity, the amount of capacity available, the short-term availability of suitable crude oil feedstock, the timing of scheduled maintenance, re-scheduling flexibility, occurrences of unscheduled downtime, and inventories.

As time passes, capacity of existing refineries may be expanded and new refineries built, so that price elasticity of supply rises over time. Of course, the rate of increase of supply elasticity over time is limited by lags related to perception, design, planning, investment decision, regulatory, funding, construction, and commissioning requirements and issues. Construction of new refineries in advanced economies has been severely impeded by regulatory processes in some cases.

Low price elasticities of demand (ignoring the sign) and supply in the short-term are important explanatory factors for pronounced short-term price effects of refined oil product shocks that are proportionately much larger than the shock to supply or demand. For example, a supply shock of a 5 per cent reduction in global supply of refined products would translate into a market clearing price increase of 25 per cent, based on the formula in the previous sub-section and assumptions of a short-term price elasticity of demand of –0.1 and a short-term price elasticity of supply of 0.1.

The proportionate short-term price effects of refined product shocks could be expected to be smaller than for equivalent crude oil shocks, because price elasticity of demand would be higher (ignoring the negative sign) than for crude oil as explained above, and price elasticity of supply typically would not be any less than for crude oil.

In the long-term, price elasticity of demand and price elasticity of supply could be expected to be higher for refined products than for crude oil. The former would apply because of the gap between crude oil and refined product prices. The latter would result from the scarcity of above-marginal deposits which increases with the economic surplus they can yield.

Estimates of Price Elasticities of Demand and Supply

Crude Oil

In this report, the focus of attention is a major short-term supply loss. Therefore, estimates of short-term price elasticity of demand and supply are required, not estimates of long-term elasticities.

A recent econometric study by Baumeister and Peersman (2012) found that there has been a substantial decrease in short-term price elasticities of demand (ignoring the negative sign) and supply for crude oil since the mid-1980s. The decrease was particularly marked between the mid-1980s and early-1990s.

Their analysis indicated a decline in short-term price elasticity of demand (ignoring the sign) from about –0.6 in the late1970s and early-1980s to around –0.15 for the past five years. In the same time-frame, short-term price elasticity of supply was estimated to have fallen from about 0.4 to 0.02. This was a major explanatory factor for increased crude oil price volatility since the 1980s that was documented by Baumeister and Peersman (2012).

These elasticities suggest that a supply shock involving a 5 per cent reduction of supply would have resulted in a price increase of less than 7 per cent in the late-1970s or early-1980s, but a price increase of more than 29 per cent now. Both demand and supply have become so inelastic in the short-term that small changes in supply can cause large price changes. The implication is that an oil shock of a particular type and magnitude would lead to a much larger oil price change now than at the time of the ‘first oil crisis’ and ‘second oil crisis’ of the early 1970s to early 1980s.

There are various reasons for reductions in short-term price elasticities for crude oil. A non-exhaustive range of reasons has been provided by Baumeister and Peersman (2012). These reasons have been summarised below.

First, from the early-1980s, there was a transition from an administered oil price regime involving long-term contracts with specified oil prices to a spot trading system. Under the former system, increases in demand were accommodated by changes in quantities, rather than prices, at least until contracts were renewed or replaced.

Second, oil futures or derivatives were developed from the early-1980s. These provided hedging mechanisms for producers and users of crude oil. This reduced the responsiveness of hedged entities in both groups to spot oil price changes (reduced price elasticity of demand and supply).

Third, oil futures trading may result in revision of expectations about future spot prices, creating arbitrage opportunities between spot and futures markets. Responses involve adjustments to above-ground inventories or extraction rates. The latter involves changes to below-ground inventories (resources). The result of exploitation of these opportunities would be greater responsiveness of spot prices to supply or demand shocks (effectively lower price elasticity of demand or supply).

Fourth, the oil shocks of the 1970s resulted in oil conservation, and switching to alternatives to oil. Because of lagged responses, this would have resulted in reduced price elasticity of demand for crude oil from the early-1980s.

Fifth, declining price elasticity of demand reduces incentives for dominant reserve-owning countries to increase capacity. This has been evident over the past 25 years or more. It has reduced short-term price elasticity of supply. Resulting increases in price volatility may have increased uncertainty regarding returns to exploration and development investment, discouraging investment elsewhere and exacerbating low short-term price elasticity of supply.

Sixth, the precautionary demand element of total crude oil demand tends to increase as capacity utilisation rates increase from already high levels. This makes total crude oil demand even more inelastic.

Dargay and Gately (2010) estimated long-run price elasticities of demand for crude oil (and product categories) using data for the period 1970 to 2008. They found that elasticities for the 1971-1989 period were about 4.33 times those for the 1989-2008 period. This is consistent with the trend for short-term elasticities documented by Baumeister and Peersman (2012).

Cooper (2003) estimated short-run and long-run price elasticities of demand for crude oil for 23 countries. These estimates were based on data for the period 1979-2000. France and the United States were at the top of the range with short- and long-run elasticities of –0.069 and –0.568, respectively, for France and –0.061 and –0.453, respectively, for the United States. Australia was towards (but not at) the bottom of the range with short- and long-run elasticities of –0.034 and –0.068, respectively. Cooper’s estimates suggest an overall global short-run price elasticity of demand for crude oil that is one-third of the estimate provided by Baumeister and Peersman (2012).

Smith (2009a) observed that a value –0.05 for short-term price elasticity of demand for crude oil and a figure of 0.05 for short-term price elasticity of supply were indicative of estimates in the economics literature on the crude oil market. Smith’s indicative figure for short-term price elasticity of demand for crude oil is consistent with Cooper’s estimates. His indicative value for short-term price elasticity of supply is more than double the estimate (0.02) provided by Kilian and Murphy (2010) and Baumeister and Peersman (2012).

Kilian and Murphy (2010) provided a much higher estimate of short-run price elasticity of demand for crude oil than other econometric analysts. Their estimate was –0.44. “One reason” that they nominated for the difference between their estimate and those made by others was “that standard econometric estimates of the crude oil demand elasticity fail to account for the endogeneity of the price of crude oil.”

Baumeister and Peersman (2012) pointed out that the model used by Kilian and Murphy assumed a stable relationship between prices and quantities demanded over the entire post-1973 period. It does not appear that this is a reasonable assumption. Relaxation of this assumption could be expected to lower the short-term price elasticity of demand for crude oil provided by Kilian and Murphy (2010).

On the other hand, Kilian and Murphy (2010) pointed out that their estimate and the lower estimates of others do not allow for the behaviour of crude oil users in respect of depletion or accumulation of inventories. They argued that it was more useful for policy purposes to produce estimates of price elasticity of demand that incorporated inventory responses. They observed that such an elasticity estimate had not previously been estimated or even discussed elsewhere in the relevant economic literature. Kilian and Murphy described it as a “price elasticity of demand *in use*”, and referred to the conventional concept as “price elasticity of demand *in production*”. They produced an estimate of –0.26 for the short-term price elasticity of demand for crude oil *in use*.

Kilian and Murphy (2010, p. 24) argued that this estimate “suggests that even the inclusion of inventories does not overturn our findings that the short-run price elasticity of oil demand is much higher than previously thought.” Of course, if the price elasticity of demand estimates of others were adjusted to take account of inventories to produce “in use” estimates, they would be lower than presented above.Refined Products

Price Elasticity of Demand

There are many widely cited estimates of short- and long-term price elasticity of demand for automotive fuel covering various OECD countries.[[16]](#footnote-16) Invariably, estimated long-term elasticities have been substantially higher (ignoring the negative sign) than short-term elasticities, consistent with the increasing range of opportunities to adjust fuel-use that become available as time elapses.

Dargay and Gately (2012) found that long-term price elasticity of demand for oil products used in transport was very much lower (ignoring the negative sign) than for oil products used for other purposes. The significance of this is indicated by the relative usage of refined products for transport and other purposes. In OECD countries, transport products account for around 58 per cent of all oil products. The transport percentage is not as high in other countries as a group.

A recent review by Dahl (2012) of hundreds of studies relating to about 65 countries found that the range of price elasticities of demand for diesel tended to be slightly higher (ignoring the sign) than those for petrol, although the median elasticity estimate for petrol was about double that for diesel.

Consistent with Dahl’s findings regarding differences between estimates of elasticities for petrol and diesel, the Bureau of Infrastructure Transport and Regional Economics (2008) suggested that price elasticity of demand for diesel fuel in trucks was less in the long-term than for petrol and diesel in light vehicles. In contrast, Chesnes (2009) indicated that price elasticity of demand for diesel could be double or more (ignoring the negative sign) the price elasticity of demand for petrol.

Among OECD countries, estimates tend to be considerably lower for Australia, Canada and the United States than for European countries (Breunig, Gisz, 2009; Brons, Nijkamp, Pels, Rietveld, 2008; Graham, Glaister, 2002; Espey, 1998). Also, Dargay and Gately (2010) have estimated that that long-term price elasticities are much lower in countries outside the OECD that are growing relatively quickly, including China, than in OECD countries overall. A review of estimates by Dahl (2012) confirmed that long-term elasticities were lower for rapidly developing economies than OECD countries, but Dahl’s results indicated the difference was not large.

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Since a short-term interruption of supply from the Persian Gulf would affect product prices globally, it is appropriate to use elasticity estimates representative of global demand, not those relating to one country or region, when estimating impacts on prices in Australia. For OECD countries, surveys by Espey (1998) and Graham and Glaister (2002) have suggested estimates of short-term price elasticity of demand around –0.25. A different survey approach used by Brons, Nijkamp, Pels and Rietveld (2008) suggested short-term price elasticity of demand estimates around –0.35.

Havranek, Irsova and Janda (2012) undertook a meta-analysis of estimates of price elasticities of demand for petrol for countries around the world. They produced an average estimate of short-run price elasticity of demand of –0.09. They argued that other surveys of price elasticity of demand provided greatly overstated averages because of selection bias. They claimed that insignificant or positive sign estimates of price elasticity of demand were rarely reported, while implausibly large negative sign estimates were typically included.

For Australia, Breunig and Gisz (2009) estimated the short-term price elasticity of demand for petrol in Australia to be in the range –0.1 to –0.14. Graham and Glaister (2002) reported a short-term price elasticity of demand of –0.05 for Australia.

Hymel, Small and Van Dender (2010) estimated short-term price elasticities of demand for the United States of –0.054 to –0.075, depending on the data set used. Hughes, Knittel and Sperling (2008) provided comparable United States estimates. An estimate of –0.07 was provided by Coyle, DeBacker and Prisinzano (2012).

Kilian and Murphy (2010) criticised the estimates by Hughes, Knittel and Sperling and those provided by earlier work of other analysts, but did not refer to similar recent estimates. Kilian and Murphy argued that the estimates of Hughes, Knittel and Sperling were too low (ignoring the negative sign), because they did not take into account endogeneity of the price of crude oil and products, and did not adequately allow for the influence of unpredictable changes in global oil production. Kilian and Murphy (2010) provided an estimate of about –0.26. However, Kilian and Murphy’s analysis unrealistically assumed a stable relationship between prices and quantities demanded over the entire post-1973 period.

Econometric analysis by Small, Van Dender (2007a,b); Hughes, Knittel, Sperling (2008) and Hymel, Small, Van Dender (2010) indicates that the short-run price elasticity of demand for automotive fuel has declined considerably since the late-1970s and early-1980s. This finding is consistent the results of surveys of multiple estimations of elasticities based on data from different time periods (Greene, 2012).

However, the data underpinning the later estimates usually relate to time periods ending around 2005. These estimates may have been influenced by high income growth and relatively low fuel prices in the late-1990s and before 2005, because short-term price elasticity of demand tends to be lower when fuel prices are lower and incomes are higher (Hymel, Small and Van Dender (2010; Sentenac-Chemin, 2012). In the context of higher fuel prices, and low or negative income growth in many countries over the past four to five years, price elasticity of demand could be expected to be higher.

Allowing for lower price elasticities of demand in China and other rapidly growing non-OECD economies than in the OECD overall, and price elasticities of demand for products that are no less than and may be up to twice those for crude oil suggests short-term price elasticities of demand for automotive fuel in the range –0.1 to –0.17 for rapidly growing non-OECD countries, and an indicative overall global range of –0.15 to –0.25

Price Elasticity of Supply

Estimates of price elasticity of supply of refined products are not readily available. We were able to find only one estimate of short-run elasticity of supply.

Doyle, DeBacker and Prisinzano (2012) estimated that short-run elasticity of supply of petrol was 0.29, based on United States quarterly tax data for the period 1990 to 2009.

Types and Causes of Shocks

The economic literature on oil shocks has focused mainly on shocks in the market for crude oil and dates back to the mid-1970s. Relatively little attention has been given to shocks in the market for refined products, and the limited literature available on this topic is recent.

Oil shocks appear to have attracted much greater attention than refined product shocks for two reasons. First, there has been a series of high profile events during the 32-year period from 1973 to 2005, which have been associated with crude oil supply disruptions and/or fears of supply loss. Second, the short-term price elasticities of demand and supply of crude oil are extremely low compared to those for most other goods and services and lower than corresponding elasticities for refined products.

Crude Oil Shocks

Economic analysis of shocks in the crude oil market was initiated following the severe oil shocks of 1973-74 (Arab-Israeli war) and 1979-80 (Iranian revolution, then Iran-Iraq war). Then, a new analytical focus was provided by the sharp oil price drop in 1986 (the collapse of OPEC support for the oil price). Interest in the economic effects of oil shocks was renewed by upward spikes in oil prices in 1990-91 (Iraq’s invasion of Kuwait), and in 2002-03 (the Venezuelan crisis and the Iraq war), although these price movements were much smaller than the price spikes associated with the1970s oil shocks.

Over the past four years, there has been a significant quantity of new economic literature on crude oil shocks, and there has been a substantial shift in focus. The recent literature has been concerned with:

* causes and effects of the extraordinary rise in oil prices after 2003 and prior to October 2008, the subsequent oil price slump in late-2008, which continued in 2009, and the strong oil price revival in 2010 and 2011
* the effect of activity in oil futures markets on spot prices for crude oil
* distinguishing between types of oil shock and their causes
* reconsideration of causes of pre-2004 shocks
* contrasting of effects of different types of oil shocks and underlying causes.

Over the past 3-4 years, various analysts (for example, Kilian, 2009a; Kilian, Murphy, 2010; Dvir, Rogoff, 2010; Baumeister, Peersman, Van Robays, 2010) have explained that crude oil price shocks can be triggered by:

1. *oil supply shocks* – shocks to physical availability of crude oil
2. *aggregate demand shocks* – shocks to demand for crude oil arising from changes to global economic activity
3. *speculative oil-specific demand shocks* – shocks resulting from buying or selling of oil for precautionary, price hedging, investment or purely speculative purposes (which may overlap) in response to “expectations shifts” or changes in perceptions of uncertainty in relation to future supply and demand and consequent prices
4. *combined shocks* – more than one of the types of shock above exert influence on crude oil prices around the same time.

They have explained that these types of shock tend to influence prices with varying degrees of rapidity and for different periods of time. In addition, they have explained that the various forms of shock have different economic effects and these can vary greatly between economies in accordance with differences in their industrial structures.

Until 2007, supply shocks attracted much more attention than demand shocks for four reasons. First, supply shocks tended to be associated with dramatic, high profile political and military events, notably Middle East conflicts, or other spectacular occurrences, such as devastation in the Gulf of Mexico caused by Cyclones Katrina and Rita. Second, aggregate demand shocks have been less dramatic, affecting prices gradually over time, rather than abruptly. Third, aggregate demand shocks have sometimes played a facilitating role for supply shocks, but this has often been overlooked, and the consequences of the shocks have been entangled and difficult to distinguish. Fourth, oil-specific and oil product-specific demand shocks may have been triggered by supply shocks and aggregate demand shocks, adding to the entanglement of causes and consequences.

Refined Product Shocks

Recently, Kilian (2010b) began to extend his categorisation of shocks to include shocks to supply of automotive fuel, exemplified by oil refinery (refined product supply) shocks. He suggested that the concept of speculative oil demand shocks in response to “expectations shifts” could be extended to oil products, but did not develop this line of analysis, focusing mainly on comparison of the effects of oil refinery shocks and his three categories of oil price shocks on refined product prices.

Economic modelling by Kilian (2010b) indicated that an unanticipated disruption of U.S. oil refinery output would cause an immediate and highly statistically significant increase in the real price of automotive fuel that would remain statistically significant for three months. He explained that the modelling results were consistent with the petroleum product price effects of damage to oil refineries caused by Hurricane Katrina, which hit the United States Gulf (of Mexico) Coast in late August 2005. This severe weather event, and Hurricane Rita which hit the Gulf Coast a month later caused the largest refined product supply shock in the world over the past few decades.

Obviously, a major refined product supply shock would result in considerable uncertainty regarding its duration and significance. It would also cause changes in perceptions of uncertainty regarding future shortfalls that could persist even after supply had been restored to pre-shock levels. It is difficult to assess how much a speculative oil demand shock arising from such ‘expectations shifts’ would add to the price increase from the short-term oil product supply shock, and how long the effects on real refined product prices would persist.

In view of the preceding analysis, refined oil product price shocks could result from:

* *crude oil supply shocks* (pass through of crude oil price increases)
* *aggregate demand shocks* (global growth of demand for goods and services generally)
* *speculative crude oil demand shocks* (pass through of crude oil price increases)
* *speculative refined product oil demand shocks*
* *refined product supply shocks*
* *combined shocks*.

Because refined product prices rise and fall with crude oil prices, crude oil supply shocks and speculative crude oil demand shocks would also translate into refined product shocks. Aggregate demand shocks affect crude oil prices because demand for crude oil is derived from demand for refined products. Two additional potential shocks apply to refined products:

* refined product supply shocks separate from crude oil supply issues
* speculative demand for products, separate from precautionary demand for crude oil.

As for crude oil, more than one shock may apply simultaneously. Again, contemporaneous shocks may also interact.

Inventories and Speculative Demand

In recent years, the relative importance of the various sources of price shocks in explaining major oil price events over the past 40 years, and the extent to which they have interacted with each other have been keenly scrutinised and debated.[[17]](#footnote-17) The presence, role and influence of speculative oil demand shocks and their interaction with other sources of price shocks have been the main sources of controversy, with central issues being the role and significance of changes in inventories or stocks.

If the futures market is in contango (futures prices exceed current spot prices) and the spread is large enough to exceed crude oil holding costs (storage and interest cost) – a case of strong contango – there would an incentive to sell oil forward and to purchase crude oil on the spot market and hold it for delivery under the forward contract. Alternatively, a producer could slow production, which means higher remaining underground reserves (a form of inventories). Therefore, arbitrage activity could be expected to lower futures prices and increase spot oil prices, moderating the spread.

This strong link between futures and spot markets does not exist if the futures market is in backwardation (current spot prices exceed futures prices) or weak contango (futures prices exceed current spot prices, but not sufficiently to cover crude oil holding costs). It is not possible to buy crude oil in the futures market and then sell at an earlier time in the spot market (Tilton, Humphreys, Radetzki, 2011).

However, there is a weaker mechanism through which the futures market can still influence the spot market during periods of backwardation and weak contango. Users of crude oil are prepared to bear costs of holding inventories of crude oil up to some level because having stocks on hand reduces risks of supply disruption and delays in acquiring additional supply to respond to a demand surge.

The amount of inventories a crude oil user would purchase on the spot market for these convenience benefits depends on the storage and interest costs of holding inventories and the weak contango (an offset to holding costs) or backwardation (an additional opportunity cost of holding inventories). The larger (smaller) is the holding cost, which rises (declines) with increases (decreases) in backwardation the smaller (larger) would be the amount of inventories held for convenience purposes. However, the influence of futures markets on spot market activity in respect of convenience stocks would diminish as stocks approach zero with increasing degree of backwardation and as inventories rise to a level beyond which no further positive convenience benefits are yielded (Tilton, Humphreys, Radetzki, 2011).

It has been suggested that rising futures prices may affect spot prices by re-shaping price expectations. This could apply when futures markets are in strong contango, but not when they are in backwardation or weak contango. Speculators who, despite futures prices, consider the spot price in future will be higher than the current spot price, could make larger profits from buying oil futures (in backwardation or weak contango) and selling the oil in the spot market in the future, than by buying oil in the spot market now and holding it for future sale in the spot market (Tilton, Humphreys, Radetzki, 2011).

Despite these considerations, and the strong focus of precautionary, hedging, investment and pure speculative activities in futures markets, participants in these activities still trade in spot markets at times of backwardation and weak contango, as well as during periods of strong contango (Tilton, Humphreys, Radetzki, 2011).

Because the spot-future price spread is an important determinant of influence of futures market activity on spot prices, the incidence of contango and backwardation situations in futures markets is a matter of significance. An econometric study by Hamilton and Wu (2011) indicated persistent backwardation in oil futures with relatively modest variation prior to 2005. They observed that this was consistent with the interpretation that the primary source of the backwardation was hedging by commercial producers, because the discounting of forward prices (backwardation) compensated purchasers of forward contracts – the hedgers’ counterparties. From 2005, there was substantial change. The volume of trading in oil futures contracts increased substantially, and the backwardation spread declined on average, but became much more volatile, often changing to significant contango. Hamilton and Wu (2011) nominated increased participation by financial investors in oil futures markets as a factor in changing the nature of the spot-future price spread for crude oil futures contracts, because of their pursuit of portfolio diversification.

In an article frequently cited in the literature on speculation in oil markets, De Long, Shleifer, Summers and Waldmann (1990) explained how the activities of rational speculators could destabilise prices of financial assets, rather than stabilising them as suggested by the efficient market hypothesis. Their analysis applies to commodity futures prices. It also extends to commodity prices both directly indirectly through the interaction of futures and spot prices, as explained above.[[18]](#footnote-18)

De Long, Shleifer, Summers and Waldmann (1990) classified market participants into three categories:

* *passiv*e *investors* who invest and trade on the basis of analysis of fundamentals
* *positive feedback traders* including
  + “noise traders” acting on extrapolative expectations regarding prices or chasing trends
  + traders applying stop-loss orders
  + traders who liquidate positions because of inability to meet margin calls
* *rational speculators* who respond an informed, rational way to new information and the activities of other market participants.

The efficient market hypothesis relies crucially on rational speculators to provide market stability by returning prices to fundamental values. The hypothesis assumes that rational speculators buck irrational trends created by “noise traders” and other positive feedback traders.

One problem with this view is that risk-averse behaviour in the context of risk exacerbated by the unpredictability of irrational behaviour could moderate the responses of rational speculators to departures from fundamentals. This means noise-driven price movements could be dampened, but not completely eliminated.

A more serious problem is that rational speculators might stimulate trend chasing by “noise traders”. Rational speculation in response to good news stimulates buying by “noise traders”. Rational speculators would recognise and anticipate this. Consequently, they could buy more aggressively than justified by fundamentals, increasing the stimulus to buying by “noise traders”. Buying by “noise traders” could continue on the basis of trend extrapolation. Therefore, the trading behaviour of rational speculators could be destabilising, stimulating irrational trends inconsistent with fundamental values. Later, with prices climbing well above fundamentals, “noise traders” would still be buying while rational speculators would start to buck the trend by are selling, which would have a stabilising effect on prices (De Long, Shleifer, Summers and Waldmann (1990).

An objection to this argument is that because positive feedback traders would be buying when prices are rising and selling when they are falling, they would lose so much that they exit the market or otherwise learn from their mistakes. However, De Long, Shleifer, Summers and Waldmann (1990, p. 383) have presented various reasons why this objection was not convincing and positive feedback trading can keep recurring in the long-run. In any event, history supports their position.

The preceding analysis has shown that crude oil prices can be affected by speculative demand of rational and irrational varieties, and by activity in futures markets as well as spot markets. Moreover, it indicates that sources of speculative demand are more diverse than inventory convenience and hedging by commercial producers and users of crude oil.

It is widely accepted that speculative oil-specific demand shocks are more likely to occur when there has been little spare capacity. Then, an event raising doubts about adequacy of supply at current prices is more likely to induce speculative buying. Conversely, an event relieving concerns about supply adequacy at current prices is more likely to result in an unwinding of any previous build-up of stocks in the context of earlier lack of spare capacity.

When negative supply shocks trigger and overlap with increases in speculative demand, the inventory effects of these shocks tend to work in opposite directions, while the price effects tend to be in the same direction. The same applies when positive supply shocks and speculative demand reductions overlap. The nett change in inventories in the event of overlapping shocks can be up or down and it can change over time.

It has often been argued that the behaviour of inventories is the key to the presence and importance of speculative demand shocks (For example, see Hamilton, 2009a,b; Dvir, Rogoff, 2010; Kilian and Murphy, 2010). However, different interpretations of historical behaviour of inventories and what should be included in inventories have been used in support of, and against the applicability of the speculative demand concept in various circumstances.

Hamilton (2009a,b) claimed that inventory movements tended to moderate price shifts following shocks, rather than exacerbate them. He also argued that historical inventory movements did not support the existence of speculative demand shocks.

The main purpose of inventories is to mitigate shocks, such as supply disruptions or demand surges. If an upward demand or downward supply shock applies to a commodity, its price rises. If the shock and price rise are perceived to be short-lived, stocks of the commodity are run down at the higher price to be replenished at the “normal”, lower price later. In effect, stocks of the commodity are transferred from a time of adequacy to a time of shortage. If a downward demand or upward supply shock is perceived to be temporary, inventories would build up, effectively transferring commodity stocks from a time of surplus and relatively low price to a time of “normal” adequacy and price. Therefore, inventory movements tend to moderate price shifts from temporary demand or supply shocks.

Dvir and Rogoff (2010) explained that this behavioural pattern was dependent on the shock being perceived to be temporary and supply not being restricted. The importance of these conditions can be illustrated as follows.

When an upward aggregate demand shock occurs, existing and potential market participants would be caught between two contradictory forces. The reduction in relative availability and rise in price of the commodity following the shock would indicate an inventory run-down in the short-term, to the extent the shock is temporary. However, if it is thought the aggregate demand shock could persist or there could be a series of such shocks, and if supply is restricted, the expectation or fear of continuation of high or rising prices would induce higher or rising demand for inventories. If enough market participants anticipate that the aggregate demand shock or series of shocks is likely to persist, and that supply restrictions would continue, the influence of stock-building would dominate the tendency to run-down inventories. Then, the nett speculative demand influence would add to the effects of shocks on price.

The supply restriction condition should not be overlooked. To the extent that supply was perceived to be flexible, the expectation or fear of high or rising future prices would be moderated, reducing demand for inventories and the exacerbation of the effects off shocks on price via the influence of speculative demand. Indeed, Dvir and Rogoff (2010) highlighted the importance of concurrence and interaction of shocks. Moreover, they emphasised the role of persistent artificial supply constraints, such as OPEC’s restrictions on production capacity. Supply shocks are not confined to occasional events associated with wars, civil unrest, and natural disasters.

Adelman (1995) stressed the importance of speculative demand shocks in the context of supply side constraints and threats of such constraints by Middle Eastern oil producing countries at the time of the ‘first and second oil crises’. He also explained how these shocks interacted. Indeed, he argued that Middle Eastern producing countries deliberately encouraged speculative demand and then exploited that demand shock to raise their production-linked taxes and official prices to sustain prices caused by speculative demand at new, higher levels.

Kilian and co-authors have discussed in depth the role of speculative demand effects in the context of various aggregate demand and supply shock events in specific periods ranging from a year or two to five years since 1972. However, they have not focussed on the role of prolonged periods of production capacity constraint by OPEC members as either a persistent supply shock or a contextual matter from 1973 to the present time.

Because of controversy regarding the implications of inventory movements for identification of causes of oil price shocks, Kilian and Murphy (2010) formulated a structural vector autoregressive (VAR) model of the global crude oil market that for the first time explicitly included a role for shocks to oil inventories or stocks, in addition to roles for shocks to demand and supply (flows) in the market for crude oil.

The model allowed for negative oil supply shocks or supply disruptions (flow supply shocks) to cause the draw-down of inventories to smooth consumption of refined products, as well as for the price of oil to rise in response to the supply reduction. It also allowed for reverse outcomes from positive oil supply shocks.

The model also allowed for speculative oil demand to rise in response to a supply disruption (negative supply event) and consequent price rise, for the purpose of building inventories. This could be pursued by attempting to re-build above ground stocks, including storage in tankers at sea, or by leaving oil below ground in anticipation of price increases (Davidson, 2008; Frankel, Rose, 2010; Kilian, Murphy, 2010).

Symmetrically, the model allowed for speculative demand to fall to reduce crude oil stocks following a positive supply event and consequent price fall. Again, the inventory effects of the supply event and the change in speculative demand are in opposite directions, the price effects are in the same direction, and the nett change in inventories could be up or down and vary over time.

The model also allowed for aggregate demand shocks (a shock to flows) to raise or lower the price of crude oil, depending on the direction of the shift in the level of economic activity. It allowed for a lagged draw-down of inventories and then a build-up to support higher usage.

In addition, the model allowed for the existence of a residual shock that could include weather shocks, unexpected changes to strategic reserves, and changes to companies’ inventory technologies or preferences for inventories.

Kilian and Murphy (2010) used the model to disaggregate or decompose movements in the real oil price and oil inventories from June 1978 to August 2009. Intuitive explanations of model results for oil market shocks during this period of 31 years have been outlined, along with contextual information on each shock, in the next sub-section. For completeness, the concepts have also been applied to explain the roles of various types of shock in the ‘first oil crisis’ in 1973-74.

Historical Oil Shocks

There have been several high profile examples of major oil shocks over the past 40 years. Historically, combinations of different types of oil shock appear to have been the most common occurrence. Analysis of the circumstances reveals how different types of oil shock may combine to influence prices or may act in isolation on some occasions. Such analysis provides an important foundation for prediction of the effects of a major oil supply shock in current economic circumstances.

Arab-Israeli War and Repudiation of Government-Company Agreements, 1973-74

During the “first oil crisis” of 1973-74, the nominal price of crude oil quadrupled and the real price more than tripled in a period of a few months. For many years thereafter, it was common for commentators to attribute this price shock to production cuts by Middle Eastern producers and an oil embargo against the United States and some other countries following the Arab-Israeli (Yom Kippur) war in October 1973. This perception was buttressed by data showing a drop in production, as well as the spectacular price increase. However, important circumstances were overlooked in forming this view. In 1972, prices of other mined commodities surged in real terms in response to strong growth of global aggregate demand. Crude oil prices did not experience similar growth. The existence of substantial excess supply of crude oil was one reason. Another constraint was the 5-year Tehran/Tripoli agreements between oil companies and Middle Eastern producing countries provided a moderate improvement in government receipts per barrel of crude oil extracted in exchange for assurances that governments would allow oil companies to extract as much oil as they saw fit. Nevertheless, nominal crude oil prices rose faster than provided under the agreements, because governments increased their take through taxes effectively linked to quantity produced and taking part ownership of production or “participation” (Adelman, 1995). However, the nominal crude oil price increases were more than offset by rising inflation and, in the case of prices denominated in United States dollars, by depreciation of that currency (Kilian, 2008b, 2010c; Radetzki, 2006, 2008).[[19]](#footnote-19)

With demand for petroleum products and therefore crude oil growing strongly in response to the strong growth of global economic activity, oil companies expanded oil production from spare capacity with moderate increases in payments per barrel to host governments. By the beginning of 1973, many Middle Eastern countries were producing at levels close to nominal capacity, with the exception of Saudi Arabia. Output from Saudi Arabia increased further in early in 1973 (Adelman, 1995; Kilian, 2008b).

While use crude oil continued to grow in 1973, the rate of growth of consumption slowed. However, growth of demand remained strong because of inventory building to avoid anticipated increases in the government take through higher taxation and “participation”. This build-up of inventories extended beyond crude oil to refined products. As demands from Middle Eastern countries for higher “takes” from taxation and “participation” increased during 1973, fear of higher government “takes” and consequent higher prices caused increased speculative demand for inventories of crude oil and refined products. This led to higher prices, which were followed by concerted increases in government “takes”, which then supported prices at higher levels. The Tehran/Tripoli agreements had been effectively repudiated before the Arab-Israeli war in October 1973 (Adelman, 1995).

The war commenced on 6 October 1973. On 17 October 1973, the Organisation of Arab Petroleum Exporting Countries (OAPEC) agreed on production cuts of 5 per cent per month, commencing immediately and continuing until Israel withdrew completely from Arab land occupied in June 1967, particularly Jerusalem, and restored legal rights of Palestinian people. A few days later, Saudi Arabia and Kuwait applied larger cuts. OAPEC also announced an embargo against the United States and the Netherlands, and reduced shipments to some other countries (Adelman, 1995). The pattern of ratcheting-up crude oil prices, which was established before the war, continued during the remainder of 1973. The announcements regarding production cuts created fear, inducing speculative demand, which drove up the price. The floor price was set by the tax “take”, which was nearly doubled on 16 October, and then more than doubled from the higher base in late December 2003. Morris Adelman’s description of the mechanism in the period October-December 1973 has been re-produced in Box 1.

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| --- |
| Box2 **Role of speculative demand and taxes in ‘first oil crisis’** |
| “Over the three months October through December, total lost output was about 340 million barrels, which was less than the inventory build-up earlier in the year. Considering as well some additional output from other parts of the world, there was never any shortfall in supply. It was not loss of supply but fear of possible loss that drove up the price. Nobody knew how long the cutback would last or how much worse it would get. Additional cuts were scheduled.  Precautionary demand was driven by the fear of dearth. Oil might be only a small fraction of a buyer’s total cost of operation, but without it, a factory, or a power plant, or a truck fleet would stop dead. The loss was so great that it paid to take out expensive insurance against even a minor probability. Panic aside, it made sense for refiners and users to pay outlandish prices for oil they did not need.  Speculative demand included those seeing a quick turnover profit or crude oil buyers trying to buy sooner rather than later. But an additional factor may have been even more important: oil product prices were largely controlled by contract or government. Every buyer and seller at the much lower mainstream prices knew that if the production cuts continued, those prices would also rise. Moreover, OPEC had nearly doubled the per barrel tax in October and would again.  Thus, buyers and sellers could hold crude oil or products with little downside price risk. Their increased demand raised prices all the more. “The spot crude oil market dropped dead last week ... as sellers decided to hang on to every barrel.” [Petroleum Intelligence Weekly Special Report, October 1990). Those with stocks of oil or products sold as little as possible. Some sought to buy for an immediate resale gain, others to hold for higher prices soon. Thus the effects were out of all proportion to a loss of at most 9 percent for a month.  Not the amount of cutback or ‘shortfall’ but the fear of dearth did the damage.”  *Source*: Adelman (1995), pp. 110, 112. |
|  |

On 4 December, Saudi Arabia announced, without explanation, cancellation of the additional production cut of 5 per cent scheduled for the month. By mid-December 1973, it was becoming clear that production shortfalls were not as severe as had been feared (Adelman, 1995). The reduction in the global production rate during the period October 1973 to March 1974 was 4 per cent. The real crude oil price increase approached 200 per cent (Hamilton, 2009b). The peak output reduction by OAPEC countries was about 2.67 million barrels per day in November and December 2003. In January and February 2004, the size of the output reduction compared to pre-October 2003 shrank to 0.8 million barrels per day and 0.57 million barrels per day, respectively (Kilian 2008b).

By mid-January 1974, crude oil was in substantial excess supply. If crude prices had been ruled by supply and demand in a competitive market, the price surge of 1973 would have been reversed. However, the market was not competitive, the OPEC countries collectively had substantial market power and they exercised it to raise prices further, with excess capacity also growing. By August 1974, excess capacity in OPEC countries had risen to about 20 per cent. During 1974, the relevant governments raised their “take” through tax and “participation” arrangements by more than 50 per cent. The governments raised their taxes and sales prices of their “participation” oil in concert and generally refrained from offering lower prices to sell more oil. This raised contract prices. Meanwhile, open market crude oil and refined product prices typically rose through speculative demand in anticipation of the government action pushing up official prices. By the end of 1974, crude oil and product storage tanks everywhere were full. With prices set in these ways, the market determined quantity demanded, and production was adjusted to match that quantity (Adelman, 1995).

Analysis of the circumstances of the 1973-74 oil crisis has revealed that the price spike was attributable not just to an oil supply shock. Two other types of shock also played roles. Specifically, aggregate demand and oil-specific precautionary demand shocks also contributed to the price spike. In addition, the nature of the supply side shock was more complicated than just loss of production.

Kilian (2008b, 2010c) argued that a comparison of the spike in the oil price and the earlier spike in prices of other mined commodities suggested that up to 75 per cent of the increase in the real price of crude oil could be explained solely by strong growth of demand for crude oil driven by growth of global economic activity. Moreover, analysis of the change in supply indicated that less than 25 per cent, and probably only about 20 per cent of the oil price spike could be attributable to an oil supply shock, leaving 75 per cent to 80 per cent of the price spike to be explained by growth of aggregate demand and oil-specific speculative demand (Kilian, 2008b; 2010c).

Radetzki (2006, 2008) perceived contributions from aggregate demand, speculative demand, and supply shocks to the spike in crude oil prices in 1973-74. He pointed out that crude oil prices rose much more than other mined commodity prices. He attributed this to the supply management actions of OPEC, large sales of metals from the United States Government’s strategic stockpiles between mid-1973 and mid-1974, and sales in late-1974 of excess stocks of metals held by Japanese companies. Radetzki was not as definitive as Kilian on relative contributions of different types of shock to the crude oil price spike.

Hamilton (2009b) acknowledged that an aggregate demand shock contributed to the crude oil price spike, but considered the supply shock to be more important. He doubted that speculative demand contributed to the spike because inventories of crude oil and refined products declined for 3-4 months from October 1973. He argued that if speculative buying had been occurring, it should have been evidenced by a build-up of inventories.

However, this does not indicate the absence of a significant speculative demand shock. The initial decline in inventories may simply mean the expected run-down in inventories in response to the supply shock outweighed the influence of speculative demand for 3-4 months. The later build-up of inventories to levels above those prevailing before the shock is consistent with the existence of a speculative demand shock. This view is consistent with the analysis of Dvir and Rogoff (2010).

In any event, Morris Adelman explained that that there was a substantial build-up of inventories from the beginning of January 1973 to early-October 1973. He estimated that the increase in crude oil inventories was substantially in excess of 552 million barrels (2 million barrels per day), compared to lost output of 340 million barrels in the three month period, October to December 1973. In addition, he argued that outside the oil industry there had been substantial build-up of inventories of refined products during 1973 prior to October. Then, inventory levels climbed again to the capacity of available storage during 1974 (Adelman, 1995).

The embargo on oil supplies to the United States and the Netherlands, and reduced shipments to some other countries was rendered ineffective by diversion of shipments from country to country. The embargo was not responsible for queues more than 1.5 kilometres long at fuel service stations in the United States. This queuing was the result of controls on fuel prices in the United States and administrative allocation of supplies (Adelman, 1995, 2004; Kilian, 2008b). Morris Adelman, (2004, p. 19) commented:

“We ought not blame the Arabs for what we did to ourselves.”

Iranian Revolution and the Iran-Iraq War, 1978-1980

The ‘second oil crisis’ involved another huge increase in the real price of crude oil. The peak was more than double the real price level established as a result of the ‘first oil crisis’ (Hamilton, 2009b). During and after the ‘first oil crisis’, Middle Eastern and North African countries progressively took over oil company producing assets. This process commenced before the ‘first oil crisis’. As this process continued, governments transitioned from use of production-based taxes to selling oil to collect their take. The transition made it more difficult to maintain a floor under the crude oil price following spot price surges caused by speculative demand increases resulting from fears regarding supply that they had sought to create or exploit. With the companies in place, they could raise their production-based taxes in concert and let the companies compete above the floor set by cost plus tax. Without the companies, governments had to set production and market shares and rely on others not to cheat (Adelman, 1995).

The traditional view is that the initial price surge of the ‘second oil crisis’ was driven by disruptions to oil supply associated with the Iranian revolution in late-2008 and early-2009. These disruptions occurred during the period, December 1978 to February 2009. Restoration of Iranian production was well advanced by April 1979. However, the big surge in the real oil price did not commence until May 1979.

Kilian (2008b, 2010c) and Kilian and Murphy (2010) attributed the price surge to a resurgence of global economic activity (aggregate demand) combined with speculative demand driven by fears of military conflict in the Persian Gulf and consequential oil supply interruptions, in the context of high oil production capacity utilisation rates in OPEC countries and worldwide. Inventory behaviour was consistent with this explanation, falling sharply initially and then rising above pre-shock levels by May 1979.

Adelman (1995) provided a more detailed explanation. He pointed out that there was adequate spare capacity in late 1978 and the first half of 1979 to cover disruption of supply from Iran. However, it was widely expected that OPEC would increase official prices at its December 1978 meeting, and fear of supply disruption was strong. Speculative buying occurred and inventories rose contra-seasonally. Loss of Iranian production in November was covered by other producers. However, OPEC announced price rises for each quarter of 1979 at its December meeting. The annual rate of increase was 14.5 per cent.

Iran was out of the world market again in January until early March 1979, when exports re-commenced, but at a reduced rate. In late January, Saudi Arabia announced a cut in production of 2 million barrels per day. Major oil companies had already been involved in heavy speculative buying of crude oil, pushing up spot prices. Governments raised official prices towards spot levels.

Spot prices eased in March following resumption of exports from Iran, but surged in May following production cuts by Saudi Arabia in April. Official prices took-off in pursuit. While the rise in spot prices temporarily ceased after Saudi Arabia raised output in July 1979, other governments cut production and OPEC governments continued raising official prices. Spot prices surged again late in 1979, following production cuts by some governments and renewed fears about supply. Spot prices turned down early in 1980, but official prices continued to rise, albeit more slowly through to August 1980. Meanwhile, inventories accumulated (Adelman, 1995).

Following the break-out of war between Iran and Iraq in September 1980, the supply of oil suffered a major disruption. Their combined capacity dropped from 11 million barrels per day to 6 million barrels per day, where it remained until 1990. The real oil price climbed further, with some resurgence of speculative demand. Official prices climbed behind the spot price. Inventories again fell initially before climbing above pre-stock levels, but only partly because of speculative demand. Inventoriesalsogrew because of unexpected increases in oil production, including growth of production outside of OPEC. This dampened the oil price. Some selling of inventories occurred because of high holding costs. By July 1981, spot prices were back at levels prevailing before the Iran-Iraq war, with spot and official prices approximately the same (Adelman, 1995; Kilian, Murphy, 2010).

Collapse of Saudi Arabian Support for Oil Price, 1986

In late-1985, Saudi Arabia abandoned its attempts to support the crude price by curtailing its own production. The result was a major increase in oil supply. This positive oil supply shock translated into a sharp fall (about 50 per cent) in the real crude oil price.

Kilian and Murphy (2010) argued that a speculative demand drop, represented by reduction of stocks, reinforced the oil price fall. They explained that this shift in speculative demand was caused by changes in price expectations as a result of altered perceptions of OPEC’s market power. They pointed out that while inventories rose initially as expected because of the increase in Saudi Arabian production, they subsequently declined consistent with a downward speculative demand shock.

Iraq’s Invasion of Kuwait, 1990-91

Oil supply was disrupted following Iraq’s invasion of Kuwait in August 1990. The average global reduction in the oil production during the August-October 1990 period was 2.9 per cent. The real crude oil price spiked to around double the level before the invasion, which was around the real price prevailing before Saudi Arabia abandoned its pre-1986 support for the oil price through cuts to its own production. The upward price movement was quicker than in 1973 and 1979, and the downturn commenced much sooner, less than three months after the invasion. (Adelman, 1995; Hamilton, 2009b). The traditional view is that the supply shock was responsible for the price spike. This seems to be supported by an initial decline in inventories, but that reduction was small in the context of the size of the supply shock. However, the reality was more complicated.

The disruption occurred at a time of excess crude oil supply and weak prices. The amount of excess capacity in the Persian Gulf region at the time, about 5 million barrels per day (excluding Iraq and Kuwait) exceeded the combined production rate of Iraq and Kuwait before the conflict by about 1.5 million barrels per day. While the spare capacity could not be brought into use instantly, inventories of crude oil and refined products were at high levels and could cover the disruption on an interim basis (Adelman, 1995).

According to Adelman (1995, p. 293):

“Thus, the 1990 oil crisis was like the others: there was no shortage, but the *threat* of shortage generated precautionary demand for more inventories, which raised prices, which brought additional speculative demand. Expectation of a higher price is a self-fulfilling prophecy.”

Kilian and Murphy (2010) argued that a speculative demand shock was operating simultaneously with the supply shock. The speculative demand shock was tending to increase inventories, while the supply shock was causing them to be run down. Meanwhile, both shocks contributed to the sharp increase in real crude oil prices. Their modelling results suggested that the supply shock was responsible for about two-thirds of the price spike.

Kilian and Murphy (2010) suggested that the speculative demand increase commenced 2-3 months before the conflict, because of increasing tension in the Middle East. However, the potential price effects of this demand shock were offset by rising crude oil production.

They explained that the decline in real oil prices from late October 1990 was caused almost entirely by a decline in speculative demand, rather than increased oil production. This was reflected by a decline in inventories. The underlying shift in expectations was attributed to removal of a previously perceived threat to Saudi Arabian oil fields in the context of conflict in the Middle East (Kilian, Murphy, 2010).

Adelman (1995, p.296) argued that additional factors contributed to the short duration of the oil price surge and the decline in speculative demand. Of particular importance was the behaviour of Saudi Arabia:

“After a month’s silence let the price rise, they (Saudi Arabia) increased output and let it be known they would keep it high. That was far cry from 1979-1980, when their prolonged refusal to ensure more supply kept driving up the price for over a year.”

Adelman (1995) argued that knowledge in the market that strategic petroleum reserves in the United States, Germany and Japan might have been used to address the ‘crisis’ moderated the surge of speculative demand. One way in which it did this was by helping to quell panic in governments.

Adelman (1995) noted that some “token sales” were made from strategic petroleum reserves after crude oil prices had turned down and sales from strategic reserves were no longer needed. He commented that if large or unlimited amounts had been offered for sale or if options for future sale had been offered when the ‘crisis’ began, the price upheaval could have been prevented.

Venezuelan Oil Supply Crisis and Iraq War, 2002-2003

Civil unrest in Venezuela was followed by a sharp, well-defined reduction in crude oil production from December 2002. Then, in early-2003, Iraqi oil production ceased temporarily as a result of war with the United States and its allies. The combined supply shock was similar in magnitude to the 1970s supply cuts (Kilian, 2008b; Kilian, Murphy, 2010).

The real oil price rose in response to the Venezuelan event and inventories fell. An increase in speculative demand because of the potential of conflict between the United States and Iraq dampened the decline in inventories, but reinforced the oil price rise.

However, the combined Venezuelan and Iraqi supply shocks did not generate a large oil price spike, because they were more than offset by an unexpected increase in global oil production early in 2003 – a countervailing positive supply shock. The positive oil shock led to inventory accumulation, and induced a reversal of the speculative demand shock. The speculative demand shock worked in the opposite direction to the positive oil shock in respect of inventories, and in the same direction in the case of the oil price (Kilian, Murphy, 2010).

Hurricanes Katrina and Rita, August-September 2005

Supply of crude oil and refined products from the Gulf of Mexico/U.S. Gulf Coast region was temporarily disrupted by Hurricanes Katrina and Rita in late-August 2005 (landfall, 29 August) and late-September 2005 (landfall, 24 September), respectively. This supply shock has received relatively little attention in the economic literature on oil shocks. It appears that this relative neglect is attributable to the responses by the United States Government and the International Energy Agency (IEA) that largely neutralised the crude oil component of the supply shock, and to the shock’s timing early in the 2004-2008 crude oil price surge which attracted substantial attention from politicians and economists in respect of causation (discussed below). However, the shock is of interest in the context of this report because of the combination of crude oil and product supply shocks, the IEA response, and the context of strongly rising demand for deriving from aggregate demand for goods and services globally.

Following Hurricane Katrina, Gulf of Mexico crude oil production was reduced by about 1.4 million barrels per day initially. The amount of shut-in production had declined to about 0.7 million barrels per day after 10 days and to about 0.6 million barrels per day just before Hurricane Rita.

Refined petroleum production capacity in the Gulf of Mexico fell initially by about 2 million barrels per day after Hurricane Katrina, with some production resuming after 1-2 weeks and other capacity not being available for more than three months. In the month immediately following Hurricane Katrina the average loss of Gulf oil refinery throughput was 1.57 million barrels per day. North American oil refinery throughputs for September 2005 were approximately one million barrels a day lower than the same period in 2004.

The supply disruption caused by Hurricane Katrina resulted in an increase in United States petrol prices of about 18 per cent over the next few days. Because there is an integrated international market for refined petroleum products, as well as crude oil, this substantial supply loss affected prices globally. This is illustrated by Figure C1, which shows export petrol price movements from the refining and trading hub of Singapore, the benchmark for Australian retail prices. Retail petrol prices in Europe behaved similarly. Obviously, the integrated market moderated the effect that the supply disruption would have caused in the United States if that economy had not been open to imports from the rest of the world.

Figure C1 Singapore Export Petrol Price Movements Compared with Crude Oil Price Movements in 2005-06, Highlighting Effects of Hurricane Katrina and Rita and IEA Stock Releases

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a Acpl – Australian cents per litre

Data source: Caltex Australia (2006).

A striking feature of Figure C1 is that petrol prices (before taxes, transport costs, and wholesale and retail margins) rose substantially relative to crude oil prices. This could be attributed to the structure of U.S. Government and IEA action, which moderated crude oil prices much more than refined product prices.

On 31 August, the U.S. Government announced a decision to release Strategic Petroleum Reserve crude oil to provide loans totalling more than 13 million barrels to refiners. On 2 September 2005, all 26 IEA members agreed to a package of emergency response measures, including use of emergency stocks, increased production, and demand restraint totalling 60 million barrels (2 million barrels per day). Emergency stocks of 52 million barrels of oil and refined products were to be made available by releases from government stocks (29 million barrels) and reduction of private sector stockholding obligations (23 million barrels), with almost half of the emergency stock releases being in the form of refined products. The crude oil releases were to be made from the U.S. Strategic Petroleum Reserve. (IEA, 2008). Crude oil production increases were to provide about 6.6 million barrels.

While the supply of refined products was disrupted more than crude oil supply, the combined U.S. and IEA response was stronger for crude oil than refined products. Another factor that may help explain the relatively small spike in crude oil prices was reduced demand for crude oil as a result of the reduction in refining capacity and return to normal demand as spare capacity elsewhere was brought into service (Kilian, 2010b).

The IEA action would have reduced the period of time the refined product and oil price spikes lasted. By increasing supply it would have caused a moderation of prices increases. By reducing uncertainty regarding supply, it would have induced a reversal of speculative demand buying in response to the supply shock. This reversal may also have prevented a higher product price peak.

More crude oil and refined products capacity was taken out of service following Hurricane Rita. In the case of crude oil, the peak nett reduction in production capacity was over 1.5 million barrels per day. For refining, the peak nett loss of capacity was about 4.8 million barrels per day in early-October 2005. The difference between loss of capacity and throughput was substantial because August is typically the summer peak period for oil refinery throughput in the United States, while September and October are normally months characterised by depressed oil refinery throughput, as maintenance takes place. The normal aggregate reduction in throughput is normally about one million barrels per day.

The price impact of the Hurricane Rita supply disruption was minimal (see Figure C1). Thereafter, crude oil and product prices continued to decline until early December, dropping below levels attained before Hurricane Katrina. There could be at least two reasons for this. First, earlier U.S. Government and IEA action helped offset supply losses. Second, imports of refined products arrived in the United States at record rates in the three weeks following the Katrina product price spike (see Box 2). These shipments were supported by higher refined product production outside the United States that had been induced by the Katrina price spike, as outlined below.

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| --- |
| Box 3 Katrina and Rita Supply Shocks and Market Forces |
| “The Katrina-generated spike in gasoline prices sent a signal heard around the world. …… gasoline tankers raced to the U.S. and in particular to the highest priced market, the Gulf Coast. ‘The cavalry came in the form of the surge in gasoline imports’, summarised the Energy Information Administration, ‘setting all-time records in three successive weeks ...... that was critical in helping to keep gasoline prices from going higher following Hurricane Rita and to help them start dropping substantially thereafter.’’’  Source: Bradley, Tanton (2007), p. 6. |
|  |

Aggregate OECD oil refinery throughput in September 2005 rose by 59,000 barrels a day relative to the same month in the preceding year, despite the disruption to U.S. Gulf Coast oil refinery operations. Oil refinery runs in OECD Europe increased by 0.427 million barrels a day. In OECD Pacific, oil refinery runs increased by 0.625 million barrels per day, compared to the previous year. The IEA explained that approximately 0.33 million barrels a day of this 1.05 million barrel a day increase in throughput outside the U.S. could be attributed to lower scheduled oil refinery maintenance in Europe and the Pacific, suggesting that the remaining 0.72 million barrels a day of the extra oil refinery runs were induced by market forces. These adjustments were reflected by increases in refining margins indicated in Figure C1.

By the end of November 2005, oil refinery throughput rates for the U.S. petroleum refining industry overall were back to normal levels for that time of year, although Gulf Coast throughput rates still had not fully recovered to normality. As U.S. oil refinery throughput rates recovered, imports of refined products declined (Bradley, Tanton, 2005).

It appears that action by the U.S. Government and the IEA in response to damage caused by Hurricane Katrina, and market responses may have temporarily reversed a strong upward movement of crude oil prices that commenced in the second half of 2003. The trend re-emerged from December 2005.

Strong Global Economic Expansion, 2003-2008

Kilian and Murphy (2010) found that the surge in the real price of oil between mid-2003 and September 2008 was caused mainly by shifts in demand for crude oil associated with growth of global aggregate demand, powerfully underpinned by growth of economic activity in China, India and other rapidly developing Asian economies. Their modelling did not find evidence of a contribution from increases in speculative demand, even during 2007-08 when the real crude oil price rose sharply. They said that this was confirmed by analysis of oil inventory data. Their findings were consistent with those of several other respected economic analysts (for example, Radetzki, 2008; Hamilton, 2009a,b; Smith, 2009a,b; Kesicki, 2010; Büyükşahin, Harris, 2011).

In a recent review of work on the role of speculation in oil markets, Fattouh, Kilian and Mahadeva (2012, p. 18) argued that structural vector autoregressive (VAR) models that nest alternative explanations of the real price of oil, including speculative demand, provide strong evidence of speculation in the oil crisis of the 1970s, 1986, 1990, and 2002-03, but do not support the view that speculation was an important determinant of the real oil price in the 2004-2008 period. Instead, for the latter period, VAR models “imply that spot and futures prices (for crude oil) were driven by a common component reflecting economic fundamentals.” Fattouh, Kilian and Mahadeva (2012) also argued that the absence or presence of speculative pressures in oil markets cannot be inferred from analysis of oil inventory data without a structural model.

It is important to consider these views in the context of the supply position and the ongoing behaviour of the OPEC oil cartel.

Although the volume of proved reserves in OPEC countries doubled over the period 1973-2008, OPEC’s production capacity has remained virtually unchanged since 1973. OPEC’s installed production facilities are sufficient to extract just 1.5 per cent of its proved reserves each year. Non-OPEC producers have invested in production facilities able to extract 5.6 per cent of their proved reserves each year. It seems OPEC has limited oil production by avoiding provision of new production capacity (Smith, 2009).

It appears that from 1973 to 1985, and from 1991 to 2005, Saudi Arabia had adjusted its production to support prices at times of slack demand and raised production to moderate price increases resulting from supply disruptions elsewhere (Hamilton, 2009a; Kilian, Murphy, 2010). However, after global oil production rose in 2003 and 2004 and into 2005, it stagnated until the second half of 2007. One contributing factor was a 23 per cent decline in non-OPEC production, the first significant decrease in non-OPEC production since the ‘first oil crisis’. Another was that Saudi Arabian production was not increased in response to the stagnation of global production and strongly rising crude oil prices from 2005. Indeed, Saudi Arabian production fell. It was about 0.85 million barrels per day lower in 2007 than 2005 (Hamilton, 2009a,b; Smith, 2008; Kilian, 2009b, 2010a). It appears that Saudi Arabian may have moved to a new price policy (Hamilton, 2009a).

Artificial capacity constraints in OPEC could be regarded as a form of persistent supply shock. Adelman (2004) described this as “the real oil problem”, rather than Peak Oil. Kaufmann (2011) has also highlighted this matter. Dvir and Rogoff (2010, p. 3) observed that taking a long-term view of the oil market served to enrich the debate in the literature on sources of oil shocks because:

“....shocks to the oil market may have remarkably different effects on the real price oil across historical periods, not only due to their origin on the supply or the demand side, but also because of the ability (or lack thereof) of key players in the market to restrict access to supplies. In particular, in periods when the ability to restrict access to supplies was lacking, the oil market showed remarkable flexibility and relative price stability, even in the face of massive disturbances in both supply and demand.”

The supply situation prevailing in the period 2005-2007 fitted neatly the circumstances in which Dvir and Rogoff (2010) argued speculative demand would add to price increases resulting from a persistent aggregate demand shock. Therefore, the identification of causes of the substantial surge in crude oil (and other mined commodity prices) in this period is problematic.

Several respected oil market specialists have argued that the effects of the aggregate demand shock on the crude oil price were exacerbated by speculative demand in the 2007-08 period. Econometric analysis by Frankel and Rose (2010) found evidence of destabilising speculative effects arising from actions based on ‘bandwagon expectations’ – forecasts of future commodity prices that extrapolated recent trends – during the 2007-08 period. In other words, there was evidence of destabilising speculation based on positive feedback trading by “noise traders” as described by De Long, Shleifer, Summers and Waldmann (1990). Similarly, Kaufmann (2011) produced evidence of destabilising speculation.

Frankel and Rose (2010) explained that prices for crude oil and other mined commodities continued to rise in the 2007-08 period despite a series of downgrades of forecasts economic growth. ENI Vice President, Leonardo Maugeri (2009) pointed out that from August 2007, growth of oil production began to outstrip non-speculative demand growth, with new production coming on line.

Maugeri (2009) argued that expectations based on earlier price trends had influenced strong increases in oil prices in 2007-08. He said that this would not have occurred without inadequate data provision, and misleading analysis and forecasts by high profile organisations that distorted perceptions of market fundamentals. He stated that inventories grew as supply growth outstripped non-speculative demand growth. Maugeri claimed that the accumulation of inventories was not included in official statistics until later.

Growth of inventories during the period 2005 to 2008, would undermine the view that speculative demand did not contribute to the substantial rise in oil prices during this period. This was noted by Kaufmann (2011), who presented data showing that private inventories of crude oil held in the United States rose substantially in the period 2004 to 2008 in terms of both volume and days of forward consumption.

In addition, it is relevant that, in effect, inventories can be raised by slowing production, which leaves oil in reserves below ground. This can be prompted by anticipation of price increases (Davidson, 2008; Frankel, Rose, 2010). Indeed, it is noteworthy that Saudi Arabian production declined from 2005 when crude oil prices were soaring to an historical peak in 2008.

Global Financial Crisis and Partial Recovery, 2008-2012

Kilian (2010a,b) argued that the collapse of the oil price in late 2008 and 2009 was caused mainly by unexpected changes in global activity combined with “unprecedented expectations shifts” triggered by the global financial crisis. The expectations shifts, through speculative demand reductions, exacerbated the reduction in demand for oil resulting from the shift in global economic activity.

Hamilton (2008b) also suggested that the economic reversal was unexpected. However, Frankel and Rose (2010) argued that the signs of an impending downturn were clearly evident and publicised.

Hamilton (2008) commented that the sharp global economic decline in response to the global financial crisis was not enough by itself to explain the magnitude of the dramatic decline in the oil price. He suggested that the effect of the severe economic reversal was reinforced by delayed responses to high oil prices in 2007-08.

Kilian (2010c) and Kilian and Murphy (2010) attributed the subsequent partial recovery of the crude oil price primarily to a recovery of global real economic activity. As in the 2004-2008 period, the recovery was underpinned by growth of economic activity in China, India and other rapidly developing Asian economies.

Aggregate Demand Shocks: Cycles and Structural Shifts

The economic literature focusing on the relative importance of crude oil supply shocks, aggregate demand shocks and speculative demand shocks has abstracted from a growing, parallel body of literature focused on analysis of demand side influences on movements of prices of mined commodities (including petroleum). This parallel body of analytical work has sought to distinguish between influences on mined commodity prices of:[[20]](#footnote-20)

* cyclical changes in the level of global economic activity (the economic or business cycle)
* speculative activity
* “structural shifts” in markets for mined commodities at various times over the past 140 years
* “super cycle” phenomena.

It is apparent that behaviour of prices of petroleum and other mined commodities over the past decade has been influenced by each of the first, second and third of these phenomena. The fourth is different perspective on the third.

Detailed discussion of these influences on mined commodity prices is beyond the scope of this study.

Economic Implications of Oil Shocks

The distinction between types and causes of oil shocks has great economic importance. The economic consequences of an oil shock depend crucially on its cause or causes. There are important differences between the economic effects of oil and refined product price increases resulting from aggregate demand shocks, oil and refined product supply shocks, and precautionary (speculative) demand shocks.

The economic effects of oil shocks also vary between countries in accordance with differences in economic structures. These effects have changed over time as economic structures have changed.

The differences between economic effects of the various types of oil shock have important implications for formulation of macroeconomic policy responses. Appropriate responses will differ according to the causes of the shocks. A complication for formulation of policy responses is that more than one type of shock may be operating around the same time.

The different economic effects of different types shocks and implications for policy for various categories of country are discussed below. Further discussion linked to economic modelling results can be found in articles by Baumeister, Peersman and Robays (2010) and Kilian (2009a, 2010a).

Aggregate Demand Shock

A shock to prices of crude oil and products caused by an unexpected increase in global economic activity would result in a transitory increase in real national income and inflationary pressures in all countries, as well as an increase in crude oil and refined product prices. If the unexpected increase in the rate of growth of global economic activity unexpectedly persists, the higher rate of growth of real national income and inflationary pressures would persist. Monetary authorities could be expected to intervene to dampen inflationary pressures.

Such an aggregate demand shock would cause relatively large increases in prices of all mined commodities and other natural resource-based commodities, such as food and fibres. This would occur because to varying degrees, these natural resource based commodities are characterised by relatively low price elasticities of demand and supply. Because Australia is a large producer of a diverse range of commodities, it would tend to be particularly affected by such an aggregate demand shock. This has been exemplified by the commodity price boom of 2004-2008 and its revival from 2010.

The particularly strong increase in inflationary pressures in a major commodity producer like Australia would be ameliorated by a floating currency. An increase in the nominal exchange rate (the value of the Australian dollar relative to other currencies) could be expected to ameliorate the inflationary pressures. An interest rate response could also be invoked.

Oil Supply Shock

An oil supply shock would cause markedly different effects in net oil-importing countries than in countries that are nett exporters of oil, nett exporters of oil and other energy, and nett exporters of energy but not oil.

Nett oil-importing countries would experience a permanent fall in real economic activity and an increase in inflationary pressures. Monetary authorities might respond with an interest rate increase to address inflation or a reduction to address the decline in economic activity. This would be influenced by exchange rate movements.

Nett exporters of oil and other forms of energy, such as Norway and Canada, could be expected to experience a permanent rise in real economic activity, because of the expansionary effects of higher prices for the oil and other energy products that they produce. Exchange rate appreciation would tend to offset inflationary pressures from higher oil product prices and increased economic activity.

Countries like the United Kingdom, which are nett oil exporters, but net importers of other forms of energy, could experience effects on economic activity working in opposite directions. Any reduction in economic activity would tend to be transitory. Inflationary pressures would tend to increase because of higher prices of energy products. The relative importance of nett oil exports and nett imports of other energy forms would determine the extent to which exchange rate movements offset or exacerbate inflationary pressures and the likely intervention of monetary authorities to adjust interest rates.

In countries like Australia that are nett exporters of energy, but nett importers of oil, there would effects on economic activity working in opposite directions. Higher oil prices would tend to cause a contraction of national income, while higher prices for energy commodities in general would tend to be expansionary for nett exporters of energy. Again, any reduction in economic activity would tend to be transitory, depending on the relative importance of the opposing forces. These same opposing forces would also determine the direction and magnitude of movements in the exchange rate and the nature and extent of monetary intervention. The economic effects of an oil supply shock on Australia could be insignificant or positive overall. As Australia’s nett energy export balance increases because of large increases in exports of coal and liquefied natural gas and coal seam methane, the likelihood of positive overall economic effects on Australia increases.

Speculative Oil-Specific Demand Shock

It is likely that an increase in speculative oil-specific demand would cause a temporary reduction in real national income and a temporary increase in the price level.

Intuitively, however, one would expect that there were would be countervailing effects for countries that are nett oil exporters or nett energy exporters. Higher prices for these products would be stimulatory, countering to some degree the effects of higher prices of energy products on economic activity. Similarly, these higher export prices would tend to cause exchange rate appreciation.

Surprisingly, this intuition was not supported by results of modelling by Baumeister, Peersman and Van Robays (2010). They found that nett oil exporters and nett energy exporters would experience temporary reductions in real national income, although not as large as for nett energy importing countries. For Australia, they found the reduction would be less than in comparable countries, Canada, Norway, and the United Kingdom. Also, their modelling indicated that exchange rates in nett energy-exporting countries would not respond significantly to a speculative demand increase and inflationary effects would not differ greatly from those in nett energy importing countries. For Australia, they found a larger effect on the price level than other developed nett energy-exporting countries and nett energy-importing countries, but a relatively small exchange rate movement. Baumeister, Peersman and Van Robays (2010) did not provide an intuitive explanation for these modelling results.

Changes Over Time and Across Countries

Baumeister, Peersman and Van Robays (2010) have argued that the potential economic effects of oil shocks of a particular type and magnitude have changed fundamentally over time, and that the changes in potential economic effects have varied across countries.

Baumeister and Peersman (2012) have estimated that short-term price elasticity of demand for crude oil becomes significantly more inelastic or lower (ignoring the negative sign) from the mid-1980s. In addition, they observed that short-term price elasticity of supply had become highly inelastic over time. This means an oil shock of a particular type and magnitude would lead to a much larger oil price change now than at the time of the ‘first oil crisis’ and ‘second oil crisis’ of the early 1970s to early 1980s.

Baumeister, Peersman and Van Robays (2010) explained that the economic implications of potentially greater price shifts now have been moderated somewhat by noticeable reductions of oil intensity and energy intensity in all developed countries since the 1970s. However, the differences between countries are substantial, particularly in respect of oil intensity.

In addition, nett oil-importing/exporting and nett energy-importing/exporting positions have changed over time to varying degrees across countries. Norway, Australia, Canada and the United Kingdom (in that order) have significantly improved their positions since the 1970s and early 1980s. In contrast, the United States has improved its position only slightly, with Japan and European countries making moderate improvements (significantly better than the United States but significantly less than Norway, Australia and Canada.

An important relevant policy change for Australia was the move to a floating exchange rate about 25 years ago. This meant that changes in the nominal exchange rate could occur automatically in response to shocks, allowing changes to the real exchange rate to occur without high inflation and allowing more moderate adjustments in monetary and fiscal policy to stabilise the economy.

These changes have implications for Australia’s vulnerability to (susceptibility to economic harm from) oil shocks. Australia’s vulnerability would now be greater than at the time of ‘first and second oil crises’ to the extent that price elasticity of demand and supply for crude oil have declined during the intervening period. On the other hand, Australia’s susceptibility to economic harm from oil shocks has declined since the time of ‘first and second oil crises’ because of lower oil intensity, improvements to Australia’s position as a nett exporter of energy, and the floating exchange rate.

Refined Products Supply Shocks

The world’s largest refined product supply shock over the past few decades was associated with temporary loss of refining capacity along the United States Gulf Coast because of Hurricanes Katrina and Rita in late August 2005 and late September 2005, respectively.

The increase in refined product prices resulting from this sort of shock would tend to cause a temporary reduction in national income and an increase in the price level in countries around the world. Obviously, there would be an additional hit to national income in the country hosting the disabled refining capacity. In countries with spare refining capacity, there would be a temporary stimulus to economic activity helping to offset the effects of higher refined product prices in other parts of the economy.

Nett energy-exporting countries, such as Australia, would not gain from higher prices of other energy products, unlike they would in the case of a crude oil supply shock, because crude oil prices would not rise and induce increases in prices of other energy products. When refining capacity is lost, demand for crude oil from that source disappears. The previous demand level can be restored only to the extent that there is spare refining capacity elsewhere. Consequently, crude oil prices could fall or remain unchanged (Kilian, 2010b).

The economic effects in Australia of refined product supply shock in the form of a loss of refined capacity elsewhere would be a temporary loss of real national income and higher price level. The loss of national income from the increase in product prices following the shock would be offset only to the extent that Australian refineries could expand production.

Compound Shocks

Analysis of past oil shocks has shown that more than one type of shock and underlying cause may be operating around the same time. Several historical examples of such occurrences have been discussed above, but the focus was on crude oil shocks.

Oil shocks may take the form of refined oil product shocks, as well as crude oil shocks. The persistent aggregate demand shock in the period, 2004-2008, was obviously a refined oil products shock, as well as a crude oil price shock, because demand for crude oil derives from demand for products. The early period of this prolonged shock coincided with a refined oil products supply shock caused by Hurricanes Katrina and Rita in late 2005. The latter was accompanied by a speculative demand increase (shock) for refined products.

If a major refined petroleum products shock occurred in 2012, the context would be multiple interacting sources of shock. Because of the aggregate demand shock of the substantial slump in global economic activity associated with the global financial crisis, there is significant spare refining capacity globally. However, this spare capacity is diminishing following another aggregate demand shock, the unexpectedly rapid resurgence of growth in China, India and other rapidly developing Asian economies. The run-down of spare capacity is being hastened by scheduled closures of inefficient refineries. The latest aggregate demand shock has raised crude oil prices to relatively high levels (but not to third quarter 2008 levels) in the context of ongoing constraints on production capacity (but not reserves) in OPEC countries. Consequently, refined product prices have climbed to relatively high levels. Spare global refining capacity means short-term price elasticity of supply is higher than when there is little spare capacity. With product prices already high because of high crude oil prices, short-term price elasticity of demand would be higher than when product prices are lower, according to some analysts (for example, Hymel, Small, Van Dender, 2010), but a survey of hundreds of estimates by Dahl (2012) suggested that there would be little difference.

If a major refined products shock occurred at various other times in the future, the context could be quite different.

For example, if Chinese and Indian demand for mined commodities unexpectedly strengthened (another aggregate demand shock), crude oil prices would climb higher, and spare oil refinery capacity could disappear, pending lagged investment responses. In the context of little spare refining capacity and high product prices before the refined products shock, speculative demand increases could exacerbate a spike in prices of refined products arising from the refined products supply shock. The height of the spike would be exacerbated by an extremely low price elasticity of supply of refined products. How low price elasticity of demand (ignoring the sign) would be in these circumstances would depend on the tendency of higher prices to increase this elasticity and higher incomes to lower it. Some analysts have identified such tendencies (for example, Hymel, Small, Van Dender, 2011), but others have not (Dahl, 2012).

An alternative example could involve a major refined products supply shock in the context of a downward aggregate demand shock (say, a recession in China and India), when there is substantial spare refining capacity, lower crude oil prices, relatively low refined product prices before the shock, and relatively low crude oil prices. Then, the impact of the shock on product prices would be moderated by a higher short-term price elasticity of supply. In this set of circumstances, price elasticity of demand would tend to be higher because of lower incomes, but lower as a result of lower refined product prices, according to some analysts (see Hymel, Small, Van Dender, 2010). According to results of a review by Dahl (2012) effects of price and income changes on price elasticity of demand could not be discerned.

When different types of shocks occur around the same time, the combined economic effects of the shocks and their underlying causes would have to be taken into account when considering policy responses. These deliberations should include consideration of the economic implications of interactions between causes. Good analysis will be complex.

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1. Note that although Australia is a net energy exporter and that the prices of LNG and coal have some relationship to oil, there is limited ability for consumers to switch between fuels in the very short time frame covered by the analysis. [↑](#footnote-ref-1)
2. This was temporarily halted in February 2012 owing to commercial problems in Iranian sales to China. [↑](#footnote-ref-2)
3. Brent Crude is a major trading classification of sweet light crude oil comprising Brent Blend, Forties Blend, Oseberg and Ekofisk crudes. Brent Crude is sourced from the North Sea. The Brent Crude oil marker is also known as Brent Blend, London Brent and Brent petroleum. Dated Brent is a rolling assessment that reflects the price of physical, wet Brent-Forties-Oseberg-Ekofisk cargoes loading no less than ten days forward. The other benchmarks crudes are the OPEC Reference Basket, Dubai Crude and West Texas Intermediate. Brent is the leading global price benchmark for Atlantic basin crude oils. It is used to price two thirds of the world's internationally traded crude oil supplies. [↑](#footnote-ref-3)
4. For more details see http://www.ret.gov.au/energy/energy\_security/emergency\_response/Pages/EmergencyResponse.aspx [↑](#footnote-ref-4)
5. It should be noted that some domestically produced crude is not considered to be appropriate replacement feedstock for all Australian refineries. For economic modelling purposes, however, only net imports are relevant to determining impacts on the Australian economy. [↑](#footnote-ref-5)
6. KPMG Econtech report, *Economic Contribution of the Australian Refining Industry*, p.15, December 2009. [↑](#footnote-ref-6)
7. Caltex submission, *Senate Inquiry on Research and Development Tax Credit Scheme*, 19 May 2010, http://www.caltex.com.au/latestnews/pages/newsitem.aspx?id=13187 [↑](#footnote-ref-7)
8. <http://iranprimer.usip.org/blog/2012/jan/05/will-iran-dare-close-strait-hormuz>, accessed on 22 June 2012 [↑](#footnote-ref-8)
9. Elisabeth Bumiller, Eric Schmitt, and Thom Shanker, “U.S. Sends Top Iranian Leader a Warning on Strait Threat,” *New York Times*, January 13, 2012 [↑](#footnote-ref-9)
10. Peter Apps, “Iran Could Close Hormuz – But Not For Long,” Reuters.com, January 5, 2012 [↑](#footnote-ref-10)
11. Jonathan Schroden, *A Strait Comparison: Lessons Learned from the 1915 Dardanelles Campaign in the Context of a Strait of Hormuz Closure Event*, CNA (Center for Naval Analyses), September 2011, pp. 38-39. The analysis by Talmadge cited in the CNA report is: Caitlin Talmadge. “Closing Time: Assessing the Iranian Threat to the Strait of Hormuz,” *International Security*, Summer 2008: 82-117. The CNA report cites the following source for the subsequent dispute over Talmadge’s assumptions regarding Iranian capabilities: William D. O’Neil and Caitlin Talmadge. “Costs and Difficulties of Blocking the Strait of Hormuz,” *International Security*, Winter 2008/09: 190-198.) [↑](#footnote-ref-11)
12. From the income side, GDP is equal to the returns to factors plus all tax revenues. [↑](#footnote-ref-12)
13. Australia's terms of trade are calculated by dividing the implicit price deflator for exports by the implicit price deflator for imports. [↑](#footnote-ref-13)
14. Note that although Australia is a net energy exporter and that the prices of LNG and coal have some relationship to oil, there is limited ability for consumers to switch between fuels in the very short time frame covered by the analysis. [↑](#footnote-ref-14)
15. Essentially, in the near term the decline in terms of trade associated with the increased average price of imports is being paid from net national savings with the consequence that there will be an increase in net foreign debt (or decline in net foreign savings). Alternatively, regions whose terms of trade increase are increasing their net savings, with the consequence that there will be a decline in net foreign debt (or increase in net foreign savings). [↑](#footnote-ref-15)
16. For example, see Espey (1998), Graham and Glaister (2002), Hughes, Knittel and Sperling (2008), Brons, Nijkamp, Pels, Rietveld (2008), Breunig and Gisz (2009), Hymel, Small and Van Dender (2010), and Dahl (2011). [↑](#footnote-ref-16)
17. For example, see Kilian, 2008c, 2009a,b; Hamilton, 2009a,b; Smith, 2009a; Dvir, Rogoff, 2010; Kilian, Murphy, 2010; Balke, Brown, Yücel, 2010; Baumeister, Peersman, Van Robays, 2010. [↑](#footnote-ref-17)
18. For example of adaptation of this analysis to oil markets in the context of the last few years, see Kaufmann (2011), Tokic (2012). [↑](#footnote-ref-18)
19. Radetzki (2006, 2008) pointed out that the acceleration of inflation was not caused solely by strongly growing aggregate demand. The boom in commodity prices had been preceded by two consecutive years of widespread crop failures. [↑](#footnote-ref-19)
20. For example, see Humphreys (2009, 2010), Roberts (2009), Radetzki, others (2008), Radetzki (2006), Cuddington, Jerrett (2008), Cuddington, others (2007), and Roberts, Rush (2010). [↑](#footnote-ref-20)