RBA ECONOMICS COMPETITION 2011

The Economics of Natural Disasters

Second Prize

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For a growing number of people, the threat of natural disasters is an ominous and ever-present one. From floods and cyclones, to earthquakes and bushfires, natural phenomena have devastating societal impacts across the globe. The broader economy is not immune to the positive and negative consequences of natural disasters, which have been increasing in frequency and magnitude of destruction in recent times (see FIGURES 1 and 2) (EM-DAT: The CRED International Disaster Database, 2011; Raddatz, 2009). This essay will discuss the impacts of natural disasters on a nation's capital stock, productivity, economic growth, and inflation in both the short-term and long-term. In addition, the implications for monetary and fiscal policy will be investigated, utilising relevant graphical tools where appropriate.

FIGURE 1: Estimated damaged caused by reported natural disasters 1975 – 2010
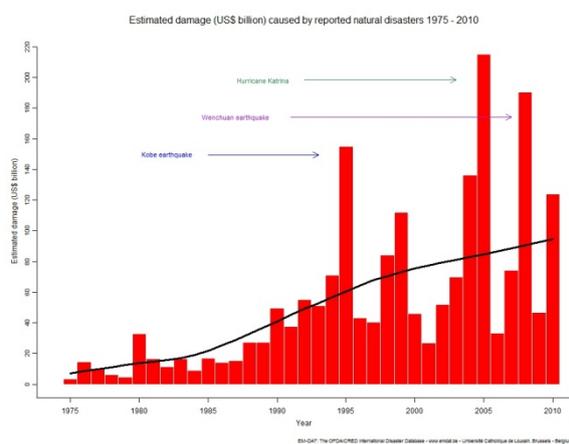
FIGURE 2: Number of people reported affected by natural disasters 1975 – 2010

(EM-DAT: The CRED International Disaster Database, 2011)
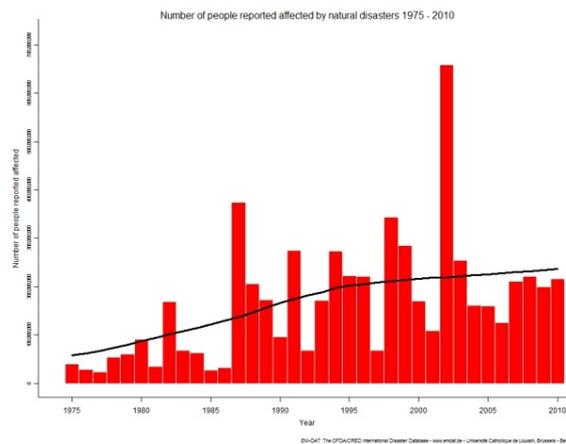
(EM-DAT: The CRED International Disaster Database, 2011)

**<u>Capital Stock and Productivity</u>**

To varying degrees, natural disasters impact the level of capital stock in the short-run through the destruction of infrastructure including factories, property, equipment, roads, and other assets (Noy, 2008; The cost of calamity, 2011). This reduction in capital negatively impacts the productive capacity of the economy, since less capital implies lower levels of production (Noy, 2008; Skidmore & Toya, 2002; The cost of calamity, 2011;). If a disaster strikes an industrial area, the economic impact will be more severe than if the event had befallen an area where limited production occurs (Kim, 2011; Noy, 2008; The cost of calamity, 2011; Westpac Banking Corporation, 2011). The 2011 Japan earthquake caused a

widespread halt to production in the short to medium-term, and reduced the nation's productive capacity through destruction of public and private infrastructure (The cost of calamity, 2011). Part of the lost production can be recovered by using alternative capital reserves or utilising remaining capital more intensively, but quality is often diminished (The cost of calamity, 2011). More labour can also be used to produce the required output, though this may place inflationary pressures on the economy through wage and price increases (Skidmore & Toya, 2002; The cost of calamity, 2011).

The long-run consequences on the economy depend on how quickly assets can be repaired, as well as the quality of the new capital stock compared to the pre-disaster state (The cost of calamity, 2011). The World Bank found that floods, while negatively impacting agricultural production in the short-run through crop damage, can increase productivity in the long-term as a result of improved soil fertility (PricewaterhouseCoopers, 2011; Reserve Bank of Australia, 2011a; The cost of calamity, 2011; The World Bank, 2011). As primary inputs in the production of other items, increased agricultural output has ripple benefits for long-run economic growth in other sectors such as manufacturing and services industries, particularly in developing nations (Hallegatte & Dumas, 2009; Noy, 2008; The cost of calamity, 2011). Additionally, rebuilding capital at a superior standard improves long-run productivity for households, firms, and governments compared to before the natural disaster (Bennett, 2008; Hallegatte & Dumas, 2009; Skidmore & Toya, 2002; The cost of calamity, 2011; Westpac Banking Corporation, 2011). Natural disasters can also be catalysts for adopting new technologies that further improve long-run economic productivity (Hallegatte & Dumas, 2009; Skidmore & Toya, 2002; The cost of calamity, 2011;).

Economic Growth

FIGURE 3: Solow-Swan Growth Model
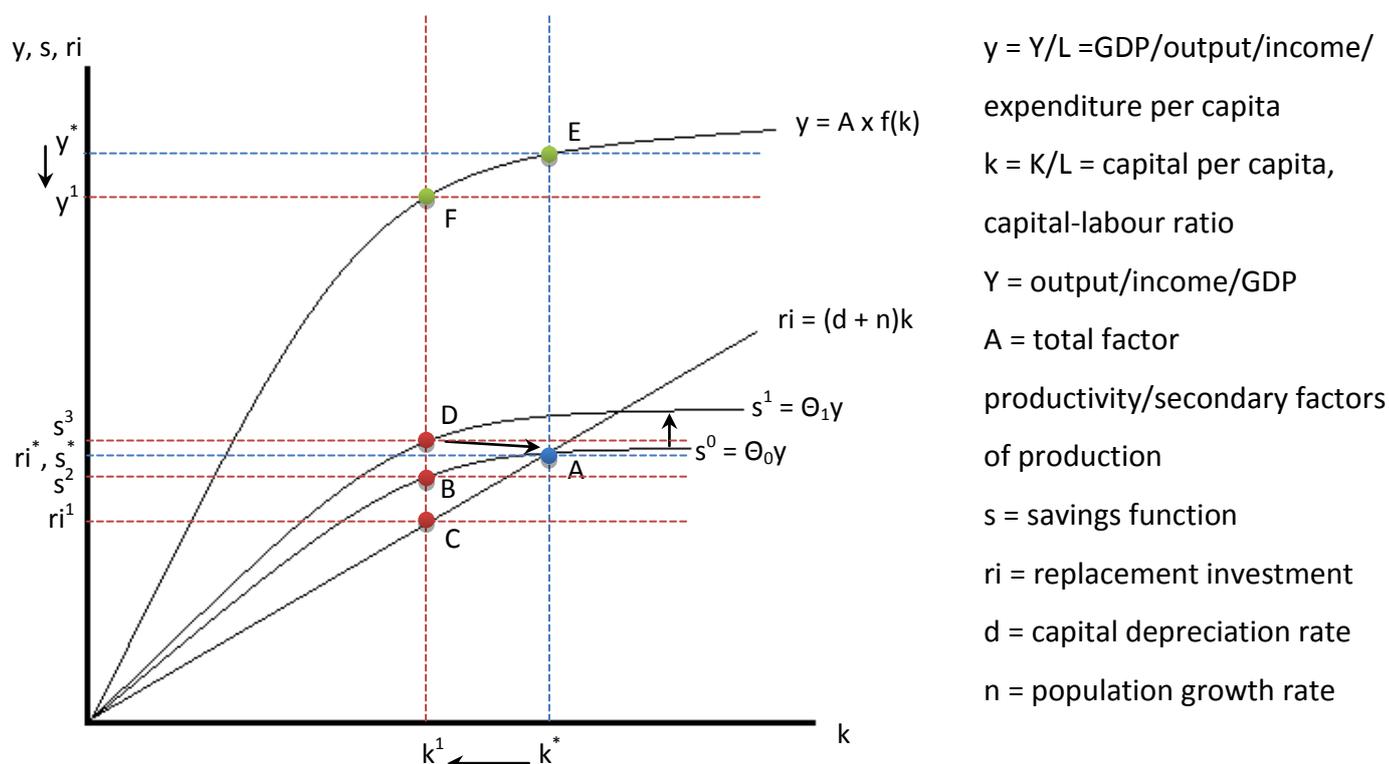
The neo-classical growth model (Solow-Swan growth model) in FIGURE 3 provides a graphical tool for the analysis of the impact of natural disasters on economic growth, defined as the percentage change in gross domestic product (GDP) over time (Bernanke, Olekalns, & Frank, 2008). GDP is a measure of the market value of final goods and services produced in a country over a given period of time, which is most commonly calculated using the expenditure approach as the sum of consumption, investment, government spending, and net exports (exports less imports) (Bernanke et al., 2008; Reserve Bank of Australia, 2011a). The Solow-Swan growth model focuses on the positive relationship between capital per capita and long-run GDP/output/income/expenditure per capita (Bernanke et al., 2008). The following analysis will assume diminishing marginal productivity of labour and capital; constant returns to scale for both inputs combined; constant technology, labour, capital depreciation rate, and population growth rate; and that the pre-flood economy was in its steady state at point A ($ri^* = s^*$) (Bernanke et al., 2008; Okuyama, 2003). The steady state occurs when capital per capita and GDP per capita are both constant and there is zero economic growth since replacement investment equals savings (Bernanke et al., 2008; Okuyama, 2003).

In the event of a natural disaster, capital per capita will be reduced from the steady state level k^* to k^1 in FIGURE 3 as a result of damage and destruction of public and private assets (Bernanke et al., 2008; Okuyama, 2003). Consequently, production moves from point E to F, and output per capita is reduced from the steady state level y^* to y^1 (Bernanke et al., 2008; Okuyama, 2003). This will be felt in the economy as an immediate short-term fall in GDP per capita, attributable to immediate short-term delays to planned spending, reduced tourism activity, and rising uncertainty from consumers, as well as declining inventory stocks, falling exports (particularly coal), and reduced trading days (Baum, 2011; Bernanke et al., 2008; Floods cause worst-ever economic damage: Swan, 2011; Noy, 2008; Reserve Bank of Australia, 2011b; Smith, 2011). These impacts were particularly evident following the 2010-11 Queensland floods (see FIGURES 5, 6, and 7) (Floods cause worst-ever economic damage: Swan, 2011). Short-term business investment can also be delayed by rising uncertainty amongst firms, as depicted in the FIGURE 4 following the Queensland floods (Kline, 2011; PricewaterhouseCoopers, 2011; Reserve Bank of Australia, 2011b).

FIGURE 4: Business Conditions and Confidence (NAB Business Survey)

(Reserve Bank of Australia, 2011b)
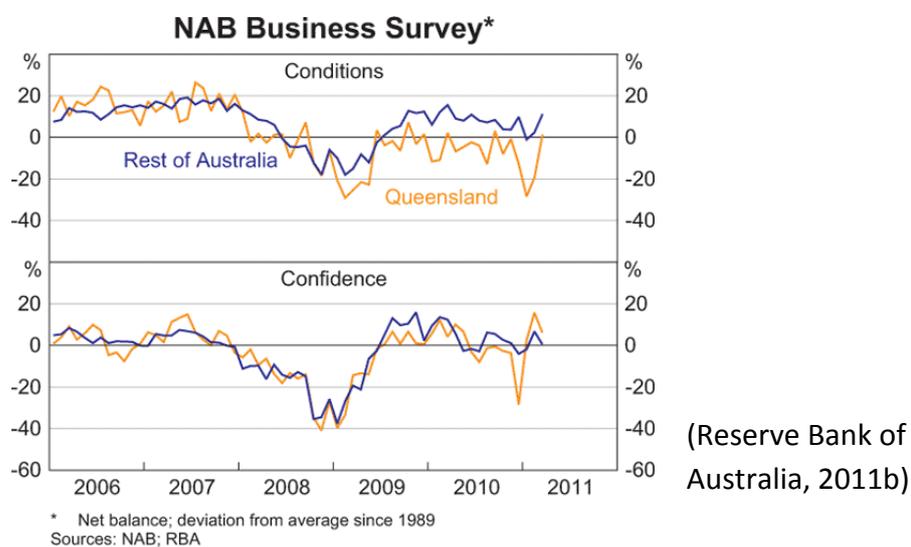
Savings per capita are exceeds replacement investment, since point B and s^2 exceeds point C and ri^1 where production is y^1 (Bernanke et al., 2008). Replacement investment is the sum of investment in capital that has depreciated or worn-out over time, and investment to equip new workers with the current capital-labour ratio (Bernanke et al., 2008). There will be positive economic growth in the short to medium-term, with rising output and capital per worker, represented as investment above replacement investment

which increases the size of capital stock (net investment) (Bernanke et al., 2008; Cavallo, Galiani, Noy, & Pantano, 2010; Okuyama, 2003; Smith, 2011). Positive economic growth is predicted in the medium-term following the 2010-11 Queensland floods (see FIGURE 6), attributed to government spending on reconstruction, increased consumption activity to replace and repair damaged assets, and improving exports (particularly coal) following damage to capital resources (see FIGURE 7) (Bernanke et al., 2008; Kline, 2011; PricewaterhouseCoopers, 2011; Reserve Bank of Australia, 2011a; Reserve Bank of Australia, 2011b; Westpac Banking Corporation, 2011). Business conditions and confidence will also increase as firms anticipate improved activity associated with reconstruction (see FIGURE 4) (Baum, 2011; Reserve Bank of Australia, 2011b). Additionally, the savings function s^0 will move upwards to s^1, as more resources are allocated to capital accumulation post-natural disaster, raising the savings rate from Θ_0 to Θ_1 (Bernanke et al., 2008; Okuyama, 2003). The larger difference between point D and s^3 and point C accelerates the rate of growth, but Θ_1 will eventually return to Θ_0 following the rebuilding effort, and the steady state of point A will be achieved in the long-run with zero economic growth (Bernanke et al., 2008; Cavallo et al., 2010; Davis & Weinstein, 2002; Okuyama, 2003).
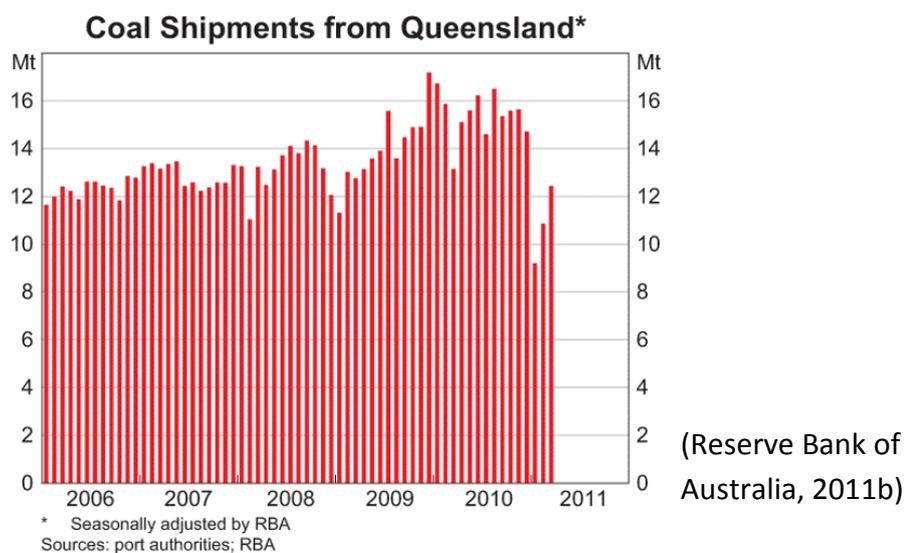
FIGURE 5: Australian GDP Growth
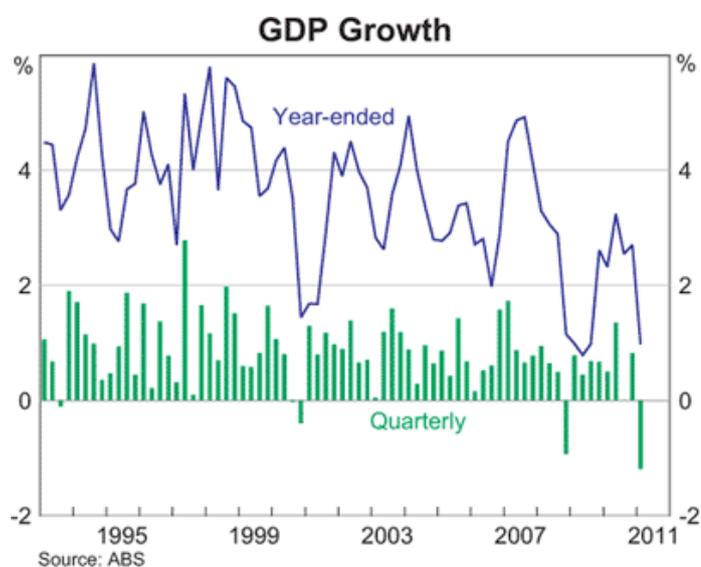
FIGURE 6: Predicted Australian GDP

(Reserve Bank of Australia, 2011c)
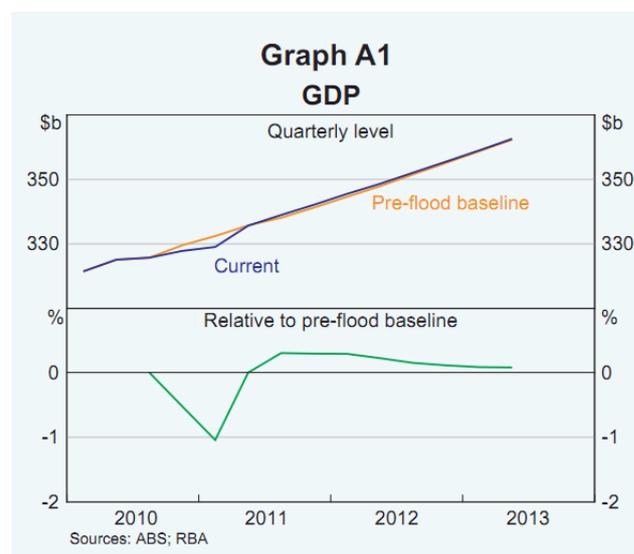
(Reserve Bank of Australia, 2011a)

FIGURE 7: Coal Ships from Queensland

Coal Shipments from Queensland*

* Seasonally adjusted by RBA
Sources: port authorities; RBA

(Reserve Bank of Australia, 2011b)

It is important to consider the limitations of this analysis. This model fails to consider opportunity costs that arise from redirecting government funds from other priority areas (health, education, and other infrastructure projects) to fund the rebuilding process in disaster affected areas, resulting in a redistribution of wealth (PricewaterhouseCoopers, 2011). For example, following the 2010-11 Queensland floods, both State and Federal Governments declared that they would be re-evaluating their spending priorities so as to meet rebuilding expenses (PricewaterhouseCoopers, 2011). The Solow-Swan growth model assumes that economies converge to a steady state with zero economic growth in the long-run; however, most national economies have not yet achieved this state (Bernanke et al., 2008). Furthermore, endogenous growth models that focus on secondary factors of production provide a more complete picture of the consequences of natural disasters on economic growth (Bernanke et al., 2008).
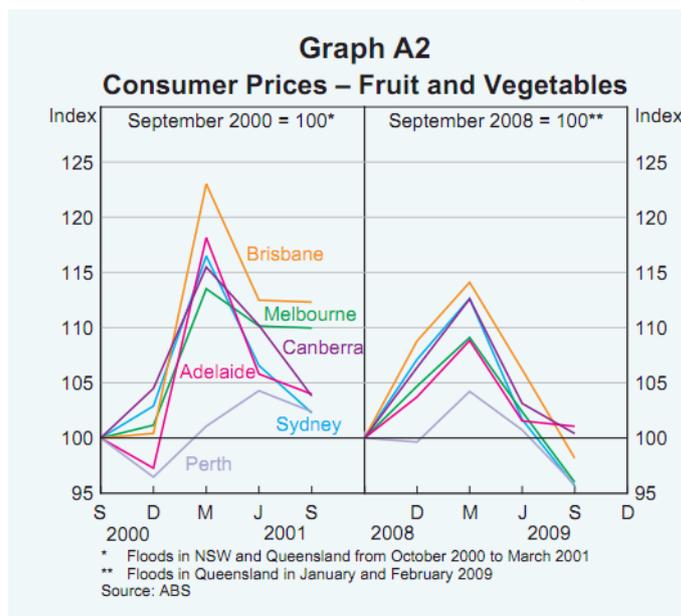
Inflation

FIGURE 8: AD-AS Model – Self-correcting Economy
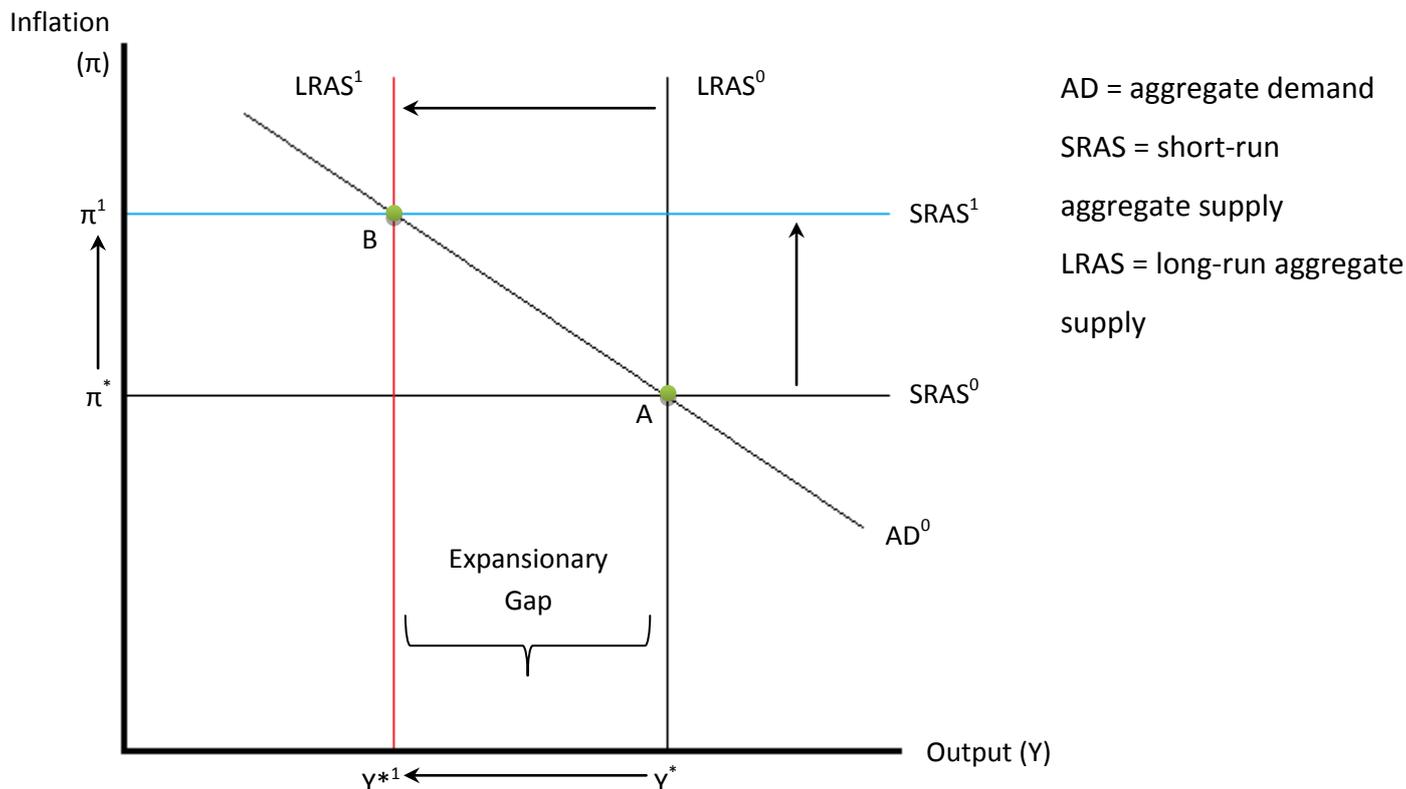
The aggregate demand-aggregate supply (AD-AS) model can be used to analyse the consequences of natural disasters on inflation (Bernanke et al., 2008). FIGURE 8 examines a self-correcting economy, whereas FIGURE 12 shows how a monetary or fiscal policy response influences the economy (Bernanke et al., 2008). FIGURES 8 and 12 assume constant aggregate demand following a natural disaster, and that the pre-disaster economy was in long-run equilibrium at point A (Bernanke et al., 2008). There is a negative shock to potential output in the form of a natural disaster, whereby capital stock is damaged or destroyed and the level of potential output falls from Y^* to Y^{*1} and $LRAS^0$ falls to $LRAS^1$ in both figures (Baum, 2011; Bernanke et al., 2008; Reserve Bank of Australia, 2011a). Point A now represents short-run equilibrium and an expansionary gap equal to the difference between Y^* and Y^{*1} forms, decreasing cyclical unemployment and placing upward pressure on wages and prices (Bernanke et al., 2008). These temporary inflationary pressures, experienced following Hurricane Katrina in the USA and the 2010-11 Queensland floods, are often attributed to rising food and agricultural output prices (see FIGURE 9), and increasing demand for construction materials, housing, and labour consistent with the rebuilding process, though some housing demand will be offset by emigration (Australian Bureau of

Statistics, 2011; DeLisle, 2005; Floods cause worst-ever economic damage: Swan, 2011; Keen & Pakko, 2011; PricewaterhouseCoopers, 2011; Reserve Bank of Australia, 2011a; Reserve Bank of Australia, 2011b). The implications for underlying inflation are less than those for headline inflation, measured by the Consumer Price Index (CPI) (see FIGURES 10 and 11) (DeLisle, 2005; Reserve Bank of Australia, 2011b).

FIGURE 9: Consumer Prices – Fruit and Vegetables
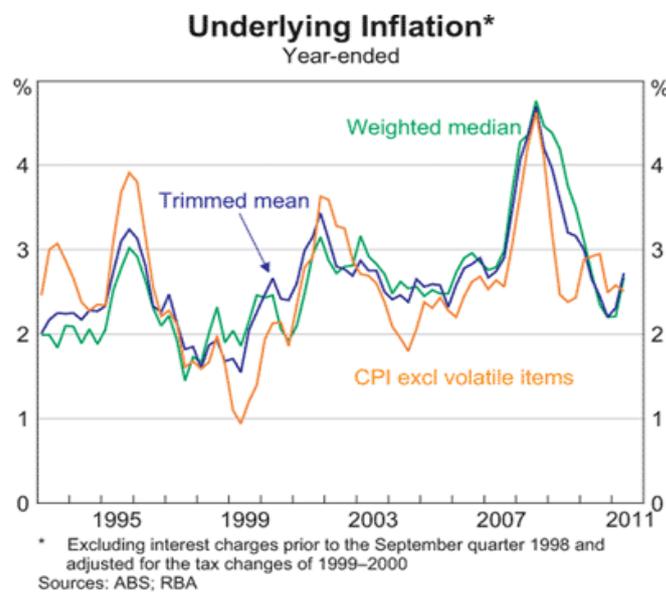

(Reserve Bank of Australia, 2011a)

**FIGURE 10:** Consumer Price Inflation – Australia   **FIGURE 11:** Underlying Inflation – Australia

(Reserve Bank of Australia, 2011c)   (Reserve Bank of Australia, 2011c)

In FIGURE 8, the economy is assumed to be self-correcting (Bernanke et al., 2008). Since short-run equilibrium output Y^* exceeds potential output Y^{*1}, production is not sustainable in the long-run (Bernanke et al., 2008). Prices and wages will increase, and coupled with the rise in food prices from supply shortages associated with climatic disasters, $SRAS^0$ and the level of inflation π^* rise to $SRAS^1$ and π^1 (Bernanke et al., 2008). Long-run equilibrium now occurs at point B, at a lower potential output and higher level of inflation than pre-disaster (Bernanke et al., 2008; Floods cause worst-ever economic damage: Swan, 2011). However, potential output will eventually return to Y^* ($LRAS^0$) as rebuilding and replacement of damaged assets increases the productive capacity of the economy and assuming no other inflationary effects, inflation will return to π^* ($SRAS^0$) (Bernanke et al., 2008).

FIGURE 12: AD-AS Model **–** Monetary or Fiscal Policy Response
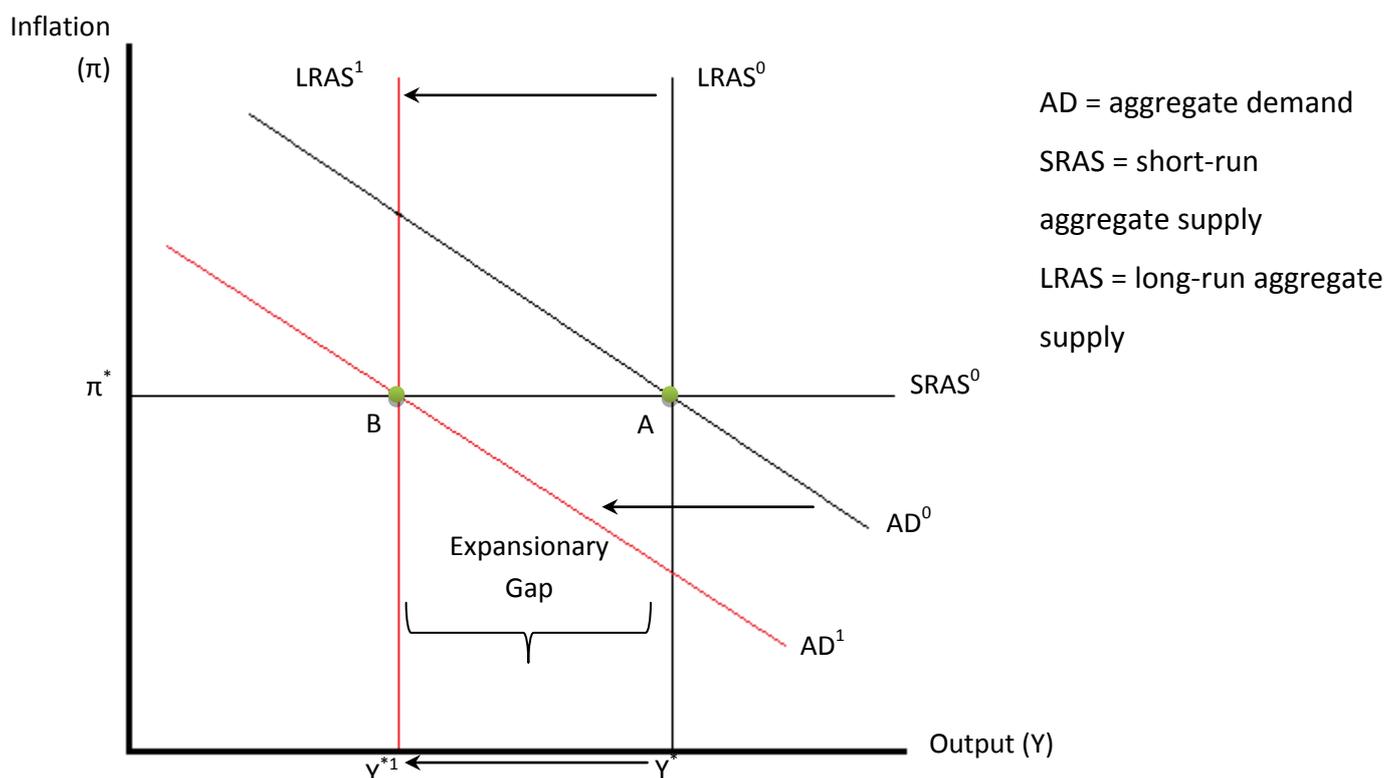
To close the expansionary gap in FIGURE 12 and reduce inflationary risk, the central bank can respond by raising the cash rate in the medium-term to decrease consumption, investment, and net exports, causing aggregate demand to shift leftward from AD^0 to AD^1 (Bernanke et al., 2008; Floods cause worst-ever economic damage: Swan, 2011). The same outcome will be achieved from the imposition of a tax on households, reducing consumption by lowering disposable income (Bernanke et al., 2008). Long-run equilibrium

now occurs at point B, with the level of inflation π^* stable (Bernanke et al., 2008). However, potential output will eventually return to Y^*, since the rebuilding and replacement of damaged assets will increase the productive capacity of the economy, causing a recessionary gap and leading to the central bank decreasing the cash rate to increase consumption, investment, and net exports (Bernanke et al., 2008). Alternatively, government spending and transfer payments funded by a tax will produce the same result (Bernanke et al., 2008). Assuming no other inflationary effects, inflation will remain constant at π^* (Bernanke et al., 2008). Note that the inflationary impacts of a natural disaster depend on the stage of the business cycle the economy is experiencing (Noy, 2008; PricewaterhouseCoopers, 2011). For example, if there is a recessionary environment with substantial unutilised resources, these can be reallocated or used at increased intensity without creating significant upward pressure on prices and wages, and thus inflation remains relatively constant (Noy, 2008; PricewaterhouseCoopers, 2011).

Problems with Monetary and Fiscal Policy

It is important to consider that fiscal or monetary policy responses to a natural disaster will have wider effects not captured in the AD-AS Model, such as the imposition of a flood levy on Australian taxpayers following the 2010-11 Queensland floods, chosen ahead of a change in the cash rate (see FIGURE 13) (AAP, 2011; Reserve Bank of Australia, 2011b). The levy will target middle to high-income earners, and funding will also be reduced on many public projects to support the flood rebuilding activity and payments to victims (AAP, 2011; Australian Government: The Treasury, 2011; Packham & Massola, 2011; Pereira, & Roca-Sagalés, 2011; Reserve Bank of Australia, 2011b; Wilson, 2011). Consequently, there will be a negative effect on disposable income, employment and consumer confidence in areas not affected by the floods through a redistribution of wealth, a consequence also experienced if a cash rate increase was enacted instead.

FIGURE 13: Australian Cash Rate

Australian Cash Rate

(Reserve Bank of Australia, 2011c)

* Calculated using average of weighted median and trimmed mean inflation
Sources: ABS; RBA
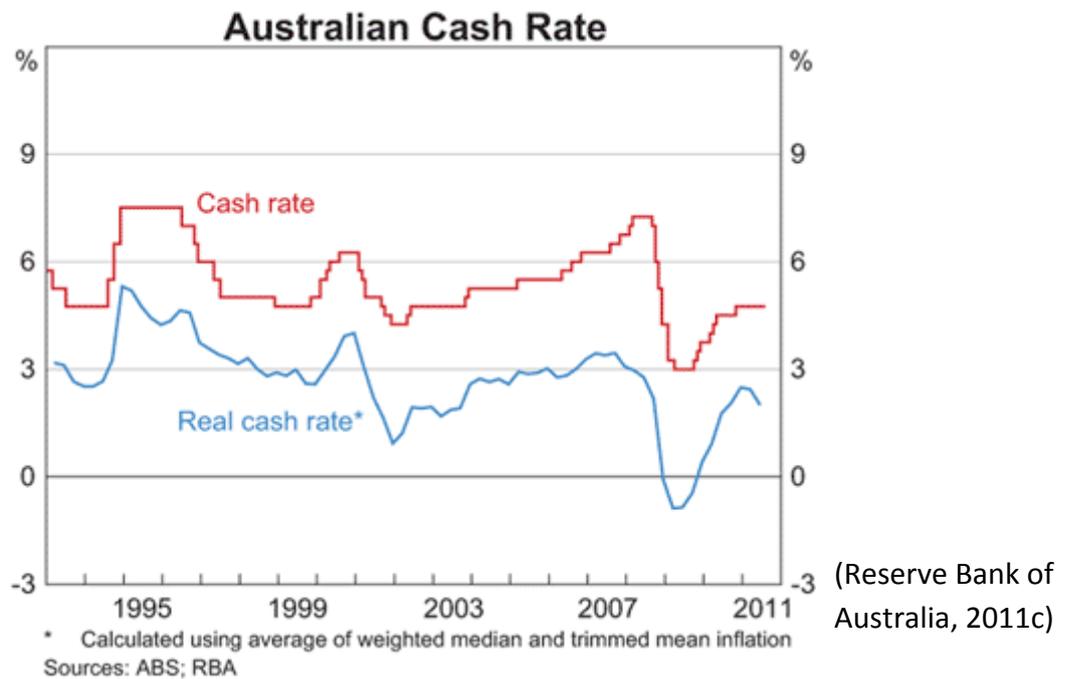
The flood levy is expected to raise approximately one-third of the funds the Australian Government requires to meet the damage bill and payments to victims (Australian Government: The Treasury, 2011). Thus the tax will not completely offset the increase in spending, meaning a budget deficit will arise (assuming a balanced pre-disaster budget) (Bernanke et al., 2008; PricewaterhouseCoopers, 2011). A deficit would reduce national savings, increase the real interest rate, and decrease private investment through crowding out (see FIGURE 14) (Bernanke et al., 2008; de Mendonça, & de Castro Pires, 2010). Alternative policies such as borrowing from overseas or issuing bonds may be cheaper administratively and for households, but the nation would risk entering a more severe budget deficit (Bernanke et al., 2008; de Mendonça, & de Castro Pires, 2010; Wilson, 2011). A cut in transfer payments would have a similar impact on net taxes as the levy, but would target low-income residents and cause a more harsh redistribution of wealth. Both policies would hinder economic growth through reduced capital formation (de Mendonça, & de Castro Pires, 2010; Pereira, & Roca-Sagalés, 2011).

FIGURE 14: Market for Savings and Investment – Budget Deficit
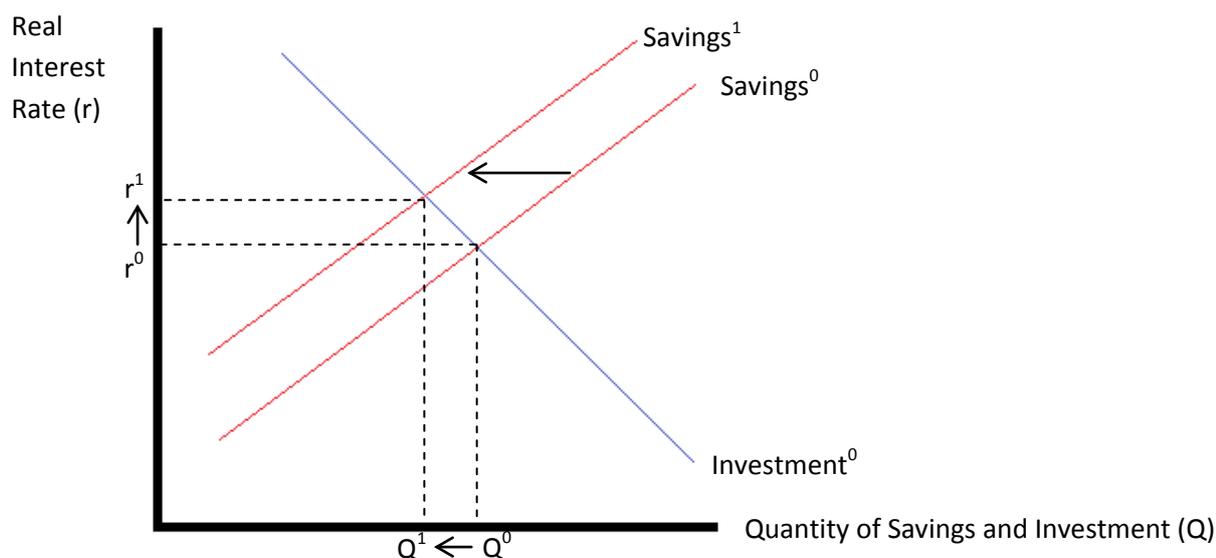
Conclusion

This essay has utilised graphical models and historical data to analyse the impact of a natural disaster on a nation's economy. Although capital stock is significantly depleted initially, productivity in the long-run often improves as a result of superior quality capital and technology. Economic growth is negatively impacted in the short-run by a loss of capital, but accelerates positively as assets are replaced and repaired. Upward pressure is placed on inflation from rising wages and prices, but is only temporary and managed by monetary and fiscal policy. Thus it appears that despite the significant social implications that follow a natural disaster, it is merely the profile of the economy that varies in the short to medium-term, with long-term effects on the economy less severe (Davis & Weinstein, 2002; PricewaterhouseCoopers, 2011). Consequently, governments should devote their attention to ensuring they are able to respond to community needs when a natural disaster strikes, and develop policies to lessen the potential destruction that may result from future disasters (Hallegatte & Dumas, 2009).

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