Responsiveness and the resilience of Queensland economy to climatic disasters: through a Post-Keynesian lens

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1. Introduction

United Nation International Strategy for Disaster Reduction Secretariat (UNISDR 2008) defines disasters as "A serious of the functioning of a community or a society causing widespread human, material, economic, or environmental losses which exceed the ability of the affected community or society to cope using its own resources". Natural disasters can also be reviewed as a risk integral to development instead of interruptions (ADB, 2009) and this vulnerability can be reduced by controlling disaster risk through making disaster risk management a vital consideration in policy-making process (Freeman, Martin et al. 2003). In recent studies the importance of economics of the climate change, natural disasters shocks and responses to the have been highlighted, however, most of these discussions fail to adequately integrate this relationship into a general macroeconomic model.

The agriculture and coal and mining industries in Queensland have been hardly hit by the occurrence of recent natural disasters in the region. 80% sorghum crop has been damaged and coal exports was about 15 million tonnes lower than expected from December 2010 to March 2011 (The Courier Mail, 2011)[1]. Financial market made quick responses to crises as reflected by the movements on prices of particular stocks such as QLD based mining companies. Volatility has also been witnessed in capital market through movements on market index in general, which the damage on agriculture and mining industries both contributes to it. The occurrence of recent QLD natural disasters limits the option of agriculture products on the market and the output of resource products, which force the commodity price rising dramatically. As the consequence, energy and agriculture sectors of commodity future market experienced dynamic market movements as well. Therefore, we also aim to show the impact of recent QLD disasters on Australian stock and capital market and explore the significance of this impact.

Therefore, the main objective of this paper is to analyse the dynamic effect of recent years natural disasters on Queensland's key macroeconomic indicators, and to investigate the degree of responsiveness of different sectors of the Queensland economy to region's recent natural disasters by modelling and studying economic impacts these shocks using the contemporaneous feedback effect analysis. The research also focuses on the trade-off between natural disasters and sources of economic development of the region such as investment, saving, income distribution and labour market fluctuations. In this study we assume that Queensland economy faces exogenous, random shocks (unexpected variation) to

[1] http://www.couriermail.com.au/business/agriculture-and-mining-hit-hard-by-loss-of-production-due-to-floods-in-eastern-australia/story-fn7kjcme-1225992475038

climate conditions, which can have substantial impact on key economic indicators, then the main intention is to examine whether key economic indicators differ significantly in their responses to climatic shocks in the medium term to long run.

2. Literature Review

A body of research into the economic effects of natural disasters has been emerging since the 1980s, considering both the socio-economic impact caused by natural disasters and considering how the socio-economic conditions within a country prior to a natural disaster impacts on the response to the natural disaster when it occurs. There have been two distinctly different approaches to research in this area, considering either impact of disasters across a range of countries to assess how the disaster impact is mitigated or increased by local factors, or considering the impact of a specific disaster or disasters over time in one specific region or country to see how local economic conditions are affected by the disaster.

Within the first category of research, a large number of authors have conducted research focussing on a wide range of countries. They have compared the different economic impacts resulting from a wide range of natural disasters affecting these countries, and drawn conclusions on how the existence of differing socio-economic factors before the natural disasters affect the impact the natural disaster has on the economy. This has also resulted in a range of policy recommendations to enable a country to be better prepared for any natural disaster that may befall it. Several authors (Gassebner, Keck et al. 2010), (Ibarrarán, Ruth et al. 2009), (Noy 2008), (Padli, Habibullah et al. 2010), (Toya and Skidmore 2006) found that developing countries experience much larger shocks to their macro-economies than developed countries. Additionally these researchers found that countries with larger economies, higher literacy or educational attainment, better institutions, higher incomes per capita, larger government structures, higher degrees of openness and democratic rather than autocratic governments appeared better able to prevent disasters adversely affecting macro-economic factors.

In further work exploring the reasons for these findings, Skidmore and Toya (2002) established that disasters provide opportunities to update capital stock and adopt new technologies which increases factor productivity and induces higher GDP growth. The positive factors identified above all contribute to the country's ability to take advantage of this opportunity in a way that a poor and underdeveloped country could not.

Hallegatte and Ghil (2008) extended this analysis to consider differences in economic impact depending on whether the natural disaster occurred during a time of economic boom or recession, finding that a disaster occurring during a recession would have a far more favourable impact on the economy, due to the availability of human and physical capital for the rebuilding work required, compared to a disaster during a boom where shortages of capital can delay rebuilding efforts and cause inflation.

Other studies such as Kahn (2005) have considered the relationship between the level of GDP and the number of deaths from natural disasters, finding that although the incidence of natural disasters was no different in richer and poorer countries, the number of resulting deaths from such disasters was significantly higher in the poorer countries.

In the alternate approach to research in this area, a number of authors have focused on a specific natural disaster or series of natural disasters in a particular region and examined the impact of disaster(s) on the economy, and then attempted to draw conclusions from that specific disaster impact that can be applied to a wider range of scenarios. The most commonly studied region and type of disaster has been the impact of hurricanes in the USA. Hurricanes cause a wide range of damage through wind, storms and flooding, and occur fairly frequently, for example there were 19 significant hurricanes in Florida alone between 1988 and 2005 (Belasen and Polachek 2008) and therefore provide a good source of varying data and scenarios suitable for study.

Belasen and Polacheck's (2008) study on the impact of hurricanes on Florida found that the disasters caused significant increases in earnings but decreases in employment levels in the directly affected regions, whilst causing reduced earnings in neighbouring regions, with the effects dissipating over time. Veen and Logtmeijer (2005) also found that disasters could have an economic impact on regions outside the affected region if the outside areas economic infrastructure passed through the disaster zone.

Shaughnessy et al (2010) found that hurricanes had an immediate and sustained effect of reducing the inequality of incomes whereas Chang (1983) found that the initial impact of the disaster was positive, significantly increasing revenues, but over time the full effect became negative. Xiao (Xiao 2011) also found a short term impact of reduced employment but also found a decrease in per capita income initially, but this rebounded over the next few years assisted by insurance and government support the rebuilding effort, other than in the farm sector where the decline in employment and income was long term and significant. Burrus et at (2002) also found a rebound in activity due to rebuilding efforts mainly funded by insurance and government assistance for high intensity hurricanes, but found that low intensity hurricanes cause a significant impact on economic activity as there is no rebound effect and these type of hurricanes occur with far higher frequency than the major hurricanes. In another study which included considering the intensity of the hurricane, Hallegatte (2008) found that above $50billion the total losses caused by the disaster increased in a non-linear relationship with the direct losses caused, indicating that for major disasters the direct loss was not a good indicator of the economic damage caused by the disaster.

Outside of research on the USA, in a study focusing on Australian natural disasters, (Worthington and Valadkhani 2004) it was found that certain natural disasters, namely cyclones, bushfires and earthquakes, did have a significant impact on the Australian stock market, however no significant effect was found from floods and storms. This study did not attempt to consider wider economic impacts of these disasters on Australia. Albala–Bertrand (1993) studied disasters in Central America and found that falls in output due to disasters were a very small portion of the total countries GDP and compensation required to rebuild was an even smaller portion, therefore natural disasters do not have a significant impact on the total economy of the country effected. (Charveriat 2000) argues that in the short term, major natural disasters might have an impact on a country's GDP due to the loss of assets and the associated disruption of economic activity. But GDP growth and other flow indicators do not fully capture the effect of disasters, whose principal impact is on the stock of human and physical capital. In the longer term, the destruction of capital can have effects on factor endowments, income distribution, regional inequalities, growth trajectory and public indebtedness.

Different researchers have used a range of different modelling approaches, including input-output models (Burrus, Dumas et al. 2002), (Hallegatte 2008), (Veen and Logtmeijer 2005); autoregressive integrated moving average regression models (Baumann, Baade et al. 2007), (Xiao 2011), (Worthington and Valadkhani 2004); income density functions (Shaughnessy, White et al. 2010); and other regression analysis based approaches (Belasen and Polachek

2008), (Schmidt, Kemfert et al. 2010). However, West and Lenze (1994) cast doubt on the reliability of regional models for predicting the effects of natural disasters due to the complex linkages and problems in obtaining sufficient accurate data.

Whilst a number of the cross country comparison papers referred to above included Australia within their sample, there has been little research specific to Australia other than Worthington and Valadkhani (2004) who focused purely on the impact of natural disasters on the stock market. This paper seeks to address the gap in the literature by employing a Kaleckian-Post-Keynesian open economy model to model scenarios demonstrating how Queensland's recent natural disasters have affected the key macroeconomic indicators, and examine the different responses of the different indicators to the exogenous severe weather shocks in the medium to long term.

3. Methodology

3.1 Empirical Model

We utilise a Kaleckian-Post-Keynesian open economy model, which is augmented by a demand driven labour market, a reserve army effect in the Marxian sense and technological change. This model was first introduced by (Bhaduri and Marglin 1990) and later extended by Stockhammer and Onaran (2003 and 2005). The goods market consists of behavioural functions for accumulation, savings, and net exports, and is then complemented by a distribution function, a productivity function and unemployment. In this study we assume that economy faces exogenous, random climate shocks, which can have substantial impact on key macroeconomic indicators, then the main intention is to examine whether key macroeconomic indicators differ significantly in their responses to severe whether shocks (unexpected variation) in the medium term to long run (see Chaiechi 2012).

By employing the Structural vector autoregressive (SVAR) approach, the study firstly investigates that if there is a cointegrating relationship between the key variables and whether proxies by imposing short and long-run restriction on SVAR model. The traditional means of analysing an estimated structural VAR model is through the impulse response function (Hamilton, 1994). Impulse response functions represent the dynamic response of a variable in the model to an error term (referred to as a shock or innovation) in one of the structural equations. The short run restrictions impose contemporaneous feedback effects among the real sector variables and whether/ climate shocks following the methodology described in Bernanke (1986), Blanchard and Watson (1986), and Sims (1986), and the long run restrictions in SVAR approach is an alternative to cointegration for capturing long-run equilibrium relationships.

The outcome of post-Keynesian assumption is that more investment and accelerated endogenous technological change leads to higher employment rate and increases the export volumes and consequently achieves higher economic growth. Post Keynesian models also accept the possibility of repeated market failures and externalities, and acknowledge the importance of structural changes, therefore post Keynesian prefer multi-sectoral models over aggregated models. Another important implication that PK models have is that they argue policies to increase accumulation will lead to higher economic growth and technological changes, however not all technological changes increases the rate of economic growth Consequently these models seem to be especially suitable for sustainability analysis.

Accumulation $$g_t^i \equiv \frac{I_t}{K_t} = \alpha_0 + \alpha_1 z_{t-1} + \alpha_2 \pi_{t-1} - \alpha_3 r_t + \alpha_4 gx_{t-1} + \alpha_5 dv_t + \alpha_6 Dis_t \quad (1)$$

Savings $$g_t^s = \beta_1 z_t + \beta_2 \pi_t + \beta_3 Dis_t \quad (2)$$

Income Distribution $$\pi_t = \gamma_0 + \gamma_1 z_t + \gamma_2 u_t + \gamma_3 gx_t + \gamma_4 Dis_t \quad (3)$$

Productivity growth $$gx_t = \tau_0 + \tau_1 g_t^i + \tau_2 z_t + \tau_3 Dis_t \quad (4)$$

Net Export $$nx_t = -\delta_1 z_t + \delta_2 \pi_t + \delta_3 Dis_t \quad (5)$$

Employment $$u_t = n - e_1 g_t^i - e_2 \Delta z_t - e_3 \pi_t + e_4 u_{t-1} + e_5 gx_t + e_5 Dis_t \quad (6)$$

Market equilibrium $$g_t^i = g_t^{stotal} = g_t^s - nx \quad (7)$$

g_t^i : Growth of Capital Stock (investment)

g_t^s : Saving Rate

z : Capacity Utilisation (capital productivity)

π : Profit share

r : Interest rate

nx: Net export (normalised by GDP)

u : Unemployment rate

gx : Productivity Growth

Dis: Dummy variable for Disasters

3.2 Data and Variables Definition

The variables we have included in the model are the variables from the system of equations, including investment, savings, income distribution, unemployment, productivity growth , and net export as endogenous variables, and interest rate, capacity utilisation, and natural disaster dummy variable as exogenous variable. The followings provide ways in which variables are proxied, collected and measured. The data were obtained from various sources such as Australia Bureau of Statistics (ABS), Reserve Bank of Australia (RBA), the Office of Economic and Statistic Research - QLD government, and the Bureau of Meteorology for the period of 2002: Q1 to 2010: Q4 for the state of Queensland.

Data on number of disasters experienced is considered as a measure of inherent vulnerability in the absence of mitigation; however one should note that this measure does not accurately portray current vulnerability to natural disasters. Natural disaster variable enters into our model as a dummy independent variable. Since the unit of observation is time in this research, the dummy variable represents whether, in each time period (quarterly in this case), natural disasters (Flood and Tropical Cyclones) have occurred in QLD during 2002: Q1 to 2010: Q4. Therefore, dummy variables used in this paper tend to isolate certain quarters that are systematically different from other periods covered by the dataset, in a way that periods with no disaster are given 0 as value for the dummy variable and quarters in which natural disaster are experienced are given 1. Natural disasters in this study refers to the number of time Queensland has experienced major Floods and Tropical Cyclone events , other types of natural disasters such as Bushfire, Earthquakes, Tsunamis are not taken into consideration as the state is not prune to such disasters.

Investment: The estimates of capital stock and consumption of fixed capital are prepared using the perpetual inventory method (PIM). The accumulation (investment) is measured using the following:

Investment= Physical capital stock + (1- depreciation rate of capital) x Grossed Fixed Capital Formation

Income distribution or Profit Share: following (Dutt 1995) rate of profit can be expressed as; $r = (1\text{-}Va)\ u$, where V is the real wage rate, a is the ratio of labour to GDP and therefore income distribution or profit share in income will be (1-*Va)*.

Capacity Utilisation: the actual capacity utilisation (u) can be expressed as $u=Y/K$, where K is stock of physical capital and Y is nominal GDP.

Savings : saving is the ration of Gross savings/ GDP.

Productivity Growth : growth rate of K/L, where L is the number of labour and K is capital.

Net Export : difference between export and import normalised by GDP.

Unemployment Rate: data on unemployment rate are available for the state and is understood as percentage per annum.

Interest rate: Interest rate is measured applying the following formula. IRT= (DEP+1)/ (INF +1), where DEP is deposit rate and INF is inflation rate

Natural Disasters: The number of natural disaster events historically experienced in Queensland during 1980-2010.

4. Estimation Techniques

4.1 Stationarity

Many economic time series exhibit trending behaviour or non-stationarity in the mean, and may have no tendency to return to a long-run deterministic path, therefore a linear combinations of non-stationary time series will lead to spurious regression. Moreover, for a Structural VAR approach, advanced by (Shapiro and Watson 1988) and (Blanchard 1989) showed that if variables are non-stationary, shocks continue to accumulate over time and so have permanent effects. Therefore, the presence of unit roots in the variables can give rise to spurious regression if the VAR is estimated in levels.

We follow (Granger 1986) that states a non-stationary time series can achieve stationarity if the series is differenced appropriately. A series is integrated of order d, I(d), if the series becomes stationary after differencing d times. So we determine whether the variables to be included are $I(0)$ or $I(1)$. This will determine whether a reduced form representation in levels or in first differences is required. For this purpose, the augmented Dickey-Fuller (ADF) unit root test has been conducted and results are provided in Table 1.

Table 1: Stationarity Tests

	Augmented Dickey-Fuller			
	Level		**First D**	
	No Trend	**Trend**	**No Trend**	**Trend**
Investment	0.1913	0.9999	0.0236*	0.0084***
Savings	0.1452	0.2668	0.0000***	0.0001***
Income Distribution	0.0663 **	0.2102	0.000***	0.000***
Productivity Growth	0.0005***	0.000***	0.000***	0.000***
Net Export	0.3752	0.3507	0.0004***	0.0024***
Unemployment	0.1689	0.9328	0.000***	0.000***
Capaity Utilisation	0.1517	1.0000	0.0504**	0.0116*
Interest rate	0.1641	0.3511	0.0032***	0.0166**
Disasters	0.000***	0.000***	0.000***	0.000***
Profit rate	0.1518	0.9999	0.0504**	0.0116*

*** (**), (*) indicates that t-statistic is significant at 1% (5%), and (10%)

One major issues in performing ADF tests are the inclusion (or not) of an intercept term, a trend term, or both. ADF test results are very responsive to the presence of intercept and trend terms, so the ADF test is carried out both with “intercept (no trend)” and “intercept with trend” and the probability of t -statistics are provided in the table above. The result of ADF test indicates that is almost impossible to reject the null hypothesis of a unit root (non-stationary data) for all the variables at level. However, by differencing the data once and reapplying the test, it seems that stationary data are achieved and the null hypothesis of unit root is easily rejected mostly at 1% significance level. The results show that the variables are integrated at first difference (i.e. the data are I(1)), and the conclusion is that from now on the first differences of the variable series are used in the analysis, which display a stochastic trend.

4.2 SVAR Identification and Estimation

VAR methodology does not consider the structural relationships among the variables. In this sense, Structural VAR (SVAR) analysis attempts to solve the traditional identification problem. SVAR framework allows investigating what exactly a given theoretical view implies for the dynamic linkages in an empirical model which has been identified on this basis (Gali 1992). SVAR models allow for the estimation of structural shocks and impulse responses (dynamic linkages) from empirical data and therefore, can be used to evaluate economic theory. SVAR models therefore require additional information about the theoretical setup in order to identify the structural parameters; this identification is obtained by imposing parameter restrictions that can be justified by the economic theory. Therefore, the SVAR can be used to predict the effects of specific policy actions or of important changes in the economy (Narayan, Narayan et al. 2008). We follow (Stockhammer and Onaran 2003) and (Stockhammer 2005) that explicitly explains the post- Keynesian restrictions imposed on the VAR model to investigate contemporaneous feedback effects among variables. The SVAR model in this paper unambiguously favours Post-Keynesian macroeconomic theory and gives priority to the hypothesis that investment causes Savings (for more details see

(Chaiechi 2012)). Therefore, the ordering of the variables according to the Kaleckian Post-Keynesian theory which we used throughout this study is the vector:

$$\boldsymbol{Y_t' = (INV_t, SAV_t, AW_t, NX_t, GX_t, U_t)}$$

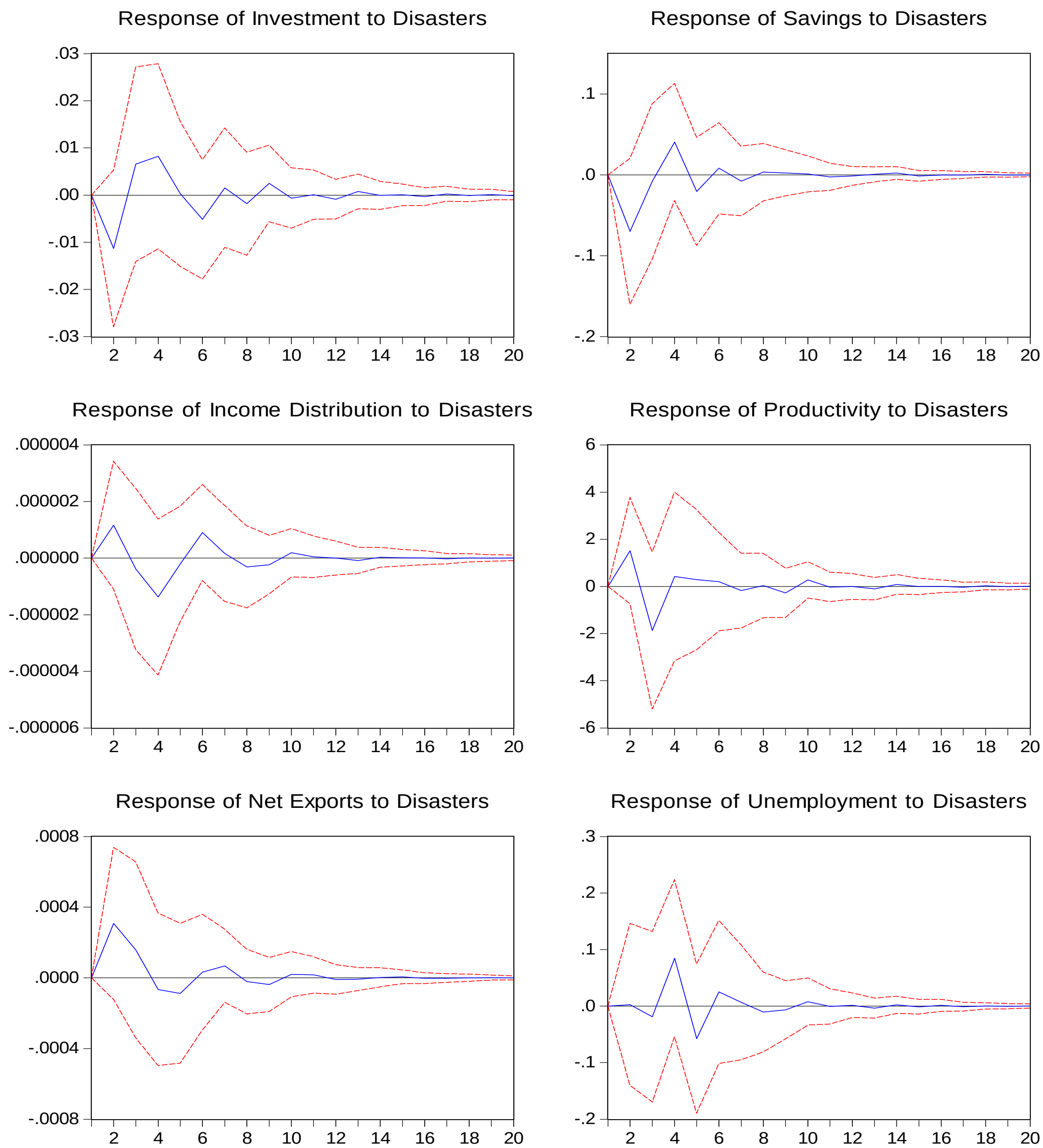
The results of SVAR modelling is not provided here due to space strength, however, the results indicate that a higher level of investment significantly boosts the volume of export , which is in line with our Kaleckian macroeconomic model indicating investment as the drive for economic growth.

4.3 Impulse Response Function (IRF)

Impulse response functions represent the dynamic response of a variable in the model to an error term (referred to as a shock or innovation) in the structural equations. The transmission of the shock will depend on the form of the structural equations. Plotting the impulse response function is a practical way to visually represent the behaviour of variables in our model in response to the natural disasters shocks. These shocks are unexpected variations in climatic event and can have substantial impact on key macroeconomic indicators, particularly on investment, productivity, export and consequently on labour market outcomes. Figure 2 show the impulse response functions. The standard error bands are obtained by Monte Carlo standard errors. Graph includes a point estimation of impulse response functions as well as lower and upper bounds for a 95% confidence interval. The solid blue line portrays the macroeconomic variables changes in response to a standard deviation of one whereas the dotted lines represent the 95% error bands. The speed of adjustment after a structural shock (disaster shocks) is measured by the number of periods before the impulse-response functions cross the zero line. The sizes of the shocks applied to the SVAR system in this study are measured as one-standard deviation shock of the structural error.

Figure 2 represents the responses of the key macroeconomic variables to the occurrences of natural disasters (Flood and Cyclones) in Queensland economy. Unexpected change in climatic events seems to create immediate and sharp decline in investment and savings levels which last around a year (4 quarters) before it goes back to the pre-shock level (ceteris-paribus), this in the short run is due to the destruction of physical capital and infrastructure including factories, property, equipment, roads, and other assets. The impact on national savings will be negative simultaneously as more resources are now required to be allocated to capital accumulation post-natural disasters. The response of Productivity is initially positive for couple of quarters and then negative for another couple of quarters before it becomes slightly and steadily positive for a long term before it crosses the zero line and meets the pre-disaster level. 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 (The World bank 2011). The reason that the productivity can be affected positively by disasters in the long run can be justified by the fact that when disasters strike tendency for adapting new technologies that further improve the long term economic productivity will increase , these new technologies are often more resilient to the severe climatic events (Hallegatte & Dumas, 2009; Skidmore & Toya, 2002).

Figure 2: Impulse response of the Key macroeconomic indicators to the climatic shock (i,e Natural Disasters)



Loss of capital and investment and reduction in income distribution (producer's profitability) after the second quarter will place upward pressure on prices and wages which consequently will increase unemployment, this is the effect that starts showing almost 3 quarters post-disaster.

5. Conclusion

In particular, the magnitude and volatility of the responses to disaster shocks was studied, and results consistently indicate that disaster shocks have significant and rather long-lived (up to

10 quarters after events) persistent impact on major macroeconomic indicators, however, all six macro indicators (investment, Savings, Income distribution, Productivity, net export and Unemployment) show stability signs and that they are able to absorb the disaster shocks with some delays (up to 10 quarters in average). Result conclude that, while the economic impact of the Queensland's recent natural disasters have been significant and while recent flood ad cyclone events have altered the profile of economic activity and growth of the state , it is likely that the impact of disasters lessen in medium run and the shocks are fully absorbed by economic units of the state. This can be due generation of huge amount of economic activities which results from reconstruction programs that are mainly funded by Federal Government (partially through one-off levy and spending cuts). These economic activities target rebuilding homes, restoring workplaces and fixing up damaged infrastructure.

The impulse response analysis shows an obvious possibility that macroeconomic and employment shocks by natural disasters truly do not affect the economic stability of the state in long term and the effects of such shocks are rather temporary and a turnaround in different sectors of state economy is expected within 2 years after occurrence of disaster events. The final conclusion is that natural disasters (Flood and Tropical Cyclones) will alter economic profile and economic growth of Queensland overtime, however, the impact of disaster events on key economic indicators is expected to smooth out in the medium term.

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