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The Mining Boom, Productivity Paradox, Dutch Disease & Monetary Policy Challenges for Australia

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I. Introduction

The Australian economy in the mid-2010 decade has experienced the largest mineral resources export boom in its recorded history. The current mining boom has surpassed both in its macroeconomic impact and in its protracted duration the previous iconic mining booms such as the gold rush of the 1850s, the Korean wool boom of the 1950s and the Japanese driven energy boom of the 1970s. The current mining boom has been fuelled by the demand for mineral resources from the fast growing and urbanizing mega Asian economies of China and India causing the rise in world price of primary commodity exports to sky-rocket the Australian TOT to reach the highest peak in 2011Q2 over the past 140 years of its recorded history.

The previous resource booms were short-lived and turned into resource curses because of the failure to implement policies and establish the macroeconomic institutional framework that would deliver stability and sustained long-term growth. A comparative review of the past mining booms that engulfed Australia indicate that they shared some major common features in that they were the upshot of :

1. Major global events such as wars.
2. Significant macroeconomic changes due to recessions.
3. Supply shocks, such as the oil price shock resulting in stagflation or simultaneous increase in inflation and unemployment in the 1970s.
4. Changes in the exchange rate regime due to the collapse of the Bretton Woods system of pegged exchange rates and generalised floating by industrial countries.
5. Inflation targeting replacing monetary targeting that malfunctioned because of the changing nature of monetary aggregates.
6. Financial deregulation caused by the 'impossible trinity' of pursuing independent monetary policy under flexible exchange rate regimes with capital mobility.
7. Labour market reforms, which in the Australian context replaced the centralised wage-fixing system that that transmitted wage increases in one sector across the economy through the operation of the principle of comparative wage justice resulting in bouts of wage inflation followed by increase unemployment (Conolly and Orsmund 2011). However, the introduction of enterprise bargaining forged through the various Accords between the government and trade unions by linking wage increases to productivity subdued inflationary pressures.

The current mining boom, the largest in Australia's recorded history, has the potential to deliver a cornucopia of sustainable macroeconomic benefits or turn into the boom into resource curse, because of the failure to implement appropriate monetary and adjustment policies and establish flexible financial and labour market institutional frameworks. Therefore, it is imperative that appropriate short-run monetary and long-term adjustment policies be designed preemptively

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to harness and the potential benefits of the resources boom to promote sustainable long-term growth. Both the lessons of Australia's past mining booms and cross-country international historical evidence demonstrate that failure to design appropriate policies and institutional frameworks can turn a mineral resource boom into a resource curse through the spread of Dutch disease effects.

The rest of the paper is organised as follows: Section 2 reviews the 'productivity conundrum'' that has blighted the Australian economy by turning the productivity surge of the 1990s decade to a productivity slump in the 2000 decade. This section explains that the productivity conundrum is a transitory phenomenon that will rectify when the investments in the mining sector attain capacity production. Section 3 sheds light on the resource curse phenomena that manifests in the shape of the twin forces of first: deindustrialisation that occurs due to the change in the sectoral composition of the structure of the economy and second, due to Dutch disease effects that eventuate from growth dynamics that accompanies a mining boom as a result of the sky-rocketing TOT and exchange rate appreciation. Section discusses the monetary policy design based on the triangle model of the Phillips curve model and three benchmark TV-NAIRU models to moderate the wage aspiration effects that could emanate from the changes in productivity due to the mining boom . Section 5 presents the concluding observations highlighting the complexity of the monetary policy design that confront a small open economy such as Australia that is experiencing a massive mining boom. A major contribution of the paper is the empirical analysis of repercussions of the mining boom and monetary policy design is analysed using State Space methodology and the Kalman Filter. The empirical analysis is based on a seasonally adjusted quarterly data set covering the period 1978Q3-2011Q1. The data set has been sourced from the Key Indicators and National Accounts published by the ABS (See Appendix for the time-series and dataset used in this paper). A number of software packages such as EViews 8.0, RATS 7 and STAMP 8.3 were used in the empirical analyses.

II. The Productivity Paradox

A review of the performance of the Australian economy over the past four decades reveals that productivity measured in terms of labour productivity (LPR) (output per hours worked) and multifactor productivity (MFP) (output per input of all factors of production) have been the crucial determinant of Australia's living standards as measured by per capita income. Accounting for growth of output in terms of MFP, Capital deepening (CAP) and Labor Productivity (LPR) based on Trans log growth accounting framework yielded decade-wise average growth rates for GDP and its components for the four deades 1980s, 1990s, 2000s and 2010sas reported in Table 1.

Table 1

Decade	CAP	LPR	MFP	GDP/VA
AVG1970s	1.57	-0.26	1.27	2.59
AVG1980s	1.86	0.97	0.40	3.23
AVG1990s	1.50	0.31	1.74	3.55
AVG2000s	2.24	0.58	0.42	3.24

Notes: CAP: Capital Intensity, LPR: Labor Productivity (Output per hours worked), MFP: Multifactor Productivity. The above estimates are based by fitting a Translog production function to data from 12 industries in the market sector. The Translog fit enables growth accounts to be additive. Laspeyere index numbers have been used to estimate GDP/VA, Tornquvist indexes based on weighted change in capital stock measures capital services, while labour input index was estimated using a simple elemental index based on hours worked., Source: ABS Cat. 5206.0.55.002 Experimental Estimates of Industry Multifactor Productivity 2011-12.

The decade-wise contributions to average GDP growth rates in Table 1 reveal that growth in MFP declined from 1.74% to 0.42% and LPR despite the increase in CAP from 1.50% to 2.24% increased modestly from 0.31% to 0.58% The slump in productivity in 2000s decade when compared to the surge in productivity in the 'golden age' of 1990s led to much consternation amongst both politicians and policymakers. Because, if the productivity slow-down continues into the future it would undermine the living standards of Australians as measured by growth in per capita income. The analysis of growth in per capita income depends crucially on the three P's: Population, Productivity and the Participation Rate.

An algebraic expose of how the 3 P's determine per capita GDP is explained by the formula (Endnote 1) based on Eslake and Walsh (2011).

The slump in productivity in the 2000 decade compared to the previous 1990s decade would have depressed Real GDP per capita and living standards, but TOT hike driven by the mining boom causing increased real gross domestic income (RGDI), i.e.. RGDP adjusted for the changes in the TOT, to increase and offset the adverse effects of productivity slump. During the 1990s decade the TOT effect subtracted approximately 0.1% p.a. from the growth of RGDP. But over the 2000s decade the increase in the TOT boosted the growth of RGDI by 0.9% p.a. This gain from the TOT more than offset the adverse effects of the decline in productivity and prevented a decline in RGDP as reported in Table 2.

Table 2

Table 2. Contributions of the 3 Ps & TOT to GDP (Living Standards)

Decade	POP	PAR	LPR	GDP	TOT	GNI
1990s	1.4	-0.1	2.1	3.4	-0.1	3.3
2000s	1.8	-0.3	1.4	3.1	0.9	4

Sources: ABS Cat. 5206
Treasury (2010) Intergenerational Report.
Eslake & Walsh(2011)

According to the projections of the Intergenerational Report Treasury (2010) the trends in population growth, and labor force participation rate are anticipated to decline due to the demographics of the ageing population. Furthermore, the TOT movements are not expected to add to the growth of GNI over the next two decades. Therefore, the onus for the increasing the growth of real GDP and living standards in the next two decades of 2010 and 2020 is expected to fall squarely on the increase of productivity. The slump in productivity in 2000 and the gloom predictions about the demographic effects of the ageing population led to much consternation both among politicians and policymakers. This led to the setting up of Parliamentary Inquiry (2011) to identify the causes of the productivity slump of the 2000 and recommend policy measures to reverse the declining productivity trends. The slump in productivity in the 2000s decade despite a record rise in the TOT powered by the mining boom conjures up a conundrum that requires explanation. The evolution of a mining boom-bust cycle can be stylized in terms of a three overlapping phase heuristic model where the macroeconomic effects are driven: In Phase I by the increase in the TOT. In Phase II by the inflow of investment into the mineral resource sector. In Phase III by the increase in mining production and exports (Plumb et al. 2013). The productivity conundrum experienced during the decades of the 1990s and 2000 have been attributed to various causes such as the: mismeasurement of labour due to labour hoarding during recessions, increase in directly unproductive (DUP) activities due to the proliferation of red and green tape. The widening of the chasm between the domestic production frontier and the world's best practice production frontier as measured by the US production frontier, where the production frontier measures the maximum output that can be produced efficiently from a given set of factor input (Banks 2011, D'Arcy and Gustaffson 2012).

The emergence of the productivity slump in the 2000s was a fall-out from the lumpy investment in mining projects (coal, iron ore, liquefied natural gas (LNG) and coal seam gas(CSG) that had a long-gestation period leading to a lower productivity during the gestation period where projects did not reap the benefits of economies of scale because they were operating below full capacity. In the short-run the increase demand for finite exhaustible mineral resources, in the absence of new resource discoveries, jacks-up the scarcity rents and resource prices due to the operation of efficient competitive market forces leading to conservation of resources, as hypothesised in the Hotelling Rule (Hotelling 1931). However, the optimal exploitation of homogenous finite natural resources in resources in the long-run as subsumed in the Hotelling Rule are undermined in the short-run because of: market power, non-constant returns to scale, quasi-fixity of capital inputs and missing inputs makes natural resources heterogeneous. (Zheng and Bloch 2010). Productivity Commission studies for Australia during the current mining boom contends that resource heterogeneity occurs because in the short-run the extraction costs of natural resources increase as less accessible resource bodies have to be mined, using more costly capital intensive techniques, and the failure to take into account these missing inputs has led to underestimation of multifactor productivity (MFP) to the tune of 2.5% in 2000s decade (Topp et al. 2008). The mismeasurement of MFP has probably contributed to the exaggeration of the severity of productivity slump during 2000s decade and has magnified the productivity conundrum that occurred during the study period.

a) The economy-wide repurcussions of the TOT boom

The record increase in the TOT due to the increase in global demand for Australia's mineral exports not only caused the productivity surge and slump during the study period has economy-wide repercussions. Since Australia is a small open economy and a price taker in the world market. the occurrence of a mining boom can drive the economy to hit capacity limits and lead to overheating in a economy operating at full employment, becausee AD exceeds AS unleashing inflationary pressures. Therefore, the design of proper monetary policy to keep

Global Journal of Management and Business Research (B) Volume XIV Issue II Version I Year 2014

inflation within the target zone and establishing sound institutions to manage the strucural adjustments required to achieve internal balance (full employment and stable inflation) and external balance (a sustainable current account deficit) to prevent a resource boom from turning into a resource curse is a policy imperative that requires attention. However, the design of optimal monetary policy in economy on the cusp of a mining boom has to take account of many economy-wide repercussions due to the mining boom. In the sequel we review the dynamics of two phenomena: deindustrialisation and Dutch Disease effects that that can convert a resource boom to a resource curse if they are ignored by policymakers.

III. The Resource Curse - Deindustrialisation & Dutch Disease Effects

Deindustrializtion occurs due to changes in the economic structure as an economy matures or develops causing the share of industry to shrink relative to agriculture and services in tri-sector classification of the economy. Manufactruing is a sub-sector of the much broader industrial sector which encompasses mining and construction. But changes in productivity or labour intensity of manufacturing plays the catalytic role in deindustrialisation through the restructing of the sectoral composition of the economy when measured in terms of the sectoral share of employment or value-added or GDP as a percentage of the total employment and GDP of the mactoeconomy. Neoclassical or Solow growth theory (Solow 1956) accords no role to industrial policy to counter the short-term adverse effects of the diminishing marginal productivity of capital and in the long-run economic growth is determined by exogenous forces of capital accumulation and technical progress. However, heterodox or structuralist growth perspectives in contrast to neoclassical growth theory identifies that growth in productivity in manufacturing or decrease in its labor intensity plays a dynamic role in accelerating or retarding long-term economic growth in advanced capitalist economies. This thesis is exemplified in the three Kaldorian laws (Kaldor 1967). The first law postulates that growth in manufacturing productivity acts as an 'engine of growth' for the whole economy. The second law, also known as the Verdoon law, after Verdoon (1949), postulates that increasing labour productivity by activating dynamic economies of scale boosts productivity in the manufacturing sector. The third law, postulates growth in labor productivity ignites a virturous cycle that bolsters productivity of both manufacturing and non-manufacturing sectors.

A noteworthy empirical study (Tregenna 2008) applies a decomposition technique to 48 countries and clarifies that deindustrialisation due to increase in labor productivity or inversely an increase in labor intensity can result in not only the share of employment but also the value added of GDP when compared to their magnitudes in the macroeconomy. Tregenna also embraces the Kaldorian prespective that manufacturing is a 'leading engine' of long-term growth because manufacturing is imbdued with a host of growth promoting special characteristics such as as backward and forward linkages, spread effects, learning-by-doing (LBD) economies, innovation and technical progress, salubrious balance of payments effects and dynamic economies scale. Tregenna (2011) In a comprehensive literature survey of deindustrialisation reviews the various conceptualisations of deindustrialisation: According to Singh (1977) deindustrialisation is a manifestationof macroeconomic disequilibrium due to inefficient or high cost manufacturing production resulting in both decrease domestic consumer welfare and international competitiveness manufactured exports. Tregenna (2009) in a seminal study, defined deindustrialization as the consistent reduction in the share of employment and valued of industry in the total employment and GDP in the macroeconomy. According to Rawthorn and Wells (1987) deindustrialization manifests as a persistent fall in of the share of industrial employment of a country or a region due to the interactionof diverse factors such as income elasticity of demand, outsourcing , new international division of labour and Dutch disease effects. Such deindustrializtion can be regarded as postive if the job losses in the manufacturing sector due increase in productivity is offset by the increase of job creation in the service sector, otherwise deindustrialization can be regarded as negative. Saeger (1997) contends on the basis of a study of 23 OECD countries that manufacturing imports from developing countries or the South has led to deindustrialization of the North. Rawthorn and Ramaswamy (1997) based on a study of 18 OECD countries contend that deindustrialization of the North is due to industrial growth dynamics and not due to competitive inroads from the South. Rowthorn and Coutts (2004) summarizes five explanations of deindustrialization as advanced in the literature. First, outsourcing of some manufacturing activities to cheaper specialized producers resulting in an illusory rather than a real reduction of manufacturing employment. Second, the fall in the relative price of manufactures decreases its share consumer expenditure. Third, higher growth in productivity of manufacturing leads to slower growth in manufacturing employment relative to service sector employment. Fourth, increase in productivity in manufacturing in advanced countries are associated with the production of more sophisticated capital intensive products relative to labor intensive products, resulting in decrease in employment . Fifth. increase productivity in manufacturing will lead to decreasing investment in manufacturing sector and therefore decrease in employment and GDP generated by the sector. Sixth, Dutch disease effects that arise from resource discoveries as described by Palma (2005, 2008) and elaborated in the next section can be a major force in deindustriaization in advanced countries such as Australia.

The decadewise changes in the sectoral composition of the Australian macroeconomy reported in Table 1 reflects the deindustrialisation dynamics observed due to the changes in productivity the productivity slump in the 2000s decade compared to the surge in 1990s resulted in the reduction of both employment and output or GDP due both deindustrialiation dynamics as observed in other advanced countries and also due to the Dutch disease effects generated by mining boom. The shrinking of the manufacturing sector and the expansion of the service sector over the decades corroborrates that the Australian economy exhibited the same deindustrialisation dynamics as other advanced economies as they developed insert and matured over the decades.

Table 3

Decade	Agriculture ,Forestry & Fishing	Mining & Construction	Manufacturing	Employment Services	Total	Total Employment
	%	%	%	%	%	000
AVG 1980	5.9	8.6	15.7	69.8	100.0	4929.2
AVG 1990	5.2	8.3	13.2	73.4	100.0	5938.3
AVG 2000	3.9	9.5	10.6	76.0	100.0	7512.7
AVG 2010	3.1	11.0	8.6	77.4	100.0	8787.6

Agriculture, Forestry & Fishing	Mining & Construction	Manufacturing	Services	Total	GDP GDP
%	%	%	%	%	$ million
2.5	11.9	12.9	72.7	100.0	636152.8
2.4	12.9	11.6	73.1	100.0	776070.5
2.3	11.8	9.6	76.3	100.0	1107473.1
2.2	11.9	8.2	77.7	100.0	1305647.0

a) Dutch Disease Effects

The productivity conundrum or the productivity paradox that occurred in the decades of 1990s and 2000s as analysed in the previous Section 2 witnessed the harbinger of the biggest mining boom to engulf Australia in the mid-2010 decade that occrred in Australia since its Federation 1989. Historical evidence is replete with examples that resource booms turn into a resource curse as exemplified by the aftermath of the adverse macroeconomic effects that ravaged the Dutch economy after the North Sea oil and gas boom of the 1970s. Some of the causes that converted a resource boom into a curse have been identified in the literature: they are the:

i. The retardation of growth due to increase commodity price and income volatility.
ii. The Increase in corruption, rent-seeking activity eroding the effectiveness of democratic policy making and institutions
iii. The pursuit of procyclical fiscal policies resulting in wasteful expenditure leading unbalanced growth due to the failure to promote the development of the non-resource sectors.
iv. Failure to pursue prudent monetary policies that anchor inflation expectations.
v. Failure to deregulate labour markets.
vi. Pursuit of the wrong exchange rate regim.
vii. Distorted taxation policies and the like (Sachs and Warner 2001).

b) The Resource Curse or Dutch Disease (DD) model

The cannonical ' Dutch Disease' (DD) Model as conceptualised in the seminal paper by (Corden and Neary 1982) and the "Core" model is recapitulated by Corden (1984) in terms of a neoclassical or factor endowment trade model comprising of three sectors. The Corden core model is analogous to the Gregory (1976) models an follows on the pedigree of the Salter (1959), Swan (1960) dependency model by dichotomizing the tradable sector into a booming tradable sector driven by world resource prices and a nontradable sector. The price of tradables are determined by forces of supply and demand in the world market, while price of nontradables are determined by domestic market forces. The core Corden- Gregory DD model of a small open economy comprises of three sectors:

Sector 1 : Booming tradables sector (mining sector).
Sector 2 : Lagging tradables sector (includes parts of manfacturing, agriculture & service sectors).
Sector 3 : Nontradables sector (services sector).

Global Journal of Management and Business Research (B) Volume XIV Issue II Version I Year 2014

The booming tradable sector would be activated by the rise in the world price of resources as has occurred during the current mining boom in Australia, where the price of mining exports (coal and iron ore) grew by 140% driven by demand from the fast growing emerging market economies of China and India. The booming tradable sector sets in motion two effects: a resource movement effect and a spending effect. The resource movement effect pulls factors of production into the booming sector from the the lagging tradable and nontradable causing their output to fall leading to 'direct deindustrialisation'.

Corden (2011) contends that the resource movement effect by pulling capital and labor to the more profitable booming mining sector creates a shortage of skilled labor in the non-booming sectors of the economy. However, in the Australian context the recource movement effect does not create significant adverse DD effects because of two reasons: First, skilled immigration (through the issue of 457 visas) overcomes skilled labor shortages in the booming mining sector. Second, free international capital mobility ensures that foreign capital can flow freely to the booming sector if it satisfies the national criteria specified by the Foreign Investment Review Board. Therefore, direct adverse DD effects of the resource boom in Australia are according to the empirical judgement of Corden (2011) are likely to be modest. The adverse DD effects of the mineral resource boom in Australia are generated mainly by the spending effect.

The spending effect arises both because incomes and capital investment in the booming mining sector rise due to the rise in the world prices of mining exports. The causes a rise in the terms of trade and an appreciation of the real exchange rate. The capital inflow into the booming sector further reinforces the exchange rate appreciation. In Australia during the current mining boom (2005-2011) the real exchange rate measured by the Austrlian TWI (Trade-Weignted Index) increased by 31% in response the rise of the terms of trade by 41% mainly driven by the sky-rocketing mining export (coal and iron ore) prices that peaked at 140% over their long-term average value. The real appreciation of the exchange rate rendered uncompetitive exports from the lagging tradable sector, which included traditional manufactures, some agricultural exports and services related to tourism, and export of education and health services. Thus, the locus of the adverse DD effect due to the real exchange rate appreciation falls squarely on the lagging tradable sector activities, which in the Australian context includes parts of manufacturing, agriculture and services such as tourism and education.

The lagging sectors are the losers due to the adverse DD effects caused by the real exchange rate appreciation of the booming sector exports. The gainers of the mining boom are the investors and employees in the booming sector and the losers are investors and employees in the lagging or non-booming sectors. If tax-revenue from the potential gainers of the booming sector are spent prudently increasing community welfare thus compensating the losers, the adverse DD effects on the losers in the mining sector can be mitigated. However, full Pareto compensating tax-redistribution never eventuates and in reality the non-booming sector bears the full brunt of adverse DD effects.

c) The '"Two speed economy""

It is noteworthy that the DD or resource curse effects have a spatial dimension, which manifiests as in a "two speed economy", where the resource rich regions/states prosper while the resource poor regions/ states stagnate or decline. The spatial or 'two speed effects' of mining boom can be measured using a structural change index (SCI) as proposed by Conolly and Osmund (2011) (See Endnote 4)

During the current mining boom in the 2000s decade the SCI measured in terms of nominal output and investment has been the highest on record over the past 50 years. But the SCI index in terms of real output and employment has fallen rather than increased during the 50 year period. The resource rich states of Western Australia and Queensland the SCI for investment, output and population growth has been higher than the other three resource poor states during the mining boom period implying that were laggard because of DD effects. The SCI for the 8 industry groups which ABS published data measured in terms of nominal output and investment increased, while measured in t terms of real output and employment has hardly changed. This lack lustre performance has occurred because the long gestation lags between investment and output in mining industries, because of two DD effects associated with mining investments. First, mining investments have a long gestation lag between output and investment an secondly, they are capital intensive and therefore fail to lead to significant inreases in jobs or emplyoment in the short-run because production is at sub-optimal scale or capacity in the short-run.

d) Accounting for changes in Productivity – the elephant in the room

As the mining boom evolves through the different phases productivity too vary in sympathy. The changes in productivity has repercussions on wage aspriations and inflation. Past mining booms occurred under the centalised wage-fixing system, where increase in award wages in one industry was transmitted to other industries through the principle of comparative wage justice regardless of the productivity record of that industry. Therefore, under the mining booms TOT increases led to wage explostions that fuelled double digit inflation and high unemployment rates. However, the current mining boom has occurred under a deregulated labour market that replaced the centralise wage-fixing system. Besides, the floating of the

Global Journal of Management and Business Research (B) Volume XIV Issue II Version I Year 2014

exchange rate and inflation targeting has anchored inflation expectations leading to more subdued wage growth in 2000s replacing the wage explosions in the 1980s.

The link between productivity and wages has international and domestic dimensions and makes a well functioning labour market with a proper industrial relations system the 'elephant in the room' in designing policies to boost productivity.

The rise in price of tradables (mineral resource exports) is associated with the higher productivity of the tradable sector in advanced economy such as Australia. The higher produtivity in the tradable sector results in higher prices and wages in the tradable sector, which spill sover to the nontradable sectors (utilities and services). This results in higher prices for not only tradables but also nontradables in an advanced economy such as Australia compared to nontradables in developing countries. This Balassa-Samuelson effect explains why haircuts are more expensive in Australia than in Indonesia (Balassa 1964).

e) Structural adjustment and labour productivity

Australia currently boasts of one of the lowest unemployment rates amongst the advanced economies. The unemployment rate has hovered around 5.25% despite the occurrence of high degree of labour turnover as shown by the high degree of dispersion, measured by the low coefficient of variation of the 19 industries for which ABS publishes data. Furthermore. relative wages in the mining sector and related professional service industries has increased by more than 10% compared to the economy-wide average since 2005. At the same time relative wages of manufacturing, retail and accommodation industries have declined (Lowe 2012). Nevertheless, there is scope for further reform in Australia's industrial relations (IR) to make it more flexible and productive to cope with increasing challenges of global competitiveness. The Employer lobbies contend that the current Fair Work Act that safeguards penalty rates and generous parental leave entitlements inhibit workplace flexibility and innovation by jacking up wages and making manufacturing and other exports internationally uncompetitive. Therefore, reform of the Industrial relations and Fair Work Act has been flagged as an urgent requirement to keep the lid wage inflation as well as to boost the international competitiveness of manufactured exports (Willox 2012).

IV. Monetary Policy Design Issues

Eq. (1) of the 'triangle model' specified that in the absence supply shocks , when the unemployment rate equals to NAIRU, inflation equals expected inflation or steady state inflation , i.e. in symbols when $ut = ut^*$,, $\pi t = \pi t^e$ e yielding steady state or a stable inflation rate. It also follows that if the unemployment rate falls below NAIRU, then because aggregate Eq. (1). predicts that if aggregate demand exceeds aggregate supply, the economy may be hitting 'capacity constraints leading to 'overheating' and unleashing of inflationary pressures. Such a scenario would suggest that monetary policy should be tightened to dampen inflationary pressures. i.e. in symbols when $u < u^*$, a tight monetary policy stance would be required to keep the inflation rate in the stable target zone.. The converse scenario signalling the need for expansionary monetary policy eventuates when $u > u^*$.

However, the assumption of a constant NAIRU robs it from acting as a leading indicator in crafting the stance of monetary policy. Moreover, a constant of NAIRU or the text-book NAIRU peddled by Gordon (1997) for the US, lacked both empirical and theoretical support. Empirically it was observed that in most industrialised countries NAIRU was time-varying rather than constant. Theoretically, NAIRU was postulated to be time-varying and not a constant " carved in stone" but rather a " level that it would be generated out of the Walrasian system of general equilibrium equations, provided there is embedded in them the actual structural characteristics of the labour and commodity markets" (Friedman 1968). Therefore TV-NAIRU and the unemployment gap can play a pivotal role in crafting the stance of monetary policy to keep inflation at bay. NAIRU could be falling over time due to the interplay of a number of factors such as:

i. Demographic change due to ageing baby boomers exhibiting a lower NAIRU as their skills increase.
ii. Competitive forces due to trade liberalisation and shift from centralised wage bargaining to enterprise bargaining has lowered NAIRU.
iii. Hysteresis, because increase in unemployment leads to skill atrophy and eventually the insiders would have to lower NAIRU because of pressure from outsiders.
iv. Last but not least, surges and slumps of productivity could also affect NAIRU through changes in workers wage aspirations. Friedman also observed any attempt by policymakers to systematically keep NAIRU will only lead to eve accelerating inflation. Only in the long-run the Phillips curve is vertical at the natural rate with no tradeoffs between inflation and the unemployment rate. Therefore, both on empirical and theoretical grounds a TV-NAIRU model would provide more useful guidelines for designing monetary policy to achieve stabilisation cannot be gainsaid.

The implications of the mining boom for design of monetary policy can be analysed using the 'triangle' model of the Phillips curve or the expectations augmented Phillips curve as specified by Gordon (1997) and others. The 'triangle' model describes that that change in inflation is the upshot of effects of past inflation or inertia, the demand pull effects of the

Global Journal of Management and Business Research (B) Volume XIV Issue II Version I Year 2014

business cycle as proxied by the unemployment gap and exogenous cost-push effects of supply shocks such as the terms of trade shock or productivity shocks as specified in the signal or measurement Eq. (1) below:

$$[(\pi]_t-\pi_t^e) = \beta(L)\left(\pi_{t-1}-\pi_{t-1}^e\right) + \gamma(L)\left(u_{t-1}-u_{t-1}^*\right) + \delta(L)X_{t-1} + \varepsilon_t \quad (1)$$

where $\pi^e t$::inflation rate, π^eet: expected inflation, , $\pi^e t$:= , $\pi t-1$ adaptive expectations defining the change inflation as $\pi^e t$:= , $\pi t-1$), the unemployment gap or Ugap = (ut –ut*), where ut is the unemployment rate an ut* :is the natural rate or NAIRU. The vector Xt: comprises of exogenous supply shocks such as the TOT or productivity shock. The terms $\beta(L), \gamma(L), \delta(L)$ are lag polynomials. The disturbance term is white noise (i.e. has no serial correlation) and is distributed independent normal with mean zero and constant variance i.e..et ~~NID ~ $(0, \sigma^2_\varepsilon)$.

The triangle model of the Phillips curve specified in Eq.1 has become a centre piece of the intellectual framework for designing monetary policy stance in the RBA (Gruen et al. 1999). However, in the 1970s when the Phillips curve tradeoffs broke down under stagflation proponents of rational expectations theories declared that the Phillips curve had failed on a grand scale (Lucas and Sargent 1978). The modern expectations augmented Phillips curve or the triangle model specified in Eq.1 by Gordon and Mankiw is based on sound micro-foundations rooted in New Keynesian 'sticky price' theories (Aguiar and Martins 2005). . The theoretical robustness of the triangle model has made it the candidate of choice for the empirical analysis of monetary policy design issues using State Space and Kalman Filter econometric methodology in this paper.

The triangle model of the Phillips curve (Eq.1) postulates that in the absence of supply shocks, when inflation equals to stable expected inflation the unemployment rate equals the natural rate or NAIRU (ut*). Eq. (1).also provides useful insights for policymakers to design the stance of monetary policy to keep inflation within the prescribed target zone.

According Eq. 1 if aggregate demand exceeds aggregate supply, the economy may be hitting 'capacity constraints' and 'overheating' due to infrastructure bottlenecks or skill shortages. Such scenario could occur when ut < ut* fuelling inflationary pressures suggesting tightening of monetary policy to douse a possible inflation conflagration. inflation dragon at bay. When ut < ut* , the converse scenario of deflation that could emerges prompts that expansionary monetary policy would be appropriate .Thus, the unemployment gap or deviation of the unemployment rate from NAIRU i.e.Ugap = (ut < ut*) is a good leading indicator of inflationary pressures that may be incubating in the economy and provide useful information to chisel out the appropriate expansionary stance of monetary policy. When ut > ut* the converse scenario would prompt the chiselling out of tight monetary policy stance to achieve the goals of macroeconomic stability or internal balance. In this paper we use three different models to analyse the implications of deviation of the unemployment rate from NAIRU or the Ugap and the information it provides to craft a monetary policy stance to keep inflation with the target zone.

The three benchmark models that play a pivotal role in the design of monetary policy architecture in a small open economy that is experiencing a sky-rocketing TOT due to mining boom having repercussions on inflation and productivity:

i. Constant NAIRU model.
ii. Random Walk Time-Varying (TV) NAIRU model.
iii. Productivity augmented TV-NAIRU model.

i. The Constant NAIRU model or text--book NAIRU was used by Gordon to explain the inflation scenario prevailed in the US in the 1970s (Gordon 1997). The Constant NAIRU model for Australia for the sample period 1978Q3-2011Q1 has been estimated for Australia by applying the OLS technique to the triangle model of the Phillips curve as specified in the Eq. (1) below: :

$$[\Delta\pi]_{\downarrow t} = \gamma_{\downarrow}0 + \beta(L)[\Delta\,\pi]_{\downarrow}(t\text{-}1) + \gamma(L)(u_{\downarrow}(t\text{-}1)) + \delta(L)X_t + \varepsilon_t\,,$$

The estimate of constant NAIRU can be derived by dividing the intercept term by the sum of coefficients of the unemployment rates. In symbols: NAIRU or u* = $\gamma 0/\gamma$ 1), where γ (1) = the sum of coefficients of the unemployment rate.

$$[\Delta\pi]_{\downarrow t} = \gamma_{\downarrow}0 + \beta(L)[\Delta\,\pi]_{\downarrow}(t\text{-}1) + \gamma(L)(u_{\downarrow}(t\text{-}1)) + \delta(L)X_t + \varepsilon_t\,,$$

The estimate of constant NAIRU can be derived by dividing the intercept term by the sum of unemployment rate coefficients as indicted below:

u* = -$\gamma 0/\gamma$ (1),Friedman (1968) where γ (1) = the sum of coefficients of the unemployment rate. The estimate of constant NAIRU for the sample period 1977Q2-2000Q1 for Australia is u* = 0.0059/0.0008= 6.5 % as derived from OLS estimates are reported in Table 8.

Table 8 : OLS Estimates of constant NAIRU

Dependent Variable: DINF
Method: Least Squares
Date: 10/11/12 Time: 12:08
Sample (adjusted): 1979Q2 2010Q4
Included observations: 127 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.005916	0.003340	1.771294	0.0790
DINF(-1)	-0.675413	0.088614	-7.621963	0.0000
DINF(-2)	-0.430110	0.100457	-4.281549	0.0000
DINF(-3)	-0.205956	0.088687	-2.322281	0.0219
U(-1)	-0.000872	0.000465	-1.878222	0.0628
X1	-0.001231	0.000846	-1.455159	0.1482

R-squared	0.327978	Mean dependent var	-0.000103
Adjusted R-squared	0.300209	S.D. dependent var	0.008054
S.E. of regression	0.006737	Akaike info criterion	-7.116241
Sum squared resid	0.005492	Schwarz criterion	-6.981870
Log likelihood	457.8813	Hannan-Quinn criterion.	-7.061648
Durbin-Watson stat	1.983649		

However, a constant NAIRU is sterile from a practical policy perspective and it also lacks theoretical foundations. Therefore, Time-Varying or TV-NAIRU model has been formulated to overcome the deficiencies of the Constant NAIRU model.

ii. Time-Varying NAIRU (TV NAIRU) model, Friedman (1968) hypothesised that "NAIRU is not carved in stone…it is the level that would be ground by the general equilibrium equations, provided there is embedded in them the actual structural characteristics of labour and commodity markets, including market imperfections, stochastic variability in demands and supplies, the cost of gathering information about job vacancies and labour availabilities, the cost of mobility, and so on." (Staiger and Watson 1997) conceptualised that the Time-varying NAIRU (TV-NAIRU) model captured adequately the Friedmanite time profile of the natural rate of unemployment or time-varying NAIRU due to changes in institutional structure of the labour and commodity markets. The natural rate or NAIRU can change over time due to the interplay of a number of factors such as: Demographic change due to ageing baby boomers exhibiting a lower NAIRU as their skills increase.

iii. Competitive forces due to trade liberalisation and shift from centralised wage bargaining to enterprise bargaining has lowered NAIRU.

iv. Hysteresis, because increase in unemployment leads to skill atrophy and eventually the insiders would have to lower NAIRU because of pressure from outsiders. iv. Last but not least, surges and slumps of productivity could also affect NAIRU through changes in workers wage aspirations. Friedman also demonstrated that any attempt by policymakers to keep unemployment rate from the natural rate will only generate an ever accelerating natural rate of unemployment in the short-run. However, in the long-run there would be no tradeoffs between inflation and unemployment and the Phillips curve would be vertical at the natural rate of unemployment.

The TV-NAIRU model or the RW NAIRU model conceptualised by Staiger and Watson (1997) can be specified in terms of the signal or measurement equation (1) and a state or a RW transition equation (2) as given below:

$$[\Delta\pi]_t = \beta(L)[\Delta\pi]_{(t-1)} + \gamma(L)(u_{(t-1)} - u^*) + \delta(L)X_t + \varepsilon_{(t)},$$

$$\varepsilon_t \sim N(0\sigma_\varepsilon^2)$$

$$u_t^* = u_{t-1}^* + n_t,\ n_t \sim N(0,\sigma_n^2) \qquad (2)$$

Where signal to noise ratio $\lambda = \frac{\sigma_n^2}{\sigma_\varepsilon^2}$

In order to obtain MLE of parameters of the above unobserved components structural time series model follow the procedure indicated below:

TV - NAIRU model is estimated from the system of equations comprised of Eq.(1) , the triangle model of the Phillips curve and Eq.2 which specifies as a RW.

The time-profile of NAIRU and Ugap is estimated using the State Space (SS) methodology by applying the KF to obtain the unobserved of the state vectorising MLE techniques. The empirical analysis of the triangle model of the Phillips curve and TV-NAIRU to obtain time-profiles of NAIRU and Ugap and optimal estimates of the hyperparameters require the implementation of three operations:

Operation 1: Convert the system of Eq. 1 and Eq. 2 specifying the Phillips curve and RW NAIRU into(SSF) to facilitate the estimation of time-profile of the unobserved components of the state variables (NAIRU, UGap) using the Kalman Filter.

Endnote 4: provides algebraic expose of State Space methodology.

Operation 2: The Kalman Filter (KF) is a powerful recursive algorithm that facilitates the optimal estimation of state variables. The KF also facilitate the computation of predictions and smoothing estimates of unobserved components of the state variable state variable updating prediction and smooth estimates using all the available information/ estimates for the prediction and smoothing of the unobserved components of the state vector.

Endnote 5 : provides an algebraic expose of the KF

Operation 3: The KF provides prediction error decomposition of the log-likelihood function which provides MLE of parameters state vector and hyperparameters.

Endnote 6: provides an algebraic expose of the calculation MLE for the model parameters using prediction error decomposition based on the Kalman Filter (Kalman 1960). The KF has been widely used in determining the navigation path of space shuttles, intercontinental ballistic missiles and drones. In this paper we have used the terminology of Harvey (1989) to describe SSF, methodology and the KF. . The same ground is also covered by in the text-books of Hamilton (2007).Commandeur and Koopman (2007). and others.

a) *Estimation Issues*

There are three specifications issues that needs to be addressed in order to obtain meaningful TV-NAIRU estimates from the triangle model of the Phillips curve: They are:

i. The simultaneity bias problem
ii. Inflation expectations problem
iii. The 'pile up' problem.

i. All the right hand variables of the triangle model, Eq. (1) should be entered as lagged and not contemporaneous in order to avoid simultaneity bias in estimating the single equation triangle model.

ii. The specification of inflation expectations in the triangle model, Eq. (1) is not model endogenous and therefore, ad hoc. Since inflation has a unit root (see Table 4), we assume adaptive expectations i.e. $\pi_t^e = \pi_{t-1,}$ 1, this provides the justification for the estimation inflation in first differences or $\pi_t^e = \pi_{t-1},$ $\pi_t^e\ t-1,$).

iii. The 'pile up' problem

The size of the signal-to-noise ratio $\lambda = \sigma_\eta^2/\sigma_\varepsilon^2$) is the key determinant of the smoothness of the time-profile of NAIRU and Ugap / Ifσ_ε^2 2 =0 then λ =0 and the TV-NAIRU model collapses into the constant NAIRU model therefore, obtaining an appropriate value for λ that can yield a time profile for NAIRU and Ugap that will be provide useful information for monetary policy design is imperative.

In the estimation of the unobserved components model specified in Eq.(1) and Eq. (2) above due the presence of nonstationary state variables, the MLE of the signal –to-noise ratio λ has a point mass of zero even when the true value exceeds zero (Gordon 1997). The various estimation issues encountered in measuring in estimating an appropriate value for overcome this problem by imposing an appropriate value for λ that yields a time-profile for NAIRU that is not over-smoothed.

Therefore some practitioners of State Space modelling fix thereby altering the signal-to-noise ratio (λ),by changing the magnitude of the non-zero elements of Q. In this paper we set f Q to be approximately 0.4. The elements of the variance-covariance matrix λ are set at a large value, 4, reflecting the uncertainty surrounding the true value of NAIRU .In imposing a value λ we follow the methodology of Laubach (1997). An alternative method of estimating the signal-to-noise ratio λ, using the median unbiased estimates of the variance (($\sigma 2\eta$) has been mooted by (Watson 1998). But this method results in wide confidence intervals for the MLE estimates of λ rendering them more unreliable than the method of imposing a value for λ.

Because inflation is always and everywhere is regarded as a monetary phenomenon, theoretically the specification of inflation in terms of changes focuses attention on the real short-run trade-offs and obviates the need to explain the role of nominal factors that come into play if inflation had been specified in level terms (Fabini and Mestre (2001)

Table 4 reports the results of the ADF and PP tests that confirm that inflation has a unit root.

Table 4 : Unit Root Tests

Test	π	p-value	CV 5%	CV 1%	Order I
ADF t-stat	-1.6542	0.0210	-1.9422	-2.5534	I(1)
	$\Delta\pi$				
ADF t-stat	-10.0747	0.0000	-1.9422	-2.5534	I(0)
Test	π	p-value	CV 5%	CV 1%	Order I
PP test	-2.5501	0.0000	-1.9422	-2.5534	I(1)
	$\Delta\pi$				
	-22.5762	0.0000	-1.9422	-2.5534	I(0)

An important stylised fact that has been observed Is the co-movement of productivity and the natural rate (NAIRU) over the sample period 1978Q3-2011Q1 for Australia, yields a high significant negative correlation (see Table 5).

Table 5

Covariance Analysis: Ordinary
Date: 10/09/12 Time: 13:57
Sample: 1978Q3 2011Q1
Included observations: 131

Correlation t-Statistic Probability	PROD	UN
PROD	1.000000 ----- -----	
UN	-0.682328 -10.60091 0.0000	1.000000 ----- -----

r = -0.68, |t| =10.60, p=0.0000

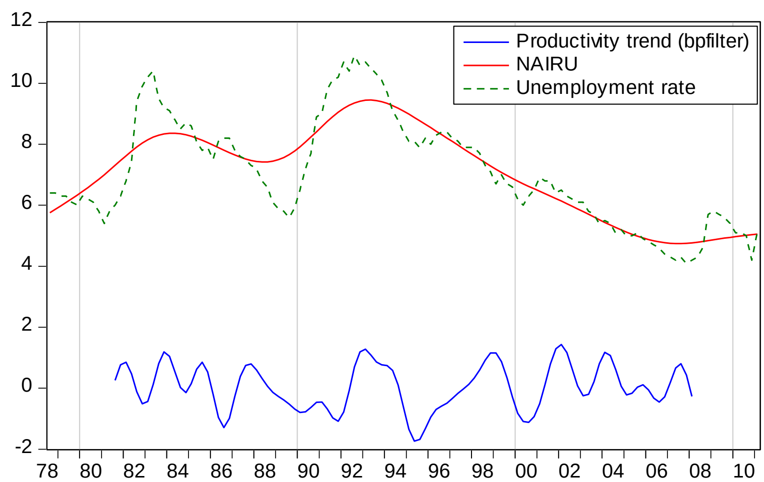

Figure 5

Table 6 : Decade-wise Averages: Productivity, NAIRU, Unemployment, Inflation & UGAP

Trend	80Q1-90Q1	90Q1-00Q1	00Q1-10Q1	10Q1-11Q1
Productivity growth	0.25	0.09	-0.02	0.14
Unemployment rate	7.27	7.28	7.86	6.78
Inflation	1.94	2.04	1.87	2.19
UGAP	-0.39	-0.37	0.05	-0.67

Productivity growth trends reported in Table 6 indicate that after recording a surge over the decade 1980s revealed dramatic slump in productivity in the 1990s decade. In the first decade of 2000 productivity turned negative and indicates a pick-up in decade 2010.

The average unemployment rate remained fairly constant in the 1980s and 1990s decade before recording a rise in the 2000 decade and then falling by more than 1% in the decade 2010. The inflation rate increased in 1990s compared to the 1980s decade.

Table 7 : Max, Min & AVG recorded over the sample period

	Max	Min	AVG
NAIRU	1993Q2 9.5	2007Q3 4.7	7.7
INFL	1993Q2 4.1	1998Q4 -0.3	1.9
UNE	1992Q3 10.9	2010Q4 4.2	7.4
PROD	1992Q3 3.2	2008Q1 -3.6	0.9

During the 1990s NAIRU peaked at 9.5% in 1993Q2 and the declined to 4.7% in 2007Q3 recording an average of 7.4% over the sample period. The unemployment rate (U) varied in sympathy with NAIRU reaching a peak of 10.9% in 1993Q2 and falling to 4.2% in 2010Q4 yielding an average rate of unemployment of 7.4% for the sample period.(See Table 7).

The reduction in NAIRU and unemployment rate failed to demonstrate the expected negative Phillips curve tradeoffs between the inflation rate and the unemployment rate. It could be conjectured that simultaneous rise in the inflation rate, the unemployment rate and the natural rate (NAIRU) lead to a breakdown of the conventional Phillips curve tradeoffs could be argued to be the result of the flattening of the Phillips curve due to impact of the productivity slowdown in the decade 2000s due to terms-of-trade effect generated by the mining boom..

iv. The Productivity Augmented TV-NAIRU Model

The Productivity Augmented TV-NAIRU model presented in the paper replaces the assumption that the NAIRU in the TV-NAIRU model is purely driven by an unobserved white noise variable as hypothesised by Staiger and Watson (1997). by the productivity growth augmented triangle model Phillips curve as conceptualised by Ball and Moffitt (2001), Slacalek (2005) and Bryson (2008).. A noteworthy feature of the Productivity Augmented TV-NAIRU model is that workers' real wage aspirations change after a lag with changes in productivity.

The effect of productivity growth on unemployment has theoretical support from the job search literature In this paper we follow Slacelek (2005) and postulate that productivity growth has two competing effects: i. The 'capitalisation effect' –where higher labour productivity growth increases the value of workers to the firm causing an increase in job vacancies leading to a fall in the unemployment rate. ii. The 'creative destruction effect' where old jobs are destroyed and replaced by new jobs due to structural change. This causes a productivity acceleration and shortens the employment duration causing the natural rate to rise. The correlation between these two productivity growth effects and the natural rate is therefore determined by the relative strength of these two effects. The empirical finding of a negative correlation between trend productivity growth and the natural rate indicates that the 'capitalisation' effect dominates the ''creative destruction' effect'.

By incorporating additional information in the form of trends in productivity growth in signal or measurement Eq. (1) the variation in the time-profile in NAIRU can be made a better policy tool to craft the appropriate stance of monetary policy by taking into account the cyclic position of the economy and the impact of exogenous shocks such as the TOT shock and productivity shocks incorporated in the vector Xt. The inclusion of additional variables in the signal equation reduces the uncertainty or unexplained variation as shown by the increase in the variance of λ or λ 2λ.

The estimation of TV-NAIRU from the triangle model of the Phillips curve augmented by productivity variables provide a more robust estimate of the long term trend or time-profile of NAIRU than the estimate of the trend using the Hordrick-Prescott (HP) filter. Since the KF provides an optimal estimator of the trend (minimum mean squared error linear estimator according to Harvey (1989).) .The degree of time-variation or the smoothness of the time profile of NAIRU is governed by the signal-to-noise ratio [illegible] and it also encounters the pile up problem encountered in the RW TV-NAIRU model. The problem can be resolved as before by imposing a reasonable value for [illegible] to derive a time-profile for NAIRU whose smoothness provides useful for policy-makers

The productivity conundrum i.e the surge in productivity while the economy was experiencing a mining boom resulting in increase mineral exports cause the TOT to sky-rocket hypothesised that that the surge in productivity in the 1990s and the slump in productivity in 2000s led to large changes in the unemployment inflation tradeoffs as hypothesised by Ball and Moffitt (2001). During a productivity surge the Phillip curve flattened yielding a favourable inflation unemployment tradeoffs and during a productivity slump the tradeoffs became unfavourable. Ball and Moffit hypothesise that productivity changes causes changes workers 'real wage aspirations after a lag..They introduced inertia into the process of real wage adjustment. Furthermore, it is assumed that wage aspirations (A) are determined not only by contemporaneous inflation and productivity but also by their past levels. Wage aspirations (A) is discounted sum of past levels of productivity growth and a weighted average of past wage increases, where weights decline exponentially. The combination of price-setting and wage-setting equations with adaptive expectations and supply shocks yield the productivity augmented Phillips curve specified below:

$$\pi_t = \beta(L)\,[\Delta\pi]_{\downarrow}(t-1) + \gamma(L)(u_{\downarrow}(t-1)\_$$

$$[u_{\downarrow}(t-1)^{\uparrow}*)]^{\uparrow}\,\delta(L)X_{\downarrow}(t-1) - f_{\downarrow}t\,(\Theta_{\downarrow})\,(t-1) - A_{\downarrow}(t-1) + \varepsilon_t(t),$$

$$u_t^{*} = nu_{t-1}^{*} + u_t,\ u_t \sim N\,(0, \sigma_u^2)/$$

The productivity augmented Phillips curve implies that inflation declines when productivity exceeds wage aspirations (θt-1-At-1). In the steady state changes in productivity are matched changes in wage aspirations i.e.(θt -= At).but in the short-run changes in productivity could exceed changes in wage aspirations (θt- > At), exerting downward pressure in inflation. We could regard movements in (θt--At) as persistent supply shocks for a given NAIRU.

A productivity surge could lead to the unemployment rate to fall below NAIRU (u <u*) causing real wage aspirations of workers' (A) to increase after a lag, unleashing inflationary pressures. Conversely a productivity slump can depress real wage aspirations (A) to increase leading to deflation requiring an antidote of expansionary monetary policies to achieve stabilisation goals. The productivity paradox associated with the productivity surge in the 1990s and productivity slump in the 2000s affected real wage aspirations. The 'real wage aspirations' produces two separate effects: The first effect, the 'capitalisation effect' that increase in labour productivity by increasing real wage aspirations increases unemployment and generates inflationary pressures. The second, a Schumpeterian type of ''creative destruction effect' truncates duration of unemployment can cause NAIRU to rise.

The information content associated with the trend growth in productivity due to an increase in real wage "aspirations'' can be dichotomised into a 'capitalisation effect' that relates labour productivity negatively to unemployment due to job creation and a Schumpeterian style 'creative destruction effect' that truncates unemployment duration causing NAIRU to rise (Slacalek 2005). A detail exposition of the modelling of how productivity changes affect workers' real wage aspirations and impinge on NAIRU and inflation is given in Endnote 7.

Endnote 7 : Productivity and Wage Aspirations

In the next section we present empirical findings related to the productivity augmented Phillips curve for Australia for the sample period 1978Q3-2011Q1.

b) *Australian Empirics from the Productivity Augmented Phillips Curve*

A decade-wise analysis of Phillips curve tradeoffs reveal the existence of negative trade-off between inflation and unemployment. In the 1990s the productivity surge was associated with a growth rate of 2.18% p.a. way above the benchmark trend productivity growth rate of 1.5% for the sample period under study. During the productivity surge decade of the 1990sinflation decreased while employment increased. These empirics lend support to the 'wage aspiration' hypothesis that contends that increase in productivity reduces inflation because employment increases after a lag due inertia or the slow adjustment of real wage aspirations to actual real wages. In the 2000s decade of the productivity slump, the short-run tradeoffs between inflation and unemployment became more unfavourable because productivity growth slumped to 1.39% per annum, below the 1.5% trend productivity growth rate. During this period the unemployment rate was higher by 1% when compared to the productivity surge period and inflationary pressures gathered momentum but inflation declined due to strong inertia in wage aspirations (see Table 11).

Table 11: Percentage change in Productivity, Unemployment and & Inflation

Decade	Productivity	Unemployment	Inflation
1980s	1.18	6.12	7.94
1990s	2.18	8.93	2.27
2000s	1.39	7.72	3.12

The reduction in the gap between the unemployment rate and inflation rate during the episode of productivity slump in 2000s compared to its increase the episode of productivity surge of the previous decade of the 1990s is depicted in Figure 7,. These findings support the contention that the productivity slump worsened the short-run Phillips curve tradeoffs in 2000s and improved during the productivity surge in the 1990s support the predictions of the wage-aspiration hypothesis See. Figure 7 for the changes in the gap between inflation rate and unemployment rate.

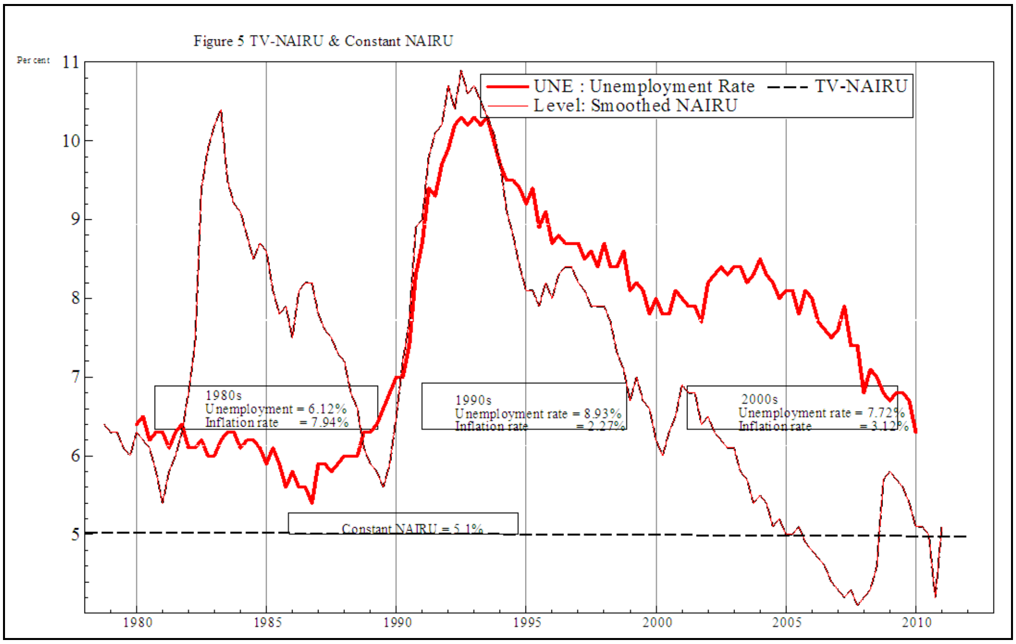

Figure 7

The recursive estimation of the 'wage aspiration' term (A) in Eq.(iii) has been obtained using as the initial value the starting value of the HP filtered trend of the real wage growth rate series. The discount parameter β is set equal to 0.95. Here we follow closely the procedures of Ball and Moffitt (2001) and derive the target level of real wage growth in Eq. (vii) and Eq.(viii). The difference (θ-A) and the smoothed HP trend are shown in Figure. 8. The negative trend implies that productivity (θ) has exceeded wage aspirations (A) during the mining boom not by much. This could be attributed to the strong inertia of wage aspirations that occurred during this productivity surge period.

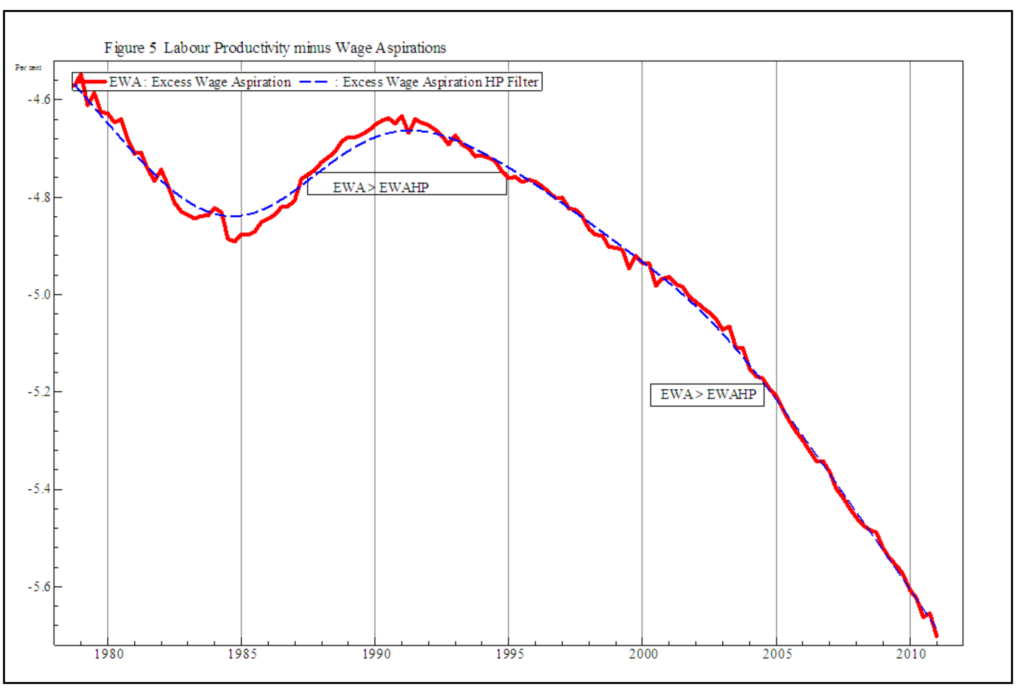

Figure 8

The empirics of the univariate and bivariate Phillips curve tradeoffs incorporating productivity and TOT shocks shed further light on the nexus between productivity ' wage aspirations' hypothesis during the mining boom. The "wage aspirations" augmented productivity shock were estimated using the KF. These estimates indicate that the unemployment gap (Ugap) was higher in the bivariate models than in the univariate models. See Table 9 below.

Table 9

Variable	Mean	Standard Deviation
Unemployment rate (u)	7.056	1.7661
NAIRU (un)	7.056	1.4679
Unemployment Gap (ugap)	9.76E-14	0.7656

Therefore the bivariate model estimated using the KF indicates that when the TV-NAIRU that follows a RW with drift the unemployment gap emerges as more robust leading indicator providing useful information for the design of the appropriate monetary policy stance to achieve internal balance. The coefficient of the unemployment gap in the bivariate model is -1.40 compared to the lower coefficient of -1.36 for the unemployment gap in the univariate model. Both models pass a battery of diagnostic tests and the bivariate model appear to give a better fit than the univariate model according to the log likelihood statistic. These empirical results confirm that the inclusion of information on the changes in "wage aspiration" effects (A) that are caused changes e productivity shocks and the exogenous TOT shocks improve the usefulness of the unemployment gap (u*-u) as a useful indicator for the designing monetary policy to achieve the inflation targeting goals in a SOE. The MLE of the state variables and the hyperparameters for the sample period under are consistent with conjectures of the wage-aspirations hypothesis. See Table 12

Table 12

Ox Professional version 6.10 (Windows/U) (C) J.A. Doornik, 1994-2010
STAMP 8.30 (C) S.J. Koopman and A.C. Harvey, 1995-2010

Univariate Model
Phillips Curve augmented with productivity & TOT shocks
OLS
UC(1) Estimation done by Maximum Likelihood (exact score)
The database used is E:\ABSDAT.in7
The selection sample is: 1978(4) - 2011(1) (T = 130, N = 1 with 1 missing)
The dependent variable Y is: DLCPI
The model is: Y = Irregular +

Log-Lik -126.55 (-2 LogL = 253.11).
Prediction error variance is 6.16417
Summary statistics

	DLCPI
T	129.00
p	4.0000
std.error	2.4828
Normality	84.224
H(42)	0.38629
DW	2.0239
r(1)	-0.023638
q	14.000
r(q)	0.12129
Q(q,q-p)	7.1827
R^2	0.54997

Cycle other parameters:

Variance	1.06253
Period	16.45934
Period in years	4.11483
Frequency	0.38174
Damping factor	0.86826
Order	1.00000

State vector analysis at period 2011(1)
Value Prob

Bivariate Model
Phillips Curve augmented
Productivity &TOT shocks with NAIRU as a RW with drift
UC(2) Estimation done by Maximum Likelihood (exact score)
The database used is E:\ABSDAT.in7
The selection sample is: 1978(4) - 2011(1) (T = 130, N = 1 with 1 missing)
The dependent variable Y is: DLCPI
The model is: Y = Trend + Irregular + Cycle 1 + Cycle 2 + Explanatory vars
Steady state...........
Log-Lik -125.506 (-2 LogL = 251.012).
Prediction error variance is 5.76514
Summary statistics

	DLCPI
T	129.00
p	6.0000
std.error	2.4011
Normality	81.732
H(41)	0.37757
DW	2.0573
r(1)	-0.033377
q	16.000
r(q)	-0.053698
Q(q,q-p)	7.7865
Rd^2	0.46190

Cycle other parameters:

Variance	1.43063
Period	20.99076
Period in years	5.24769
Frequency	0.29933
Damping factor	0.82429
Order	1.00000

State vector analysis at period 2011(1)
Value Prob

-

Cycle 1 amplitude 0.06753 [.NaN]	Level 44.21087 [0.00001]
	Slope -0.11076 [0.00000]
Regression effects in final state at time 2011(1)	Cycle 1 amplitude 0.00000 [.NaN]
	Regression effects in final state at time 2011(1)
Coeff RMSE t-value Prob	Coeff RMSE t-value Prob
UGAP_1 -1.3633 0.3717 -3.6669 [0.0003]	UGAP_1 -1.4066 0.3795 -3.7060 [0.0003]
DLTOT_1 -0.00112 0.02140 -0.05237 [0.95832]	DLTOT_1 -0.0007 0.0214 -0.03381 [0.9730]
EWA_1 -2.73238 1.13363 -2.41030 [0.01738]	EWA_1 -8.46105 1.75694 -4.81580 [0.00000]

V. Concluding Observations

Designing monetary policy to achieve goals of internal and external balance in a small open economy on the crest of mining boom is a challenging task. In the previous section we have presented three benchmark models of NAIRU that could provide useful information on time-varying NAIRU and Ugap that would guidelines designing the monetary policy stance at various stages of the business cycle. A special focus of the analysis was the effect of wage aspirations to fluctuations of productivity in response to the mining boom albeit with inertia.

The design of monetary policy in small open economy evolving through a mining boom has to confront many other complex issues than the ones focussed on in this paper.

A major issue that arises in relation to the linearity or nonlinearity (convexity) of the triangle model of the short-run Phillips curve. Empirical studies have demonstrated the Australian Phillips curve is convex and linear like US Phillips curve (Debelle and Vickery 1998)..It could be conjectured that convexity of the short-run Phillips curve is caused by AD exceeding AS resulting in the overheating of the economy because it has hit capacity constraints due to infrastructure bottlenecks and skill shortages, thereby unleashing inflationary pressures. The convexity of the Phillips curve rests on firm New Keynesian micro foundations that attributes the convexity due to phenomena such as menu costs, efficiency wages, downward rigidity of nominal wages. (Ball et al. 1988). Nonetheless, dissenters have argued that short-run Phillips curve is concave rather than convex due to the prevalence of monopolistic competition (Eisner 1996) and the effects of information asymmetries (Stiglitz 1997),

The linearity or convexity of the short-run Phillips curve offers widely differing perspectives on NAIRU has implications for NAIRU and design of monetary policy to achieve goals of stabilisation as illustrated using Figure 9. Here, PP' represents the short-run Phillips curve and NAIRU is given by u*. A comparison of points L and L' indicates that one percentage point increase in inflation results in smaller Ugap (u-u) that is smaller in size than the gap =(u2 –u)* required to reduce inflation by one percentage point. A one percentage positive inflation shock causes the natural rate of unemployment, determined by the point of intersection of the LL' –curve and the x-axis to be greater than NAIRU (u*) by α. Here, α is the difference between NAIRU and the natural rate . Larger the inflation shock, larger will be the shift of LL' to the right giving a larger α (the deviation of NAIRU from the natural rate)(Debelle and Vickery 1998).

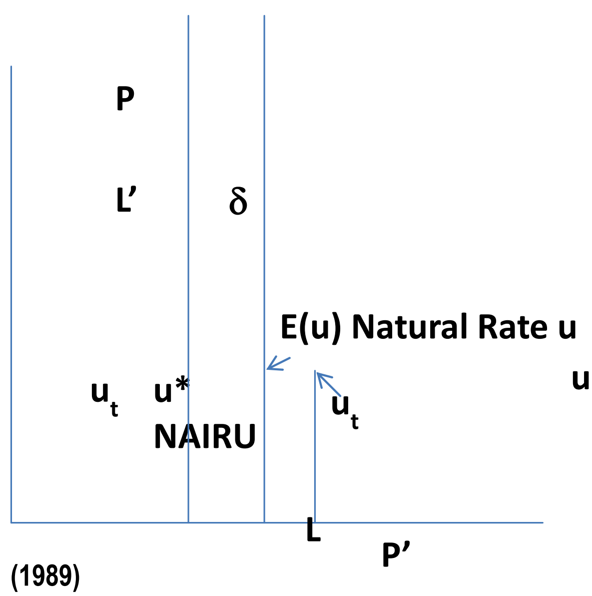

Figure 9

The convexity of the short-run Phillips curve has significant implications for the design of monetary policy. If the Phillips curve was linear then when u < u* then stance of monetary policy should be contractionary while monetary policy stance should be expansionary when u > u*. Nonlinearity requires that policymakers should overcome more complexities. If the short-run Phillips curve was convex and monetary policy is slow to respond to counter inflationary pressures arising from u < u*, then u may have to be (Kalman RE. 1960) higher than u* for longer period than had u > u*. The convexity of the short-run Phillips curve underscores the need forward looking or pre-emptive monetary policy to counter inflationary pressures that could result in costly recessions down the track. Convexity also requires that deep recessions should be avoided as they are costly. Therefore, rather than the 'cold turkey' approach to disinflation favoured by (Ball 1994). a gradualist approach would be less costly and preferable. Notwithstanding, the eventual success of monetary policy in achieving the goals of stabilisation will depend on the credibility of actions of the central bank or policymakers.

Therefore, the locus of TV-NAIRU and the size of Ugap required to achieve the monetary policy stabilisation goals such as inflation targeting will crucially depend on issues of endogenous policy credibility which have not been analysed in this paper. In order to achieve the goals of inflation targeting many central bankers either overtly or covertly draw guidelines from simply policy reaction functions in the shape of the Taylor rule.

The Taylor rule prescribes that the policy instrument (the overnight cash rate or short term interest rate) should be adjusted in response to either deviations of output from potential (the output gap) and/or the deviation of the observed inflation rate from the target rate in order to keep inflation within the prescribed target zone (Taylor 1993).. Recent research indicates that Taylor rule can be outperformed by inflation forecast based (IFB) rules which adjust the policy instrument of short-term interest rate in response to the output gap and deviation of the inflation rate from an inflation forecast, rather than the inflation target. Such inflation forecast rules have a crucial hallmark of inducing authorities to set the short-term interest rate/overnight cash rate on the basis of future inflation forecasts and are referred to inflation forecast based (IFB) rules rather than inflation target rules as subsumed in the Taylor rule, Inflation forecast based (IFB) rules. This paper does not explore how policy rules perform in models with endogenous policy credibility, NAIRU uncertainty and the convexity of the Phillips curve. Policymakers and central bankers are fully cognizant of the need to take account of the features referred to in designing robust monetary policy reaction functions that take account of endogenous credibility because at least theoretically they predict they outperform simple rules that gloss over such information (Laxton and Eliasson 2001). The task of designing robust monetary policies to cope with inflationary pressures in a small open economy in the throes of mining boom bristle with complex challenges as adumbrated in the concluding observations. The paper's main contribution is confined to shedding light on the designing of plausible stance for monetary policy to prevent the productivity gyrations emanating from a mining boom from turning into a resource curse.

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Abbreviations

Abbreviations	
ABS	Australian Bureau of Statistics
ACF	Autocorrelation Function
ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
AWE	Average Weekly Earnings
BIC	Bayes' Information Criterion
CAP	Capital Services
DUP	Directly Unproductive Activity
EMP	Employment
Chindia	China India
GDP	Gross Domestic Product
GF	Gordon Filter
GLS	Generalized Least Squares
GNI	Gross National Income
HET	Heteroscedasticity
HP	Hordrick -Prescott Filter
KF	Kalman Filter
LJ-Box	Ljung -Box Statistic
LLH	Log Likelihood
LLM	Local Level Model
LTM	Local Trend Model
MLE	Maximum Likelihood Estimates
NAIRU	Non Accelerating Inflation Rate of Unemployment
NID	Normal Independent Distribution
NORM	Normal Distribution
OLS	Ordinary Least Squares
PROD	Labour Productivity
PP	Phillips Perron
RBA	Reserve Bank of Australia
RW	Random Walk
SCI	Structural Change Index
SOE	Small Open Economy
SSF	State Space Form
STM	Structural Time Series Models
TFP	Total Factor Productivity
TOT	Terms of Trade
TV	Time-Varying
Ugap	Unemployment Gap
UNE	Unemployment Rate
US	United States

Figures

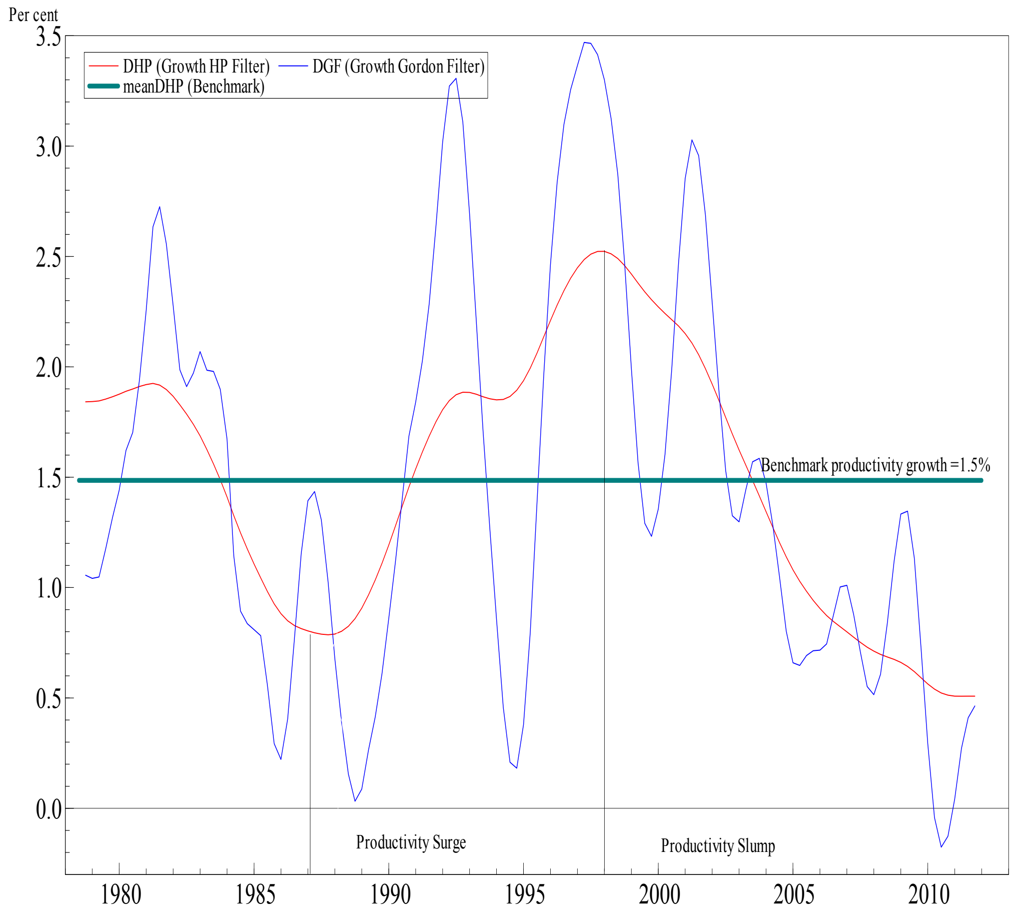

Figure 1 : Trends in Producting Growth – The Produtivity

Notes: The HP Filter (Hordrick and Prescott 1997) assumes that the time seriesf yt = log of labour productivity can be deccomposed into a trend and cyclical component. By minimizing the loss function L: over the sample size S: yielding the deviation of productivity

$$L = \sum_{t=1}^{S} (y_t - y_t^*)^2 + \lambda \sum_{t=2}^{S-1} (\Delta y_t^* - \Delta y_{t-1}^{*T})^2$$

From its trend in the first term and the variability of the trend in the second term. The relative weight assigned to the two terms is given by the smoothness parameter . The smoothness of the trend increases with the magnitude of . For a quarterly time-series is assumed that =1600 in deriving the HP filter. Gordon (2003) in the Gordon filter (GF) assumes that =32.

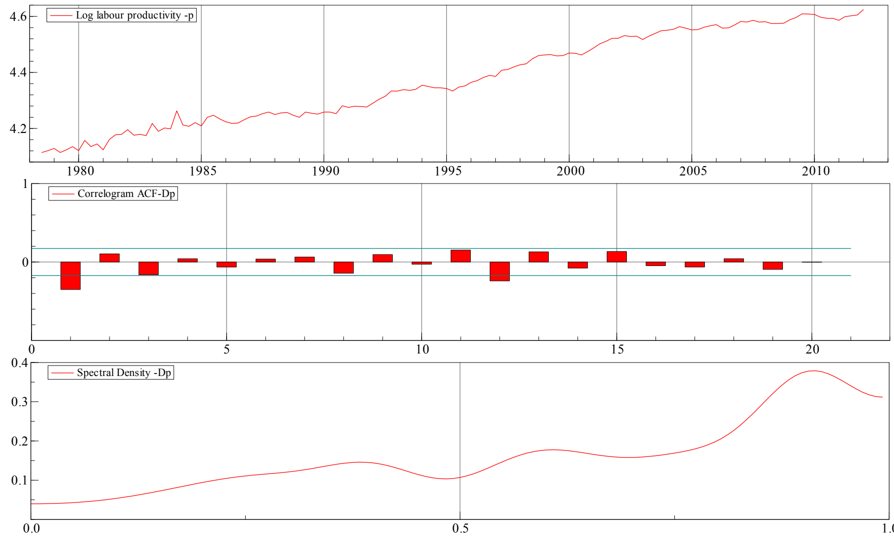

Figure 2 : Trend of Log Labour Productivity , Correlogram and Power Spectrum of Dp

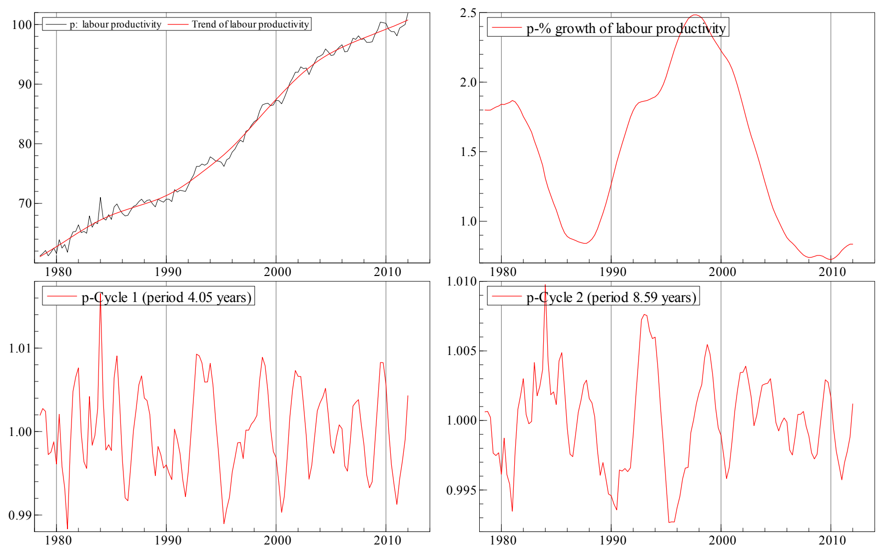

Figure 3 : Unobserved Components of Labour

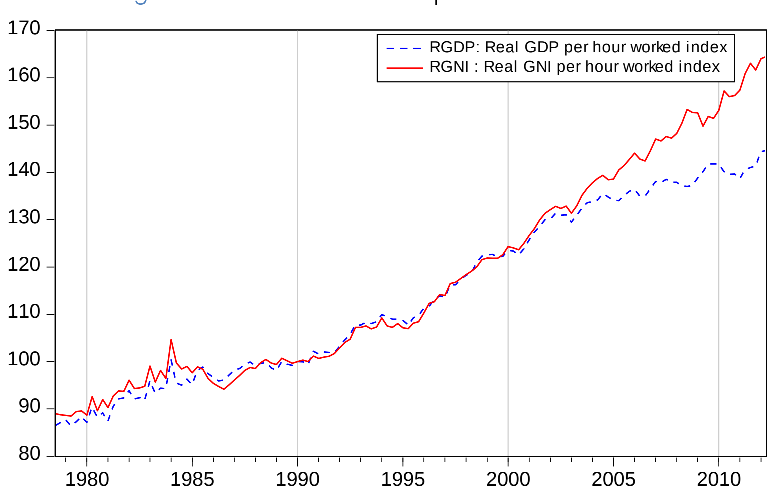

Figure 4 : Indexes of Real GDP and Real GNI per hour worked.

Source: RBA & ABS

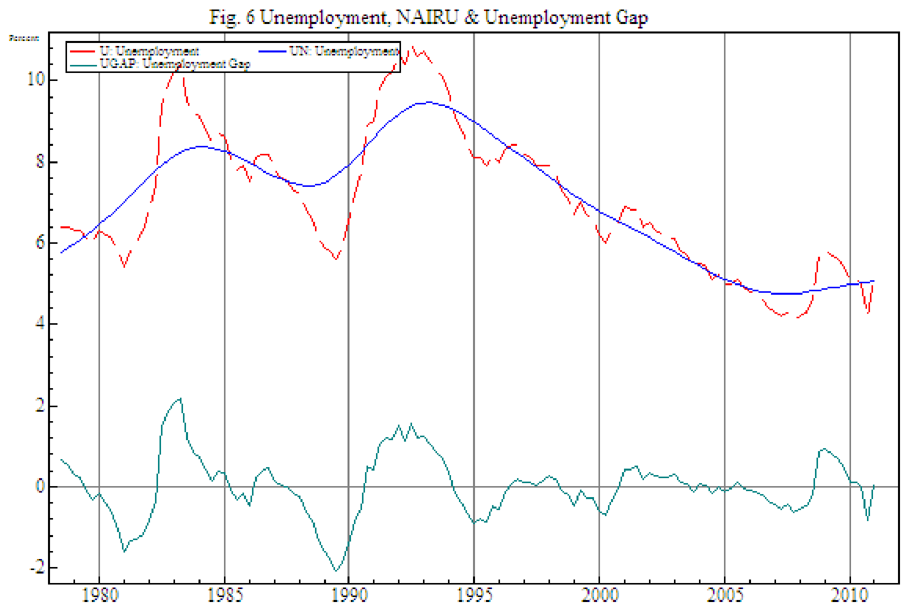

Figure 6 : Unemployment,

Tables

Table 10 : Empirics of the 'triangle ' Phillips Curve model'

Sspace: MIGUEL
Method: Maximum likelihood (Marquardt)
Date: 10/03/12 Time: 18:05
Sample: 1978Q3 2011Q1
Included observations: 131
Partial observations: 3
Convergence achieved after 104 iterations
WARNING: Singular covariance - coefficients are not unique

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	-9.192368	NA	NA	NA
C(2)	1.513653	NA	NA	NA
C(3)	0.921892	NA	NA	NA
C(4)	-1.365266	NA	NA	NA
C(6)	-36.83538	NA	NA	NA
C(8)	0.996537	NA	NA	NA
C(9)	0.992828	NA	NA	NA

	Final State	Root MSE	z-Statistic	Prob.
UGAP	-0.784987	0.632456	-1.241173	0.2145
UN	5.845487	0.447214	13.07091	0.0000

Log likelihood	-265.9055	Akaike info criterion	4.166496
Parameters	7	Schwarz criterion	4.320132
Diffuse priors	0	Hannan-Quinn criterion.	4.228925