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Path Dependence, Place Dependence, and the Evolution of a Patchwork Economy: Evidence from Western Australia, 1981-2008*

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Abstract:

This paper contributes to debates about that application and relevance of evolutionary concepts in the analysis of regional economies. In particular, we address the proposition that geography and history matter in shaping regional economic development by drawing on the concepts and methodology of dynamic econometrics, offering an analysis of Western Australia, 1981-2008. More specifically we test for path and place dependence using data on incomes per capita for regions within the State. The results provide evidence of both path and place dependence, although indicate that there is a degree of heterogeneity in how places are evolving and responding to shocks.

I EVOLVING DISCOURSES OF REGIONAL ECONOMIC GROWTH

Over the past decade, we have witnessed an emerging discourse within economic geography that is grounded in the use evolutionary concepts to account for the dynamics of capitalist space economies (BOSCHMA and MARTIN, 2007; MACKINNON, 2011; MACKINNON *et al.*, 2009). Indeed, evolutionary economic geography is fast becoming a major contributor to debates within both economic geography 'proper', and the New Economic Geography, or geographical economics, in explaining the changing spatial distribution of economic activities (MARTIN and SUNLEY, 1998; FINGLETON, 2001; GARRETSEN and MARTIN, 2010). Conceptual and methodological differences notwithstanding, all of these perspectives seem to agree that both history and geography matter when accounting for the changes in capitalist space economies. For economic geography proper, claims regarding historical and geographical contingency tend to be grounded in intensive case study research and local models, drawing largely on qualitative methodologies (BARNES, 1996). In contrast, geographical economists draw on formal econometric modeling to justify claims about tendencies for local economies to either converge over time or display persistent geographical inequalities (FINGLETON, 2003; DURLAUF *et al.*, 2009). To date, however, engagement between evolutionary economic geography and other perspectives has been largely conducted at a conceptual and methodological level, with relatively less attention directed towards attempts to evaluate the empirical validity of competing explanatory claims.

The purpose of this paper is to contribute to the emerging discourse around evolutionary economic geography by developing empirical models that move beyond discourse and narrative in evolutionary 'thinking' towards empirical testing in the context of a 'peripheral' resource dependent and export oriented economy: Western Australia, 1984-2008. This is a period in which Australia increasingly engaged with the processes of globalization and neoliberalism, encompassing the economic restructuring of the 1980s and 1990s, the resource boom of the early-to-mid 2000s, and the immediate impacts of the global financial crisis (FAGAN and WEBBER, 1994; O'CONNOR *et al*., 2001; O'NEILL and FAGAN, 2006). More recently, there has been an increase in both popular and political discourse on issues surrounding the problem of regional dynamics and spatial inequality, the emergence of a 'two speed' economy and the concomitant place dependence associated with a persistent and in some cases worsening uneven development (CLEARY, 2011). Indeed, one of the central issues concerning policymakers in Australia is the emergence of a 'patchwork economy' in which some regions are profiting from the nation's recent mining boom, while others are being left behind (GILLARD, 2011).

In this paper, we explore the potentials and limitations of employing the theoretical architecture of dynamic econometrics to detect evidence of path dependence and place dependence in the regional economies constituting the Western Australian economy. Assuming that is it both possible and fruitful to use time series concepts to detect path dependence in regional economies, we can then employ those models to gain some insights into the relevance of evolutionary economic geography for understanding the dynamics of regional economies. Here, our empirical modeling is intended to provide evidence regarding the contemporary historical trajectory and geography of development Western Australia, as conceptualized in terms of both path dependence and place dependence. We would emphasise at the outset that the objective of the paper is not necessarily to offer an explanation for the nature of development, but to operationalise and test for path and place dependence. In section II we operationalize the evolutionary concepts of path dependence and place dependence in the context of some relatively simple empirical dynamic econometric models. In section III we bring these models to bear on the evidence from the recent history of the Western Australian economy to test for the presence of both path dependence and place dependence. This section draws on income per capital data provided by the Australian Taxation Office for the period 1981-2008. Finally, in section IV we reflect on potentials and limitations of our empirical modeling for the ways in which we think about evolutionary 'thinking' and the evolution of the 'patchwork economy' across Western Australia.

II EMPIRICAL MODELLING OF EVOLUTIONARY DYNAMICS: PATH DEPENDENCE, PLACE DEPENDENCE, AND 'SHIFTING' EQUILIBRIA

Recent interest in evolutionary thinking draws on an array of perspectives encompassing Generalized Darwinism (ESSLETZBICHER and RIGBY, 2007), complexity thinking (PLUMMER, 2003), and adaptive systems theory (BOSCHMA and MARTIN, 2010; BOSCHMA and MARTIN, 2007). Situated within this broader discourse, evolutionary economic geography draws on a rich suite of theoretical constructs to understand the dynamics of regional growth and change, including 'persistence', 'lock-in', 'historical contingency', 'path dependence', 'hysteresis', 'sustainability', and 'resilience' (TONTS *et al.*, 2012; SIMMIE and MARTIN, 2010). Rather than try to unpack the complex set of ideas that constitute evolutionary economic geography, in this paper we focus on operationalizing the concept of 'path dependence', which, for some, is seen as the key concept through which to understand evolutionary dynamics (MARTIN & SUNLEY, 2006; MARTIN, 2010).

In the recent literature it is typical to identify evolutionary dynamics as processes operating in historical rather than logical time (ROBINSON, 1979; KALDOR, 1985; SETTERFIELD, 1995). More specifically, the evolutionary dynamics of regional economies have been grounded in a discourse characterized by irreversible non-ergodic processes in which future outcomes depend on past events and outcomes (e.g. DAVID, 2005). Using the critical realist distinction between open and closed systems, MARTIN and SUNLEY (2010) have developed a useful heuristic framework to distinguish between evolutionary and equilibrium 'thinking' (SAYER, 1999; LAWSON, 1997). Equilibrium 'thinking' is associated with a closed systems ontology in which disequilibrium is characterized by an observed trajectory that converges to pre-determined (*ex ante*) equilibria. If the out-of-equilibrium adjustment is globally stable then the system converges to either a deterministic point or a stochastic limiting distribution. However, if the adjustment process is only locally stable then there exist multiple equilibra towards which the process can converge: depending on set initial conditions and the values of key parameters the system may become locked into one of these equilibria (DAVID, 2005; GARRETSEN *et al.*, 2010; BRACKMAN, 2009). In contrast, evolutionary 'thinking' is associated with an open systems ontology in which there is no pre-determined equilibrium towards which a system is converging. Rather, out-of-equilibrium processes are characterized by unfolding trajectories, path dependent processes that are capable of creating their own landscapes, endogenous tendencies to deviate from equilibrium, and coevolution with equilibrium landscapes, at best, an emergent property of the system (PLUMMER and SHEPPARD, 2006).

Despite the broad scope of evolutionary thinking, the majority of theoretical discourse has focused on constructing ideal type explanations that focus on tracking the trajectories of firms, economic sectors and regional economies (BOSCHMA and MARTIN, 2010). Such empirical modeling that does exist has focused on explicating the nature of path dependence and 'lock-in' by charting the history of a single variable using turn-based processes (PAGE, 2006; SETTERFIELD, 1997). Set against this backdrop, we initially confine our empirical analysis to modeling path dependence as a univariate process, modeling trajectories of income per capita for regional economies that are embedded within a regional economic system. However, we also move beyond the univariate context by considering the significance of place dependence in terms the performance of local economies relative to average performance across a regional economy. Conceptually, this extension allows us to explore the potential for the existence of common trends between different path dependent processes operating between regional economies within the same economic system. Whilst this involves drawing on a suite of concepts that are compatible with equilibrium oriented modeling, we argue that such equilibrium-based approaches remain within the spirit of evolutionary thinking.

Following convention in time series econometrics, we define evolutionary dynamics in terms of the structure of probabilistic dependence of a data generation process (DGP), the features of which we are attempting to capture with an empirical model (HENDRY, 2009). Define a (univariate) data generation process for regional income per capita at time t (y_t) which depends on the previous history of y_t, t = 0, ……., t-1 and a series of random shocks ε_t drawn from a normal distribution. Since both the history of the process (f^j) and the variability of the random shocks (σ_t^2) are defined as time varying parameters, the data generation process is assumed to be non-constant. In this instance, non-constant properties of the data generation process are equivalent to time dependent properties of the probability distribution, which we define here as a path dependent process (PAGE, 2006; KATZNER, 1993):

$$y_t = \sum_{j=0}^{j=t-1} f^j\left(y_j\right) + \varepsilon_t \qquad \varepsilon_t \sim N(0, \sigma_t^2) \tag{1}$$

where the series of random shocks to the system, ε_t, are a normally distributed random variable with mean zero $E(\varepsilon_t) = 0$, constant variance $E(\varepsilon_t^2) = \sigma^2$, and serial independence $E(\varepsilon_t \varepsilon_{t-1}) = 0$.

In general, this model specification can be non-linear, displaying observed trajectories that are sensitive to both initial conditions and parameter values (GRANGER and TERASVIRTA, 1993; TONG, 1990). Here, we limit ourselves to a exploring the potentials for capturing evolutionary dynamics within a linear conceptualization of the geographical world. Whilst not capturing the array of out-of-equilibrium scenarios that are possible in non-linear systems, even relatively simple linear systems can generate the types of path dependency that are consistent with open ended evolutionary 'thinking'. To illustrate this argument, consider a reduction of equation (1) to simple second order linear model of the data generation process in which there exists a non-stationary date generation process due to a location 'shift' parameter ($\beta_0^t = \beta_1 + \beta_4 I_{(t)}$) that varies over time (HENDRY and MIZON, 2010; CASTLE *et al.*, 2010):

$$y_t = \beta_1 + \beta_2 y_{t-1} + \beta_3 y_{t-2} + \beta_4 I_{(t)} + \varepsilon_t \qquad \varepsilon_t \sim N(0, \sigma^2) \qquad (2)$$

where β_1 contains regionally specific deterministic components (constant, trend), β_2 is a locally specific adjustment parameter, which determines the persistence of the data generation process, and $I_{i(t)}$ is in indicator variable representing a location shift, or structural break. The location shift parameter β_4 is estimated recursively as the history of the process unfolds. The possibility of structural breaks in the history of the data generation process means that the long-run equilibrium expected value is potentially time dependent:

$$E(y_t) = \frac{\beta_1 + \beta_{4(t)}}{1 - \beta_2 - \beta_3}$$

Clearly, this argument about the historical contingence of structural breaks is generalizable to all the parameters defining the adjustment process in equation (1). It is important to note that whilst non-stationarity in the data generation process due to structural breaks can be detected empirically *ex post* such breaks are not predicted *ex ante* on the basis of information available prior to a structural break. As a corollary, whilst the adjustment path of equation (1) is with respect to equilibrium, such equilibria are not predetermined. Rather, equilibria shift in response to historically contingent changes in parameters. Such parameter changes can be the result of either exogenous changes in the system being modeled or the operation "deep" endogeneity; the result of changes in the state variables in the system driving parameter changes (WILSON and BENNETT, 1985; SETTERFIELD, 1995, 1998).

Another source of path dependence in the simple linear model specification is non-stationarity due to the presence of a stochastic trend process, conventionally referred to as a unit root process (HARVEY, 1993). Reparameterizing equation (2) in terms of first differences:

$$\Delta y_t = \alpha_1 + \alpha_2 y_{t-1} + \alpha_3 \Delta y_{t-1} + \alpha_4 I_{(t)} + \varepsilon_t \qquad \varepsilon_t \sim N(0, \sigma^2) \qquad (3)$$

where, $\alpha_1 = \beta_1$, $\alpha_2 = \beta_2 + \beta_3 - 1$, $\alpha_3 = -\beta_3$, and $\alpha_4 = \beta_4$. As is well known, if $|\alpha_2| < 0$ then the dynamic adjustment with respect to equilibrium is path independent and the data generation process converges to a stable limiting equilibrium distribution. However, if $|\alpha_2|$=0 then the data generation process is a path dependent stochastic trend process (unit root) which displays persistence over time, with no tendency to revert to equilibrium following random shocks to the system. Rather, the dynamics of this system are path dependence in the sense that the observed trajectory depends on both the initial conditions of the system and the accumulation of shocks that the system experiences over the history of the process. This linear model specification is limited in the sense that it is capable of capturing the dynamics of what has been referred to phat dependent processes rather than 'true' path dependence, being determined by the set of random shocks rather than the sequence of ordering of those shocks (PAGE, 2006; MARTIN and SUNLEY, 2006). If $|\alpha_2|$>0 then the process is explosively unstable. Typically, in the literature, this is a scenario considered to be either economically not-meaningful and/or unsustainable. Finally, the first difference adjustment parameter is intended to capture hysteresis processes $\alpha_3 = -\beta_3$ in the sense that equilibrium is contingent upon the disequilibrium trajectory of the data generation process (KATZNER, 1993, BLANCHARD and KATZ, 1992; SETTERFIELD, 1998).

If this model specification is sufficient to capture the process generating the data, and the assumptions underpinning the white noise process are met, then the model is defined as congruent with the data (HENDRY, 1995). Conventionally, it is possible to test for congruence using a conventional battery of mis-specification tests (HENDRY and NIELSON, 2007). Under these conditions, it is possible to test for the presence of path dependence due to structural breaks, hysteresis, and stochastic trends as restrictions on the general model specification. Specifically, the null hypothesis of path dependence due to stochastic trends $(\alpha_2 = 0)$ can be tested against the alternative of path independence $(\alpha_2 < 0)$, conditional on the presence of structural breaks and/or hysteresis. Similarly, imposing the linear restriction $\alpha_3 = 0$ is a test for the presence of hysteresis conditional on the presence of a unit root process and/or structural breaks. Finally, structural breaks can be tested using recursive, rolling and or sequential methods (BANERJEE *et al.*, 1993).

Moving beyond the (univariate) context of path dependence in the evolution of regional economies it is possible to explore the notion of place dependence by modeling relationship between individual regional economies and all of those regional economies that are considered to constitute a regional economic system. This involves decomposing the variability in local income into local components and common trends across the regional economic system. Following BRECHLING (1967) and THIRLWALL (1966), here we choose to model the dynamics of regional economies in terms of the responsiveness of regional income per capita to the average income per capita across the regional economic systems. While income per capita are not a perfect measure of economic performance, in this context they provide a reliable annual time-series over a period long enough to enable to detection of path and place dependence. Modeling the evolution of a regional economy relative to a measure of the overall history of performance across a regional economic system can be considered as analogous to modeling population dynamics using the types of replicator dynamics that are typically employed in evolutionary game theory, where the evolution of a particular 'trait' or 'agent' depends on the 'fitness' of that 'trait' or agent relative to some measure of overall fitness across the agents operating in the system (Plummer *et al.*, 2012, Binmore, 2007; Gintis, 2009). Here, we condition our model of path dependence (equation (1)) on average income dynamics and incorporate the possibility of structural breaks in the path of regional economies:

$$y_t = \theta_1 + \theta_2 I_{(t)} + \theta_3 y_{t-1} + \theta_4 y_{t-2} + \theta_5 \bar{y}_t + \theta_6 \bar{y}_{t-1} + \theta_7 \bar{y}_{t-2} + \varepsilon_t \qquad (4)$$

where $\bar{y}_t$ is average income across the regional economic system at time t, θ_1 contains the deterministic components of income change, θ_2 is the responsiveness of income to a structural break at t, θ_5 is the contemporaneous impact of average income on local income, and θ_3, θ_4 and θ_6, θ_7 are the first and second order lagged responses to regional income and average income respectively. According to the Granger Representation Theorem, if regional income and average income are stochastic trend processes integrated of the same order and there exists a stationary linear combination of these path dependent processes, then the processes are cointegrated and there exists a long run equilibrium (Engle and Granger, 1987, 1991). At equilibrium,

$$E(y^*) = \frac{\theta_1 + \theta_2 I_{(t)}}{(1 - \theta_3 - \theta_4)} + \frac{(\theta_5 + \theta_6 + \theta_7)}{(1 - \theta_3 - \theta_4)} \bar{y}^*$$

or equivalently,

$$E(y^*) = \delta_1 + \delta_2 \bar{y}^*$$

where the elasticity of regional to average income, δ_2, is the cointegration parameter. In addition, the location of long run equilibrium, δ_2, is contingent upon the existence of possible structural breaks that occur in the history of the disequilibrium adjustment process, which may result from the co-breaking of individual path dependent processes (HENDRY and MASSMAN, 2007). To provide an interpretation in which the analogue with evolutionary dynamics is more apparent, equation (4) can be re-parameterized as an error correction, which makes explicit the role of both disequilibrium dynamics and long-run equilibrium in accounting for the observed trajectory of regional income in response to exogenous shocks:

$$\Delta y_t = \theta_5 \Delta \bar{y}_t + \gamma[y_{t-1} - \delta_1 - \delta_2 \bar{y}_{t-1}] - \theta_4 \Delta y_{t-1} - \theta_7 \Delta \bar{y}_{t-1} + \varepsilon_t \qquad (5)$$

where, $\gamma = (\theta_3 + \theta_4 - 1)$ is the speed of adjustment, or responsiveness, of regional income to deviations from the long run relationship between regional and average income levels, which define the equilibrium correction mechanism (ECM).

Assuming that the sign on the speed of adjustment parameter is negative (positive), then if the ECM is positive (negative) this will result in a decrease (increase) in regional income. In so far as regional income does not react immediately to changes in average income, the ECM represents an adaptive adjustment process similar to those found in in evolutionary population modeling. In the case of linear systems, the difference is that the ECM is negative feedback mechanism, restoring equilibrium, whereas in evolutionary models selection is typically a positive feedback, selecting for the fitter traits or agents. Furthermore, in a cointegrated system such as equation (5), the long run equilibrium is a moving equilibrium concept rather than predetermined equilibrium. At any moment in time, equilibrium depends on the cointegration parameter, the initial conditions of both regional and average income and the set of random shocks impacting on the history of each variable. Finally, in our model specification the cointegration relationship and, hence, the location of long-run equilibrium can change as the result of unanticipated structural shifts that emerge during the history of the adjustment process. Accordingly, there is no predetermined equilibrium towards which a system is evolving and this notion of equilibrium employed in the ECM is compatible with evolutionary 'thinking'.

III THE EVOLUTION OF A PATCHWORK ECONOMY: EVIDENCE FROM WESTERN AUSTRALIA, 1981-2008

One of the defining characteristics of the Western Australian economy is its relative geographical isolation. While there are clearly legal/regulatory and macro-economic ties with the rest of Australia, its economic structure and high level of export dependence make it quite distinctive. This isolation means that the State's labor market can be viewed as part of an internally coherent economy. While much of the recent economic success of Western Australia has been driven by the rapid expansion of the minerals and petroleum sector, agriculture and, to a lesser extent, services play a key role in shaping the dynamics and structure of regional labor markets across the State (CLEMENTS and JOHNSON, 2000; LAWSON and DWYER, 2002; KENNEWELL and SHAW 2008). The recent performance of the Western Australian economy is telling, with A$121 billion in export earnings in 2011, of which the minerals and energy sector contributed A$111 billion (DEPARTMENT OF STATE DEVELOPMENT, 2012). Major export sectors included iron ore (A$62 billion), oil and natural gas (A$20 billion), gold (A$16 billion) and agriculture (A$10 billion). All of these industries are highly capital intensive and located in non-metropolitan, and often highly remote, regions. The primary function of the Perth metropolitan area is to act as a service, logistics and political hub (KENNEWELL and SHAW 2008). This uneven distribution of economic activity (and population) is highly suggestive of a 'patchwork economy'. Indeed, while the Western Australian economy grew at an average of 4.5 per cent between the early 1990s and 2009 (BATTELLINO, 2010) growth rates are highly variable and volatile across the regional economies within the State (HASLAM-MCKENZIE and TONTS, 2005).

In this paper, the State has been regionalized into 13 functional labor markets using the classification criteria originally employed by the Australian Office of Local Government (OLG) (1988) (see Figure 1). While any regionalization of local labor markets should not employed uncritically, especially in the context of highly mobile workers and fluid employment structures (PECK, 1989), this notion of local labor market does provide a comparatively meaningful set of regions with which to explore the nature and degree of spatial inequality. Typically, a functional labor market can be defined in terms of both the supply and demand conditions prevailing in a local area or region, including labor mobility within and between local labor markets (MITCHELL and WATTS, 2010). The OLG regionalization employed in this paper adopted a nodal structure in which regions were organized around metropolitan or non-metropolitan regions of 10,000 people or more, although a small number of towns with smaller populations were used. Local government areas formed the building blocks of the regional structure, which also took account of economic structure, remoteness and transport linkages.

[Insert Figure 1 about here]

Figure 2 and Figure 3 show the evolution of income per capita across the Western Australian regional economy over the period 1981-2008. This draws on annual income per capita data provided by the Australian Taxation Office for the time period under analysis. Figure 2 displays the overall trend over this period, with a high degree of synchronicity between local labor markets. Whilst income per capita appears to have been stable from the beginning of the 1980s until the mid-1990s, subsequently there has been a rapid increase in income across all labor markets. This is confirmed in Figure 3, which shows that growth rates appear to have been relatively stationary up until the mid-1990s after which there is an increasing trend in growth rate across local labor markets. Within this overall pattern of accelerated growth in income there is evidence of cyclical variations in all labor markets. These cycles appear to have been more volatile during the 1980s with 1990-1991 witnessing a rapid decline, especially in the Lower Great Southern, Northern Wheatbelt and Southern Wheatbelt.

Disregarding the structure of local dynamics over this period, Table 1 summarizes the overall pattern of income level and income growth. The highest incomes were in Central Perth, Pilbara-Kimberley, and Goldfields, which are those localities most closely tied into the resources sector. In contrast, the lowest incomes were to be found in the non-metropolitan labor markets of South West, Northern Wheatbelt, Southern Wheatbelt, and Lower Great Southern, which were labor markets tied mainly to agriculture. In addition, over this period, the fastest growing economies were those of the Perth metropolitan region and the Goldfields, with the lowest being in the non-metropolitan labor markets of Lower Great Southern, Northern Wheatbelt and Southern Wheatbelt. In addition, a simple Pearson's correlation coefficient of 0.66 [p=0.013] indicates that there is a significant positive relationship between income level and income growth. Taken together, these patterns are suggestive of the existence of a 'patchwork economy', with a high degree of variability in performance across regions. However, as is well known, such summaries can be misleading, producing spurious correlations amongst variables that have stochastic trends. Put differently, we should be skeptical of 'stylized facts' derived from path dependent processes that need unpacking within a more rigorous conceptual and statistical framework, which is provided in this context by evolutionary economic geography.

Table 2 summarizes the results from testing for path dependence in each local labor markets using equation (3). These models are estimated using ordinary least squares, which has been shown to be a consistent estimator of the parameters in this model specification (HENDRY and NIELSEN, 2007). All statistical tests are conducted at the 5% significance level. In this model specification α_0 is a constant whilst α_1 is a deterministic trend. Conditional on the other variables in the model, a constant growth rate is only significance in the Goldfields and the Northern Wheatbelt. In contrast, there is evidence of an increasing deterministic trend in income growth across all local labor markets. Other things being equal, this suggests that incomes return to their long run growth path in response to exogenous shocks. However, other things are not equal. Using the conventional Dickey-Fuller test, all localities fail to reject the null hypothesis of a unit root in the data generation process, suggesting path dependence. The simultaneous presence of deterministic and stochastic trends is indicative of a data generation process characterized by a stochastic trend with drift, displaying persistent disequilibrium dynamics in response to exogenous shocks, with no long run tendency to return to an increasing equilibrium growth path.

Testing for the existence of a stochastic trend is equivalent to testing for the presence of a random walk in equation (3). This can be tested as a zero restriction on the α_2 parameter. The existence of path dependence in the history of income growth across the local labor markets of Western Australia is largely confirmed by the test for a random walk process. There is no evidence in the sample to reject a random walk for all local labor markets, with the exception of Goldfields, Mid West, Northern Wheatbelt, and Southern Wheatbelt. Furthermore, testing for the significance using a zero restriction on α_3, there is no evidence of hysteresis, other than in the Goldfields. Whilst these results might suggest that some local labor markets do not have path dependent processes, these results should be treated with caution. As is well known, t distributions tend to over-reject the null hypotheses of a unit root and the Dickey-Fuller results are more reliable test for the presence of non-stationary processes (HENDRY and NEILSEN, 2007). Accordingly, as defined in this paper, we conclude that there is evidence of path dependence in the evolution of income for all local labor markets constituting the Western Australian regional economy. Nonetheless, there is some evidence that might indicate that over this period something different is occurring in a small number of non-metropolitan labor markets. The common pattern in three of these regions, Mid West, Northern Wheatbelt and Southern Wheatbelt is the high degree of dependence on agriculture, which has, in relative terms, become gradually less important in terms of its overall contribution to economic growth (Davies and Tonts, 2010). In the case of the Goldfields, the demise of gold's status as a currency reserve in the late 1980s and through the 1990s, and then its resurgence as a financial 'safe haven' following the September 11 terrorist attacks in 2011 might explain the trajectory of that particular region.

In terms of path dependence resulting from location shifts in the data generation process, there is evidence of structural breaks covering the late-1980s and early 1990's in the metropolitan Perth local labor markets, excluding Central Perth (South West Metro, South East Metro, North Metro, East Metro). In addition, there is evidence that the South West and Goldfields experienced exceptionally large declines in their growth rates in 1989 and 1988 respectively. Although the tests for parameter constancy indicate location shifts in the data generation process they do not identify the sources of this potential parameter instability. This warrants further research, however we would speculate that in the case of the Goldfields a drop of more than 20 per cent in the international gold price between 1987 and 1989 (in the wake of the 1987 stock market crash), together with a contraction in nickel operations, contributed to declines in growth rates (TONTS and DAVIES, 2009).

Similarly, in the South West fall-out from the 1987 crash led to a downturn in the region's alumina industry. In the case of Perth, this period was characterized by a decline in the city's (albeit small) manufacturing industry and services sector – both of which are closely tied to the resource economy.

There are a number of mis-specification issues that warrant further consideration. There is evidence of incorrect functional form for Western Australia and East Metro. In addition, there is evidence of unconditional heteroscedasticity in Peel, Central Perth, and Pilbara-Kimberly. Diagnostic testing rejecting the null hypothesis of correct specification do not suggest alternatives. This raises the possibility of, amongst other things, time dependence in the variance of the data generation process (σ_t^2) (McAleer, 1994). Finally, the non-normality in Lower Great Southern is due to an exceptionally large decline in income in 1991.

Table 3 compares the ADL model dynamics and long-run equilibrium analysis. All statistical tests are conducted at the 5% significance level. Firstly, in addition to the existence of a long run equilibrium relationship between local and Western Australian income levels, there is evidence that disequilibrium dynamics are significant in all localities, with the exceptions of East Metro and Lower Great Southern. Second, the significance of the deterministic components varies between local labor markets. Other things being equal, a constant local growth rate is only significant in Lower Great Southern, Goldfields and Mid-West while there is a positive deterministic trend in Central Perth and Goldfields and a negative deterministic trend in North Metro, Lower Great Southern, Pilbara-Kimberly and Southern Wheatbelt. This indicates that there is a significant difference between the deterministic trends in these localities and Western Australian and, hence, variation is place dependence across the regional economy.

In terms of the long run equilibrium relationship between local and Western Australia's income levels, the elasticity of local income with respect to changes in Western Australian income is only statistically significant different from unity in Lower Great Southern and Goldfields. However, there appears to be a high degree of variability in responsiveness, indicating place dependence, at least in terms of long run equilibrium dynamics. With the exception of Lower Great Southern, the most responsive localities are in Perth metropolitan region and the less responsive are in the non-metropolitan labor markets, with the Goldfields being the most disconnected from the rest of the Western Australian regional economy. Again, we would conjecture that the unusual performance of the gold industry itself over the past three decades, with a steady decrease in the use and exchange value of gold during the 1980s and 1990s, followed by a return to favour as a financial reserve in the 200s might explain this disconnection (TONTS AND DAVIES, 2009)

However, these findings should be treated with some caution. With the exceptions of East Metro, Mid-West and the Northern Wheatbelt, there is no evidence in the sample to reject the unit root tests for non-stationarity, indicating that there may spurious correlations and that there does not exist an equilibrium (cointegration) relationship between local income levels and Western Australia's income level. However, once the first order differences are included, it is possible to reject the Engle-Granger test for all but Central Perth, North Metro and East Metro, indicting that there exists a cointegration parameter and, hence, a long run equilibrium relationship between local and Western Australian income levels. Put differently, once derivative control, expressed as the rate of change in the difference between local and Western Australian income, is accounted for in the disequilibrium dynamics is accounted for then a long run equilibrium exists. Finally, there is evidence of shifts in the location of the long run equilibrium during the early 1990's recession for for South East Metro (1991), South West (1988), Northern Wheatbelt (1990-1991), and Southern Wheatbelt (1990-1991), with North Metro (2006-2008) experiencing a shift in the lead up to the recent global financial crisis.

For each local labor market, Table 4 summarizes the disequilibrium dynamics for ECM model specification of equation (5), drawing out the adaptive nature of the out-of equilibrium dynamics of place dependence. First, the responsiveness of local economies of evolution of Western Australia's disequilibrium (θ_5) is significant for all local economies, with the most responsive local economies being Central Perth, Lower Great Southern and Northern Wheatbelt and the least responsive being the Goldfields. Second, the rate of change in the ECM is only significant for Peel, Northern Wheatbelt, and Southern Wheatbelt. Third, although the speed of responsiveness is significant for all economies other than Central Perth an South West Metro there is a degree of variability in the speed of responsiveness of the

ECM. Accordingly, there is place dependence in speed with which each local economy adapts to changes in the dynamics of Western Australian income. Intriguingly, the rank ordering of the speed of responsiveness of the regional economies is extremely diverse, and is not necessarily linked to location or economic base. This requires further investigation into how local conditions might be driving responsiveness, including the role of institutional and regulatory structures, enterprise competitiveness, infrastructure and human capital. Finally, a number of mis-specification issues remain, however, in the multiple testing context these are not considered to be problematic as they could be rejected at the 1% significance level (HENDRY and NEILSEN, 2007)

IV EVOLUTIONARY ECONOMIC GEOGRAPHY AND THE DYNAMICS OF LOCAL ECONOMIES

The so-called 'evolutionary turn' in economic geography (GRABHER, 2009) has begun to reinforce the truism that time and space matter in understanding the spatial distribution of economic activities. To date, however, much of the work on evolutionary economic geography has been conceptual, with a relatively small body of research offering detailed empirical accounts of the validity of the claims. Accordingly, we have aimed to operationalize the key concepts of path dependence and place dependence using recent advances in dynamic econometrics. Moreover, we do this in an environment that offers a sharp contrast to the 'core' manufacturing and service-based economies that have typically constituted evolutionary analyses to date (e.g. ESSLETZBICHER and RIGBY, 2007; SIMMIE AND MARTIN, 2010). Assuming the plausibility of linear approximations of the evolving economic landscape the modeling presented in this paper are capable of empirically testing for the presence of path dependence and place dependence, at least in terms of the different ways in which local economies adapt to changes on the regional economic system. Even though our models constitute relatively simple linear systems they are evolutionary processes, resulting from either stochastic trends, shifts in location, and/or adaptive equilibrium correction mechanisms. Based on the analysis conducted here, we would argue that even though these models are capable of generating 'shifting' equilibrium landscapes they are nonetheless compatible with 'evolutionary thinking'. On the one hand, shifts in the location are not predictable *ex ante* but emerge during the history of a path dependent process. On the other, adaptive equilibrium corrections are the result of common trends in path dependent processes, which themselves depend on initial conditions and the history of that process.

In the context of the recent Western Australian experience, we find evidence of both path dependence and place dependence, supporting the evolutionary economic geographic claims that history and geography matter to the dynamics of regional economies. We found that history matters in so far as there is evidence of path dependence in the dynamic trajectory of regional economies across Western Australia, with no long run tendency for economies to return to their pre-existing growth trajectories in response to exogenous shocks. While all regional economies displayed path dependence, there is however evidence that a something different is happening in a small number of non-metropolitan regions that clearly warrants further investigation. The distinctiveness of these regions seems likely to be explained by, *inter alia*, the structure and performance of economic base, trading networks, enterprise competitiveness, human capital, and institutional and regulatory conditions. Indeed, all of this would suggest that understanding regional and local path dependence requires the development of models that are attuned to the particular processes operating at these scales (BARNES and HAYTER, 2005). Within Western Australia, there is also evidence that a small number of local labor markets exhibited structural change, indicative of open systems capable of creating their own equilibrium landscapes. In some respects this is not surprising given the enormous amount of new resourced-led investment in the State over the past three decades that has contributed to a radical reshaping of the space economy.

It is also evident that geography matters insofar as 'place' dependence exists across the regional economies comprising Western Australia. Specifically, for most of the regional economies across Western Australia, there exist a long-run 'shifting' equilibrium relationship between local and State wide evolutionary paths in response to exogenous shocks. This suggests that there is a degree of synchronicity or economic integration across Western Australia. Yet, it is also apparent that different regional economies respond at different speeds to shocks. The reasons for this are not clear, though again appear to be linked to particular local and regional conditions. What is particularly evident from this analysis of place dependence is that Western Australia conforms to current political and popular discourse about the 'patchwork economy'. So, while there is evidence of a degree of integration within the State economy, there is a high degree of geographical variability in performance and responsiveness of shocks.

We would stress that while this paper has provided evidence that path and place dependent processes are operating in Western Australia, detecting this is clearly very different from offering an explanation for why these are occurring. Further work is needed to better understand the underlying drivers of these processes at multiple temporal and spatial scales. Indeed, we would suggest that more 'fine grained' modeling is needed that captures the range of institutional, economic, social and environmental processes that contribute to path and place dependence. Moreover, this work needs to explain not only the reasons for dependence, but also be able to explain the structural breaks that are evident for some regions. As MARTIN and SUNLEY (2006) have pointed out an important part of the evolutionary project needs to be explain path creation and how some regions are able to radically alter their development trajectories. A more detailed understanding of explaining these process is likely to come not simply from the conceptual architecture of evolutionary economic geography, but by drawing on a range of complementary explanatory frameworks that take time and space seriously, including the work on geographical political economy (SHEPPARD, 2011), socio-spatial dialectics (PLUMMER and SHEPPARD, 2006) and local models (BARNES and HAYTER, 2005).

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Figure 1 Functional Regions of Western Australia

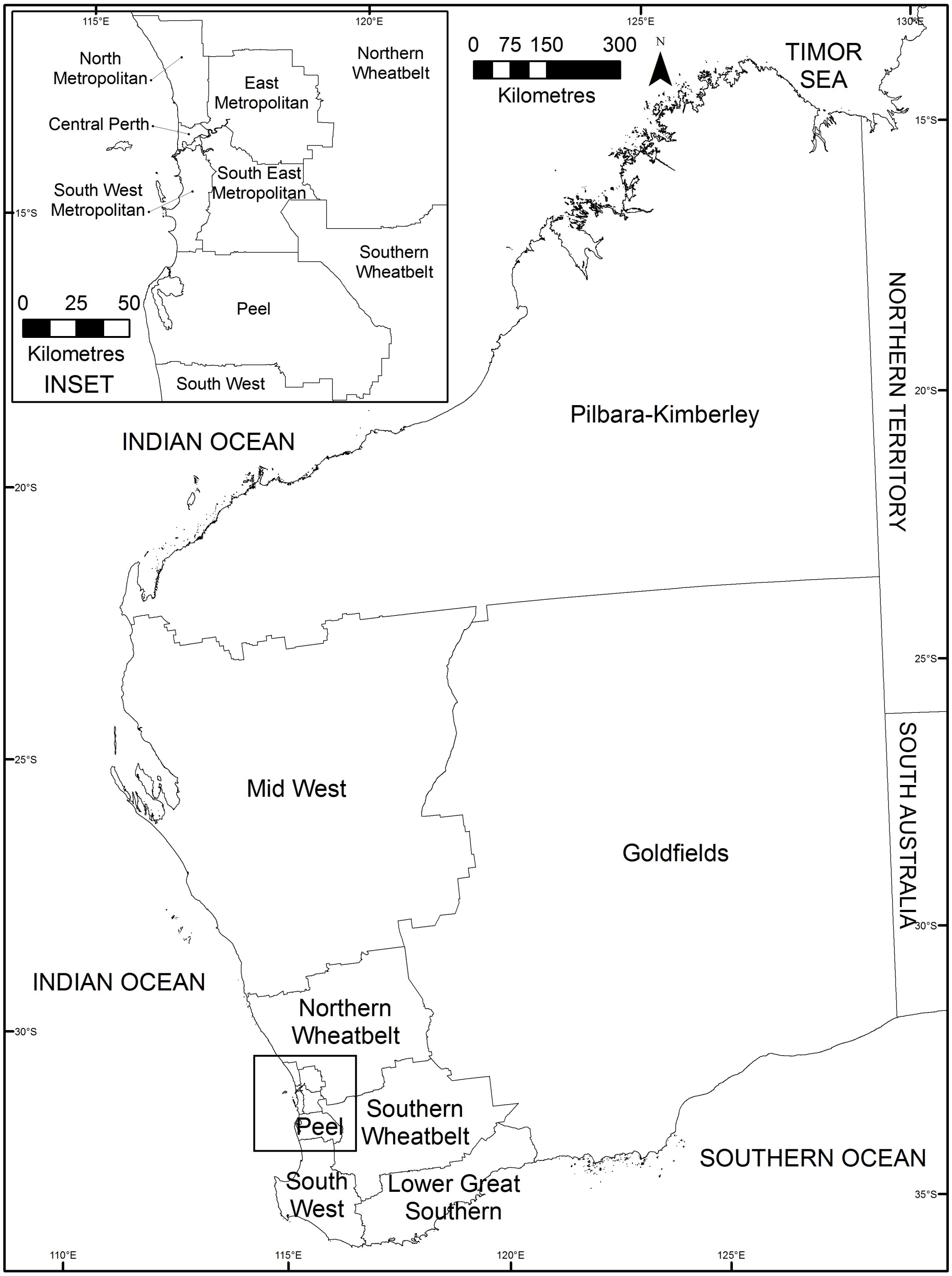

Figure 2: Real Income per Capita Across Western Australia, 1980-2008

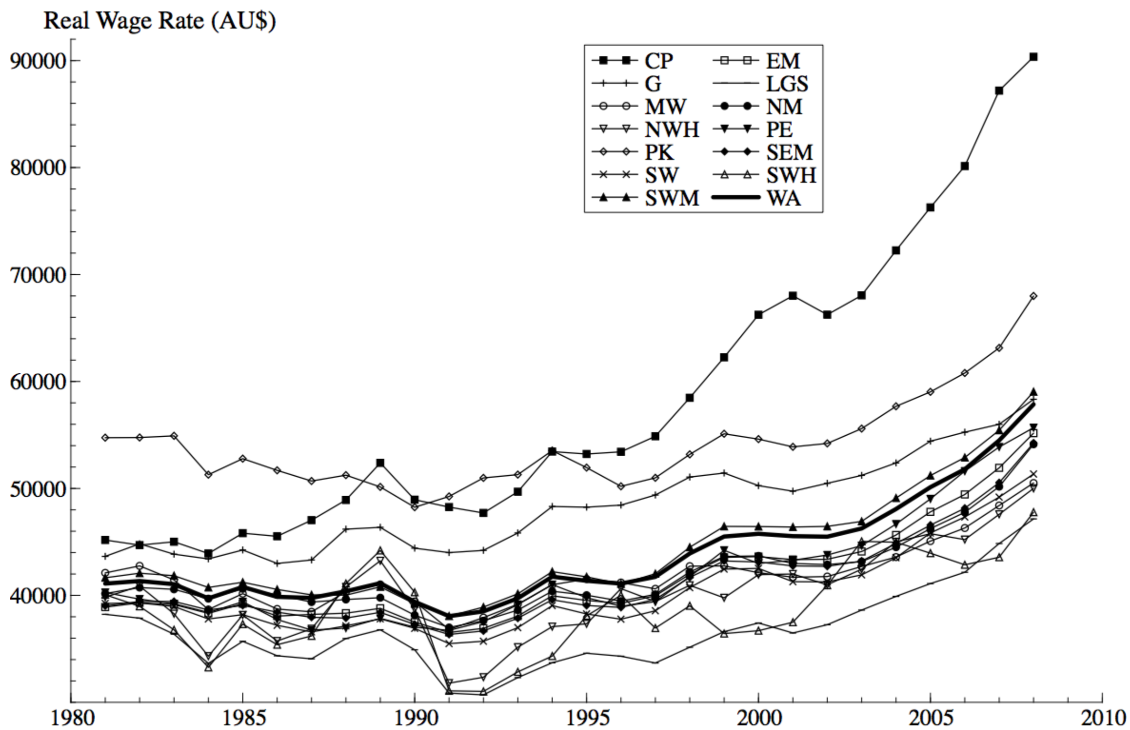

Figure 3: Growth in Real Income per Capita Across Western Australia, 1980-2008

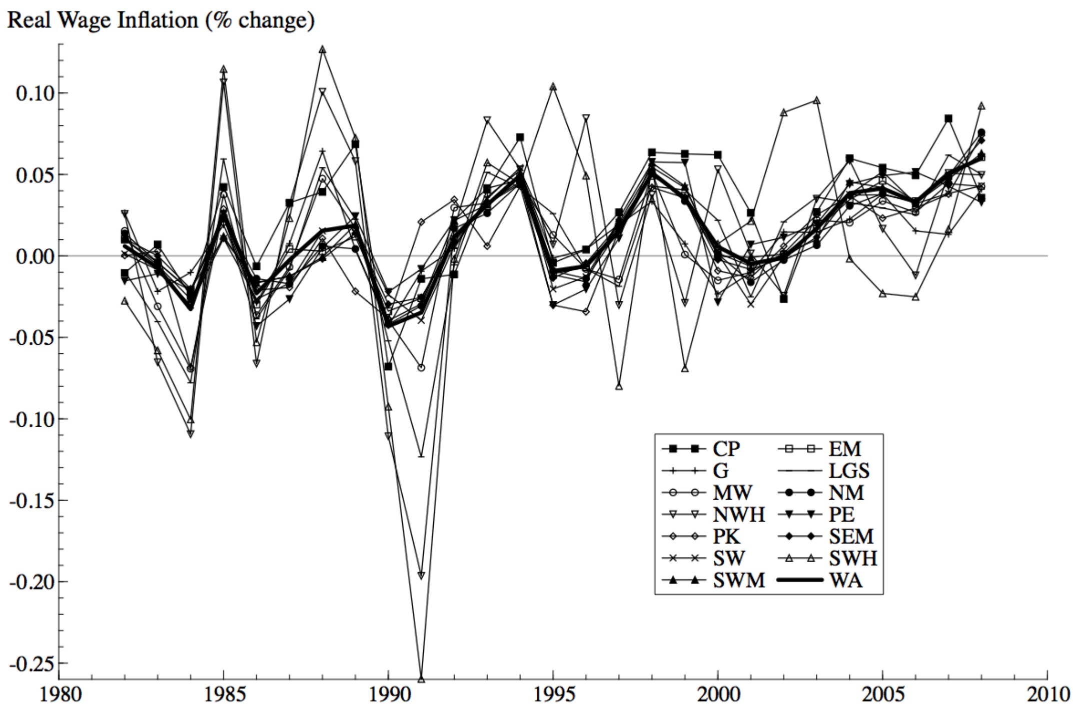

Table 1: Real Income per Capita: Descriptive Statistics and Normality Test

	Mean Income	Normality Test	Mean Growth	Normality Test
Central Perth	57983	10.95**	0.026	1.928
Pilbara-Kimberley	54068	12.09**	0.008	0.852
Goldfields	48296	4.03	0.012	0.419
South West Metro	44185	13.38**	0.013	0.994
Western Australia	43630	14.53**	0.013	0.597
Peel	41908	16.04**	0.012	3.616
North Metro	41906	13.74**	0.011	0.381
Mid West	41751	6.05*	0.007	4.361
East Metro	41643	15.25**	0.013	0.602
South East Metro	41240	14.23**	0.012	1.429
South West	40301	12.31**	0.010	2.363
Northern Wheatbelt	40082	0.64	0.008	6.222*
Southern Wheatbelt	38810	0.12	0.007	5.923
Lower Great Southern	36601	5.32	0.008	7.381*

* 5% Significance Level
** 1% Significance Level

Table 2: Testing for Path Dependence

Region	α_0	α_1	α_2	α_3	DF	Break	Spec
Western Australia	0.688 (1.05)	0.002* (0.001)	-0.067 (0.099)	0.235 (0.222)	-0.322	none	RESET 4.41*
SW Metro	0.723 (0.921)	0.003* (0.001)	-0.070 (0.087)	0.279 (0.214)	-0.43	88, 89,92, 93,94	none
East Metro	0.415 (0.999)	0.002* (0.001)	-0.040 (0.095)	0.232 (0.225)	-0.051	88, 89	RESET 6.31**
SE Metro	0.362 (0.948)	0.002* (0.001)	-0.036 (0.090)	0.369 (0.222)	0.21	91, 92 93 94	none
Peel	1.140 (1.02)	0.003* (0.001)	-0.111 (0.097)	0.166 (0.216)	-0.96	none	HETERO 5.22**
Central Perth	1.71 (1.33)	0.006* (0.003)	-0.162 (0.126)	0.147 (0.221)	-1.37	none	HETERO 3.27*
South West	1.448 (1.014)	0.003* (0.001)	-0.140 (0.096)	0.346 (0.205)	-0.94	89	none
North Metro	0.476 (1.119)	0.002* (0.001)	-0.048 (0.106)	0.389 (0.227)	0.27	88, 90, 91	none
Goldfields	5.572** (1.748)	0.006* (0.002)	-0.525** (0.165)	0.380* (0.191)	-2.45	88	none
Mid West	3.236 (1.569)	0.003** (0.001)	-0.309* (0.149)	0.186 (0.208)	-1.89	None	none
Lower Great Southern	1.886 (1.249)	0.004** (0.001)	-0.184 (0.120)	0.196 (0.212)	-1.31	None	NORM 9.36
Northern Wheatbelt	5.555** (1.816)	0.006** (0.002)	-0.534** (0.174)	0.280 (0.196)	-2.67	None	none
Pilbara-Kimberly	0.533 (1.343)	0.003* (0.001)	-0.052 (0.124)	0.300 (0.233)	-0.51	None	HETERO 2.96*
Southern Wheatbelt	5.70 (1.79)	0.005* (0.002)	-0.544** (0.171)	0.389* (0.193)	-2.43	none	none

*   5% Significance Level
** 1% Significance Level

Table 3 ADL Model Dynamics and Long-Run Equilibrium Analysis

Region	Lag 1+	δ_0	δ_1	δ_2	$\delta_2 - 1 = 0^{++}$	Root 1+++	Root 2+++	Root 3+++	Root 3 (lag)	Spec
Central Perth	4.03*	-0.64	0.014**	1.07**	0.244	-2.67	2.44	-2.60	-2.55	none
Peel	9.60**	2.14	0.004	0.79**	0.753	-1.93	1.31	-2.18	-3.25*	none
SE Metro	5.33*	-0.49	-0.001	1.043**	0.335	-2.17	2.36	-2.69	-3.33*	1991
North Metro	7.76**	-0.702	-0.008**	1.067**	0.404	-2.08	2.42	-2.10	-2.70	2006-08
SW Metro	6.78**	-0.618	0.000	1.06**	0.690	-2.02	1.96	-0.52	-1.23	none
East Metro	2.21	0.029	0.000	0.99**	0.057	-2.84	2.91	-3.31*	-3.78*	none
South West	4.93*	0.928	-0.001	0.91**	0.979	-2.18	1.91	-2.50	-3.15*	1988
Lower Great Southern	3.18	-3.40*	-0.007**	1.31**	4.34*	-2.90	2.66	-2.95	-3.56*	none
Goldfields	13.42**	8.05**	0.006**	0.25*	40.96**	-3.28	1.51	-2.83	-3.55*	none
Mid West	9.53**	3.83*	-0.002	0.639**	5.91	-2.71	1.96	-2.99*	-3.09*	none
Northern Wheatbelt	3.83*	1.40	-0.003	0.86*	0.104	-2.29	1.33	-3.05*	-4.08*	1990-1991
Pilbara-Kimberly	4.72	1.76	-0.003	0.86**	1.16	-2.56	2.29	-2.66	-3.38*	Reset 3.82*
Southern Wheatbelt	4.62*	0.897	-0.004	0.91	0.023	-2.40	1.23	-2.42	-3.26*	1990-1991

* 5% Significance Level
** 1% Significance Level

+ Lag 1 uses and F-test of the joint null hypothesis (linear restriction) that the disequilibrium adjustment is not significant $\beta_1 + \beta_2 = 0$. This is equivalent to testing difference between the general and restricted R^2, controlling for degrees of freedom.

++ Test against the null hypotheses of unit elasticity ($\alpha_2 - 1 = (\beta_3 + \beta_4)/(1 - \beta_2) - 1 = 0$), using a chi^2 test of general restrictions on the ADL model, probability values reported in brackets.

+++ Root 1 tests the null hypothesis that $(\beta_2 - 1) = 0$, Root 2 tests the null hypothesis $(\beta_3 + \beta_4) = 0$,. PCGive only reports significance for Root1. Finally, Root 3 is the test using Engle-Granger procedure.

Table 4 ECM Model Dynamics and Long-Run Equilibrium Analysis

Region	$\theta_5 \Delta\bar{y}_t$	$\gamma_1 ECM_{t-1}$	$\gamma_2 \Delta ECM_{t-1}$	Break	Spec
Central Perth	1.20** (0.153)	-0.45 (0.26)	0.121 (0.266)	none	none
Peel	1.02** (0.09)	-0.47** (0.16)	0.489* (0.186)	1998-2000	none
SE Metro	0.929** (0.040)	-0.625** (0.196)	0.357 (0.200)	none	RESET 4.16*
North Metro	0.928** (0.043)	-0.48** (0.18)	0.409 (0.221)	none	RESET 4.36*
SW Metro	0.957** (0.049)	-0.34 (0.03)	0.07 (0.06)	none	none
East Metro	0.968** (0.027)	-0.79** (0.027)	0.316 (0.192)	none	Normality 6.99*
South West	0.958** (0.053)	-0.624** (0.203)	0.384 (0.217)	none	none
Lower Great Southern	1.160** (0.147)	-0.764** (0.217)	0.349 (0.208)	none	RESET 7.42*
Goldfields	0.664** (0.095)	-0.567* (0.172)	0.188 (0.186)	none	none
Mid West	0.928** (0.106)	-0.543** (0.188)	0.173 (0.200)	none	none
Northern Wheatbelt	1.240** (0.293)	-0.793** (0.205)	0.439* (0.188)	none	RESET 4.27*
Pilbara-Kimberly	0.957** (0.133)	-0.638** (0.204)	0.384 (0.707)	none	none
Southern Wheatbelt	0.988** (0.438)	-0.467** (0.158)	0.381* (0.172)	none	none

* 5% Significance Level
** 1% Significance Level