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Wool and the relative resilience of Western Australian Wheatbelt economies

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Abstract

This article seeks to examine the path dependence and relative resilience of rural economies by focusing on the dynamics of the wool industry, a former mainstay of the economic base of many, if not most, Australian rural economies throughout most of the twentieth century. Based on a case study of the Western Australian Wheatbelt, a region in which broadacre cropping and Merino sheep grazing formed a cohesive farming enterprise type for many decades, we employ dynamic econometric models to test the relative resilience of the wool sector for four of the region's constituent local government areas (LGAs) from just prior to the onset of the Second World War to the closing years of the twentieth century. The testing reveals evidence of both path dependence in the general model specification and a tendency for the four LGAs as a group to return to their long-run developmental trajectories following a "shock." However, divergence across the performance of the four LGAs suggests the persistence of historical and ecological gradients that require further investigation.

KEYWORDS

ecological resilience, engineering resilience, evolutionary economic geography, path dependence, Western Australia, wool production

1 | INTRODUCTION

The last two decades or so have seen an expansion of academic and practitioner-oriented literature on the causes of and appropriate policy responses to rural decline, broadly construed. Some work has focused on the plight of individual small country towns or particular regions (Cocklin & Dibden, 2005; Halseth, 2017; Stimson et al., 2003), whereas others have concentrated on the potential role of different economic or socio-cultural strategies in revitalising such affected places (Connell & Dufty-Jones, 2014; Gibson & Connell, 2012; McManus et al., 2012; Pike et al., 2016). In concert with the growing utility of conceptual approaches to bridge the epistemological divide between the environmental and social sciences, researchers in the field of local and regional development have increasingly adopted insights from both evolutionary economic geography (EEG) and social/ecological resilience "thinking" (Boschma & Martin, 2010; Cote & Nightingale, 2012; Essletzbichler & Rigby, 2007; Sheppard & Plummer, 2020). Building on arguments promulgated by Tonts et al. (2012), our focus is on the processes by which rural space economies evolve over time and space. Specifically, we deploy concepts first developed by the *Stockholm Resilience Center* (Biesner & Haydon, 2003; Holling, 1996) to empirically test both the ability of rural space economies to both "bounce back" to an equilibrium (*Engineering Resilience*) and retain their functioning and structure in the face of perturbations or "shocks" (*Ecological Resilience*) (Martin & Sunley, 2015).

We present a case study of the relative resilience and robustness of rural economies by focusing on one former mainstay of the economic base of many—if not most—Australian rural economies throughout most of the twentieth century: the wool industry. The sector's strategic importance for rural regions and the nation more broadly during 1950s and 1960s was encapsulated in the oft-made remark that "Australia rides on the sheep's back" (see Cashin & McDermott, 2002). Alongside wheat, wool was a central element in Australia's constructed comparative advantage, given the nation's relative abundance of land suitable for extensive grazing; a relative scarcity of labour; and wool's generally high value to weight ratio, rendering it economic to send to export markets (Blainey, 1971; Cashin & McDermott, 2002). The sector's development was hastened along by the successful introduction of the Spanish merino breed and ongoing breed improvement (Cashin & McDermott, 2002). With gold, wool was the export commodity that Australia depended on for foreign reserves throughout the latter half of the 19th century, and it continued to be a significant contributor to export income until well after the mid-1950s (Cashin & McDermott, 2002).

However, the inherent uncertainty attending natural production systems—together with the volatile export markets on which these goods are typically traded—often translates into instability for "home" regional and local economies. Drawing on a case study of the Western Australian Wheatbelt, a region in which broadacre cropping and Merino sheep grazing formed a cohesive farming enterprise type for many decades (Burvill, 1979), the article investigates dynamics within the wool sector for four of this region's constituent local government areas (LGAs) from just prior to the onset of the Second World War to the closing years of the twentieth century through the theoretical lens of EEG and resilience modelling. Spanning both the Fordist regime of accumulation and the onset of the post-Fordist era, the paper is attentive to major regulatory shifts in the national macro-economy, the sectoral dynamics of the wool industry and how those dynamics have played out "on the ground" in the context of the Western Australian Wheatbelt.

Section 2 selectively reviews literature on the application of EEG concepts to understanding rural economic dynamics, focusing especially on closely related ideas about path dependence, lock-in, and resilience.

Key insights
Provided here is a distinct account of long-run developmental trajectories of four Western Australian Wheatbelt local government areas in terms of relative resilience to shocks. Most perturbations have had only transient impacts on production of their key staple commodity. The Fordist decades from 1945 to the 1970s saw wholesale expansion and intensification of the agricultural base in the broad case study region. Buoyant prices for wool at the start of the period and throughout the boom created ideal conditions to establish and expand the State's wool industry, including in newly opened lands east of the Wheatbelt.

Section 3 explores notions of both engineering resilience and ecological resilience via a simple typology of potential developmental trajectories that might be observed in response to an exogenous shock; these are then formalised into an empirically testable model specification. Section 4 brings this empirical model to bear on the comparative case study of four communities in Western Australia's Wheatbelt. First, we describe the historical, environmental, and political factors that led to construction of the Western Australian Wheatbelt as an agricultural region before identifying potential shifts in long run development trajectories. We use (a) local knowledge to identify "shocks" due to either extreme events or major regulatory shifts; (b) concepts drawn from Regulation theory to identify both the timing of a macroeconomic shift from Fordism to a Neoliberal regime of accumulation; and (c) contextual knowledge of public-private policy initiatives. Second, we present some stylised facts about the evolution of the comparative case study prior to formally testing for the presence of both engineering and ecological resilience. In Section 5, we consider the broader implications of our empirical results for resilience thinking about the dynamics of rural communities and public–private policy effectiveness.

2 | TOWARDS AN UNDERSTANDING OF THE SPACE/TIME OF RURAL ECONOMIES: AN EEG PERSPECTIVE

The fundamental and far-reaching changes that most Australian rural regions underwent during the 1980s, 1990s, and 2000s occurred as federal and state governments applied neoliberal principles to virtually all facets of their fields of policy (Tonts & Haslam-McKenzie, 2005). Those changes triggered much research on myriad causes and consequences of a long-running, if spatially and temporally discontinuous rural crisis (Gray & Lawrence, 2001; Lawrence, 1987; Pritchard & McManus, 2000). At the time, the prognosis was grim for many rural regions and towns, especially those located in more remote, agriculturally dependent, and lower amenity zones. Continued rationalisation within the farm sector was always lurking but was exacerbated by spiralling interest rates through the late 1980s. The contemporaneous removal of virtually all forms of farm protection (Pritchard, 1999; Smailes, 1996) helped spur a process of demographic decline as young people moved out for better opportunities for education and employment elsewhere (Argent & Walmsley, 2008). During the same period, public and private sector cuts to key services such as banking, schools, and telecommunications (Argent & Rolley, 2000; Herbert & Pritchard, 2004; Productivity Commission, 1999) disproportionately affected smaller rural towns and further undermined their demographic, social, and economic bases (Pritchard & McManus, 2000; Smailes et al., 2014). Over time, though, stories of rural decline began to be supplemented with more positive narratives: research highlighting the relative success of "little towns that did" (Barnes & Hayter, 1992) and of promising signs of rural rebound and revitalisation as communities sought to reinvent their economies and socio-cultural functions. Increasingly, this notion of resilience became central to a more hopeful research agenda seeking to account for rural places' capacities to resist or react to and potentially rebound from the "shocks" that they are prone to (Gibson & Connell, 2012; McManus et al., 2012).

Although the multi-pronged notion of resilience has become a central element of EEG, the growing popularity of the former has not directly translated into EEG's wider adoption into investigations of rural economic change (c.f. Tonts et al., 2012). That said, a growing number of studies have employed resilience thinking as a means of developing more comprehensive and robust analyses of contemporary regional development trends (Bristow & Healy, 2020; Cellini & Torrisi, 2014; Fingleton et al., 2012; Plummer & Tonts, 2013; Plummer & Tonts, 2015). In investigations of natural resource-dependent economies, "place/path dependence" and "lock-in" are closely related concepts that are increasingly central to both EEG generally and resilience thinking more specifically in investigations of natural resource-dependent economies (Markey et al., 2019; Measham et al., 2019). Conventionally, path dependence refers to situations where a production technology or method becomes dominant, via increasing returns to scale and other positive feedback loops, and the fortunes of entire industrial branches rely increasingly on it (Arthur, 1994). Within EEG, *path* dependence is often regarded as a form of *place* dependence given the role of historical antecedents and the local space economy's natural resource, human, and financial capital endowments in shaping industry structures, labour markets, and firms' capacities for technological innovation (Martin & Sunley, 2015; Plummer & Tonts, 2013).

In many respects, the condition of "lock-in" flows logically from such an understanding of place dependence. Wilson (2014) recognises four main types of lock-in: structural; political; economic; and socio-psychological. Structural lock-in refers to the influence of a community's inherited natural resource base, along with the physical and social infrastructure that enables local economic and socio-cultural development. Economic lock-in relates to processes by which regional economies create and reinforce virtuous spirals of growth via increasing dynamic returns to scale and embed key industries and lead businesses "in place." Political lock-in incorporates the manner in which the formal and informal governance of local and regional economic development and strategy acts to both enable and constrain local economic strategies. This situation can occur through local planning laws and via the actions of local elites, who dominate and skew local development strategies to suit their own developmental preferences at the expense of alternative pathways. Fourth, socio-psychological lock-in addresses the behavioural and cognitive factors that underlay much economic decision-making and perpetuate certain forms of development, often in spite of so-called rational market signals. An example of this form of lock-in can be seen in the "export mentality" and concomitant developmental inertia of many staples-dependent regions (Hudson, 2005; Markey et al., 2019). Although the discussion above treats the four forms of lock-in in isolation, it is important to see them as closely interrelated and as a functional whole.

Inter alia, the notion of lock-in helps explain why regions remain trapped in a vicious cycle of decline, unable or unwilling to break away from old, moribund development trajectories. This point is echoed in the closely related literature on regions as complex adaptive systems (CAS) (Bristow & Healy, 2013) which, while acknowledging the structural obstacles that regions face in creating and controlling their own developmental pathways, emphasises the idea that forms of local individual and collective decision-making are vital to regional economies' adaptability and resilience. Nonetheless, while those living in (and leading) regions can create their own strategies to some degree, they usually do not do so in conditions of their own making. Those living in more remote, sparsely settled regions dependent on natural resource exports within federated political systems face particular strategic disadvantages in this respect. For instance, during the 2000s, a group of primary resource-dependent communities from inland British Columbia, Canada, sought to overcome the negative consequences of resource dependence by negotiating with the provincial government for a greater share of royalties from the liquefied natural gas (LNG) extracted from their lands. Their coordinated and collective efforts proved initially successful, with localities receiving a fairer share of local gas extraction royalties. The funds were then invested primarily in services and infrastructure that broadened local economic bases and helped the region to overcome some of the more negative aspects of path dependence (Markey et al., 2019). However, the cohesive front presented by the various communities dissipated over time, and a subsequent agreement was less favourable to the Peace River region communities (Markey et al., 2019).

In relation to the subject of this article, the wool industry and its key producing regions, Tonts et al. (2014) used wages and employment data to gauge the impact of the early 1990s wool market "shock" on Western Australian regions, finding that the floor price removal and concomitant drop in prices instigated a dramatic increase in employment and decrease in wages across the case study regions. From 1992, though, sustained improvement in all indicators was noted, which is suggestive of the relative resilience of the case study regions. Plummer et al. (2018) used the same set of measures to investigate the effectiveness of local and regional development policies in tackling the economic decline caused by the wool market collapse. They found that the rationalisation of State Government employment in rural regions, almost simultaneous with the early 1990s wool price drop, led to a structural break in regional wages. On the other hand, in some towns, employment trends showed evidence of engineering *and* ecological resilience, with trajectories ratcheted downwards compared to the period prior to deregulation. Adopting a broader and more qualitative perspective, Argent (2021) argued that the wool floor price removal had very serious negative consequences for the wool-dependent Kangaroo Island, South Australia, economically, demographically, and socially—an impact that would take close to a generation to recover from.

3 | MODELS AND METHOD: PATH DEPENDENCE AND RESILIENCE

From the perspective of EEG, path dependence and resilience may be considered as two sides of the same coin, with attention focused upon both the ability of local economies to "bounce back" to their long-run developmental trajectories following "shocks" (*engineering resilience*) and on the degree to which these economies are able to adapt and transform themselves when subjected to external disruptions (*ecological resilience*) (Holling, 2001; Walker & Cooper, 2016). Discourse is now moving from concepts and metaphors towards empirical testing using dynamic econometric models (Cellini & Torrisi, 2014; Fingleton et al., 2012; Plummer & Tonts, 2013, 2015; Plummer & Yamamoto, 2019). Building on those developments, our focus in this paper is empirical testing of resilience "thinking" in the context of wool production in the Western Australian Wheatbelt.

To fix ideas, Figure 1 represents a typology of the potential impacts of a "shock" on both the long-run developmental trajectory of a regional economy and the short-run disequilibrium adjustments following a "shock." The upper panel shows three potential long-run developmental scenarios of a locality whereas the lower panel shows the corresponding growth rate dynamics, encompassing both *engineering resilience* and *ecological resilience*.

From the "start point" to time "a," an economy is assumed to be on a long-run equilibrium growth trajectory. At time "a," there is an exogenous "shock" to the system—which lasts until time "b"—after which the economy is assumed to exhibit three possible responses: (1) continue on the lower long run growth trajectory; (2) return to its long run trajectory but with a downward "ratchet" effect on the level of economic activity; or (3) experience a short run transitory increased growth rate until it reaches the level of economic activity that would have been expected had the shock not occurred. Scenario (1) represents a permanent downward step change in the long-run growth rate whereas both scenarios (2) and (3) represent short run impulses that differ in terms of their long-run responses. In scenario (2), the impulse has a permanent "ratchet" effect on the evolution of the economy, whereas in scenario (3), the shock has only a transitory impact, returning to the former long-run equilibrium growth trajectory. Accordingly, only scenario (3) represents *ecological resilience*. Finally, scenarios (1)–(3) represent unobserved deterministic long-run equilibrium trajectories. The observed evolution of economic activity will fluctuate stochastically around those long-run equilibria, depending on a set of random "shocks" to the locality. If the evolution of economic activity returns to long-run equilibrium following a "shock," then the locality displays *engineering resilience*; otherwise, it displays path dependence.

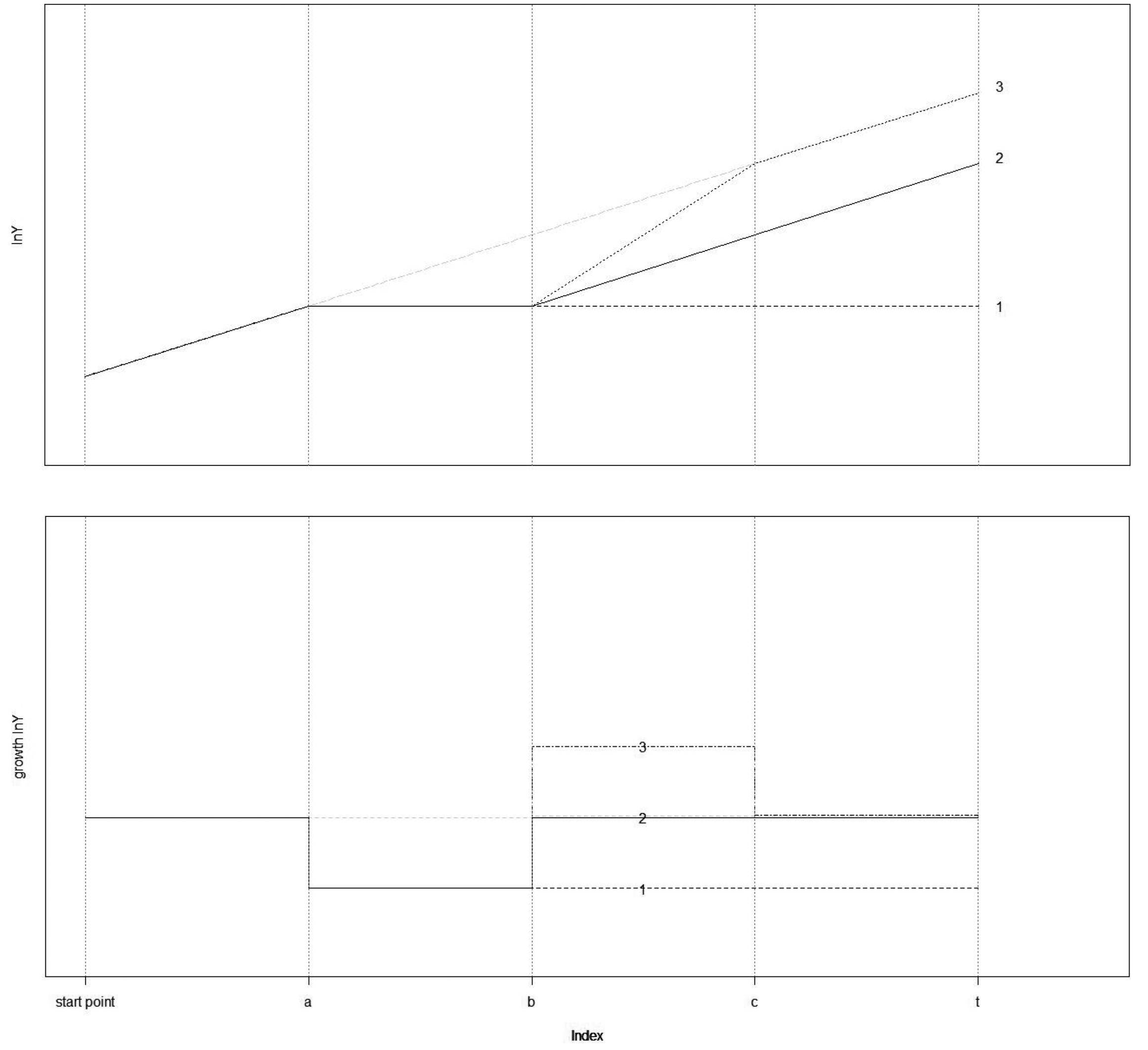

FIGURE 1 A resilience typology

Formally, the set of possible long-run developmental trajectories illustrated in the resilience typology can be captured using a simple linear autoregressive model specification. For expository purposes, consider a second order process where Z_t is defined as the level of wool production of the locality at time t (*All variables are measured in logs*):

$$Z_t = (\beta_{0t} + \beta_{1t}T) + \beta_2 Z_{t-1} + \beta_3 Z_{t-2} + \varepsilon_t, \tag{1}$$

where β_{0t}, β_{1t} capture unmodeled deterministic constant and trend (T) components and β_2, β_3 capture the out-of-equilibrium reactions to external unanticipated "shocks," which are assumed to be a white noise error process: $\varepsilon_t \sim N(0, \sigma^2)$.

Rearranging (1) in terms of growth rates:

$$\Delta Z_t = \theta_{01t} - \theta_2 Z_{t-1} - \theta_3 \Delta Z_{t-1} + \varepsilon_t, \tag{2}$$

where $\theta_{o1t} = (\beta_{ot} + \beta_{1t}T)$, $\theta_2 = (1 - \beta_2 - \beta_3)$, $\theta_3 = \beta_3$. Along a steady state equilibrium growth path, $(\Delta Z_t) = E(\Delta Z_{t-1}) = 0$, $E(\varepsilon_t) = 0$, where the long-run equilibrium is defined as $E(Z_t) = \frac{\theta_{01t}}{(\theta_2)}$.

Drawing on existing research, both path dependence and resilience can be defined in terms of the (non) stationarity of the dynamic econometric model represented in Equations (1), re-parameterised in (2) (Plummer & Tonts, 2015; Plummer & Yamamoto, 2019). As is well known, in the context of a linear approximation, a dynamic adjustment process is stationary and hence stable if $\theta_2 = |1 - \beta_2 - \beta_3| < 0$(Hendry, 1995). Assuming constant parameters ($\theta_{o1t} = \theta_{01} \forall t \in T$), if this condition holds, then the local economy displays *engineering resilience* to external perturbations or "shocks." As a corollary, if the data generation process is non-stationary in the sense that it is characterised by a stochastic trend ($\theta_2 = |1 - \beta_2 - \beta_3| = 0$), then the long-run trajectory is path dependent in the sense there is persistence, or memory, with no tendency to return to equilibrium following a "shock."[1] Similarly, the presence of non-constant parameters results in a "shift" in the long-run developmental trajectory towards which a locality is converging. Accordingly, non-stationarity due to either a hysteresis effect ($\theta_3 \neq 0$) and/or a "location" (mean) shift ($\theta_{o1t} \neq \theta_{o1} \exists t \in T$) can be interpreted as a lack of *ecological resilience*.

Given these definitions, it is possible to test for *path dependence*, *engineering resilience*, and *ecological resilience* as linear restrictions on a valid general model specification (Equation 1) as follows:

i. *Engineering Resilience*: $H_o : \theta_2 = 0, H_a : \theta_2 < 0$
ii. *Ecological Resilience* (Hysteresis effects): $H_o : \theta_3 = 0, H_a : \theta_3 \neq 0$
iii. *Ecological Resilience* ("location" shift): $H_o : \theta_{o1t} = \theta_{01} \forall t \in T, H_a : \theta_{o1t} \neq \theta_{o1} \exists t \in T,$

where the test of each linear restriction is conditional on the specification of a congruent general model. Equation (1) is a congruent model specification under the assumptions of (a) linearity (or linear approximation) in the parameters; (b) constant parameters; and (c) normality (Juselius, 2006). A theoretically informed, parsimonious, and congruent model specification can be obtained using a general-to-specific model selection strategy, where at each stage, validity is evaluated through a suite of mis-specification tests of the assumptions of the properties of the data generation process (Doornik & Hendry, 2001; Hendry & Krolzig, 2002).

Testing for *ecological resilience* due to "location" shifts involves testing for the potential to impact on the long-run development trajectory of a locality using (a) an indicator variable $D^T_{st} = (\ldots., 0, 0, 0, 1, 1, 1, 0, 0, 0\ldots.)$ to capture a step change, such as the move from fixed to floating exchange rate; (b) $D^T_{pt} = (\ldots., 0, 0, 0, 1, 0, 0, 0\ldots.)$ to capture a permanent "one-time" intervention such as a drought and $D^T_{trt} = (\ldots., 0, 0, 0, 1, -1, 0, 0, 0, \ldots.)$ to capture a "one-time" transitory intervention that is subsequently removed or cancelled out. Formally, location shifts can be represented as follows:

$$\theta_{o1t} = (\beta_{ot} + \beta_{1t} T)\left(\lambda_2 D_{st} + \lambda_3 D_{pt} + \lambda_4 D_{trt}\right).$$

If the λ_i, parameters are statistically significant then there is evidence that the events have an impact on the long-run equilibrium trajectories and, hence, the *Ecological Resilience* of these localities.

[1]Conventionally, $|\beta_2 - \beta_3 - 1| > 0$ is not considered to be economically meaningful and, accordingly, is ignored in this definition of resilience/path dependence.

4 | COMPARATIVE CASE STUDIES: RESILIENCE ACROSS THE WHEATBELT

4.1 | The Western Australian Wheatbelt in national and international contexts

Next, we consider the evolution of the wool industry for four LGAs located across the southern portion of the Western Australian Wheatbelt: Dumbleyung, Kojonup, Wagin, and West Arthur (Figure 2). The Wheatbelt became subject to European settlement and cultivation from the early 1830s, gradually and violently supplanting the Indigenous Noongar population. However, it was not until the 1920s that the foundations for modern agriculture were established, the state government implementing a group settlement scheme to "open up" the country via land clearing, farm establishment, and the extension of the railway network (Burvill, 1979). This approach to land settlement brought initial success, with wheat production expanding rapidly during the 1920s, though the isolation, tough environmental conditions and a collapse in the wool price saw many farmers becoming seriously indebted.

Debt reconstruction for the region's farmers continued through the troubled 1930s, and many were either forced off by creditors or abandoned their farms (Wheatbelt NRM, 2013). Following the conclusion of the Second World War, and consistent with federal and state governments' embrace of a productivist philosophy, the Western Australian Government released substantially more land for agriculture and the area cleared within the Wheatbelt more than doubled between 1940 and 1970, while the area sown down to crops and pastures expanded tenfold (Burvill, 1979). A combination of strongly supportive government policy, relatively cheap fuel, easier access to appropriate technology (that is, bulldozers and associated machinery), and the more ready availability of industrial inputs to improve soil fertility and crop and pasture productivity underpinned this massive expansion (Allison & Hobbs, 2004). The environmental impacts of the widespread clearing were dramatic, with dryland salinity recognised as a major problem from the early 1920s (Wheatbelt NRM, 2013).

The case study LGAs have been selected on the basis that they have historically strong reputations for sheep-grazing and wool-growing throughout much of the twentieth century, a reputation that carries into the current century. The most recent agricultural census

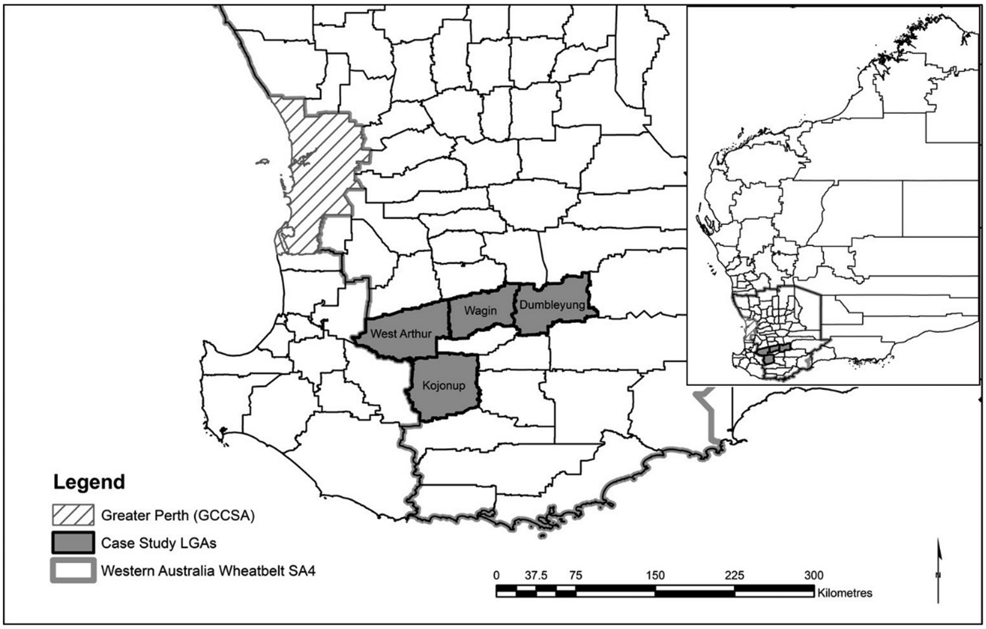

FIGURE 2 The Western Australian Wheatbelt case study area in context

data—collected by the Australian Bureau of Statistics (ABS)—reveal that these LGAs contained the highest density of sheep farmers—and sheep—in the Wheatbelt (Department of Primary Industries and Regional Development, 2021). Each comparative case is defined according to ABS data collected at the LGA level, within a broader and relatively stable regionalisation known as the Wheatbelt.

Accordingly, the four communities provide a comparative case study with which to evaluate both the *engineering resilience* and *ecological resilience* of localities dominated by the wool industry for the period from 1935 to 1996. To the best of our knowledge, this work represents the most comprehensive time series of economic statistics for regional Australia, encompassing significant socio-economic transformations across the Western Australian rural landscape. These transformations include broader changes in accumulation strategies, institutional structures, and social modes of regulation, including direct policy interventions by the Australian government in the wool industry.

In the context of understanding the significance of these transformations for the evolution of the wool industry across the four LGAs, we can classify events depending on whether they were external "shocks" were driven by broader scale, global economic developments, or were propelled by intentional public–private policy interventions in the Australian wool industry. The period from 1935 to 1996 encompasses long-run transformations in both the regime of accumulation and the social mode of regulation of capitalist economies, including Australia (Fagan & Webber, 1994; Martinus et al., 2018; O'Neill & Fagan, 2006). Specifically, the period from 1935 to 1972 represents a Fordist regime of accumulation, characterised by a relatively rapid expansion of domestic and international staples and manufactured goods markets via a combination of accelerated demographic growth after 1945 and bilateral and multilateral trade agreements such as Most Favoured Nation status with Japan and the General Agreement on Tariffs and Trade process, respectively. The demand side of the regime was complemented by the ongoing augmentation and intensification of the rural production base as the nation embraced a productivist ethos and set of practices (Argent, 2002). Notably, the wool sector experienced a sudden and dramatic decline in output and income during 1970 that lasted a season or so. In the short run, the 1973 Organisation of Petroleum Exporting Countries oil price crisis may have had a mildly stimulatory impact for wool as it increased the production cost of synthetic fibres, though that advantage was likely annulled by the generally depressed macroeconomic national and international conditions of the time, especially given that wool is generally a luxury fibre. However, this period was followed by a neoliberal regime of accumulation in which protection and support were episodically stripped out of virtually all industries across the Australian economy (Gray & Lawrence, 2001; Lawrence, 1987; Pritchard & McManus, 2000). Formally, we include an indicator variable $D^F_{st} = (1, 1, 1, 0, 0, 0....)$ to represent the Fordist regime of accumulation, which takes on a value of unity prior to 1973, zero otherwise.

Set against the backdrop of these broader changes in the global regime of accumulation were other significant political economic changes that, at least potentially, directly affected the wool industry during the period covering the Second World War and its aftermath and the

Korean War. Accordingly, we include an indicator variable $D_{st}^{ww} = (..., 0, 0, 0, 1, 1, 1, 0, 0, 0....)$ to pick up the potential impact of the Second World War covering the period 1939–1949. During this decade, the Australian Government was the main purchaser of wool and large stockpiles accumulated in the nation's ports due to the suspension of international markets. Subsequently, international demand for wool boomed and Australia exploited its comparative advantage in the context of the desolation of European farm lands. In 1949, rationing ended, and imports of foreign farm machinery and materials were permitted, facilitating farm production intensification. Australia deregulated its financial system and floated its currency in 1983, and the nation experienced historically high interest rates and levels of farm debt increased dramatically (Lawrence, 1987; Pauly, 1987; Peterson et al., 1991). Accordingly, we include an indicator variable $D_{st}^{d} = (...., 0, 0, 0, 1, 1, 0, 0, 0, 0....)$ from 1935 to 1983 to capture the potential impact of deregulation. Finally, we include indicator variables $D_{st}^{K} = (...., 0, 0, 0, 1, 1, 0, 0, 0, 0....)$ to pick up the impact of a dramatic increase in the demand for wool during the Korean War.

Within this broader socio-economic context, the Australian Government initiated a series of wool industry policy initiatives, beginning in 1952 with "Black Jack" McEwan's announcement that the government would facilitate the expansion of agriculture as a means of funding its other major nation-building strategies (Hooke, 1970). This work was followed by the introduction of a wool reserve floor price in 1970 after the wool price collapse noted above. This minimum reserve price scheme was suspended in 1990 and subsequently abolished in 1991, which in itself triggered a major collapse in the wool market that affected all of Australia's wool-growing regions and took many years to recover from. The potential impact of wool industry policy is captured with an indicator variable covering the 1952 to 1991 period, $D_{st}^{P} = (...., 0, 0, 0, 1, 1, 1, 0, 0, 0....)$.

Our measure of production for the wool industry in the four LGAs is the total wool clip measured in kilograms. This measure is derived from historical statistics registers, yearbooks, and data collected by the ABS and Department of Agriculture and Food, WA (DAFWA). In terms of measuring the evolution of the industry, wool production is an appropriate measure of farm-level responses to regulatory and market changes in the sector because it captures in a clear and precise manner decisions to increase or cut production, for whatever reason. Historically, in such broadacre agriculture-dependent staples-dependent regions, farmers hedged their exposure to market shocks in one sector by switching production emphasis to another (for example, plant more wheat and run fewer sheep or vice versa) or diversify into a thirds enterprise type such as cross-bred fat lamb production. While wool production figures incorporate both Merino and cross-bred wool, Merino wool production dwarfs the cross-bred cut for the period under analysis. In addition, wool production is a readily available statistic for the whole of the analytical period of our case study.

While there are obvious differences across the four LGAs over the period from 1935 to 1996, "stylised facts" underpin their long-run developmental trajectories. Figure 3 shows the evolution of total wool production across the four communities and should be read in conjunction with Table 1.

Overall, the graph and summary statistics show that there was an increase in wool production from 1935 to 1996, with a high level of synchronicity across the four communities. On average, Kojonup and West Arthur had the highest levels of total wool production, followed by Wagin and Dumbleyung. Casual empiricism would

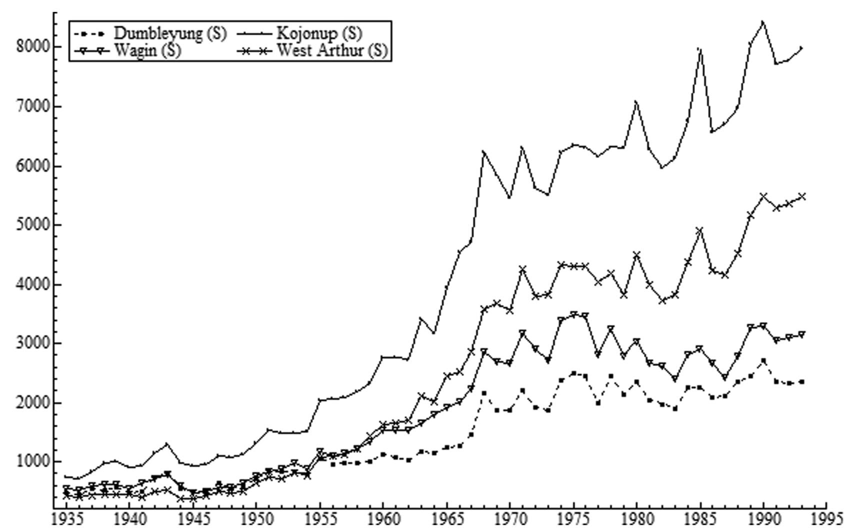

FIGURE 3 Long-run developmental trajectories—total wool clip, ('000 kg)

TABLE 1 Case study LGAs total wool clip (‘000 kg)

1935–1993	$\overline{Z}$	$s_{\overline{Z}}$	$s_{\overline{Z}}/\overline{Z}$	Skew	Ex. K	Jarq Bera	Min	Max
Dumbleyung	1,427.80	736.41	0.516	0.135	−1.580	17.953	443.82	2,703.90
T Prob						*[0.0001]***		
Kojonup	3,963.60	2,583.70	0.652	0.144	−1.580	18.137	717.04	8,427.10
T Prob						*[0.0001]***		
Wagin	1,862.00	1,042.80	0.560	0.038	−1.609	17.911	481.51	3,478.00
T Prob						*[0.0001]***		
West Arthur	2,473.80	1,778.50	0.719	0.173	−1.561	17.975	378.94	5,489.90
T Prob						*[0.0001]***		

Abbreviation: LGAs, local government areas.
**Statistically significant at the 99.9% level of confidence.

suggest the possible presence of two trend breaks in the evolutionary trajectories of wool production across all communities: (a) the period encompassing the pre-WWII period and the war years in which the long-run trend was stationary; (b) a post-war boom that ended in the late 1960s; and (c) a relatively “flat” or stationary period of wool production after 1970. Within these overall developmental trajectories, there are clear fluctuations around the trends that, by hypothesis, result from out-of-equilibrium dynamics in response to external perturbations or “shocks” to these local communities. On average, as measured by the coefficient of variation, the highest degree of fluctuation was experienced by West Arthur, followed by Kojonup, Wagin, and Dumbleyung.

4.2 | Testing for path dependence and resilience across the Wheatbelt

The most effective way to identify potential trend breaks in the long-run equilibrium trajectories of the four case study LGAs is by considering the growth rates in wool production (Equation 2). By definition, step changes in a growth rate correspond to trend breaks in levels of wool production. Figure 4 shows both equilibrium shifts and deviations from long run trajectories (growth rates) and should be read in conjunction with Table 2.

Evidence of equilibrium shifts is derived from a general model, which is estimated and includes all the indicator variables identified a priori as external perturbations or “shocks” that might potentially “shift” the long-run developmental trajectory for each LGA. Subsequently, this model is simplified using *autometrics*, a general-to-specific model selection algorithm, to arrive at a “final” valid model specification that is both theoretically informed and adequately captures the structure of the underlying data generation process (Hendry & Krolzig, 2002; Plummer & Yamamoto, 2019). Figure 4 shows the deviations from those long-run trajectories for each community for the “final” model specification.

Overall, the average growth rate from 1935 to 1996 was highest in West Arthur and Kojonup followed by Wagin and Dumbleyung. Set within the context of these overall growth patterns, the rank ordering of fluctuations was reversed, with Dumbleyung experiencing the greatest fluctuations, followed by Wagin, Kojonup, and West Arthur. However, based upon evidence in Figure 4, there is proof of structural breaks, or step changes in growth rates and one time permanent “ratchet” effects and/or transitory impulses for each of the four communities. All four LGAs experienced impulse “shocks” during WWII, although the nature of these differs across communities. Specifically, there was a sharp drop in the growth rate of wool production in 1944 for West Arthur and Kojonup. This drop corresponded to a permanent downward “ratchet” effect on their long-run evolutionary trajectory. Similarly, there was an impulse downward “ratchet” effect on Wagin’s evolutionary trajectory, which covered the period from 1943 to 1945. In contrast, Dumbleyung underwent a transitory drop in growth rate in 1942, which was corrected over 1943/44 and which corresponded to a temporary rather than permanent downward “ratcheting” in its long-run developmental trajectory.

During the post-war period, Dumbleyung, Wagin, and Kojonup all experienced initial periods of positive growth in wool production followed by sharp declines to approximately zero growth by the end of the period, 1996. Dumbleyung was the first to experience this decline in 1967/1968, followed by Wagin in 1976, and Kojonup in 1985. In addition, in 1955, Dumbleyung experienced a permanent “ratchet” increase in its long-run evolutionary trajectory, but this increase was followed by a permanent decline in the growth rate of

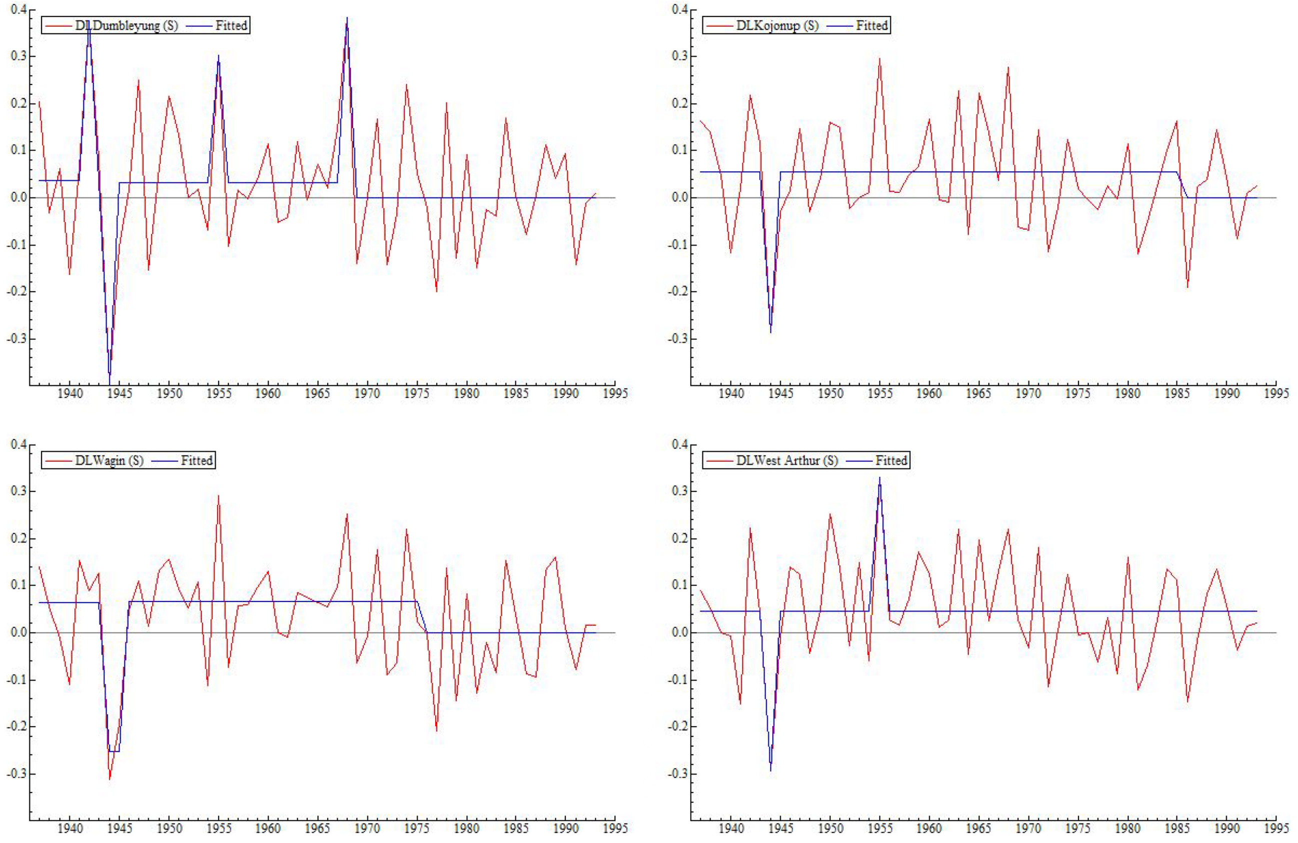

FIGURE 4 Long-run growth rate dynamics in wool production, four WA Wheatbelt local government areas (LGAs)

TABLE 2 Case study LGA wool production growth rates, 1936–1993

1936–1993	$\overline{Z}$	$s_{\overline{Z}}$	$s_{\overline{Z}}/\overline{Z}$	Skew	Ex. K	Jarq Bera	Min	Max
Dumbleyung	0.03	0.14	5.10	0.148	0.780	4.139	−0.40	0.38
T Prob						*[0.1263]*		
Kojonup	0.04	0.11	2.70	−0.069	0.414	2.118	−0.29	0.29
T Prob						*[0.3468]*		
Wagin	0.03	0.12	3.86	−0.397	0.225	1.975	−0.31	0.29
T Prob						*[0.3726]*		
West Arthur	0.04	0.11	2.55	−0.073	0.431	2.203	−0.29	0.33
T Prob						*[0.3324]*		

Abbreviation: LGA, local government area.

wool production. In contrast, West Arthur experienced a similar positive "ratcheting" of its developmental trajectory in 1955 but returned to positive growth after this "shock."

Finally, Table 3 shows the simple Pearson correlation statistics across the four communities for both long-run developmental trajectories and deviations around those trends. As might be expected, there are very high correlations between the long-run developmental trajectories of the LGAs though these are likely to be spurious correlations in the presence of stochastic trends or path dependent processes. Controlling for possible non-stationarity, there is evidence of high correlations between growth rates across these LGAs. Such high correlations point to common processes operating across all the four communities that warrant modelling in terms of relative resilience.

Testing for path dependence, *engineering resilience* and *ecological resilience* across the four case study areas involve estimating a valid empirical model of Equation (2) and imposing the relevant set of linear restrictions (i), (ii), and (iii). Table 4 shows the results from estimating the dynamic model specification parameterized in terms of growth rate dynamics.

TABLE 3 Correlations between wool production growth rates and deviations from long-term equilibrium, Pearson's *r*

Long-run developmental trajectories (levels)				
1935–1993	**Dumbleyung (S)**	**Kojonup (S)**	**Wagin (S)**	**West Arthur (S)**
Dumbleyung (S)	1.000	0.982	0.986	0.983
Kojonup (S)	0.982	1.000	0.972	0.997
Wagin (S)	0.986	0.972	1.000	0.977
West Arthur (S)	0.983	0.997	0.977	1.000
Deviations from long-run equilibrium (growth rates)				
1936–1993	**Dumbleyung (S)**	**Kojonup (S)**	**Wagin (S)**	**West Arthur (S)**
Dumbleyung (S)	1.000	0.819	0.863	0.787
Kojonup (S)	0.819	1.000	0.761	0.867
Wagin (S)	0.863	0.761	1.000	0.753
West Arthur (S)	0.787	0.867	0.753	1.000

TABLE 4 Path dependence, hysteresis, and resilience in WA Wheatbelt wool production[a]

1937–1993	Dumbleyung		Kojonup		Wagin		West Arthur	
DLWC	**ΔZ**	**G - S**	**ΔZ**	**G - S**	**ΔZ**	**G - S**	**ΔZ**	**G - S**
θ_0	2.482		1.135		1.171		0.776	
T Prob	0.044		0.088		0.141		0.167	
θ_1	NA	NA	NA	NA	NA	NA	NA	NA
T Prob								
θ_2	−0.170		−0.069		−0.077		−0.048	
T Prob	0.049		0.110		0.158		0.203	
θ_3	−0.119		−0.160		−0.179		−0.255	
T Prob	0.411		0.252		0.209		0.078	
Fordism	−0.054		0.019	0.057	0.042		0.065	0.063
T Prob	0.492		0.726	0.003	0.485		0.250	0.001
WWII	−0.135		−0.145		−0.130		−0.151	
T Prob	0.094		0.020		0.051		0.018	
Deregulation	−0.038		−0.033		−0.049		−0.057	
T Prob	0.557		0.514		0.348		0.254	
Korea	−0.017		−0.045		−0.022		−0.040	
T Prob	0.881		0.594		0.807		0.645	
Policy	0.028		−0.011		0.013		0.009	
T Prob	0.717		0.849		0.836		0.867	
Adj R^2	0.031		0.067		0.055		0.113	
F	1.257		1.571		1.465		2.023	
T Prob	[0.291]		[0.167]		[0.202]		[0.071]	
AR	2.289	1.916	3.813	3.434	1.457	0.014	5.615	2.640
T Prob	[0.1126]	[0.1569]	[0.0292]*	[0.0394]*	[0.2432]	[0.9857]	[0.0065]**	[0.0805]
ARCH	0.000	0.471	0.117	0.518	3.728	0.025	0.049	0.512
T Prob	[0.9895]	[0.4954]	[0.7333]	[0.4747]	[0.0587]	[0.8739]	[0.8259]	[0.4772]
NORM	4.834	3.982	0.313	2.705	0.982	2.237	0.539	3.713

TABLE 4 (Continued)

1937–1993 DLWC	Dumbleyung ΔZ	Dumbleyung G - S	Kojonup ΔZ	Kojonup G - S	Wagin ΔZ	Wagin G - S	West Arthur ΔZ	West Arthur G - S
T Prob	[0.0892]	[0.1366]	[0.8552]	[0.2585]	[0.6120]	[0.3268]	[0.7638]	[0.1563]
HETERO	1.175	N.R.T	1.169	N.R.T	1.457	N.R.T	0.743	N.R.T
T Prob	[0.3327]		[0.3366]		[0.1919]		[0.6682]	
RESET	0.689		1.272	1.478	0.757		0.026	0.607
T Prob	[0.5068]		[0.2896]	[0.2372]	[0.4745]		[0.9745]	[0.5488]

[a]ADF = Augmented Dickey Fuller (ADF) test for unit root for variable X: $\Delta X_t = \beta_0 + \beta_1 T + (1-\beta_2)X_{t-1} + (1-\beta_3)\Delta X_{t-1} + \varepsilon_t,\ \varepsilon_t \sim N(0,\sigma^2)$ with critical values of (a) constant plus trend: 5% = 3.52, 1% = 4.20 and (b) constant: 5% = 2.94, 1% = 3.60. *AR* denotes a Liung & Box test for residual autocorrelation, ARCH denotes Engle's test for autoregressive conditional heteroscedasticity, *NORM* denotes a Jacque–Bera test for normality, *HETERO* denotes a Breusch–Pagan test for heteroscedasticity, and *RESET* denotes the Ramsey functional form misspecification test. N.R.T = no regressors to test.
*5% significance level.
**1% significance level.

Overall, evidence shows that the evolution of wool production is relatively simple, and there is a consistent narrative across the case study LGAs. In the case of the general model specification, which includes potential equilibrium "shifts," the models are congruent with the data with the exception of autoregressive errors (ARs) for Kojonup and West Arthur. For each model, the overall fit is not statistically significant, a common feature of models fitted on first differences. Furthermore, with the exception of the impact of WWII on Kojonup and West Arthur, there is no evidence that any of the indicator variables are individually statistically significant at the 5% significance level, suggesting *ecological resilience* to "shocks." Furthermore, the individual tests for *engineering resilience* conditional on the set of "shifts" suggest that there is no evidence to reject the null hypothesis $H_o: \theta_2 = |\beta_2 - \beta_3 - 1| = 0$ in favour of the alternative hypothesis $H_a: \theta_2 = |\beta_2 - \beta_3 - 1| < 0$ at the 5% significance level. Finally, there is no evidence of hysteresis effects, with the estimated $H_o: \theta_2 = 0$ not being statistically significantly different from zero at the 5% significance level. As a corollary, the evidence indicates path dependence (stochastic trend) rather than either hysteresis of a stationary equilibrium for each of the communities in response to external "shocks."

While there appears to be evidence of path dependence in the general model specification, the evidence is different for the "final" congruent model specifications, indicating the presence of a stationary equilibrium for each of the localities. Specifically, the out-of-equilibrium dynamic adjustments in response to exogenous shocks are not statistically significant in the final model specification. Substantively, this finding means that there is a tendency for these LGAs as a group to return to their long-run developmental trajectories following a "shock." However, there are differences across the LGAs. Change in Dumbleyung and Wagin displays *engineering resilience* with a tendency to return to long-run equilibrium following a "shock." Furthermore, the results display *ecological resilience* in the face of structural breaks. Similarly, Kojonup and West Arthur appear to display *engineering resilience*, following long-run developmental trajectories. However, these LGAs experienced downward structural shifts in their long-run developmental trajectories accompanying the end of the Fordist regime of accumulation. As a corollary, while these two LGAs display *engineering resilience*, they lack *ecological resilience*, at least in response to the 1970s crisis in capitalism. According to our chosen model selection criteria, the final model specification is our preferred model insofar as it represents a theory consistent, parsimonious, and congruent model of the data generation process.

5 | SUMMARY AND CONCLUSION

We have sought to explore the relative resilience of archetypal broadacre agriculturally dependent LGAs throughout the *longue durée* of the post-Fordist "long boom," its subsequent foundering in the 1970s and 1980s, and the advent of a neoliberal regime. In doing so, we have focused on wool—a staple commodity produced throughout most of the non-tropical agricultural regions of Australia that played a key role in their economic development. In the process, we have revealed important features of these small, narrowly based local economies and the nature of their adaptation to a range of forces over time, space, and geographical scale. In the context of the substantial political, economic, social, and environmental changes across the Western Australian Wheatbelt, including a long-term decline in farm numbers, increased use of technologically mediated inputs, and greater farm productivity, our findings capture an important aspect of the farm adjustment process in the neoliberal era.

The foregoing statistical analysis reveals a distinct account of the long-run developmental trajectories of the four Wheatbelt LGAs in terms of their economic evolution and relative resilience to shocks. While the subregion that the LGAs form has been subject to several broad-scale socio-ecological disturbances, most of those perturbations have had only a transient impact on its output of a key staple commodity. The Fordist boom decades saw a wholesale expansion—and intensification—of the agricultural base in the region brought about by a familiar and fortuitous package of policy settings, technological fixes, and favourable domestic and international demand conditions such as demographic expansion or protected markets. Buoyant prices for wool after 1945 and throughout the boom created ideal conditions for accumulation, aided by the "opening up" of the more marginal lands east of the Wheatbelt, for the establishment and expansion of the State's wool industry.

The evidence suggests that these local economies demonstrate engineering resilience in the sense that these communities return to their long run developmental trajectories following an exogenous shock. The foregoing analysis suggests that this process played out unevenly across the Wheatbelt. Both Dumbleyung and Wagin display *ecological resilience* in the sense that their long-run developmental trajectories were not impacted by exogenous shocks. In contrast, both Kojonup and West Arthur experienced significant downward "shifts" in their long-run developmental trajectories as a result of the transition from a Fordist to neoliberal macro-economic regime of accumulation across the Australian economy.

On one hand, the *ecological resilience* of both Dumbleyung and Wagin might be considered normatively "good" insofar as these economies may recover from broad-scale global economic shocks and "unusual" extreme events. On the other hand, the overall results imply that economic trends in these LGAs have been resistant to public–private policy initiatives designed to enhance their long-run growth potential. This finding suggests that once the initial socio-ecological and economic "package" of broadacre export-oriented agricultural development had been rolled out across the Wheatbelt, it induced a form of cognitive "lock-in" among local farmers, together with public policy inertia in relation to agricultural and regional development. In practice, there may have been ecological limits related to, for example, rainfall, and soil fertility, to local farmers' capacity to diversify away from wool production and into other more profitable enterprise types in the eastern-most LGAs.

However, a major exception to the resilience narrative relates to the impacts of the transition from a Fordist to neoliberal regime of accumulation in Kojonup and West Arthur. The deep and severe crisis that gripped wool-growing regions and communities across Australia with the sudden removal of the floor price scheme for wool in the early 1990s saw many farmers exit the industry under unsustainable debt loads. Many diversified into alternative enterprises to complement or substitute their wool growing; hence, the wool clip quickly declined and remained low for several seasons. For these western-most and more accessible LGAs, diversification out of wool growing may have been a viable option for many farmers who marked a more or less permanent movement out of the sector. Within the broader transition, then, the differential impacts of major regulatory change across the case study communities, along with their broader demographic and social impacts, warrant further investigation. Finally, conceptually as well as practically, the paper provides further demonstration that resilience can be meaningfully operationalised and tested for within EEG analyses of non-metropolitan regional economic change.

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The authors have no conflicts of interest to declare in relation to this research.

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No ethics approval was required for the research for this particular paper as it relies solely on secondary historical data.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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