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An Approach for Analyzing the Vulnerability of Small Family Businesses

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Abstract: In a given operating environment, small family businesses typically have fewer resources to minimize vulnerability. Identifying this exposure is basic to strategic analysis and, potentially, public policy analysis. This can become even more important when structural change in the environment is expected while its exact character is not known. The implications of climate change for Australian family farms are an example. This paper reports a study designed to analyse the vulnerability of dairy farms in Victoria, Australia. The study draws on production control (applied general systems) theory, value chains and image theory to capture comprehensively the lock-in arising from salient past decisions and impact on the current business structure and strategy. This is the path dependence that defines the constraints and associated options available to small family businesses. The authors identify benefits associated with the use of dynamic analysis of vulnerability over static analysis. Generalizable implications regarding analysis of vulnerability in small family businesses are offered.

Keywords: small family businesses; vulnerability; Australian agriculture; path dependence; production control theory; image theory; value chains

1. Introduction

Identifying business vulnerability is a fundamental element of strategic analysis and, at times, public policy analysis. This can become even more important when structural change in the environment is expected while its exact character is not known. The implications of climate change for Australian family farms comprise a meaningful example of this given the nature of agriculture and high degree of vulnerability of these businesses. This paper describes research about the influences on vulnerability for these businesses, as well as the implications for strategic analysis and public policy that result from such vulnerability.

Agriculture in southern Australia can be described as "the canary in the coal mine" to the potential impacts of climate change. Not only is southern Australia one of the regions identified as the most vulnerable to climate change in the world [1–3], farming in Australia is characterised by the highest level of farm income variability in the OECD [4]. Farm businesses are essentially factories without roofs in which the production system is reliant on, or exposed to, natural inputs (e.g., rainfall, heat, sunlight, pests and diseases). These businesses are commonly subject to vagaries in output prices and input access that are substantially beyond farmer control.

It is expected that climate change will require that farmers make more significant changes to their farms than they currently do [5–7] to minimize their vulnerability. Yet, farmers are likely to be constrained in the change choices available to them. Revealing the nature of such constraints will help understand the implications of the impacts for businesses and public policy.

Given the exposure to variability in inputs and the high proportion of family owned and operated farm businesses, agriculture in southern Australia is a potentially rich context for analyzing vulnerability in small businesses. Cowan [8] conducted doctoral research to characterize the constraints on adaptation of irrigated dairy farms in northern Victoria. Findings from the Cowan [8] research are described in this paper, focusing on the insights on methodologies for understanding management decisions in small family businesses in general.

This paper is structured to describe (1) the operating context for Australian family farms and how managers minimize business vulnerability, (2) a conceptual model for identifying the influences on vulnerability, (3) findings regarding influences on vulnerability, and (4) the implications for Australian family farms and small family businesses in general.

1.1. Managing Business Vulnerability

Businesses can metaphorically be described as open managed systems [9–12] in which the business manager seeks to control the business–environment interaction to maximize benefits and minimize threats to business operations, output and the fundamental business purpose of achieving adequate profit [13]. When a business is not able to make a profit over time because of relevant variability in the operating environment, it is deemed to be vulnerable. Hence, the vulnerability of a business is determined by the capacity of the strategy and structure chosen by the manager to buffer the business from shocks in the operating environment, or where this is not possible, adapt the business to the new operating context. Vulnerability in this context is the opposite of resilience [14]. Vulnerability has been the emphasis of some research in considering responses to climate change [15–17], though there are gaps in the influences being measured in vulnerability assessments.

In some organizational contexts, such as agriculture, vulnerable businesses may persist. Farms that are failing financially can also persist for long periods; family farms especially so. Despite the inevitable disappearance of such a business, there are characteristics about the nature of these family businesses that enable persistence. The flexible attitude that can be adopted to acceptable return on investment, compared to capital market views; the ability to deploy costless family labour in the business or to subsidize the business with strategic off-farm employment by family members; and the capacity, often, to adopt a degree of subsistence lifestyle can all attenuate the collapse of a farm business that is incapable of achieving profit without these enabling factors. Persistence does not necessarily, therefore, signal low vulnerability. This implies that the ability to detect the failure of a business in the presence of current persistence is relevant to this enquiry, particularly as it may relate to timely public policy responses to structural change in operating environments that may portend business collapse.

In a given operating environment, small family businesses typically have fewer resources than larger businesses to manipulate vulnerability. Small family businesses are defined here as private businesses, incorporated or not, owned and managed by a single family and employing a total of the equivalent of fewer than five continuing full-time employees. Decision-making authority is in the hands of one or two people. Their limited resources for vulnerability management arise from their small organization size. This limits the depth of their skill base, their typical capital invested and borrowing capacity and, relatedly, the range of significant strategic changes that can be afforded.

Smallness commonly signals another impediment to managing vulnerability: the existence of near-perfectly competitive industry structure: what Emery and Trist [18] defined as a *placid, randomized environment*: the forecastability of the environment is poor. Where this exists, the exposure to lack of control of prices and input costs, and therefore profit margin, and, in the case of agriculture, lack of output control, amplifies the impacts of environmental variance. Firms in such causal contexts have an inferior relationship with their operating environment, to the extent that “there is no distinction between tactics and strategy” ([18]). Most farm sectors within Australian agriculture exhibit such a near-perfectly competitive structure [19,20].

Family firms exhibit qualitative differences in their behaviour independent of size effects. For example, family firms display constrained business flexibility and decisions related to discontinuous adoption [21]. In Australian agriculture, Nalson [22] found that decisions being made on the family farm regarding production and consumption changed as family circumstances changed. As well, Kaine [23] identified that farmers make innovation adoption decisions in a manner more akin to consumers than typical businesses. This seems to reflect the lack of professional purchasing skills and the presence of personal identification of farm decision makers with the family business, both engendering more subjectivity in decision making processes than is true in larger firms. The effect of these influences is to make decisions more personally-cum-family rational at the possible expense of objective, business rationality.

Decisions are not made in isolation by small business managers. Each is made among the myriad of day-to-day and longer-term decisions. This implies a need to identify the consequences for future decisions, the relevant contextual impact, of the interactions among decisions, particularly as to the way they modify resilience.

1.2. Australian Agriculture

The vulnerability of farms to climate change lies in the potential for increased variability in critical inputs, such as temperature and rainfall, which farmers must manage if they are to maintain viable businesses [24]. Farmers already struggle to manage variability in critical inputs, as can be seen in the widespread impacts of drought [25–27]. For example, in the 2002–2003 drought, agricultural output and exports contracted by almost 25% and farm employment dropped by around 15%, reducing Australia's GDP growth by 1% [28]. The potential for increased frequency of drought has been identified as a salient issue associated with climate change [29,30].

The majority of farms in Australia are small family businesses [4,31]. In the Agricultural Census of 2010–2011 there were over 93,000 farming families, representing 69% of farm businesses [32]. Of all Australian farms in that census, 55% had an estimated value of agricultural operations of less than A$100,000 [32]. Some 36% covered no more than 50 hectares of land, and a further 36% between 50 and 500 hectares [32]. The trend to fewer, larger farms is about the same in Australia as in other developed economies [28]. One effect of this is to increase the proportion of agricultural output produced by larger farms. A decade ago, 50% of Australian agricultural output was estimated to be produced by the largest 10% of farms, and 10% by the smallest 50% of farms [28].

Farm households have an average of around 40% less disposable income than other Australian households and around 330% greater equalized net worth [32]. This mix of income and wealth reflects the variability of income, and its average low level, and the financial resources required to absorb this over time. The preponderance of small family farms in part reflects the unattractiveness of agriculture as an investment to capital markets, given the variability and level of returns.

A feature of Australian family farms that ameliorates income variability is the significant proportion (30% in 1989–1990 increasing to 45% in 2002–2003) of farm-owners (average of four hours per week) and spouses (average of nine hours per week) who earn off-farm salaries and wages [33]. This varies from sector to sector and state to state but is, on average, stable over time compared to farm income and profit and can, for those farms engaging in it, surpass farm profit. On broadacre family farms in Australia in 2002–2003, off-farm employment income averaged 37%, at A$33,500, of farm income on those farms engaging in it [33]. From 1989–1990 to 2002–2003, off-farm income (including investment income and all other sources) averaged around 65% of total family income on broadacre family farms, never falling below 50% [33].

This expansion of the portfolio of family "business activity" may reflect various incentives, one of which is the appeal of smoothing total family income. It likely also reinforces the identification of the (nuclear) family with the farm, on which the vast majority of Australian family farmers reside: the commitment to the farming business is defining of the family identity.

In the case of farm family businesses, there is a persistent pressure that arises from their near-perfectly competitive industry structure. This is not common to many other small family businesses. The structure of the industry (along with high production uncertainty and the export orientation of agriculture in Australia) has an effect that agricultural output levels cannot deliberately be managed, as they can be in less intensely competitive industries, to ensure a minimum level of price and profitability. This leads to a relentless reduction, of 2% per annum on average [33], in the ratio of prices received for output to prices paid for inputs: the "terms of trade". This threatens the viability of the industry unless productivity increases to offset the reductions in margins [33]. In turn, this creates a persistent imperative for farmers, of all sizes of farms, to seek out productivity gains. This is true of many types of firms because productivity gains enhance profit; in this case, however, the pressure arises, unavoidably, from the need to avert secular declines in profit.

In the 30 years to 2003–2004, productivity in agriculture improved at more than double the rate of the market sector as a whole (2.8% compared to 1.1%) and was the source of the total increase in agricultural output over that period [33].

The emergence of significant secular changes, such as those resulting from climate change, in the farm operating environment may disturb profoundly the viability of the existing long-run financial homeostasis for the average small farm. Detecting this effect in a timely manner may be important for effective responses. Analysis that facilitates the projection of vulnerability to businesses should assist in this.

2. Theoretical Approach and Methods

The interest in this research was in understanding the vulnerability of small family farms. Vulnerability is determined by the capacity to resist detrimental influences and to adapt when it is beneficial to do so. This implies a need for consideration of interactions between the farm and environment, elements (or subsystems) of the farm, and the farmer and the farm, as the points of "interaction" are where activity occurs. An important factor in considering these interactions is analyzing how they influence the farm system as a whole, through time.

There has been some effort to consider influences on decisions within some of these interactions within the adaptive capacity and vulnerability literature [7,15,33–35]. Even so, these approaches have not comprehensively included all of these interactions. For example, Rodriguez, deVoil, Power, Cox, Crimp and Meinke [33] identified that not all influences could be explicitly incorporated into their simulated farms. As well, while Webb, Stokes and Marshall [34] considered socio-economic constraints criteria, there was little discussion of the rationale for selecting the chosen set.

2.1. Developing a Conceptual Model of Influences on Vulnerability

An aim of this research was to develop a comprehensive understanding of the set of influences on farmer business decisions, grounded in a clear rationale, which could be applied to small family business contexts. The set of influences, described as constraints, collectively describe the vulnerability of a farm business at a given time. With this aim in mind, a conceptual model was developed that enabled analysis of constraints on decisions through consideration of intra-farm, farmer-farm and farm-environment interactions. The conceptual model incorporates production control theory, image theory, value chains and path dependence (see Figure 1). These theories will be described in the next sections, with an emphasis on their application in the research. Further information is available in Cowan [8].

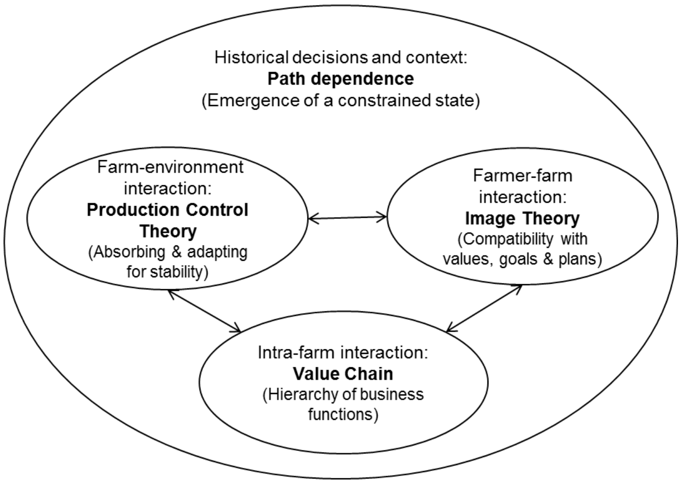

Figure 1. A conceptual model of how interactions influence vulnerability in farms (adapted from Cowan [8]).

2.1.1. Farm-Environment Interaction: Production Control

The farm-environment interaction is a potential source of constraint on farm decisions, given the importance of this interaction to business profitability. The dynamics of the production system form the most obvious place to see this interaction. Farmers transform inputs (e.g., fertilizer, water, labor) through the biophysical production system into outputs. Changes in inputs alter output quality and quantity; hence, maintaining the flow of inputs is important for producing farm outputs at sufficient quantity and quality. From a systems perspective, the on-going capacity of the farm to adequately to produce outputs in the face of variable inputs reflects a "steady-state" and is an indicator of system stability or equilibrium [36–39].

Understanding how farmers manage variability in farm inputs has been the focus of an area of applied research, grounded in general systems theory [40] and cybernetics [37], which is described here as production control theory [41,42] (described in Cowan [8] as farm control theory). While the focus here is on farms, production control theory has relevance to system regulation processes in business production systems more generally. Though agriculture had been previously considered through a general systems theory lens (for example, Dillon [43]), production control theory offers an applied systems methodology for understanding variability management in farms. For example, it has been applied to farming experiences in the Sunraysia region of northern Victoria to analyse the impacts of climatic variability on grape producers [27]. Here, elements from production control theory from Cowan, Kaine and Wright [42] and Kaine and Cowan [41] are summarized with a focus on concepts that are central to considering how managing variability in inputs constrains decision-making.

Farmers configure their farms so that the farm behaviour, day-to-day operations, is able to *absorb* input variability so that it does not lead to variability in outputs. For example, a manager of an irrigated farm regularly uses an irrigation allocation, scheduling practices and existing infrastructure (channels and gates) to manage access to irrigation water. This is described in relation to tactical and strategic flexibility in Cowan, Kaine and Wright [42]. As well, the differences among the types of tactics (called system regulators) are described in Kaine and Cowan [41] where aggregation, error control and anticipation regulators are distinguished.

When the existing farm configuration is not able adequately to manage the flow of inputs, the farmer needs to change the configuration, *i.e.*, *adapt* it. Adaptation is intended to return the farm to a state where the farm's behaviour is able to absorb variability. Practically speaking, this entails improving management so that there are no negative consequences for farm output. For example, were the irrigated-farm manager not able to access water when needed, the manager would likely face losses and may elect to take action to increase access (e.g., install a dam, purchase a permanent water entitlement or alter infrastructure to increase irrigation efficiency).

Where it is not possible to adapt the farm to preserve the business, the farm will fail and disappear or transform into a new system. This aligns with the concept of "structural adjustment" often used in reference to the exit of farms from agriculture. For example, if the irrigated-farm manager were unable to improve access to irrigation water, the crops relying on this water will fail, and, should this pattern persist, the farm business would fail. This specific conception of adjustment differs from circumstances where adjustment is used as a synonym for adaptation (e.g., Smit and Wandel [44]).

Production control theory indicates that constraints limit the set of behaviours available to the farm in day-to-day operations undertaken to maintain steady-state (*i.e.*, for absorption) and limit the capacity to make alterations to the production system (*i.e.*, for adaptation). This becomes an issue when variability threatens to push farm behaviour away from steady-state or unexpectedly shocks the business out of steady-state. Hence, the constraints of concern here are those that impede the capacity of the farmer to respond to variability, as they represent limitations to absorption and adaptation.

2.1.2. Intra-Farm Interactions: Value Chains

Decisions can possibly be constrained through the interaction among elements of the farm. Understanding these constraints required a model of a farm that disaggregated the business to the level at which operational decisions are made. A firm as a value chain is the dominant model of a firm in the operational management literature [45]. Porter's value chain model was used to distinguish different functional elements of an individual business and the relationships among these elements ([46] p. 37). While Porter [46] used this model to analyse the competitive advantage of a firm, here the value chain model has been used to define activities and linkages of a firm in a parsimonious yet comprehensive way that could be applied to any firm.

Porter [46] classified the interconnected activities of a firm as either *primary* or *support* activities. Primary activities are "involved in the physical creation of the product and its sale and transfer to the buyer as well as after sale assistance" ([46] p. 38). The five primary activities are: inbound logistics, operations, outbound logistics, marketing and sales, and service. Firms will differ in the emphasis they place on these activities, based on the type of business. For example, a farm business will emphasize inbound logistics and operations over service; which is unlikely to be the case for a business in a service industry. Support activities "support the primary activities and each other by providing purchased inputs, technology, human resources and various firm-wide functions" ([46] p. 38). The four support activities are: procurement, technology development, human resource management and firm infrastructure.

The distinction between primary and support activities is an important aspect of the value chain model. While primary activities are those involved serially in the physical creation and distribution of a firm's product, each support activity has the potential to influence all of the primary activities. Given the functional hierarchy [47] in firms, support activities are higher-order constraints than primary activities. This indicates that changes to support activities could entail more significant impacts because they are more far-reaching when compared to changes within primary activities.

In addition to highlighting the functional hierarchy in a farm, and mapping the production system qualitatively, the value chain model enables us to consider access to inputs through the procurement function. It also enables consideration of the intersection between the farm and family through the human resource management and infrastructure (notably finance) functions. The emphasis within production control theory on the production system misses these dimensions of constraints, lending value to the addition of value chain component to the conceptual framework.

2.1.3. Farmer-Farm Interactions: Image Theory

Understanding the influences on an individual's decision-making matters to farm decisions, given that the majority of farms in Australia are small family businesses in which one to two people make most of the decisions. Such would be the case with most other small family businesses.

Image theory was used to consider how a farmer's store of knowledge influences decision-making [48]. This store of knowledge is described in terms of a farmer's *value image* (principles, morals and ethics), *trajectory image* (agenda of personal and farm goals) and *strategic image* (collective plans and associated or implied tactics for the farm business to undertake in order to more closely approximate the trajectory image).

All decisions begin with assessing (screening) options for compatibility, according to image theory [48,49]. The object of this step in decision-making is to reject options that are not compatible with images. For example, an alternative being considered as a plan of action will be rejected if it does not align with principles and goals. Simply put, a decision option must be acceptable to all images to be included in the set of decision options. Compatibility is non-compensatory. Misalignment with a principle, goal or plan cannot be compensated for by alignment with other principles, goals or plans [49]. While image theory describes a number of elements in the decision-making process, of central use to this research was how the images may consciously and unconsciously filter out options during decision-making based on non-compatibility with an individual's existing principles, goals and plans.

Hierarchy has implications for how farm change decisions are considered within image theory. Generally, individuals are highly unlikely to change their principles radically or speedily [50]. This means that, if a need for change to the farm is triggered, a change decision can occur to either plans or goals. Even so, change is likely to be assessed within farm business plans and associated or implied tactics (within the strategic image) before considering a change to farm and personal goals (within the trajectory image) (see Figure 2). This is because a change to goals will require changes to subordinate plans to align with the new goal and is likely to have a much greater impact across the farm.

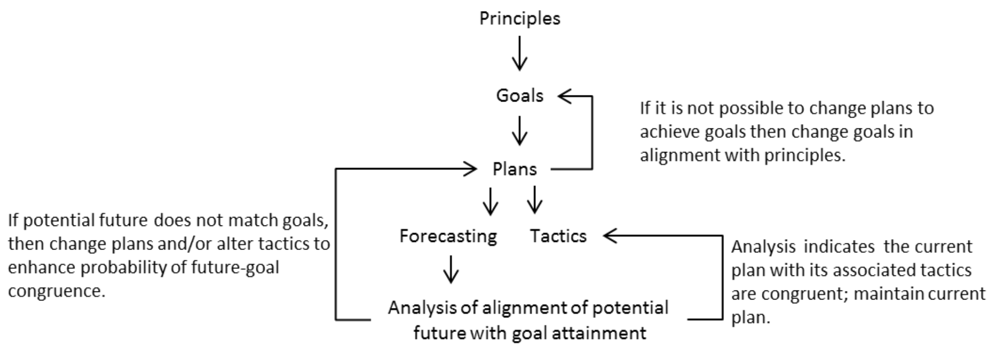

Figure 2. Simple example of a decision hierarchy (from Cowan, *et al.* [51], who adapted it from Cowan [8]).

Principles and goals relate to many facets of the farmer's life beyond the farm, including the farm family [21,52]. For example, a farmer's decision to pursue off-farm income is not necessarily based on a need identified for an alternative income stream to manage variability in farm profits; it may arise from the wish of a spouse to pursue a profession, albeit perhaps on a part-time basis. A benefit of using image theory is that it enabled us to consider how farmer decision evaluations may intersect with multiple domains of life, including the farm family.

2.1.4. Historical Decisions and Context: Path Dependence

Farm management decisions are made within a given context rather than in isolation [23,53]. Production control theory suggests that variability management through absorbing and adapting are a part of this context. The value chain construct suggests that the hierarchy of functional activities is a part of this context. As well, image theory suggests that an individual's principles, goals and plans are a key element in this context.

These three models offer a way to consider separate interactions and sets of constraints on farm decisions. What is not offered by these three models is a way to consider how elements interact with each other in the collective of farm decisions. Such consideration was critical, as the collective interaction among constraints in a farm at a given time reflects the farm's current constrained state. To use systems nomenclature, this collective constraint can be described as an emergent property of these multiple interactions.

Consideration of this emergence is offered within path dependence theory, which originated in economics to explain technology adoption processes and evolution in industry [54,55] and has since spread to other fields such as irreversibility in natural selection and chaos theory [56,57]. Path dependence of managed systems has been explored across three interrelated domains: the political and institutional realm [56,58,59]; prevailing technologies at the market economy level [60–62]; and within an organization or firm [54,63,64]. The application of path dependence theory in this research falls within the domain of the firm-level analysis. Even so, there are fundamental elements of path dependence that are common across approaches.

A farm business is not created at a single point, but instead is built through time as a dynamic process [54]. Path dependence theory allows consideration of how sequences of activities through time, as a dynamic process, influence the options available within a farm system. This means that path dependence (see Table 1) can be used to reveal constraints faced by a farmer that stem from the history of decisions made about the farm.

The "path" on farms is the critical production path at the farm business level. The critical production path is the interconnected sequence of activities or components that are essential for a set of outputs of a farm production system. The path includes not only what is being produced (output), but also includes how it is being produced; hence, the sequence of activities.

Table 1. Path dependence concepts (from Cowan, Wright, Kaine and Cooksey [51]).

Path Dependence Term	Definition
Critical juncture	A decision point in which a change in the system or environment has triggered a need to make a change to the current system structure
Reinforcement mechanisms	Feedback and externalities that emerge from the outcome of previous decisions
Path dependence	A process of increasing sensitivity of a system to previous decisions which is reinforced by mechanisms, leading to an outcome of lock in or irreversibility
Irreversibility	A system state where the path is locked in and cannot be changed. Irreversibility indicates that, while altering the path may be desired, the cost of doing so is too great.

Path dependence describes the increasing sensitivity of a system to the collective influences of decisions through time, leading to an outcome of lock-in or irreversibility [63,65–67]. *Irreversibility* indicates that, while altering the path may be desirable, the cost of doing so is too great. Costs to change trajectories, also called switching costs, include those associated with changing system components and opportunity costs from both embedded investment (sunk cost) and efficiency gains due to high competency [66,68,69]. In a practical sense, path dependence reduces the decision options available to the farmer, such as narrowing the range of acceptable behaviours within the system as technical efficiency increases. It also locks out options for altering the overall path of the farm business, such as adaptation to components of the production system and changes within value chain functions. In reality, all change comes at a cost to the system. As lock-in increases, the cost of changing the path trajectory also increases. This means path dependence reflects a continuum of constraints and is a description of "degrees" rather than "absolutes".

Path dependence in a business originates with a decision to make a change to the business at a *critical juncture* [54,66]. A critical juncture describes a decision-maker's perception of an internal (e.g., on-farm) or external (e.g., off-farm) threat to, or opportunity for, the business that triggers a need to make a change to the current business configuration [54].

At a critical juncture, a decision is made to follow one path from among those available within the current set of options [54]. The selection of a path here implies that the decision-maker has identified a link between the decision and a desired future or goal. Subsequent decisions support the initial decision, decreasing the likelihood of altering paths [58,63]. These subsequent decisions are determined by the outcome from the sequence of previous decisions and current context, which includes reinforcement mechanisms [58,63]. For example, an irrigated horticulturist who decides to move from flood to micro-jet (spray) irrigation, because of a perception that this will significantly improve irrigation efficiency, is at a critical juncture. The decision to shift to spray irrigation would be reinforced by subsequent changes in management practice such as using the sprays for fertilizing crops and setting up automatic irrigation.

Reinforcement mechanisms, such as feedback (e.g., economies of scale and increasing returns) and externalities (costs or benefits borne outside of the farm such as nutrient runoff) play a key role in path dependence by reinforcing the current farm business trajectory [55,65,66,69]. As reinforcement mechanisms increase the degree of path dependence, the amount of change (and therefore resources) required to alter the path also increases, leading to irreversibility [67].

Practically speaking, path dependence should be most apparent at a critical juncture, in which the farmer perceived a threat to, or opportunity for, the business that generated a decision to alter the farm business path. This is because a critical juncture indicates a constrained state within the existing structure. Tracing decisions from a critical juncture, it should be possible to identify subsequent changes to the farm system that reinforce the initial decision.

Within the conceptual model (see Figure 1), path dependence provides a lens for describing the manifestation of the dynamic and cumulative impact of constraints defined within production control theory, value chain and image theory. Path dependence derives its meaning in this context from these domains of constraints. Additionally, the impacts of the constraints described within production control theory, value chain and image theory can only be practically and meaningfully understood through the integrating lens of path dependence, rather than in isolation.

2.2. Methods of Data Collection and Analysis

Data collection focused on identifying existing farm contexts grounded in historical decisions of irrigated dairy farms in northern Victoria, from the perspective of the farmer. Victoria's irrigated dairy industry was chosen because the industry had faced multiple years of drought and a policy change regarding access to the public irrigation system [26,70]. Hence, the industry was seen as particularly stressed and a potential source of data about change decisions on farms. The farmer was used as the primary source of data because, first, the farmer was presumed to be the most knowledgeable about the farm business and, second, as the primary decision-maker, the farmer's perception of issues (e.g., threats and opportunities) pertaining to the farm mattered.

The qualitative data gathered in this research were drawn from personal interviews in 2013. Prospective participants in the research were sought using a purposive, theory-based sampling approach in which the constructs in the conceptual model were used to define the parameters for the sampling [71]. Interviews were conducted with 12 dairy farmers and four farmers who had changed from dairy production to another enterprise type (e.g., cropping). All 16 farmers had actively managed their current farm for 20 years or longer. This 20 year minimum criterion related to an interest in ensuring that the interviewee had sufficient experience on that particular farm to have a sound understanding of the history of decision-making regarding the farm business.

Interviews were semi-structured in design, as a conversation guided by a broad structure and purpose [72]. The purpose here was to describe the history of farm decisions and current farm circumstances. Interviews were recorded and transcribed for meaning. The transcripts were converted into narratives about each farm, with identifiers removed. The conversion of transcript data into a narrative enabled the researcher to combine interrelated data into historical sequences, a form of data that was amenable to coding. The narratives were "second-order" transcripts that anchored all subsequent data analysis [73]. Participant validation [74] of the narratives was sought to make sure that the narrative reflected the individual's farm story.

Using the integrated conceptual model (Figure 1) as the guiding framework for analysis, the farm narratives were coded using qualitative data analysis (QDA) software [75] where constructs of constraints were identifiable; that is, critical junctures, adaptations, changes to goals or plans, and whether the changes occurred in the support or primary activities of the farm (Figure 3). The coded data were then analyzed to consider patterns of intersections (*i.e.*, sets) among constructs, as an indication of the usefulness of these constructs for understanding sources of constraints. The coded data were also used within a sequential decision mapping process to identify reinforcing decisions stemming from critical junctures. Following these steps of analysis, the usefulness of the conceptual model for understanding farm constraints was considered.

While the theories directed the type of data being sought, care was taken in the research process to ensure there was openness to emergence of unexpected in the data gathering and analysis [76]. This included the use of open-ended questions during data gathering, which enabled the interviewee to guide the direction of the interview, and the use of open and descriptive coding in the analysis process. Details regarding the analysis process, including tools used to manage research validity and reliability, are available in Cowan [8].

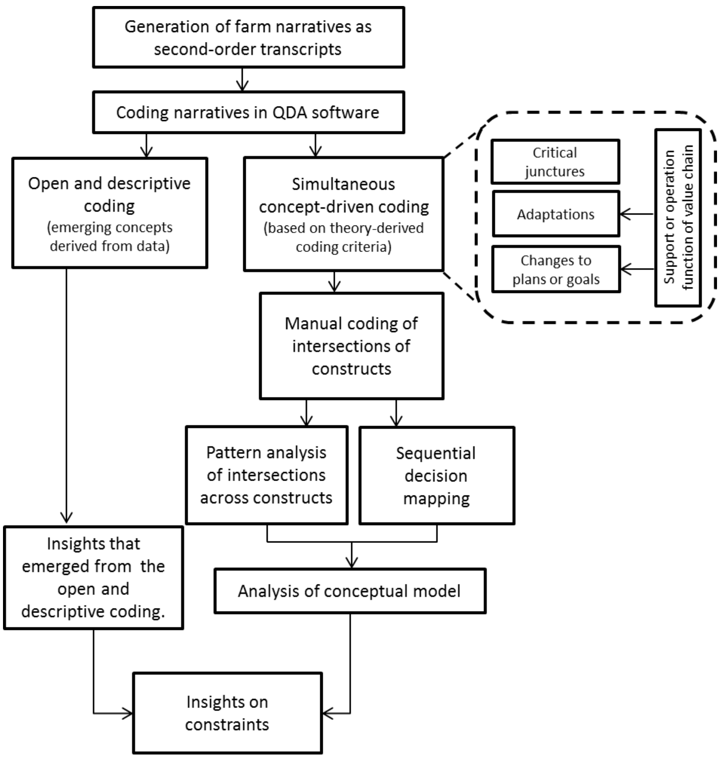

Figure 3. The analysis process used in this research (from Cowan [8]).

3. Results and Discussion

The first aim of the analysis was to identify patterns in the intersections across, the concurrence, and the domains of constraints that were derived from production control theory, image theory and value chains. Table 2 summarizes the patterns that were identified across the narratives, with the rows indicating the patterns, or "sets", and the numbers indicating the number of times data was coded into them in the narratives. The identified intersections indicated some compatibility across theories. As well, there were differences in the patterns which specified dissimilarities in domains of constraints among the theories. A full analysis of the reason for intersections, or not, grounded in the theories from which the domains of constraints were derived, is offered in Cowan [8]. Important here is that the constraints across the theories overlapped in a logical way, highlighting the benefit of using a multidimensional model. As well, there were no indicators of constraints outside of the theories identified in the open coding process, suggesting the model is sufficiently comprehensive.

The second aim was to use path dependence as a lens for understanding the dynamic and compounding influences of constraints by mapping critical junctures and subsequent sequences of decisions through time according to theory constructs. This was done through a sequential decision mapping process in which identified constraints were linked to critical junctures as reinforcing mechanisms.

Table 2. Patterns of intersections across dimensions of constraints in the narratives (adapted from Cowan [8]).

Produ-ction Control Theory	**Image Theory**		**Value Chain Support Functions**				**Value Chain Primary Functions**			
Adaptation	Plan	Goal	Infrastructure	Technology	Procurement	Human Res. Man.	Inbound logistics	Operations	Outbound logistics	Market.& Sales
√	790	0	157	380	17	71	5	144	1	3
				Support function total: 625				Primary function total: 153		
√	0	31	18	6	0	5	0	3	0	0
				Support function total: 29				Primary function total: 3		
×	201	0	82	5	75	30	7	4	1	6
				Support function total: 192				Primary function total: 18		
×	0	100	32	0	1	28	0	0	0	0
				Support function total: 61				Primary function total: 0		
×	0	0	38	0	1	0	0	0	0	1
				Support function total: 39				Primary function total: 1		

The rows indicate patterns identified in the research and the numbers indicate the number of times data were coded according to the dimensions. Some data were coded as changes to multiple functions. Service function is not included given no data were coded as such.

There were 264 critical junctures identified across the farm narratives. The sources of these critical junctures were identified as: extreme weather, changes to public policy, market changes, personal and family context changes, and endogenous threats or opportunities for the farm (or for profit margins). Of the 264 critical junctures identified across the farm narratives, 235 were identifiable as associated with reinforcing decisions. As well, of the 1085 sections of data coded as constructs of constraints, 1059 were identified as linked to critical junctures (see Table 3). Additionally, there were 29 critical junctures that were not identifiable as leading to specific reinforcing decisions and 26 sections of data coded as constructs of constraints that were not identifiable as stemming from a specific critical juncture. These anomalies, explored in depth by Cowan [8], were clearly explained and deemed not to reflect gaps or misalignment within the conceptual model.

The rationale used within the decision mapping process is articulated within the individual farm matrices in Appendix E of Cowan [8]. Table 4 is an example of the identified linkages within one of the narratives. Note that the names attributed to the farmers in this research are pseudonyms.

Table 3. Summary of results of decision mapping (adapted from Cowan [8]).

Characteristics	Sources of Critical Junctures						
	Extreme Weather CJ*S	Policy Change Cjs	Market Changes Cjs	Personal & Family Issues Cjs	Identified Opportunity On-Farm Cjs	Identified Threats On-Farm Cjs	Total**
# of CJs linked to reinforcing decisions	25	18	12	73	56	57	235
Total number of reinforcing decisions associated with this source of CJ	249	79	51	368	217	171	1059 (26 were not linked)
Range (# of reinforcing decisions linked)	2–26	1–13	1–15	1–44	1–44	1–11	
Median (# of reinforcing decisions linked)	9	2	2	4	2	2	
Mean (# of reinforcing decisions linked)	10	4	4	5	4	3	
Number of CJs not linked to reinforcing decisions	0	2	1	17	7	2	29

* CJ means critical juncture ** The totals are not a summation of the totals in the subsection (row), as six critical junctures were identified in relation to two sources, meaning subsection totals are higher.

Table 4. Example of identified linkages between critical junctures and reinforcing decisions from Narrative 6 (adapted from Cowan [8]).

Coded Data	Rationale
CJ: In 1991 Frank's younger brother finished school and returned to work on the farm.	Change in family labour units
RD: Given there were to be three people working on the farm they decided to buy another property to continue to increase the size of the business.	increased labour leads to growing business phase
RD: bought a 637-acre outblock development of land	buying land to grow business
RD: to redevelop the outblock so that they could use it for fodder production and running dry/young stock.	bought to aid in growing the business
RD: put up fencing	fencing of land bought to aid in growing the business

Table 4. *Cont.*

Coded Data	Rationale
RD: laser graded 100 acres	laser grading of land bought to aid in growing the business
RD: Frank and his family have invested considerable resources over the recent farm history on improving the outblock.	reflection on investment in the new block bought to aid in business growth
RD: put in 50 acres of perennial pasture for the heifers they planned to run on the property.	installation of pasture on newly developed land bought to grow the business
RD: 70-90 beef cattle on the outblock as well, because they had enough land to carry the extra stock at the time	extra land in newly purchased block means there is space for beef cattle
RD: Much of the outblock has been used for fodder production.	use of land bought to grow the business
RD: Frank has also grown oats and wheat.	use of land bought to grow the business
RD: brings the fodder from the outblock home to the dairy farm to feed to his cows.	use of land bought to grow the business
RD: He now uses that land for stock over the winter.	use of land bought to grow the business
CJ: Frank's farm didn't cope very well with really wet winters . . . the wet winters were not good for the cows. The cows would get mastitis because they would be "lying in the wet all the time".	Threat identified in land not being good in wet -Reduces farm capacity to graze cows over winter.
RD: Once they bought the outblock they had another option for the wet winters.	option for managing grazing cows over winter
RD: changed his pasture mix in recent times so that the dairy farm is mostly annuals and can handle a lot more water over the winter.	changing to annuals reduces threat associated with wet winters, but change was made in response to drought.
CJ: They did it to increase cash flow over the winter to help with their loan repayments for the new property.	opportunity identified with winter milk prices. Problems with wet winters reduced with access to new outblock, plus they need money to pay for increased debt associated with the outblock
RD: started split calving	change practice associated with desire for winter milk money in 1991
RD: have practiced split calving "on and off" over the years.	change practice associated with desire for winter milk money.
CJ: He is doing it because of fertility issues.	Threat identified due to fertility issues
RD: Over the last three or four years Frank has been split calving again.	split calving due to fertility issues
RD: He got five Swedish Red heifers	changing breed due to fertility problem decided to try a different breed because of the farm's fertility problems.
RD: Frank decided to start using the Scandinavian Friesian semen to help improve fertility while maintaining a Friesian herd.	after changing breed due to fertility problem decided to change to a Friesian genetic line due to concern that he will lose his Friesian genetics if he goes with the Reds - which would have given him cross bred cows

CJ = critical juncture, RD = reinforcing decision

3.1. Path Dependence is a Reality for Farms

Overall, the outcome of the decision mapping employed in the analysis supported the claim that path dependence exists in farms, can be very constraining and can tip the farm suddenly into a more vulnerable state. Path dependence was apparent in the experiences of lock-in that were identifiable within several farm narratives. An example here is the state of Paul's dairy farm before he changed his business to a cropping enterprise (Narrative 16):

> *With the dairy enterprise, Paul described how they had "gone down a certain pathway" to a "large herd that was intensively fed". They "couldn't break out of that path very easily". Paul pointed to the difficulties he had getting cows in calf as an example. The calving problems pushed Paul into calving three times a year. As well, Paul and Patricia had an increasing problem treating sick cows.*
>
> *Overall, Paul and Patricia had a number of problems indicating that their production system was "unsustainable on a whole stack of levels". Paul didn't think that his dairy farm was "sustainable in the long term, from a workload viewpoint, from a farming system viewpoint, from an animal health viewpoint, from a lifestyle viewpoint".*

Interestingly, for three of the four farmers who shifted out of dairy production, the decision to change was clearly linked to the path-dependent state in the farm business. In addition to Paul's experience, Owen had intensified as much as possible given his lack of land for expansion, but had been unable to expand the business for years because of an inability to make further improvements (Narrative 15). As well, Matt was forced to sell the dairy enterprise after his son left and Matt faced debts associated with a series of recent changes (Narrative 13).

Across the 16 farms, what became apparent quite quickly was the limited set of feasible options available to make farm system changes. This is related to the limited set of production paths available associated with dairy farming. The initial decision to create a dairy farm eliminates a whole set of options given that dairy production requires the capacity to maintain a herd of lactating cows and extract milk from the herd on, typically, a twice-daily basis. For example, farmer interviewees bred Jerseys, Friesians or cross-breeds. "With breeding choices it was just a decision that if you went one way you had to keep going ... go Friesian or go back to Jerseys and stop there" (Narrative 2). The limited set of feasible options implies some degree of commonality across production systems.

3.2. Diversity in Constraints

While the limited set of feasible production decision options implies commonality, other factors in the findings indicate diversity in experiences and the associated degree of constraint among farm businesses.

First, similar changes in the operating environment led to critical junctures for some and not for others. Reconfiguration (or modernization) of the public irrigation system is an example of this. The modernization program imposed alterations to irrigation access points for all irrigators. It also included the negotiated rationalization (removal) of access points and spur channels affecting irrigation practices. Though the policy applied to all irrigators, only where the policy was perceived to be a threat or opportunity to the business was a critical juncture triggered. For example, Colin identified that "[d]uring the modernization process NVIRP [Northern Victoria Irrigation Renewal Project], he put in five mechanized gates. Having the new gates 'saved a bit on labour'" because he rationalized an outlet and the other five outlets were converted to flume gates (Narrative 3). As well, "[i]n the middle of the drought Isaac's outlets to the public irrigation system were automated as a part of an irrigation modernization program". This led to "concerns over 'gates not opening or shutting properly'" which forced Isaac to alter how he timed irrigation to ensure he is there when the water was meant to turn off (Narrative 9).

Second, at times, similar critical junctures led to different responses. The difference in responses to fertility management is an example of this. Fertility issues were identifiable as a source of critical juncture within nine narratives. High numbers of "empty" (*i.e.*, non-pregnant) cows pose a risk to the farm business, given the importance of maintaining herd lactation. There were a number of ways to manage fertility problems that farmers described. These included changing herd genetics, improving nutrition, administering supplements that promote ovulation, drying off the cows early enough to allow sufficient rest before calving and changing the calving pattern (typically spring or spring/autumn as "split" calving). The management responses actually undertaken by the farmers differed. For example, Colin did not consider split calving to be an option because he ran his business as a single person operation. Split calving required milking all year round and he did not know "how they get the energy" for split calving (Narrative 3). Instead Colin "started breeding Jerseys" (Narrative 3). In contrast, when considering changing genetics as an option, Paul stated that he "didn't believe that strategy had any credibility" as genetics were not necessarily the issue (Narrative 16). Instead, Paul focused more on nutrition and breeding practices as a response.

Third, similar responses resulted from different critical junctures, at times. An example of this is highlighted in the different reasons farmers decided to alter their calving patterns (Table 5). Some farmers described the reason behind their calving pattern choice in terms of managing fertility issues (e.g., Narrative 9, 10), financial gains (such as an opportunity to receive winter milk incentives) (e.g., Narrative 4, 8), matching herd needs with feed availability (Narrative 2, 13), farm labour constraints (Narrative 3, 7) and compatibility of grazing pressure with the farm in wet weather (Narrative 11, 14).

Table 5. Summary of contextual factors influencing calving pattern decisions of dairy farmers (from Cowan [8]).

Narrative	Spring Calving	Split or Autumn Calving	Contextual Factors Associated with Calving Pattern Choice					Rationale
			Herd Fertility Issues	Financial Benefits	Feed	Labour	Wet Weather	
1	√					√		Spring calving gave him 6 weeks off. He considered autumn calving because of change in feed availability and winter incentive but didn't change because of costs associated with changing over (e.g., extended lactation) and there would be no money over Christmas period
2	(√)	√			√			Switched to split calving due to drought and change in feed availability. Maintained a Friesian herd
3	√					√		single person farm, workload issues
4	√	(√)	(√)	√				changed back to spring after costs of split calving were calculated to be greater than benefits
5	√	(√)			√			Converted to autumn calving during drought due to feed availability, but returned to spring calving after the drought
6	(√)	√	√	(√)			(√)	First time split for $, then back to spring due to wet, then back to split for fertility
7	(√)	√	√			(√)		After converted to split calving he found it draining, because there was not downtime—Eventually he sold the herd and converted to cropping so he gets more downtime
8	(√)	√		√				Split calving for winter milk incentive
9	(√)	√	√					Split calving to manage fertility issues
10	(√)	√	√					Split calving to manage fertility issues
11	√						√	For winter milking would have set up feed pads and sheds to house cows due to land not being good in wet
12		√	√	√				Split calving to manage fertility issues and obtain the winter milk incentive
13	√	(√)		(√)	√			tried split calving one year to obtain the winter milk incentive but didn't stick to it as too different to current system (feed needs trumped extra income)
14	(√)	√	√				√	& changed proportions to increase autumn calving because they bought land that was better in winter

Table 5. *Cont.*

Narrative	Spring Calving	Split or Autumn Calving	Contextual Factors Associated with Calving Pattern Choice					Rationale
			Herd Fertility Issues	Financial Benefits	Feed	Labour	Wet Weather	
15		√	√					Ended up calving all year round, based on fertility issues
16	(√)	√	√					Ended up having to keep altering calving to suit empty cows, went from 2 to 3 calvings a year

(√) indicates data about previous decision regarding calving (those who have altered calving patterns more than one).

While these examples of variation in experiences with critical junctures imply diversity among farms, they do not offer a reason for such heterogeneity. As previously stated, the limited set of options for configuring a dairy production system implies commonality among production systems. This suggests that the heterogeneity among farms is associated with other factors. Such factors were identified in this research associated with the family and personal context of the farmer, as well as the dynamic interaction among constraints.

3.2.1. The Role of the Farmer and Family

The sources of 91 critical junctures identified in the research related to the family and personal domain of the farmer, of which 73 were linked to chains of reinforcing decisions (see Table 3). This related to: changes in personal and family goals, including marriage and children; episodes of family tragedy; or changes to farm ownership, management, succession planning and available family labour. Insights from this research on how one's family and personal circumstances influence change decisions are considered in-depth within Cowan, Wright, Kaine and Cooksey [51].

It is worth noting here that, at times, while these critical junctures led to changes in the farm, some stemmed from issues that were not directly related to the farm but instead related to the goals of the farmer and family. Lachlan's off-farm business interests are an example of this. Lachlan "became involved in another business off-farm that was essentially a seven-day-a-week business", which reduced the time he had to put into the farm (Narrative 12). This led to changes on the farm, such as "Lachlan employed someone to manage the milking and Lachlan came home in the afternoons to do all of the other farm work" (Narrative 12).

Another example of this was Neil's decision to make changes to the farm's infrastructure to meet his family goals. Neil was concerned that the "huge" hours invested in dairy farming "could 'get pretty tough on the family life'" (Narrative 14). Neil and his wife "wanted to decrease the amount of time that Neil was putting into the farm so that he could 'spend a bit more time at home with the kids'" (Narrative 14). "Growing feed and irrigation were the biggest jobs on his dairy farm, alongside milking the cows. He hoped to make those jobs easier to make dairy farming 'quite a reasonable lifestyle'" (Narrative 14). Neil decided to invest in converting his farm over to a pipes-and-riser irrigation system which required less of his time to manage.

Personal and family circumstances are a significant source of the diversity in production path decisions and the associated path dependence. This means that apparently similar production systems can have differences in their degree of path dependence based on farmer's idiosyncratic personal and family contexts. Hence, considering the farmer's trajectory image, as the source of personal and farm business goals is central to understanding constraints. Overall, what constituted a critical juncture for a farmer was endogenous, which means that it was defined by the context of the farm business, including the personal circumstances of the farmer.

3.2.2. The Dynamic Interaction among Constraints

Path dependence entails consideration of the interaction, through time, between critical junctures and reinforcing decisions. This suggests that dynamics matter, which was confirmed in the findings of this research. Following are examples of the role dynamics played in the experiences of farm managers, focusing on critical junctures, given their indication of a constrained state.

First, dynamics could be seen in the compounding nature of some critical junctures. For example, some critical junctures were triggered by multiple sources that converged to create a need for change: Paul described that his "world came crashing down from the point of view of water availability, and a combination of low milk price and high feed price" (Narrative 16).

At other times, critical junctures were generated through compounding problems. Ben's experience offers an example of this:

> *In 1995, there were significant changes in the family: Ben and Betty had their first baby, a daughter, and, in late 1995, Ben's mother died of cancer. This increased the pressure on Ben to do more on the farm as Ben's father decided that it was time to transition away from owning and managing the farm (Narrative 2).*

Such compounding problems imply an increasingly constrained state that leads to the critical juncture.

The identification of compounding sources of critical junctures found in the narratives aligns with the thinking underpinning this research that multiple dimensions of constraints may be influencing the farmer at a particular time. As well, it is possible that a confluence of multiple changes simultaneously can generate a critical juncture, while separately they may not. This indicates that potential sources of critical junctures are best understood in the light of other potential sources of critical junctures, highlighting the benefits of considering critical junctures in relation to the different constructs of constraints offered in this multidimensional model.

Second, at times, the histories of farm decisions were described in a way that revealed the compounding constraints as sequences of critical junctures. For example, Isaac experienced a critical juncture when his "father retired in about 2001–2002, just prior to the drought" (Narrative 9). In response, Isaac purchased his father's share of the business. "In order to buy Isaac's father out of the business Isaac and his wife borrowed about 40 per cent of the farm asset value from a bank" (Narrative 9). When the drought took hold, this created a second critical juncture. "[W]hen the drought arrived it was 'stressful' and 'a traumatic time' for Isaac" (Narrative 9). The critical juncture that occurred for Isaac due to drought is, in part, linked back to the increased debt incurred when he purchased his father's business.

A striking example of serial critical junctures was the experience on Matt's farm in relation to a series of decisions about irrigation water (Narrative 13) (see Figure 4). In the early 1980s, Matt's farm was consistently struggling to have enough water, even with 100 per cent of "sales" water (water purchased in addition to the farm's allocated entitlement), due to low irrigation entitlements that stemmed from initial policy decisions at the time of the soldier settlement scheme in the 1940s. At that time, in the early 1980s, there "were reduced-interest rate salinity loans available to do infrastructure upgrades" (Narrative 13). This created a critical juncture. Matt and his family decided to access the loan program to put in a 50 ML dam in the middle of the farm as it would enable them to irrigate more areas of the farm more easily and efficiently.

Given the size and depth of the dam, there was a risk that some of the water would be wasted unless they installed a sufficiently large pipe to enable access. The pipe they installed produced such fast flows that it blew out the farm's irrigation channels, making irrigation unworkable (Narrative 13). This created another critical juncture. Matt and his family then had to install bigger channels in the irrigation system to manage the faster flows.

Once the larger channels were installed and faster flows were being achieved, Matt and his brother realized that they could not manage the irrigation as they used to. They simply could not get around to the irrigation bays fast enough given the faster flows (Narrative 13). This created another critical juncture. They had to come up with a way to manage their farm irrigation in light of the faster flows. This led them to automate their irrigation system. While the automation technology on the farm has changed over the years, since the initial decision to automate, Matt continued to run the irrigation as an automated system.

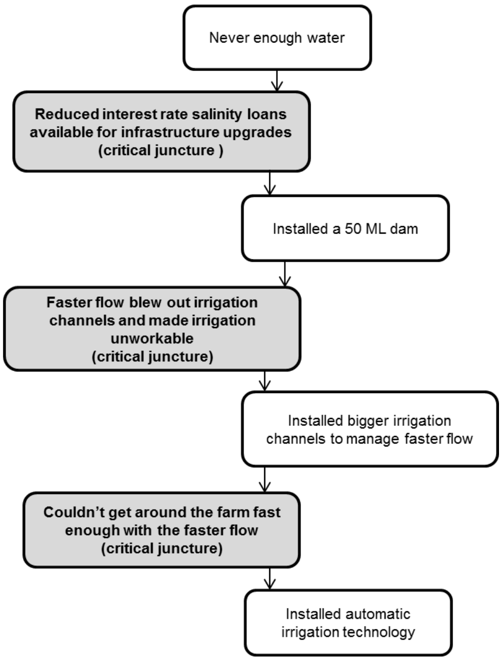

Figure 4. A cascade of critical junctures caused by problems integrating infrastructure changes within the existing production system; an example from Narrative 13 (from Cowan [8]).

In this example, the cascading effect of one critical juncture leading into another related to problems integrating the infrastructure changes within the existing production system. At other times, a series of critical junctures can occur stemming from an injection of change to context, which does not cascade from the initial critical juncture. This can reflect a tension between competing critical junctures. An example of this can also be seen in Matt's narrative (see Figure 5).

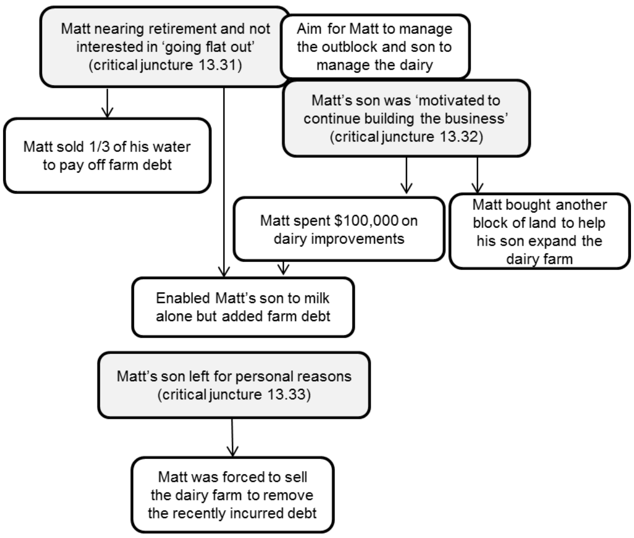

Figure 5. A series of critical junctures associated with changing context, example from Narrative 13 (from Cowan [8]).

Matt was not interested in "going flat out" as he was nearing retirement and sold a third of his irrigation water to pay off all of the existing farm debts (Narrative 13). The family's goal was for Matt to manage a 500 acre (non-contiguous) outblock and his son to manage the dairy farm, as Matt's son was "motivated to continue building the business" (Narrative 13). This did not necessarily align with Matt's aim to minimize debt as he neared retirement, which was reflected in his decision to sell some of his water.

Matt was persuaded by his son to buy another block of land and fund a A$100,000 dairy (milking) shed upgrade to make it "a one-man shed" (Narrative 13). This enabled Matt's son to milk alone, an important factor given Matt's interest in reducing his workload. The changes also increased farm debt. In this circumstance, Matt was trying to balance his personal goal for retirement with his son's goals regarding building the business.

Unfortunately, Matt's "son announced that he was leaving the farm for personal reasons" shortly after Matt paid to upgrade the dairy shed and bought the new land (Narrative 13). Matt could not run the farm alone and had to sell the dairy business. While selling the dairy farm "was unexpected and traumatic", it was through selling the business that Matt and Marie were able to extinguish the debt incurred through the recent changes (Narrative 13).

The cumulative effects of serial critical junctures arguably go to the core of the problem of using relevant distributions of variables, in a comparative static analysis way, to judge the likely impacts of change. Often implicit in static analysis is an assumption of compensatory effects: that, for example, a flood (extremely high rainfall) offsets a drought (extremely low rainfall), and a surge in prices follows a slump in prices. The reality of the impact of sequences of critical junctures, or "impactful events", on plausible, subsequent absorption or adaptation responses, and the potentially idiosyncratic nature of these from small business to small business, is apparent in these narratives. One way to characterize the effect of this process is that it persistently modifies, over time, the practical meaning, across an industry sector, of relevant distributions of variables (prices and inputs). That is, the assumption of compensatory effects can be expected to become increasingly divorced from reality, generally, as path dependence progressively defines the exact nature of the vulnerability that evolves for each specific family business from its initial restriction of flexibility: the commitment to a specific production system, a product-market domain.

3.2.3. Time

Time was a critical factor influencing constraints farmers faced. There are two elements of time of relevance here: the timing of events in relation to relevant elements of the farm and context, and the amount of time available to respond.

The timing of events had an influence on farm constraints. For example, two farmers identified timing as a factor leading to their children not being involved in the family farm. Harry described how his son "started working on the farm in the 1970s, during the crash in the market for stock" (Narrative 8). Farmers were killing and discarding stock in pits, as they could not afford to feed the animals. Harry's son "'got educated when the cattle went in the pit' and chose a different career path" (Narrative 8). Isaac described how his "son left school at about the same time that Isaac had cut back his herd size" during a recent severe drought (Narrative 9). Isaac believed that his son "'probably would have come home on the farm' if the timing had been different" (Narrative 9). Timing is likely to be a factor when considering compounding and serial critical junctures.

The length of time available to a farmer between identifying a critical juncture and the need for a response was a determinant of the response options available. At times, critical junctures emerged suddenly in the task environment (e.g., flooding: Narrative 4), within the family (e.g., death of a family member: Narrative 5), or as identified opportunities or threats within the farm (e.g., anthrax outbreak: Narrative 13).

As urgency for a response increases, the options available to the farmer decrease. This was the case for farmers managing fertility issues, a problem in which time was an impediment on decisions.

Herd fertility was identified as a problem within 11 narratives and could appear quite suddenly. While there were a number of options for managing fertility that interviewees described, most of these were only useful in the next season (e.g., nutrition management) or beyond (changing genetics) and did not address the current circumstance.

In reality, options for managing fertility were quite limited for farmers when suddenly faced with a number of "empty" (non-pregnant) cows. To manage the immediate problem, farmers needed to either cull the cows, carry the empty cows with reduced lactation for a year or join the cows and, in doing so, shift to split calving. This required a quick decision. Most interviewees who had fertility problems immediately altered their calving pattern from spring to split calving in response. However, altering the farm calving pattern did not *correct* the infertility problem for interviewees; instead, it offered a way to *manage* it, in which cows are given a second chance to get in-calf. This implies reduced efficiency in herd lactation through time as joining procedures had to be repeated and cows of lower productivity were carried into another calving season. While split calving can appear to be an insufficient response to a fertility problem, especially given farmers were still struggling with it (e.g., Narrative 9), there were few options, given the timeframe within which farmers had to make a response decision.

Time can be described as an impediment in decision making. As a lack of time reduced the set of change options for the farmer, the path dependence associated with the current path increased. This implies that consideration of critical junctures and potential responses to them needs to be mindful of time. Hence, a dynamic framing of constraints is critical for a comprehensive understanding of decision options in farms.

As well, the influence of timing injects the possibility of "luck" to the nature of constraints on farms. This implies that outcomes can be the result of interactions between the farm and changes in context that can emerge in unknown and unexpected ways. For example, it is possible that a very similar decision, such as a land purchase, is made by different farmers and leads to very different outcomes, in part because of time. This suggests that inferences about the capabilities of managers based on the survival, or not, of the business may be incorrect.

Time was found to influence the business decisions of these farmers. As well, time plainly matters in understanding the cumulative effects of critical junctures on firms, as described in the previous section. This further implies the merit of dynamic analysis.

3.3. The Performance of the Approach

Path dependence worked very effectively as an approach for assembling the constraints that arise out of the decisions of farm managers. Overall, path dependence reflected the emergence of a constrained state that stemmed from the interaction of constraints derived through the three theories (production control, value chain, and image) and the existing path.

The approach involved the identification of constraints in the overall farm management context that were well beyond those considered in aggregate analysis (e.g., [77,78]). The rich diversity in constraints on decisions revealed across farms suggests there is no reliable basis for sectorial modelling of decision making in response to climate change or other sources of secular change.

The results do, however, enable contemplation of the aggregate implications of constraints acting over farm decision making in response to secular change, such as increased climate variability, and suggest that a comparative static analysis of responses to climate change may provide an overly optimistic perspective of response capability and timeliness.

The diversity in sources of constraints, seen clearly in the critical junctures, led to diversity among farms, in terms of paths and path options, hence path dependence. While one could easily infer considerable homogeneity across the farm businesses, this would conflict with the substantial diversity in farms that was found to stem from the farmer and family. Analysis of decision making needs to focus on farmers' objectives and perceptions, described in terms of principles, and personal and higher-order business goals, as these were key determinants of choices made in relation to the farm.

The diversity of farm paths and path dependence is more complex than can be understood through static contemplation of multiple sources of constraints. This is due to the cumulative effect of compounding constraints. This analysis revealed the dire consequences that emerged for farmers from the accumulation of impacts associated with serial years of drought and compounding factors of policy change and reductions in output prices. Simply put, path options narrowed for farmers as they depleted limited farm, personal and family resources to manage variable milk prices and back-to-back years of reduced access to irrigation water. This implies that there are risks of incomplete and possibly invalid analysis associated with failure to contemplate the dynamic and cumulative impacts of constraints. In essence, lack of attention to path dependence can lead to assumptions of greater flexibility than actually exists. This finding was consistent with the thinking of Thompson and Powell [79] and O'Meagher, *et al.* [80] which highlighted the importance of considering cumulative effects from multiple interacting sources of variability in the development of Australian drought policy.

One implication of these findings is that vulnerability is not observed adequately by contemplating secondary data such as trends in relevant variables in operating environments or farm (or firm) debt. Management contexts are more subtly constrained. There would seem to be a need for common models of path dependence, within industry sectors, to be sought if the diversity of vulnerability is to be identified in sufficient fineness for policy purposes, including skills training.

4. Australian Family Farms and Climate Change

Our research findings suggest that farmers are already struggling to cope with the endemic uncertainty that they face in the operating environment, which could be seen in the path dependence that we identified in the experiences of the dairy farmers. However, the increased variability and associated uncertainty stemming from climate change can only imply increased vulnerability for Australian farms.

The increased vulnerability can be seen in the business options for managing climate change impacts. Farmers will need to configure their farms in a way that expands their repertoire of responses (described as "tactical" and "strategic" flexibility in production control theory) to maintain viable businesses as input variability increases with the progression of climate change. There are tradeoffs associated with this, such as a reduction in technical efficiency [63,81,82]. For example, a dairy farmer's decision to create a feed reserve for times of drought locks away resources that could otherwise be used on the farm. There are also costs associated with exercising or activating business responses to manage variable access to inputs, including the loss of flexibility that can occur to respond in the future. For example, if a dairy farmer uses a feed reserve during drought this reduces the capacity to do so in the future, until a new reserve can be created. This is an important consideration given the compounding nature of impacts identified in the research. Overall, the costs to farm businesses suggest increased vulnerability over time.

Internationally, there has been increasing pressure to increase climate change adaptation, such as the recent Paris Agreement by the United Nations Framework Convention on Climate Change [83]. This pressure will likely encourage government intervention in agricultural sectors to mitigate climate change impacts (e.g., methane) and support industry adaptation to impacts (e.g., altering what is being produced and how it is being produced). For example, governments may need to intervene to ensure that the adaptation in agricultural industries is sufficient in strength and timeliness to meet expectations for Australia's emission reductions while maintaining viable industries.

An element of industry adaptation is that some farm businesses will fail at a higher rate than they currently do because of the increased vulnerability they face. However, the persistent slow decline that can occur in family farms may leave people stuck in failing businesses. Agricultural adjustment policy could play an important role in supporting the timely transition of farms.

5. Applicability of the Approach to other Small Family Businesses

There is little surprise in the suggestion, and our finding, that the history of firm management and performance plays a major role in defining the context for future decisions and performance, and therefore vulnerability. Path dependence analysis, and the use of production control theory, value chain concepts and image theory, offer the possibility of systematic exploration of the existence and magnitude of path dependence, as well as the attendant management constraints.

The contribution of this approach is that it makes it possible to escape the coarseness of effectively assuming away the rich variety in businesses within a sector when it is analyzed using static approaches. The same is true of aggregate analysis of small firms within a sector: it is unlikely that aggregate statistics formed over secondary data can wash out relevant diversity across the firms. The type of approach used in this study can help avoid errors generated by relying on such analysis. It does this by enabling the mapping of key processes and relationships, including business-family relationships, thereby identifying paths and path dependencies.

For some purposes, such as contemplating taxation policy, this is very likely irrelevant because the policy is usually not sector-specific. For others, such as considering industry policy (investment incentives, rationales for assistance, business adjustment assistance, *etc.*), policy effectiveness is likely to be closely linked to the fit of the policy with individual business contexts. There is nothing in our findings to warrant an assumption that salient characteristics of such individual contexts can be expected to "average out" usefully either in aggregate or over time.

This approach offers a feasible way to lift the analysis of industry sectors to a more sophisticated level thereby enabling more apposite policy, both public and private. Further work to refine analysis using this approach, and make it less resource intensive, would enhance the potential contribution.

The agricultural context of the original study was chosen for a variety of reasons, not least the clarity of the presence of threats associated with climate change for Australian agriculture. The lack of management control overall, relative to other small family businesses, provided as demanding and complex a context as any in which to test the analytical approach. This encourages the expectation that the approach is relevant to other sectors and very likely susceptible to efficiencies in application in them, given their less routinely unpredictable operating environments.

6. Conclusions

The Australian agricultural sector is subject to considerable volatility and seriously exposed to whatever shocks climate change is going to bring. The near-perfectly competitive structure of the sector, while having many societally appealing characteristics from the point of view of economic theory, is arguably unmanageable in the long-term. For this reason, among others to do with the geographic remoteness of farms in one of the most urbanized nations in the world, government policy often reacts to the welfare impacts of extremes in variability of inputs. Small family farms are the characteristic target government, backed by public pressure, has in mind. Despite sustained argument for fewer economically "irrational" responses to "crises" on farms, from the prevailing neo-liberal perspective, these reactions are persistent. Indeed, the matter of the appropriateness of government intervention in an industry becomes more complex with a greater awareness of business heterogeneity and, particularly, a clearer view of the impacts of unforecastable events in the operating environment. Specifically, the notion that a competent manager must be aware of, and deal with, risk and uncertainty in the operating environment of their business connotes much less to policy makers if the survivability of a business relies significantly on luck in the sequence of plausible events encountered.

Relatedly, government policy directed at non-farm small business is usually under active consideration, not least because such a significant proportion of employment is generated there. In this domain, as in agriculture, policy effectiveness, and the avoidance of perverse incentives (that is, dysfunctional policy), relies on well-designed policy which, in turn, relies on valid understanding of the management context into which policies are targeted and will evoke their response.

Particularly in the context of small family businesses, with their richer variety and complexity of motivations than corporations, aggregate and static analysis is often inadequate for useful government policy. The same is true of useful policy advice from small business representative organizations. The approach considered here may have an important role to play in enhancing policy design.

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