

4 Analysing path dependence in farms

4.1. Introduction

In the previous chapter I described the research design and methods associated with a conceptual model for characterising constraints on decision-making in farms.

Characterising constraints requires analysis of relationships among multiple dimensions of constraints. This includes consideration of how constraints, as defined from different domains in the literature (i.e. farm control theory, images and value chain functions), intersect in the farm. This also includes consideration of how constraints influence each other dynamically and cumulatively (i.e. critical junctures and reinforcing mechanisms). These two elements provide the backbone for analysis that is described in this chapter.

The analysis is offered here in three parts. First, I describe the relevant characteristics of the farms and producers who participated in the research. Second, I consider the patterns in relation to intersections among dimensions of constraints and highlight insights that can be derived from patterns that emerge. Third, I describe the cumulative and dynamic relationship among constraints through consideration of critical junctures and reinforcing decisions that flow from them.

I then focus on a number of implications that can be derived from this analysis of constraints. In the next chapter I contemplate the ability of the conceptual model

adequately to characterise the decision-making context of producers. This will lead into discussion of constraints on decision-making in relation to climate change and implications for policy development and implementation.

4.2. Farm and farmer characteristics

I interviewed 12 current dairy producers and four producers who had converted from dairy to different farm enterprises. Two of the four ex-dairy producers had converted to cropping (Narrative 7 and 16), one had converted to stock agistment (Narrative 13) and one had converted to beef (Narrative 15). I sought interviews with producers who had been on their farms for at least 20 years, to ensure the interviewee could describe historical sequences of decisions about the farm. The newest producer (Narrative 4) among the interviewees arrived on the farm in 1989, 23 years before the interview. The interviewees ranged in age from 41 to 79, with a mean age of 54.8 (See Table 4.1). When considering the current dairy producers only, the age range was the same and the mean increased to 55.

Table 4.1: Data regarding current dairy producer interviewees

Narrative	Family first acquired land	Approx. age of primary interviewee	current land area (acres)*	Current milking cow #s
1	1920	65	91	140
2 (pair)	1961	47	808	330
3	1905	56	300	130
4 (pair)	1989	60	598	200
5 (pair)	1949	50	744	250
6	1967	47	897	220
8	1966	79	533	400
9	1960	55	300	180
10 (pair)	1872	68	310	260
11 (pair)	1944	48	393	180
12	1955	45	160	170
14	1957	41	860	340
Range	1872-1989	41-79	91-897	130-400
Mean	1946	55	500	232
Median	1956	52.5	463	210

*May include both dry and irrigated land

Table 4.2: Data regarding ex-dairy producer interviewees

Narrative	Current enterprise	Family first acquired land	Age of primary interviewee	current land area (acres)*
13	agistment	1949	63	500
15	beef	1957	64	720
7	cropping	1960	45	500
16	cropping	1940	44	withheld

*May include both dry and irrigated land

Five of the interviews were actually conducted with pairs of interviewees¹⁸. Four interviews were conducted with a husband and wife (Narratives 2, 4, 5 and 10). One interview was conducted with an 88 year-old retired father and his son, who is the current farm manager (Narrative 11). Farm narratives for the interviews conducted in pairs were written reflecting this. Both interviewees from an interview were given the opportunity to review the narrative and provide feedback. In three of the paired interviews the husband had the longer history with the farm (Narrative 2, 5 and 10), while one couple (Narrative 4) had bought the farm together. Age information regarding the farm manager participating in the research was derived from information given, by the husband in four cases and the son in one case, who were the current primary decision makers for the farm.

All but one (Narrative 4) of the interviewees had a multi-generational family history with managing their farms. The interviewees' families arrived on the farms over a diverse timeframe, ranging from 1872 to 1989, with a median of 1956. Fourteen interviewees had acquired the farm from another family member. Approaches to acquiring the farm varied and included purchasing the farm outright, private mortgages, establishments of family trusts, share-farming and inheritance.

Two of the 16 interviewees bought their dairy farms from someone outside of the family. These interviewees bought their farms in 1966 (Narrative 8) and 1989 (Narrative 4). The pair of interviewees who bought their farm in 1966 nevertheless had a multi-generational history with managing the farm as their son also managed the family farm.

¹⁸ There were other interviews where an interviewee's wife was present but did not verbally contribute to the interview. These were not considered as paired interviews. There was one interview (Narrative 16) that required follow up with the interviewee's father to clarify a small amount of specific data, but this was not counted as a paired interview.

The dairy farms ranged in size from 91 acres to 897 acres (with a mean of 500 and a median of 463). These dairy producers milked between 130 and 400 cows (see Table 4.1). One of the two cropping enterprises was on 500 acres, while the land area of the other business is not included in the narrative as it was withheld by the interviewee. The beef cattle enterprise was on 720 acres and the agistment enterprise was on 500 acres (see Table 4.2).

4.3. Analysis of relationships across dimensions of constraints

The first aim of the analysis was to identify patterns of intersections across the domains of constraints that were derived from farm control theory, image theory and value chains. To some extent, intersections were expected to indicate a degree of compatibility across theories. Where intersections did not exist, this was expected to indicate differences regarding domains of constraints, highlighting the benefits of using a multidimensional model. An important aspect of identifying congruence and dissimilarity was clarity regarding the reason for intersections, or not, grounded in the theories from which the domains of constraints were derived. In this section I describe what was found regarding patterns of intersections across constructs.

I begin by considering the intersections between adaptation and images. This enables contemplation of where production system changes interacted with producer objectives. Following this, I discuss differences among plan and goal image changes that were not associated with adaptation. I then discuss findings associated with the value image and guiding principles that emerged in the open-coding aspect of data analysis. Finally, I analyse the intersections between the value chain functions and adaptations and images. Overall, the intent of this approach was to build analysis of patterns by systematically adding relationships for consideration. Throughout the discussion an emphasis is placed on understanding and explaining dissimilarities among constraints.

Adaptation implies the existence of constraint on absorption. As well, adaptation is the active manifestation of a producer's capacity to make alterations to the production system. It is through adaptation that change is most clearly defined as overt responses in farm management to changes in the environment. Hence, I begin contemplating relationships here through consideration of adaptation.

Change within images was considered first in relation to adaptation. The model that I proposed in the previous chapter is based on the supposition that a hierarchy exists, with the value image sitting above farm business and personal goals, which sit above farm plans. Given the supposition that the value image and higher order goals in the trajectory image determine the producer’s framing of farm business goals, which determine farm plans, this hierarchy implies differences in constraints. Hence, distinguishing between these three images was the focus here. Implicit here was the notion that incompatibility of options within images, described by where change occurs, was reflective of constraint.

There were 821 adaptations identified in the 15 interviews conducted for this research (see Table 4.3). All data coded as adaptation were simultaneously able to be coded as changes within images, either strategic or trajectory, which suggested a strong degree of compatibility between farm control theory and image theory. Of the 821 adaptations, 790 were also coded as a change in plans (strategic image); such as when Edward “purchased an extra 110 cows” (Narrative 5), Isaac “sowed a paddock of lucerne on the 60-acre block” (Narrative 9) and when Matt “decided to sell a third of the farm’s 615 ML of permanent water entitlement in 2010” (Narrative 13). These data consistently described change to the production system or management practices directly relating to the production system.

Table 4.3: Patterns of intersections across dimensions of constraints

Farm control theory	Image theory		Value chain support functions				Value chain primary functions			
	Plan	Goal	Infra-structure	Techn-ology	Procur-ement	Human Res. Man.	Inbound logistics	Oper-ations	Out-bound 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			

Some data were coded as changes to multiple functions. Service function is not included given no data were coded as such.

Of the 821 adaptations, 31 sections of data were simultaneously coded as changes to goals (trajectory image) rather than plans. These 31 data segments differed from those identified as changes to plans in that the changes described were clearly of a higher order, in relation to family and personal or business goals (see Table 4.4). Some related to an intersection between family or personal goals and the farm. For example, “[w]hen Isaac’s children were ‘getting a little bit older’ and they all wanted to go away during school holidays, Isaac brought the spring calving back to around July 20th” describes a farm adaptation (changing calving timing) associated with a family level goal (timing of family holidays) (Narrative 9). Others related to changing farm business goals. For example, on Owen’s farm, the “farm business split in two”, which described an adaptation (splitting of the production system) that logically implied a change in farm business goals (Narrative 15).

Approximately half of these adaptation and goal intersections were instances where the producer described changing enterprises. For example, when “they got out of sheep” on John’s farm (Narrative 10) or when, “after five or six years, Paul’s father got out of sunflowers for three reasons” (Narrative 16). Changing enterprises entailed changing farm business goals.

The consistent link I found between adaptation and image change supported the idea that a change in system structure (adaptation) implied, at a minimum, a change in lower plans in the farm production system. The fact that there were differences, with some adaptations linked to plan change and some to goal change, highlighted two important points in this research. First, the difference indicated that the dimensions of constraints were not simply different ways of describing the exact same phenomenon. If they were synonymous, there would be no distinction between adaptations that were linked to plan change and those linked to goal change. Instead, there was a clear distinction between these two types of intersections, with changes to goals representing higher-order change in the farm business or family.

Second, the distinction between goals and plans that were both linked to adaptation brings to mind a question regarding whether there may be different types of adaptation, with different constraining effects on the farm business. The notion of adaptation in the farm systems literature relates broadly to all change on a continuum between absorption and adjustment, though it does not offer a clear way to distinguish types or degrees of

adaptation. Currently, distinctions to be made regarding different adaptations stem from insights drawn from the intersections with image and value chain constructs.

Table 4.4: Data coded as adaptations and goal changes

Narrative	coded data	Rationale for identification as a higher order change
3	bought his uncle's farm which brought the original 300-acre farm back	Personal goal to bring the original family farm back to one property after it was separated in an earlier generation
6	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	Family circumstances led to a change in labour units on the farm, which was the impetus for buying more land here
6	As Frank had just left school to work on the farm, Frank's father decided to purchase the block so that they could increase the farm size and milk more cows.	Changing family circumstances led to a change in labour units on the farm
6	This turned the farm into a predominantly one-man operation as their father was elderly.	Changing family circumstances led to a change in labour units on the farm
7	Geoff and Gini decided to go into cropping.	Changing farm enterprise implied changing farm business goals
9	At that time there was 'not much debt' in the farm. 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.	Buying farm implied changing farm business goals
9	When Isaac's children were 'getting a little bit older' and they all wanted to go away during school holidays, Isaac brought the spring calving back to around July 20th	Changing family goal led to change in farm
10	they got out of sheep	Changing farm enterprise implied changing farm business goals
11	In around 1978, Karl decided to get out of dairy completely and converted the farm to beef cattle.	Changing farm enterprise implied changing farm business goals
11	Keith decided to convert the 243 acres to dairying	Changing farm enterprise implied changing farm business goals
11	started new enterprises in dairying and pigs.	Changing farm enterprise implied changing farm business goals
13	decided to build a piggery so that he could use the surplus skim milk himself rather than give it away.	Changing farm enterprise implied changing farm business goals
13	subdivide a half an acre of the 58-acre block, upon which he built a house for himself and his wife	Changing family goal led to change in farm
13	sold the 400-acre dairy farm with 800 ML of temporary water	Changing farm enterprise implied changing farm business goals
14	bought a dairy farm	Buying farm implied changing farm business goals
14	Neil and his father started to run the business together and Neil was paid a share of the milk cheque (rather than a wage)	Changing structure of farm management entailed changing business goals
15	After three to four years of the same pattern, 'it started to get a bit much'. The farm was not bringing in enough income to pay for both Owen and his son. Owen offered the business to his son, as Owen had 'had enough'. Owen's son didn't want to take over the business and took a part-time off-farm job that quickly turned full-time.	Changing labour available to farm as a result of intersection with family
15	farm business split in two.	Splitting farm implied change to farm business goals

15	sold the dairy herd.	Changing farm enterprise implied changing farm business goals
15	Owen's father moved into town and stepped out of the dairy side of the farm business, though he did come out and help on the dairy farm.	Changing family circumstances led to a change in labour units on the farm
16	sold the family's original dryland farm and moved his family to the irrigated farm	Selling dryland farm and focusing on irrigated agriculture implied changing farm business goals
16	Peter and his wife took over a soldier settlement block that belonged to Paul's mother's parents.	Changing farm business goal when taking over a new enterprise type, dairy property
16	They maintained their investment in the dairy property until the late 1970s, as which point they sold the block.	Out of dairy farming entailed changing farm business goals
16	After being out of dairy farming for two years, Paul's parent bought a 200 acre dairy property near the 380 acre home block.	Buying a dairy enterprise entailed changing farm business goals
16	the other 525 acres was returned to a separate mixed farming block. The two blocks were run as "standalone" blocks.	Conversion of property to a mixed farming business entailed introduction of different enterprises and therefore different farm business goals
16	plant 20 acres of their best land to peaches and apricots	New enterprise meant a change in farm business goals
16	Peter decided to go into sunflowers	New enterprise meant a change in farm business goals
16	modified their plans, sold the herd and went into cropping.	changing enterprise meant a change in farm business goals
16	The orchard didn't last long however, as changes in the market reduced profitability of fruit production.	Getting out of fruit entailed changing farm business goals
16	after five or six years, Paul's father got out of sunflowers for three reasons.	Getting out of sunflowers entailed changing farm business goals
16	used the block for mixed farming	Enterprise decision regarding land use was linked to new farm business goal

4.3.1. Changes to plans that were not adaptations

There were 301 changes in plans and goals that were not identifiable as adaptations (refer back to Table 4.3, p. 103). The reason for this can be described differently for changes to plans and to goals. The strategic image, where plan changes occurred, relates to the farm business as a whole, including elements that are outside of the production system. Hence, changes in plans regarding aspects of the business outside of the production system were not adaptations as defined here. To understand this distinction more clearly we can turn to the value chain constructs for describing functions. These functions describe the farm business as a whole, which means changes in plans were identified as changes to at least one function.

Using the intersection between functions and the plan image helped in understanding how plan changes differed from adaptations. Within the narratives, 210 function changes were identified in connection with 201 changes in plans. Of these 210 function changes 187 were within infrastructure, procurement and human resource management

support functions of the farms. An additional 14 of the function changes occurred within inbound logistics, outbound logistics, and marketing and sales primary functions. These functions represent aspects of the farm business that clearly sit outside of the production system.

There were nine intersections between changes in plans and functions that, on the face of it, could have been adaptations but were not coded as such. These related to operations and technology development. I looked more closely at these data, given the apparent misalignment with the dominant pattern and found that, while they were unusual, they were logical (see Table 4.5). These instances related to registering a herd, hiring a consultant nutritionist, altering the procurement of feed and managing feed needs through the use of agistment.

Table 4.5: Changes to plans and operations or technology development that were not adaptations

Narrative	Coded data	Coded as	Rationale for not being identified as adaptation
1	"register his Jersey cows in 1980"	plan technology	Registering was new but no change to farm production system indicated in this statement. Changes to breeding in this case was described separately.
1	"help of a nutritionist"	plan technology	Hired nutritionist as source of information. The new source of knowledge was the identified technology. No described changes in farm practices associated with uptake of information here, though it may be implied.
2	"purchase in some extra feed, such as cotton meal"	plan technology procurement	Alteration to feed being procured. No implication in statement that how the cows were fed changed.
6	"had to feed out hay to his stock"	plan operations procurement	Had a history of feeding out his stock. There was a need to access increasing amounts of feed. No clear link to a change in practice.
6	"To prevent problems Frank agists locally"	plan operations	Managing feed needs by outsourcing feeding, not a production system impact.
8	"Harry agisted more of his cows. He trucked the cows wherever they could get agistment"	plan operations	Managing feed needs by outsourcing feeding, not a production system impact.
10	"agisting the young stock from his farm on this other block"	plan operations	Managing feed needs by outsourcing feeding, not a production system impact.
16	"bought grain for a fraction of the typical price by buying it from someone who 'had a contract for taking away the grain cleanings from around bunkers'"	Plan technology procurement	Change to purchase of feed including the type of feed being purchased. No indication here that farm feeding practices changed.
19	"agisted heifers to Tasmania."	Plan technology	Managing feed needs by outsourcing feeding, first time used the practice (hence technology development), not a production system impact.

The registration of the herd was not itself an adaptation; it was linked to other statements in the narrative regarding changes to herd management; hence the associated adaptations were identified within other coded statements. This was evidence of the importance of considering the interconnected narrative even when disaggregating and coding data.

The hiring of a nutritionist provided a new source of information that may or may not have led to changes in farm practices that would have indicated adaptation. In this statement the link to a change in practice was not clear, though it may have been implied. This anomaly highlighted the possibility that accessing a new source of information does not necessarily indicate an adaptation.

The other seven anomalous intersections all related to the use of feed; either the use of imported feed or outsourcing feeding through the use of agistment. Three of these anomalies were data that were also coded as procurement, which indicated that the changes related to the access and use of inputs rather than changes to the production system itself. The other four anomalies¹⁹ related to outsourcing feeding through agistment which did not align easily with value chain functions. In general terms, a dairy herd is a system component used to produce the milk, and nutrition is the energy given to the herd to enable the process of milk production²⁰. The idea that the herd, or part of it, can be shipped outside of the farm to be fed elsewhere may not have analogues in non-farm management practices. The anomalous intersection here may have been a by-product of farms not being central to Porter's conception of a firm. Hence, misalignment here draws attention to another source of benefits of considering farms within a multidisciplinary model.

¹⁹ Of the four anomalies described here three related to outsourcing through agistment were coded to operations, while one was coded to technology. The distinction related to the fact that the one linked to technology was identified as a first use of that practice.

²⁰ The herd-nutrition link occurs in a day-to-day sense, as cows need to obtain nutritional inputs to produce milk. If nutritional inputs drop then milk production will drop. The link also occurs in a seasonal sense, through the cycle of pregnancy, drying-off of cows, and calving that are needed to encourage higher-volume milk production.

4.3.2. Changes to goals that were not adaptations

There were 100 non-adaptation changes to goals identified within the farm narratives (refer back to Table 4.3. p. 103). While changes to plans in the strategic image are specifically in relation to the farm business, changes in the trajectory image can be in relation to the farm business or other aspects of the producer's life. This means that goal changes do not automatically lead to change in the farm business or, more specifically, the farm production system where adaptations occur.

In the narratives, there were 51 points where narrative data were simultaneously coded as changes to goals and value chain functions, indicating a change in the farm business outside of adaptations to the production system. All but one²¹ of these occurrences were associated with the infrastructure and human resources management support functions. The intersection between goal and infrastructure changes generally related to matching finances between personal or family needs and the farm. This can be seen in the following examples of data coded as changes to goals and infrastructure:

“any money that came in was being invested off-farm to set Keith and his wife up for retirement” (Narrative 11);

“Peter found that his off-farm businesses were his main sources of income and provided resources for the farm” (Narrative 16);

“Money that could have gone toward farm improvements had to be used elsewhere, to meet other priorities” (Narrative 1); and

“there has been a lot of pressure to keep his costs down so he ‘wasn't burdened with children at university on one hand and low milk prices and bank interest on the other hand’” (Narrative 3).

The intersection between changes to the human resource management and goals related to matching personal and family circumstances to farm management needs. This can be seen in the following examples of data coded as changes to goals and human resource management:

²¹ One intersection related to procurement and a decision to purchase temporary water during the drought to ensure there was some green grass. This was done as “a mental health insurance policy” for the producer, to look after his personal wellbeing during a stressful time, rather than for farm business reasons (Narrative 13).

“1969 Albert began working as an artificial breeding inseminator off-farm, which led to a 26-year part-time career in AI in which he artificially inseminated over 50,000 cows.” (Narrative 1);

“The tricky thing is that his wife is no longer interested in working in the dairy.” (Narrative 3);

“focus now is finding ways to make running the farm easier.”

(Narrative 6); and “Mark left the farm to pursue other interests overseas” (Narrative 13).

These links between changes in support functions and goals highlighted the interconnection between the farm business and family.

In the narratives there were 49 non-adaptation goal changes that were not linked directly with function changes. Twenty five of these were simultaneously coded as critical junctures, which indicated a trigger for change had been identified that intersected with a change in goals. This could be seen in Edward’s experience, in which family circumstances drove him to change his professional goals and return to the family farm.

Edward had no intentions of giving up music when they started having children. He thought he could do both. But he would come home after being on the road for a couple of weeks and his children wouldn’t know who he was. That changed things for Edward and he moved back to the farm with his growing family. (Narrative 5)

Another example of the connection between goals and critical junctures could be seen in Keith’s experience in which he was struggling to match family and farm goals when his wife’s off-farm business took more of her time away from the farm.

About four years ago his wife’s business was thriving and she was off the farm for an increasing amount of time. Keith took on the role of ‘home dad’. This meant that he looked after the house and managed the children’s needs. Keith did that over three years and it was difficult. The most challenging part was the evening milking as that same period was when he needed to be looking after the children and their needs and preparing the evening meal. Keith just couldn’t be in two places at the same time and he was “burning out”. (Narrative 11)

Goal changes at critical junctures indicated a trigger for change rather than the change itself; hence, it is consistent that they were not coded as adaptations or value chain

functions. What was expected was that further changes to images, adaptations and value chains would be evident as flowing from the critical juncture and would be apparent in the decision mapping analysis.

A change in the trajectory image entails changes in the strategic image. It was expected that change to the strategic image would intersect with value chain functions and, at times, adaptations. There were 24 points in the narrative coding where changes in goals were apparent, though no other domains of constraints were identified. It is worth considering why these goals did not intersect with other domains of constraints given my interest in congruence and dissimilarity across constructs.

While it is true that the trajectory image will entail changes to the strategic image, where changes to plans occur is determined by relevance. The goals being considered here were those of the producer, which means the goals could have been personal, family, or farm related. Seventeen of the coded data points were related to family and personal goals, while seven were related to the farm (see Table 4.6). It is possible that some goal changes may have entailed changes to personal and family plans outside of the farm, which may not have been picked up in the interviews and coding, given the interview focus on the farm business.

Potentially, such goal changes may have still had an influence on the farm business. Though some family and personal goal changes may not have altered farm context sufficiently to require a change in the farm business through adaptation or changes to functions, they may have constrained the business nonetheless. This was most obvious in relation to finances. While farm finances were clearly a part of the farm system, the intersection between family finances and the farm was not so clear. This meant that changes to goals that altered personal and family finances could constrain options for the farm business, though these constraints may have been less overt.

Table 4.6: Changes in goals that were not adaptation or changes in value chain

Coded Text	Personal & family goals	Farm related goals
Albert and his wife were putting two kids through university during that period (Narrative 1)	✓	
If he milked 150 cows for five years that should clear the debt and allow him and his family to have a reasonable lifestyle. Also, if none of his children were interested in farming, he and his wife could stay on the farm for longer if there was no debt. (Narrative 1)		✓
Using bulls was a bit easier and allowed them to spend more time with their children. (Narrative 2)	✓	
Edward wants to 'take control of the groundwater in the region'. (Narrative 5)		✓
Edward wasn't fully invested in farming at that time anyway. He was pursuing a career as a professional musician. (Narrative 5)	✓	
acknowledged that his business exists within a volatile world market that is not very high paying. This means that for the business to survive it needs to have 'very simple systems'. (Narrative 5)		✓
Frank didn't want to seem as though he was pushing his father aside as Frank took on more management of the farm business over the years. Frank and his brother still included their father in the farm as much as possible. Frank thinks that probably kept their father alive an extra 10 years. (Narrative 6)	✓	
When the partnership was dissolved, Geoff put a lot of effort in setting up his farm so that he could get more time away from the farm as he has 'never had a lot of time off'. Since he left school he had worked on the farm seven days a week. (Narrative 7)	✓	
The last four or five years that Geoff and Gini ran the farm as a dairy they really focused on keeping a 'great life balance'. (Narrative 7)	✓	
The 188 acres was bought in Harry's son's name. While Harry's son had been working on the farm for 16 years at that time, all of the land was in Harry's name. There were also some family circumstances at the time which meant that it made the most sense to buy that property separately from the farm. (Narrative 8)	✓	
Harry was able to clear all of the farm debt and buy a unit [apartment] in Melbourne, to diversify the income. (Narrative 8)	✓	
set the property up as a dairy business (Narrative 9)		✓
Isaac's son left school at about the same time that Isaac had cut back his herd size. Isaac thinks he 'probably would have come home on the farm' if the timing had been different. (Narrative 9)	✓	
Over the previous six months it had been dry again and Lachlan was starting to wonder if he should really be farming. He had considered selling the farm and moving into town. (Narrative 12)		✓
Lachlan's father was 'never really a farm bloke' and saw it as 'just a means of making money and a job'. Lachlan's father had always had other businesses that were profitable and 'he'd just had enough of the farm'. (Narrative 12)	✓	
Lachlan's eldest child, a son, was born during the time Lachlan ran the farm in partnership, so having extra time for family was important. (Narrative 12)	✓	
keep the 500-acre outblock and continue to run it as an agistment enterprise. (Narrative 13)		✓
Matt and Marie no longer had any debt after selling the farm and the water. This meant that Matt wasn't under any pressure to make the 500-acre block profitable. Making a bit of money was nice but not a necessity. Running the agistment enterprise was a way for Matt to 'slow down' at his own pace rather than just get out of farming. Selling the farm was 'traumatic' and the agistment enterprise was something Matt enjoyed. (Narrative 13)	✓	
With a growing family, being able to increase productive land and cow numbers was important. (Narrative 14)	✓	
Neil's father was considering selling the farm. (Narrative 14)	✓	
bought for Owen's brother (Narrative 15)	✓	
father bought an existing dairy farm (Narrative 15)		✓
He knew that he could do a lot more with his farm but wasn't motivated to do so as he had 'bought a caravan, unfortunately'. He described the beef-cattle as 'a totally different lifestyle'. He had even taken up lawn bowls. (Narrative 15)	✓	
had two separate marketing campaigns to sell the farm (Narrative 16)	✓	
Total times coded	17	7

Another possibility regarding these instances of a lack of congruence between goal change and other constructs may have related to limitations in the coding process itself. Practically speaking, the process of simultaneously coding data to identify congruence of constructs relied on data being spatially connected in the narrative. This was not always the case, especially regarding higher-order changes to goals. Six of the seven data segments²² identified as farm-related goal changes were examples of this:

“If he milked 150 cows for five years that should clear the debt and allow him and his family to have a reasonable lifestyle. Also, if none of his children were interested in farming, he and his wife could stay on the farm for longer if there was no debt.” (Narrative 1);

“Edward wants to ‘take control of the groundwater in the region’.” (Narrative 5);

“acknowledged that his business exists within a volatile world market that is not very high paying. This means that for the business to survive it needs to have ‘very simple systems’.” (Narrative 5);

“set the property up as a dairy business” (Narrative 9);

“keep the 500-acre outblock and continue to run it as an agistment enterprise.” (Narrative 13); and

“father bought an existing dairy farm” (Narrative 15).

While these statements alluded to activity and change, they did not describe the change at a level that was compatible with identifying changes to functions or adaptations in the farm system. For example, to ‘set the property up as a dairy business’ change would be necessary across all functions and the entire process could be described as adaptation, making classification of constructs at this level meaningless.

In reality, it was likely that there was a degree of lag between a goal change and related changes to plans. A goal of setting up a property as a dairy business may have had little immediate practical meaning. The subsequent sequences of changes that were made through time toward setting up the business would have had practical meaning. It is these subsequent changes that were more likely to be identifiable as changes to function and as adaptations. This implied a serial relationship across decisions, with plan changes flowing from changes to goals. Such a relationship cannot be clearly analysed

²² In the seventh data segment, “over the previous six months it had been dry again and Lachlan was starting to wonder if he should really be farming. He had considered selling the farm and moving into town” (Narrative 12), a producer was in process of making a decision about the farm and therefore reflected a change of goal in process.

simultaneously with the analysis of congruence across constructs. Instead, the serial relationships across decisions are explored in greater depth in the decision mapping section of analysis.

4.3.3. The value image

Overall, there were many more changes to plans than to goals identifiable in the data: 991 plan changes as compared to 131 goal changes. This was understandable and consistent with an interpretation of hierarchy in image theory which indicates that, when possible, changes in the strategic image will be attempted before moving up the hierarchy to alter a goal at the trajectory image. An individual's value image is the least likely to change (Beach & Connolly, 2005). A characteristic of principles within the value image is that they actively filter out decision options with little conscious awareness by the decision-maker.

Identifying changes to the value image that were of relevance to the farm was problematic in this research. The value image reflects the principles of the farm manager. In 14 out of the 16 narratives, the farm business changed managers at least once in the history interviewees described. Logically, this implied a change in *whose* value image was influencing the farms. Of interest here were the elements of the value image that influenced decisions relating to the farm. It is possible that the set of principles that interacted with the farm may have been sufficiently similar when changing from one farm manager to another that the value image had not changed in relation to the farm. Because of this possibility, I chose not to infer that a change in farm manager automatically entailed a change in the value image in relation to the farm. Instead, I decided to only code value image changes interacting with the farm where they were explicitly described as such.

During the process of coding I noticed instances where producers were expressing strong views that may have been reflective of their value image. These were not being captured in the coding, given that the focus was on identifying images in which change occurred. However, the value image filtered out incompatible decision options and was therefore clearly a constraint on producer decisions. I thought it was worthwhile capturing these data in order to identify any patterns that may have existed across the

farms regarding the value image. I coded expressions of strong views within the narratives broadly as ‘guiding principles’.

I found that there were differences among the views expressed by producers (see Table 4.7). A useful framing of these differences was in terms of hierarchy. Some views were in relation to the family and personal domain, others considered the farm business and the final set focused on the production system. This hierarchy implied a difference in the permanence or tenacity of views.

The views within the family and personal domain focused on personal and family goals. For example, Albert described how “[h]e wants to keep the farm in the family as it has been for four generations” (Narrative 1). As well, Edward stated that he is “‘not scared of change’ ... [o]ne thing he has learned is that ‘the good stuff comes when you break the rules’” (Narrative 5). Issues relating to finances were also classified within the family and personal domain. For example Isaac described how he was “‘a pretty conservative sort of a person’ who likes to have something in reserve; ‘something up [his] sleeve’” (Narrative 9). These views were more reflective of what is described in image theory as the value image, encompassing “values, morals and ethics” (Beach & Connolly 2005, p. 161). They were very persistent and influential on decisions. Hence, these are referred to as ‘values’ in Table 4.7.

Some views that were expressed in relation to the farm business focused on productivity. For example, “Albert described how making improvements to efficiency was crucial if the business was going to survive, because ‘if you stand still, the costs just kill you’” (Narrative 1). Other views in the farm business domain of the hierarchy related to simplicity. For example, “Geoff’s view on farming was ‘keep it basic and simple and you’ll keep doing it’” (Narrative 7). Farm business views are described in Table 4.7 as ‘guiding principles’ because they were lower-order than family and personal values. These guiding principles are closely aligned to the notion of ‘policy’ in strategy literature (Kast & Rosenzweig, 1985). Guiding principles were less persistent than values, though more so than views expressed in relation to the production system. Guiding principles were highly influential on the farm decisions.

Table 4.7. Expressions of values, guiding principles and beliefs in the farm narratives

Case	Data	Family and personal		Farm business		Production system		
		Family & personal values intersection with farm	Values relating to financial management	Guiding principles regarding productivity	Guiding principles regarding simplicity	Beliefs about self-sufficiency in feed production	Beliefs about breeding	Beliefs about herd management, including matching feed to cow needs
1	Albert believes that the region's growth pattern naturally lends itself to spring production. It just seems that you can grow your best feed through spring and summer as long as you've got water for irrigation. In the winter it takes more feed just to keep them warm and dry, let alone to produce milk.							✓
1	Albert described how making improvements to efficiency was crucial if the business was going to survive, because 'if you stand still, the costs just kill you'			✓				
1	He wants to keep the farm in the family as it has been for four generations	✓						
1	His overall aim is to have a bit of flexibility in his feeding system.					✓		
2	A lot of the Australian breed bulls were sired by overseas Friesians but are 'more reliable' because they are proven for Australia. This means they are used to Australian conditions and are from more pasture-based grazing cows. This is compared to the differences with the United States, with different conditions and where they use more barns and feed pads.						✓	
2	He wants to get away from having to buy in any protein; he wants to be more self-sufficient.					✓		
2	If numbers went beyond 180 it would have required a lot of imported feed, which 'was one of the things you just didn't do' back then.					✓		
2	With breeding choices 'it was just a decision that if you went one way you had to keep going'						✓	
3	always tried to feed the cows on grass as much as possible					✓		
3	Colin has set up his business as 'a one man operation'	✓						

Case	Data	Family and personal		Farm business		Production system		
		Family & personal values intersection with farm	Values relating to financial management	Guiding principles regarding productivity	Guiding principles regarding simplicity	Beliefs about self-sufficiency in feed production	Beliefs about breeding	Beliefs about herd management, including matching feed to cow needs
3	Colin never borrows money		✓					
4	Dennis and Donna 'weren't ever big into borrowing money to make improvements' to the farm.		✓					
4	Dennis and Donna have always had the intention of growing sufficient feed on the farm to meet the needs of their cows.					✓		
4	They prefer to calve earlier anyway as it 'follows the natural curve of grass growth through spring and summer and the demand on the cows'.							✓
5	'Grass is pretty easy to grow and manage' and that is how Edward prefers to feed his cows if he can.					✓		
5	business exists within a volatile world market that is not very high paying. This means that for the business to survive it needs to have 'very simple systems'.				✓			
5	Dairy cows are 'more flexible than people think. They change routines relatively easy.'							✓
5	didn't want a cow driving the system': he wanted to drive the system.							✓
5	Edward 'had no doubts that the udder would drive the mouth'							✓
5	Edward is 'a huge fan of longevity as a measure' of good breeding						✓	
5	Edward is 'not scared of change' and is very comfortable with changing his calving according to how much water he has. One thing he has learned is that 'the good stuff comes when you break the rules'.	✓						
5	Edward's father believed that Edward buying the farm (as opposed to inheriting, leasing or share farming) was important because it meant that Edward could do whatever he wanted to with it.	✓						
5	really only cares about what is going to do the job for him. 'I don't care if it's purple, got one eye or three legs, it's in.						✓	
7	'farming's a gamble whichever way you go'.			✓				

Case	Data	Family and personal		Farm business		Production system		
		Family & personal values intersection with farm	Values relating to financial management	Guiding principles regarding productivity	Guiding principles regarding simplicity	Beliefs about self-sufficiency in feed production	Beliefs about breeding	Beliefs about herd management, including matching feed to cow needs
7	Geoff gets enjoyment out of watching the crops as he and his wife drive around the countryside. One of the frustrations that Geoff used to have with cows was that he would grow a paddock of 'good green lush grass' and the cows would tread all over it and eat it.	✓						
7	Geoff thinks that it is cheaper to grow feed in the paddocks and prefers to grow feed for his cows.					✓		
7	Geoff was really focused on trying to 'keep things basic and simple and low maintenance'.				✓			
7	Geoff's father had a view that 'there's no off-the-farm time'	✓						
7	Geoff's view on farming was 'keep it basic and simple and you'll keep doing it'				✓			
9	'a pretty conservative sort of a person' who likes to have something in reserve; 'something up my sleeve'.		✓					
9	Isaac has always carried enough supplementary feed to get through 12 to 18 months					✓		
10	The reality with the farm was 'if you sell it they can't ever get it back'.	✓						
11	Karl needed the balance of annuals and perennials to enable him to maintain self-sufficiency in feed production.					✓		
11	Keith had a business strategy to keep his overheads down.		✓					
11	Self-sufficiency with regard to feed production was important to Karl.					✓		
12	important when managing the farm to 'run it as a business'.			✓				
12	Lachlan doesn't have 'a love' for one breed of cow over the other. He is interested in what is going to make him the most money.						✓	
12	making sure any infrastructure work was 'twice as good or twice as much' as what he currently needed			✓				
13	he always focused on increasing cow numbers as a way to keep the farm profitable.			✓				

Case	Data	Family and personal		Farm business		Production system		
		Family & personal values intersection with farm	Values relating to financial management	Guiding principles regarding productivity	Guiding principles regarding simplicity	Beliefs about self-sufficiency in feed production	Beliefs about breeding	Beliefs about herd management, including matching feed to cow needs
13	Keeping cows eating grass was a 'key point' to Matt.					✓		
13	Matt had always looked at the farm as a family farm that he would manage with his father, brothers and then eventually would be managed by the next generation.	✓						
13	The decision to sell the farm was unexpected and traumatic for Matt and Marie. Matt's father had been 'so thrilled with it being in the family'. Matt had planned on continuing to run the farm with his son. After selling the farm Matt didn't miss the cows; 'to lose that history' of what the family had done on the farm was the biggest loss	✓						
13	Matt's father was always willing to borrow money to buy more land for the farm and 'always owed money'		✓					
13	their parents stipulated that they all needed to get a trade other than farming before they could work full-time on the farm.	✓						
13	Up until that point they often took in neighbours' cows in the winter so that people could go on holiday. Matt and Marie always milked some cows through winter anyway and would get down to 'maybe one round' of cows on the rotary dairy.							✓
13	'What's two more cows or 10 more cows on a rotary system?' After the anthrax experience, based on veterinary advice, Matt and Marie decided that they were going to run a closed herd.							✓
14	Historically, the herd was a 'closed herd', which meant that they bred all of their own replacements rather than buying in stock.							✓
14	However, he was 'a little bit sad and disappointed' because buying in cows meant 'you lose your breeding'. Over the last 20 years or more Neil and his family had a 'straight Friesian' 'closed herd'. He associated his herd genetics with 'pride within yourself'.	✓						✓

Case	Data	Family and personal		Farm business		Production system		
		Family & personal values intersection with farm	Values relating to financial management	Guiding principles regarding productivity	Guiding principles regarding simplicity	Beliefs about self-sufficiency in feed production	Beliefs about breeding	Beliefs about herd management, including matching feed to cow needs
15	always produced their own supplementary feed. They 'never bought hay; never bought silage'.					✓		
16	his grandfather "wasn't one of those fellows that hangs on to the bitter end"	✓						
16	Peter was ready to do the same thing his father had done - pass on farm management to his sons.	✓						
16	Paul had heard that changing to cross-bred cows was an approach that some farmers had used to manage fertility issues, he "didn't believe that strategy had any credibility"						✓	
16	Paul's father "was adamant that he personally was never going to milk cows"	✓						
	Total	14	5	5	3	12	6	9

A final set of views expressed related to the production system and focused on feed production, breeding and herd management. Some views were expressed about the importance of self-sufficiency with regard to feed production for the cows. For example, on Owen's farm they "always produced their own supplementary feed... 'never bought hay; never bought silage'" (Narrative 15). As well, "Isaac has always carried enough supplementary feed to get through 12 to 18 months" (Narrative 9). Some expressions of views related to cow breeds. For example, Edward "really only cares about what is going to do the job for him. 'I don't care if it's purple, got one eye or three legs; it's in.'" (Narrative 5). Views also related to herd management. For example, Dennis and Donna "prefer to calve earlier ... as it 'follows the natural curve of grass growth through spring and summer and the demand on the cows'" (Narrative 4). As well, Edward believed that "[d]airy cows are 'more flexible than people think. They change routines relatively easy [sic] '" (Narrative 5). Production system views are described here as 'beliefs'.

Beliefs were the least persistent of those identified. While grounded in higher-order values and guiding principles, beliefs were likely to be more readily modified by experience or other credible information than guiding principles. It was in the realm of beliefs that double loop learning was most likely to be seen. Within double loop learning, deeper scrutiny is employed to evaluate actions.

Given that values, guiding principles and beliefs rule out incompatible decision options, it is logical that producers who expressed different views of relevance to the farm would describe differences in related farm business decisions. The influence of different views on farm decisions could be seen in a comparison of Colin's and Matt's experiences. Colin's and Matt's farms were developed through time based on very different values relating to finances.

"Colin never borrows money" and when he "developed his farm he preferred to do it slowly and avoid debt" (Narrative 3). At the time of the interview, Colin's farm was the same 300 acres it had been for over 50 years. Colin milked out of the same dairy that was built in the 1960s and he maintained a herd that had increased from 98 cows in the early 1970s to 130 cows in 2012.

In contrast Matt described how his "father was always willing to borrow money to buy more land for the farm and 'always owed money'" (Narrative 13). Matt's farm had 145

acres in the early 1960s which was increased over time to a 400-acre dairy block and 500-acre outblock. A herd of 80 cows in the early 1960s had increased to a milking herd of 600 cows. The 8-a-side herringbone dairy installed in the early 1960s had been replaced by a large rotary dairy in 1989.

The aim in providing this example is not to imply that one view and approach is preferable to the other. In both cases the producers were able to manage their farms over an extended period of time as viable businesses. As well, both producers described a recent constraint that stemmed, to some degree, from their view about finances.

Colin thought that his old dairy was an impediment to him. His wife no longer wanted to milk and yet he couldn't manage milking on his own. The dairy set-up could not be altered to incorporate the automatic cup removers that would allow Colin to milk on his own. This makes it a "difficult dairy" (Narrative 3). As well, the old dairy would make it difficult to sell the farm. However, given Colin's age and current circumstances, he was not interested in building a new dairy. Colin was in this predicament at the time of the interview and hadn't yet worked out what to do.

In contrast, Matt had invested in more land and upgrades to his dairy because his son was "motivated to continue building the business" (Narrative 13). This included taking on more debt. Unfortunately, Matt's son decided to leave the farm for personal reasons and Matt faced a large farm that he could not manage on his own, as well as some debt. He ended up having to sell the dairy farm as well as all of the water associated with his outblock.

Goals and plans linked to higher-order views, such as values, were not always achievable. This was the case for Matt. Matt had a strong view, based on family values, about the importance of the farm staying in the family. "Matt had always looked at the farm as a family farm that he would manage with his father, brothers and then eventually would be managed by the next generation." (Narrative 13) Matt's son decided to leave the family farm after a number of decisions had been made based on his involvement in the business. His leaving meant Matt and Marie had to sell the dairy business:

The decision to sell the farm was unexpected and traumatic for Matt and Marie. Matt's father had been "so thrilled with it being in the

family”. Matt had planned on continuing to run the farm with his son. After selling the farm Matt didn’t miss the cows; “to have lost that history” of what the family had done on the farm was the biggest loss. (Narrative 13)

There was a strong sense of personal grief in Matt’s story about selling the farm that was grounded in the loss of goals based on keeping the farm in the family.

The hierarchy of values, guiding principles and beliefs were not always coherent: elements could conflict, at least in the short term. This was highlighted in Neil’s experience in which a tension emerged between the need for more time with his children and his herd genetics. Neil needed to increase his herd size quickly so that he could hire a share farmer, which was crucial for him to “spend a bit more time at home with the kids” (Narrative 14). However, Neil associated his herd genetics with his self-image. Hence, it reflected his personal values to some degree. He found that he couldn’t increase his herd size fast enough with his current herd and decided to start buying in cross-bred cows, which was the financially feasible option available to him.

Neil didn’t have any problems with the cows he bought into his herd. However, he was “a little bit sad and disappointed” because buying in cows meant “you lose your breeding”. Over the last 20 years or more Neil and his family had a “straight Friesian” “closed herd”. He associated his herd genetics with “pride in yourself”. (Narrative 14)

Neil’s values relating to his family trumped the values relating to maintaining herd genetics, even though Neil ‘thought that building his Friesian genetics back to what they were would take him up to 10 years’ (Narrative 14). Like Matt’s experience, there was a clear sense that Neil struggled with the change.

Consideration of the value image clearly has relevance for understanding farm constraints. The identification of a hierarchy of values, guiding principles and beliefs with differences in persistence and influence highlights the complexity that exists when trying to identify constraints based on an individual’s expressions of views.

4.3.4. Identifying changes in value chain functions

Identifying the patterns regarding how changes in functions interacted with other domains of constraints in the coded narratives was useful for understanding the

constraints of farms in generating value, as determined by the producer's business objectives. The hierarchy of value chain functions describes how the interaction among functions determines the capacity of a firm to create value, with support functions having an increased likelihood of generating impacts across the firm. Overall, there were 946 changes to support functions and 175 changes to primary functions identified across the coded narratives (refer back to Table 4.3, p. 103). The patterns that emerged regarding linkages between function changes and other constructs of constraints were logically consistent with the theories. All adaptations and changes to plan images were linked to changes in functions. While most of these links were to support functions, there were a number of instances where changes in primary functions intersected with adaptation and changes to plans. Patterns of function change intersections with adaptation and image changes differed, depending on the function. Next, consideration is directed toward the differences between functions.

4.3.4.1. Technology development

Within the support functions there were 391 changes in technological development. Of these, 386 occurred in conjunction with adaptation and changes in plans or goals. Of the 386, 380 coded as technology development and adaptation were identified as plan changes. Given that technology change predominantly occurs on farms within the production system, it is not surprising that this change was strongly linked to adaptation. As well, given that technology change generally entails a change in production system activities or tactics, the alignment with a change in plans also makes sense here.

There were six occurrences where data coded as technology change and adaptation were linked to changes in goals rather than plans. Five of these occurrences related to changing farm goals:

Karl “started new enterprises in dairying and pigs” (Narrative 11);

Matt’s father “decided to build a piggery so that he could use the surplus skim milk himself rather than give it away” (Narrative 13);

Paul’s father decided to “plant 20 acres of their best land to peaches and apricots” (Narrative 16);

“Peter decided to go into sunflowers” (Narrative 16); and finally,

Paul and his wife “modified their plans, sold the herd and went into cropping” (Narrative 16).

All of the five occurrences described changes in enterprise, which included a change in business goals. As well, in all of the occurrences, the producer described the broad change and then went on to describe the detail of what that change meant at the production system level. For example, Matt went on to describe how his father “built very simple yards with water troughs” and then eventually “built a big brick piggery”. This indicates the link between technology development and goals in these cases reflected a higher-order description of farm change.

There was one occurrence where the datum had an identified link between technology development and goals which differed from the previous five cases. In this circumstance the decision to alter practices on the farm was directly attributed to personal goals: “When Isaac’s children were ‘getting a little bit older’ and they all wanted to go away during school holidays, Isaac brought the spring calving back to around July 20th” (Narrative 9).

While this was only identified once in the narratives, this does not imply that it was the only time that personal goals influenced production system decisions. I identified a number of instances in a previous section (see section 4.3.2) where changes in family and personal goals were apparent. As well, in a forthcoming section on critical junctures, the profound influence of the family on the farm is described.

There were five instances where the pattern of intersections between constructs differed. In these five cases, data segments were identified as changes in technology development and the plan image, though they were not linked to adaptation. Three of the five incidences involved innovations regarding inputs, such as when Ben needed to “purchase in some extra feed, such as cotton meal” (Narrative 2), Albert needed the “help of a nutritionist (Narrative 1) and Paul “bought grain for a fraction of the typical price by buying it from someone who ‘had a contract for taking away the grain cleanings from around bunkers’” (Narrative 16). One incident related to the first use of agistment as a management practice when Paul “agisted heifers to Tasmania” (Narrative 16). The fifth occurrence related to a decision to “register his Jersey cows in 1980” made by Albert (Narrative 1). This change did lead to adaptations of the production system, in relation to herd management, though this was not spatially connected in the data.

Overall, the location of technology development within the support functions of the value chain pointed quite clearly to the potential, far-reaching impacts of technology change on farm business capacity to generate value. The intersections with adaptation and images supported this idea. This implied that technology development may have led to unanticipated constraints in other functions of the farm. Given that the research and development into new technologies is often considered at a component or sub-system level, rather than at a production system or farm business level, this suggests that unconsidered constraints to their uptake may exist in these higher levels.

4.3.4.2. Procurement

There were 94 sections of data coded as changes to procurement. Patterns emerged in the intersections between procurement and other domains of constraints that help frame how we think about the use of farm inputs. Of the 94 sections of data coded as procurement change, 77 were not simultaneously coded as adaptation. The implication of this was that procurement occurred outside of the biophysical production system, which was where adaptation occurred. All but one of these 77 data were associated with changes to plans or goals. Given that procurement is a support function, this logically implied that change would affect other farm functions; the links to changing goals and plans identified in the analysis supported this idea.

Seventeen procurement changes were associated with adaptation. I initially thought this was unexpected. However, of the 17 procurement changes that were associated with adaptation, 14 instances were simultaneously linked to other function changes that interacted with procurement (see Table 4.8). For example, Matt (Narrative 13) dug a groundwater bore which was a change in technology and also entailed a change to procurement.

Overall, these 14 incidents in which procurement was linked with adaptation and simultaneously with other functions indicated that the link to adaptation may not have come from procurement alone, but from the other changes.

There were three sections of coded data in which procurement change, separate from other functions, intersected with adaptation. Hence, these data differed from the typical pattern. Two of these sections were clearly linked to other sections of data in which adaptation and other function change had occurred. John described how he “bought in a

heap of heifers” which was associated with a business decision to change his herd genetics as he was “gradually converting from Dairy Shorthorn to Jersey-Friesian crosses”, a technology development change (Narrative 10). Lachlan described how he “got a groundwater licence to pump 320 ML” which followed the decision to “put in a shallow groundwater bore”, which was coded as technology change (Narrative 12).

Table 4.8: Changes to procurement simultaneously coded with other functions

Narrative	Coded Data	Other function coded
4	decided to try a new way to get the nutrition they needed for their cows. They purchased maize to feed out to the cows	technology development
8	connected the bore to the 188-acre block	technology development
13	put in a groundwater bore to obtain supplementary irrigation water	technology development
13	dug a second groundwater bore	technology development
16	used a lot of “bi-product feeds” (e.g. waste lollies, brewers grain)	technology development
8	given an allocation of 470 ML	infrastructure
8	sell 200 ML of permanent water	infrastructure
8	give half of the water saved through increased water-use efficiency to the government for environmental flows	infrastructure
8	gave his son 35 ML of permanent water to ensure that there was enough water to qualify	infrastructure
9	applied ‘some years ago’ to get the water right increased	infrastructure
14	sold the 300 ML of permanent water off the 120-acre block	infrastructure
15	water rules changed which allowed water rights to be amalgamated. This enabled Owen to use the water wherever he needed it most	infrastructure
16	bought another adjacent block comprising 200 acres and a “huge water right” because it had an irrigation entitlement and it also had creek access	infrastructure
10	decided to purchase hay to feed the cows rather than watering	Operations

The third section of data that was atypical entailed the first time a producer purchased temporary water. “The first time Neil had to buy temporary water was in 1996 or 1997. He bought 200 ML of temporary water because there had been ‘a few dry years’” (Narrative 14). This was coded as procurement as it was an alteration in sourcing an input and it was identified as an adaptation because it was noted as the first time the producer used this tactic. Unlike the other two anomalous sections of data, this data section was not linked to other function changes. The inconsistency highlighted a difficulty that existed, at times, in distinguishing farm management practices from farm business practices. Given that procurement was so closely related to inbound logistics and operations, changes to procurement decisions may have been difficult to distinguish

from changes to the use of inputs. This suggests permeability between the biophysical production system and the farm business.

4.3.4.3. HRM and infrastructure

While technology development and procurement had clear patterns of intersections with other constraints, both HRM and infrastructure were more dispersed. These two functions intersected across adaptation, plans and goals. This implied a difference between these two functions compared to technology development and procurement.

Change to the HRM function was identified 134 times in the narratives. Seventy one of these were simultaneously coded as changes in plans and adaptations, while 30 reflected changes in plans that were not adaptation. Five were identified with changing goals and adaptation and 28 were coded with changing goals but not adaptation.

Infrastructure change was identified 327 times in the narratives. Of these, 289 were identified with other domains of constraints²³. More than half of these instances, 157, were associated with adaptation and plan change; 18 with adaptation and goal change; 82 with changes to plans that were not also adaptations, and 32 that were identified with a goal change but not adaptation.

By considering a farm as a hierarchy of systems, with the production system sitting within the farm business, which is beneath the farm family, useful insights began to emerge regarding the difference between the two sets of support functions (HRM and infrastructure compared with technology and procurement) (see Figure 4.1).

Technology development can be described as predominantly fitting within the production system domain, which was supported by the finding that 386 out of 391 technology development changes occurred in conjunction with adaptation, which occurred in the production system. Procurement change can be described as generally occurring at the farm business level. This was supported by the finding that 77 out of the 94 procurement changes identified in the data were not identified as adaptations.

²³ The 38 instances where infrastructure change was identified separate from other domains of constraints are considered in the next section.

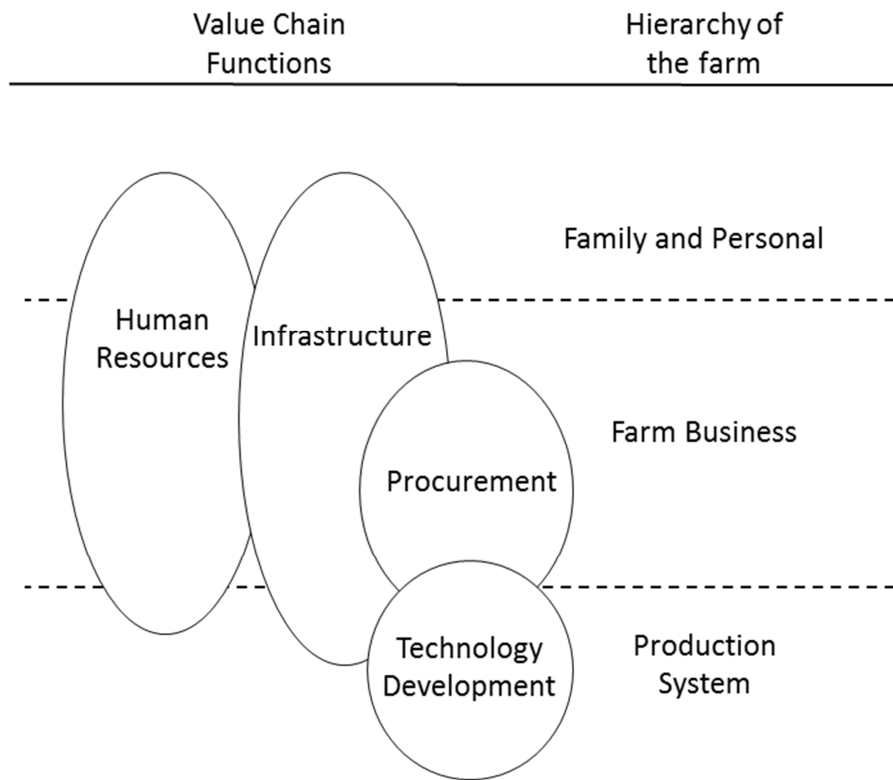


Figure 4.1: Visual representation of value chain functions in the farm hierarchy

In contrast, changes to HRM and infrastructure can be described as fitting across the farm business and family level in the hierarchy of systems. HRM in these family businesses was affected largely by the interaction between the farm and family, given that available labour was derived largely from the family. As well, decisions about infrastructure, such as finance, were often made in relation to family, as is discussed in the next section. Given this higher-order focus of HRM and infrastructure across levels of farm business and family, it was reasonable that patterns of constraints vary.

4.3.4.4. Infrastructure change identified in isolation: the importance of finances

Value chain functions were initially intended to be coded where other domains of constraints (images and adaptation) were identified, to offer a way of describing how constraints interacted in the farm. This means that the intention was *not* to code these separately from adaptation and image changes. However, I found that there were instances where the narratives reflected potential constraints in the farm arising from changing finances that were not identifiable as changes in farm functions, adaptations or

image changes²⁴. Given that finances were arguably best defined as a fungible component of the infrastructure function, I coded these data as infrastructure.

There were 38 segments of narrative data that were coded as such changes to infrastructure²⁵. For example:

“He went backward by \$60,000-70,000 in the first year of the drought because of extremely high feed costs. Also, during the drought, not only was there no water, but the price of milk fell as well, due to the strength of the Australian dollar. Since then he has been able to maintain the debt but hasn’t been able to lower the debt over the last few years.” (Narrative 1);

“Colin said that they ‘just squeaked through’, though he had to borrow some money from his wife’s inheritance to pay upfront for hay. He did eventually pay the money back to his wife, at the end of last financial year.” (Narrative 3);

“Dennis thinks the biggest constraint on him laser grading the farm was financial . . .” (Narrative 4); and

“Harry had shares in Murray Goulburn Cooperative (a processing plant) and was able to borrow some money against these.” (Narrative 8).

The producers clearly considered finance to be an important element in their decision-making, which meant it was potentially a constraint. Of interest here is why the data regarding finance didn’t align with the constructs from image theory and farm control theory.

Implicitly, the fact that producers were cognisant of financial issues indicated an intersection with plans or goals, though in these instances the intersections were not explicitly identifiable. It may be that such changes were not spatially connected in the narrative and hence not simultaneously coded as such. It may also be that while finances had narrowed the set of potential decisions, it did so in ways that were not yet known.

²⁴ There was also one instance where a change in procurement was identified separate from adaptation and image change. This was not seen as an anomaly to the pattern, as it was associated with a critical juncture.

²⁵ In two of the segments there was also a link made to marketing and sales in one and procurement in the other. This was because the infrastructure discussion alluded to those functions, without describing change in them.

Alternatively, it may be that finance in these instances was not a constraint. Finances were expected to become constraints when they removed, or discounted the appeal of, decision options; hence they were identifiable at the time they constrained, which may have been well after the initial decision affecting finance. This meant that such constraints may only have been identifiable in hindsight and that considering the sequence of decisions on farms through time was a crucial mechanism for understanding constraints related to finance. Coding these instances of infrastructure change enabled consideration of the serial element of constraints in the decision mapping component of analysis.

Generally, consideration of finances tells us, simultaneously, much and little about constraints on farms. Over all, financial resources were a significant consideration in producer decision-making. Current financial circumstances were, to a large degree, a description of the extant constrained state of the business. Put another way, the financial resources available bound the set of decision options being considered. There were some challenges, however, in framing finances in this way.

Broadly, financial circumstance can be described as an aggregate of lower-order constraints. Considering constraints at a level of finances may not help to understand the combination of factors that led to a constrained state. These factors are the dimensions of constraints as defined by this integrated model. This implies that meaningful analysis of constraints needs to consider the multiple dimensions, rather than an aggregate notion of finances. Relatedly, the aggregated framing of constraints in financial terms does not take into account the compounding nature of financial constraints as the dynamic and cumulative outcomes of decisions. Path dependence is a useful framing of the compounding nature of constraints through time, including finance.

The close interaction between the farm and the family in relation to finances meant that constraints on farm finances were to a large degree based on family finances. In a sense, the interaction can be described as permeable, in that the boundaries between the farm and family may have been only vaguely delineated in financial terms. As well, the farm and family finances may have been tightly coupled, making them highly sensitive to variations in each other. The hierarchy of images was found to be useful in highlighting the intersection between the farm and family.

4.3.4.5. Primary functions

Overall, there were fewer changes identified within primary functions (175 in total, compared to 946 identified in support functions). While changes to support functions could be seen across all four functions, changes in primary functions predominantly occurred in relation to a few key functions. There were no instances of changes to service, which was unsurprising given that customer service is not a core function of farming. There were two identified changes to outbound logistics, 12 instances of identified changes to inbound logistics and 10 changes to marketing and sales. Most of the changes to primary functions occurred within operations: 151 out of the 178 instances.

The operations function on farms generally occurs in the primary production system; hence, it is logical that of the 151 changes in operations, 147 of these occurred in conjunction with adaptation and plan or goal change. There were four instances where operations was not simultaneously coded as adaptation and plan or goal change. Three of these instances related to the practice of agistment, which was an operational decision about the farm that did not necessarily entail adaptation. One of these four instances was simultaneously coded as a change in procurement.

There were 12 identified changes to inbound logistics. One of these related to accessing whey from milk factors for pig production. The other 11 instances were in relation to accessing irrigation water, such as the experience of interviewee 6 in which “a neighbour [was] ‘being real friendly’ and allowing Frank to go through his property to connect to the backbone” (Narrative 6). Four of the 11 instances were simultaneously coded as procurement changes, such as Albert’s case for whom a change “...gave him access to 85 ML of saline shallow groundwater, which need[ed] to be shandied for use on his pasture” (Narrative 1). One of the instances was simultaneously coded as technology development as it related to a change to the irrigation access point for the farm. The predominance of water as the focus within inbound logistics was not surprising, given its importance among purchased inputs to irrigated dairy and the need to actively manage accessing the input.

There were only two identified changes to outbound logistics. In both cases these related to grains production by the two producers who had transitioned from dairy farming. For example, Paul “used a storage contractor rather than buying silos for their

grain” (Narrative 16). As well, Geoff described “the importance of storage so that he can hold on to grain until he gets a good price” (Narrative 7). It is logical that a grain producer would use storage as a tactic for managing pricing. This is a practice that is unavailable to dairy producers. Outbound logistics play less of a prominent role in dairy business decisions once a relationship is established with a factory. Milk needs to be picked up regularly or it spoils and the income is lost. Therefore, outbound logistic decisions are made in alignment with milk factory needs.

Relatedly, marketing and sales changes were not made by the dairy farmers in relation to their milk production, as they had little capacity to control the price they received for their milk. There were 13 identified changes to marketing and sales, three of which were also identified as changes to support functions. One of the marketing and sales changes related to grain production by an ex-dairy farmer: “With grain production, ‘if the market circumstances didn't suit, you didn't have to sell, because you could store it.’ Paul could time the sale of his grain when it suited and the buyers ‘were being more reasonable with you’.” (Narrative 16)

Overall, there were three ways that marketing and sales changes were made by interviewees on their dairy farms. The first way was to alter the marketing and sales of related enterprises on the farm, such as Albert who “developed a profitable product line in selling bulls” (Narrative 1). The second way marketing and sales changes were made was through opportunistically selling surplus stock or feed. For example, Albert decided to “sell surplus heifers into special sales” (Narrative 1), “Geoff decided to strip the grain rather than cut it for hay...the first time that Geoff sold grain” (Narrative 7), and Lachlan “produce[ed] a couple of hundred extra bales of lucerne hay that he was able to sell for \$50 a bale” (Narrative 12). The third type of change to marketing and sales was in relation to managing replacements for the herd. Neil decided to “sell his replacement heifer calves and use the money to buy in dairy cows” (Narrative 14). By selling his heifer calves on the international market and buying in milking cows he reduced the amount of time he had to carry non-productive cows by around two years. At the time of the interview Neil had used this practice for two to three years and he planned to continue doing it while the price difference made it worthwhile.

Managing Milk Prices

None of these four changes to marketing and sales related to milk, the focal output being generated through the dairy production system. In reality, there were few ways that interviewees were able to manage the price they got for their milk. This was due to the fact that raw milk supplies a commodity market.

Two producers, Harry and Lachlan sought to manage their milk price by altering the calving pattern so that the business could take advantage of the winter milk incentive. “While [Harry] had traditionally calved in the spring he decided to start calving some cows in the autumn so that he could get the better pay that comes with winter milk. ‘It pays you to milk all year round’” (Narrative 8). Lachlan chose split calving “because he got more money with calving in the autumn and milking through the winter” (Narrative 12).

One producer, Matt, was able to change which milk processing company he sold his milk to.

“Tatura Milk had fewer than 300 suppliers and a ‘waiting list at least a mile long’ because they paid a 10 to 20 per cent higher rate than other milk companies. While Matt and Marie were not on the waiting list, they got into Tatura Milk because they milk a large number of cows.”
(Narrative 13)

Once they were in a contract with the new processor, they were still locked into a rate set by that processor.

This same producer, Matt, made another attempt to obtain more money for his milk by boosting his milk production, as “Tatura Milk was offering ‘considerable incentive’ to farmers who were producing over 300,000 kilograms of milk solids” (Narrative 13). Matt’s farm was close to producing this amount and he decided to take in 80 cows from another producer, who was unwell, to produce the amount of milk solids needed for the bonus. “Unfortunately, one of the new cows died of Anthrax within weeks of arriving”, which caused quarantine problems that far outstripped any potential benefits that would have been achieved through obtaining the bonus (Narrative 13). After that experience, Matt and his wife, Marie, decided to “run a closed herd” (Narrative 13).

4.3.5. Implications from pattern analysis

Within this stage of analysis I considered the patterns of intersections across dimensions of constraints in farm control theory, image theory and value chains to identify congruence and dissimilarities across dimensions. Overall, I found a high degree of connection across constraints from the different theories. This indicated congruence across concepts. I also found that there was some diversity among the intersections across dimensions of constraints, which highlighted that the constraints from the theories were not simply different ways of describing the same constraint. Through close scrutiny of these differences I was able to explain the reasons behind the dissimilarity, which predominantly aligned with the theories.

I found in this stage of analysis that a much deeper understanding of constraints on farms emerged when considering these constraints across the three theories. This largely related to an understanding of the role of hierarchy in constraints that emerged. Building on Figure 4.1, Figure 4.2, below, is a visual representation of the overall pattern of where constraints intersected in the hierarchy of the farm, with the family and personal representing the supra system and the production system representing a subsystem.

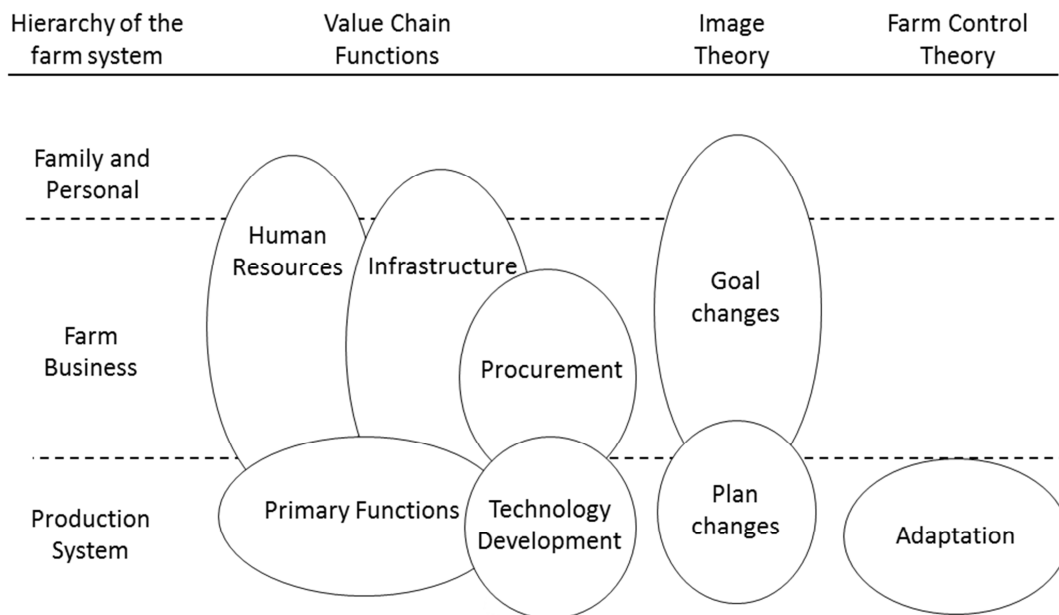


Figure 4.2. Hierarchy of constraints identified in pattern analysis, building on Figure 4.1

Adaptation occurred centrally in the farm production system. Changes to farm plans were identifiable at the farm production system and business level, while changes to goals were predominantly seen at the farm business and family level. Value chain function changes also applied to different levels in the hierarchy, with HRM and infrastructure interacting more readily with the family and personal level in the hierarchy, procurement interacting at the farm business level and technology development and primary functions interacting at the production system level. The potential for a strong influence of the family on the farm business was found to be an important characteristic in this hierarchy, especially in relation to farm labour (human resource management) and finances (infrastructure). This was highlighted further by the fact that many critical junctures emerged in relation to these factors, which is described more fully in the next section.

What is missing from this pattern analysis is consideration of how these constraints build upon each other through compounding and serial decisions, to increase the degree of constraint. This is path dependence. In the next stage of analysis I mapped the sequences of decisions on farms to identify the role of path dependence in constraining farm decisions.

4.4. Analysis of path dependence through decision mapping

In the previous section I described my analysis of patterns in intersections among dimensions of constraints. This was in aid of assessing compatibility across different domains of research regarding sources of constraints on decision-making. The thought was that consideration across these three domains (farm control theory, image theory and value chains) offered a more comprehensive understanding of constraints than would be achieved through their consideration in isolation. Comprehensively characterising constraints in farms also needs to consider the dynamic and cumulative relationships among constraints. This is the role of path dependence, a lens for meaningfully understanding the dynamic relationship among dimensions of constraints. In this section I describe analysis of the cumulative and dynamic relationship among constraints through consideration of critical junctures and reinforcing decisions that flow from them.

The approach employed for this step of the analysis can be broadly described in terms of decision mapping, in which linkages were identified between the multiple dimensions of constraints and critical junctures. My aim was to map decisions through time on individual farms in order to identify whether a pattern emerged that suggested the existence of path dependence as a constraint. Such a pattern would entail a trigger to alter the path followed by sequences of decisions that reinforced the new or altered path. These reinforcing decisions are the simultaneously coded adaptations, and changes to images and value functions, that were described in the previous section. If such patterns were identifiable in the data, this would offer evidence that path dependence exists in farms.

The entry point to discussion of the decision mapping results is consideration of critical junctures. A critical juncture is the path dependence construct describing a trigger for changing the trajectory of the farm business path. In the next section I describe the findings relating to critical junctures, framed around discussion of their sources. From critical junctures, I go on to describe the outcome of identifying linkages between critical junctures and adaptations, image and function changes (as reinforcing decisions). While the overall degree of success regarding linkage identification is considered, emphasis is placed on understanding where the pattern did not hold or why linkages were not identifiable in some circumstances. I then focus on a number of implications that are derived from this framing of constraints, which includes examples from the narratives relating to drought, exiting agriculture and herd fertility management.

4.4.1. Sources of critical junctures

There were 264 sections of data in the narratives that were coded as critical junctures across the narratives. When looking at the critical junctures, I found that they could be meaningfully classified into six types, based on their sources. These are extreme weather, such as drought and flooding, policy changes, market changes, changes to the personal or family context, and identified endogenous opportunities or threats on-farm (See Table 4.9). A full table classifying the sources of critical junctures can be found in Appendix F.

Table 4.9: Sources of critical junctures identified in the farm narratives

Source of critical juncture	Description of source of critical juncture	Number of Critical junctures ²⁶
Extreme weather events	<ul style="list-style-type: none"> Any weather events that influenced changes to the farm business; e.g. drought and flood. 	25
Policy	<ul style="list-style-type: none"> Compulsory changes to rules or policies Change in policy context that offer an opportunity for the farm business. 	20
Markets	<ul style="list-style-type: none"> Changes in the market create threats or opportunities for the farm business 	14
Personal and family context	<ul style="list-style-type: none"> Changes to farm ownership, management, succession planning, available family labour. Change in personal and family goals including marriage and children. Episodes of family tragedy 	91
Identified opportunity in the farm (or margin)	<ul style="list-style-type: none"> Business development opportunities relating to the land area, land development, herd and dairy. Enterprise change for improved business margins. 	63
Identified threat in the farm (or margin)	<ul style="list-style-type: none"> Threats associated with current farm use of land, labour, herd or dairy. Current enterprise seen as a threat to the business. 	59

Critical junctures were coded in the decision mapping using a unique code that comprised the narrative number followed by the critical juncture number in the narrative. Hence, if Narrative 12 had five identified critical junctures, these would have been coded as 12.1, 12.2, 12.3, 12.4 and 12.5. This unique coding is included in the forthcoming discussion of analysis where individual critical junctures are considered. This coding is useful for easily finding the individual critical junctures in the decision mapping in Appendix F.

4.4.1.1. Drought- and flood-related critical junctures

There were 25 critical junctures identifiable in the data that were associated with extreme weather events, namely drought or flooding. In all narratives, Victoria’s most recent drought was a critical juncture, leading to changes in the farms. For example:

“drought helped to ‘force’ the move regarding split calving. They had no summer pasture during the drought and had a lot of autumn and winter pasture. If they wanted to make the most of what they had, they needed to milk more cows through the winter, to make use of that grass” (Narrative 2, 2.12);

²⁶ Eight sections of data were identified with two sources of critical junctures, as they described two sources concurrently. Hence, the total number of critical junctures in the table of 272 is eight greater than the coded data.

“Then for nine years from the early 2000s it was enough to just make it through the year. The drought really slowed Colin down; all of his ‘ambitions just were put to the side’” (Narrative 3, 3.7); and “John and Jacqui learned ‘a whole new way of farming’ because of the drought” (Narrative 10, 10.15).

Four of these same producers experienced a critical juncture 35 to 40 years previously due to drought:

“In the early 80s there were ‘some dry years’. Once water got scarcer Albert needed to find another way to get the water” (Narrative 1, 1.6); “couple of years after Ben came to work on the farm, there was a drought that led the family to start feeding cows ‘in the bail’” (Narrative 2, 2.5);

“There was a dry period in around 1974-75 and Frank’s father started looking for more water for the farm” (Narrative 6, 6.3); and

“There was a drought over the 1976-1977 season. It was the first in which Owen didn’t get his full water right” (Narrative 15, 15.9).

As well, one narrative highlighted a critical juncture that emerged due to flooding: The flooding meant that the cows couldn’t get enough grass and it was hard to get hay as everyone else needed it. Subsequently, the cows’ nutrition wasn’t good enough during joining and they ended up with ‘a lot of empty cows’ (Narrative 4, 4.3).

I had expected that a significant drought in the survey region, which ended in 2009, would be a source of critical juncture for at least some interviewees. The finding that *all* interviewees experienced a critical juncture during the drought was unsurprising, especially given other research had identified the decade of drought as leading to unprecedented change in the region’s irrigated dairy farming (HMC Property Group, 2010; Kiem & Austin, 2013). Findings associated with differences in response to the recent drought are considered in section 4.5.

4.4.1.2. Policy change-related critical junctures

Policy change can be compulsory, such as the development of new rules, or voluntary, such as the introduction of incentives. Policy change can have positive, negative or little impact on the farm business. It is policy change entailing positive or negative impacts on the farm business that are sources of critical junctures.

There were 20 critical junctures that emerged due to a change in policy. Eighteen of these were related to changes in water policy. Two related to other policy changes. Before considering changes to water policy, these other policy changes will be described.

In Neil's family history, the establishment of a tobacco quota in Victoria led to circumstances where the farm could no longer support two families. This was because "the quota assigned to the farm was too small to support both Neil's father and uncle" (Narrative 14, 14.1). The policy led Neil's father to move and begin a dairy business.

On Matt's family farm, the introduction of "reduced-interest-rate salinity loans available to do infrastructure upgrades" had a huge impact on farm irrigation, given "[a]t that time the farm irrigation comprised little bays and 'mud stops with shovels'" (Narrative 13, 13.16). Matt and his family used the loans to begin laser grading, "which absolutely transformed irrigation", and build a large dam on the farm (Narrative 13, 13.16).

The 18 instances where water policy-related critical junctures were identified described different changes to water policy. For example, Karl described an opportunity associated with the expansion of public water storage infrastructure, (likely in the 1950s). Due to the enlarged storage capacity irrigators were offered access to more irrigation water.

About a year after Karl took over the family farm Lake Eildon was enlarged to enable a greater regional storage capacity for water. Karl, and other irrigators were offered the chance to double their water use through "sales" water. Karl "never ran out of water" (Narrative 11, 11.8).

This was highlighted by Karl as a significant event for his business, with the increased access to water likely guiding farm production decisions.

Two of these related to changes to entitlements as granted under the Water Act of 1964.

Peter said that the amendment of the Water Act in 1964 was "a critical point for the farm". Up until then the allocations were "unrealistically low". The act "had a massive impact on what happened" on the farm. Given the farm had four allotments, they received enough water with the changes that they "became serious irrigation farmers" while before

they were “just dryland farmers with some irrigation” (Narrative 16, 16.6).

In around 1959 the rules regarding water changed so that water rights were determined by titles rather than acreage (Narrative 10, 10.2).

For both of these producers, the critical juncture stemmed from an increased access to irrigation water which led to changes in how they farmed. The change led Peter to become a “serious irrigation farmer” and it enabled John’s father to convert the dairy farm to perennial pasture from lucerne.

While these two producers described policy change that expanded their water entitlement, two other producers experienced critical junctures associated with changes to water rules in the 1990s that decreased their water. Keith described how when “water started to become scarcer” due to changing water rules, he had to redevelop his pasture much faster than he expected (Narrative 11, 11.17). Paul also described how the “[water entitlement] wasn’t a problem for them up until about 1997, when water rules changed” (Narrative 16, 16.16). The change meant Paul and his brother received less water and “had to buy in two-thirds of their irrigation water needs in a year when they received a 100 per cent allocation” (Narrative 16).

Owen also experienced a critical juncture associated with water policy in the 1990s, when the “water rules changed” (Narrative 15, 15.12). Owen identified a beneficial impact by increasing the degree of flexibility he had in relation to his water use. The policy change “allowed water rights to be amalgamated...[which] enabled Owen to use the water wherever he needed it most” on the farm (Narrative 15).

Modernisation as an example of a policy-derived critical juncture

The modernisation of the public irrigation system was a more recent example of a policy derived critical juncture identified within six of the farm narratives. The modernisation program imposed alterations to irrigation assess points for irrigators. It also included the negotiated rationalisation of access points and spur channels affecting irrigation practices.

For two producers, while the critical juncture entailed some farm level change it had been positive. Colin identified how “[d]uring the modernisation process NVIRP put in five mechanised gates” (Narrative 3, 3.8). Colin “saved a bit on labour” when he

rationalised an outlet and the other five outlets were converted to flume gates (Narrative 3). After “the public irrigation infrastructure had been upgraded...Keith thought that the new system ‘works great’” (Narrative 11, 11.19). In the upgrade Keith rationalised a spur which included converting 18 acres to dryland cropping (Narrative 11).

The consequences of modernisation were not viewed as favourably by Isaac. “In the middle of the drought Isaac’s outlets to the public irrigation system were automated as a part of an irrigation modernisation program.” (Narrative 9, 9.10) For Isaac, the change led to problems with “gates not opening or shutting properly” which forced him to alter how he timed his irrigation schedule to ensure he is there when the water was meant to turn off (Narrative 9).

There were two other producers, whose farms had yet to be ‘modernised’, with identified critical junctures due to modernisation. “Geoff’s farm is 1.5 to 2 kilometres from the backbone on a spur channel. At the time of the interview he was ‘in the middle of discussions’ regarding his farm’s access to irrigation water” (Narrative 7, 7.14). While the implications of modernisation were uncertain, the distance from the backbone implied some farm-level change was likely to be necessary.

Unlike Geoff’s circumstances, Dennis and Donna had already been impacted upon by the modernisation policy, though not through the implementation of the program. Dennis and Donna had purchased a 211-acre block and had begun a process of development on this new land when irrigation modernisation was announced. The announcement injected a degree of uncertainty regarding access to water on that block into the future, so they stopped the development. “They stopped what they were doing, never put in the lucerne because they thought the system was going to change ‘anytime’. Of course, ‘eight years down the track they still haven’t done anything’” (Narrative 4, 4.15). The delay in the implementation of the modernisation program has also locked Dennis and Donna out of accessing grants for funding irrigation efficiency on farms that other producers were receiving.

“Because the decision has not yet been made about their spur, Dennis and Donna are still waiting for their farm to be modernised through NVIRP. They are still using Dethridge wheels at their connection to the public irrigation system. As well, because they are not on the

backbone, they cannot access the on-farm water use efficiency grants.

“They wonder why we're upset.” (Narrative 4).

Not only were Dennis and Donna uncertain²⁷ about how to develop a 211-acre block that they had purchased, they were also locked out of some development options for the farm business because of the delay.

One producer saw the potential to link the imposed change through the modernisation program with grants for funding irrigation efficiency on farms.

NVIRP wants to get rid of the spurs on the irrigation system as a part of an irrigation modernisation program. As well, there are government incentives (round two) for water-use efficiency upgrades. Frank has put these two things together to redevelop his dairy property (Narrative 6, 6.17).

This example indicated two policy-derived sources of the critical juncture, compulsory change in terms of modernisation and the identified opportunity associated with funding available through the irrigation efficiency grants.

In addition to Frank's critical juncture described above, six other critical junctures were identified in the farm narratives that were linked to irrigation change associated with the grants for funding irrigation efficiency on farms.

Albert “was successful in acquiring funding through two state and federal programs that are providing him considerable funding towards \$225,000 worth of on-farm improvements. He never could have afforded this kind of upgrade without the funding” (Narrative 1, 1.9);

Ben laser-graded four paddocks with the “help of a recent federal government water efficiency grant” (Narrative 2, 2.14);

“At the time of the interview Edward was in the process of doing some irrigation development work that was funded through Round Two of the Catchment Management Authority's on-farm irrigation efficiency program” (Narrative 5, 5.12);

“After the drought Harry's son used an irrigation modernisation program and a water efficiency grant” (Narrative 8, 8.17);

²⁷ Irrigated grape producers in the Sunraysia region of Northern Victoria also expressed uncertainty regarding investment in their businesses in the face of uncertainty regarding their access to irrigation water (Cowan, Wright, & Kaine, 2011).

Also from Narrative 8, Harry was “planning on putting in an application for the next round of funding for water efficiency grants to get pipes and risers installed on the 345 acres of land that he owned” (Narrative 8, 8.18); and

Neil “applied to convert the whole dairy farm to a pipes and risers system” through irrigation efficiency grants (Narrative 14) “Neil was interested in pipes and risers was ‘for the lifestyle’. 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, 14.20).

There were state and federal farm irrigation efficiency grants offered to irrigators across the same period of time that irrigation modernisation policy began the implementation phase. The farm irrigation efficiency programs generally offered irrigators funding for on-farm irrigation work in exchange for 50 per cent of the irrigation water saved through the works, which was then allocated for environmental flows. While the irrigation efficiency grant programs were separate from modernisation, their tandem implementation meant that they were closely linked. Hence, these critical junctures were likely to be closely linked to modernisation.

There were no threats identified as critical junctures relating to the irrigation efficiency grants. However, it is worth noting that one interviewee highlighted a potential future threat to the regional industries due to the recent availability of grants for irrigation upgrades.

Paul thought that the problem with agriculture in the region was being ‘masked’ by Government’s investment in the irrigation infrastructure. When the money through these ‘farm water programs’ is gone, Paul is very unsure what the future holds for irrigation in the district. However, Paul is certain that ‘the toughest years in irrigation are still ahead of us’ (Narrative 16).

Overall, there were 11 narratives that highlighted critical junctures associated with either modernisation or new irrigation efficiency grants. This means that there were five producers for whom such critical junctures were not identified. For some producers

modernisation led to no change in the farm and, for others, modernisation was overshadowed by other issues.

There were three producers for whom the modernisation program was described in the narrative, but did not have sufficient noticeable impacts on the farm associated with it to indicate a critical juncture. Lachlan described how the only change for him was that “one irrigation outlet was converted from a Dethridge wheel to a ‘flow meter’ as a part of the upgrade with no ill-effect” (Narrative 12). For Matt, modernisation led to the rationalising of a spur channel which had little impact on his farm as “Matt hadn’t used the spur outlets since he built the dam, 25 years ago” (Narrative 13). Owen noted that his “irrigation outlets were converted from Dethridge wheels to Magflow meters” and that he “‘did very-little’ to change his on-farm irrigation system at the time the public infrastructure was changed” (Narrative 15). For these three producers the policy change had little impact on their farms. None of these interviewees participated in the farm water grant program and there was no indication that modernisation led these producers to alter their systems in response to a new opportunity.

There were two other producers for whom modernisation was not identified as a critical juncture. In these cases, modernisation was less significant than other issues that were identified as critical junctures. For John and Jacqui, drought was a critical juncture which required that they learn “a whole new way of farming” (Narrative 10, 10.15). While John identified that money received for rationalising Dethridge wheels and some “associated on-farm work” was useful, it was in relation to managing the critical junction of drought; as “NVIRP money helped get John and Jacqui through the drought” (Narrative 10).

During the time that modernisation was occurring Paul was trying to get out of agriculture by selling the farm. When a buyer could not be found Paul changed his goal by shifting from dairy to cropping production. It was through the time that he was transitioning to cropping that he “‘changed a lot of things’ regarding how the farm’s water was structured” (Narrative 16). While the modernisation policy may have influenced his decisions on farm irrigation, how it has done so is unclear. The decision to change enterprises was clearly identifiable as the critical juncture for Paul.

This modernisation example highlights the variety of impacts a change in policy can have on those whom the policy affects. A significant feature of the modernisation example is the intersection between the imposed change through government policy and voluntary change with the availability of grants for funding irrigation efficiency on farms. Of course, the actual impact of a policy change cannot be understood solely through identifying it as a critical juncture. It is what the policy enables, or locks out, regarding subsequent decisions that determine its true impact.

4.4.1.3. Changes in Markets

There were 14 critical junctures that stemmed from market changes. Four of these related to changes in the dairy industry regarding product expectations. For Harry, the factory milk “payments changed to focus on protein” (Narrative 8, 8.12). This “meant that increasing the amount of milk became more important than butter fat” and Harry decided to change his herd genetics to Friesians, to take advantage of the opportunity (Narrative 8).

In three circumstances the milk factory shift to purchasing whole milk from farms was identified as a critical juncture (10.4, 11.11, 13.4). In all three cases, the producers had both pig and dairy enterprises. For example, when “the factories started taking whole milk rather than just cream...[th]is meant that there was no longer excess skim milk for the pigs.” (Narrative 10, 10.4). The market change influenced farm decisions relating to both dairy and pig production.

There were ten critical junctures identified in the narratives that related to the prices producers received for their output. Neil described how “there was one year in which the ‘milk price was terrible’” (Narrative 14, 14.2). The poor market prices drove Neil’s family to produce cabbages as an alternative source of income for the farm. Matt’s father decided to focus on “the production of butter fat” by shifting out of fruit and into dairy “because the market price his father was getting for the fruit was low” (Narrative 13, 13.2). As well, Matt and Marie had to get off-farm work when there was a “huge drop in milk prices in 1975” (Narrative 13, 13.15).

The impact of a drop in market prices on the farm was determined, in part, by the current financial circumstance of the farm. For example, “the money that Harry was getting for his milk decreased as price for butter fat dropped” (Narrative 8, 8.3). At the

time Harry “was ‘broke’[as well]. Harry got a letter from the bank that told him to stop writing cheques from the farm account until he came up with some money” (Narrative 8, 8.3). Harry had to borrow more money against other assets and sell off stock to get through the crisis. More recently, “Murray Goulburn dropped the milk price which put Harry and Helen under so much financial pressure that they considered getting completely out of dairy” (Narrative 8, 8.16). This was at a time when Harry’s “property was mortgaged and he was ‘battling to keep going’” (Narrative 8, 8.16). This time Harry sold 200 ML of his permanent water to manage the problem.

The other critical junctures relating to market prices appeared to be describing the same industry crisis, though the dates differed. Descriptions of this period in regional history that resulted in critical junctures were remarkably similar: farmers were “[s]hooting all the cows” (Narrative 10, 10.6); “when farmers were ‘shooting cows’ because ‘they were worthless’” (Narrative 13, 13.19); “there was ‘a major crisis in the cattle sector’. Producers were ‘shooting cattle and livestock were at give-away prices’. “Peter started ‘looking for an alternative’ to cattle” (Narrative 16, 16.7).

For Karl, the downturn in the market during this industry crisis, when he “recalled other farmers having to shoot their stock” (Narrative 11, 11.12), combined with a conflict he was having over milk collection to produce another critical juncture, when he “got discouraged” with dairy farming (Narrative 11, 11.13). Karl ended up converting his farm to beef cattle.

4.4.1.4. Family and personal context critical junctures

The sources of 91 critical junctures can be described as relating to changes in the family and personal context, which entailed changes to personal and family circumstances in a way that altered farm business decisions. Broadly these can be described as relating to personal and family goals, including marriage and children; episodes of family tragedy; or changes to farm ownership, management, succession planning and available family labour.

Personal and family goals

Decisions made to enter into farming were coded as critical junctures. Such decisions were underpinned by personal goals; hence, these were classified as relating to family and personal context. For example, Matt’s father “wanted to change from his pre-war

career in the railroads to farming, as his family was from a farming background” (Narrative 13, 13.1). As well, Albert described how his “grandfather started out as a share farmer on the property” (Narrative 1, 1.1).

Other critical junctures that were described as changes in personal goals related to changes to off-farm activities or businesses that led to alterations on the farm. For example, Albert “retired from his off-farm artificial breeding work” and started “focusing on doing a few more things around the farm” (Narrative 1, 1,10). As well, Lachlan “became involved in another business off-farm that was essentially a seven-day-a-week business”, which reduced the time he could put into his farm (Narrative 12, 12.11).

Some goal changes related to moving toward retirement. For example, Matt decided to focus on “reduc[ing] their debt and refinanc[ing] their loan...[as he] was in his early 60s and didn’t want to ‘keep going flat out’” (Narrative 13, 13.31). “Owen and Olivia decided that they no longer wanted to run the dairy farm” (Narrative 15, 15.15). When “Harry turned 70 he decided that he was going to stop milking cows as he thought he had ‘done enough’” (Narrative 8, 8.19).

Some of these critical junctures were derived from changes in personal or family goals related to decisions to get out of dairy farming²⁸. These goal changes were closely linked to the farm not achieving the benefits needed by the family or individual. For example, “Karl ‘got discouraged’” with dairy farming and converted to beef cattle (Narrative 11, 11.13). As well, “Paul and Patricia were just ‘marking time’ and by 2008 they’d ‘had a complete gutfull’” of dairy farming and converted to cropping (Narrative 16, 16.20).

Another example of this was Lachlan’s experience. “Lachlan was under a lot of stress. He was ‘sick of working and not making money’. Lachlan decided that the time was right to sell the cows because things were starting to turn around and ‘people started getting a bit of confidence’. Cattle prices and milk prices were improving as well” (Narrative 12, 12.12). An important characteristic of this example is that Lachlan

²⁸ There were other critical junctures from which producers altered their enterprises that were classified as either an identified opportunity or threat in the forthcoming section. The critical junctures classified as intersecting with personal goals differed in that the producers indicated a high degree of stress, or highly emotional response to their circumstances, that implied a conflict with their personal wellbeing that underpinned the critical juncture.

described the intersection of several distinct factors. Not only was he concerned about his low financial returns but the drought was beginning to 'turn around' and the market prices for both milk and stock had improved. Lachlan's was not the only experience of a critical juncture occurring due to multiple factors. This issue is considered in greater detail in section 4.4.3.5. of the analysis.

Getting married and having children were sources of critical junctures within the farm narratives. In some cases getting married and having children drove decisions regarding the need to expand or otherwise alter the farm. For example, "Harry had a growing family and was looking to expand his farm business so that he could support his wife and children..." (Narrative 8, 8.2). As well, "Ben and his parents knew that there were going to be 'two families trying to make a living' from the farm. An extra house had to be built and, while Betty did work off-farm, there was a 'push to try and milk more cows'" (Narrative 2, 2.8). In other cases, marriage of the son was a trigger for passing on the management of the farm. For example, "Albert and his wife took over the farm in 1978, after they were married" (Narrative 1, 1.2) and "[t]he day that Owen was married the farm was signed over to his name" (Narrative 15, 15.5).

There were also examples where triggers for change were identified by the need to match farm business goals with family goals relating to children. For example:

"But he would come home after being on the road for a couple of weeks and his children wouldn't know who he was. That changed things for Edward" (Narrative 5, 5.4);

"They 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, 14.17); and

"About four years ago his wife's business was thriving and she was off the farm for an increasing amount of time. Keith took on the role of 'home dad'. This meant that he looked after the house and managed the children's needs. Keith did that over three years and it was difficult. The most challenging part was the evening milking as that same period was when he needed to be looking after the children and their needs and preparing the evening meal. Keith just couldn't be in

two places at the same time and he was ‘burning out’” (Narrative 11, 11.20).

The need to match the farm to family needs can be seen in Neil’s decision to convert to pipes and riser irrigation on his farm “for the lifestyle” (Narrative 14, 14.20). “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, 14.20). Neil was concerned that the “huge” hours invested in dairy farming “could ‘get pretty tough on the family life’” (Narrative 14).

Family tragedy

The untimely death of a family member was identified by several producers as traumatic for the family and leading to impacts on the farm. I identified these as critical junctures because of their clear impact on decisions relating to the farm. These impacts include changing who makes the farm decisions, reducing production for a period of time and stalling in a decision to sell the farm.

For example, John had to permanently take over all farm management decisions when his father “‘just lost interest’ in the farm in the mid-1960s after the tragic death of one of John’s sisters” (Narrative 10, 10.7). As well, after Neil’s brother was killed in a car accident in 1986 “Neil’s father was considering selling the farm” (Narrative 14, 14.4). It was only because Neil, at 14, expressed interest in coming to work on the farm when he finished school that his father kept farming. Even so, during the next couple of years the stock numbers were reduced to “make life easier for that time” and the family went overseas for an extended trip (Narrative 14).

Dennis and Donna had “‘been ‘thinking about moving on maybe to another farm or out of farming’. However, when they lost their son they just ‘weren’t ready to move’” (Narrative 4, 4.17). Several years later, they were still on the farm “plodding on” (Narrative 4). In recent years Edward and Ellen’s “three children were involved in an automobile accident and one daughter died. The other two children were also injured. Edward broke his leg at the scene of the accident and Ellen had broken her arm in the dairy a week earlier” (Narrative 5, 5.10). Due to these circumstances, Edward and Ellen had to alter farm by selling all of their dry stock and converting to once a day milking. They hired someone to manage the farm.

Grief was certainly present in the interviews and the narratives. While grief is likely to influence the capacity to make decisions about the farm, understanding responses to grief is beyond the scope of this research. It can be said that the untimely loss of a family member may interact with an individual's value image and lead to fundamental questioning of personal goals. These critical junctures also clearly influence farm business goals, succession planning, and farm labour.

Changing family labour, management and ownership

There were a number of family-based critical junctures that directly influenced available farm labour for the business. Some of these related to children returning to work on the farm, thereby increasing available labour. For example, "Ben left school in 1981 and became an apprentice on the farm" (Narrative 2, 2.3) and Harry's "son came back to work on the farm in the early 1980s and has been on the farm ever since" (Narrative 8, 8.6). These critical junctures can lead to expansion and growth decisions, based on having more farm help and increased pressure to support an expanded workforce. For example, "[a]s Frank had just left school to work on the farm, Frank's father decided to purchase the block so that they could increase the farm size and milk more cows" (Narrative 6, 6.4).

Other examples of critical junctures that stemmed from changing labour related to decisions by individuals that reduced available farm labour. For some producers the consequences of these changes were significant. For example, when Colin's wife said she was "no longer interested in working in the dairy", Colin realised that he had a significant issue because he didn't want to hire help but needed support when breaking in new heifers because he had a "difficult dairy" (Narrative 3, 3.9). When "Frank's younger brother decided to leave the farm" in 2008, it "turned the farm into a predominantly one-man operation" by halving the workforce (Narrative 6, 6.14). Matt and Marie's "son announced that he was leaving the farm for personal reasons" just after considerable investment had been committed in the dairy farm, based on the idea that he would be taking over the business (Narrative 13, 13.33). Following their son's decision to leave, Matt and Marie were forced to sell the dairy business, which was "unexpected and traumatic" (Narrative 13).

Overall, it was apparent that the role of the family as a farm labour force could strongly overlap with the family as a support network. Decisions to work on the farm or leave

the farm were not necessarily made for business reasons. Offspring could be seen coming and going within the farm narratives as sources of farm labour and members of the household. For example, “Mark, came to work on the farm in the very late 1960s, after being retrenched from his job as a mechanic” (Narrative 13, 13.12). Similar to marriage, this can put pressure on the farm to generate sufficient income for the expanded family.

When labour altered due to a family member’s decision to leave the farm, at times the significance of this related to issues of succession planning and farm ownership. There were several examples in the narratives where unexpected such changes led to changes in farm ownership. Matt and Marie were hit by “a bit of a bombshell” when “Matt’s brother Mark and his wife announced that they wanted to be bought out” (Narrative 13, 13.27). Edward “discovered that he and his father couldn’t work together very well as ‘two bosses just don’t go down’” which led Edward to buy the family farm (Narrative 5, 5.6). When “Geoff and Gini wanted to get out on their own and run their farm as they wanted to” the family partnership had to be split in two (Narrative 7, 7.8). Paul had two brothers, both of whom decided to leave the farm at different times, at a cost to Paul. When his second brother left in the mid-1990s, Paul had to borrow “about 60 per cent of the value of the farm” to pay off his brother and father (Narrative 16, 16.15).

Change in ownership indicated the potential for a new set of farm business goals by a new farm manager, hence its identification as a critical juncture. There were many other examples where changes in ownership were identifiable as critical junctures in the farm narratives. In Colin’s farm history, the family “farm was split into two 150-acre blocks and given to Colin’s father and uncle who ran them as two separate businesses” (Narrative 3, 3.1). Isaac’s “father bought out his brother and took on sole management” (Narrative 9, 9.2). Lachlan’s “grandfather had five sons and divided the 600 acres up into sections, giving a block to each son in the mid-1950s” (Narrative 12, 12.1). “Peter and his wife took over a soldier settlement block that belonged to Paul’s mother’s parents” (Narrative 16, 16.9).

4.4.1.5. Imperative for increased productivity as a source of critical junctures

The final two sources of critical junctures, contributing 122 of the 264 critical junctures identified in the narratives, were those related to endogenous opportunities or threats within the farm that influenced productivity and the business margin. What became

clear to me when I was considering these critical junctures was that they were embedded in a persistent need to increase productivity that could be seen across the farm narratives. Before considering these critical junctures in detail it is useful to first describe this need to increase productivity as it helps frame the opportunities and threats in a meaningful way.

Dairy farming, like much of Australian agriculture, exists within a near-perfectly competitive market. A fundamental problem associated with this perfect competition is the relentless decline in the terms of trade in the dairy industry. The declining terms of trade means that income generated by producing the same outputs from the same inputs decreases over time. Albert described how “if you stand still, the costs just kill you” (Narrative 1). Owen describes this problem within his farm experience when “[a]ll through the 1990s they continued to milk 180 cows, their farm ‘maximum’, and ‘were just going backwards’” (Narrative 15). This creates a continuing imperative to increase productivity if a dairy business is to remain profitable.

There are two general mechanisms for increasing productivity: expansion (to capture economies of scale) and efficiency improvements. Across the farm narratives I found that the imperative for increasing productivity entailed changes to business structure through expansion and efficiency, which were reflected in critical junctures. This could be seen the farm development decisions through time (See Figure 4.3).

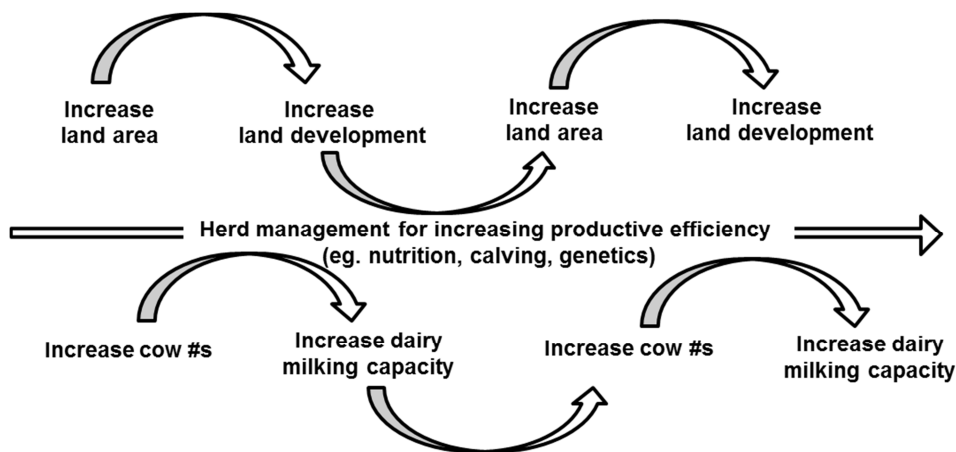


Figure 4.3: Simple illustrative example of dairy farm development through time

There were two interrelated streams of expansion and efficiency decisions made through time, relating to feed production and the herd, identifiable in the narratives. Change in terms of the feeding system generally entailed the acquisition of land

(expansion) and the development of land to increase its output of feed for the herd (efficiency). These two broad mechanisms for increasing production are clearly related. Narratives reflected cycles of land acquisition followed by land development and the more land acquisition. Identified threats and opportunities within this cycle that led to changes to farm development were identified in the narratives as critical junctures.

Output growth in terms of the herd entailed increasing the size of the herd (expansion) and increasing the capacity of the dairy shed to enable an increased rate of milk extraction (efficiency). These two mechanisms for increasing production are also clearly related. Farm narratives reflected decisions to expand the herd and then increase the dairy in response to the larger herd. For example, “[o]ne of the governing factors on herd size according to Ben is the dairy, or ‘milking shed’” (Narrative 2). Identified threats or opportunities within this cycle that led to changes in farm development were critical junctures.

Another important element within the narratives relating to the imperative to increase productivity was managing the herd for productive efficiency. This included practices such as selection of herd genetics, breeding and calving practices, as well as nutrition management. Changes to these farm practices were not as obviously linked to an interrelated cycle as was identifiable in the feed production and herd. Instead change tended to be sporadic. These elements, especially changing genetics and calving patterns, are discussed further in sections 4.4.3.2 and 4.4.3.4.

The feed production and herd streams of expansion and efficiency decisions are interrelated. The degree of coupling between feed production and the herd determines the extent that a critical juncture resultant from a threat or opportunity within one stream leads to change in the other. It is logical that dairy businesses relying upon farm production of feed for stock will have a high degree of coupling between the two streams of development. A significant degree of coupling was apparent in a number of the critical junctures. The link between herd size and land was seen in Neil’s narrative:

Neil was trying to build up cow numbers again since the drought. He was trying to do it quickly to increase income because he had bought the extra 160 acres. He was also “trying to push share farming” which meant he needed enough cows to “sustain things at a reasonable level” (Narrative 14, 14.19).

Harry's experience was another example of this. "When he bought the 120 acres and leased 100 acres in the early 1970s" this was a trigger to increase his dairy to "a 20 unit herringbone" as he was increasing his herd size due to having more land (Narrative 8, 8.10). A high degree of coupling can make distinguishing sources of critical junctures regarding feed production and the herd 'messy' at best. However, describing critical junctures in this manner offered an avenue for understanding critical junctures in relation to the continuing imperative for productivity enhancement.

Sixty three of the critical junctures that were underpinned by an imperative to increase productivity related to identified opportunities in the farm or for the business margin. The remaining 59 critical junctures relating to an imperative for increased productivity stemmed from threats identified to the farm or to the business margin. 'Opportunities' were framed as identified options for change that were perceived to offer benefits to the farm business, in terms of increasing productivity. 'Threats' were framed as identified impediments within the farm or to the margin that necessitated change to the farm if the productivity imperative was to be achieved. In reality, the distinction between threats and opportunities could be difficult to discern. Of importance here is that, collectively, threats and opportunities were linked to an imperative to continually increase productivity. The link of these critical junctures to the productivity imperative was explicit in some cases, such as when "Paul and his brother decided to 'go through another expansion phase'" (Narrative 16, 16.13) and Karl focused on "[g]etting bigger" after he set up his dairy and pig enterprises (Narrative 11, 11.5). John identified a threat to his business posed by not increasing production for his business. "With costs increasing John knew that he had to do more: 'get bigger or get out'" (Narrative 10, 10.8).

For most of the identified threats and opportunities the link to a growth imperative was implicit rather than explicit. Overall, these critical junctures related to enterprise options, land area and development, the dairy shed, and herd management including aspects such as calving, fertility and genetics.

Changing enterprises

There were several critical junctures that stemmed from identified opportunities to change enterprises. For example, Karl's decisions to go into dairy, pigs and "run a beef cattle enterprise as a part of the farm business" were all identified opportunities

(Narrative 11, 11.3, 11.4 and 11.9). Peter saw an opportunity to go into stone fruit on his farm after there had “been serious floods ‘which destroyed large areas of stone fruit trees’” (Narrative 16, 16.4). Interestingly, Geoff began to seriously contemplate converting to a cropping business after he sold some grain that was surplus to his dairy farm needs. He described it as “one of those stepping stones” as it “gave him ‘the taste of it’ and increased his confidence for cropping” (Narrative 7, 7.11).

Some of the critical junctures associated with changing enterprises related to identified threats from the current enterprise and how this led the producers to convert to dairy farming. Lachlan “realised pretty quickly that he was not going to make any money out of hay and beef” which spurred him to go into dairy (Narrative 12, 12.3). Keith had a similar experience when he took over the beef cattle enterprise. “He realised that they ‘were going backwards fast staying in beef’. They couldn’t ‘sustain a decent income on beef’. The lack of income from beef meant they couldn’t put fertiliser back on the pasture and that meant Keith couldn’t grow enough grass” (Narrative 11, 11.15). Harry “pulled out the fruit trees on his orchard...[because] birds were eating the fruit and he ‘couldn’t get labour to pick it’” (Narrative 8, 8.14). Peter got out of producing sunflowers due to poor prices, “a serious root disease called sclerotinia” and “‘terrible trouble’ with bird pests” (Narrative 16, 16.8).

Opportunities and threats associated with feed production

There were a number of critical junctures that emerged due to issues relating to feed production. These included issues relating to land acquisition (expansion) and development (efficiency). For some producers, opportunities for increasing productivity clearly stemmed from the expansion of land area. For example, when Harry bought “120 acres and leased 100 acres in the early 1970s” this created an opportunity for him to increase his herd size (Narrative 8, 8.10). Characteristics of the land being purchased, such as topography, productive capacity, and proximity to the farm, were important determinants regarding the opportunity identified within the critical junctures.

The topography of the new land was important to Neil, who had problems with grazing stock in wet weather. Neil identified that “the new 160-acre block had ‘a fair bit of undulation’ which meant that there were more options for where to put cows during wet winters” (Narrative 14, 14.18). As well, topography determined the configuration of

Isaac's irrigation infrastructure, which was set up to follow the "natural flow" of water on his property (Narrative 9, 9.5).

Increasing productive capacity did not necessarily mean increasing land area. Ben "sold off [a] 250 acre dry block" so that he could "buy a 238-acre irrigated block" (Narrative 2). While the new block was smaller he saw it as an opportunity to "run more young stock than they could carry on the dry block" because of the greater productive capacity of the irrigated block (Narrative 2, 2.13).

For some, proximity of the land to the existing farm was a key determinant of it being seen as an opportunity. For example, Dennis and Donna bought a block, though they acknowledged "that it [was] a bit of a risk" because it was not on the backbone of the irrigation system (Narrative 4). However, the opportunity offered in the land's location could not be ignored, given "it's just next door and they don't make land next door" (Narrative 4, 4.16). This sentiment was echoed in Harry's experience. A neighbour, who "owned property between some of Harry's blocks sold 120 acres to Harry", in part because of its proximity to Harry's farm (Narrative 8, 8.7). Harry had to borrow significantly and "find another neighbour willing to buy [his] 32-acre block" for the purchase to be possible.

There were threats to the farm business identified in association with the land by some producers, which led to changes in the farm. For several producers, the low-lying nature of their farms and poor drainage led to problems with managing cows in wet weather. This led to a need to change some aspect of the farm. Colin redeveloped his farm to improve the drainage because "[a] persistent problem on the farm is that it 'isn't a good farm in a wet year'" (Narrative 3, 3.4). Frank bought an outblock to enable overwintering his cows because his farm "didn't cope very well with really wet winters...[t]he cows would get mastitis because they would be 'lying in the wet all the time'" (Narrative 6, 6.9). "In very wet winters Neil's father found feeding hay out to the cows in the paddocks difficult" (Narrative 14, 14.7). This led him to build a hay shed for feeding cows over the winter.

Matt also had problems with his land in wet weather, though his problem was worsened by the farm layout. Sequences of land purchases over the years had led to a long and narrow farm, with the milking shed at one of the narrow ends. This became a problem:

The 307-acre farm (including the 50-acre leased block) was narrow and a mile long. Matt and his family had redeveloped areas of the farm that were at the farthest point away from the dairy. This meant a longer walk for the cows to come in for milking. Walking longer distances used more energy and reduced milk production. The region was experiencing wet winters in the late 1980s. In wet weather cows were getting stuck in the mud, getting mastitis, and it was taking even longer to move them down to the dairy shed for milking. Overall, milking was taking too long (Narrative 13, 13.21).

To manage the problem, Matt built a new rotary dairy at a more central location on the farm.

Three producers had critical junctures associated with salinity-based threats to their farms. Edward's father had a bore installed "to help reduce salinity" (Narrative 5, 5.5). Lachlan's farm "had a 20-acre block that had a salinity problem due to poor drainage on low-lying country" (Narrative 12, 12.6). He changed his farm to manage this when he upgraded his irrigation infrastructure, including improving the drainage by putting in a recycling system. Matt's farm "developed a 'rising salt problem' which was leading to tree deaths" (Narrative 13, 13.22). This led him to put in a groundwater bore and convert a portion of land to a fan paddock for salt disposal.

Land Development

Opportunities to increase efficiency of feed production within the existing land were also sources of critical junctures in a few of the narratives. For Frank, the critical juncture was "a plan to 'modernise' the farm with wider bays that would enable easier management of irrigation and use less water" (Narrative 6, 6.5). Owen also "wanted to redevelop the farm in the 1980s" and had a whole farm plan developed (Narrative 15, 15.10). For John, "[e]ver since laser grading emerged as an irrigation management practice in Australia" he has been using it to drive pasture development (Narrative 10, 10.5). Neil and his father "saw relatives growing corn" while on an overseas trip (Narrative 14, 14.8), which encouraged them to start producing it themselves and feeding the grain to cows in the dairy. This was Neil's introduction to feeding in the bail, and he "found that 'it definitely does make a difference' with milk production" and continues to use the practice (Narrative 14).

A few critical junctures stemmed from the threat to development they posed for the farm. Lachlan's farm "was 'an old-fashioned, old-style' farm with 'a lot of laneways and channels and little paddocks'" when he took it over (Narrative 12, 12.5).

Redeveloping the entire farm was an imperative if he was to increase productivity.

When Matt bought a new block he "found the irrigation system to be 'terrible'" (Narrative 13, 13.25). He altered the irrigation system to reduce the problem. Edward found that:

He couldn't do the development work he wanted done on the home block to help achieve this. The ageing infrastructure really needed upgrading but the layout meant that the work needed to be done in "serious chunks" which would have taken too much of the farm out of production at a time (Narrative 5, 5.11).

Given this identified problem, Edward decided to start buying other blocks in the area which enabled him to progress with the development work.

There were two critical junctures that threatened land development, which were identified in relation to limitations in accessing irrigation water (and not associated with drought or a change in policy). "Within a couple of years of taking over the farm Lachlan realised that he needed more water if he wanted to milk more cows" (Narrative 12, 12.7). As well, Matt's farm had a low irrigation entitlement due to the way land was originally partitioned and allocated water. "When water rights were originally allocated to land, larger blocks had less water per acre of land than smaller blocks. While the farm had been subdivided into smaller parcels of land it was not possible to increase the amount of water beyond the combined total in the original allocation" (Narrative 13, 13.5). Matt's family applied for a drainage pumping license so that they could increase the productive capacity of the farm by increasing water access.

Threats to development were identified within two narratives that were associated with equipment for feed production. Geoff and his brother had problems associated with producing square bale hay. Not only was "feeding it out to the cows...difficult" but [i]t required two people to feed it out safely as doing it by yourself 'was a bit dangerous'" (Narrative 7, 7.3). They changed to round bale silage, which entailed different machinery, as well as harvesting and feeding practices. John had to convert to producing wrapped silage when his share farmer left. "The second share farmer had his

own feed cart for the pit silage. When he left he asked for too much money for the feed cart and John just told him to take it with him” (Narrative 10, 10.14).

One threat to development in the narratives related to the operation of an outblock that was run as a feed source for the dairy cows. Paul and his brother “‘applied a lot more scrutiny to the cropping operation’ on the outblock in 1998. They realised that they ‘couldn't make it economically work’ to continue growing maize on the block” (Narrative 16, 16.14). This led Paul and his brother to shift the outblock over to annual pasture production and meant that they were buying more feed for the herd.

For a couple of producers, farm development decisions led to new identified threats as critical junctures, which required further change. Since Frank redeveloped his outblock “the 405 ML of water that came with it is not enough to irrigate it fully” (Narrative 6, 6.12). This deficit in irrigation water led Frank to put in a recycle dam and a groundwater bore.

Matt’s decision to put in a large dam on his property to increase productivity ended up producing such a fast flow that the “faster flow of water ‘just about blew out the channels’” (Narrative 13, 13.17). This meant that Matt had to change the irrigation infrastructure to cope with the new rate. However, once his irrigation system was set up to manage the fast flow this led to another problem. Matt and his brother “were running around every two hours shutting off bays” due to the faster irrigation (Narrative 13, 13.18). Matt and his brother struggled to manage irrigation on the new system and “would end up with a ‘flood down the end like a lake’ because they missed shutting off a bay” (Narrative 13, 13.18). This new critical juncture led to the adoption of automated irrigation.

While most labour-based critical junctures were identified within the realm of the family, there were three critical junctures associated with non-family labour. When John’s sharefarmer “bought his own farm and left in about 2006” this forced John to look for another sharefarmer to manage the farm (Narrative 10, 10.13). Karl had an ongoing issue finding the labour he needed for his farm. This problem only worsened when Karl bought an extra 217-acre block. “Fairly quickly Karl worked out that the extra block ‘was too much’ for him given the labour problems” (Narrative 11, 11.10). Karl ended up giving that extra block to his son to run as a separate business to reduce

the labour issue. As Lachlan was building up his farm business a critical juncture emerged due to the mounting labour pressure on him. “He became increasingly aware that, as a one-person operation, he was working seven days a week with no time off” (Narrative 12, 12.8). Because of this, Lachlan started looking around for a way to share the workload. He ended up starting a partnership with a neighbouring farmer, which amongst other things meant they “could each have alternate weekends off” (Narrative 12).

Herd

There were a number of critical junctures that related to opportunities and threats associated with increasing productivity of the herd regarding increasing herd size (expansion) and increasing the capacity of the dairy shed to enable an increased rate of milk extraction (efficiency). There were also opportunities and threats identified that were associated with herd management, especially in relation to calving and fertility.

Herd size

Matt and Marie experienced two identified opportunities as critical junctures that resulted from their large herd. Their decision to increase the herd to around 400 cows meant that they were able to bypass a waitlist to change milk processing companies “because they milk a large number of cows” (Narrative 13, 13.23). This was a significant benefit to them given the new processor, Tatura Milk, paid a higher price for the milk. Later, Matt and Marie found that Tatura Milk was “offering a ‘considerable incentive’ to farmers who were producing over 300,000 kilograms of milk solids” (Narrative 13, 13.30). Given their already large herd size, Matt and Marie only needed to increase their cow numbers by 80 to qualify for the incentive.

There were a few instances where the current herd size was seen as a threat to increasing farm productivity, requiring change in the farm. These all related to the issue of feed production. Keith found that given “his increasing cow numbers, he needed to also increase his pasture productivity” (Narrative 11, 11.16). “Owen described how they ‘were always struggling’ to have enough feed when they had 180 cows. However, the farm had to be heavily stocked to be profitable” (Narrative 15, 15.6). After putting on a share farmer John had to increase his herd size to keep the business profitable. This led to “...pretty tough times” for John because he couldn’t produce enough feed (Narrative

10, 10.12). John and his share farmer had to alter the farm feeding system to manage the increased herd. They put in a feed pad and also started producing and feeding pit silage.

There were a few critical junctures that occurred in relation to an identified opportunity to increase the herd size and which were described in relation to increased labour and carrying capacity of the land. An opportunity to expand the herd for Isaac was identified when “there were two of them working on the farm and they thought the ‘farm could handle’ increasing cow numbers” (Narrative 9, 9.4). Increased labour was an influencer on John’s decision to increase his herd. John found that “[h]aving a share farmer meant that the farm could continue to increase cow numbers” (Narrative 10, 10.11). As an aside, while labour may have driven John to expand his herd, he then discovered that his feeding system was not sufficient for the larger herd (see previous paragraph).

Matt “saw the potential and the productivity gains’ that could be made with the land, given the new infrastructure” when he developed some recently purchased land (Narrative 13, 13.26). Matt then increased the size of his milking herd because of the increase in available feed. As well, after a series of changes including Harry’s son coming to work on the farm, the purchase of 120 acres and laser-grading, Harry decided it was time to focus on “building up a herd” (Narrative 8, 8.9). When Harry started building up the herd this led to a decision to “double the units [in his dairy shed] to 12” to manage the increased numbers (Narrative 8).

Dairy

There were several critical junctures stemming from the imperative to increasing the efficiency of milk extraction, which related to altering or replacing an existing dairy. For example, Frank described the decision to “put in an 18-a-side swing-over” dairy as stemming from the productivity imperative: “[b]igger dairies and faster milking’; it was what others were doing” (Narrative 6, 6.7). After Isaac increased his herd size he “wanted to be able to milk quicker”. He altered the dairy shed so that he “increased the number of cows they could milk at a time” (Narrative 9, 9.7). As well, “Colin’s father built a six-a-side double-up dairy which meant that 12 cows could be milked at a time” (Narrative 3, 3.2).

At times, the threat posed by not changing, which had to do with inefficiency at milking time, was described within the narrative. For example, John built a 24-a-side swing-over

herringbone when “[t]hey were spending four hours in the morning doing the milking, which was too much time in the dairy” (Narrative 10, 10.9). As well, Harry found that “[w]ith the increased number of larger cows it was taking too long to milk” (Narrative 8, 8.11). This pushed Harry to put in a 32 swing-over dairy.

Neil had a “26 cow herringbone dairy” which was big enough for his farm; however, he had a problem associated with the dairy’s “terrible yard set-up” (Narrative 14, 14.13). He found “[c]hanging the yard to the dairy ended up being difficult because there was a dam that impeded the changes they wanted to make” (Narrative 14, 14.13). Building a new rotary dairy offered Neil an opportunity to fix his yard problem.

The dairy could be a significant constraint, which was apparent in Paul’s experience whereby the poor condition of the dairy was a critical juncture which pushed him to make a significant decision about his future in dairy farming.

By the mid-2000s Paul was very aware that “the farm needed a huge new investment in infrastructure and enthusiasm”. Neither Paul, nor Patricia, was prepared to give it. The biggest infrastructure problem was the dairy. The existing dairy was old, which meant high maintenance requirements. Its small size meant that milking was time consuming, generating high staffing requirements (Narrative 16, 16.19).

Paul decided get out of dairy farming by selling the farm. When no buyer could be found, they converted to cropping²⁹.

An issue that appeared as critical junctures for a few producers related to the size of their cows and their dairies. This issue was closely linked to herd genetics. The response was the same in all three instances. Matt needed “to accommodate the larger crossbred cows and enable them to milk more cows at a time” when he changed his herd genetics (Narrative 13, 13.10). He increased the number of stalls in his dairy and converted to straight rails. Isaac saw an opportunity to accommodate larger Friesian cows and

²⁹ The importance of the dairy as a source of constraint was echoed in Colin’s experience. While the critical juncture for Colin was the fact that “his wife is no longer interested in working in the dairy” (a family labour issue), this has left Colin in a difficult situation in which the “dairy is the main issue he has on the farm at the moment” (Narrative 3, 3.9).

“squeeze more cows in” and converted his zigzag rails to straight rails (Narrative 9, 9.7). Neil found that his increasingly larger cows were presenting a problem for his business. “[H]e couldn’t fit as many cows as before. For example, instead of fitting 26 cows in the dairy he could only fit 23 or 24 cows” (Narrative 14, 14.12). This was reducing his milking efficiency. Neil also changed the rails in his dairy to accommodate the larger cows.

Herd management

There were a number of critical junctures associated with threats and opportunities identified in relation to herd management. These differed from the feed production and herd size/dairy critical junctures in that they did not follow a cyclical pattern. These related largely to decisions about calving, herd genetics and fertility. There were also a smaller number of critical junctures that related to threats associated with current practices, which I will consider first.

Dennis and Donna experienced several critical junctures when herd management decisions led to poor outcomes. Dennis and Donna were new to farming when they bought their dairy farm in 1989. When relaying the problems they experienced Dennis stated “you probably shouldn’t let people without more experience own animals” (Narrative 4).

One critical juncture for Dennis and Donna stemmed from their lack of experience with nutrition. “They did not get the nutrition right to begin with and it was ‘fairly hard on the animals’; some of the cows ‘got a bit skinny’ and a few died” (Narrative 4). While “[i]t took Dennis and Donna a while to learn more about the nutrition”, they “developed their own approach to over-wintering cows” and “bought more land” to increase their feed production (Narrative 4).

Feeding cows was an issue for Dennis and Donna at other times as well. They set up a “feed pad in the laneway to the dairy” which ended up being “a mistake” because cows would get very dirty and end up with infections (Narrative 4, 4.2). This led them to change how they feed out, to “sacrific[ing] a paddock” (Narrative 4). Problems emerged from this practice. “Cows were getting mastitis and when they tried to re-sow at the end of the season, ‘there was just so much stuff that you couldn’t get rid of it’” (Narrative 4,

4.11). They had to change practices again to one where they rotated cows around paddocks when feeding them.

Dennis and Donna were looking for a new source of feed for their cows during the recent drought and decided to try sorghum. Unfortunately, a couple of cows “just bled to death” when they “stabbed their milk vein on the sorghum stalks” (Narrative 4, 4.12). This “put Dennis and Donna ‘right off’ growing sorghum” and led them to look for alternative feeds (Narrative 4, 4.12).

Dennis and Donna decided to install a calving pad. They saw it as an opportunity to aid in herd management.

The intention was to make it easier to check on the cows when they are close to calving. It also enabled Dennis and Donna to have more feed control up until calving, to ‘lead feed for milk fever’ and get the cow’s ‘gut ready for pasture’ after calving (Narrative 4, 4.4).

They changed practices again a few years later when “they found that it led to more problems than benefits” (Narrative 4, 4.5).

Two critical junctures associated with herd management were found in other producers’ narratives. Matt “had a couple of bad experiences with bringing outside cows onto the farm”, including the introduction of Anthrax to the herd (Narrative 13, 13.29). This led Matt to alter his herd management so that he could maintain a “closed herd”, which means no outside cows are allowed on the farm (Narrative 13, 13.29). Ear tagging was important for Geoff and his brother, who managed a partnership farm with two integrated herds. However, “[t]hey were finding identification of cows difficult because ear tags were dropping out”. This led Geoff and his brother to change their herd identification program to freeze branding rather than tagging (Narrative 7, 7.7).

Calving

Decisions regarding a farm’s calving pattern were, at times, associated with the imperative to continually increase farm productivity. Frank changed to split calving “to increase cash flow over the winter to help with their loan repayments for the new property” (Narrative 6, 6.10). Harry “decided to start calving some cows in the autumn so that he could get the better pay that comes with winter milk” (Narrative 8, 8.12).

Matt described the opportunity he saw from split calving associated with the ““very high

milk payments' for autumn and winter milk" that the milk processor was paying (Narrative 13, 13.24). Conversely, Dennis and Donna "figured out that they would be better off" switching to spring calving from split calving (Narrative 4, 4.13). "The difference was due, in part, to the fact that the cows were dried off earlier for autumn calving so they had a shorter lactation and a lower overall milk production throughout the year" (Narrative 4, 4.13).

Calving decisions were linked to feed availability and the capacity to manage cows in wet weather, which was seen within some of the critical junctures. For example, Edward decided to convert to spring calving given "the combination of the surety of water in carryover and the added 93 acres of perennial pasture under the centre pivot", factors that have increased his capacity to grow summer feed (Narrative 5, 5.13).

Neil had changed his pasture mix due to drought, which altered the timing of feed availability on his farm. He found that "the amount of feed he could grow through the autumn, winter and spring was 'a hell of a lot more with a lot less water' than he could grow through the summer" (Narrative 14, 14.18). As well, while Neil's farm typically could not manage cows in a wet winter, a recent purchase of a 160-acre block with "a fair bit of undulation" offered Neil "more options for where to put cows during wet winters" (Narrative 14, 14.18). The combination of feed availability and herd management options in wet weather made split calving a workable option for Neil.

Herd fertility

Issues with herd fertility came up in several farm narratives as a source of critical junctures. In all cases, they implied a threat to the business. Colin "was having some fertility issues with the Friesians" (Narrative 3, 3.5). Geoff "discovered that 24 (20 per cent) of his 120 cows were not in calf" (Narrative 7, 7.9). Isaac "got the cows in calf but 'they just seemed to be one or two cycles behind what the pregnancy test showed'" (Narrative 9, 9.11). Dennis and Donna found that "the Friesians were having increasing fertility problems" (Narrative 4, 4.6). Edward "was constantly struggling to maintain his Holstein breeding, mostly through infertility" (Narrative 5, 5.8). John was also "having problems getting cows in calf ... John described it as something that 'creeps up on you'. At first he noticed more cows were calving later. Then he started having an increasing

number of empty cows” (Narrative 10, 10.10). Neil also experienced fertility problems in which it was “harder and harder to get the cows in calf” (Narrative 14, 14.6).

At times, the decision to change calving patterns was associated with fertility issues. For example, Frank’s narrative states outright that his shift to split calving “is because of fertility issues” (Narrative 6, 6.11). Paul found “[t]he proportion of empty cows ‘ended up being too high a proportion’ for Paul and his brother to continue to ‘wear the losses’ associated with sticking to spring calving” (Narrative 16, 16.12). As well, Dennis and Donna had converted to split calving due to fertility issues. After they converted back to spring calving for productivity reasons the problem emerged again. “The cows started to develop fertility problems again after they had converted back to spring calving” (Narrative 4, 4.14). The relationship between calving and fertility is discussed in greater depth in section 4.4.3.4.

Herd genetics

Related to the issue of fertility is herd genetics. Fertility issues were identified by a number of interviewees as largely being associated with Friesians and other large cross-breed cows, because they have been pushed genetically to be highly productive. It was the potential of increasing milk production by using Friesian genetics that was a source of critical juncture for several producers. Colin “was looking for more milk and bigger cows” (Narrative 3, 3.6). Isaac focused on breeding Friesians because they were “supposed to be the better milking cow” (Narrative 9, 9.6). Harry converted to Friesians because they “were better cows for volume” (Narrative 8, 8.12). Karl sought a greater milk volume as it “meant more cream for the factory and more skim milk for the pigs” (Narrative 11, 11.6). Owen’s decision to convert to Friesians differed from the others. He switched to Friesians because of an “interest in using the outblock to start a beef enterprise” (Narrative 15, 15.4): while Friesian-Hereford crosses are good beef cattle, Jersey-Hereford crosses are not.

Two critical junctures were identified in relation to the establishment of a Jersey stud. When “the Jersey Society opened the books to register Jersey cows with sufficient records” this influenced Albert to focus on developing a Jersey stud (Narrative 1, 1.4). Matt’s family also “started the process of setting up a Jersey stud” (Narrative 13, 13.6). However, “after the factories started taking bulk milk, more breeds of dairy cows

became available through the use of artificial insemination...[Matt's father] began to question his use of bulls and the Jersey stud" (Narrative 13, 13.7).

A few critical junctures could be seen in relation to problems associated with the current herd genetics. Albert identified a need to "do something to sort out the mixed-breed 'motley group of cows'" (Narrative 1, 1.3). Ben's herd was "a mix of cross-breeds. It was like 'liquorice all sorts.'" (Narrative 2, 2.4). Dennis and Donna started having a "bigger gap between the best and worst heifers" due to their herd genetics (Narrative 4, 4.7).

Geoff described how, after they decided to convert to Friesians, the transition from Jerseys created calving problems that they had to manage.

[T]hey started getting little Jersey cows having big Friesian calves.

When a cow's calf was too big it could sometimes lead to nerve damage in the hips and paralysis. If this happened then the cow would have to be put down. Geoff and Gary were losing anywhere from four to ten cows a year because of this (Narrative 7, 7.6).

Due to this new problem, Geoff and his brother started selecting for small framed Friesian genetics.

Problems with calving associated with Friesians were echoed by Colin. "There were times when it was like Colin was 'pulling every second calf'. It was stressful and time consuming. This is especially true as Colin has set up his business as 'a one man operation' and keeping that side of the labour down is important" (Narrative 3, 3.5). Friesians also "tended to pug out the paddocks" on Colin's farm (Narrative 3, 3.5). Colin decided to convert to Jersey cows due to these Friesian issues.

4.4.2. The role of reinforcing decisions in farm constraints

If path dependence exists in farms, it should emerge, in part, as sequences of reinforcing decisions that flow from the critical junctures identified in the previous section. Hence, after identifying critical junctures in the farm narratives, the next step in my analysis was to ascertain whether sequences of reinforcing decisions could be identified as stemming from critical junctures. If sequences of reinforcing decisions were identifiable then this offers demonstrative evidence that path dependence exists in farms. In this section I describe the results of this analysis, described in terms of decision mapping.

The findings from the mapping process will be discussed as well as insights the analysis offers for understanding constraints in farms.

Overall, there were 1349 sections of data that were coded in this research. Of this, there were a total of 264 critical junctures identified in the narratives. This leaves a remaining 1085³⁰ sections of data that reflect a combination of adaptations, changes to images and changes to business functions. The aim of the decision mapping component of the analysis was to identify instances where the 1085 data sections could be identified as stemming from the 264 critical junctures, as this provides evidence for the existence of path dependence in farms.

Adaptations, image and function changes were linked to a critical juncture where it was clear that the change reflected the path defined at the critical juncture. The rationale for identifying linkages was recorded in each farm matrix (see Appendix E). An example of identified linkages between critical junctures and reinforcing decisions is offered in Figure 4.4. At times, the rationale for identifying linkages could be clearly seen at the critical juncture. For example, critical junctures associated with identified opportunities in the farm were a close intermeshing of the critical juncture (awareness of opportunity) and response (seizure of opportunity).

At other times the rationale for identifying linkages relied on consideration of the critical juncture as well as the immediate response to the critical juncture. For example, an identified threat to the farm may lead to a number of different responses. The linkages along the altered path related not just to the critical juncture itself, but also to the choice of response. This required consideration of linkages within farm context. An example of this can be seen in the different producer responses to an identified threat associated with herd fertility (see section 4.4.3.4).

³⁰ Any critical junctures that were simultaneously identified as a change in images, function changes or adaptations were not included in this total.

<p>“1991 Frank’s younger brother finished school and returned to work on the farm.” CJ 6.8 Rationale: Family derived juncture – change in family labour units</p>
<ul style="list-style-type: none"> • “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.” Rationale: Increased labour units leads to growing business phase • “bought a 637-acre outblock” Rationale: buying land to grow business • “to redevelop the outblock so that they could use it for fodder production and running dry/young stock” Rationale: buying land to grow the business) • “put up fencing” Rationale: fencing of land bought to aid in growing the business • “laser graded 100 acres” Rationale: laser grading of land bought to aid in growing the business • “Frank and his family have invested considerable resources over the recent farm history on improving the outblock” Rationale: refection on investment in the new block to aid in business growth • “put in 50 acres of perennial pasture for the heifers they planned to run on the property” Rationale: installation of pasture on newly developed land bought to grow the business) • “70-90 beef cattle on the outblock as well, because they had enough land to carry the extra stock at the time” Rationale: extra land in newly purchased block means there is space for beef cattle • “Much of the outblock has been used for fodder production” Rationale: use of land bought to grow the business • “Frank has also grown oats and wheat” Rationale: use of land bought to grow the business • “brings the fodder from the outblock home to the dairy farm to feed to his cows” Rationale: use of land bought to grow the business • “He now uses that land for stock over the winter” Rationale: use of land bought to grow the business)
<p>“Frank’s farm didn’t cope very well with really wet winters...” CJ 6.9 Rationale: Identified threat in land not being good in wet weather – Reduces farm capacity to graze cows over winter.</p>
<ul style="list-style-type: none"> • “Once they bought the outblock they had another option for the wet winters” Rationale: option for managing grazing cows over winter • “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” Rationale: changing to annuals reduces threat associated with wet winters, but change was made in response to drought.
<p>“They did it to increase cash flow over the winter to help with their loan repayments for the new property.” CJ 6.10 Rationale: 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.</p>
<ul style="list-style-type: none"> • “started split calving” Rationale: change practice associated with desire for winter milk money in 1991 • “have practiced split calving ‘on and off’ over the years. ” Rationale: change practice associated with desire for winter milk money.

Figure 4.4. Example of identified linkages between critical junctures and reinforcing decisions within Narrative 6

Of the 264 critical junctures I found that 235 were identifiable as leading to reinforcing decisions. As well, I found that, of the 1085 sections of data coded as constructs of constraints, 1059 were identifiable as linked to a critical juncture (see Table 4.10). In Appendix G are displayed the number of linkages for each critical juncture identified in the research. The identified relationship between the critical junctures and farm decisions supports the claim that path dependence exists in farms. However, there were a number of data segments that did not fit this pattern. These were 29 critical junctures that were not identifiable as leading to specific reinforcing decisions and 26 sections of data coded as adaptations, changes to images and function changes which were not identifiable as stemming from a specific critical juncture. Next, I will look closely at these anomalies.

Table 4.10: Summary of results of decision mapping

	Extreme weather CJs	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 (29 were not linked)
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	

* CJ means critical juncture

**The totals are not a summation of the totals in the subsections, as six critical junctures were identified in relation to two sources, meaning subsection totals are higher.

I did not draw significant inferences from the number of linkages that were associated with critical junctures in my analysis. Whether a critical juncture led to two or ten reinforcing decisions did not provide meaningful insights. Dependence of a business on a decision is not tied to the number of decisions but instead is tied to the reversibility of the decision. This means a single decision with a high degree of irreversibility can be a more significant constraint than a large number of related, reversible decisions.

4.4.2.1. Critical junctures not linked to reinforcing decisions

There were 29 critical junctures that were not identifiable as leading to specific reinforcing decisions (see Table 4.11). The reasons for this related to the interrelatedness and recency of the critical juncture, links to the persistent imperative for increasing productivity or difficulty with identifying explicit outcomes from higher-order sources of critical junctures.

Table 4.11: Critical junctures that were not identifiable as linked to reinforcing decisions

CJ	Coded date	Why it was not linked to reinforcing decisions
1.1	grandfather started out as a share farmer on the property.	Initial acquisition of the farm
1.2	Albert and his wife took over the farm in 1978, after they were married	Family/personal source of critical juncture
3.1	farm was split into two 150-acre blocks and given to Colin's father and uncle who ran them as two separate businesses.	Initial acquisition of the farm
4.12	Dennis and Donna had a couple of cows that stabbed their milk vein on the sorghum stalks when they went to sit down. The cows just bled to death. 'It just poured out like a tap.' That just put Dennis and Donna 'right off' growing sorghum again.	Problem associated with trialling a new practice.
4.17	Dennis and Donna lost their son in an accident three years ago. At the time they had been 'thinking about moving on maybe to another farm or out of farming'. However, when they lost their son they just 'weren't ready to move'. Since then they are still here, still 'plodding on'.	Current critical juncture
5.1	Edward's grandfather bought the farm	Initial acquisition of the farm
5.4	Edward had no intentions of giving up music when they started having children. He thought he could do both. But he would come home after being on the road for a couple of weeks and his children wouldn't know who he was. That changed things for Edward and he moved back to the farm with his growing family.	Family/personal source of critical juncture
6.1	Frank's father and his father's uncle bought a 150-acre property with a 170-ML water entitlement in 1967.	Initial acquisition of the farm
6.15	Frank's father passed away in 2010.	Interrelated with critical juncture 6.16 "Frank said that they were going to sell the farm but he has now decided that he is going to stay." Linkage in mapping was to 6.16.
7.1	parents bought an 80-acre dairy farm	Initial acquisition of the farm
8.4	One son started working on the farm in the 1970s,	Family labour
8.5	chose a different career path	Family labour
8.18	planning on putting in an application for the next round of funding for water efficiency grants to get pipes and risers installed on the 345 acres of land that he owned. The next round of funding was due to open in about six months.	Current critical juncture
9.2	father bought out his brother and took on sole management	Initial acquisition of the farm
9.3	When he left school in 1976, at nearly 18 years of age, he came back to work on the farm as a part of a farm apprenticeship.	Family labour
11.1	purchased the original 138-acre farm	Initial acquisition of the farm
11.8	About a year after Karl took over the family farm Lake Eildon was enlarged to enable a greater regional storage capacity for water. Karl, and other irrigators were offered the chance to double their water use through 'sales' water. Karl 'never ran out of water'.	Interrelated with critical junctures 11.3 "went into dairy production" and 11.4 "went into pig production". Linkages in mapping were to 11.3 and 11.4.
11.12	'pig prices dropped'. 'Everything was going wrong' for Karl as the milk and cattle prices also fell with a downturn in the market. Karl recalled other farmers having to shoot their stock.	Interrelated with critical juncture 11.13 "Karl 'got discouraged'". Linkage in mapping was to 11.13.
13.8	milking 80 cows and decided to put in an eight-a-side herringbone dairy with zigzag rails	Critical juncture and reinforcing response reflected in the same data
13.9	extended the dairy to make it a 12-a-side herringbone	Critical juncture and reinforcing

	with zigzag rails.	response reflected in the same data
14.9	he original walkthrough dairy was changed over to a 'five or six double-up herringbone'	Critical juncture and reinforcing response reflected in the same data
14.10	extended to milk 12 cows	Critical juncture and reinforcing response reflected in the same data
14.11	then 26 cows	Critical juncture and reinforcing response reflected in the same data
15.7	extended to a 10-cow walk through.	Critical juncture and reinforcing response reflected in the same data
15.8	built a 10 swing-over herringbone dairy	Critical juncture and reinforcing response reflected in the same data
15.11	Owen's son came back to work on the farm in the early 1990s.	Family labour
15.14	When Owen's son decided to leave the farm 'it made life a lot simpler' for Owen. Early in the drought Owen could tell that his son 'wasn't 100 per cent keen' on farming. After his son's decision to leave, Owen could make decisions without having to worry about his son's future on the farm.	Interrelated with critical juncture 15.15 "Owen and Olivia decided that they no longer wanted to run the dairy farm". Linkage in mapping was to 15.15
15.16	Owen had been having 'quite a few issues' with his Herefords	Current critical juncture
16.5	In the 1960s Peter was married. He and his wife built a house on the 160 acre portion of the farm.	Family/personal source of critical juncture

Closely interrelated critical junctures

In looking closely at the 29 anomalous critical junctures I found that four of them were closely interrelated with other critical junctures. Reinforcing responses were identifiable in relation to these closely-related critical junctures.

The death of Frank's father was identified as a critical juncture, "Frank's father passed away in 2010", though no reinforcing decisions flowed from this critical juncture (Narrative 6, 6.15). However, this was followed closely by another critical juncture: "Frank said that they were going to sell the farm but he has now decided that he is going to stay" (Narrative 6, 6.16). The two critical junctures are clearly related. The death of Frank's father led Frank and his brother to consider the future of the farm. From the decision to stay, three reinforcing decisions were identified in the data: Frank's decision to "[work] out 'what everything's worth' so that he can see what he may have to do to pay his younger brother out"; Frank's "focus [on] finding ways to make running the farm easier"; and Frank's decision to "[buy] a new baler" (Narrative 6).

A critical juncture for Owen was when his son decided to leave the farm.

When Owen's son decided to leave the farm "it made life a lot simpler" for Owen. Early in the drought Owen could tell that his son "wasn't 100 per cent keen" on farming. After his son's decision to leave, Owen could make decisions without having to worry about his son's future on the farm. (Narrative 15, 15.14)

This critical juncture aided decision-making during the subsequent critical juncture, when "Owen and Olivia decided that they no longer wanted to run the dairy farm" (Narrative 15, 15.15). Twelve reinforcing decisions flowed from this second critical juncture which related to converting the farm from dairy to beef cattle production.

A critical juncture was identified in Karl's narrative in relation to increased access to water.

About a year after Karl took over the family farm Lake Eildon was enlarged to enable a greater regional storage capacity for water. Karl, and other irrigators were offered the chance to double their water use through "sales" water. Karl "never ran out of water". (Narrative 11, 11.8)

Other critical junctures, when Karl "went into dairy production" and "went into pig production" were closely linked to the increased access to water which made the interrelated pig and dairy enterprises possible for Karl (Narrative 11, 11.3 and 11.4).

Karl experienced another critical juncture, from which reinforcing decisions were not identified. This was when "pig prices dropped". 'Everything was going wrong' for Karl as the milk and cattle prices also fell with a downturn in the market. Karl recalled other farmers having to shoot their stock." (Narrative 11, 11.12). Shortly after this "Karl 'got discouraged'" with his farm circumstances (Narrative 11, 11.13). This discouragement was related to the market downturn in the previous critical juncture, but was also due to conflict with a tanker driver over milk collection. Karl decided to convert his farm to beef cattle and a series of six reinforcing decisions were identified in the data regarding this change.

Overall, links to subsequent farm decisions could be seen flowing from these four critical junctures, though this was through other interrelated critical junctures. This may relate, in part, to the compounding and serial nature of some critical junctures (see section 4.4.3.5).

Current critical junctures

Three critical junctures were currently being experienced by producers. Owen described that he "...had been having 'quite a few issues' with his Herefords" given their white faces mean they have a propensity for eye cancers (Narrative 15, 15.16). Owen "was 'thinking seriously about probably changing and going into Angus'" but he "wasn't sure what decision they would come to" (Narrative 15). Harry was "planning on putting in an application for the next round of funding for water efficiency grants to get pipes and risers installed on the 345 acres of land that he owned" (Narrative 8, 8.18). What this meant for his farm was yet to be seen. Dennis and Donna have put off a decision regarding "moving on maybe to another farm or out of farming" because their son was killed in an accident (Narrative 4, 4.17). They described themselves as "still 'plodding on'" as they work through the decision in conjunction with coping with their personal loss. Given the current nature of these critical junctures, they had yet to generate sequences of reinforcing decisions in the narratives.

Critical junctures associated with increasing productivity imperative

There were seven critical junctures that were implicitly associated with the imperative for increasing productivity (see section 4.4.1.5). In each circumstance, these related to identified opportunities to build or extend the dairy shed. The opportunity was the critical juncture and the change to the dairy was the response. Hence, these critical junctures were simultaneously coded as adaptations, changes to the plan image and within the technology development function of the farm. In each of these circumstances, no further reinforcement decisions were identified in the narratives although, in each case, additional changes to the dairy were made over time, as new opportunities (or threats) were identified and acted upon in relation to the existing dairy shed.

On Matt's farm critical junctures were identified when his father was "milking 80 cows and decided to put in an eight-a-side herringbone dairy with zigzag rails" in the early 1960s (Narrative 13, 13.8). He then "extended the dairy to make it a 12-a-side herringbone with zigzag rails" in the 1970s (Narrative 13, 13.9). Neil described early changes to the dairy, after his father bought the farm in the late 1950s, when "the original walkthrough dairy was changed over to a 'five or six double-up herringbone'" (Narrative 14, 14.9). It was "later extended to milk 12 cows" (Narrative 14, 14.10), and then extended again to accommodate "then 26 cows" (Narrative 14, 14.11). Shortly

after buying the farm in the late 1950s, Owen's father "extended to a 10-cow walk through" dairy (Narrative 15, 15.7) and then in 1964 "built a 10 swing-over herringbone dairy" (Narrative 15, 15.8).

The critical junctures in these cases were derived from the persistent imperative to increase productivity in the farms and the act of expanding or building a dairy reflects a response to the critical juncture. This means that a link between a critical juncture and reinforcing change is identifiable in the data, though in a limited way. These critical junctures, and responses to them, are indicative of an enduring potential of critical junctures that can be triggered through the identification of opportunities, in alignment with the hierarchy of images. The decisions to expand milking capacity by these producers went on to influence subsequent decisions to increase herd size.

Problem with a new practice

One critical juncture reflected a problem that developed from the adoption of a new practice. During a prolonged drought Dennis and Donna were looking for alternative sources of feed for their cows. They decided to "put in two paddocks of sorghum for grazing...because it was the 'recommendation at the time as it grew more tonnage'" (Narrative 4). Unfortunately, the sorghum led to problems for the cows, which reflected a threat to the business and was therefore identified as a critical juncture.

Dennis and Donna had a couple of cows that stabbed their milk vein on the sorghum stalks when they went to sit down. The cows just bled to death. "It just poured out like a tap." That just put Dennis and Donna "right off" growing sorghum again. (Narrative 4, 4.12)

Dennis and Donna decided not to use sorghum again and continued to look for alternative feeds in response to drought.

Dennis and Donna were, essentially, trialling sorghum on their farm. While the problems associated with sorghum were identified as a critical juncture, there were no identified reinforcing decisions in the data beyond the decision to stop producing it. This may relate, in part, to sorghum having a high degree of reversibility. Further discussion of reversibility and trialling (probing) can be found in section 4.4.3.7.

Higher-order change

Overall, there were 14 critical junctures that could be described as deriving from family and personal context. Seven critical junctures were related to the initial acquisition of the farm by ancestors of the producer being interviewed and were closely linked to the personal and family goals of these ancestors. These critical junctures were:

- Albert's "grandfather started out as a share farmer on the property" (Narrative 1, 1.1),
- The family "farm was split into two 150-acre blocks and given to Colin's father and uncle who ran them as two separate businesses" (Narrative 3, 3.1),
- "Edward's grandfather bought the farm" (Narrative 5, 5.1),
- "Frank's father and his father's uncle bought a 150-acre property with a 170-ML water entitlement in 1967." (Narrative 6, 6.1),
- Geoff's "parents bought an 80-acre dairy farm" (Narrative 7, 7.1),
- Karl's father "purchased the original 138-acre farm" (Narrative 11, 11.1), and
- Isaac's "father bought out his brother and took on sole management" (Narrative 9, 9.2).

While all decisions about the farm flow from these initial decisions, and therefore the personal and family goals of the decision-maker, a lack of data regarding the initial decisions about the farm is unsurprising.

Four critical junctures were associated with changes in available labour in the family but were not associated with identified reinforcing decisions. These were when one of Harry's sons "started working on the farm in the 1970s" (Narrative 8, 8.4) and then "chose a different career path" (Narrative 8, 8.5); when Isaac "left school in 1976, at nearly 18 years of age, [and] came back to work on the farm as a part of a farm apprenticeship" (Narrative 9, 9.3); and when "Owen's son came back to work on the farm in the early 1990s" (Narrative 15, 15.11).

Though no reinforcing decisions were identified in relation to these critical junctures this does not imply that such changing circumstances are not influential. For example, Owen's son's return to the family farm did not lead to identifiable reinforcing decisions in the data (Narrative 15, 15.11). However, "[w]hen Owen's son decided to leave the farm 'it made life a lot simpler' ... [as] Owen could make decisions without having to worry about his son's future on the farm" (Narrative 15). This implied that Owen's

son's initial decision to work on the farm had an influence on the decisions his father was making about the farm, based on the son's future involvement.

There were three circumstances where a change in family and personal goals clearly intersected with the farm, though these were not identifiable as linked to reinforcing decisions in the narratives. Albert described how "[he] and his wife took over the farm in 1978, after they were married" (Narrative 1, 1.2). "In the 1960s Peter was married. He and his wife built a house on the 160 acre portion of the farm." (Narrative 16, 16.5) Edward "moved back to the farm with his growing family" when his family goals were not being achieved in his existing career as a musician (Narrative 5, 5.4).

In these circumstances, the lack of linkages between the changing family and personal goals to any reinforcing decisions can broadly be described as relating to the higher-order origins of these critical junctures. Remembering that this research is focused on understanding farm-level decisions, it is possible that some changes within the family and personal context may not always lead to overt farm-level change. Where the current farm goals and plans align with altered personal and family goals and plans, change is not needed.

Where a change in the family or personal context does lead to change in the farm, it may be difficult to distinguish from other sources of change in the farm business context. For example, altered family context due to the birth of a child may indicate a need to increase production in the farm to ensure the farm can generate sufficient income to support the increased family. Distinguishing this from the persistent imperative to increase productivity is difficult. Given the interviews with producers focused on the history of the farm business, I assume that any information offered by the interviewee about the family or personal context was considered relevant to the farm business, even if explicit reinforcing decisions were not identifiable.

4.4.2.2. Coded data that was not identifiable as an explicit reinforcing decision

There were 26 (out of 1085) data segments coded as adaptations, changes to images and function changes which were not identifiable as stemming from a specific critical juncture (see Table 4.12). In some circumstances, laser-grading and its on-going relationship with pasture improvement made identifying an explicit critical juncture problematic. In other circumstances changes in farm management or policy lacked

sufficient significance to indicate a critical juncture. Some data represented descriptions of farm context in relation to critical juncture. Some data reflected personal and family context that influenced farm decisions, though not to a degree that a critical juncture was identified. Finally, some data reflected general descriptions of farm finances. These 26 data segments will now be considered in greater detail.

Table 4.12: Coded data that was not linked to a critical juncture

Narrative	Coded section of data	Why segment is not linked to a critical juncture
1	borrowed Jersey bulls from the neighbour for joining	Description of context leading up to a critical juncture (1.3)
1	used to get some cows from the market in Bendigo, though half would have to be returned because of poor performance or bad temperament	Description of context leading up to a critical juncture (1.3)
1	laser graded 50 per cent	Farm development activity with an implied association with increasing productivity imperative, but not clearly linked to a critical juncture
1	whole farm was sown to summer pasture.	Farm development activity with an implied association with increasing productivity imperative, but not clearly linked to a critical juncture
1	Money that could have gone toward farm improvements had to be used elsewhere, to meet other priorities.	Description of change in family context that influenced the farm, but not to a sufficient degree to indicate a critical juncture.
1	Albert and his wife were putting two kids through university during that period	Description of change in family context that influenced the farm, but not to a sufficient degree to indicate a critical juncture.
2	the new channel regulators have led to better delivery of water, given the farm is on the backbone. They now only have to give a day's notice to get water, while before it was four days	Change in the policy setting that lacked the degree of significance necessary to indicate a critical juncture.
2	started the process of grading	Farm development activity with an implied association with increasing productivity imperative, but not clearly linked to a critical juncture
3	working on the home farm in the early 1970s as a waged employee.	Change to labour that lacked the degree of significance necessary to indicate a critical juncture.
3	Any money he has made has gone back into the farm	Description of farm finances - provides important contextual data for understanding the state of the farm business when considering temporally related critical junctures.
3	Basically, his finances are 'year-by-year'. If it has been a tough year, he spends less on the farm and he seems 'to strike it lucky' in that, every time he has made a commitment to spend money on the farm, the money has been there. He has got a bit of money put away so he can 'sleep a little bit better'. Colin thinks there is 'not a lot of margin' these days. He worries about the potential for more and more costs associated with farming - such as water, irrigation allocations and government policies.	Description of farm finances - provides important contextual data for understanding the state of the farm business when considering temporally related critical junctures.
4	laser graded the worst 10% of the farm	Farm development activity with an implied association with increasing productivity imperative, but not clearly linked to a critical juncture
4	do not have a Sunday milker at the moment either. Their previous milker retired and they haven't looked yet for	Change to labour that lacked the degree of significance necessary to indicate a critical

	anyone else.	junction.
5	When Edward and Ellen first bought the farm they had 20 per cent equity in the business. Today, Edward describes the business as worth about \$3 million, with \$1 million of debt.	Description of farm finances - provides important contextual data for understanding the state of the farm business when considering temporally related critical junctures.
6	They did occasionally hire help, but only when they were going away or, in more recent times, if they were busy with hay making.	Change to labour that lacked the degree of significance necessary to indicate a critical juncture.
6	Frank didn't want to seem as though he was pushing his father aside as Frank took on more management of the farm business over the years. Frank and his brother still included their father in the farm as much as possible. Frank thinks that probably kept their father alive an extra 10 years.	Description of context leading up to a critical juncture (6.15 and 6.16)
7	buy a tractor	Description of context leading up to a critical juncture (7.10)
8	already laser graded some of his other land which he started doing in the 1970s and continued laser-grading portions of the farm over the years.	Farm development activity with an implied association with increasing productivity imperative, but not clearly linked to a critical juncture
8	Harry's entire farm, except for 20 acres, was laser graded.	Farm development activity with an implied association with increasing productivity imperative, but not clearly linked to a critical juncture
9	applied 'some years ago' to get the water right increased.	Lack of data regarding degree of significance makes identifying relationship with a critical juncture impossible
9	When Isaac's children were 'getting a little bit older' and they all wanted to go away during school holidays Isaac brought the spring calving back to around July 20th.	Change to calving practices that lacked the degree of significance necessary to indicate a critical juncture.
9	more recent times Isaac preferred 75 per cent spring- and 25 per cent autumn-calving cows.	Change to calving practices that lacked the degree of significance necessary to indicate a critical juncture.
10	His parents had moved off the farm and into town.	Description of change in family context that influenced the farm, but not to a sufficient degree to indicate a critical juncture.
12	His one irrigation outlet was converted from a Dethridge wheel to a 'flow meter' as a part of the upgrade with no ill-effect.	Change in the policy setting that lacked the degree of significance necessary to indicate a critical juncture.
14	used artificial insemination (AI) and stud bulls to 'mop up'.	Description of context leading up to a critical juncture (14.6)
15	irrigation outlets were converted from Dethridge wheels to Magflow meters.	Change in the policy setting that lacked the degree of significance necessary to indicate a critical juncture.

Some of the coded data segments were clearly associated with an identified opportunity to increase productivity, though they were not linked explicitly to critical junctures in the narratives. These data were as follows:

- Albert described how he “laser graded 50 per cent” of his farm, after which the “whole farm was sown to summer pasture” (Narrative 1)
- Ben’s father “started the process of grading” (Narrative 2)

- Dennis and Donna described how the previous owner “laser graded the worst 10% of the farm” (Narrative 4)
- Harry “already laser graded some of his other land which he started doing in the 1970s and continued laser-grading portions of the farm over the years” (Narrative 8) so that at the time of the interview “Harry’s entire farm, except for 20 acres, was laser graded” (Narrative 8).

These data largely related to laser-grading, a management practice often associated with pasture development. Given pasture development often occurs over time on farms, it is unsurprising that specific critical junctures were not identified.

Some data segments that were not linked to a critical juncture related to ongoing changes in farm management that lacked sufficient significance to trigger coding the data as an identified opportunity and there were no other changes described in the narratives in relation to these data. Three of these related to farm labour. Dennis and Donna described how they “do not have a Sunday milker at the moment...[as t]heir previous milker retired and they haven’t looked yet for anyone else” (Narrative 4). Colin described working “as a waged employee” on the farm about 40 years ago (Narrative 3). Frank described how “[t]hey did occasionally hire help, but only when they were going away or, in more recent times, if they were busy with hay making” (Narrative 6). Two of these related to Isaac’s descriptions of calving preferences. Isaac decided, when his “children were ‘getting a little bit older’ and they all wanted to go away during school holidays [to bring] the spring calving back” by a couple of weeks (Narrative 9). Isaac also described how in more recent times he “preferred 75 per cent spring- and 25 per cent autumn-calving cows” (Narrative 9).

Some of these data segments related to a change in the policy setting that did not lead to a critical juncture. For example, Ben described how “the new channel regulators [associated with irrigation modernisation] have led to better delivery of water [and they] now only have to give a day's notice to get water, while before it was four days” (Narrative 2). However, Ben also described how modernisation “hasn’t had a lot of effect on the farm, as yet [and he has] been waiting for about four years for [his] Dethridge Wheels to be converted to flume gates” (Narrative 2). Owen also described how his “irrigation outlets were converted from Dethridge wheels to Magflow meters” (Narrative 15). Owen “thought the new system was ‘fantastic’ and that it worked well

for him” though he “did ‘very-little’ to change his on-farm irrigation” (Narrative 15). Lachlan’s narrative described how “[h]is one irrigation outlet was converted from a Dethridge wheel to a ‘flow meter’ as a part of the upgrade with no ill-effect”, though the irrigation upgrade “has had little impact on Lachlan’s farm” (Narrative 12). The lack of a link between these descriptions of policy change and critical junctures for the producers demonstrate that policy can have largely neutral consequences in some circumstances.

Some of these coded data segments were descriptors of farm context in the lead up to a critical juncture. For example, on Neil’s farm they “used artificial insemination (AI) and stud bulls to ‘mop up’” in their cattle breeding practices (Narrative 14). After this description of context the narrative went on to identify that “[t]hey’d had some fertility problems on the farm and through the years they found it ‘harder and harder to get the cows in calf’” (Narrative 14, 14.6).

For Geoff, the decision to “buy a tractor (the old one had died)” influenced farm finances in the lead up to drought (Narrative 7). Geoff described how it “took around four years to pay off the debt” on the farm, because of the new tractor (Narrative 7). While “Geoff and Gini were debt-free” when the drought hit, they were not as far along financially as expected (Narrative 7). Ultimately the drought “sort of pushed” Geoff to change his feeding system (Narrative 7, 7.10).

Another example was Albert’s narrative in which farm breeding practices were also described. Albert’s father “borrowed Jersey bulls from the neighbour for joining” and “used to get some cows from the market in Bendigo, though half would have to be returned because of poor performance or bad temperament” (Narrative 1). However, once “Albert came to work on the farm in 1965 he told his father that they needed to try and do something to sort out the mixed-breed ‘motley group of cows’”, which was a critical juncture for the farm (Narrative 1, 1.3).

As well, Frank’s narrative described how he “didn’t want to seem as though he was pushing his father aside” as he took on more farm management over the years (Narrative 6). Frank thought that this “probably kept [his] father alive an extra 10 years” (Narrative 6). This described the context leading to two interrelated critical junctures, when “Frank’s father passed away in 2010” (Narrative 6, 6.15) and when “they were

going to sell the farm but he has now decided that he is going to stay” (Narrative 6, 6.16).

Some of these data segments were descriptions of family context that influenced the farm, but not to a sufficient degree to indicate a critical juncture. John described how “[h]is parents had moved off the farm and into town” though his father continued to work on the farm to a similar degree as prior to the move (Narrative 10). Albert described how “[m]oney that could have gone toward farm improvements had to be used elsewhere, to meet other priorities” (Narrative 1). An example of this for Albert was “putting two kids through university” (Narrative 1).

Three sections of coded data were descriptions of farm finances. Edward described the change in farm debt when comparing the “20 per cent in equity” he had in the farm when he took over the business to the farm’s current status in which “the business as worth about \$3 million, with \$1 million of debt” (Narrative 5). Colin described how “[a]ny money he has made has gone back into the farm” (Narrative 3). Colin went on to describe his approach to managing farm finances:

Basically, his finances are “year-by-year”. If it has been a tough year, he spends less on the farm and he seems “to strike it lucky” in that, every time he has made a commitment to spend money on the farm, the money has been there. He has got a bit of money put away so he can “sleep a little bit better”. Colin thinks there is “not a lot of margin” these days. He worries about the potential for more and more costs associated with farming - such as water, irrigation allocations and government policies. (Narrative 3)

These data provided important contextual data for understanding the state of the farm business when considering temporally related critical junctures.

Finally, there was one section of coded data for which a critical juncture may have occurred, though this is not certain. Isaac’s father “applied ‘some years ago’ to get the water right increased” on the family farm (Narrative 9). There was a gap in Isaac’s knowledge regarding the change as “Isaac [was] not certain how much irrigation water came with the property in 1960” prior to the increase (Narrative 9). While it is possible that the successful application for an increased water right may indicate a critical juncture associated with an identified threat or opportunity, this is not certain.

4.4.2.3. Exiting dairy

I sought data from those who had changed enterprises to identify insights offered by their experiences in exiting from dairy production. I expected that analysing those who left dairy may offer some striking examples of path dependence as a determinant of the decision to change enterprises. Four of the producers who participated in this research had shifted from dairy to other enterprise types. Two of these producers, Geoff and Paul, converted to cropping enterprises. Matt converted to an agistment enterprise and Owen converted to a beef-cattle enterprise.

In this section I draw on the narratives to summarise the experiences of these four producers relating to their decision to exit dairy production. I then offer some insights that were derived from consideration of these experiences. These insights relate to path dependence in the trigger for change, capability as a constraint, family and finances, reversibility and time associated with decision-making.

Geoff converts to cropping (Narrative 7)

Geoff's narrative described a constant tension between the farm and his principles regarding personal and family time. From an introduction to farming in which his father held a view that "there's no off-the-farm time", Geoff "put a lot of effort in setting up his farm so that he could get time away from the farm". This included a view on farming to "keep it basic and simple".

During the drought Geoff converted to lot feeding his cows because he did not have sufficient water to maintain his pasture. This meant that Geoff produced hay and silage, which he fed to his cows in a sacrifice paddock. Once the drought began to ease, Geoff continued lot feeding his cows because he 'found it easier to manage and anyone could do it'. In reality, Geoff "didn't have a big interest in cows". He would "rather find a dead cow in the paddock than a sick cow which was going to require hours of his time looking after it [as it] was time wasting". He used to get frustrated when "he would grow a paddock of 'good green lush grass' and the cows would tread all over it and eat it".

Geoff had planned to be "slowing down from milking cows or out of dairy" by the time he was 40. He turned 40 during the middle of the drought when "cows were going for \$500 a cow, which wasn't high enough for Geoff". He had "a good relief milker at that

point” and the business was “just making enough money,” which was sufficient at the time, given the drought. However, just over a year before the interview, Geoff’s relief milker quit. Within a few days Geoff had sold some of his cows in a move to get out of dairying. Not only had the relief milker left, but the price for cows was “paying well” and he’d “basically had enough of milking cows”. Though it happened suddenly, “it wasn’t a sudden decision as Geoff had been thinking about getting out of dairy for five years”.

Geoff became interested in cropping after he harvested and sold some excess grain once the drought had broken. He described it as “one of those stepping stones” which “gave him ‘the taste of it’ and increased his confidence for cropping”. Geoff’s interest in cropping was helped by the fact that machinery is his “weak spot” and he loves “sitting on a tractor”. Overall, Geoff found that he was “no worse off” financially with cropping and that “lifestyle-wise it’s better”. He also found that having sufficient storage for grain was an important factor for cropping. However, Geoff was not certain about cropping as “if grain drops down to something like \$100 a tonne he needs to have other ways to make some income”. In converting to cropping Geoff just cut back every alternate fence and has maintained the laneways and stock troughs so that he has other options for using the farm to generate an income. This could include selling it as a dairy farm.

Summary

Geoff was aiming to maintain a farm business that enabled him to generate sufficient income while also maintaining a balanced lifestyle. He was able to maintain this to a limited degree with dairy farming. Fertility issues with his Friesian herd forced a shift to split calving, which meant an increased workload on the farm. A relief milker helped take on some of the workload. Once the relief milker left, this was a critical juncture that triggered a decision to exit dairy, which Geoff had been contemplating.

Geoff’s personal preferences for machinery over cows could be clearly seen in the narrative. Even with this preference, Geoff maintained the dairy enterprise infrastructure to ensure he had other options open to him, including selling the farm as a dairy business. While Geoff had an interest in cropping stemming from a recent positive experience with selling wheat, he was uncertain to some degree and wants to maintain some reversibility.

Paul converts to cropping (Narrative 16)

Paul's narrative described problems that emerged due to his intensified production approach that led him to convert to cropping. Paul had "gone down a certain pathway" to a "large herd that was intensively fed". He "couldn't break out of that path very easily". Increasing problems with calving and treating sick cows were identified as stemming from his intensified system. As well, the intensive system made it difficult for Paul to manage during the drought. He wanted to be able to sell cows and then buy them back when conditions improved. However, this was not an option for him, because "socialisation issues amongst cows 'was an enormous problem'" for his large herd. Paul described his farm as "unsustainable on a whole stack of levels...from a workload viewpoint, from a farming system viewpoint, from an animal health viewpoint, from a lifestyle viewpoint".

In addition to the issues with his large herd, the farm needed a new dairy as the existing dairy was old and had high maintenance requirements. However, the location of the dairy also needed to change, due to its inadequate size for the large herd. This meant "a lot of renovations and various other forms of grief" which Paul was not prepared to undertake. Over two years, Paul and his wife tried to sell the farm, so they could get completely out of farming. However, the "farm wasn't marketable as a dairy farm, because it needed a new dairy" and was not sold. By 2008 Paul and his wife "had a complete gutfull" of dairy and decided to go into cropping given they couldn't sell the farm.

Paul had a history of cropping as a part of fodder production. Not only did he have experience, but he also had a large enough tractor for cropping. When he decided to convert to cropping he only needed to buy an air-seeder and a boom spray. The farm's history of cropping (before Paul's time as manager) meant the existing farm "layout was conducive" to cropping; with large-sized paddocks, few trees on check banks, and fences that were easily removed.

Storage was important to Paul, as it enabled him to have more control over his grain prices: "if the market circumstances didn't suit, you didn't have to sell, because you could store it." Paul identified a key factor that interested him in cropping was "his greater capacity to control the price he got for his product". Over time Paul bought more land and silos for storage.

Paul was able to reduce his dependence on paid staff when he converted to cropping. This was a big benefit to him as “throughout his time in dairy farming, it got increasingly difficult to manage staff”. The number of staff increased while the “quality of the workforce declined”. With cropping Paul only managed two employees.

Summary

Paul had intensified his dairy enterprise to such a degree that he could identify the constraints it placed on his management options to respond to drought. He was not able to sell cows to reduce the pressure for feed, due to socialisation issues. As well, Paul was unable to increase the size of his dairy in its current location. Significant changes were needed to continue in dairy production.

Paul and his wife tried to adjust out of agriculture when he had his farm on the market for sale over a two year period. When this was unsuccessful Paul decided to change the farm to a different enterprise, cropping. The farm layout was compatible with cropping, given the farm history with the enterprise. As well, Paul had personal experience with growing crops as a part of fodder production. Paul identified that he would have more control over his output price and reduce his need to manage employees.

Matt focuses on agistment (Narrative 13)

Matt was pushed into a quick decision about the future of his farm due to changing family circumstances. Matt’s son was married in 2005 and moved onto the farm with his wife. The farm comprised a 400 acre dairy enterprise and a 500 acre outblock that was used for fodder production for the dairy and for agistment. By 2011 Matt was “in his early 60s and didn’t want to ‘keep going flat out’”. His son took over most of the management of the dairy enterprise while Matt managed the business’s outblock. As well, Matt’s son encouraged investment in more land and upgrades to the dairy to enable him to manage the milking as a single person operation. This required an increase in farm debt.

Shortly after this Matt’s son left the farm due to personal reasons. This left Matt with a debt and insufficient labour to manage the farm. Matt thought that “continuing to run the 400-acre dairy farm and the 500-acre outblock without his son was going to be too difficult”. Matt decided to sell the dairy part of the business but keep the outblock.

Selling the dairy farm was “unexpected and traumatic”, representing a loss of history as the farm would now not be kept within the family.

Matt expanded the existing agistment enterprise. “Running the agistment enterprise was a way for Matt to ‘slow down’ at his own pace” rather than being forced out of farming. After selling the dairy farm Matt no longer had any farm debt and therefore “wasn’t under any pressure to make the 500-acre block profitable”.

Summary

Matt had mapped out plans for the future of the family farm, grounded in his principles about the importance of keeping the farm in the family. The business plan included a succession plan for his son to take over the business. When Matt’s son decided to leave the family business this required a revision of farm business goals. While the sudden loss of the farm from the family was clearly disturbing for Matt, his decision to sell the dairy enterprise has left him with much less financial pressure than he would have faced had he decided to maintain the dairy block in some form.

Matt removed the majority of the dairy production enterprise from the business when he sold the dairy block. What remained was the outblock, that was used for fodder production for the dairy cows and for running drystock. The change required to convert this outblock to an agistment enterprise entailed predominantly an expansion of current practices, given Matt already agisted on the block.

Owen focuses on beef cattle (Narrative 15)

Owen’s decision to shift from dairy production to beef cattle related to his farm being an insufficient size to support him and his son. Owen described how his “biggest issue was tied up with acquiring more land”. Owen had a 120-acre dairy block and a 600-acre partially irrigated outblock that was too far away to graze the milking cows. From the 1960s onward the outblock was used for fodder production and running dry stock. As well, Owen ran 100 head of steer each year as a beef cattle enterprise on the 600-acre outblock, which was “a good sideline” for the farm business.

Owen had plans to redevelop his farm in the 1980s, but “realised very quickly that he needed to increase the size of his farm”, otherwise he couldn’t take land out of production to do the development work. He identified two options: to “wait and hope to

buy a neighbouring property; or 'sell up and move' to a bigger farm". He decided to wait for an elderly neighbour to sell him a nearby property rather than move. This postponed redevelopment.

While Owen was waiting for the neighbouring block to be offered for sale, his son decided to come and work on the family farm. The business struggled through the 1990s as it supported two families and ran at its "maximum" intensity. The business was "going backwards" because productivity improvements were impeded by the lack of land for redevelopment. By the time the neighbour's land was finally offered for sale in the mid-2000s, Owen could not afford to buy it, due to the prolonged drought.

In the first year of the drought Owen and his wife used up "close to \$100,000 of their personal savings" to buy feed and water to keep the farm going. Owen thought he was "lucky" because he didn't have farm debts prior to the drought; however, over the years of the drought he had to "minimise all expenses". He focused on "paying his son's wages", while Owen didn't make any money. Owen eventually offered his son the farm, as the business was not making enough money for the two of them. His son declined the offer and left the farm business for another job.

When Owen's son left "it made life a lot simpler"; as Owen could take his son out of the equation when considering the future of the farm business. Over the next two years Owen "just bumbled through" and eventually decided to no longer run the dairy enterprise. Owen started building up his existing beef cattle herd, using his dairy herd to generate Friesian/Hereford crosses. He then sold his dairy cows. Owen was in his early 60s and looking to reduce his workload. Beef-cattle offered him a "totally different lifestyle". While Owen and his wife's "income had dropped 'fairly dramatically'" this was alright as they had no farm debt and Owen's wife had an income that was sufficient for daily expenses. The beef-cattle enterprise just needed to make enough for a "certain amount of improvements each year".

Summary

Owen identified two options available to him in the 1980s. Once he decided to stay, relying on the purchase of a neighbouring block, this impeded his capacity to increase his land area and to efficiency of his existing block (which he could not redevelop). Once he made the decision not to sell the farm and move, he stuck with this idea for 15

or more years as other constraints on his business compounded his financial difficulties before the drought constrained his finances to the degree that the purchase was no longer an option. The cumulative constraints that compounded pressure on the business included Owen's son's return to work on the farm. Not only was the business not making productivity improvements that were necessary to maintain the business but the farm also needed to support two families rather than one.

Owen and his son were running the farm as intensively as they could, given their constraints. This implies that there was likely to be little flexibility built into the system to cope with variability in water access. This idea is supported by the relatively early impacts of the drought on the business and Owen's savings. The already marginal business couldn't support two labour units which led to the need for a decision over who was going to manage the farm.

When Owen's son decided to leave, Owen was able to take a couple of years to decide what to do with the dairy enterprise. He had no debt and could manage the farm on his own. The farm already had a beef cattle enterprise. Owen was able to fairly easily transition over to a focus on beef, an enterprise that seemed worthwhile for Owen as a transition to retirement.

Insights associated with considering those who exited dairy

These are four individual experiences and I do not intend to imply commonalities across those who have moved from dairy production to other enterprises. Even so, there are some insights from these narratives that are useful to highlight here.

First, the accumulation of decisions through time that led to the decision to exit dairy production could be seen across all four narratives. Even so, the accumulated experiences as well as the critical junctures for transitioning out of dairy differed among the narratives. These related to: personal and family goals; change in family; and constraints on the capacity to continue to increase production in the business. The identified difference suggests that approaches to describe change triggers based on milk prices (for example, see Seyoum & Karanja, 2014; Tauer, 2006) are likely to miss significant sources of constraints that influence farm decisions, such as family- and personal-sourced critical junctures. The diversity of triggers for change aligned with the

overall finding that there were several different sources of critical junctures across farm experiences.

Interestingly, for three of the producers the decision to change out of dairy was clearly linked to the path dependent state in the farm business based on previous decisions. Paul had intensified and grown in size as much as he could, without having to inject a large amount of resources into the business. Owen had intensified as much as possible given his lack of land for expansion, but had been stagnate for years because of an inability to make further improvements. Matt was forced to sell the dairy enterprise after his son left and Matt faced debts associated with a series of recent changes.

Second, in all four experiences the producers had some kind of previous experience with the enterprise that replaced dairy. Owen and Matt did not actually take on new enterprises, but exited dairy to focus on an expanded existing enterprise. Geoff and Paul already grew crops as feed production for their cows and had harvested grain for market, to some extent. This implies constraint on farm decisions, in part, associated with capability. This was echoed by one of the dairy producers, Lachlan, who thought it was best to “stick to what you know and what you think you’re good at”, which for him was dairy farming (Narrative 12).

The alignment of existing capabilities to decisions about the farm implies a degree of irreversibility associated with capabilities in the business (Kogut & Kulatilaka, 2001). This is likely to be a significant issue in farms as micro-businesses, which often rely on the capabilities of one or two people. Capability links directly the producer with the farm, as the source of management decisions. Altering capability as a way to alter decision options is associated with learning (Kogut & Kulatilaka, 2001). The constraining effect that learning can have on decisions is considered in relation to drought in section 4.5.3.

Third, across the four experiences, concerns over financial implications differed depending on the producer’s goals. Matt and Owen were both nearing retirement and therefore seeking lower input enterprises. In both cases, they discussed wanting to lessen the time required on the farm because they were nearing retirement. In contrast, Geoff and Paul both had families that included school-aged children. In both cases they chose relatively high-input enterprises from which they were seeking to enable the

maintenance of profitable businesses. The pressure to make the enterprise profitable clearly lay with Geoff and Paul.

These dissimilarities can be usefully understood as differences in the trajectory image. Altering enterprises entails altering farm business goals. For Paul and Geoff, low profit enterprises are not an option, reflecting incompatibility with their personal and family goals. Alternatively, Matt and Owen had retirement-focused goals which made high-input enterprise options incompatible. These differences demonstrate how personal and family goals define, to some degree, options for the farm business. This is not to imply that profit is not still a fundamental purpose of the farm business (see section 2.1). In all four narratives, some income generation through farm productivity was expected. However, both Matt and Owen had no debt and the amount of income needed from the farm was much lower.

Fourth, Geoff and Paul both described a degree of compatibility between their new cropping enterprises and converting back to dairy production. Their discussion of this option implies consideration of reversibility in their decision making. This was not the focus for Matt and Owen who were winding back in their professional lives; discussion from these two related to eventually selling the land. Differences in reversibility were seen in the other farm narratives as well. This is discussed in section 4.4.3.7, with a focus on differences between highly irreversible decisions and probing as highly reversible change.

Fifth, the amount of time taken to make the decision to exit dairy differed, ranging from what appeared to be within days to multiple years. What was clear was that there were distinctions between deciding to get out of dairy production, the selection of a new enterprise, making the move to exit dairy and beginning production within the new enterprise. This represented some challenges when trying to identify critical junctures. For example, while it appeared that Geoff decided to exit dairy and sold his cows within three days because his relief milker quit, in reality, he had been planning on exiting from dairy for several years. While the relief milker represented the trigger to exit, it was the context underpinning the move that offered deeper insights. Similar distinctions can be seen in relation to other types of farm decisions. The importance of context is considered in greater depth in section 4.4.3.3.

Overall, consideration of the experiences of those who exited dairy production offered some clear examples of constraints leading to path alteration and constraints on what producers viewed as options for change in the path. Differences in critical junctures, the constraining influence of capability, differences in the trajectory image reflected in farm goals, reversibility and the importance of context for understanding triggers for change were all key understandings that stemmed from this consideration. Importantly, many of these insights were also applicable to those who maintained dairy farms and are considered in forthcoming sections.

4.4.3. Implications from decision mapping

Fundamentally, the decision mapping employed in the analysis supported the claim that path dependence exists in farms. In a vast majority of instances, critical junctures were identified as triggers for change and linked to reinforcing decisions. Additionally, the small number of anomalies could be rationally explained. There are a number of implications that emerged from the decision mapping which are useful for understanding decision-making on farms. I discuss these in the forthcoming section, including some insights associated with producer responses to drought and exiting dairy production.

4.4.3.1. A persistent imperative for increasing productivity

Overall, some critical junctures were more easily identifiable than others. Those that emerged due to a change in the task environment were fairly straightforward to identify, such as policy, extreme events, market prices and the farm family (see Figure 4. 5). Identifying the sources of critical junctures within the farm system was more challenging. I found it was best achieved through consideration of the persistent imperative to increase productivity, which underpinned these critical junctures. This led me to the first insight that was highlighted through the process of decision mapping, the importance of a persistent imperative for increased productivity in farms.

The persistent imperative in farms to increase productivity implies an enduring potential for critical junctures that arise from identified opportunities to do so. Critical junctures thus derived comprise a fundamental driver of the farm development path. The identification of opportunities depends on the extent to which the producer perceives an opportunity and reacts to it, which is determined by the hierarchy of images. This

indicates that framing change in farms in relation to changes in images, along with adaptation and function changes, may be crucial for understanding some farm-derived sources of critical junctures.

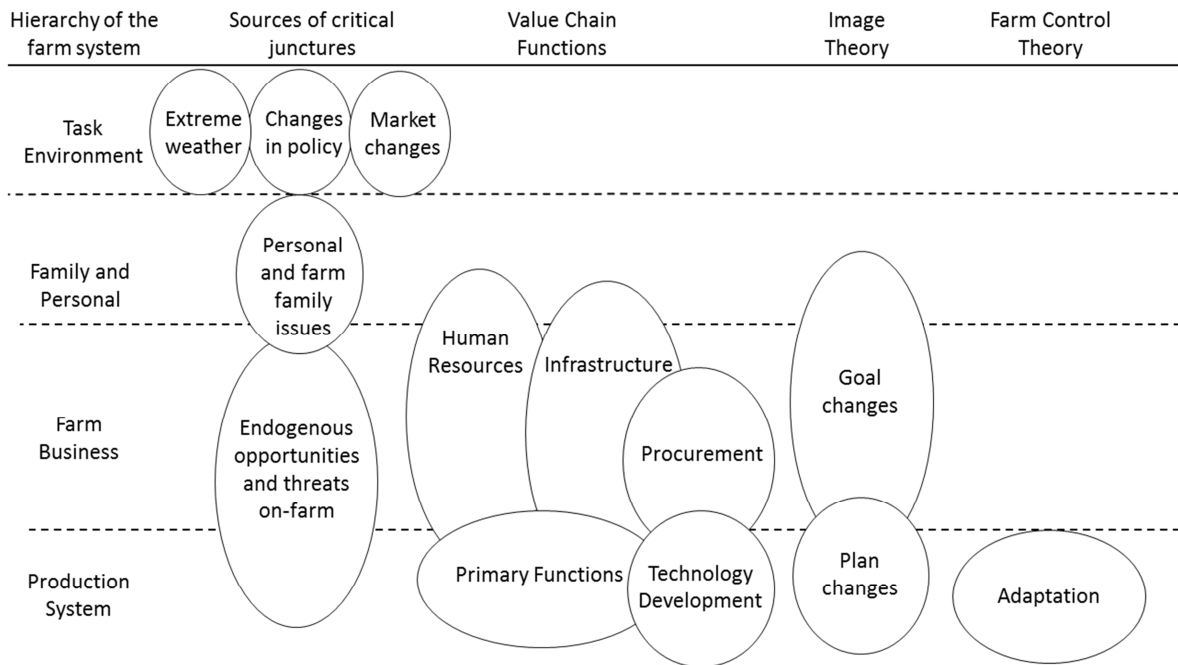


Figure 4.5: Sources of critical junctures in relation to other constructs of constraints, building on Figures 4.1 and 4.2

4.4.3.2. Limited options

Across the 16 farms, what became apparent quite quickly is the limited set of feasible options available to make farm system changes. This is associated with the limited set of production paths available associated with dairy farming. The initial decision to create a dairy farm knocks out a whole set of options given dairy production requires the capacity to maintain a herd of lactating cows and extract milk from the herd on, typically, a twice-daily basis. There are numerous examples in the narratives of the limitations on decisions. Producers bred Jerseys, Friesians or cross-breeds. Joining was managed through the use of bulls, AI or a combination of the two. Calving was planned for the spring and/or autumn. This implies some degree of commonality across production systems.

4.4.3.3. Context matters

In the analysis I found that what constituted a critical juncture was endogenous, which means that it was defined by the context of the farm business, including personal

circumstances of the producer. This was evident in the experience of interviewees in relation to the change in policy context when irrigation modernisation was implemented. While it was a critical juncture for some producers, it was not for others.

Responses to critical junctures were also context dependent. Given the practical reality of dairy farming, there are a limited set of potential production system configurations which relate to management of a herd for milk extraction and the generation of nutrition for the herd. Within these practical limitations context derived differences existed in producer responses to critical junctures.

At times this meant that different producer responses were generated from similar critical junctures. An example of this was producer responses to cow fertility problems. Producers managed fertility in different ways: by altering herd genetics, changing their calving pattern, focusing on improving nutrition and the use of medications to promote ovulation. What approaches were employed was determined by farm context. For example, poor drainage in wet winters was identified by several producers as a limiting factor in the use of split calving (Narrative 6, 11, 14). This is concrete evidence of equifinality in complex systems.

Context also meant that, at times, similar farm decisions were made due to different critical junctures. An example of this can be seen in the decision to change the dairy herd over to Friesian genetics. Harry decided to change his herd genetics to Friesians when the milk factory “payments changed to focus on protein,” because “increasing the amount of milk became more important than butter fat” (Narrative 8). In contrast, Owen’s decision to convert from Jersey to Friesian genetics related “mainly to [his] interest in using the outblock to start a beef enterprise,” as Friesians could be crossed with Herefords in beef production (Narrative 15). In contrast again, Karl converted to Friesians for an increased milk volume so that he had sufficient milk for his pigs (Narrative 11).

Another example of this is highlighted in the reason for producer decisions to alter calving patterns. Producers described the reason behind their calving pattern choice in terms of managing fertility issues, financial gains (e.g. winter milk incentives), matching herd needs with feed availability, farm labour and compatibility of grazing pressure with the farm in wet weather (see Table 4.13).

Table 4.13: Summary of contextual factors influencing calving pattern decisions of dairy producers

Case	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 (eg 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

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

4.4.3.4. Time

Time was a critical factor influencing constraints producers 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.

First, the timing of change had an influence on the farm constraints. This could be seen in relation to the timing of when children returned to work on the farm in two farm narratives. Two producers identified timing as a factor leading to their children not being involved in the family farm. First, Harry described how his son “started working on the farm in the 1970s, during the crash in the market for stock” (Narrative 8). Harry’s son “got educated when the cattle went in the pit’ and chose a different career path” (Narrative 8). Second, 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.

Second, the length of time available to a producer 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), within the family (e.g. death of the farm manager), or as identified opportunities or threats within the farm (e.g. anthrax). Logically, as urgency for a response increases, the options available to the producer decrease. This was the case for producers managing fertility issues, which I consider in the next section.

Broadly, time can be described as an impediment in decision making. As a lack of time reduced the set of change options for the producer, 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 producers and leads to very different outcomes, in part because of time. This calls into question assumptions about the capabilities of producers as farm managers based on the survival, or not, of farms.

Fertility management

Herd fertility is an example of a problem in which time can be seen as an impediment on decisions. Fertility management was identified within 11 of the farm narratives as a problem; sufficiently significant in nine cases to be identified as a source of critical juncture (see Table 4.14). High numbers of empty cows pose a risk to the farm business, given the importance of maintaining herd lactation. When a producer uses an annual calving approach, cows that are not in calf are generally culled. An increased rate of infertility implies that the producer needs to cull a greater number of cows, which has negative consequences on farm productivity. Geoff faced this problem. While he typically sold his empty cows, culling 20 per cent would have left “a bit of a hole” in the herd, especially given Geoff and his wife had just bought the farm and taken on significant debt in the process (Narrative 7).

Importantly, fertility problems could appear quite suddenly. For example, in 1993 Dennis and Donna “ended up with ‘a lot of empty cows’” one season (Narrative 4). Geoff described his herd fertility problem as “unusual” as typically, regardless of what he did, the infertility rate for Geoff’s cows was 11.5-12 per cent” (Narrative 7). Fertility could also be variable. Lachlan described how his herd’s fertility “varied from year to year”; ranging from just below 90 per cent to “as low as 50 per cent” (Narrative 12).

Table 4.14: Summary of the two main responses to fertility issues by producers

Case	Fertility issue	Split calving	Herd genetics	Rationale for response
3	Colin “was having some fertility issues with the Friesians” (Narrative 3, 3.5).	x	✓	Split calving was not an option given he was a single person operation
4	Dennis and Donna found that “the Friesians were having increasing fertility problems” (Narrative 4, 4.6). “The cows started to develop fertility problems again after they had converted back to spring calving” (Narrative 4, 4.14).	✓	✓	Converted to split calving to manage fertility. Still had fertility problem, even while split calving, so changed genetics. Converted back to spring calving when worked out the costs outweighed the benefits.
5	Edward “was constantly struggling to maintain his Holstein breeding, mostly through infertility” (Narrative 5, 5.8).	x	✓	Believed genetics of Friesians are ‘over designed’. He wants to drive when they calve based on feed availability. Split calving wouldn’t fix this problem – he did convert to autumn calving during drought because of feed but has convert back to split once the drought was over, things the natural cycle of cows and grass is aligned with spring calving
6	Frank’s narrative states outright that his shift to split calving “is because of fertility issues” (Narrative 6, 6.11).	✓	✓	Split calving used for fertility, but he is concerned that if weather gets too wet he may have to change back. He has also decided to change genetics.
7	Geoff “discovered that 24 (20 per cent) of his 120 cows were not in calf” (Narrative 7, 7.9).	✓	x	High empty rate led him to carry extra cows through as he couldn’t afford to cull. However he found the split calving draining – no down time (eventually sold herd)
9	Isaac “got the cows in calf but ‘they just seemed to be one or two cycles behind what the pregnancy test showed” (Narrative 9, 9.11).	✓	x	Split calving for fertility issues, currently using Prostaglandin for problem
10	John was also “having problems getting cows in calf ... John described it as something that ‘creeps up on you’. At first he noticed more cows were calving later. Then he started having an increasing number of empty cows” (Narrative 10, 10.10).	✓	x	Changed to split calving in response
12	“Some years fertility dropped and could be as low as 50 per cent”	✓	x	Split calving to manage fertility issue and winter milk incentive
14	Neil also experienced fertility problems in which it was “harder and harder to get the cows in calf” (Narrative 14, 14.6).	✓	x	Changed to split calving in response to fertility problem. Proportion of spring/autumn calves have changed as land has been bought that is better in wet weather
15	“As time went on it got harder to get cows in calf, and the reality was that they ‘had cows calving all the time’ in the later years.”	✓	x	Ended up calving ‘all year round’
16	Paul found “[t]he proportion of empty cows ‘ended up being too high a proportion’ for Paul and his brother to continue to ‘wear the losses’ associated with sticking to spring calving” (Narrative 16, 16.12).	✓	x	Ended up having to keep altering calving to suit empty cows, went from 2 to 3 calving periods a year

There were a number of ways to manage fertility problems that producers 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. Responses actually undertaken by the producers depended on context. This included what the producer identified as the underlying cause of the problem, which is evidence for the role of beliefs in decision making. For example, Colin identified the issue as associated with his herd genetics and “started breeding Jerseys” instead (Narrative 3), while Paul “didn't believe [changing genetics] had any credibility” as genetics were not necessarily the issue and focused more on nutrition and breeding practices as a response. The compatibility of the change option with the current farm system was also a factor in the response taken. For example, Colin didn't 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 didn't know “how they get the energy” for split calving (Narrative 3).

Another contextually constraining factor was the time available to make a decision. Most of the options for managing fertility that producers described were only useful in the next season and didn't address the current circumstance. For example, because Isaac ‘had an especially bad year’ with fertility in the previous year, he started “administering Prostaglandin” this year as a preventative, which is “supposed to help cows cycle more quickly” (Narrative 9). Nutrition management and joining practices also only hold relevance in addressing future incidents of high rates of empty cows.

The decision that required the longest timeframe was altering herd genetics. Most producers had self-replacing herds, in which future dairy cows were created through calving. Using this approach, altering genetics would require a season at a minimum and could take much longer than this. The other consideration to add into this is the likelihood of a protracted timeframe employed in the process of selecting new herd genetics.

In reality, options for managing fertility were quite limited for producers when suddenly faced with a number of empty cows. By the time pregnancy testing was completed too much time has progressed to join the empty cows and expect calving to occur in alignment with the rest of the herd. To manage the immediate problem producers

needed to either: cull the cows, carry the empty cows with reduced lactation for a year or join the cows for autumn calving. This required a quick decision.

Nine of those who had fertility problems immediately altered their calving pattern from spring to split calving in response. For example, “[t]he proportion of empty cows ‘ended up being too high a proportion’ for Paul and his brother to continue to ‘wear the losses’ associated with sticking to spring calving” (Narrative 16). As well, when Dennis and Donna ended up with “a lot of empty cows” they “shifted part of the herd over to autumn calving” (Narrative 4).

For the two producers who did not convert to split calving, this was related to incompatibility with the current farm system. Given Colin had his farm set up as a one person operation “the last thing he would want to be doing [in the autumn was] ‘tending to calving cows and feeding calves’ during a time that he would be ‘oversowing pasture and watering the whole of the farm’” (Narrative 3). For Edward, maintaining the calving pattern to match available feed over spring and summer was an important management practice. He “didn’t want a cow driving the system” (Narrative 5)³¹. Edward decided to change his herd genetics as he wondered whether Friesian genetics have been “over-designed” (Narrative 5).

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.

In reality, producers still faced fertility issues, even after converting to split calving. Isaac (Narrative 9) was currently managing fertility issues at the time of the interview. As well, while Owen and Paul (Narratives 15 and 16) had shifted to split calving, the fertility problem persisted up until they each exited the industry. For example, Owen described how “the reality was that they ‘had cows calving all the time’ in the later years” (Narrative 15). Two of those who converted to split calving for fertility reasons,

³¹ Edward’s response to drought offers further evidence of the importance of matching calving to feed availability for him. During the drought years Edward shifted to autumn calving after he converted his pasture to annuals, which required less water and maximised feed production over the winter. After the drought Edward shifted his herd back to spring calving again as his pasture was reverted to summer active perennials.

Narratives 4 and 6, went on to alter their herd genetics. For example, Dennis and Donna found that, even with split calving, then were getting a “high empty rate” and decided to look for a different breed (Narrative 4).

Split calving, as response to fertility problems, can appear insufficient; especially given producers were still experiencing fertility problems. However, given the timeframe within which producers had to make a response decision, there were few options. The alternatives of culling the empty cows or carrying empty cows for a year were clearly more costly. Management approaches that may have addressed the underlying problem, such as nutrition and genetics, were not available as options for addressing the present problem.

4.4.3.5. Compounding critical junctures

Context aids in considering another important point, the potential for a critical juncture to be related to multiple sources. There were instances where producers described critical junctures that had multiple sources that converged to create a need for change.

For example:

Just as Matt and Marie were negotiating taking on full responsibility of the family farm, the region was settling into a number of years of drought. “It was really an emotional, tough time” for the whole family (Narrative 13, 13.28).

In the 2002 season, Paul didn’t get his full entitlement of irrigation water. He described 2002 as “a real shock” because they had “treated water as if it was always going to be there”. It was the first drought-affected year that Paul and Patricia experienced and their “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, 16.17).

NVIRP wants to get rid of the spurs on the irrigation system as a part of an irrigation modernisation program. As well, there are government incentives (round two) for water-use efficiency upgrades. Frank has put these two things together to redevelop his dairy property (Narrative 6, 6.17).

At other times critical junctures were generated through compounding problems.

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, 2.9).

Neil described the period of time from when his father got ill and then through a protracted drought as "a challenging decade" (Narrative 14, 14.15).

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 producer at a particular time. As well, it is possible that a confluence of multiple changes simultaneously can generate a critical juncture, while alone they may not. Clearly, potential sources of critical junctures are best understood in light of other potential sources of critical junctures. This highlights the benefits of considering critical junctures in relation to the different constructs of constraints offered in this multidimensional model.

4.4.3.6. Serial critical junctures

At times, farm histories 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, 9.8). 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, 9.9). 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 4.6). By

the early 1980s Matt’s farm was consistently struggling to have enough water, even with 100 per cent of sales water, due to low irrigation entitlements that stemmed from initial policy decisions at the time of the soldier settlement scheme. At the same time, there “were reduced-interest rate salinity loans available to do infrastructure upgrades” (Narrative 13, 13.16). This created a critical juncture. Matt and his family decided 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.

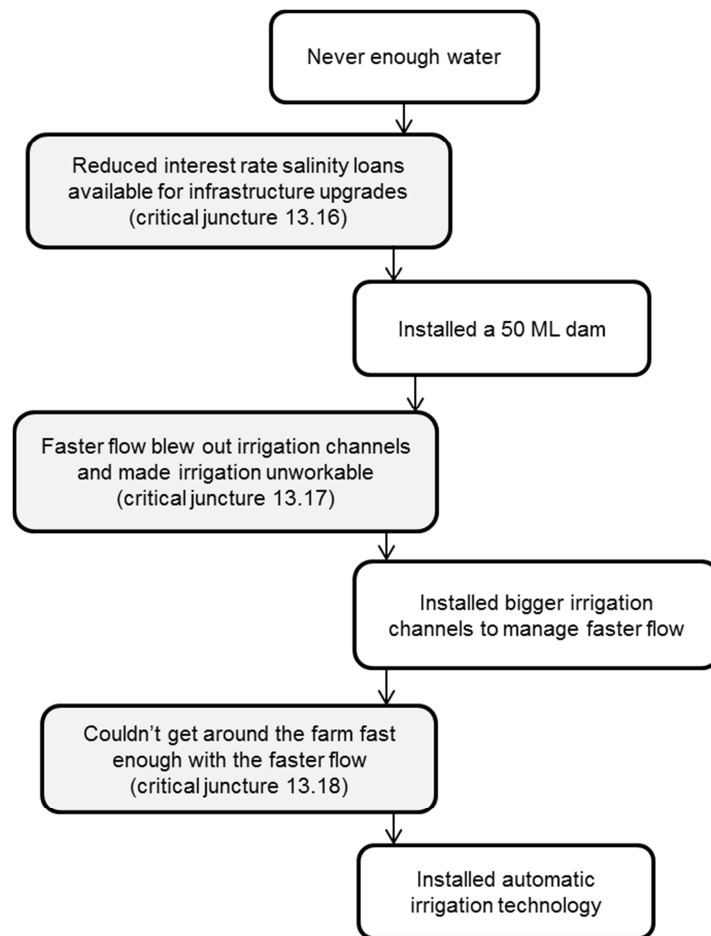


Figure 4.6: A cascade of critical junctures caused by problems integrating infrastructure changes within the existing production system, an example from Narrative 13

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-sized 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, 13.17). 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 realised that they couldn't manage the irrigation as they used to. They simply could not get around to the bays fast enough given the faster flows (Narrative 13, 13.18). This created another critical juncture. They had to come up with a way to manage their farm irrigation in face of the faster flows. This led them to automate their irrigation system. While the automation technology over the years has changed, since the initial decision to automate, Matt continued to run the irrigation as an automated system.

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 4.7).

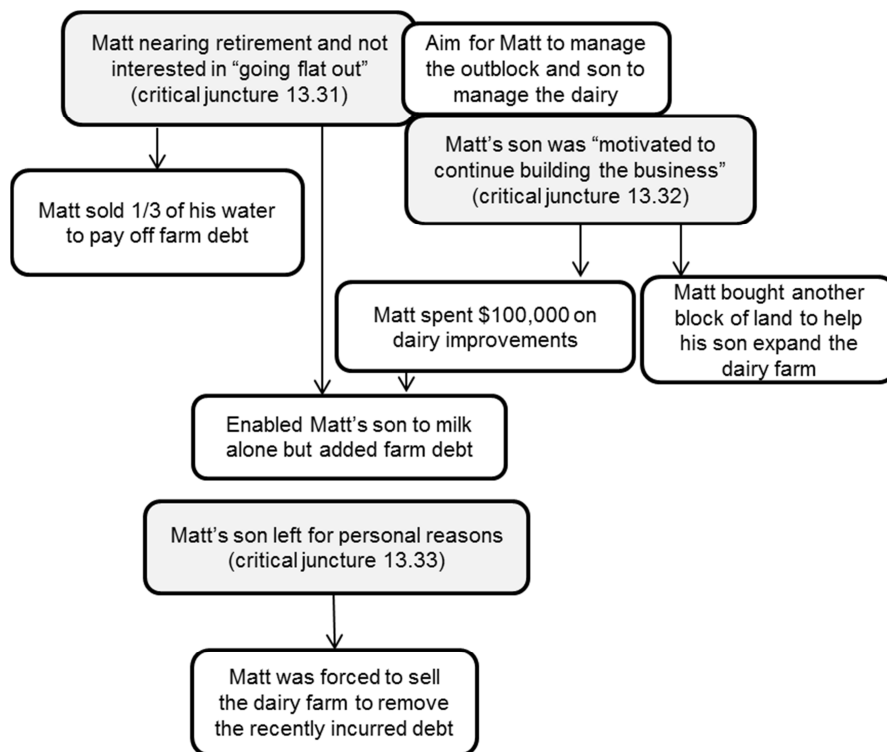


Figure 4.7: A series of critical junctures associated with changing context, example from Narrative 13

Matt was nearing retirement and not interested in “going flat out” (Narrative 13, 13.31). To enable this, Matt had sold a third of his irrigation water, which paid off all of the debts on the farm. The aim was for Matt to manage a 500 acre outblock and his son to

manage the dairy farm. Matt's son was "motivated to continue building the business" (Narrative 13, 13.32). This did not necessarily align with Matt's aim to minimise debt as he neared retirement, which was reflected in his decision to sell some of his water.

Matt's son persuaded Matt to buy another block of land and to fund \$100,000 worth of dairy shed improvements 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 winding back his workload. The changes also increased farm debt. In this circumstance, Matt was clearly trying to balance his personal goals with his son's goals regarding increasing the business.

Unfortunately, Matt's "son announced that he was leaving the farm for personal reasons" shortly after Matt paid to upgrade the dairy and bought the new land (Narrative 13, 13.33). Matt could not run the entire farm on his own and had to sell the dairy business. Selling the dairy farm "was unexpected and traumatic" (Narrative 13). However, it was through selling the dairy farm that Matt and Marie were able to extinguish the debt incurred through the recent changes.

There were clearly differences between serial critical junctures, which can be seen in both of these examples from Narrative 13. However, in both examples, understanding the serial critical junctures was aided through identifying linkages in decision mapping.

4.4.3.7. Irreversibility and probing

When looking at change decisions in the narratives, it was clear that there were differences among decisions with regard to the degree of path dependence they implied within the farm. The fundamental way to characterise this is in terms of the irreversibility³² of the decision. Irreversibility is a path dependence concept that describes the system state in which the current path is locked in to such a degree that change is not possible (see section 2.3.2.3) Irreversibility can be described along a

³² The irreversibility of interest to this research is that which locks the business into consequences relating to farm output quantity and quality, alters the perceived riskiness of the business and alters the perceived value of the business. It is important to note that the degree of irreversibility is the perception of the producer grounded in their values and beliefs.

continuum between highly reversible and highly irreversible states. As irreversibility increases, the costs associated with reversing the previous decision increase.

Irreversibility implies a tendency for a longer-term commitment to what could be suboptimal infrastructure or practices in the farm. This could be seen in Ben's experience. Ben's parents made a number of changes to their dairy to increase the number of cows they could milk at a time. They "altered the dairy by replacing the zigzag rails with straight rails and 'pushed an extra cow in the shed'" (Narrative 2). However, "it was 'probably the worst thing' that they could have done because the new set-up cramped the cows into too small a space so 'they weren't happy in the shed' which made it hard during milking" (Narrative 2). Even so, they stuck with the existing set-up for nine years. It was only when a new critical juncture was created because Ben was engaged and the farm needed to support two families that a new dairy was built. At the same time that more land was bought in preparation for increasing the herd size.

Another example of irreversibility can be seen associated with the 26-cow herringbone dairy on Neil's farm. While Neil's dairy "was big, it 'had a terrible yard set-up'" (Narrative 14). However, Neil and his father couldn't build a new yard "because there was a dam that impeded the changes they wanted to make" (Narrative 14). They ended up "building a whole new dairy, which would allow them to alter the yard set-up as well" (Narrative 14). The costs associated with building a new dairy would have been considerably higher than building a new yard.

While some decisions were highly irreversible, others are highly reversible. This is the case with probing (Kurtz & Snowden, 2003). Probing is the active seeking of appropriate responses or actions in complex circumstances, where previous patterns of action are no longer effective. Kogut and Kulatilaka (2001) argue that probing injects flexibility in responses to uncertainty. Probing implies the emergence of a critical juncture. It is a rational response to uncertainty and entails a higher-order change in images.

For example, there was a degree of probing in Ben's post-drought response. Ben wanted to be self-sufficient in terms of pasture production but was uncertain about what the right pasture mix was for his farm. The drought killed all of his perennial pasture, which will take "six, eight, ten years to get back" (Narrative 2). Then he had "enough water to

‘nearly drown’” over the last two years (Narrative 2). Given this uncertainty, he has only sown a small amount of perennial pasture. He also “put in a small amount of lucerne this year and wanted to see how that works out” (Narrative 2). He described the process of working out the correct pasture mix as “trial by error at this stage” (Narrative 2).

At times, probing did not lead to acceptable results. This was the case for Dennis and Donna when their decision to try sorghum led to two cow deaths, due to milk vein punctures (Narrative 4). Keith “tried ‘a little bit’ of autumn calving but found that the farm was ‘too flat to run dairying through the winter’” (Narrative 11). Matt also tried split calving but found that “[i]t was so ‘different to the current system’ that it created too much extra work” (Narrative 13).

When probing does not achieve desired results it can lead the producer to backtrack and try something else. This means that some farm decisions can appear random or as a series of ‘fits and starts’. However, each reversed decision provides new knowledge to the producer regarding what doesn’t work within the current farm context. A high degree of uncertainty can be punctuated by repeated probing in farms.

Like all change, there are costs associated with probing. Costs here relate to the activity of probing, outcomes of probing and diminished time available for future responses. This implies that repeated probing can increase the constrained state of the farm. Importantly, once probing has identified a desired set of appropriate activities in the farm, a new pattern is established. Hence, sequences of decisions that reinforce these appropriate activities derived from probing generate path dependence.

4.4.3.8. Limitations in the decision mapping

The difference between highly irreversible changes and probing identified in the data highlighted an important point associated with this research. The identification of linkages between critical junctures and other constructs of constraints through the decision mapping did not necessarily mean that the constructs were always reinforcing mechanisms. For example, probing is clearly a relevant mechanism that can narrow path options. However, another possibility is that probing in response to a critical juncture may not always alter constraints. This means that there is the possibility that some highly reversible decisions in the narratives were erroneously identified as influencing

path dependence. This implies a potential to overstate the constraining influence of probing decisions in path dependence.

Relatedly, it is possible that some of the highly irreversible decisions identified in the narratives in response to a critical juncture represented structural determinism, which means the initial decision was the source of constraint without regard to reinforcing decisions. It is important to remember, however, that this research is about revealing path dependence in the farm as a whole. This means that, while some decisions may represent structural determinism to a subsystem or component, this would not be the case at the farm business level³³. Significantly, I did not find any evidence of a single decision that determined the trajectory of the farm business path which was not reinforced by other decisions.

Overall, this implies a limitation to the research approach when considering specific reinforcing decisions in relation to critical junctures. The approach did not reveal structural determinism at a subsystem or component level and it may have overstated the influence of probing as a reinforcing mechanism.

4.5. Drought - learning and information

Drought was a recent extreme experience for all producers interviewed in this research (Quiggin, 2007). The potential for increased frequency of drought has been identified as a salient issue associated with climate change (Davenport & Brooks, 2004; Wei, Langford, Willett, Barlow, & Lyle, 2011). Quiggin's (2007) modelling found that drought, as a manifestation of variability, will lead to more detrimental impacts in Australia's Murray-Darling Basin than long-term trends toward drier conditions. It is thus pertinent here to contemplate some insights that can be derived uniquely through consideration of the constraints on producer responses to this drought.

Irrigation water is a critical factor in the productive capacity of the land (Elliott et al., 2013). Hence, irrigation water is a critical input for irrigated dairy businesses. Given this, a reduction in the access to irrigation water can have significant unfavourable consequences for producers. Drought led to a reduction in access to irrigation water

³³ This broadly aligns with recent work by Bergek and Onufrey (2013), who argue that considering path dependence in terms of a single technology stream in a business loses sight of the potential for interaction among technology streams. They conceptualise this in terms of multiple paths while I conceptualise it as a hierarchy of paths with the farm business path sitting above subsystem paths.

generating a critical juncture for all of the producers interviewed in this research (see section 4.4.1.1). This is consistent with documented evidence of a protracted dry period between 1997 and 2009 across Southern Australia’s Murray-Darling Basin (Verdon-Kidd & Kiem, 2009). The impacts on the dairy industry could be seen in lower milk output in Northern Victoria during periods of very low water allocations (see Figure 4.8) (Wei et al., 2011).

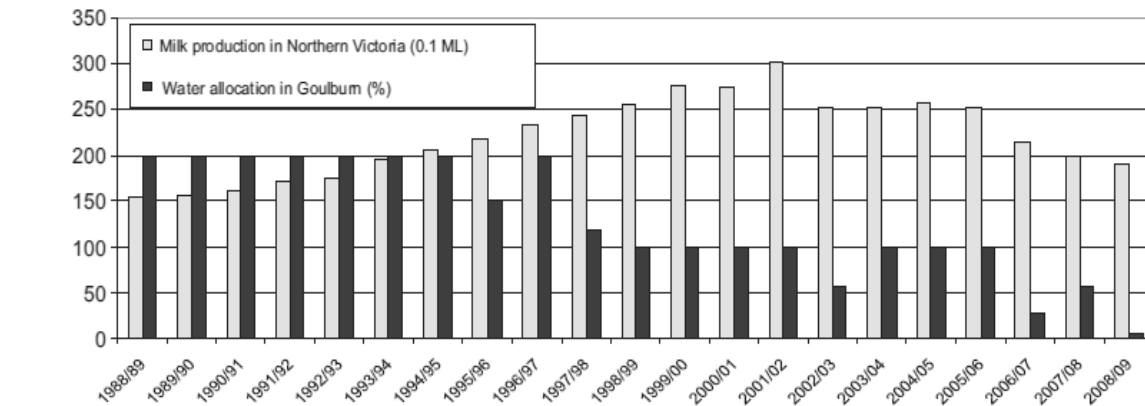


Figure 4.8. Water allocation and milk production in the Goulburn-Broken District of the MDB, from Wei et al. (2011)

Given drought was a critical juncture across all farm narratives, it is worth considering what insights can be derived from comparing producer experiences. In this section I offer some insights that are relevant to the analysis of path dependence in farms. I contemplate differences in the timing of drought for producers and how this relates to the source of variability. I also consider producer responses to drought and how some of these reflected double-loop learning associated with change to higher-order images. Before this, I briefly summarise the experiences by each producer in relation to drought (see Table 4.15).

Table 4.15: Summary table of producer experiences with drought

Case	Perception of when drought began to impact on business	Changes that reflected plan changes and double-loop learning response	Post drought response
1	When allocations dropped below 100 per cent	After an initial response to borrow heavily to get through the first year or so the producer realised that the drought was going to persist. He realised that he "had to get a lot smarter if he was going to maintain the business."	Maintained half the amount of perennial pasture as pre-drought Aiming for "flexibility in his feeding system"
2	When allocations dropped below 100 per cent	Changes to production system meant he had to put more thought into matching nutrition to cow needs so he hired a nutritionist	Recently started putting a small amount of perennial pasture and lucerne to increase self-sufficiency Uncertain regarding the right pasture mix - described it as "trial and error"
3	When allocations dropped below 100 per cent	Developed a new strategy for managing irrigation in which he saved allocation and purchased temporary water to enable oversowing of pasture in autumn	Sowed one third of the farm to perennial pasture, a smaller proportion than pre-drought, and focused on maximising productive use of water Put in 15 acres of lucerne as a source of hay and good grazing feed
4	Lack of sales water an issue When allocations dropped below 100 per cent	Bought permanent water to manage the loss of sales water Changed how they managed their feed, trying different practices until they found what worked for them (e.g. shifted from use of a feed pad to a sacrifice paddock to a paddock rotation)	Farm set up as 25 per cent perennial pasture, much less than the 66 per cent pre-drought, and the rest was annuals and crops The farm was more flexible and pasture could be more easily changed
5	When groundwater dried up in 2009 However, he had previously bought more land to access more groundwater in 2006, which increased his reserves.	Was shocked when groundwater dried up, as always thought it was reliable Changed to mostly annual pastures and autumn calving to match feed availability and calving	Actively looking for ways to produce more feed with less water, so bought more land with groundwater bores Used grant funding for pasture upgrades, automation and a centre pivot (intended for perennial pasture) Focused on generating a reserve of feed Shifting back to spring calving as when there was water spring calving was easiest Wants to control area's groundwater to manage over pumping and rising salt because it is important water source for him
6	When allocations dropped below around 50 per cent	Converted feeding system to annuals and crops and developed a new feeding approach for the herd	Maintaining only 25 acres of perennial pasture Similar productivity from an annuals-based feeding system when compared to previous system and new system was viewed to be easier
7	When sales water dropped to 50 per cent, so that he could only get 150 per cent of his entitlement Just got drier and drier from there	Shifted to a lot feeding approach which included use of a significant amount of supplementary feed and growing more annuals (including lucerne) and crops	Maintained lot feeding because it was easier and could be done by anyone Began share farming and eventually sold the cows, converting to a cropping enterprise.

Case	Perception of when drought began to impact on business	Changes that reflected plan changes and double-loop learning response	Post drought response
8	When allocations dropped below 100 per cent	Relied heavily on a deep-lead groundwater bore, as it was cheaper than surface water and installed a shallow groundwater bore Converted feeding system from predominantly perennial pasture to annuals and lucerne	Pasture mix was still predominantly annuals Currently installing pipes and risers using on-farm irrigation grant funding and the influence of this on pasture mix was unknown
9	Water was below 100 per cent allocation and he lost access to water on his leased block as owners sold it on the temporary market.	Early on in the drought, watered some selected paddocks and relied on large feed reserves After reserves declined, cut back on all expenses, relied on annual pasture, increased supplementary feeding Developed a watering strategy in which he worked out expectations in water for the season and irrigated to suit, focusing on maximising production on what he did grow. Developed a more flexible approach to herd size, maintaining stock numbers based on water and feed availability.	Pasture management seen as different since drought: used soil testing to select paddocks for fertilising and planted 60 acres of lucerne Built up 12 months' worth of fodder reserves Focused on building up herd numbers again
10	Changes to water rules, including a drop of sales water Then drought worsened during low allocation years, when allocations were below 50 per cent	Learned "a whole new way of farming" because of the drought which meant less reliance on pasture-based feeding and purchasing feed	Oversowed pasture back to a similar balance of annual and perennial pasture as pre-drought
11	Drop in availability of sales water Impacts peaks when receiving allocation on average below 50 per cent	Expedited farm redevelopment Focused on self-sufficiency in feed production and keeping overheads down, though he did start feeding in the bail and bought a silo to help with this Developed a herd management pattern in which he matched cow numbers to feed availability in the season (which was associated with water)	Increased herd back to pre-drought numbers Focused on maintaining rather than expanding the farm (costs too great to increase productivity further) and farm income being invested off-farm for other purposes
12	When allocation reduced to 50 per cent	Converted pasture from perennials to annuals and maintained existing lucerne Already relied on supplementary feed, so while needed to buy more, he didn't alter feeding practices	Sold herd at end of drought and bought new cows two years later, which required a \$250,000 loan Cleaned up and sowed most of his pasture to annuals for the new herd Would consider putting in perennial pasture with more certainty regarding access to water at a price he could afford
13	Sales water decline Following this, drainage diversion dries up at the same time that allocations begin to drop below 100 per cent. Shallow ground water bore slowed down	Bought some temporary water for a high price and irrigated a reduced area of pasture that was determined by water availability each season Fed more supplementary feed Dropped herd size by almost 20 per cent	Buying temporary water to maintain some water meant pasture was ready to go when more water was available Began setting up farm for son to take over, when son decided to leave sudden the farm was sold

Case	Perception of when drought began to impact on business	Changes that reflected plan changes and double-loop learning response	Post drought response
14	Decline in sales water	Converted irrigated outblock to crops and dairy block to annuals and lucerne (on sub-surface drip) and set up a feeding rotation that included a couple of hours grazing and feeding out in a sacrifice paddock. Eventually had to reduce herd by almost a third, but this led to reduction in cash flow and hindered the capacity to build the farm back up again after the drought	Maintained a higher proportion of annuals and lucerne since the drought as the change in water rules and allocations meant using water efficiently was going to continue to be important
15	Loss of sales water required some changes Allocation dropping below 100 per cent	Spent \$100,000 in personal saving buying water and fodder, based on the view that the drought wouldn't last long. Realised he needed to do more and minimised expenses and cut back his herd size Was considering getting out of dairy farming so did not try what other producers tried and when son left the producer converted to beef as it was lower input	Converted to beef
16	Decline in sales water led some changes Specifically identified low allocation years in 2002, and 2006-2008	After the experience of 2002, knew very quickly what to do in 2006 when drought returned	Identified a need for investment and enthusiasm if the dairy was going to be viable; instead he shifted to cropping.

4.5.1. Summaries of experiences with drought from the farm narratives:

4.5.1.1. Albert (Narrative 1)

“Historically, Albert had a 132-ML surface water irrigation entitlement and would consistently get 100 per cent of his entitlement plus 100 per cent in sales water.” Since the mid-1980s, Albert has had an 85-ML groundwater bore, which needs to be shandied for use on pasture. Drought started to affect Albert when the allocations dropped below 100 per cent. When the drought struck Albert “borrowed heavily to try and get through it” because he “thought it would last a year or two”. A large cost early in the drought was a feed pad near the dairy, as this gave Albert “another way to efficiently feed the cows after they had been milked”. However, as time went on “he realised that he couldn’t keep borrowing and just feeding out” as “[a]ll of his income was going to feed the cows. He had to get a lot smarter if he was going to maintain the business.”

With this decision Albert changed his feeding system, from perennial pasture to “a new hybrid annual rye grass”. He “continued to oversow with annuals through the drought”. This pasture set up worked for Albert and his spring calving as it “meant cows were ‘finished on a little bit of grass’ and would come back into production early in the spring”. At the same time, Albert set up a new feeding pattern “that included strip

grazing, pellets in the dairy, feeding out on the feed pad and providing hay in the paddock. He upgraded the pellets he fed out in the shed. He bought in failed crops with high protein and energy and he purchased lucerne when he could afford it. He also fed supplements to the young stock to help improve the breakdown of poorer quality hay.”

After the drought, Albert put about 50 per cent of the farm back into perennial pasture, half of what he had before the drought. He planned on maintaining 30 per cent in annuals and plants 20 per cent to lucerne. His reasoning for the new pasture mix was “to have a bit of flexibility in his feeding system”.

4.5.1.2. Ben (Narrative 2)

Ben had access to around 500 ML, when he got his full entitlement. The drought affected Ben’s farm throughout the 2000s, associated with when allocations dropped below 100 per cent. Ben converted all of his perennial pasture to annuals “[w]hen the drought hit and there was not enough water to water the perennial pasture” annuals”. Drought meant that Ben had to feed out more. “With the increased pressure to produce more silage they shifted during the drought to bulk silage in bunkers” also, while they “tried to grow as much as they could on the farm” they had to buy in extra feed. This meant they “had to put a lot more thought” into their supplementary feeding, which led them to hire a nutritionist. However, even with the changes to feed, this was not enough and Ben reduced cow numbers by parking cows. After Ben changed to annual pasture, this pushed him to shift to split calving, because he “had no summer pasture during the drought and had a lot of autumn and winter pasture”. By the end of the drought, Ben “finished up having no pasture at all” and “growing more crops because they didn't have the water to start...annuals”.

Post drought the farm was maintained with no perennial pasture for several years. Ben had “‘only just started to put a little bit’ of perennial pasture back in” in the current year, as well as some lucerne. This was because “he want[ed] to be more self-sufficient” and saw that perennial pasture and lucerne would help with that. However, he was still uncertain and described it as “‘trial and error at this stage’ to see what the right balance of pastures is for the farm”.

4.5.1.3. Colin (Narrative 3)

Colin has 350 ML of water associated with his farm. When drought struck in the early 2000s, this dropped his allocations below 100 per cent, and the allocations kept going down. With the small proportions of this that he had available to him he couldn't maintain all of his perennial pasture. Colin reduced his area of perennial pasture on his farm from 50 per cent to "virtually nothing", which "meant that [he] had to rely much more heavily on annual pastures". Colin also diversified the annuals that he grew "trying a few different crops (e.g. oats) and pasture varieties (e.g. Medics) that had reduced or no irrigation water requirement". He "oversowed a 'fair bit of ground' each year as he oversowed a lot of his perennial pasture as well ... hoping it was the end of the drought." Colin also "supplement[ed] what pasture he could grow with some purchased feed". He "had to buy in significantly more feed than usual".

As the drought continued Colin developed a new strategy for managing his irrigation water. He would use the small amount of irrigation water that he received through the season and "he would purchase a little bit of temporary water" to aid his pasture when he oversowed. While he aimed for two waterings, at times "he would just get one watering in, depending on the season and how much water he had, before winter came."

After the drought, Colin sowed back some of his farm to perennial pasture, but "is still irrigating less perennial pasture" because only about one-third of the farm was perennials. He put the perennial pasture in "laser-graded paddocks" to maximise the feed he could get from his water use. Because of this, he was "getting the same feed out of the 100 aces that he used to get 'in the old days' on 150 acres". Colin also put in 15 acres of lucerne to "provides him with good quality feed for hay and grazing". "Colin thinks that now he could carry more than 130 cows on his farm."

4.5.1.4. Dennis (Narrative 4)

Dennis and Donna "always used more water than their allocation" of 218 ML. They used to get 100 per cent of their allocation as well as sales water. When sales water was no longer available they purchased 100 ML of permanent water, which gave them a 318-ML entitlement. However, soon "they were not even getting their full entitlement".

Dennis and Donna changed how they managed feed for their cows during the drought. "They developed a feed regime that suited their cows and 'suited [their] style of

farming”. They focused on feeding out to the cows, which included purchasing feed such as “palm kernel and cereal hay”. They had to buy “a lot more feed during the drought”. Dennis and Donna moved away from using a feed pad for chopped silage to focusing on feeding out hay in the paddock “because of the cost”. While they tried sacrificing a paddock, they found just rotating the cow around worked best for them. In the second year of the drought Dennis and Donna needed to reduce feed pressure. They decided to reduce their herd size. They sold 30 cows and parking 40 to 50 cows out of the district. With the small amount of water they had, Dennis and Donna tried to keep a few paddocks watered, with a travelling irrigator. The remainder of the farm was maintained as dryland. They maintained seven paddocks one year and the next year decided that irrigating four paddocks was more feasible.

Since the drought the farm was set up to be one quarter perennial pasture, which was significantly less than the two-thirds perennial pasture before the drought. The home block was maintained as perennial pasture because they are spring calving, which “means they need some summer-active pasture for grazing”. The rest of the farm was set up as annuals and crops. Dennis believes that “the farm is ‘more flexible now’ and that they can change pasture ‘depending on water availability’.”

4.5.1.5. Edward (Narrative 5)

Edward’s farm had access to about 400 ML of each surface and ground water for irrigation at the beginning of the drought. Edward also bought another 80-acre block in around 2006, when his allocation was “down to about 30 per cent” to give him access to another groundwater bore. Given Edward’s access to groundwater, the drought didn’t affect his farm until the ground water “started to peter out”. By 2009 “there was virtually no groundwater available” which was unexpected as Edward would “have backed groundwater over the dam in the hills [i.e. reservoir] any day”.

Edward “didn’t want to buy any water” and wanted to “get the best water use efficiency out of the feed itself”, so he changed to “predominantly annual pastures”. At the same time, he moved his entire herd to autumn calving. He changed his calving and pasture because “you get your best bang for your buck for water” with autumn calving and annual pastures. The new feeding system meant Edward had “a bit of a mad panic in spring, with silage and stuff”. However, this was followed by a break over the summer, when he dried off his cows.

Since the drought “Edward was looking for ways to produce more feed with less water.” He bought more land with groundwater bores in aid of this. He was using on-farm irrigation grant funding for “laser grading, automating his irrigation system and a centre pivot” on this new land. He was going to put in 93 acres of perennial pasture under the centre pivot. Edward was also focused on “putting a ‘bank of feed’ away for the future”. At the time of the interview, Edward was in process of shifting his calving back to spring, as “[w]hen he has water, spring calving is the easiest way he can run his farm”.

Edward wanted to “take control of groundwater in the region” because he was concerned about over pumping and rising salt. He thought fixing the problem meant that “the pumping pretty much has to match the recharge”. At the time of the interview, Edward had entitlements for 1114 ML of groundwater and 363 ML of surface water.

4.5.1.6. Frank (Narrative 6)

Drought began to impact on Frank’s farm in the mid-2000s, when the allocations dropped below 50 per cent. Frank was overseas for an extended period of time when the drought began to take effect. “[H]e came back to Australia to find there was ‘nothing there’: no feed. ‘August was just shocking’ and Frank sold 110 head of stock in a week.” Frank sold almost 28 per cent of his stock over a very short period of time. “The decision to sell the 110 head of stock ended up working well for Frank and his family.”

However, selling stock was not enough, as “[t]here were at least three years that were ‘definitely bugged’, from 2007 through 2009”. Frank decided to make “significant changes to the feeding system so he could get by with less water”. He dried off a significant proportion of his pasture, maintaining “about 25 acres of perennial pasture where he focused the watering”. He also converted the entire irrigated outblock from annual pasture to crops “because they could grow more with less water”. He started a new feeding approach in which “the cows would get a ‘strip of grass’ and some hay during the day and at night they would only have hay”. To enable this he “started buying more hay”.

“Since the drought Frank has a more annual-based feeding system”, with only about 25 acres of perennial pasture in total. He now has more access to water but “has seen that he can make a similar amount of milk from an annuals-based feeding system” as he did from his previous system. Also, “Frank finds the way his feeding system is set up now

to be easier” because he doesn’t have to “water 200 acres of perennial pasture every seven days through the summer”. Instead, he “makes silage and hay in the spring to feed to the cows later” and then has a break from feed production until the autumn.

4.5.1.7. Geoff (Narrative 7)

Prior to the drought Geoff “always had plenty of water” with “100 per cent of his water right plus 100 per cent in sales water”. Geoff identified the start of his problem with water as “around 1997, when G-MW cut back on sales water so that he could only get 50 per cent in sales”. From 1997, “it just slowly got drier and drier”.

At time, Geoff had a perennial pasture based system, with only around 50 acres of annual pasture in total. Geoff’s “first response to the drought [in 1997] was to dry off 30 acres of perennial pasture.” After that first year, Geoff started growing lucerne, adding about 20 acres a year until he got up to having 80 acres of lucerne. Geoff also “found that he could go through the lucerne and direct drill cereals” in the autumn. With the shift to lucerne and drop in area of perennial pasture, Geoff significantly increased the amount of supplementary feed he was providing his cows. When this happened he shifted to “lot feeding” the herd, which he continued to do throughout the drought.

The drought continued to worsen and by 2006 it “‘sort of pushed’ Geoff into feeding in the bail”, which Geoff hadn’t done previously because of costs. Geoff “started to slowly get out of lucerne from about 2007 onward” because he had so little water that “it wasn’t enough to do anything with”. Geoff shifted to annuals “because he could sow cheap annuals and cereals, cut it for hay and silage and store feed for use as he needed it. This worked well for him given he was lot feeding.” By the time the drought broke Geoff’s pasture was comprised of 40 acres of lucerne and the balance in annuals.

Even when the drought started to ease, Geoff kept lot feeding his cows, in part because he “found it easier to manage and anyone could do it”, which helped his focus to “keep things basic and simple and low maintenance”. He began share farming and eventually sold his cows, converting to a cropping enterprise.

4.5.1.8. Harry (Narrative 8)

Throughout 10 years of drought, which started when allocations dropped below 100 per cent, Harry “relied heavily on his [470-ML] deep lead bore water to keep the farm

going”. Early on he “bought a lot of bore water” as it was “cheaper to buy and pump bore water than to buy wheel water”. As the drought continued “Harry invested \$200,000 in the installation of a shallow groundwater bore which included a licence to pump 100 ML of water”.

Harry changed the farm feeding system in response to the drought. Before the drought Harry’s farm was predominantly perennial pasture. Once drought hit, Harry began to oversow his perennial pasture with rye. He did this throughout the drought when means that “[c]urrently, the perennial pasture ‘has nearly all gone’”. As well, Harry started sowing lucerne during the drought. “[A]t least a third of the 188-acre block was under lucerne” still. Given the increased cost of feed during the drought, lucerne offered “another option for feed which didn’t take much water”. When this was still not enough to reduce feed pressure, Harry agisted more of his cows than usual. “He trucked the cows wherever they could get agistment.”

At around the same time the drought broke, Harry “decided that he was going to stop milking cows” as he had just turned 70. His son has since been managing the dairy business in a share farming arrangement. Since the drought, the pasture was still predominantly rye, though his son was commencing some redevelopment work through an on-farm irrigation efficiency grant scheme, including installation of pipes and risers. It was unclear what this meant for future pasture mix on the farm.

4.5.1.9. Isaac (Narrative 9)

Before the drought that started in the early 2000s, Isaac “never really had to worry about water”. There was always a bit of water from a block that they leased over a very long term that could be transferred to the dairy block. “That meant there was always enough.” However, in the drought the water was temporarily sold off of the leased block by the land owners each year, which dropped production of the leased block considerably and took away a source of water for the dairy block. Even so, early on in the drought Isaac had enough water to “pick a few of his best perennial pasture paddocks for watering through the season, while other farmers ran out”.

Isaac had a fairly large stock of hay and silage when accumulated before the drought. This provided the supplementary feed for the farm in the first year of the drought. However, supplies were depleted by the second year and the “home stocks of hay and

fodder were starting to matter”. In the second year Isaac “just cut everything back”, “didn’t fertilise, slash or oversow his pasture”, and “[t]he tractor stayed in the shed”. He relied on his annual pasture which he found to be “fairly good” in the drought: “they’d just come back and were all right”. Isaac bought a small amount of hay that he found to be poor quality and very expensive. He also installed feeders in the dairy, “so that he could start feeding some grain to the cows during milking”.

Isaac “was always ‘a little bit short of water’ over the drought years and tried to work out roughly how much water he would have for the year and ‘irrigate to suit’”. Isaac also focused on maximising the productivity of the pasture he did grow to “make it produce a little bit more” through fertiliser use, selecting the “right paddock” and right varieties. This differed from his pre-drought approach in which “it would just get plonked in beforehand and what grew, grew.’

“When water went down to about 30 per cent of his entitlement, Isaac wondered ‘how in the hell are we going to feed these cows?’” Managing a herd of 220 milking cows was “daunting” for Isaac. He reduced stock numbers by parking 80 cows out of the district and culling 30 cows, which brought his herd down to 110 cows in total that year. For the rest of the drought, Isaac had a more flexible approach to his herd size. The “amount of stock he carried changed, based on available water through his entitlement”. Overall, Isaac parked “three different lots of 40 to 50 cows” out of the district.

Since the drought broke Isaac had built up 12 months’ worth of fodder reserves again. Some of these reserves came out of 60 acres of lucerne he recently planted. He planted the lucerne because “the water requirements were much lower than for perennial pasture” and he wanted to “increase the amount of ‘good quality feed’ he was producing on farm”. While he had more water again, Isaac described his pasture management as “a little bit different” since the drought. He used soil testing to select paddocks for fertilising, “mainly because of the expense” of fertilising when it wasn’t needed. Since the drought, Isaac found that he was “a little bit short on numbers” in his herd, which he was “slowly trying to pick up again”, because of his decision to reduce his herd size as a drought response.

4.5.1.10. John (Narrative 10)

John had a 456-ML irrigation entitlement, though he “needed about 550 ML of water in an average year” for his pasture. This means sales water was important for John. John always “had had plenty of water” until Government altered the water rules, making water transferable and separated from the land which “emptied Lake Eildon in two years or something”. This led to “pretty tough times” where John had to park 50 cows as he couldn’t produce enough feed.

The drought worsened during several low allocation year from 2007 to 2009. John described learning “a whole new way of farming” because of the drought. He “learned not to rely so much on pasture-based feed and decided to purchase hay to feed the cows rather than watering”. It helped that John “didn’t have to change anything about the farm to start feeding out to the cows” as he “already had a feed pad”. John milked all of his cows during the drought, didn’t have to park any cows nor agist cows to manage feed constraints. John did buy and sell a small amount of temporary water.

After the drought, John oversowed his pasture back to a similar balance of summer and winter active pastures as he had pre-drought.

4.5.1.11. Keith (Narrative 11)

Drought began for Keith in 1997, when availability of sales water diminished. Keith was redeveloping his farm at the time and decided to use the drought as a motivator to redevelop faster, as he was taking pasture out of production anyway. “He focused on irrigating his smaller areas of fertile pasture and produced a lot more pasture than if he had tried to spread the water across more land.” Up until the early 2000s Keith was able to manage sufficiently with less water. The drought “reached a peak in 2002” and Keith had to park 40 to 50 cows for a season. From that point on, Keith had to work harder to manage the drought as he “got about 50 per cent of his irrigation entitlement on average”.

“Keith had a business strategy to keep his overheads down.” When the drought worsened in 2002, Keith “started drying off the new perennial pasture that he had established” with the redevelopment and “focused on growing enough pasture to graze once a day and then fed out hay and silage to the cows on the dry paddocks”. He fed out “as much hay, silage and grass as he could produce on the farm”. Keith tried to maintain

self-sufficiency with his feed production. He “produced all of his own wrapped silage”, which he started doing in 1997. Even so, Keith had to buy a small amount of hay during the drought. Keith also “started feeding pellets in the dairy” and bought a silo for storage of pellets.

In 2005 Keith decided to reduce his herd-size from 180 to around 130 cows. He developed a new seasonal herd pattern over the next few years in which he would start with 150 cows and then start culling when “the grass dried up” to where he was milking 120-130 cows. This enabled him to keep his supplementary feeding down to a minimum.

Keith started “picking the herd number up” again after the drought broke in 2009-2010. He was back up to 180 cows. Since the drought, Keith has focused on maintaining the farm. Farm income is being invested off-farm for other purposes. The amount of investment that is necessary for Keith to focus on increasing productivity, including building a new dairy, “is greater than the return he would get out of it”. As well, “he couldn’t milk more cows and still be self-sufficient with regard to his feed inputs”.

4.5.1.12. Lachlan (Narrative 12)

Lachlan needed ‘at least 250 to 300 ML’ a season to irrigate. He had an entitlement for 160 ML. Lachlan “regularly bought water on the temporary market to supplement his entitlement” prior to the drought and “never had a problem accessing water at a price he could afford”. Lachlan “started having difficulties however when his allocation was down to 50 per cent and water went up to \$100 per ML one year and \$500 per ML in the following year”. Early in the drought Lachlan used a salinity grant to install a shallow groundwater bore. It cost Lachlan \$10,000 and gave him access to 320 ML of saline groundwater. The water needed to be shandied for use on pasture so it was only useful when he had an equivalent amount of surface water. Surface water “was too expensive to buy” at some points of the drought.

Lachlan’s farm had 120 acres of lucerne and perennial pasture, as well as 40 acres of annual pasture. With the addition of bore water Lachlan was “able to maintain this proportion of pasture” early on in the drought. As drought progressed, over the subsequent years, Lachlan converted more and more of his perennial pasture to annuals, until there was no perennial pasture left. He did maintain his 16 acres of lucerne because

it offered “good summer pasture for less water”. Prior to the drought Lachlan regularly bought supplementary feed which he fed out to cow in paddocks and in the dairy. While “during the drought the amount of feed he had to buy increased considerably and the price he paid for it was much higher”, he didn’t really have to change his feeding practices. Lachlan regularly rotated his cows around his paddocks to feed out as it “meant that the cows were fertilising the paddocks along the way”.

Lachlan sold his cows in 2009. He was “sick of working and not making money” and “under a lot of stress”. However, he “made the decision to sell the cows with the idea that he may go back to farming again.” A couple of years later Lachlan “borrowed \$250,000 to buy 120 cows” to get back into dairy farming. At that time he “spent a couple of months cleaning up his pasture [and] sowed all of it, except for the lucerne, to annuals”. If he had “a few good years of rainfall” and were “guaranteed that water was going to be \$20/ML over the next 10 years or so, then he would sow perennial pasture” again.

4.5.1.13. Matt (Narrative 13)

Matt’s farm typically needed 40 per cent more water each year than his entitlement, relying on “sales” water for this extra water. Water rules were “absolutely turned upside down’ however, making sales water less readily available and altering how was could be used. Matt had a drainage diversion licence, but the drainage channel was “slowing down” in the late 1990s, at the same time that sales water was no longer available. Matt also had a shallow groundwater bore, though this “started to slow down as the dry conditions were maintained into the 2000s”.

As other options for water diminished, Matt bought temporary water. The most he paid was \$600/ML, “just to keep some green on the farm... as a mental health insurance policy”. While he bought some water, Matt couldn’t afford to buy all the water he needed. To reduce feed pressure he dropped the herd from 560 to 460 cows. Matt reduced the area of irrigated pasture that he maintained, with the area determined by the amount of water he had each season. Matt then fed more hay and grain to his herd. He “set a rotation which included some grazing time as well as some time in a dry [sacrificed] paddock” with hay.

Matt knew that “buying temporary water to maintain pasture was expensive” however “maintaining some pasture was important...as it meant that when drought ended they [were] ready to go, ‘off and running’”. Matt and his son started focusing on setting up the farm for the future, with the son managing the farm. When Matt’s son decided to leave suddenly this forced a change in plans and Matt sold the dairy farm.

4.5.1.14. Neil (Narrative 14)

While Neil had a 700 ML water entitlement, he typically “would easily use 1200 ML of water, because of the amount of perennial pasture he had”. However, “he would generally get 1400 ML with ‘sales’ water”, so never had a water scarcity problem. Neil also had access to 200 MLs of saline groundwater that needed shandyng when used for irrigation. The bores significantly dropped in production through the drought however.

Dry conditions began for Neil in around 1996 or 1997, when he had to buy 200 ML of temporary water for the first time as sales water declined. Within a couple of years Neil couldn’t afford to buy temporary water. However, when the water price dropped later in the drought, Neil did buy some water again and continued to buy water as he needed it.

Neil didn’t irrigate his outblock at all, transferring any water to his dairy block. He then “put in a crop, such as oats, and ‘hoped’ it would come to something” on the outblock. Other than using the farm’s irrigation allocation, Neil found that with the high cost of water “it was cheaper to buy feed in than to irrigate”. He then dried off most of pasture on the dairy block and sowed 60 acres of lucerne on sub-surface drip as a more water-use efficient feed. Neil fed his cows by setting up a rotation that included a couple of hours grazing and feeding out in a sacrifice paddock.

When the drought “really started to hit” Neil reduced the herd by 100 head to a total of 220 cows. However, this reduced the farm’s cash flow and “if you haven't got cash flow, you really can't do anything”. Neil found that this decision “may have ‘hindered’ things when the drought ended as Neil then had to start building his herd again with limited resources”.

Following the drought, Neil “continued to maintain an approach that reduced reliance on perennial pasture because changes to the water rules and allocations meant that he needed to ‘use water more efficiently’”. He used annuals that were oversowed with millet “to get a ‘double crop’ for grazing” and continued to maintain his lucerne. “While

before the drought the pasture mix was 80 per cent perennial and 20 per cent annual pasture, post drought the pasture mix was 65 per cent perennial pasture and 35 per cent annual and lucerne pasture.”

4.5.1.15. Owen (Narrative 15)

Owen generally used all of the water he was allocated each year, which was 200 per cent of his entitlement, including sales water. In the 1990s sales water declined and water rule changes enabled water rights to be amalgamated. So Owen had less water but he could “use the water wherever he needed it most”.

Drought started in 2001 for Owen, when irrigation allocations dropped below 100 per cent. To manage this he focused on watering the dairy block and “bought temporary water for the dairy farm, at times for ‘ridiculous prices’”. Owen did this because he “thought of it as a ‘one in a 100 year drought’ and focused on doing whatever it took to get through it”. Owen also “‘spent an awful lot of money’ buying fodder that first year, thinking they could ‘afford to do that for one year’”. Owen spent \$100,000 of his personal savings in the first drought season.

Once Owen realised that the drought was longer-term he changed his approach. Over the next few years he “minimised all expenses” and “cut back his cow numbers by culling heavily”. While Owen’s son was paid a wage, Owen made nothing over that period of time. However, having no farm debts going into the drought meant things were not as bad as they could have been. Owen “‘didn’t do a lot of the things that other farmers did’ [during the drought] because he ‘was over it’ and seriously thinking about getting out of dairy farming”. For example, he “didn’t change any of his pasture to annuals and he didn’t buy a mixer wagon: ‘the expense just didn’t warrant it’”.

Several years of the same pattern “started to get a bit much” and Owen offered the business to his son. Owen’s son decided to leave the farm instead, leaving Owen as the single source for the farm. The drought continued and “[i]t was just a nightmare really” as Owen tried to manage a 30 to 40 per cent allocation. Owen decided to dry off all of his pasture and feed out grain, wheat and hay to the herd in dry paddocks. Owen and his wife “just bumbled through for probably a couple of years” and then decided to convert the farm to beef. Beef was a lower input enterprise that enabled Owen to wind back on his workload as he neared retirement.

4.5.1.16. Paul (Narrative 16)

In the 1990s Paul needed significantly more water than his irrigation entitlement to the crops and pasture. It only became a problem in 1997, “when water rules changed”. Prior to 1997, “you could have as much water as you like, as long as you paid your water bill”. With the rule changes Paul “started having to buy temporary water regularly to ensure they had enough”. By the early 2000s, Paul typically needed three times his water entitlement of 1050 ML, which meant Paul regularly purchased over 2100 ML a year.

In 2002, Paul didn’t get his full entitlement for the first time and described it as “‘a real shock’ because they had ‘treated water as if it was always going to be there’”. He couldn’t afford to buy the extra water he needed and described how his “world came crashing down from the point of view of water availability, and a combination of low milk price and high feed price”. Paul “didn’t want to change the structure of the business” and decided to “wear the costs” of the drought. He was certain that it “would be short-lived and he wanted to be in a position where he could ‘rebound from the drought’”. He “converted a lot of his perennial pasture to annual pasture, which required a lot less water” and overall “lost \$500,000 in that year”. Over the next three years Paul rebounded well, making back the \$500,000 loss over those three years. He “had also converted ‘pretty near 100 per cent’ of his dairy block back to perennial pasture, because he ‘didn’t think another drought would happen’”.

When drought returned in 2006 Paul “didn’t muck around” and “shifted quickly back into annuals” based on his experience in 2002. He fed cows on the feed pad with purchased feed. Paul had a lot of alternative sources of feed. He used “bi-product feeds” (e.g. waste lollies, brewers grain) and “grain cleanings from around bunkers” which all “helped enormously”. Additionally, to reduce the feed pressure on his farm Paul agisted heifers to Tasmania. He was also able to sell some temporary water for a good price.

Over that three year period of drought, from 2006-2008, Paul “just” made a profit. “Paul thought that they could have kept going as it was. They were able to manage the drought a lot better than others were because they could change how they fed the cows.” However, Paul new that “the farm needed a huge new investment in infrastructure and enthusiasm” which he and his wife were not prepared to give. He shifted the business to cropping.

4.5.2. Drought as a critical juncture

Drought was a critical juncture for all 16 producers, which means the current farm production system was not able to absorb the variability in water access, putting farm stability at risk. When looking across these farm experiences, what became apparent was that there were differences among producers regarding when drought became an issue. It is when drought became an issue and required a farm response that a critical juncture was triggered. Some producers described drought beginning with the decline of sales water in around 1997 (Narratives 7, 11 and 14). Some described drought impacting on them in the early 2000s (Narratives 15 and 16). Others described problems from drought beginning in the mid-2000s (Narratives 6 and 12) and one producer described drought impacts in 2009 (Narrative 5). Differences here related to a couple of factors: the different sources of drought and the farm's capacity to absorb variable access to irrigation water.

First of all, there were different changes in circumstances that influenced irrigation allocations from the mid-1990s to the time of the interviews, which reflected compounding and serial constraints that were all described as drought. The management of the Murray-Darling Basin (MDB), where irrigation water was sourced by these producers, changed starting in 1990. Changes to MDB management were necessary because of over-utilisation of resources and declining health of ecological systems (Wei et al., 2011). Matt's narrative describes the changes:

Government rules relating to water changed as drought conditions commenced. This "made life more stressful". Overall, with the changes in water management, "things have absolutely turned upside down". Matt thought some of it wasn't good and had concerns over "water leaving the district". However, he also thought that it offered irrigators "versatility" which wasn't bad. (Narrative 13)

The decline in availability of sales water and changes in water rules (e.g. the capacity to amalgamate water entitlements) described by interviewees were results of policy change associated with MDB management. This generated an "agricultural drought" in which reduced allocations were available to producers (Wei et al., 2011, p. 907). Producers describing drought impacts starting in 1997 were describing consequences associated with agricultural drought and changing policy.

As new MDB policies were being implemented, “meteorological drought” commenced, indicating rainfall was within the lowest 10 per cent of long-term precipitation records, and maintained a persistent presence for a decade (Wei et al., 2011, p. 907). In the context of irrigated agriculture, meteorological drought is manifested very clearly into changes in irrigation allocations. This was reflected in narratives that identified drought-derived problems originating in the 2000s. Importantly, some of these producers also highlighted an earlier influence of changing water rules on their business. Within the meteorological drought, there were differences between years regarding irrigation allocations (see Figure 4.6). This difference across the drought years was reflected in the narratives. For example, Paul (Narrative 16) described distinct drought events in 2002 and again from 2006 – 2008. Overall, drought emerged for these producers out of different sources (agricultural and meteorological drought) which compounded and progressed serially through the 2000s.

Differences among producers regarding the advent of drought were also reflective of the capacity of producers to buffer against shortfalls of surface water allocations, within their existing water management. Having other sources of water (e.g. shallow and deep lead groundwater, drainage diversions and large storage dams) was one way producers buffered against, or absorbed, shortfalls. Overall, producers whose typical requirements were for significantly more water than their entitlements, and who had limited alternative sources of water, were more exposed to variable water supply.

This difference can be seen clearly by comparing Paul and Edward’s experience with drought. Paul relied entirely on surface water and typically needed to find over 2100 ML of extra water each season; an amount that was twice the size of his irrigation entitlement. Paul was first impacted by drought in 2002, losing \$500,000 in the single season. In contrast, Edward had entitlements for an equal amount of ground and surface water (400 ML each). Additionally, fairly early in the drought he adapted his farm to increase his access to ground water by buying another small block with groundwater. Edward found that the drought started generating negative consequences for his business in 2009, when groundwater declined. This means the impact for Edward was relatively short lived, when compared to Paul who had to manage drought off and on from 2002 onward.

4.5.3. Responses to drought: learning and persistence

When considering the range of experiences, a significant finding in drought responses was that there was evidence of learning, as producers managed back-to-back years of drought. In Chapter Two it was highlighted that learning is a constraining factor on decision-making, with a distinction drawn between single and double-loop learning (Argyris, 1976) (see section 2.4.4.4). Given the relevance of learning to understanding constraints on decisions, it is useful to touch on evidence of learning in the narratives.

The dominant learning practice, single-loop learning, implies lower-order change that is in alignment with the hierarchy of principles, goals and higher-order plans of the business. In terms of path dependence, single-loop learning is likely to imply the maintenance of the existing path through the reinforcement of previous decisions. In contrast, double-loop learning implies deeper thinking that entails consideration of errors at a higher level than single-loop learning. Double-loop learning can lead to change to higher order plans and goals, suggesting an alteration to the path.

Across the farm narratives there was evidence of double-loop learning in relation to managing drought, in which producers were forced to think beyond their typical approaches to farm management. John “learned ‘a whole new way of farming’ because of the drought. They learned not to rely so much on pasture-based feed” (Narrative 10). Edward describes “a learning curve” associated with having to manage the farm when his groundwater ran out (Narrative 5). Based on learning from his “2002 experience, Paul ‘didn’t muck around’ and shifted quickly back into annuals” (Narrative 16). Geoff described explicitly that the drought altered how he thought about his farming practices.

While the drought was bad, it was good for Geoff in that it made him think about how he was farming. He tried things he wouldn’t have considered 10 years ago, such as growing lucerne and wheat for hay.
(Narrative 7)

In all of these examples, the producer shifted thinking to consider change further up the hierarchy of plans associated with the farm. From an image theory perspective, this implies higher order plan or goal changes.

The distinction between single and double-loop learning could be seen most clearly within two narratives, Albert (Narrative 1) and Owen (Narrative 15), which reflect very clearly a shift from single-loop to double-loop learning. In these narratives, the

producers describe their drought response in two steps. Albert described an initial response based on thinking “it would last a year or two”, which led to significant debt (Narrative 1). He built a feed pad and bought in feed for his cows. Owen thought that it was a “one in a 100 year drought” and “spent an awful lot of money” buying feed to get through the single year (Narrative 15).

Both of these producers identified a realisation that this approach was not working and decided to change tack, which entailed contemplation of higher-order plans. When Albert realised the drought was going to continue he decided that he “had to get a lot smarter if he was going to maintain his business” (Narrative 1). He then changed his pasture system from perennials to annuals and established a new feeding pattern. When Owen realised that the drought was going to continue he changed from simply buying in significant amounts of feed to “minimis[ing] all expenses” and “cut[ting] back his cow numbers by culling heavily” (Narrative 15). He maintained this approach for several years.

When changes are made to the farm as a result of double-loop learning this implies alteration to the farm path. Isaac’s narrative describes this well:

Looking back, Isaac thinks that he “would probably be milking 300 cows if the drought hadn't come along and changed the way” he looks at things. He imagines that he would have bought some more land and his son or someone else would be working for him. The drought came along and he went a different direction than that. Whether he had “gone the right way or the wrong way, who knows and who can tell”. There are a lot of those whom Isaac classifies as “good farmers” “that are gone” or “getting out” of farming now. Isaac does know that he “actually got through the drought reasonably well” with the path he chose. (Narrative 9)

I found that several of the narratives reflected a degree of persistence associated with the changes producers made in response to drought. For example, a number of the producers were maintaining more annual pasture and crops than they did prior to the drought (see Narrative 1, 2, 3, 4, 5, 6, 14). Frank described how he “has seen that he can make a similar amount of milk from an annuals-based feeding system” (Narrative 6). As well, since the drought Neil “continued to maintain an approach that reduced reliance on perennial pasture because changes to the water rules and allocations meant that he needed to ‘use water more efficiently’” (Narrative 14). Albert described an aim “to have

a bit of flexibility in his feeding system” (Narrative 1) which was echoed by Dennis, whose farm is “more flexible now”, which means that he can alter pasture as needed “depending on water availability” (Narrative 4). The persistence of some of the management practices following the drought suggests the existence of an altered path that has been reinforced by learning and experience over the decade of drought; hence it supports the notion of path dependence in farms. That is, double loop learning has provoked a modification to the path which is now persisting while ever it appears to be adequate (which is reinforced by single loop learning).

4.6. Conclusion

This chapter reflects my research process for analysing constraints on farms. First, I applied an approach for characterising constraints on farms by identifying intersections between constructs of constraints (adaptation, image and function changes). I then established the existence of linkages between critical junctures and these constructs, described as reinforcing decisions. This included consideration of the dynamic and cumulative impact of constraints defined within farm control theory, image theory and the value chain, described in terms of path dependence. Through this process I applied the constructs that emerged to some practical issues that were apparent in the narratives, including exiting dairy production, infertility and drought. Of interest now is reflection on how useful this approach has been for characterising constraints and deriving meaningful insights regarding farm adaptation to increased variability. This is the focus of the next chapter.

5 Implications and conclusions

5.1. Path dependence on dairy farms

It is expected that increased variability associated with climate change will require producers to make changes to their farms (Anwar et al., 2013; Ash et al., 2008; Howden et al., 2010; Nelson, R. et al., 2010; Nelson, R. et al., 2010). However, producers are likely to be constrained in the choices for change available to them. Revealing the nature of such constraints will help understand the implications of the impacts of increased variability for producers and policy.

My purpose in this research was to capture the extent and nature of constraints to farm choices that arose from the accumulation and interaction of sequences of decisions made by farm managers; this amounted to analysing the flexibility of a farm to respond to its environment. Hence, this thesis reflected a study of the potential for dynamic efficiency. It was clear that tracking the history of decisions to observe the determinants of choices and contributions to flexibility would require identification of, and analysis of interactions among, all salient constraints to decisions, including extant paths. The conceptual framework chosen to do this was an integration of ideas drawn from three domains of theory. The first, developed from general systems theory, was a model to categorise absorptive and adaptation decisions on farms as tactical or strategic - called 'farm control theory' for the purpose of this study (Cowan, L. et al., 2013; Kaine &

Cowan, 2011). The second, a set of constructs from value chain analysis (Porter, 1985) to categorise generally, and form into a hierarchy, all business decisions. The third encompassed all personal preferences the decision maker(s) bring to management of their farm, captured using the constructs of Image Theory (Beach & Connolly, 2005). This mix of theories was useful in enabling the identification of a comprehensive set of constraints in farms.

Path dependence worked very effectively, it seemed, 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 (farm control, value chain, and image) and the existing path. My analysis focused on meaningfully grouping and mapping the multiple sources of influence on decisions. Capturing hierarchy among these interacting sources was essential to proper interpretation of their contribution to constraints on decisions and to plausible and comprehensive explanation of choices.

The approach involved the identification of constraints in the overall farm management context that were well beyond those considered in aggregate analysis (for example, see Berger & Troost, 2013; Hertzler et al., 2013). The rich diversity in constraints on decisions revealed across farms is quite unsurprising and suggests there is no reliable basis for aggregate modelling of decision making in response to climate change or other sources of secular change. Some insights probably arise for segmentation analysis with respect to more specific issues, such as adoption research (such as Kaine, 2008). The results do, however, enable contemplation of aggregate implications of the force of constraints acting over decision making with respect 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 surrounding response capability and timeliness.

That is, without generalising from particular constraints or sources of them, this study indicates that path dependence is real (which is hardly surprising), can be very constraining and can tip the farm into a suddenly vulnerable state. This was apparent in the experiences of lock-in that were identifiable within several farm narratives. An example of how quickly circumstances can change can be seen in Matt's decision to sell the dairy farm (Narrative 13). Matt had been investing in dairy upgrades and purchasing

new land to enable his son to take over the business, which was associated with taking on farm debt. When Matt's son decided to leave the farm, Matt had to sell the dairy enterprise because of farm debt and the increased workload. As well, within a week of returning from an overseas trip in 2006, Frank (Narrative 6) sold 110 head of stock because of the immediate impacts of drought on his capacity to feed his cows. A singular example of protracted lock-in was Owen's (Narrative 15) experience, in which he spent 15 years waiting for a neighbour to sell him a block of land, as redevelopment of Owen's land was impossible without expansion. By the time the land was available for purchase, Owen was no longer able to afford the land, due to years of declining profit and the advent of drought.

The identified path dependence was exacerbated by the persistent imperative for productivity increases in farms. At times, the associated expansion and intensification left producers confronting circumstances where they had limited options. An example of this was Paul's (Narrative 16) experience associated with his large and relatively intensive farm. When the drought began affecting Paul's business he found that his options for managing drought were more limited than other producers because of his large herd. He ruled out some of the practices that other producers had adopted to reduce feed pressure; namely, parking, selling and agisting stock. This was because he believed that these practices could result in serious socialising issues when reintroducing cows to his home herd; a consequence of having a large herd that was managed relatively intensively. As the drought continued, Paul realised that, if he wanted to maintain a profitable business, he needed to inject a significant amount of investment to continue in dairy. He didn't want to do this and left dairy for cropping. This was clearly linked to the trade-off that producers often have to make between increasing output at the expense of flexibility.

Importantly, constraints were identified as coming from different sources. This can be seen most clearly in the critical junctures that emerged associated with: opportunities or threats in the farm, changes in market prices, policy changes, family and personal changes as well as drought and flood. The differences in constraints led to diversity among farms in paths and path options.

In many ways the dairy businesses could appear homogeneous. Broadly, the dairy production systems were similar, comprising feed production and distribution, milk

extraction, as well as herd and lactation management. Given the centrality of the production system to the achievement of business purpose, one could easily infer considerable homogeneity across the farm businesses. However, this would conflict with the substantial diversity in farms that was found to stem from the producer and family.

I found producers' objectives and perceptions, described in terms of principles, and personal and higher-order business goals, were key determinants of choices made in relation to the farm. This was consistent with the findings of Kaine (2008), for example, relating to the adoption of innovations in farms. These objectives and perceptions were also sources of constraints within the business that created and locked in different paths associated with higher-order images. This could be seen clearly in several narratives in relation to principles associated with intergenerational issues (such as Matt's decisions to invest in upgrading the farm for his son, ultimately leading to him having to sell the dairy property [Narrative 13]). Farm finances were also strongly linked to personal and family objectives, reflected in investment decisions (for example, when Colin [Narrative 3] was under pressure to limit farm investment when he was paying his children's university fees).

The diversity of paths stemming from diverse family and personal circumstances means that there is also diversity in path dependence across farms. Characterising the diversity of constraints on farms requires consideration of the trajectory image, as the source of both personal and farm business goals.

The diversity of farm paths and path dependence is even more complex than can be understood through static contemplation of multiple sources of constraints. This is due to the third principal insight from the research: the cumulative effect of compounding constraints. My analysis revealed the dire consequences that emerged for producers 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 producers 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 (1998) and O’Meagher, du Pisani, and White (1998) who highlighted the importance of considering cumulative effects from multiple interacting sources of variability in the development of Australian drought policy.

5.2. What does increased climate variability mean for producers?

Much of the climate adaptation literature focuses on adaptation options rather than consideration of explicit triggers for change (for example, see Webb et al., 2013). This is because the trigger is generally assumed to be some manifestation of increased climate variability. While this is understandable in research to identify response options to increased climate variability, such an approach may lead researchers to miss other sources of constraints that may contribute to a trigger for change. In my analysis I considered increased variability in relation to other sources of constraints, which enabled a broader conceptualisation of triggers for change.

In isolation, the potential impact of increased climate variability is concerning, as it points to the possibility of farms becoming unviable in the face of significant shocks associated with it. Crucially, however, threats associated with climate variability do not impact farms in isolation. Threats can come from multiple sources in a given timeframe. For example, Paul described how the “world came crashing down from the point of view of water availability, and a combination of low milk price and high feed price” in 2002 (Narrative 16). Threats can also be sequential. This was seen clearly in the drought experiences of producers in which back-to-back years of drought generated critical junctures for all 16 producers³⁴.

To understand the impact of increased variability on the farm business it is useful to revisit farm control theory, which described the fundamental capacity of farms to manage variability. Farm stability, described in terms of the steady state, relies on the ability to absorb variability. Absorbing variability relies on the capacity, within the existing farm business strategy and repertoire of tactics, to adequately match the variability that is impacting the farm. This capacity is the farm’s flexibility (Cowan, L. et al., 2013). It is composed of the ability to modify output within the existing business

³⁴ This example is even more striking when considered in light of the knowledge that these producers reflect those who ‘survived’ the drought, as opposed to those who adjusted out of agriculture (for example, see HMC Property Group, 2010).

strategy (and its attendant farm production system) and to modify input acquisition or management, given current output intentions.

There are trade-offs associated with flexibility; the path dependence literature describes them in terms of a loss in technical efficiency (Greener, 2002; Liebowitz & Margolis, 1995; Ruttan, 1997). Flexibility and technical efficiency are both tied to specialisation in production, the former negatively and the latter positively.

There are also costs associated with *exercising* flexibility to absorb variability. This could be seen in responses to drought described in the narratives, where producers either incurred marginal resource cost increases to adopt tactical alternatives to their diminished irrigation water (e.g. buying temporary water, buying extra feed) or costs associated with strategic modifications to output (e.g. reducing stock numbers). Through their impact on financial and other reserves, the costs associated with modifying activity to absorb variability can reduce the capacity of the farm to absorb subsequent variability. For example, Isaac (Narrative 9) was able to manage in the first year of the drought because he had substantial feed reserves though, as drought continued, these reserves diminished and Isaac had to adapt his farm in response. Isaac's subsequent changes included adaptations to his production system such as installing cup removers and bail feeders in the dairy and laying-off his employee.

When absorption appears inadequate in the face of variability this indicates that the farm business is at financial risk and that adaptation is required. Put another way, adaptation is indicative of a perception by the producer of a failure of flexibility to provide sufficient absorption. Adaptation is a description of changes made to the farm production system structure to preserve performance (Cowan, L. et al., 2013). Hence, adaptation is made to return the farm to a steady state, in which it is again possible to rely on absorption to preserve farm performance. This could be seen in the responses to drought, such as when producers altered their feed production to annual pasture and cropping and changed their approaches to feeding the herd.

Adaptation implies costs associated with the change process together with constraints that the adaptation imposes on subsequent decision options for the farm. While adaptation may increase the capacity to absorb the current variable input, these costs inevitably reduce reserves. For example, Albert's (Narrative 1) decision to build a feed pad and buy

supplementary feed early in the drought put pressure on financial reserves as Albert “realised that he couldn’t keep borrowing and just feeding out”. This removed an option to purchase supplementary feed for his stock in response to a low irrigation allocation in subsequent years. Instead, Albert had to shift his feeding system from perennial to annual pasture. Central to this response was the judgement by Albert that there was a chance that low irrigation allocations would recur over a relevant time frame (implying secular change).

Beyond these costs, adaptations that increase the absorptive capacity of the farm in relation to one source of variability may have a constraining influence on the capacity to manage other sources of variability. This could be seen in Neil’s decision to install sub-surface drip irrigation to grow lucerne as a response to drought. The adoption of sub-surface drip irrigation removed some options available to Neil for that block of land, unless he decided to dis-adopt the sub-surface drip. This could include the consequent inability to plant crops that he believed would require deep ripping of the soil and, depending on the depth of the sub-surface system, some shallower-rooted pastures.

Another example of the potential to increase absorption of one source of variability at the expense of another is in relation to herd management. Several producers (Narrative 1, 2, 4, 9, 10, 11) adopted cow parking as a drought response. However, for two of these producers (Narrative 1 and 2) cow parking led to the transfer of diseases and viruses back into their herd. This entailed costs associated with treatment and loss of production. As well, Matt (Narrative 13), as a receiver of parked cows, ended up having to manage an outbreak of anthrax in his herd that stemmed from bringing cows onto his property.

The climate change literature suggests that increased climatic variability is highly likely (Anwar et al., 2013). This will require producers to activate tactical and strategic flexibility more often to maintain the capacity adequately to absorb the increased variability. More responses will be required per unit of time and this implies that costs associated with deploying responses will increase per unit of time, possibly reducing the capacity to continue using them. As a result, for example, managing the increased incidence of drought, producers are likely to require larger feed reserves and larger financial reserves (for supplementary feed). Through exercising the farm’s flexibility,

further flexibility can be materially diminished when there is not sufficient recovery time to enable replenishment of resources or reserves used to deploy flexibility.

This will lead producers to adapt their farms, though reduced resources associated with exercising existing flexibility, which will normally precede the decision to adapt, will also diminish adaptation options. For example, Owen's (Narrative 15) tactical response to purchase supplementary feed early in the drought meant that he was unable to afford to purchase a block of land that he had been waiting 15 years to buy. Purchasing this block could have increased his flexibility in response to drought by increasing his farm's feed production. Moreover, the costs associated with adaptation may also reduce some farm flexibility by consuming financial reserves. Overall, this implies that, at best, with secular change in the task environment path dependence will not decrease and may actually increase in farms as options diminish regarding both absorption and adaptation responses by producers.

The practical manifestation of this can be seen in issues associated with farm debt described by Martin (2013). Martin (2013) argued that producers use farm equity as a "reserve capacity to borrow to meet cashflow needs during periods of reduced farm income" (p. 122). However, negative consequences for profit associated with increased variability can reduce equity and the capacity to service debts, increasing farm financial risk (Martin, 2013).

For the producer, a consequence of these changed business conditions could be increased psychological stress, from having to adapt to more intensive or greater frequency of change over time (perhaps never being able to return to a steady state for a bit of respite) (for example, see Polain, Berry, & Hoskin, 2011). This in turn could exacerbate pressures within the family, which could interfere with effective decision making processes in the future. This aligns with what Janis (1992) describes as egocentric constraints. If this occurs, one could anticipate that path dependence would be completely dysfunctional approximating a state of learned helplessness and feeling of total loss of control over circumstance. Producer and community welfare issues would likely arise in such circumstances associated with poor outcomes such as mental health issues, divorce, children leaving the family farm and increased incidence of suicide.

The multiple sources of constraints on farms generate differences in paths and path dependence, implying diversity in farms. Much of the diversity among farms stems from the producer and family as drivers of constraints on decisions. This is because farms are micro businesses, in which the farm and family are tightly coupled. For example, I found that farm labour and finance decisions were closely tied to family goals. Clearly, it is essential not to underestimate the importance of producer objectives for the farm, as well as personal and family goals, as sources of constraint which are played out in the trajectory image of the producer. The tight coupling between the farm and family implies that there are likely to be significant consequences for farm families if increased variability increases pressure on farms and that this may well have unhelpful second-round effects by way of reducing management decision options and intensifying path dependence. Within climate adaptation literature family and personal objectives are often ignored as sources of constraint or dismissed as being outside the bounds of research (for example, see Anwar et al., 2013). The rich diversity would normally render inclusion very difficult, if not impossible, in quantitative analysis but the findings here suggest that ignoring the farm-family coupling may be a very problematic response to that problem.

The long-term viability of a farm business is reliant on the producer's capacity to increase productivity, through expansion and efficiency, as a matter of course. This is essentially due to the near-perfectly competitive industry context. The influence of the productivity imperative could be seen in this research; for example, as a source of critical junctures. Maximising efficiency implies increased path dependence, as the current path's capacity to cope with variety decreases. As the climate becomes more variable it is expected that farms will need to be altered in ways that enable absorption of the increased variability: farms will need to be more flexible. This was seen in responses to the drought. A number of producers altered their farms (from perennial to annual pasture) to reduce reliance on irrigation water and maintained this new configuration because of an expectation of continuing water availability problems into the future. This occurred even though some producers acknowledged that (their prior) perennial pasture-based system was the most (technically) efficient way to feed cows. Producers generally have to make decisions to trade off short-term profit maximisation with flexibility. However, climate change may shift this trade-off to further emphasise flexibility at the cost of short-term profitability.

5.2.1. Irreducible uncertainty

Unfortunately, there is a great deal of uncertainty associated with climate change impacts and how to respond. This could be seen in some of the responses to drought, when producers initially responded to a ten-year problem as though it was going to be a one- to two-year problem. Uncertainty instils doubt in decision-making and can negatively influence the quality of the decision (Beach & Mitchell, 1987). This aligns with Risbey et al. (1999) who found that an assumption of perfect information “systematically overpredicts adaptive performance” in farms (p. 137).

The consequences of change decisions may not always be known, even by the producer, due to the emergent properties associated with the complex interrelationships among farm components. For example, when Matt installed a large dam on his farm, this led to a series of critical junctures because of incompatibilities between the new dam and existing irrigation system. The likelihood of unexpected outcomes increases when producers face unfamiliar circumstances that are shrouded in uncertainty. This is because the producer is trying to project whether the current farm configuration will achieve future objectives but is doing so with insufficient clarity regarding future states of the environment and how this will interact with the farm. In such circumstances the producer’s hindsight may be the only way to know if an error was made. This is likely to be the case with decisions made to cope with changing variability.

The complexity of constrained farms and the inherent uncertainty about variability associated with climate change lead to an intractable problem for producers in forecasting and making ‘correct’ decisions in farms. Superficially, a useful response would be to increase farm flexibility, thereby sacrificing some efficiency. Without specific information about the anticipated changes (including sources, timing, extent and interactions of changes) it is not possible for producers to prepare in any other way. However, little is known regarding what flexibility to increase and the degree to which it needs to be increased. In reality, the correctness, or not, of decisions about farms is likely to only be knowable in hindsight.

In this current context many producers are unlikely to undertake significant and costly change programs on their farms in anticipation of task environment changes. It is possible that, by the time they identify the need for significant change and what that

change should look like, they may not have the time or resources necessary to respond. This suggests that, ultimately, more farm businesses will fail. While this may describe, to some degree, the context of triggers for radical change, described in terms of transformational change in the climate adaptation literature (Howden et al., 2010), it offers a quite detailed and comprehensive picture of the actual trajectories of farms that lead to system failure or, perhaps, transformation. Since the wherewithal to undertake transformational change is likely to be uncommon as the need for it is discovered, it also implies that, where transformational change occurs, this will more likely be the result of new farm businesses than a process of current family farms significantly altering their businesses through time. Hence, transformational change has little meaning for understanding change in existing family farms; rather, it is more relevant at a regional or industry level. "Creative destruction" may be a more accurate description of the process. From a policy perspective, this suggests that Government must balance investing in research that enhances farm flexibility in current farms against research into industry and regional transformation options.

Nowhere is there evidence of, or a suggestion that, offsetting changes to climate change are occurring in farm task environments. Offsetting changes could be, for example, trending increases in prices, trending decreases in input costs or significant changes in the effectiveness of climate change mitigation. As well, evidence suggests that the current adaptation options available can only partly ameliorate the impacts of climate change on farms (for example, see Quiggin, 2007). The question arises as to what this may imply for public policy.

5.3. What does increased variability mean for policy?

The discussion above indicates quite clearly that the management environment for Victorian dairy producers is going to deteriorate materially as a result of climate change. Suggestions that current climatic experiences in Australia are surpassing modelled expectations for 2030 (Milman, 2014) emphasise the uncertainty as to the rate at which this may occur. Overall, the findings in this research suggest that path dependence is not going to lessen. This may be the case for large and small farms alike. The largest dairy producer participating in this research intensified his operations to such a degree that constraints limited his capacity to manage drought and encouraged a conversion to cropping. This calls into question any assumption of the undoubted intrinsic merit of

growth in farms, per se. It demonstrates the importance of increasing flexibility to cope with increasing variability.

In the already-constrained context of farms it can be expected that increased variability in the task environment will be as difficult, or more difficult, to absorb, and that adaptation options will be limited. Given this, short-term variability is unlikely to be better managed and will result in poorer outcomes for producers. This brings to light a question regarding the appropriateness of risk management approaches to climate variability policy, such as that employed by government in the development of Australia's drought response (O'Meagher et al., 1998; Stone, 2014; Thompson & Powell, 1998). This is because such approaches are grounded in an expectation that producers should be able to tolerate the costs of variability. The ambiguity associated with changing distributions of climate variability can imply fundamental unmanageability, as was argued to be the case for financial organisations during the Global Financial Crisis (DeBelle, 2010). This has implications for the rationale for government policy as well as policy design and implementation.

A fundamental point regarding any consideration of policy responses is the need for recognition that adaptation is local. Localness is with reference to the sources of constraints, meaning that the producer's context matters. Localness is also with reference to time, as the relevance of an adaptation option will differ for a producer at different times. While there is some recognition of a need for localised approaches to policy support, how "local" has been defined generally has not included acknowledgement of farm-specific constraints. Instead localness is often framed in geographic terms, which implies homogeneity across farm contexts due to industry, community, or biophysical commonalities in context (for example, see Askew & Sherval, 2012; O'Meagher et al., 1998; Stone, 2014). Such conceptions of localness discount the potential for individual farm and family contexts to play a role in appropriate adaptation responses.

The identification of multiple and compounding sources of constraints in farms suggests that Government's capacity to identify when a particular farm business is struggling may be difficult due to the diversity of paths and path dependence. Critical to understanding the constrained state of farms is consideration of the dynamic relationship across the multiple sources of constraints. For example, where policy is designed based on shared production system characteristics, insensitivity to other

sources of constraints will mean that understanding of constraints will necessarily be incomplete. Ignoring constraints, including their cumulative effect, may lead to unexpected outcomes that lead farms to be worse off than expected. This can have negative consequences for rural communities and industries.

A simple example of this can be seen in relation to the introduction of channel automation in northern Victoria (Cowan, L., Murdoch, Linehan, & Kaine, 2005; Cowan, L., Murdoch, Linehan, & Kaine, 2006). A compulsory change to the public irrigation infrastructure, including farm outlets, was undertaken at the same time as a separate policy was implemented to reduce channel heights in some channels to reduce leakages. Irrigators then had to manage two policy changes that influenced their capacity to irrigate and some irrigators were faced with being left with land that they could no longer irrigate. Distinguishing the cause of this outcome (channel height versus the new infrastructure) was challenging. Trust in the newly introduced technology and water authority in charge of the program was low as a result of the circumstances.

In this research, producers described policy change that altered their access to irrigation water in the mid-1990s, which clearly constrained producer capacity to manage the meteorological drought that began shortly afterwards. Given that producers will already face increased pressure, the unintended consequences of policy may be serious. When policy is being altered, consideration needs to be directed toward assessing unintended constraining impacts on farms.

The diversity in paths and path dependence identified within farms implies that the appropriateness of policies designed to assist producers as climate change evolves may vary, via constraints on adaptation in paths, as family and personal circumstances vary. The generalisability across farms of production systems and related economics can be of limited value in assessing the capacity of producers to respond to shifting variability in the task environment. The heterogeneity of farms implies that policies will vary in effectiveness, efficiency and horizontal equity.

Thompson and Powell (1998) suggest a similar idea when arguing that policy which does not consider the “diversity of farming systems and risk profiles” is not likely to “lead to equitable or efficient definitions of eligibility” for support (p. 486). As well,

this thinking aligns with the findings of Askew and Sherval (2012) who found problems, including “widespread inconsistency, abuse and normalisations”, associated with exceptional circumstances funding for drought (p. 291).

Generally, Government can address increased variability in farms either by helping producers manage the consequences of the impacts of variability and/or by supporting the development of farm responses to prepare for increased variability. Options for appropriate policy responses in the context of my findings are offered next.

5.3.1. Helping producers cope with the consequences of impacts

In the past, Government has supported producers in times of hardship, such as exceptional circumstance funding in times of drought or flood (O'Meagher et al., 1998; Stone, 2014; Thompson & Powell, 1998). To whatever extent that Government wishes to continue to support agricultural industries by supporting individual producers, change may be needed regarding this support. Importantly, the vulnerability of producers to the increased risks associated with short-term variability logically implies greater stress on the need for larger buffers to manage variable performance. It is anticipated that producers will need to maintain larger financial reserves in a more variable climate to enable them to cope with the increased frequency of, and longer sequences of, periods of low profitability. Policy makers need be mindful of the altered demands likely to be placed on farm financial reserves when developing welfare and other farm support policies.

The increased level of risk that producers will face with increased variability implies that more farms will fail. Government may wish to consider whether there is a need to alter agricultural adjustment policies to make it easier for producers to exit the industry and to do so in a timely fashion.

5.3.2. Helping producers prepare for increased variability

'Farm adaptation' is defined in this study explicitly to mean the changes made to the structure of the farm production system to return the farm to a state in which variability can be absorbed (i.e. steady state); hence, adaptation is defined specifically here as a response to variability. The capacity to manage increased variability relies on the producer's ability to adapt the farm so that the new configuration is able to absorb

greater variability. Given the diversity in farms, this implies the need for a wide range of technologies that can be applied in different farm contexts. The development of new technologies that increase flexibility is clearly central to this capacity. The importance of investing in new technologies is neither a new concept nor specific to climate change. However, my findings may add some urgency to this avenue of public investment.

Understanding constraints on farms is critical for any government programs, such as those focused on technology development, to support producer responses to increased variability. Given the heterogeneity of constraints across farms, this implies a need to understand the relevant contexts of farms to a high degree of specificity. Ways of analysing the relationship between farm context and technologies are well established (for example, see Kaine & Bewsell, 2008). However, identifying the constrained state of farms and relevant policy responses is not addressed by such approaches due to the dynamic complexity.

The heterogeneity of farms implies that research intended to develop relevant technologies as adaptation options for producers would likely benefit from interaction with producers to increase the likelihood that the adaptations being developed are useful for producers in a diversity of contexts. This idea aligns with the work of Rodriguez et al. (2011), in which producers were engaged in a localised ‘co-learning’ modelling process to reveal relevant decision options.

Given the costs associated with change, especially irreversible change, Government programs to trial change options in similar contexts may be useful for producers. Important here is setting up such trials to maximise interaction with producers and producer needs. This enables producers to assess, to some degree, the compatibility between the trial site and the farm. These trials may reduce some of the perceived risks associated with change options. This is especially the case regarding trials for change options that producers can adopt through probing. At times, trialling may encourage producers to experience double-loop learning through exposure to options that might not have otherwise been considered.

It should be expected that at times producers will make mistakes. Importantly, however, mistakes will occur not due to poor decision making but because a ‘correct’ choice was not apparent at the time a decision was made. This is consistent with the notion of

second degree path dependence (see section 2.3.3.2) (Liebowitz & Margolis, 2000). Indeed, decisions not to make a change due to uncertainty fit here. Even so, there are costs associated with such errors. Generally speaking, producers can make mistakes which may only be resolved through reversals or dis-adoption, which also implies cost. In reality, producers in this research described experiences of spending years trying new approaches until they found what worked for them to manage drought. Some decisions are highly irreversible, implying a greater degree of constraint associated with the decision. Other decisions, such as probing, are highly, deliberately reversible, implying a lower degree of constraint associated with the decision.

Probing is inhibited by the magnitude of the change that is involved, or put another way, the commitment to the change. When circumstances permit, probing enables a producer to test the appropriateness of change options in the farm. Probing is likely to be an important tool used by producers in learning about relevant options for the farm given increased climate variability. However, given probing occurs on a single farm and is employed by a single producer, inferring cause and effect is especially difficult. At times, this may also diminish the capacity of the producer to experience double-loop learning, by limiting the change options being considered.

5.3.2.1. Capability, learning and adaptation

Farm adaptation in response to increased variability will require capability development as well as information about the task environment. The study reveals, as may be expected, that adaptation is triggered by producer recognition of the inability of current responses to absorb the effects of relevant variability; this is, in effect, the farm-level signal of secular change so far as the producer is concerned. There are some relevant factors that influence the capacity of producers to recognise and respond to signals associated with capability and learning.

The close link found between the producer/family and the farm business reflected the unique circumstances of farms as micro businesses, in which the producer was often a single manager. A reality of solo management was that the producer was often the main source of capability to the business. I found in analysis that capability was a constraining influence on decisions (such as by production skill sets limiting consideration of enterprise choices when leaving dairy production). This indicated that

capability was a determinant of diversity and path dependence in farms. An implication here is that changing capability may be a critical factor in altering constraints in farms.

Capability is closely linked to knowledge, which for these producers was strongly embedded in their experience on their farms. Altering capability required learning on the part of the producer. Learning is inhibited by information availability and the receptivity of the decision maker to feedback signalling that a response is needed (Argyris, 1976). These constraints on learning were identifiable in producer responses to drought.

Some producers approached the drought as though it was going to last for a year or two, based on their previous experience with drought, demonstrating a single-loop learning approach to managing the drought. This meant that their farm responses were only sufficient to cope with short-term variance in water supply. These producers incurred significant costs in the first year of the drought, thereby altering their capacity to manage subsequent years of drought by reducing the resources available to respond. Had these producers had sufficient, accurate and relevant information indicating the possibly protracted nature of the drought, and been receptive to this information, their responses may have been different. As it was, once these producers realised the drought was protracted, they made different decisions for managing the farm with less water.

The shift in thinking by these producers reflected double-loop learning, in which their previous approaches were questioned and higher-order farm plans and goals were re-evaluated and revised. Overall, across the farm narratives, double-loop learning was apparent as producers described significant changes to farm management to cope with less water. This was because the previous approaches producers relied upon as the source of knowledge for their responses to the protracted drought had been revealed to be insufficient.

This is not intended to imply that every farm that has successfully negotiated the impact of variability has necessarily employed double-loop learning. Survival can also be indicative of a farm that had sufficient tactics to absorb variability, which would likely signify single-loop learning. For example, Edward (Narrative 5) did not identify negative consequences associated with the drought until 2009, significantly later than the other producers, because he had sufficient groundwater to substitute for his surface

water for much of the drought. While Edward did eventually need to reconsider his approach, thereby engaging in double-loop learning, for a number of years Edward's farm was able to absorb the reduced access to irrigation water. It was only once his groundwater supply dropped that change was needed.

For the producers involved in this research, the shift to double-loop learning during drought involved awareness that secular change to water availability had occurred or could be occurring. The drought experience suggests that, in circumstances where producers encounter unfamiliar experiences with variability, beyond the farm's capacity to absorb the change, double-loop learning is necessary to develop appropriate management responses. Double-loop learning relies on the receptivity of the producer to the notion that change is needed and on having access to relevant information (such as timely and accurate local seasonal weather data). The diversity of paths and source constraints means that the significance of change is specific to farm and farmer; the detection of secular change from performance will be idiosyncratic, although relevant information may raise sensitivity to the possibility of secular change. Receptivity and information are clearly constraints on learning and therefore capability.

The idea that new technologies and farm management approaches will be needed by producers is consistent with the climate adaptation literature. For example, Berger and Troost (2013) argue that producers will need to adopt practices "that go beyond past experiences and involve learning, innovation and fine-tuning" (p. 3). It is consistent with the farm management literature (for example, see Kilpatrick, 2000). However, my research offers a way to understand the role of learning as a constraint on action. In some research the role of single and double-loop learning has been implied but not specifically explored. For example, Risbey et al. (1999) found that producers, relying on historical data (reflective of single-loop learning) over current context and future climate projections, underperformed when compared to those who did use these other sources of information (reflective of double-loop learning).

Central to the discussion of receptivity and information is the producer's capacity to forecast accurately the attainment of business goals given current context. This aligns with De Florio (2014), who argues that the ability of the system controller to alter the system according to "hypothesized future environmental conditions" is a critical factor in system resilience (p. 5). Forecasting requires the timely identification of signals

(threats and opportunities) among the background noise. Often, the classification of something as a signal is perceived as such because of its location in the distribution of the history of such signals that has been experienced in the lifetime of the current path. However, the experience of some producers with drought indicated that relying on previous experiences may not lead to successful outcomes, principally due to a novel series of rainfall events. The impossibility of ex ante detection of secular change by decision makers, and the likely deterioration of forecast quality when it is occurring, limits the producer's capacity to anticipate specific adaptation needs and willingness to re-allocate resources, particularly where this would involve a reduction in productivity enhancement.

Relatedly, the signal for change may not be clear, due to uncertainty. This was highly influential on Dennis and Donna (Narrative 4), who stalled in the middle of some farm improvements when public irrigation system changes were announced. Prior to GMW liaising with them over the policy, they could not know what the implications of the policy were for their farm, if any. Moreover, they could not establish when such a liaison might occur. These two sources of uncertainty left them hesitant about spending money on improvements that may not be useful in the long run. Unfortunately, after eight years they were still waiting, with less productive land, to hear about the outcome. This suggests that the capacity to adequately interpret possible effects of the manifestation of climate change is impeded by uncertainty in the capacity of the farm to cope, as a result of the uncertainty associated with other aspects of the farm system.

A challenge here is the capacity to forecast current practices in light of uncertainty regarding the projected future. Mindful of the limitations in information, consideration of scenarios that are directly relevant to the producer's idiosyncratic context may be useful in exposing the producer to possible futures that may not have been previously considered. This thinking aligns broadly with O'Meagher et al. (1998), who argue that the use of scenario planning and analysis, coupled with effective feedback, is critical to supporting adaptive learning. However, my findings imply that broader scenario planning approaches that assume relevance to different contexts will be less effective than farm-specific reflection on possible options for the future of the business.

5.3.2.2. Information

Having access to relevant information is critical for identifying appropriate responses to increased variability. As much as possible, producers need information that enables them to identify reliable signals relevant to their farm contexts. Central to this is accessing accurate information about intra- and inter-seasonal variability in the task environment. Given the uncertainty associated with increased climate variability there is, by definition, little of this information available. In this context, Government would serve the interests of dairy farmers well by considering the ways in which such information, relating both to weather and to climate, is presented to producers who are moving into more ambiguous task environments; the information value of weather data will decline as the distributions from which it is drawn shift. Changes to the content and manner of presentation of such information and data would help producers recognise this.

Information that helps producers select appropriate response options, such as new technologies, for dealing with increased variability would also benefit producers. While there has been a focus in the climate adaptation literature on identifying adaptation options for farms (for example, see Dwyer et al., 2009; Stokes & Howden, 2010), the appropriateness of these options for individual farms has not been explored extensively. Methods for understanding the relationship between farm context and technologies are well established and should be used more extensively (for example, see Bewsell & Kaine, 2006; Bewsell et al., 2007; Kaine & Bewsell, 2008; Kaine et al., 2007). Producer involvement in farm trials, probing and direct relationships with extension officers may be useful in generating information and knowledge regarding change options in context. The novel value brought here to this mundane truth is the addition of recognition of contextual demands related to coping with secular change. It can arguably be viewed as another imperative to sit alongside the imperative to cope with declining farm terms of trade.

5.4. Implications for theory and methods

Within this research I employed a novel theoretical approach that enabled analysis of the dynamic and cumulative constraints in farms. This approach offered a way to frame the comprehensive sources of constraints and the interaction of constraints through time

in farms that lead to emergent states of constraint described in terms of path dependence. Its originality stems from the use of multiple theories across disciplines in a way that systematically and explicitly linked the producer's values and goals as constraints on production choices.

The approach differs from those that only consider a subset of constraints on farms as it enabled the identification of the true breadth of constraints that producers faced (for example, see Anwar et al., 2013; Cowan, L. et al., 2013; Hertzler et al., 2013; Webb et al., 2013). This research also differs from the comparative statics approach, often used to understand decision options, as it injects consideration of interaction among constraints and time in analysis (for example, see Hanslow et al., 2014; Klein et al., 2013; Mukherjee et al., 2013; Villano et al., 2010).

Overall, the degree of dynamic complexity that was apparent in analysis of producer experiences appeared to justify the approach undertaken in this research to consider interrelated decisions in farms through time. Given the multiple dimensions of constraints identified through the application of four theoretical domains, it is arguable that there are fewer risks to research outcomes from this approach compared to a single-theory approach to analysis. Similarly, cross-sectional approaches to analysis that do not enable consideration of the dynamic complexity of constrained states will likely miss crucial insights regarding constraints.

Gathering and analysing data consistent with this theoretical approach required the use of methods that enabled the simultaneous coding of data across constructs of constraints and then identifying sequences of decisions through time in farms. Given the denseness and complexity of the data, the methods employed generated useful insights with a high degree of explicitness; a critical factor in the research process. These methods may be useful in other research in which comparisons across concepts and dynamic temporal elements are under consideration.

5.5. Applicability to other contexts

Given that variability is not an issue unique to dairy farms, it is useful to consider how applicable the approach and implications are to other contexts. The approach and findings are largely applicable to small farm businesses in the Australian and similar

contexts. The ability to capture with the method the possible differences in relationships among constraints on farmer decisions would seem to enable application across the variety of cultural and bio-economic contexts, even including subsistence agriculture. However, the approach is resource-intensive and therefore may not be useful in its current form for use in developing countries.

Further work would be necessary to identify its usefulness in non-farm micro business contexts. When conducting research into other micro businesses (for example, owner-operator chemists, trades firms and newsagents), consideration would need to be directed toward describing the value chain functions, which may have a different emphasis depending on business type. As well, the farm control theory conception of adaptation would require reinterpretation and contextualisation within the micro business, based on business type. The very common control over prices charged and margins earned by micro businesses other than farms would be expected to modify the structure of system control considerably; control would be greater as a result of the more imperfect nature of competition.

These possible differences reflect the possible dissimilarities in context among micro businesses. Importantly, the consequences of the dynamic interaction of constraints that are grounded in the personal and business objectives of an individual are likely to be persistently relevant. Given this, the implications identified in this research may be applicable to other micro businesses, agricultural and otherwise.

Whether larger farm businesses differ fundamentally in their vulnerability to climate change, given that one might assume that they do not face the same limitations as micro businesses, is a pertinent question, particularly given the common reliance on business expansion to meet declining terms of trade, *inter alia*. My research suggests that some of the relevant constraints are likely to be similar. All of the theories from which the domains of constraints were derived are relevant to larger organisations. For example, image theory has been interpreted and applied to organisations (Beach, 1990; Beach & Mitchell, 1990).

However, one would expect greater homogeneity in larger organisations with regard to the sources of constraints, given the likely lower importance of family as a source of constraint, when compared to small dairy farms. This aligns, somewhat, with recent

research by König et al. (2013) which describes a number of differences in constraints between family and non-family businesses. My findings suggest that, while large farms may not face the same limitations, they may actually face more constraints to maintaining viable, larger-scale businesses in the face of increased variability to the extent that scale is linked to specialisation.

Further, where larger farms have a corporate structure and actually operate as a corporation, the objectives of shareholders will clearly be profit-related. The owners of a farm that operates as a family farm, whatever its formal structure, may be willing to tolerate lower profit, where the business is supporting the achievement of other objectives. Capital gain, as a financial benefit, is likely of weaker short-term importance to family farms. If capital is "impatient", this creates a stronger constraint on limiting efficiency to achieve greater flexibility and this may be unhelpful in the context of climate change. As well, the maintenance of deeper reserves to better absorb more variable returns will reduce the return on investment.

5.6. Limitations of the current research

The use of narratives as the primary source of data in analysis represented a potential limitation in the research as it created a potential for my perspective of reality to be imposed on the data and analysis. I sought to group related concepts in the sequences of events that were described in the interviews through the development of narratives as second-order transcripts. This opened up the data to my influence. I sought to minimise this influence by using low inference descriptive language, quotes that enabled maintenance of the voice of the interviewee, and ensuring I included all farm-related topics in the narrative (i.e. I didn't filter out topics). Importantly, I employed a narrative validation process, by asking interviewees to review their individual narrative for accuracy and completeness. Fourteen of the 16 research participants reviewed their narratives and were overwhelmingly supportive of the documents as accurate and authentic accounts of their experiences.

During analysis, the identification and coding of constraint constructs (i.e. critical junctures, adaptations, images and value chain function changes) relied on researcher interpretation. This was managed through the development of coding rules during first pass coding, which were followed during the second pass of coding to ensure

consistency in the coding process. These coding rules have been included in the appendices (Appendix D).

The potential for gaps in knowledge regarding the history of the farm represented another limitation in the research. The farm experiences explored in this research were largely intergenerational. I only interviewed one or two generations of farm managers in this research and I was relying on each participant's memory of events. Even if the participant was the decision maker regarding decisions from 50 years ago, there were likely to be gaps regarding recollections of events. This implied potential data quality issues. A case can be made, however, that if the current farm manager believes that a previous decision about the farm was made based on particular circumstances, then this is what influences his or her perception of decision options, rather than any 'objective' assessment of circumstances. Additionally, conducting interviews with 16 producers enabled me to assess if there were significant data quality issues that could be seen as gaps in information across interview data. I found this not to be the case.

In the interviews I focused on decisions producers made about their farms and the influences on these decisions. Hence, the focus was *not* on decision-options that were implicitly or explicitly ruled out by the producer. This was based on the view that data regarding the decisions producers made was more reliable, especially considering many of these were decisions made in previous decades. Overall, the extent to which options have not been available to the producer is reflected in the cumulative effect of the history of farm decisions.

There were circumstances in which producers did discuss options that were not chosen and the reason for this. Examples include Albert's (Narrative 1) reasoning for not converting to autumn calving and Paul's (Narrative 16) rationale as to why stock reduction was not a relevant drought response for him. These experiences were in relation to fairly recent decisions (over the last few years) and they were included in the narratives.

I found in the research process that relationships among constraints were identifiable throughout the farm narratives, though there was less detail relating to decisions made further back in time. If significant details regarding previous decisions matter, then accessing other sources of information, such as historical documents and photographs,

to enable data triangulation would be useful, if unlikely. Where I focused on comparing farm experiences associated with constraint issues, I ensured the issues were recent (for example, drought and infertility) as this reduced the likelihood of gaps associated with data.

The type of data and research process imposed a limitation on the research through the potential for bias in analysis and interpretation. The richness and complexity of the data used in this research, coupled with an analytical approach that required identifying patterns across cases and linkages through time in individual cases, often required interpretation of meaning. As such there was the potential for my biases to direct the meaning being derived. Transparency and explicitness were the key mechanisms employed to guard against this threat to reliability. Hence, through the research process my rationale for coding and categorising data was explicitly noted. The rationale has been included in the thesis as matrix displays or within the extensive appendices.

The sampling process in this research was employed to target producers with a greater than 20-year history with the farm. These producers were not intended to be a representative sample. Hence, caution should be taken in extrapolating specific findings from this research to another group of producers. The conceptual model, as an analytical device for investigating constraints on farms and responses to secular change would appear to be of greater generalisability.

A final limitation in the research was identified in the analysis of linkages between critical junctures and constructs of constraints. I found that there was a potential to overstate (probing) or understate (structural determinism at the subsystem level) specific linkage relationships. While it wasn't apparent how this could be overcome, there was no significant indication that it influenced findings.

5.7. Pathways for future research

There are several possibilities associated with building upon the current research. First, this research was conducted within one industry in one area. Applying the approach to other areas and to other agricultural enterprises would likely add insights to this conception of farm constraints. Second, the climate adaptation literature acknowledges the existence of other sources of constraints, though this is generally missing from the

models. It may be worth considering the possibility of incorporating the sources of constraints identified here into agent-based modelling, for example, to better model responses to increased variability. Third, it may be worth exploring how these findings can be used to develop models for *ex ante* policy analysis.

There are also several possibilities for further research that fall out of the implications. A clear implication generated in this research was the need for extension services to work at a local level with producers to help them think more strategically about options for their farms. Doing so will require interventions that enable interaction at the double-loop learning level. A useful approach may be the incorporation of explicit discussion with producers about secular change in weather patterns which leads into consideration of longer-term determinants of path dependence. As well, consideration could be directed toward integrating into such discussions concepts derived from existing farmer tools, such as the Dairy Australia “My Region” page (Dairy Australia, 2012)

Strategic, double-loop thinking is critical for producer adaptation. Research on identifying when producers are entering a double-loop cycle and evaluating ways to support their employment of double-loop learning may be beneficial (Proctor, 2010; Rosenhead & Mingers, 2001; Senge, Kleiner, Roberts, Ross, & Smith, 1994). Relatedly, there are likely to be different capabilities associated with strategic thinking than the typical tactical approach employed by producers in task environments that they have been able to assume to be stable. Identifying these capabilities and developing and evaluating approaches for extending these capabilities in agriculture would be useful. Such capabilities could include systems thinking and creating space for creative thinking.

Research intended to develop adaptation options for farming would be best placed to do so by working with local producers to develop and trial a selection of adaptation options, acknowledging that not all adaptation options will suit all farms. Developing options that producers can test through probing will likely be beneficial.

5.8. Conclusion

Overall, this research presents a picture of a future in dairy farming that will be characterised by increasing variability in the task environment with no secular increase

in the ability to absorb it or adapt to it. The impact of this will be to increase path dependence by reducing reserves available for adaptation. There appears to be an expectation that producers need to act now by adapting their farms to increase their capacity to manage increased variability and a trend toward a hotter and drier climate. Yet producers are already constrained in their change options, due to path dependence as an accumulation of constraints, particularly as a result of their encounter with a likely manifestation of climate change in the extended recent drought.

Expectations that producers will make significant and wholesale change to their farms now to face unknown increases in variability in the future are fanciful at best. In reality, producers are adapting now to impacts of climate change that they are encountering now. It is these impacts that are a threat to farms, not potential unknown changes in the future. This implication, that producers respond to a need for change, such as a shock that is negatively influencing farm performance, implies that the triggered need has further constrained an already constrained capacity to change. Hence, some farms will fail.

If policymakers wish, or are pressured, to assist producers in this context, it may best be provided through support that enables preparation. Such policy support should focus on the development of adaptation technologies to increase farm flexibility and the provision of relevant information, regarding inter- and intra-seasonal variability and adaptation options. Central here are having information ready when producers are receptive to the need for change (i.e. when they are questioning personal and business objectives and higher-order business plans), and the maintenance of relationships with producers that enable greater understanding of their context-specific constraints.

These findings suggest that timely preparation will not always be possible. Policy to then support producers to cope with the consequences of impacts will likely be variably effective, because of the diversity in constraints that exist in farms. Given an increased likelihood of failed businesses, policy to support agricultural adjustment may be useful.

This presents considerable challenges for developing appropriate responses to support farm adaptation to climate change. These findings suggest that support should emphasise generating and maintaining technologies and information to support the needs of diverse farms. Government also needs to be prepared to respond when

producers are receptive to this information. This implies a need for increased breadth and flexibility on the part of government research, development and extension services.