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Causal attributions of vineyard executives – A mental model study of vineyard management☆

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Abstract

This article contributes a reference of causal attributions made by vineyard executives in Chile, where increasing costs and stagnating prices challenge the vineyards' profits. The investigation was motivated by the question how executives interpret the industry's mid term future and how they reflect on steering their companies. Based on in-depth interviews, causal maps were elaborated to represent the executives' mental models. These are represented as sequences of attributions, connecting variables by causal links. It was found that some mental models guide policies bound to increase the prices, whereas other models suggest taking the prices as givens and control costs. The collection of *c*ausal *a*ttributions of the *v*ineyard *e*xecutives (CAVE) has been made publicly available. As a result, CAVE can be used by other management scholars to elicit other executives' mental models and increase the data base available. Since such research will be cumulative, a minimum size for meaningful statistical analysis can be reached, opening up an avenue for improving the design of business policies. CAVE can also serve executives and consultants in constructing causal argumentations and business policies. Future research and development of supporting software are called for.

Keywords: Mental models; Strategy; Business model

1. Introduction

This article explores how Chilean vineyard executives mentally represent their industry and their firms in the mid term, using methods from mental model research – striving not only to contribute data but also opening an avenue for future research.

The executives - owners and managers - of vineyards are responsible for scanning and interpreting their business environment and devising policies to steer their firms into the future. They need to mentally invoke descriptions of the purpose and form of their industry and their vineyard, explain its functioning and observed behavior, and anticipate likely future developments. This description almost literally conforms to an early definition of 'mental model' (Rouse and Morris, 1986), which is still frequently referred to in the literature (Mathieu et al., 2000). Hence mental model research lends itself to answering the question of how vineyard executives understand their industry and their own company it that context. Since 'mental' models are the only type of models discussed here, 'model' will be used as shorthand for 'mental models' in the remainder of this article.

Over the recent years, Chilean vineyard executives feel increasingly challenged: after a restructuration during the '80s, the country's wine industry has grown rapidly starting in the mid '90s, when labor and energy costs were low, and the growth, especially in exports, has led to several new management and strategy challenges (Kunc, 2007). Already during the first decade of the new millennium, combining the art of winemaking with knowledge management has become important (Kunc, 2009). Nowadays - two decades later - the steady rise of costs combined with a market category as "best price" has put growing pressure on margins. According to data gathered by Vinos de Chile (Chile, 2015), the target prices aimed at by Wines of Chile for 2020 (Chile, 2010) appear to be impossible to reach. Two distinct archetypical kinds of business policy come to mind for defending profits: increase

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the price or decrease the unit costs by increasing the sales volume. Leaning more towards one or the other of these policies depends on how an executive reflects on his vineyard - his mental model.

A recent study of Chilean vineyards concludes that executives may distinguish very similar sets of strategic resources for developing their firms, but they perceive quite different degrees of usefulness and therefore devise different strategies concerning price and sales (Torres and Kunc, 2016). Several questions arise: (1) What do the mental models of vineyard executives contain? (2) In which aspects do they coincide, and in which aspects do they diverge? (3) Can one actually detect an orientation towards one or another type of policy in these mental models and even derive indications for business policies from them? (4) Can they be useful beyond the individual vineyard?

These questions have been studied in the context of the local wine industry in one region of Chile. Out of the approximately 300 vineyards in Chile, roughly 100 - mostly small to medium sized - are based in the Maule Region. A small sample of them has participated in an interview-based study striving to measure and analyze their executives' mental models, represented as causal maps with variables and causal links.

The resulting articulated mental models are complex systems of variables and causal links – in some cases even feedback loops – which indeed diverge into two groups: whereas one group appears to take the price of wine as a given and strives to adapt to it, the other group considers the price as a variable which can be influenced and strives to achieve such an influence. The variables and links of these models constitute a first version of a reference base of *c*ausal *a*ttributions of *v*ineyard *e*xecutives: the CAVE.

This article introduces and analyzes the 218 variables identified in the mental models and the 551 causal links which interviewees perceive between them. The most relevant variables are discussed in detail, with specific attention to the *price of wine* because the mental models diverge into two groups concerning the role played by this variable. In each group of models, the most relevant variables are tightly interconnected amongst one another, but the specific causal links differ according to each group.

Despite being only an initial step, the study is useful for management researchers because it provides an adaptable vocabulary for inquiring the mental models of wine executives in general: the variables and links can be combined such as to represent a wide range of different mental models, framing diverse business policies. Additionally, this paper proposes some orientations for representing mental models, hopefully helpful in making mental model studies easier to compare and combine. The CAVE is also useful for decision-makers, who can refer to the attributions to articulate and structure their own mental models and thereby solidify their decision making.

This work is limited by the sample size of the underlying study: it is an exploration. Also, it focuses on insights at the level of variables and links, excluding feedback loops; their analysis is beyond the scope of this paper.

The remainder of the article is structured as follows: section two lays out the conceptual and methodological underpinning of the study. The third section presents and explains the results concerning the variables and causal links of the elicited mental models with respect to the most relevant variables and the networks of links between them. Section four briefly introduces the implications of the work carried out so far, arguing for the development of software tools able to support live mental model articulation, representation and analysis. The conclusions underline the need for more data and call for methodological advances in the treatment of indirect causal influences and feedback loops.

2. Concepts and methods

2.1. Mental models – implicit, articulated and represented

'Mental model' is a compound term with different meanings for different scientific communities (Gary and Wood, 2016). Generally speaking, a 'model' is a reduced representation of something one wants to understand or construct. Something is 'mental' when it is in our minds. The term 'mental model' goes back to a Scottish psychologist (Craig, 1943). Generally speaking, mental models are one kind of knowledge structure (Doyle and Ford, 1998); such models are invoked by an individual to make sense of a situation and derive a decision or policy from it. The model is implicit unless its owner articulates it; an articulated mental model can then be represented in a specific form by researchers and be analyzed.

Psychologists are developing theories of reasoning based on mental models (Johnson-Laird, 1983). However, other disciplines also use the term. Since the beginning of system dynamics, mental models have been a source of information and an object of intervention (Forrester, 1980). In management research, mental models also have been recognized as an important research object, and the definition mentioned in the introduction is a widely accepted one (Rouse and Morris, 1986). Most studies have focused on 'shared mental models' or 'team mental models', the difference being that only some groups of individuals work together as an actual team. For instance, the research reported here deals with a group of executives belonging to the same industry, but they are not a team.

2.2. Representation of articulated mental models

One cannot study mental models without previously defining how to represent them. Different classes of phenomena or situations require different conceptual components to represent them. Therefore, there is a variety of ways how a mental model can be represented. Many team mental model studies use the so-called 'Pathfinder' method or 'Multi-dimensional scaling', representing models as undirected networks of concepts (Langan-Fox et al., 2000; Langan-Fox et al., 2004). There have even been attempts at automating the creation of such networks (Carley, 1997; Kopainsky et al., 2012). However, even in the team mental model area, 'cause mapping' - based on texts or interactively elicited - is used (Mohammed et al., 2000). If one is interested in how an executive makes decisions or designs decision policies, then cause-effect relationships are important. Therefore, a directed network consisting of elements linked by arrows is richer than an undirected network.

Authors of mental model studies frequently use the terms 'cause map', 'causal diagram', 'causal loop diagram' and 'cognitive map'. In the management literature, 'cognitive mapping' is often attributed to Eden (1992, 1994, 2004), who have developed an approach based on the 'theory of constructs' (Kelly, 1955). A construct is a brief phrase describing how a person construes a chunk of his or her lifeworld. However, the term 'cognitive map' dates back to the work of Robert Axelrod concerning the decision making of political elites (Axelrod, 2015). Logically, a diagram which maps the things held to be important and the relationships between them is a 'cognitive map'. If the person is a decision-maker and needs to design a policy, he needs causal beliefs and therefore his diagram is a 'causal map'; in a different context he may need to define a conceptual framework and elaborate a 'concept map'. It might be desirable to call the maps based on construct theory 'construct maps' – but this is not an established consensus. So for the remainder of this paper, 'causal map' or 'cause map' will refer to a diagram consisting of variables and causal links, whereas 'cognitive map' will be a diagram with constructs and causal links.

A causal map, like the one shown in Fig. 1, consists of variables and causal links. A variable is an attribute of something which can, in principle, be quantified and have different values over time. In natural language, variables are nouns, but not all nouns are variables. The direction of influence of links is indicated by an arrowhead showing which way the causal effect travels. The polarity is symbolized by a '+' or '−'. '+' is called positive polarity and means that a change of behavior in the causing variable will trigger a change of behavior in the affected variable which has the same sign. Links constitute causal attributions concerning the impact of one variable on another one.

To facilitate the discussion, variables appearing in the text and in tables will be printed in italics. For example, if the *price of wine* rises, *profits* will be higher than what they would have been otherwise; if the *price* falls, *profits* will be less than what they would have been. '−' is referred to as negative polarity because the effect has the opposite sign: if *costs* rise, then *profits* will be less than what they would have been, and if *costs* sink, *profits* will be higher than otherwise. Note that the definition of polarity implicitly assumes a 'ceteris paribus';

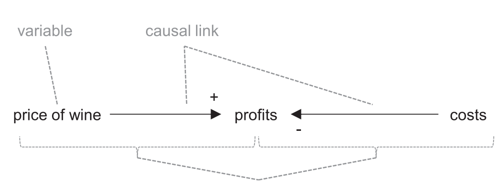

Fig. 1. Example of a causal map.

however, more than one variable may have an effect on a given variable (Schaffernicht, 2010).

Business situations are allegedly dynamic systems, where multiple factors interact and multiple agents strive to influence the system's behavior (Edwards, 1962). Many variables are interdependent, so instead of linear chains of causation one tends to find feedback loops. For instance, when *costs* increase and cause the *profit margin* to decrease, a vineyard may strive to increase the *price of wine* to increase the *profit margin*; alternatively, manual work can be replaced by *mechanization* to decrease the *costs*. Such feedback loops are said to be the building blocks of dynamic systems (Forrester, 1969), and therefore mental models of dynamic systems also take feedback loops into account (Groesser and Schaffernicht, 2012). Even though this study included the elicitation and representation of loops, the aspects analyzed here involve only variables and causal links; therefore, loops are not taken into account in this article (a brief discussion is included in Appendix A).

Causal maps have been used to represent and analyze mental models since the early '90s. After initial developments to standardize their processing (Langfield-Smith and Wirth, 1992), the 'Distance Ratio' method was developed to systematically use variables and causal links in mental model comparisons (Markóczy and Goldberg, 1995).

A number of recent studies interested in mental models in the fields of wine or natural resources have used either cognitive mapping or causal mapping. Cognitive mapping (based on constructs) appears to be a minority (González et al., 2012, Chen and Liang, 2014; Elsawah et al., 2015), one study focused on variables and causal links only (Sanò et al., 2014), another one processed concepts and links (ElSawah et al., 2013) and 5 also took feedback loops into account (Kunc, 2008; Inam et al., 2015; Torres and Kunc, 2016; Schaffernicht, 2017; Torres et al., 2017).

Usually, variables are ranked by their relevance according to how influential they are for other variables. This can be done in several ways. When only direct links are taken into account, the number of linked variables defines relevance; this is the case of the studies mentioned above. Alternatively, one can take into account sequences of links ('paths') or determine the centrality of variables (Eden, 2004). In the case of paths, each link is weighted according to the distance from the original variable. For instance, in a map with $a \rightarrow b \rightarrow c \rightarrow d$, a influences d, but not directly; c is 2 steps away from a, and therefore the link $b \rightarrow c$ is weighted as ½, whereas $a \rightarrow d$ would be 1/3. A variable's centrality represents the number of all paths going through it.

None of the mentioned studies used the frequency of variables in their respective models sample as an indicator of relevance. However, this frequency reveals which part of the interviewees perceives a variable as relevant. Therefore, the frequency of a variable in the sample of mental models is a possible indicator of relevance.

Causal links can be weighted according to their frequency in the sample. One can also invite participants to express how strong they believe each link to be, indicating ordinal numbers (Markóczy and Goldberg, 1995). As far as mental models of dynamic systems are concerned, interviewees are not expected to classify link strength (Groesser and Schaffernicht, 2012), and therefore this study did not ask interviewees to indicate link strength.

2.3. Elicitation of mental models

Since mental models must be mentally invoked and then articulated, elicitation – making a person invoke and articulate her mental model - is a sensitive issue (Eden, 1992; Laukkanen, 1994) if a project's nature is research rather than intervention (Doyle and Ford, 1998). In general, researchers strive to minimize their influence during elicitation and to yield representations that are as small as possible without losing relevant information (Laukkanen, 1994). However, there appears to be no agreement concerning an appropriate number of variables. In studies based on previously established variable lists, some authors recommend aiming at 15 to 25 variables (Lim and Klein, 2006). Other researchers, allowing participants to freely articulate their beliefs, often obtain individual articulated mental models with around 100 variables (Eden, 2004). The studies mentioned in the previous subsection typically report mental models with 8 – 49 variables and 14 to 51 links, averaging 24 variables and 30 links.

Different elicitation approaches are available (Langan-Fox et al., 2004; Mohammed et al., 2010). Frequently, the researchers try to establish a reference set of variables before eliciting the actual mental models by surveying the relevant literature and by interviewing domain experts (Markóczy and Goldberg, 1995). The owners of the mental models can then be invited to indicate if they perceive a causal link between pairs of these variables. Alternatively, mental models can be elicited by in-depth interviews or by analyzing existing documents. Some researchers use official documents like 'letters to shareholders' to extract mental models.

Each approach has advantages and problematic aspects. Previously establishing the variables based on literature and/or expert interviews is practical because it establishes a standard vocabulary; however, it also requires transparent criteria for deciding which variables are part of the selected set. Usually the search for more variables stops when additional scanning ceases to yield additional variables. The risk is that details in the mind of an interviewee are neither expressed, nor captured or processed. In-depth interviews allow participants free expression (Mohammed et al., 2000) and yield extended initial models which need to be standardized (Laukkanen, 1994). The analysis of official documents like 'letters to shareholders' is sometimes preferred because they are free of interviewer bias; however, it is debatable if such documents are written without a bias towards the shareholders.

No matter if one establishes the variables' glossary before of after the interviews: it will in general be necessary to reduce the number of details without deleting relevant pieces of information. The iterative development of a standardized set of variables – representing variables which are similar in their description (Laukkanen, 1994) or in their links (Eden, 2004) - allows reducing the details until no more variables or links can be aggregated without losing relevant information.

This study was based on in-depth, semi-structured interviews. Each interview started with the question "what do you see coming for the regional wine industry over the next 5 years or so, and how do you steer your vineyard in this context?" Framing the question towards the future avoided ex-post rationalization. The interviewee could freely elaborate and only clarifying questions were asked. The interviews took 60 min and were audio recorded. The transcriptions were coded using a scheme focusing on the identification of variables, causal links and feedback loops (Schaffernicht and Groesser, 2015). Coding proceeded in two iterations - first open, then axial - using the software atlas.ti. The resulting data were represented as a causal map using the Vensim software.

A specific method has been developed to decide which variables become part of the glossary. It selects variables which satisfy one of the following criteria: (1) a minimum number of interviewees mention the variable, (2) the variable is characteristic for an individual interviewee, (3) the variable is an input or output variable in at least one of the models, describing the business environment or an outcome variable (by aggregating it away, some essential aspect of the interviewee's mental model ceases to be taken into account), or (4) the variable is needed in a feedback loop. Variables which did not satisfy any of these criteria became aggregated: incoming causal links were redirected to the following variable. For instance, if in the sequence *innovation* → *new wines* → *differentiation*, only the first and the last variables were selected, then *new wines* was hidden and the model was represented as *innovation* → *differentiation*. The

Table 1
The vineyard sample.

Vineyard	**Interviewee**
Medium sized company, third generation family business, combines vineyard with distribution	Owner
Small size new vinery	Owner
Medium sized distribution joint venture of four vineries	Manager
Medium sized cooperative of around 140 small grape-producers	Manager
Medium sized, second generation family business, winemakers	Owner
Small size first generation winemaker	Co-owner and founder of a regional association of artisanal vineries
5th generation Spanish family business	Technical director
Small size start up winemaker	Founder
5th generation large vinery	Co-owner

connection between these two variables is a ‘path’ because it is a sequence of links. The path length in the example is equal to 2, and the path will be assigned a weight of 1/length = 0.5. This way of defining link weight is not new (Eden, 2004); it is plausible to assume that an executive is more aware of a causal effect based on a direct link than on an effect based on a sequence of links, and the longer the path, the less he will be aware of it. The path polarity is obtained by multiplying the polarities of the constituting links, positive in this case. When several paths of the original mental models become aggregated into one aggregated path during the process of aggregation, the resulting path's polarity is obtained following the same general idea; however, different original paths may have different lengths, meaning that they are not equally weighted. Each original path shall influence the overall polarity according to its weight; therefore, the individual link polarities are weighted by the path weight (and example is discussed in Appendix E).

This method therefore redefines sequences of unselected intermediate variables and causal links as paths; all relevant structural information is maintained because all sequences of links and variables between the selected variables in the original models and all feedback loops in the original models are conserved.[1] While the selected variables and aggregated paths are used for analysis, the original data with all its details – variables and causal links - is conserved in an independent data table.

2.4. Validation

Confidence in the causal maps as representation of the articulated mental models is usually established by validating them with the participating executives. This can be done in varying time scales, according to the attributes of each research. This study submitted the causal maps to the interviewees approximately one year after each interview.

Such validation refers to the frame defined by the orienting question: in the face of a different question, the same interviewee may articulate a different set of variables and causal links. In particular, a more specific orienting question, say, in marketing, would lead to the articulation of more focused mental models – however, they would be expected to be coherent with the general mental models of this study.

2.5. Sample

An interview-based study is time intensive; therefore, a small sample of vineyards was sought for. The University of Talca in the Maule Region is deeply involved with the regional wine industry by means of its Wine Center. Leading experts from this Center identified a sample of 9 vineyards along two dimensions: innovative versus traditional and small versus medium. The resulting selection includes vineyards of different sizes and ages, as shown in the following table (Table 1).

[1]Keep in mind that feedback loops were taken into account in the overall study, even though they are not the focus of the present discussion.

3. Process and results concerning variables, links and paths

3.1. Global characteristics

The initial number of variables was 638. The process of aggregation and construction of a glossary lead to a total of 447 distinct variables. The mean number of variables and links per model were 67 and 90, respectively (Table 2). Identification of relevant variables based on the frequency (number of models which contain a variable) with different cut-off values between 0.5 and 0.3 led to puzzling results, since variables like *innovation* were not selected as relevant in spite of the clear intention of the study to compare innovative vineyards to traditional ones. Analysis of the intersections between the models in terms of their variables revealed the existence of two groups of models. Models 1, 3 and 5 were joined as group 1 (G1), and models 2, 4, 6, 7, 8 and 9 formed group 2 (G2). By selecting variables which belong to at least half of the models in each respective group, the observed anomaly disappeared. The threshold of 50% works well with this small sample size, and alternative thresholds (between 35% and 75%) led to an excessive number of variables or too many relevant variables (like *innovation*) deselected. However, this is only an empirical threshold; other studies may require different thresholds, and iterative search is necessary.

The process of aggregation for comparability generated a set of 218 distinct variables; 76 of them are endogenous (they are neither input nor output variables). The mean number of variables and links decreased to 39 and 61, respectively. The links/variables ratio increased from 1.36 to 1.58, suggesting that the variables ‘aggregated away’ tended to have less than average links. The Table 2 gives an overview:

The variables in the aggregated models have different degrees of relevance. In this study, a variable's relevance stems from two aspects: (1) the number of models containing it (frequency), and (2) the number of variables linked to it. Interestingly, variables with a higher frequency also have more links with other variables (without double counting), as shown in Fig. 2.

Links heading towards at a variable influence it, whereas outgoing links influence other variables; in graph theory, this is called ‘in-degree’ and ‘out-degree’. Fig. 2 displays them separately to make clear that variables with higher frequency tend to have higher values in both indicators. The concentration of variables in the lower left areas suggests that most variables do not influence many more than 4–5 other variables. Table 3 shows the frequencies and the number of links influencing other variables.

Considering only variables mentioned by at least two interviewees (frequency $>=2$), the total number of variables decreases to 63. If only variables influencing at least 3 other variables are counted, only 67 variables are taken into account. Note that the 31 variables without distinct out-links are output variables, which by definition do not influence any other variable. The variables with a higher number of out-links do not necessarily have the highest number of in-links.

3.2. Variables in groups of mental models

The variables are not equally distributed over the two groups. Some variables belong to models of both groups, while others are only part of G1 or G2. The most relevant variables of these groups, which are analyzed in this article, are shown in decreasing order of relevance in Table 4. The top row is the set of "shared" variables, and the lower row is subdivided into two columns containing the respective subsets of variables which are only mentioned in the models of G1 or (XOR) G2. The complete sets of endogenous variables, input and output variables are reported in Appendix B. A glossary with definitions for each variable is contained in Appendix C.

The variables in Table 4 are ordered by relevance, using each variable's rank according to frequency and number of links. The shared endogenous variables are mostly general business terms. This is not very surprising, since any executive must take care of these variables, regardless of the particular strategy followed to do so. Of course, not all of the variables are equally relevant in terms of how many executives mentioned them or how many other variables they are connected with. Table 5 shows the subset of those variables whose frequency or number of out-links are at least 5. These values are set as such to reduce the number of variables displayed (the complete table is included in Appendix D).

The rows of Table 5 are separated into three sections. The variables in the first section belong to both groups, the variables in the second and third section have only been mentioned in models of G1 or G2, respectively. The columns concerning frequency indicate the total number of models containing each variable, and how many of them belong to G1 and G2. The table shows in-links and out-links separately, distinguishing between the total number of links and the number of distinct variables connected by these links. When the total number of links is greater than the number of distinct links, some of the links are mentioned in several models. The table also displays the sums of in- and out-links to give an oversight over the causal links.

Considering first the variables belonging to models of both groups, note that the most relevant variables are typical business terms. The *price of wine* has been mentioned in every model; it is influenced by 20 variables and impacts 12 variables; overall, 32 variables are directly connected with the *price of wine*, and 12 links are shared between models. *Costs*

Table 2
Global description of the original and the aggregated mental models.

Mental model #	Original models			Aggregated models		
	Variables	Links	Links/ Variables	Variables	Links	Links/ Variables
1	75	101	1.35	34	62	1.82
2	47	63	1.34	36	55	1.53
3	47	73	1.55	26	44	1.69
4	63	91	1.44	35	63	1.80
5	67	88	1.31	36	48	1.33
6	90	111	1.23	52	72	1.38
7	57	75	1.32	36	51	1.42
8	57	70	1.23	41	55	1.34
9	100	145	1.45	53	101	1.91
Mean	67.00	90.78	1.36	38.78	61.22	1.58
SDev	18.36	25.57	0.11	8.70	17.16	0.23

Table 3
Number of variables for each frequency and link number.

Frequency	Number of variables	Cumulative number of variables	Distinct links	Number of variables	Cumulative number of variables
9	1	1	12	2	2
8	2	3	11	2	4
6	2	5	9	5	9
5	8	13	8	2	11
4	5	18	7	4	15
3	21	39	6	4	19
2	24	63	5	6	25
1	155	218	4	15	40
			3	27	67
			2	37	104
			1	83	187
			0	31	218
Total	**218**		**Total**	**218**	

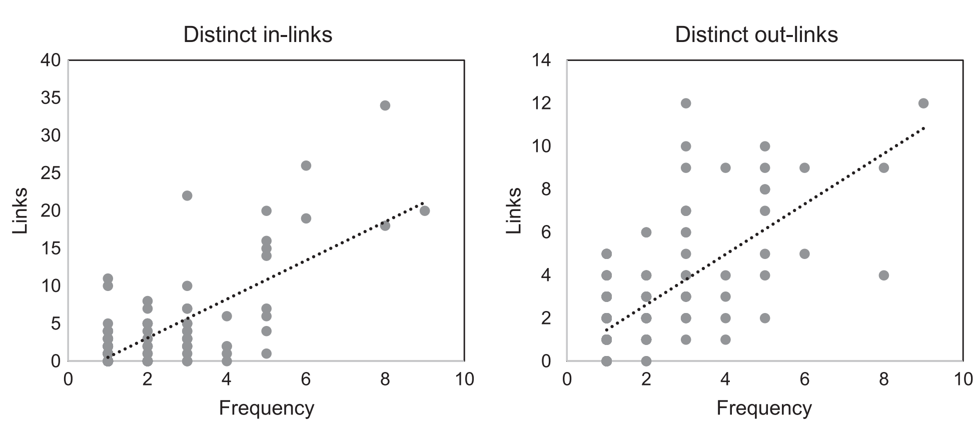

Fig. 2. The relationship between variables' frequency and their number of causal links.

are mentioned almost as frequently and are directly linked to 43 different variables, 34 of these impacting *costs*, 9 being impacted. *Production costs* are the most relevant component of *costs. Sales* and *profits* belong to fewer models, but are linked to many other variables and approximately one third of their links are shared by several models. *Production*, *differentiation*, *revenues* and *marketing costs* are mentioned almost as often; so are *price of grape*, *dominance of large vineyards* and *local partnerships between vineyards*, but the latter three variables are local to the wine industry. The *dominance of large vineyards* is a particular characteristic of the Chilean wine industry, where more than three quarters of the industry volume are represented by three companies. Mar*keting efforts abroad*, *vineyard size*, *fair trade* and *wine category* belong to fewer models, but they are as intensely interlinked with other variables as the previously mentioned variables.

Turning now to the four variables belonging only to G1, three of them are input variables: *economic growth in major markets*, *international per capita consumption* and *mergers of distributors* do not have in-links – nothing impacts them – but they do have influence on 3 – 6 other variables. Quite obviously, none of the participating vineyards has an influence on *economic growth* and *global per capita consumption*. The *mergers of distributors* are one example of certain

Table 4
Subsets of variables according to the groups of mental models.

G1∩G2: Variables mentioned by both groups (in total: 25 variables, 23 endogenous, 2 input):
Endogenous: *costs, price of wine, production costs, profits, sales, differentiation, production, marketing costs, price of grape, local partnerships between vineyards, dominance of large vineyards, revenues, vineyard size, fair trade, marketing efforts abroad*

G1/(G1∩G2): Only group 1 (48 variables, 10 endogenous, 33 input, 5 output):	**G2/(G1∩G2): Only group 2** (145 variables, 43 endogenous, 76 input, 26 output):
Endogenous: *distributors,*	Endogenous: *demand for wine, importance of volume in the majority business model, innovation, mechanization, organic vine production, territorial rootedness*
Input: *economic growth in major markets, international per capita consumption, mergers of distributors*	Input: *production area, production per hectare*

Table 5
The most relevant variables according to frequency and causal links.

Variables	Frequency			Causal links					
	Total	Groups		Incoming		Outgoing		In general	
		G1	G2	Total	Distinct	Total	Distinct	Total	Distinct
Price of wine	9	3	6	25	20	19	12	44	32
Costs	8	3	5	46	34	14	9	60	43
Production costs	8	2	6	22	18	10	4	32	22
Sales	6	3	3	23	19	14	9	37	28
Profits	6	3	3	35	26	5	5	40	31
Production	5	1	4	15	14	11	10	26	24
Differentiation	5	1	4	17	16	11	8	28	24
Price of grape	5	1	4	8	6	9	8	17	14
Dominance of large vineyards	5	1	4	1	1	9	7	10	8
Local partnerships between vineyards	5	2	3	9	7	6	5	15	12
Revenues	5	3	2	12	4	6	4	18	8
Marketing costs	5	1	4	21	20	5	2	26	22
Marketing efforts abroad	4	1	3	11	10	6	5	17	15
Vineyard size	3	2	1	4	4	13	12	17	16
Fair trade	3	1	2	2	2	13	10	15	12
Wine category	3	2	1	2	2	9	7	11	9
Economic growth in major markets	3	3	0	0	0	7	6	7	6
Distributors	3	3	0	23	22	5	3	28	25
International per capita consumption	2	2	0	0	0	6	6	6	6
Mergers of distributors	1	1	0	0	0	5	5	5	5
Demand for wine	5	0	5	20	15	11	9	31	24
Importance of volume in the majority business model	4	0	4	6	6	9	9	15	15
Organic vine production	3	0	3	3	3	10	9	13	12
Innovation	3	0	3	10	10	9	7	19	17
Mechanization	3	0	3	5	5	7	7	12	12
Territorial rootedness	3	0	3	2	2	7	6	9	8
Production area	3	0	1	0	0	5	5	5	5
Production per hectare	2	0	1	0	0	6	6	6	6

variables which are mentioned by only one executive, but influence many variables in his or her mental model. In this specific case, the executive explained that he needs to grow in order to keep pace with the growth of his international distributors and remain an attractive provider for them. *Distributors* belongs to all three of the models in G1.

The remaining 8 variables shown in Table 5 have been mentioned exclusively by executives of G2. The *demand for wine* might be expected to be mentioned by every vineyard executive; however, the five interviewees who did mention it perceive it as a variable they can influence. The *production area* as well as *production per hectare are* two variables related to the total production of wine, and several executives of this group are worried about the effect of increasing them on the *price of wine*. This is why they mention the *importance of volume in the majority business model* (where 'majority' refers to the majority of vineyards). Three variables are frequently related to the possibility of increasing the price of wine: *organic vine production*, *innovation* and *territorial rootedness* (meaning the attitude of feeling committed with the terroir and transmitting this to consumers). In a different line of reasoning, *mechanization* is mentioned as a means to decrease *costs* with undesired side effects on the originality of the resulting wine, limiting the possibility to increase the *price of wine* (and thereby counteracting the intention to improve *profits* by decreasing *costs*).

In general, some variables belong to few models but have a great number of out-links: *vineyard size*, *fair trade* and *organic vine production* are such cases. It has to be suspected that these variables play an important role in the business reasoning of the executives who mention them. This is interpreted as a point in favor of using two complementary indicators for representing the relevance of variables. Some variables are relevant because of their high frequency (many executives deem them to be sufficiently relevant to keep them in mind), while others have an elevated number of links (indicating that some executives take them as very relevant).

3.3. Spot on one variable: the role played by the price of wine

Variables are important elements of models. Clearly, if an interviewee believes that an increase in the *price of wine* will lead to increased *personnel costs*, such an assertion can only be made if the two variables *price of wine* and *personnel costs* have been declared to exist in the first place. However, the reason why a variable is relevant is that it affects other variables or that it is affected by others. A causal link establishes a relationship between two variables and thereby makes an attribution about (part of) the world.

The *price of wine* is the most influential variable in terms of models and links (Table 5). So it is straightforward to examine the attributions concerning the effects of the *price of wine*. Taken together, these attributions represent the way interviewees understand this part of their business. Consider first which variables are being influenced by the *price of wine*. Table 6 presents the data ordered by the group of vineyards and by model. For each link, it indicates the affected variable, the number of paths leading there (Paths), the overall polarity (Pol), the number of delayed links on the path (Del) and the overall weight of the paths. The overall polarity is determined by the majority: if the proposition is based on a direct link, it is the link's polarity; if it is a path, then there is a certain number of links, each with a polarity; in such cases, when there are more positive than negative links, the path polarity is positive, and negative in the opposite case. The path weight is the sum of the weights of the individual disaggregated paths. For instance, in G2, the first path is *price of wine* → *profits*, and there are seven different (disaggregated) paths between these two variables. Each of them has a certain length, and its weight is defined as 1/length. When adding, the resulting (aggregated) path weight is 1.05.

Table 6
Causal influences of the *price of wine*.

Causal influences of the price of wine						
Group	**Model**	**Influenced variables**	**Paths**	**Pol**	**Del**	**Weight**
1	1	*Revenues*	1	+	0	1.00
	3	*Revenues*	1	+	0	1.00
	5	*Revenues*	1	+	0	1.00
2	2	*Profits*	7	+	12	1.05
		Importance of price in the business model	1	–	0	0.33
		Importance of volume in the majority business model	1	+	0	0.33
		Innovation	1	–	1	0.20
	4	*Costs*	4	+	4	0.85
		Personnel costs	4	+	6	0.63
		Revenues	2	–	0	0.83
		Production	11	–	10	1.52
		Sales	1	–	0	1.00
	6	*Profits*	1	+	0	1.00
	7	*Demand for wine*	1	–	0	0.50
	7	*Profitability*	2	–	0	1.33
	8	*Demand for wine*	1	+	0	1.00
		Revenues	2	+	0	1.33
	9	*Profits*	26	–	23	2.89
		Grape sales opportunity	1	–	0	1.00

In G1, only *revenues* are affected, and in each of its constituent models, there is one direct positive causal link into *revenues*. There are no delays, and the weight equal to 1 reveals that these are direct links: recall that the weight of a path is defined as 1 / number of links on the path. Therefore, if there is one single path and its weight is equal to 1, it must be a single causal link.

In contrast, the models of G2 offer a range of affected variables. In model 2, seven paths lead from the *price of wine* to *profits*. This means that in the disaggregated model, there are seven ways to get to *profits* starting at the *price of wine*. In total, 12 of the involved causal links are delayed and their overall polarity is positive. The resulting weight is 1.05 – suggesting that these are rather long paths, with little weight each (the details of this calculation are explained in Appendix E).

This is relevant because it must be assumed that in the mind of a decision-maker, a direct causal link is more present (available) than a longer path. However, an elevated number of longer paths must be suspected to be quite present as well. According to model 4, there are 11 ways how the *price of wine* affects *production* (of wine); again, the modest weight suggests that most of these paths are long. The fact that the *price of wine* has 26 different impacts on *profits* for model 9 appears to escape most of the other models in G2, and suggests that this interviewee is extraordinarily sensitive to the *price of wine*.

There are also considerable differences between the ways how the *price of wine* is driven, as shown in Table 7

Similarly to the out-links, the models of G1 do not make the *price of wine* depend on many variables. The *wine category* is recognized by two of the three interviewees, and in model 3 we note a particular attention to the *Asian* and *European markets*, adopting the stance of a price-taker. Also, model 5 suggests a price-taker approach searching for *niches* with interesting prices. Model 1 mentions the *identification with the country brand*: it is widely recognized that the brand “Wine of Chile” is slow to change in the perception of consumers, and therefore model 1 also reveals a price-taker's stance.

For the interviewees of G2, *differentiation* is a recurrent variable, as well as *quality*. model 4 contains an elevated number of paths how *demand for wine*, *differentiation*, *fair trade* and *organic vine production* affect the *price of wine*. Overall, the variables mentioned in the models of G2 are mainly controlled by the vineyards themselves (to the exception of *average quality demanded*, *demand for wine* and *markup of domestic distributor*). This allows the hypothetical statement that these vineyards’ attitude is directed at influencing the *price of wine*, rather than adapting to it.

The causal diagram shown in Fig. 3 allows synthesizing the meaning of the *price of wine* for the two groups of models. The diagram is laid out as such to make the differences between the attributions of the two groups of models salient, and the dotted borders around the variables facilitate perceiving the groups. The variables’ sizes correspond to their frequency.

Note that the dotted areas representing the groups in Fig. 3 refer to the attributions, not to the variables. The fact that the causal links belong to one group or the other must not be confused with the membership of the participating variables. The variables *price of wine*, *costs*, *sales*, *profits*, *differentiation*, *production*, *local partnerships between vineyards*, *revenues*, *marketing efforts abroad*, *average quality demanded*, *fair trade* and *personnel costs* belong to both groups of models.

Fig. 3 clearly shows how important the *price of wine* is to the interviewees in general: it is involved in as many as 32 attributions, being influenced by 20 other variables and affecting 12 other variables (some of the links are contained in more than one model, so that their total number is 19, as indicated in Table 5). By joining the data of Tables 6 and 7, the map also makes visible that there are two feedback loops between the *price of wine* and *production* and the *price of wine* and the *demand for wine*. The meaning of *price of wine* is different for each group of models. The only exception is the link from the *price of wine* to *revenues*, which belongs to both groups.

Table 7
Causal influences on the *price of wine*.

Causal influences on the price of wine						
Group	**Model**	**Influencing variables**	**Paths**	**Pol**	**Del**	**Weight**
1	1	*Identification with the country brand*	1	1	0	0.50
		Wine category	3	1	0	1.33
	3	*Price of wine in Asian market*	1	1	0	1.00
		Price of wine in European market	1	1	0	1.00
		Wine category	1	1	0	1.00
	5	*Price of wine in niches*	1	1	0	1.00
2	2	*Differentiation*	1	1	0	1.00
	4	*Average quality demanded*	1	1	0	1.00
		Demand for wine	22	1	20	3.08
		Differentiation	23	1	20	3.38
		Fair trade	24	1	24	3.26
		Organic wine production	14	-1	12	1.57
		Production	2	1	0	1.50
		Quality	1	1	0	1.00
	6	*Differentiation*	3	1	2	0.90
		Domestic demand for wine	1	1	0	0.50
		Increased supply from other countries	1	-1	0	0.50
		Linkage to authentic stories	2	1	1	0.45
		Local partnerships between vineyards	1	1	1	0.20
		Marketing efforts abroad	2	1	1	0.45
		Quality	5	1	7	0.95
		Territorial rootedness	4	1	3	0.87
	7	*Value added*	1	1	0	1.00
	8	*Markup of domestic distributor*	1	1	0	0.50
		Production	1	-1	0	1.00

3.4. Sequences of attributions

3.4.1. Differences at the level of individual mental models

Up to here, we have only considered the immediate neighborhood of one single variable, even if it is a very relevant one. Indeed, out of the 551 causal attributions, 139 belong to the models of G1, and 397 are contained in models of G2, but only 10 belong to both groups. Of course, most of the variables connected to the *price of wine* are also linked to other variables. For instance, it ought to be suspected that *innovation* somehow affects *differentiation* and thus has an impact in the *price of wine* – even though by inspecting single causal links, this remains unseen. In that case, the fact that most of the individual attributions are only contained in one single model in this sample might mislead to the conclusion that these models are all entirely different.

By zooming out of the *price of wine*, it becomes apparent that the models contain sequences of attributions that are more similar to one another than what seems to be the case with a narrow focal point in view. The respective aggregated models reported here contain paths -sequences of attributions- that may differ in the details but describe a common theme. For instance, Fig. 4 displays the path from *innovation* to the *price of wine* according to two different models.

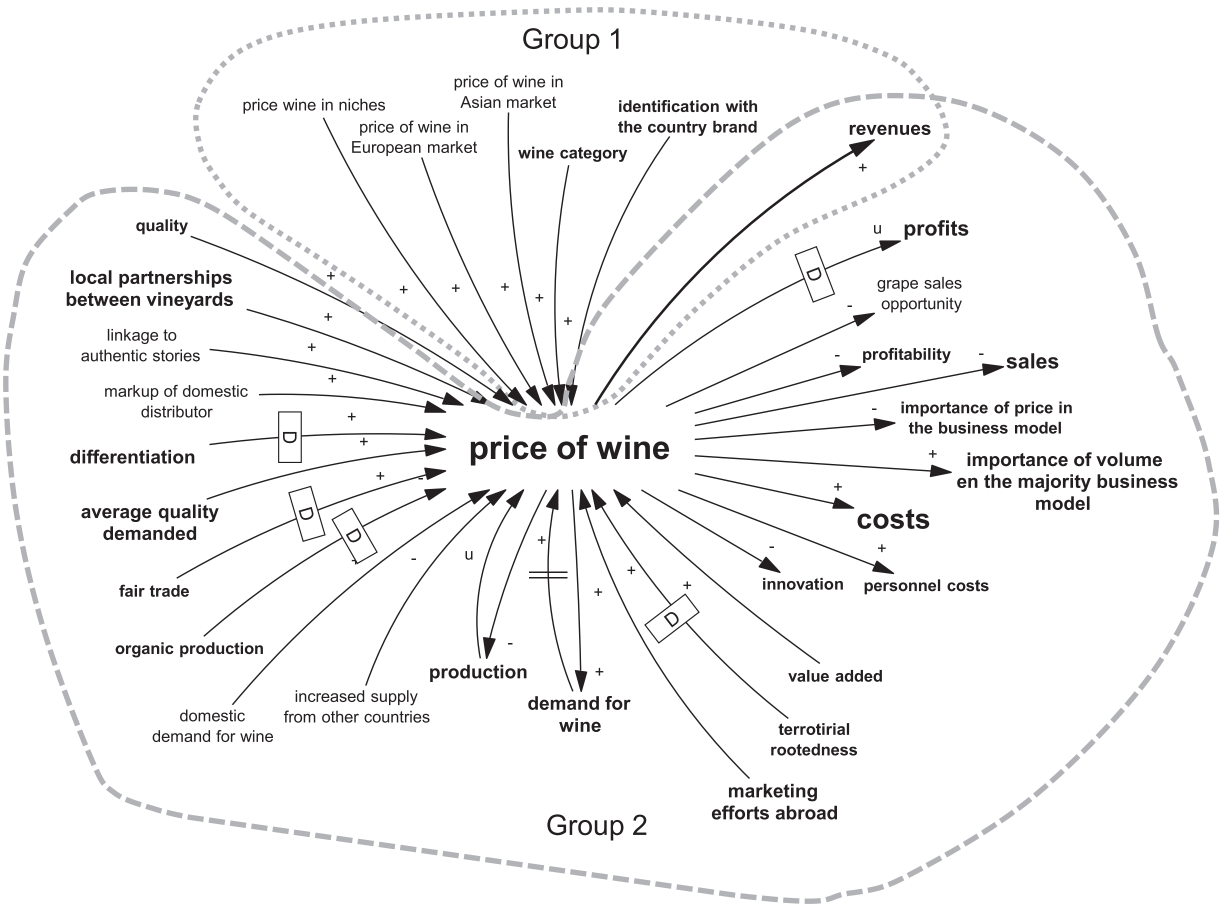

Fig. 3. Attributions around the *price of wine*.

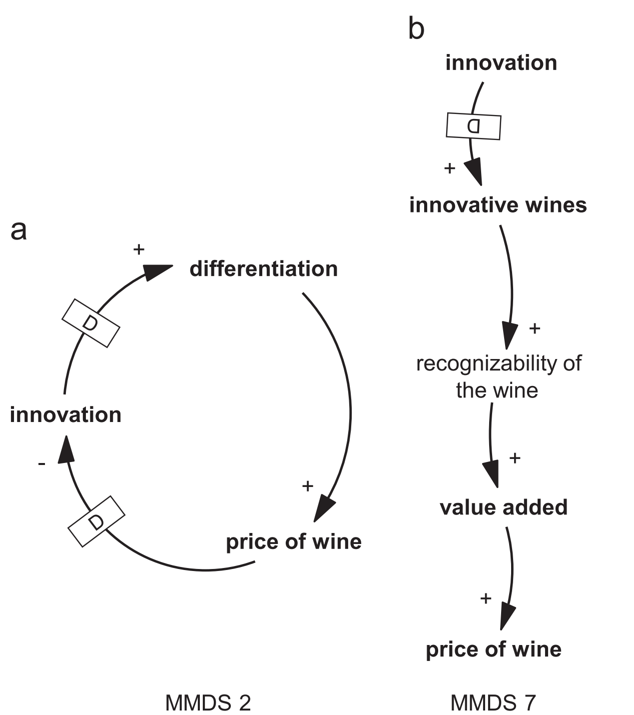

Fig. 4. The path between *innovation* and the *price of wine* according to two different mental models.

Both examples are taken from models belonging to G2, since *innovation* is not contained in G1 and therefore no link or path can exist in any of the models of G1. Fig. 4 reveals that the decision-maker who articulated model 2 conceives the relationship between *innovation* and the *price of wine* as a feedback loop: when the *price of wine* sinks, this increases the *need to innovate* which, over time, leads to an increase in *innovation*. Increased *innovation* will gradually increase *differentiation*, which in turn increases the *price of wine*. This is a balancing feedback loop, where *innovation* is used to correct gaps between the *price of wine* and its desired level. In contrast, the decision-maker behind model 7 thinks of a linear relationship, where more *innovation* leads to more *innovative wines* (over time: note the delay), which makes these wines easier to *recognize*, which increases the *value added* and therefore augments the *price of wine*. So in both cases, *innovation* has an indirect influence with positive polarity on the *price of wine*: there is a path. However, only in one of the cases, the *price of wine* has an influence on *innovation*.

This is relevant for two reasons. (1) It illustrates that indirect influences matter; (2) It also suggests that feedback loops are an important component of mental models. Mental model methods which do not take these two aspects into account are at risk to miss important information. As far as loops are concerned, they remain out of focus here for the sake of

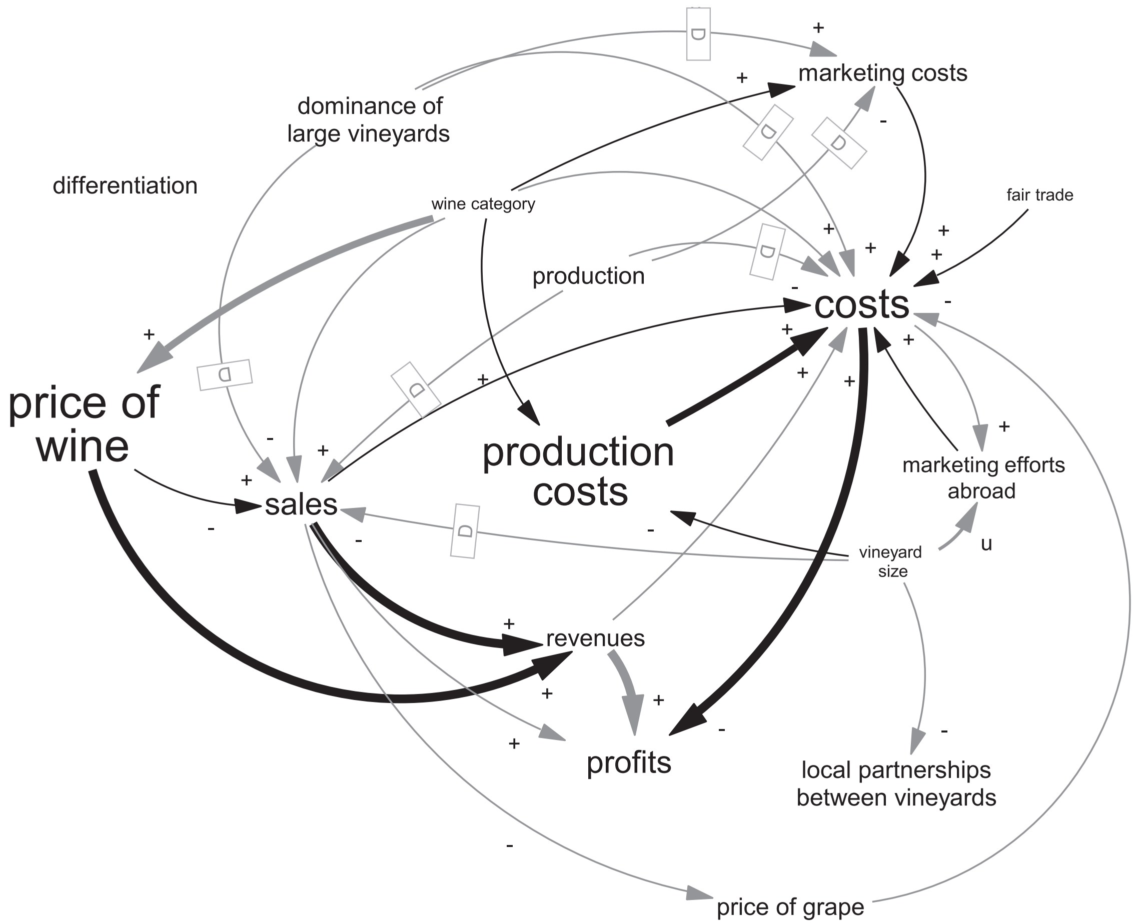

Fig. 5. Causal map of the shared variables in the mental models of G1.

briefness, but their treatment is forthcoming. Indirect influences will be discussed in the following subsections.

3.4.2. Causal attributions and sequences in the groups of models

The previous example illustrates an important insight: in comparing mental models, focusing exclusively on direct causal links may not be sufficient. *Innovation's* influence on the *price of wine* may not be direct, but this does not mean there is no influence. Consider the case of the variables shown in Table 5: amongst the entire set of 218 variables, they were particularly relevant because of their frequency or their links. Mapping the links between the variables in the upper half of Table 5 – these variables belong to both groups – facilitates the discovery of indirect influences and it reveals which causal attributions are common to both groups of models and which ones are not. We will consider the causal maps of these 16 variables according to the mental models of each group.[2]

Fig. 5 shows the variables connected by 28 links. The variables' size represents the number of models they belong to. The 11 links belonging to both groups are black, the 17 grey links only appear in G1. The thickness of links represents the relative share of models containing them in each respective group. Delay marks (a "D" in a rectangle) denote delays or lags expressed by the interviewees.

Three variables are of salient size: the *price of wine*, *costs* and *production costs*. However, as far as links are concerned, *costs* and *sales* have the highest number of in-links: they are affected by many other variables. *Fair trade*, the *dominance of large vineyards*, *wine category*, *production* and *vineyard size* appear as input variables (no in-links) and *profits* is an output variable. *Differentiation* is not linked to any of the other 15 variables; this stems from the fact that in the G1 models, it is connected to other variables, which are not common to both groups. Note the undetermined polarity of the link *vineyard size* → *marketing efforts abroad*: this is the effect of two interviewees expressing opposing causal beliefs, one attributing a positive polarity while the other perceives polarity to be negative. Most of the thicker links – mentioned by several interviewees – also belong to G2.

The diagram allows concatenating the individual links into paths, thus reconstituting a discourse of attributed causality. For instance, a higher *wine category* will lead to an increased *price of wine*, which in turn increases *revenues* and then *profits*. At the same time, the increasing *price of wine* reduces *sales* (volume), which reduces *revenues* and then *profits*. Also,

[2]The maps in this paper are simplifications: they only show the overall polarity and delays of causal links; the underlying data also contains weights depending on the number of the involved links or paths in the disaggregated models and their respective path length. However, these aspects are not relevant for the differences being analyzed here; the interested reader is invited to refer to the detailed data table in appendix D.

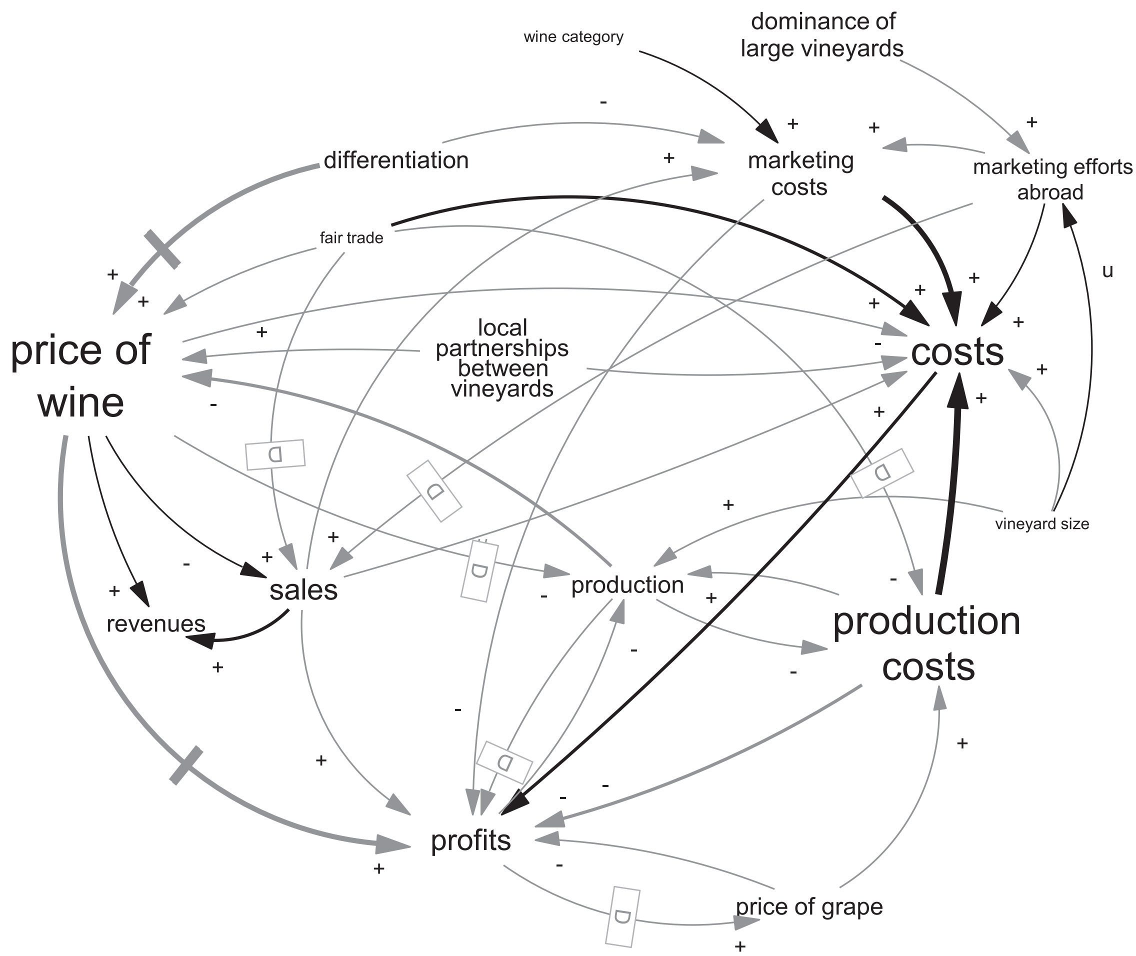

Fig. 6. Causal map of the shared variables in the mental models of G2.

an increased *wine category* leads to increased *costs*, which reduces *profits*. Which of the paths has more impact cannot be determined without quantifying each particular case; however, the qualitative causal map reveals the complexity of the management situation: a change to one variable triggers simultaneous sequences of consequences.

Fig. 6 shows the same variables (with the same sizes); 28 of the 38 causal links are grey for G2 and the 10 black ones are common to both groups. Thickness represents the share of G2 models containing them. As compared to G1, link thickness is more nuanced because G2 contains twice the number of models and therefore no link is shared by all interviewees. *Vineyard size*, *wine category*, the *dominance of large vineyards*, *differentiation*, *fair trade* and *local leadership between vineyards* are input variables, but *profits* is not an output variable now (however, *revenues* is). *Production* is now an endogenous variable, affecting three other variables. Many links are different from the map representing G1. In general terms, only 10/28 = 36% and 10/38 = 26% of the links of G1 and G2 are common to both groups, meaning that the causal attributions of the respective interviewees are more different than what might be expected from the 16 shared. In particular, the *price of wine* now has an impact on five other variables. This contrasts with the observation that *costs* reacts to as many variables as in the G1 models.

3.4.3. Indirect connections between variables

Section 3.3 has dealt with different attributions concerning the *price of wine* in the different groups of mental models, involving only direct links. Section 3.4.1 focused on different attributions made in different models concerning the relationship between the *price of wine* and *innovation*, comparing sequences of links, and Section 3.4.2 suggests that the question of indirect connections – sequences of attributions - between variables is not limited to *innovation* and the *price of wine*; it ought to be asked for all variables.

Remaining focused on the 16 variables in the upper part of Table 5, it is interesting to find out which variables have an influence on what other variables – be it direct or indirect. It is also interesting to consider possible differences with respect to these influences between G1 and G2.

The causal maps of G1 and G2 – limited to the 16 shared variables – can be represented as a 16 × 16 matrix containing one row and one column per variable. For each pair of different variables, the distance (number of links between them) from the variable in row r to the variable in column c is stored in the respective cell r,c to build a 'distance matrix' (for an introduction, refer to Oliva (2004)). Cells representing unconnected variables will have an ∞ sign, and the cells along the main diagonal are zero. If each value v with $0 < v < \infty$ is replaced by a 1, the result is a 'reachability matrix' indicating

Table 8
Connections between the 16 most relevant shared variables in G1 and G2.

	Price of wine	*Costs*	*Production costs*	*Sales*	*Profits*	*Production*	*Differentiation*	*Price of grape*	*Dominance of large vineyards*	*Local partnerships between vineyards*	*Revenues*	*Marketing costs*	*Marketing efforts abroad*	*Vineyard size*	*Fair trade*	*Wine category*	Agreement	Disagreement
Price of wine		YY	NY	YY	YY	NY	NY	YY	NN	NY	YY	YY	YY	NY	NN	NY	9	6
Costs	NY		NY	YY	YY	NY	NY	YY	NN	NY	YY	YY	YY	NY	NN	NY	8	7
Production Costs	NY	YY		YY	YY	NY	NY	YY	NN	NY	YY	YY	YY	NY	NN	NY	9	6
Sales	NY	YY	NY		YY	NY	NY	YY	NN	NY	YY	YY	YY	NY	NN	NY	8	7
Profits	NY	NY	NY	NY		NY	NY	NY	NN	NY	NY	NY	NY	NY	NN	NY	2	13
Production	NY	YY	NY	YY	YY		NY	YY	NN	NY	YY	YY	YY	NY	NN	NY	9	6
Differentiation	NY	YY	NY	YY	YY	NY		YY	NN	NY	YY	YY	YY	NY	NN	NY	8	7
Price of grape	NY	YY	NY	YY	YY	NY	NY		NN	NY	YY	YY	YY	NY	NN	NY	8	7
Dominance of Large Vineyards	NY	YY	NY	YY	YY	NY	NY	YY		NY	YY	YY	YY	NY	NN	NY	8	7
Local Partnerships between vineyards	NY	YY	NY	YY	YY	NY	NY	YY	NN		YY	YY	YY	NY	NN	NY	9	6
Revenues	NY	YY	NY	YY	YY	NY	NY	YY	NN	NY		YY	YY	NY	NN	NY	8	7
Marketing costs	NY	YY	NY	YY	YY	NY	NY	YY	NN	NY	YY		YY	NY	NN	NY	8	7
Marketing efforts abroad	NY	YY	NY	YY	YY	NY	NY	YY	NN	NY	YY	YY		NY	NN	NY	8	7
Vineyard size	NY	YY	YY	YY	YY	NY	NY	YY	NN	YY	YY	YY	YY		NN	NY	10	5
Fair trade	NY	YY	NY	YY	YY	NY	NY	YY	NN	NY	YY	YY	YY	NY		NY	8	7
Wine category	YY	YY	YY	YY	YY	NY	NY	YY	NN	NY	YY	YY	YY	NY	NN		11	4
Agreement	1	14	2	14	15	0	0	14	15	0	14	14	14	0	15	0	**132**	
Disagreement	14	1	13	1	0	15	15	1	0	15	1	1	1	15	0	15		**108**

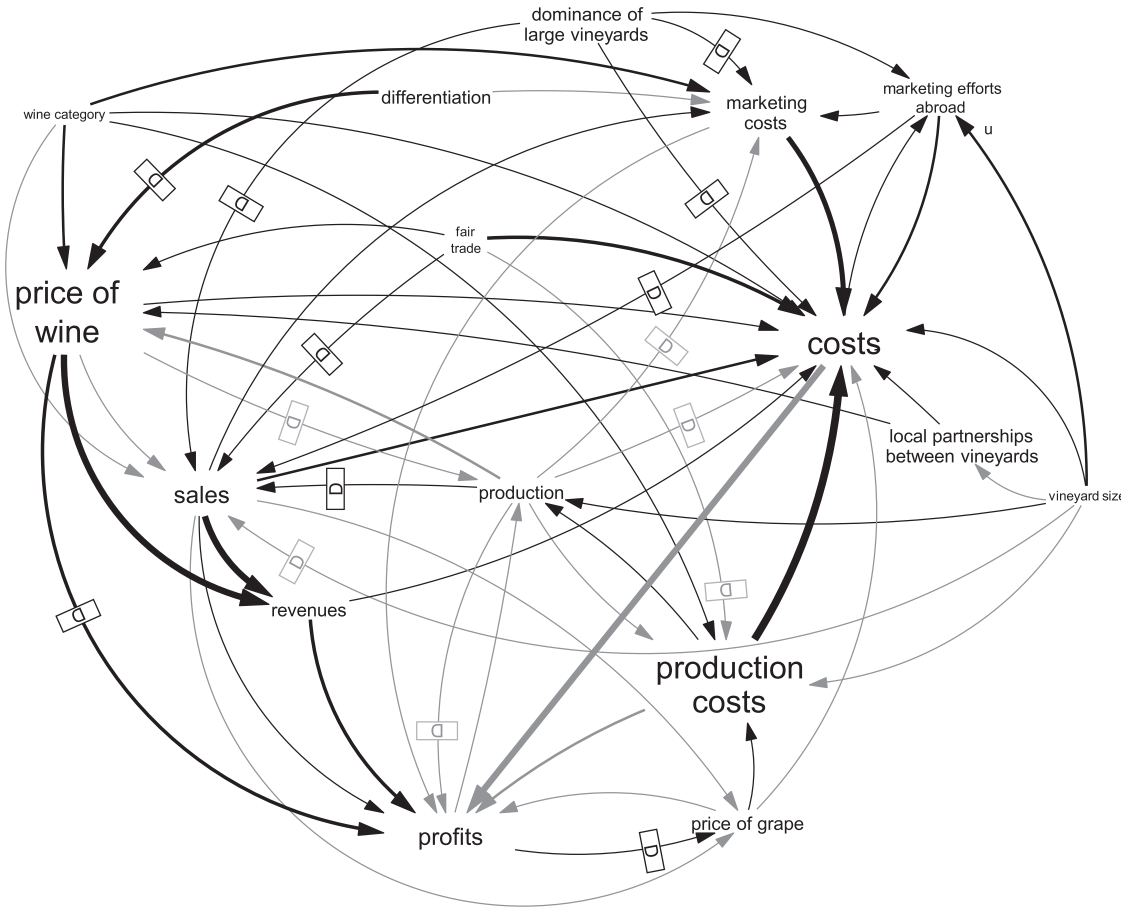

Fig. 7. Causal attributions connecting the shared variables across both groups of mental models.

which variable (column) can be reached from what other variable (row). After carrying out this procedure for G1 and G2, one can compare the cells for each pair of variables in G1 and G2. Cells receive a value consisting of two letters 'Y' and 'N' according to the following rule:

- If the cell in G1 is equal to 1, then the first letter is 'Y'; or else it is 'N';
- If the cell in G2 is equal to 1, then the second letter is 'Y', or else it is 'N'.

The resulting matrix shows the reachability of variables in G1 and G2 and allows comparing them. It is shown in Table 8. Cells representing a connection between the two concerned variables in G1 and in G2 have a dark grey background, and cells indicating the absence of connections in both groups are shaded in light grey. Cells with a white background correspond to variables that are connected in one of the groups, but not the other.

The matrix can be read by rows and by columns. Rows with only 'N' would be output variables without influence on any of the other 15 variables. Reading first in the vertical direction, there is a high degree of accordance between both model groups concerning the variables *costs*, *sales*, *profits*, *price of grape*, *dominance of large vineyards*, *revenues*, *marketing costs*, *marketing efforts abroad* and *fair trade*. With the exception of the *dominance of large vineyards* and *fair trade* – which are input variables and not influenced by any other variable in either group – these variables are influenced by all other variables in the models of G1 and G2; only *profits* appears without any influence in the remaining variables in the G1 models. In the case of *price of wine*, *production costs*, *production*, *differentiation*, *local partnerships between vineyards*, *vineyard size* and *wine category*, there is disagreement between G1 and G2 models: the sequences of attributions in G2 suggest direct or at least indirect influences, whereas G1 models do not contain such connections. *Production*, *differentiation*, *vineyard size* and *wine category* cannot be reached by the remaining variables for G1, but they are reachable in G2. Overall, there is an agreement concerning 132 of the 140 pairs of different variables, and a disagreement in the remaining 108 cases. The number of 'Y' for G1 is 103, and for G2 it is 210, revealing a higher number of connections between these 16 variables in the case of G2.

This illustrates that different mental models containing the same variables can have quite different causal attributions. Beyond the 16 variables discussed here, it would be possible to include more of the variables in the analysis; Appendix F analyzes the reachability taking into account the most relevant variables which belong to one group only.

4. Discussion

The previous section has presented the data extracted from nine mental models articulated by owners and managers of local vineyards in one Chilean region. Even though this data set has to be considered as small, it already offers a reference set of variables and causal attributions between subsets of the most relevant variables. This suggests that it is indeed possible to have a framework of variables and causal links for representing the mental models of vineyard executives, and the question (1) asking what the mental models of vineyard executives contain has received a first tentative answer.

Section 3 shows a series of detailed similarities but also differences between two groups of mental models, suggesting that even though many variables may be part of a set of mental models, the causal attributions can vary significantly. Thus, this study provides additional and detailed evidence for previous findings (Torres and Kunc, 2016). The current dataset suggests that Chilean vineyard executives reason about *costs* in very similar ways, but their thoughts concerning the *price of wine* diverge into two groups.

Indeed, the current data suggests that the differences crystalize around the *price of wine*. The differentiation between the two groups of models (compare Figs. 5 and 6) are manifest even if one examines only the attributions involving the variables shared by both groups (Table 5): 64% of the attributions of G1 do not coincide with those of G2, and 74% of the attributions of G2 are not shared by G1. Table 8 reinforced the finding that both groups diverge in their causal attributions (links and paths) more than in the variables they contain.

However, as soon as one leaves the differentiation between G1 and G2 out of consideration, it becomes clear that over the whole set of nine models, the variables are tightly interconnected. The number of cells in Table 8 containing at least one 'Y' results in 210 out of 240 cells. This becomes salient in Fig. 7, which shows the union of the causal attributions of both groups between the 16 most relevant shared variables. Size of words and the thickness of the links indicate the frequency of variables and links, respectively. Due to the elevated number of links, positive polarity is represented in black and negative polarity in grey (instead of the '+' and '−' signs).

Question (2) in the introduction asked for similarities and divergences. While these have become quite clear in Section 3, the third question remains hard to answer: can one actually detect an orientation towards one or another type of policy in these mental models, even derive indications for business policies from them? The fact of knowing that executives think of *differentiation*, *wine category*, *fair trade* and *local partnerships between vineyards* as a means to influence the *price of wine* is not sufficiently precise to speak of policies or even derive indications. Answering this question requires to narrow down the focus on single models, and probably no indications could be elaborated without engaging in a full-scale simulation modeling endeavor (Torres et al., 2017). Actually, two problem areas have been identified by inspecting individual models: the way how grape producers tend to respond to changes in the *price of grape* and the financial burden and risks inherent in the process of innovation in wine. However, these topics are beyond the current study and paper.

The last question in the introduction asked for the usefulness of mental models beyond the individual vineyard. Beyond identifying specific topics like the two mentioned recently, the current dataset concerning the variables and causal beliefs can be useful for research about strategic reasoning in two ways.

First, the current data can serve as a reference list of keywords comparable to what mental model researches search to obtain to simplify the elicitation of causal attributions (Markóczy and Goldberg, 1995; Langan-Fox et al., 2000). This means that they can be an intermediate way to articulate mental models, between open-ended interviews and pairwise comparisons: researchers can explore decision-makers' mental models by making them select an initial variable from the list, and then show the links and paths originating from this variable and make the person select the paths deemed to be relevant. For example, an executive may start by selecting from the most influential variables – like the *price of wine* and others from Table 5 – and the set of variables which influence it or are influenced by it. This can start with a map similar to the one shown in Fig. 3, but can also become as complex as the one depicted in Fig. 7. For each of the variables contained in the selected attributions, he can then repeat the unfolding of the paths originating in them, until all variables and links deemed to be relevant are included in the selection. If the executive expresses the need to add a variable, modify or add a link, the new elements can be incorporated into the database of variables and links. Each new mental model added to the nine current ones leads to the need to recalculate a series of indicators like the frequency and links of variables and the number, length, polarity, delays and weight of links. As the number of mental models increases, it will become possible to reexamine the set of groups of models, and progressively the dataset will become large enough to be amenable to statistical analysis.

This leads to a second aspect which calls for research: whereas the shared variables and links of mental models are useful for defining groups and identifying their essential characteristics, the differences between models (belonging to different groups) are allegedly relevant for understanding the differences between vineyards. This is an interesting research avenue because mental models are the underpinning of strategies, which in turn lead to different levels of performance (Gary and Wood, 2016). Some studies have inquired differences between vineyards based on the mental model approach (Torres et al., 2015; Torres and Kunc, 2016), and others have combined intervention with research (Torres et al., 2017). However, to the author's knowledge, a detailed examination of executives' mental models and their relationship to the vineyards' strategies has not been published as yet.

The mental models articulated in this study span a wide range of aspects because the framing question was broad. A more specific question, for instance aiming at marketing, would trigger the articulation of mental models with a narrower scope and an increased number of details. It is a characteristic feature of mental models that they are invoked for each particular situation (Johnson-Laird, 1983; Johnson-Laird, 2001). Therefore, a vineyard executive will not maintain and articulate one mental model, but as many as needed. However, a more specific mental model should be expected not to contradict a more general one. In this sense, it is not surprising to find that previous studies have provided some variables quite similar to the current one (Torres and Kunc, 2016): *wine sales*, *wine quality*, *country brand*, *wine production*, *firm's production capacity*, *international marketing activities* and *wine recommendations* are also part of the current study, albeit under slightly different names: *sales*, *quality*, *identification with the country brand*, *production*, *production capacity* and *marketing efforts abroad*.

The ability to store and retrieve a reference set of variables, as well as causal links (attributions) and paths available for use by researchers would be likely to enhance research: the results of individual studies would be easier to compare and to combine. Also, a basic set of processing functionalities for the frequency of variables, the classification of links (in and out) by polarity and delays, the aggregation into paths between selected variables and criteria for selecting variables as relevant would facilitate mental model research in the wine industry. A third set of functionalities refers to the articulation and mapping of mental models. For example, the current study was based on mapping with the Vensim[3] package and importing and processing with specifically programmed Mathematica[4] notebooks. Of course, an integrated toolset for articulation/mapping, processing and storing/retrieving would be desirable. First steps in this direction are planned for the near future. For the time being, the initial data set is made freely available for researchers on the CAVE website at https://vinumstrat.wordpress.com/cave/.

The variables and attributions can also be used by consultants and vineyard executives themselves. The progressive construction described in the previous paragraph allows executives to articulate their own mental model of their vineyard, which can be used as a boundary object (Black, 2013), but also as the basis for constructing scorecards and management control panels.

Even if the examination of variables and causal attributions is important to understand mental models, not everything is contained in the variables and the causal links. Recall that the dynamic behavior of systems is driven by feedback loops (Forrester, 1969), and that such loops are fundamentally important for designing business policies that do not entirely depend on external factors. Only two of the nine interviewees have mentioned such loops. However, the structure of eight of the nine mental models contains sets of interacting feedback loops unrecognized by the interviewees (Schaffernicht, 2017). Feedback loops may be hard to recognize, especially by untrained individuals. Therefore, it is also important to investigate more mental models and construct a reference set of typical feedback loops. It would also be helpful to incorporate automatic loop detection in the software tool mentioned above.

Another area of methodological advances ought to be the indirect influences. It is quite clear that exclusive focus on direct causal links can neither capture nor analyze causal influences which are transmitted over longer paths. This leads to questions like those concerning the appropriate weighting of such paths; in this study, the question has been dealt with using a plausible argumentation, but formal methods for mental model comparison still await a more thorough treatment of this question.

5. Conclusions

This study has set out to explore the mental models of nine vineyard executives, driven by curiosity to understand what they pay attention to in their medium term business environment and how they steer their companies into the future.

It has produced an initial database of causal attributions of vineyard executives – CAVE. CAVE provides a reference vocabulary of variables and causal links, which can be used by researchers as well as by executives and consultants. 218 variables have been selected out of an initial pool of over 400, because they belong to a sufficient number of models, identify a particular characteristic of a vineyard, are input or output variables or are needed for a feedback loop. A smaller subset of these variables is particularly relevant because of their frequency in the mental models or the number of causal links they participate in. Explorative analysis shows that the *price of wine* is looked upon in a divergent manner, and two groups of mental models have been identified according to this divergence. Globally, the most relevant variables are densely interconnected, even though both groups of models have quite different mental representations of the connections amongst these variables. The 551 causal links elaborated in CAVE are available together with the complete dataset of the originally elicited mental models on the Internet at vonostrat.wordpress.com.

The analysis of interconnections between variables has taken into account direct links as well as longer paths, representing indirect causal influence: leaving paths out of consideration seems to be denial of such indirect influences. However, current methods of mental model comparison do not take paths into consideration; this is an area where more methodological advances are needed.

This article has not dealt with feedback loops. This was a necessary limitation, since variables and causal links needed to be inquired. However, feedback loops are a relevant aspect of the mental models discussed here: 50 such loops are inherent in these models, and their discussion is forthcoming.

[3]www.vensim.com

[4]www.woelfram.com/mathematica

A serious limitation stems from the small sample size, which is the consequence of the time requirements of processing in-depth interviews. The variables and attributions contained in CAVE will hopefully be useful for eliciting mental models in a less time-consuming manner: a tool for selecting variables and links from the CAVE base and for storing additional mental models will be developed in the near future.

Hopefully, future research will enrich this vocabulary and incorporate the feedback loops into the reference base. An improved understanding of the strategic reasoning of executives will be used for the design and development of management tools as well as support activities like training.

There are unresolved theoretical and methodological challenges. At the level of theory, we must wonder what the relationship is between mental models which are elicited using different cues. This study prompted executives with a quite general question – which degree of coherence ought we expect when more specific business situations are evoked? Additionally in the methodological domain, the literature still needs discussion of paths as an extension of direct links, as well as of the concept 'feedback loop'.

Therefore, this article closes by inviting researchers interested in decision-making and strategy to design and carry out mental model studies.

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Appendix A. Mental model research concepts and methods

This article focuses on variables and causal links. However, the study was situated in the framework of mental models of dynamic systems (Groesser and Schaffernicht, 2012). This appendix presents a brief outline of the specifics of this type of mental models.

Considering that firms have to develop and maintain control over diverse resources, it can be argued that management situations are inherently dynamic systems (Edwards, 1962). For instance, when a good becomes scarce in a market, the price will increase; this will attract new producers and therefore the supply will increase, decreasing the scarcity and this will bring the price back to its usual value. In this example, there is an interdependence between the scarcity and the price – this is called a 'feedback loop'. As far as causal relationships are endogenous – they occur inside the conceptual boundary of a system – feedback loops are the basic system components driving behavior (Forrester, 1969; Sterman 2000).

For the purposes of studying the understanding and management of dynamic systems, a definition of 'mental model of a dynamic system' has been proposed (Doyle and Ford, 1998), criticized for its use of the term 'cognitive map' (Lane, 1999) and slightly adapted to include future systems (Doyle and Ford, 1999): "a relatively enduring and accessible, but limited, internal conceptual representation of an external system (historical, existing or projected) whose structure is analogous to the perceived structure of that system" (p. 414).

However, as stated above, a dynamic system consists of several or even many feedback loops, of which the individual variables and links are the elements. The wine industry is a dynamic system, where multiple agents and factors interact and simultaneously react to one another. Steering and developing a vineyard across times of narrowing margins therefore involves mental models of dynamic systems (MMDS), being defined as "relatively enduring and accessible, but limited, internal conceptual representation of an external system (historical, existing, or projected) in terms of reinforcing and balancing feedback loops emerging from stock, flow, and intermediary variables that interact in linear and o non-linear, delayed ways, whose structure is analogous to the perceived structure of that system" (Groesser and Schaffernicht, 2012). In this sense, a 'causal loop diagram' is a specific kind of 'causal map' which represents not only variables and causal links, but also feedback loops. The 'Distance Ratio' method has been extended to take feedback loops into account (Schaffernicht and Groesser, 2011). This is a relevant aspect for understanding and managing dynamic systems (Groesser and Schaffernicht, 2012). The general methodic approach has been published elsewhere (Schaffernicht and Groesser, 2011) and is partially automated (Schaffernicht and Groesser, 2014).

Appendix B. Variables per group of models

The article presents a selection of variables in Table 4, which is restricted to endogenous variables because input and output variables reveal less of the strategic reasoning of an executive and because the total number of variables is too large. The following Table A.1 has the same organization, but contains input and output variables, too.

Table A.1
Variables shared by both groups of models and variables only in group 1 or group 2.

G1∩G2: Variables mentioned by both groups (25 variables, 24 endogenous, 1 input): **Endogenous***: Price of wine, costs, production costs, profits, sales, production, differentiation, marketing costs, price of grape, local partnerships between vineyards, dominance of large vineyards, revenues, average quality demanded, market power of large vineyards, vineyard size, fair trade, personnel costs, wine category, identification with the country brand, associativity, liquidity, wine culture, number of artisan vineyards, marketing efforts abroad* **Input***: Alternatives to wine,*	
G1/(G1∩G2): Only group 49 (16 variables, 10 endogenous, 33 input, 5 output):	G2/(G1∩G2): Only group 2 (145 variables, 43 endogenous, 76 input, 26 output):
***Endogenous**: distributors, degree of adjustment of company size, identification with the region brand, proximity to the dealer, pressure from associated producers, efforts to find and develop distributors, growth rate of big vineyards, growth prospects of the domestic market, total debt with producers, debt with third parties.*	**Endogenous***: demand for wine, importance of volume in the majority business model, energy costs, innovation, organic vine production, mechanization, quality, territorial rootedness, investment in winemaking capacity, cost effectiveness (profitability), value added, innovative wines, consumption per capita, purchase of grapes from other producers, artificial inputs, frauds, domestic per capita consumption, failures, recognizability of the wine, sustainability, consumer desire for novelties, categorization on the market, grape sales opportunity, marketing for the company, services provided to members of the cooperative, storage capacity, mutual trust with producers, opportunity to sell wine to other vineyards, vinification for own vineyard, investment in marketing skills, grape producers related to each other, identity, leadership among the vineyards, research, estimated marketing capacity, purchase of wine from other producers, domestic demand for wine, growth target, profit sharing, shortage, marketability, sales of wine to other vineyards, wine cellaring service to other vineyards*
Input*: economic growth in major markets, international per capita consumption, authentic narrative, professionalization, mergers of distributors, age of the vineyard, price of wine in Asian market, concentration of production and marketing, costs of selling in supermarkets, degree of cultural adjustment with the distributor, price wine in niches, stability of quality, clarity of interests between the company and associated producers, clarity of processes between the company and associated producers, competitive advantages in other areas, consumer preference niches, costs of distributing to restaurants, distance from Santiago, divergence of approaches, divergence of interests, domestic price of wine, frost occurrences during the season, importance of fair trade for distributors, importance of the commercial side for finding a distributor, infrastructure supporting identity, new export markets, number of brands in supermarkets, number of large vineyards, pressure to sell in the short term, price of wine in European market, share of connoisseur consumers, term for payment to producer, work infrastructure.*	**Input***: marketing efforts in general, production area, production per hectare, demand for cellaring, demand for wine with sustainable production, natural conditions, leasing of wine cellar, taxes, labor supply, price of wine sold to other vineyards, CLP exchange rate USD, opportunity to sell wine for other vineyards, price fluctuations, export potential, number of vineyards in Chile, price of bottled wine, price of bulk wine in domestic market, price of bulk wine in export markets, development of new wines, diversification of varieties, efforts for the local community, government support, grape production unit cost for bottled wine, internal price of grapes, internal price of wine, investment in delivery capacity, production capacity for bottled wine, profitability target, restaurant, social value of wine as way of life, time to find land, time to identify appropriate variety, total integration of the process on the domain, unit cost bottled wine, unit cost of marketing bottled wine, visitor center, appropriate varieties, association of wine with getting drunk, awareness of the dangers of drinking, bulk production capacity, costs of adapting a yard to mechanized production, degree of difference of the recognized market opportunities, demand for grape, demand for identity, designation of origin, desired shortage, disposition to buy from anyone, estate bottled, Fair Trade Association, grape production unit cost for bulk wine, growth of the vineyard, importance of sustainability, increased efficiency expected from automation, increased supply from other countries, individualism of big vineyards, innovation support infrastructure, investment needed to expand own grape production, justice in deals, knowledge of consumer tastes, linkage to authentic stories, markup of domestic distributor, massiveness of distribution channels, mental propensity to innovate, population, prohibition, public contribution to innovation, public help, quality standards, relative importance of grapes for wine, risk aversion, shared brand, social importance of wine, table wine, value of tradition, volume of emerging markets, wine maturation time*
Output*: economic feasibility Asia, loss of producers willing to sell grapes, niches covered, production time, wine adaptation to market preferences*	**Output***: rural desertion, time to market, share of bottled wine, sales price stability, importance of price in the business model, economic equilibrium, grape available, difficulty of selling of differentiated vineyards, grapes for bottled wine, grapes for bulk wine, investment costs, organic wines, average boxes sold per vineyard, consolidation, external energy independence, grape production unit cost, health, impact on vineyard, improvement of genetic material, management complexity, marketing efficiency, need to establish sustainable profitability, new territories in the south, number of destination markets, regional identification with wine as part of society, tourism*

Appendix C. Glossary of the most relevant variables of CAVE

See Tables A2–A4.

Table A.2
Glossary of the variables used in the article.

	Name	Models	Links	Comment	Rank
A	*Average quality demanded*	4	5	Typical quality demanded by the majority of consumers	0,89
C	*Costs*	8	43	Costs in general (including all sub-categories)	1,00
	Demand for wine	5	24	Demand for wine in general	0,96
D	*Differentiation*	5	24	Attributes of a wine which consumers can distinguish from other wines	0,96
	Distributors	3	25	Companies which buy and distribute wine (also importers)	0,95
	Domestic demand for wine	1	3	Demand for wine in the domestic market	0,51
	Dominance of large vineyards	5	8	Ability of the big vineyards to influence prices and distribution channels in the domestic market	0,93
E	*Economic growth in major markets*	3	6	Growth if the GDP in big markets worldwide	0,84
F	*Fair trade*	3	12	Production certified to be Fair Trade	0,91
G	*Grape sales opportunity*	1	7	Opportunity to sell grapes to another vineyard (instead of making wine)	0,72
I	*Identification with the country brand*	3	7	Identification of the wine with the country (in the consumers' mind)	0,85
	Importance of price in the business model	1	4	Importance of the price of wine in the business model of vineyards (as compared to the volume)	0,57
	Importance of volume in the majority business model	4	15	Volume (of sales) in the business model of vineyards (as compared to the price of wine)	0,94
	Increased supply from other countries	1	1	Increased wine supply produced by vineyards in other countries	0,00
	Innovation	3	17	Development and marketing of new wines	0,93
	International per capita consumption	2	6	Yearly average consumption at the global scale	0,77
L	*Local partnerships between vineyards*	5	12	Partnerships amongst local vineyards to increase bargaining power or share resources and to agree on rules	0,94
M	*Marketing costs*	5	22	Costs of marketing and distribution	0,96
	Marketing efforts abroad	1	15	Efforts and costs incurred abroad to market and sell wine	0,83
	Markup of domestic distributor	1	1	Price markup applied by the distributor in the domestic market	0,00
	Mechanization	3	12	Use of machinery instead of human workforce / Automation	0,91
	Mergers of distributors	1	5	Merger of one distributor with other ones	0,62
O	*Organic vine production*	3	12	Grape growing and wine production without artificial inputs	0,91
P	*Personnel costs*	3	11	Costs of the labor force	0,90
	Price of grape	5	14	Price of a kg of grape (CLP/kg)	0,95
	Price of wine	9	32	Price of a liter of wine (CLP/ltr)	0,99
	Price of wine in Asian market	1	3	Price of wine in Asian markets (USD/ltr)	0,51
	Price of wine in European market	1	1	Price of wine in European markets (EUR/ltr)	0,00
	Price wine in niches	1	2	Price of wine (CLP/ltr) in market niches	0,36
	Production	5	24	Production of wine (leading to supply)	0,96
	Production area	3	5	Area used for cultivating wine (hectares)	0,82
	Production costs	8	22	Costs of producing wine	0,99
	Production per hectare	2	6	Grape production per hectare (kg/ha/year)	0,77
	Profits	6	31	Revenues less costs	0,98
Q	*Quality*	3	10	Quality of the wine	0,90
R	*Revenues*	5	8	Revenues in general (from selling wine or services)	0,93
S	*Sales*	6	28	Sales volume	0,98
T	*Territorial rootedness*	3	8	Committment with the terroir	0,87
V	*Value added*	3	7	Value added by the vineyard	0,85
	Vineyard size	3	16	Size of the vineyard (in sales volume, may be expressed as liters or as CLP)	0,92
W	*wine category*	3	9	Category of a wine (for instance: Premium)	0,88

Table A.3
Causal attributions of the variables of group 1 of models.

Variable 1	Variable 2	MMDS	Paths count	Path Polarity	Path delays	Path weight
Wine category	*Costs*	1	10	1	0	2,71
	Marketing costs	1	7	1	0	1,9
	Production costs	1	1	1	0	1
	Price of wine	1	3	1	0	1,33
		3	1	1	0	1
	Sales	1	6	-1	0	1,87
Fair trade	*Costs*	3	50	1	0	6,74
Costs	*Marketing efforts abroad*	5	2	1	0	0,58
	Profits	1	1	-1	0	1
		3	1	-1	0	1
		5	7	-1	0	1,57
Marketing costs	*Costs*	1	1	1	0	1
Production costs	*Costs*	1	1	1	0	1
		5	1	1	0	1
Dominance of large Vineyards	*Costs*	1	6	1	4	0,61
	Marketing costs	1	4	1	4	0,35
	Sales	1	2	1	2	0,17
Marketing efforts abroad	*Costs*	5	2	1	0	0,67
Revenues	*Costs*	3	1	1	0	0,5
	Profits	1	1	1	0	1
		3	2	-1	0	1,33
		5	1	1	0	1
Price of grape	*Costs*	3	11	-1	0	2,04
Price of wine	*Revenues*	1	1	1	0	1
		3	1	1	0	1
		5	1	1	0	1
Production	*Costs*	1	9	-1	6	0,85
	Marketing costs	1	6	-1	6	0,49
	Sales	1	3	1	3	0,24
Vineyard size	*Local partnerships between Vineyards*	1	1	-1	0	0,33
	Production costs	5	1	-1	0	1
	Marketing efforts abroad	5	3	-1	0	0,7
	Sales	5	13	-1	1	1,72
Sales	*Costs*	3	13	1	0	2,61
	Revenues	1	1	1	0	1
		3	1	1	0	1
		5	1	1	0	1
	Price of grape	3	3	-1	0	0,81

Table A.4
Causal attributions of the variables of group 2 of models.

Variable 1	Variable 2	MMDS	Paths count	Path Polarity	Path delays	Path weight
Local partnerships between vineyards	*Costs*	4	1	-1	0	1
	Price of wine	6	1	1	1	0,2
Wine category	*Marketing costs*	9	1	1	0	1
Fair trade	*Costs*	4	8	1	8	1,66
		7	3	-1	1	1,53
	Production costs	7	2	-1	1	0,75
	Price of wine	4	24	1	24	3,26
	Sales	4	12	1	12	1,97
Costs	*Profits*	2	7	-1	12	1,05
		9	1	-1	0	0,5
Marketing costs	*Costs*	4	1	1	0	1
		7	1	1	0	1
		8	1	1	0	1
	Profits	9	1	-1	0	0,5
Production costs	*Costs*	2	1	1	0	1
		4	1	1	0	1
		7	1	1	0	1
		8	1	1	0	1
	Profits	6	1	-1	0	1
		9	1	-1	0	0,5
	Production	8	1	1	0	1
Differentiation	*Marketing costs*	8	1	-1	0	1
	Price of wine	2	1	1	0	1
		4	23	1	20	3,38
		6	3	1	2	0,9
Dominance of large vineyards	*Marketing efforts abroad*	4	1	1	0	1
Marketing efforts abroad	*Costs*	4	5	1	4	1,19
	Marketing costs	8	1	1	0	1
	Sales	4	7	1	2	2,05
Profits	*Price of grape*	6	15	1	14	2,04
	Production	6	4	-1	0	1,28
Price of grape	*Production costs*	8	1	-1	0	0,5
	Profits	9	26	1	23	2,89
Price of wine	*Costs*	4	4	1	4	0,85
	Profits	2	7	1	12	1,05
		6	1	1	0	1
		9	26	-1	23	2,89
	Revenues	4	2	-1	0	0,83
		8	2	1	0	1,33

Table A.4 (*continued*)

Variable 1	Variable 2	MMDS	Paths count	Path Polarity	Path delays	Path weight
	Production	4	11	-1	10	1,52
	Sales	4	1	-1	0	1
Production	*Production costs*	6	1	-1	0	1
	Profits	6	7	-1	7	2,12
	Price of wine	4	2	-1	0	1,5
		8	1	-1	0	1
Vineyard size	*Costs*	8	3	1	0	0,92
	Marketing efforts abroad	8	1	1	0	1
	Production	8	1	1	0	1
Sales	*Costs*	*4*	*2*	*-1*	*2*	*0,48*
	Marketing costs	4	0	1	0	0
	Profits	2	1	1	0	1
	Revenues	4	1	1	0	0,5
		8	1	1	0	1

This appendix contains the alphabetical list of names and definitions of those CAVE variables which have been mentioned in the article. The number of models (frequency) and links is indicated together with a rank. The rank is defined by the following calculation: the absolute frequency is transformed into relative dividing the number of models containing a variable by the total number of models in the sample: $rf_v = frequency_v/number\ of\ models\ in\ sample$. The number of links of a variable is divided by the maximum number of links: $rl_v = links_v/\max(links)$. The $position = (rf_v + rl_v)/2$ of both indicators is then computed and the relative *position* of each variable in the range of values of *position* is used as its *rank*. The complete set of variables can be seen and downloaded from the CAVE website.

Appendix D. The most relevant variables of each group of models and their attributions

This appendix contains the data tables which have been used to generate the causal maps shown in Figs. 3, 4 and 7 of the main article. A separate table is shown for each group of mental models. Each table starts displaying the linked variables. Wherever a variable is repeated in successive rows, its name is left blank to avoid visual redundancy. The third column identifies the mental model containing the attribution. The total number of paths from variable 1 to variable 2 is indicated in paths count. Path polarity stores the compound polarity of these paths, and paths delays the total number of delayed links in these paths. The path weight is the sum of the paths' individual weights (which are calculated as 1/path length).

Appendix E. Aggregated and disaggregated paths

See Fig. A.1.

The following figure shows the part of mental model 2 that contains all variables and links which constitute paths from the *price of wine* to *profits*:

The variables *price of wine*, *innovation*, *differentiation*, *demand for wine*, *sales* and profits are bold because they belong to the set of 218 relevant variables; the remaining variables are not part of the aggregated models because they do not satisfy the criteria of being included in a sufficient number of models, of being characteristic for the vineyard or of being necessary for a feedback loop.

Many of the paths from the *price of wine* to *profits* go through the same variables and links. A search using the FindPaths command in Wolfram Mathematica produces the set of paths shown in Table A.5:

The first path has length = 2, positive polarity and its weight is ½. The remaining paths are much longer, and therefore their weights are only 1/11. They all include two causal links with a delay and their respective polarities are negative. However, the aggregated path from the *price of wine* to *profits* has positive polarity because the sum of the weights of the negative links is smaller than the weight of the positive path. The overall delays sum up to 12. These are the values displayed in Tables 6 and 7 of the main article.

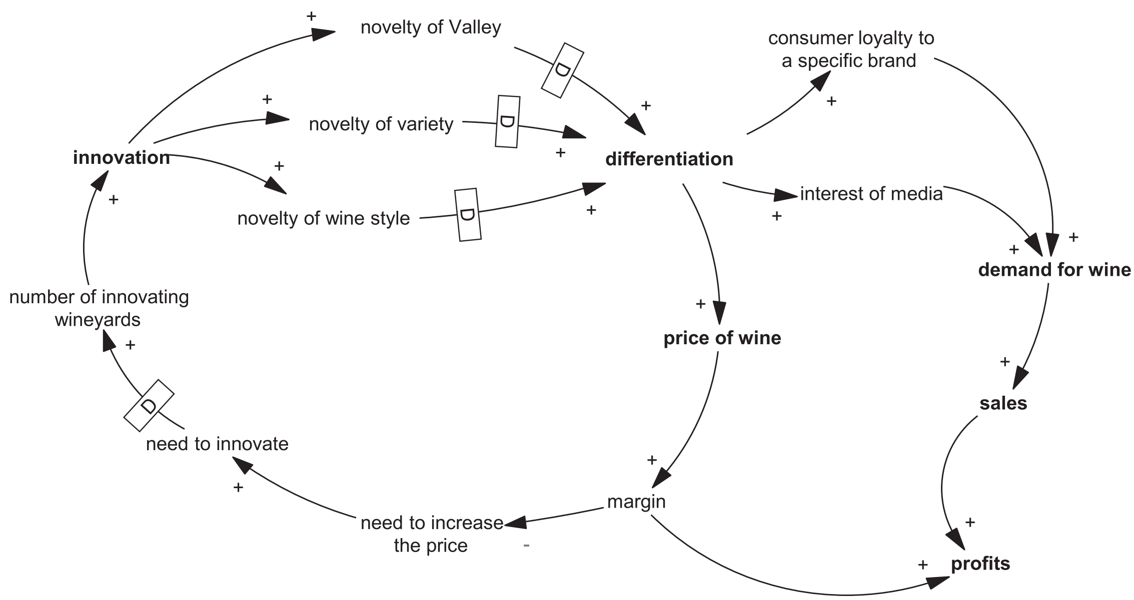

Fig. A.1. Disaggregated paths from the *price of wine* to *profits* in mental model 2.

Table A.5
Disaggregated paths leading from the *price of wine* to *profits* in model 2.

Length	Pol	Del	Weight	Path
2	1	0	0,50	*Price of wine* → *margin* → *profits*
11	-1	2	0,09	*Price of wine* → *margin* → *need to increase the price* → *need to innovate* → *number of innovating vineyards* → *innovation* → *novelty of variety* → *differentiation* → *consumer loyalty to a specific brand* → *demand for wine* → *sales* → *profits*
11	-1	2	0,09	*Price of wine* → *margin* → *need to increase the price* → *need to innovate* → *number of innovating vineyards* → *innovation* → *novelty of variety* → *differentiation* → *interes of media* → *demand for wine* → *sales* → *profits*
11	-1	2	0,09	*Price of wine* → *margin* → *need to increase the price* → *need to innovate* → *number of innovating vineyards* → *innovation* → *novelty of Valley* → *differentiation* → *consumer loyalty to a specific brand* → *demand for wine* → *sales* → *profits*
11	-1	2	0,09	*Price of wine* → *margin* → *need to increase the price* → *need to innovate* → *number of innovating vineyards* → *innovation* → *novelty of Valley* → *differentiation* → *interest of media* → *demand for wine* → *sales* → *profits*
11	-1	2	0,09	*Price of wine* → *margin* → *need to increase the price* → *need to innovate* → *number of innovating vineyards* → *innovation* → *novelty of wine style* → *differentiation* → *consumer loyalty to a specific brand* → *demand for wine* → *sales* → *profits*
11	-1	2	0,09	*Price of wine* → *margin* → *need to increase the price* → *need to innovate* → *number of innovating vineyards* → *innovation* → *novelty of wine style* → *differentiation* → *interes of media* → *demand for wine* → *sales* → *profits*

Appendix F. Analyzing paths between variables using matrices

Consider the case of the variables shown in Table 5: amongst the entire set of 218 variables, they were particularly relevant because of their frequency or their links. 16 of these variables are common to both groups, 4 belong exclusively to G1 and 9 to G2. For convenience, let us call the set of shared variables *vAll*, and the set of variables only in G1 or G2 *vG1* and *vG2*, respectively. The cause maps shown in Figs. 5 and 6 already show that most of the 16 shared variables in *vAll* are connected by multiple – though different – links. How about *vG1* and *vG2*? The three subsets can be joined to build two sets of variables which, in principle, could be related by links or paths: *vAll* ∪ *vG1* and *vAll* ∪ *vG2*. As a matter of fact, the two sets correspond to G1 and G2 – but by distinguishing the intersection between both groups, it becomes possible to compare how the shared variables are interrelated in each group.[5]

For this, it is convenient to represent the causal maps as a directed graph and show them in matrix format (Oliva, 2004). In general, a matrix representing information concerning a causal map with v variables has vXv cells; there is one row r and one column c for each variable, and each cell$_{r,c}$ represents a specific type of information about the relation between the variable in row r and the variable in column c. The map is first converted into an "adjacency matrix", representing the causal links between the variables. Based upon an adjacency matrix, a

[5]There would be no point in looking for links or paths connecting variables between the "only 1" and "only 2" groups. For instance, *vineyard size* cannot be connected to *demand for wine*, because *vineyard size* is not contained in group 2, whereas the demand for wine is not contained in group 1.

Table 9
Paths in between variables belonging the mental models of G1.

	Alternatives to wine	*Average quality demanded*	*Costs*	*Differentiation*	*Dominance of large vineyards*	*Fair trade*	*Local partnerships between vineyards*	*Market power of large vineyards*	*Marketing costs*	*Marketing efforts abroad*	*Personnel costs*	*Price of grape*	*Price of wine*	*Production*	*Production costs*	*Profits*	*Revenues*	*Sales*
Alternatives to wine	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1
Average quality demanded	0	0	1	0	0	0	0	0	1	0	0	0	1	0	1	1	1	1
Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1
Differentiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Dominance of Large vineyards	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1
Fair trade	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
Local partnerships between vineyards	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Market power of large vineyards	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Marketing costs	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Marketing efforts abroad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Personnel costs	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Price of grape	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Price of wine	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**3**	**0**
Production	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1
Production costs	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1
Profits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Revenues	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Sales	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	3	3	0
Associativity	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	1	1
Authentic narrative	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Degree of adjustment of company size	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2	2	2
Distributors	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0	3	3	3
Domestic per capita consumption	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1
Economic growth in major markets	0	0	2	0	0	0	1	0	1	0	0	1	0	1	0	3	3	3

Identification with the country brand	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	2	2	2
Identification with the region brand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
International per capita consumption	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0	2	2	2
Liquidity	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
Number of artisan vineyards	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Professionalization	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Purchase of grapes from other producers	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1
Vineyard size	0	0	2	0	0	0	2	0	1	0	0	0	0	0	1	2	2	2
Wine category	0	0	2	0	0	0	0	0	1	0	0	0	2	0	1	2	2	1
Wine culture	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1

"distance matrix" can be calculated, containing the length of the shortest path between each pair of variables. For instance, if row r of the distance matrix corresponds to the *price of wine*, and column c represents *revenues*, Then cell$_{r,c}$ of the distance matrix contains the length of the shortest path from the *price of wine* to *revenues*. If there is no path between a pair of variables, then the distance is ∞. Along the main diagonal, all distances are equal to zero. Distance matrices are convenient to understand how densely connected the variables in a model are and if there are indirect influences (paths) between variables.

In each case, we establish the distance matrix for each original model. A distance matrix contains the length of the shortest path between each pair of variables. Iterating through the distance matrices of each model belonging to one group and counting a 1 for each cell with a distance smaller than ∞, we obtain a matrix where each cell is either empty or has a value between 1 and the number of models a path between this pair of variables in this group. This allows to include longer paths, but also to detect input variables: their column is empty, because no variable in the models has an influence on them. Output variables have an empty row because they do not influence any variable. Otherwise, if a particular cell is empty, this means that the variable in this column cannot be reached from the variable in this row: there is no path or link between them.

Consider again the variables shown in Table 4; some of these variables belong to both groups, others to one group only. Examine first the case of G1, as shown in Table 8. In this table, the first rows and columns contain those variables that are common to both groups, followed by the variables which belong exclusively to G1.

Note that 8 of the 18 variables which belong to both groups (upper half of the table) are inputs for the interviewees of G1: they are perceived as part of the external environment, which cannot be influenced in a reasonable time or with a reasonable effort. Only *costs*, *local partnerships between vineyards*, *marketing costs*, *price of grape*, *price of wine*, *production*, *production costs*, *profits*, *revenues* and *sales* are endogenous. *Local partnerships* and *production* are only endogenous because of variables exclusively in models of group 1 (lower half of the table). In this case, we examine how 34 variables are connected to 18 variables. The maximum number of paths would therefore be 34*17 = 578. But of course, it cannot be reasonably expected that each variable is connected to each other variable: there are 144 such connections. 108 of the paths or links are only present in one of the 3 models belonging to group 1, 24 paths belong to 2 of these models and only 12 paths are part of all 3 models.

When looking at the case of G2, there are 47 variables: 18 shared ones and 29 which are only contained in models of the second group. Out of the 977 imaginable connections, there are indeed 372, as shown in Table 10:

This time, only three of the 18 shared variables are input variables: *alternatives to wine*, *average quality demanded* and *dominance of large vineyards*. Some variables receive notably less influences than the others: *fair trade*, *local partnerships*

Table 10
Paths in between variables belonging the mental models of G2.

	Alternatives to wine	*Average quality demanded*	*Costs*	*Differentiation*	*Dominance of large vineyards*	*Fair trade*	*Local partnerships between vineyards*	*Market power of large vineyards*	*Marketing costs*	*Marketing efforts abroad*	*Personnel costs*	*Price of grape*	*Price of wine*	*Production*	*Production costs*	*Profits*	*Revenues*	*Sales*
Alternatives to wine	0	0	1	1	0	0	0	0	0	0	1	1	2	2	2	1	1	1
Average quality demanded	0	0	1	1	0	0	0	0	0	0	1	0	2	2	1	1	1	2
Costs	0	0	0	1	0	0	0	0	0	0	1	0	2	2	1	2	1	2
Differentiation	0	0	2	0	0	0	0	0	1	0	1	1	3	3	2	2	2	3
Dominance of large vineyards	0	0	2	3	0	0	0	3	2	1	1	3	4	4	3	2	2	3
Fair trade	0	0	2	0	0	0	0	0	0	0	2	0	2	1	2	0	1	1
Local partnerships between vineyards	0	0	1	2	0	0	0	0	0	0	1	1	3	3	2	2	1	2
Market power of large vineyards	0	0	1	2	0	0	0	0	1	0	0	3	2	2	2	1	1	1
Marketing costs	0	0	4	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1
Marketing efforts abroad	0	0	1	0	0	0	0	0	1	0	1	0	1	1	1	0	1	1
Personnel costs	0	0	2	0	0	0	0	0	0	0	0	0	1	1	2	0	1	1
Price of grape	0	0	2	2	0	0	0	0	2	0	0	0	2	2	2	2	1	1
Price of wine	0	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**0**	**3**	**2**	**3**	**2**	**3**
Production	0	0	2	1	0	0	0	0	0	0	1	1	3	0	3	2	2	3
Production costs	0	0	5	2	0	0	0	0	0	0	1	1	4	4	0	3	2	3
Profits	0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Revenues	0	0	1	0	0	0	0	0	0	0	1	0	1	1	1	0	0	1
sales	0	0	1	0	0	0	0	0	0	0	1	0	1	1	1	1	2	0
Artificial inputs	0	0	2	1	0	0	0	0	0	0	0	0	2	2	2	1	1	2
Consumer desire for novelties	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	1
Consumption per capita	0	0	1	0	0	0	0	0	0	0	1	0	1	2	1	1	1	2
Cost effectiveness	0	0	1	1	0	0	0	0	0	0	1	1	2	2	2	1	1	1
Demand for cellaring	0	0	2	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1
Demand for wine	0	0	2	0	0	0	0	0	0	0	1	0	1	2	1	2	2	3
Demand for wine with sustainable production	0	0	2	0	0	1	0	0	0	0	2	0	2	1	2	0	1	1
Energy costs	0	0	3	2	0	0	0	0	1	0	1	1	3	3	4	1	2	2
Failures	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frauds	0	0	1	2	0	0	0	0	0	0	0	1	2	2	2	2	0	1

Importance of volume in the majority business model	0	0	2	1	0	0	0	0	2	0	0	1	2	2	2	2	1	1
Innovation	0	0	1	2	0	0	1	0	0	0	0	1	3	2	1	2	0	1
Innovative wines	0	0	1	2	0	0	0	0	0	0	1	1	3	2	2	1	1	1
Investment in winemaking capacity	0	0	3	0	0	0	0	0	1	0	1	0	1	1	1	1	1	1
Labor supply	0	0	1	1	0	0	0	0	0	0	1	1	2	2	2	1	1	1
Leasing of wine cellar	0	0	2	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1
Mechanization	0	0	2	2	0	0	0	0	1	0	1	0	3	3	2	1	2	3
Natural conditions	0	0	1	1	0	0	0	0	0	0	0	1	1	1	2	1	0	0
Organic vine production	0	0	3	1	0	0	0	0	0	0	1	0	3	2	3	1	1	2
Production area	0	0	2	1	0	0	0	0	0	0	1	1	2	2	3	2	1	1
Production per hectare	0	0	2	0	0	0	0	0	0	0	1	0	1	1	2	1	1	1
Quality	0	0	2	2	0	0	0	0	1	0	1	1	2	2	2	1	2	2
Recognizability of the wine	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1
Rural desertion	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Sustainability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes	0	0	1	1	0	0	0	0	0	0	1	1	2	2	2	1	1	1
Territorial rootedness	0	0	2	3	0	0	0	0	1	0	0	1	3	3	3	2	1	2
Time to market	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Value added	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2

Table 11
Reachable variables.

Reachable shared variables	**From *price of wine***		**From any shared variable**	
	Group 1	**Group 2**	**Group 1**	**Group 2**
Alternatives to wine				
Average quality demanded				
Costs	1	1	1	1
Differentiation		1		1
Dominance of large vineyards				
Fair trade				1
Local partnerships between vineyards			1	1
Market power of large vineyards				1
Marketing costs		1	1	1
Marketing efforts abroad				1
Personnel costs				1
Price of grape			1	1
Price of wine		**1**	**1**	**1**
Production		1	1	1
Production costs		1	1	1
Profits	1	1	1	1
Revenues	1	1	1	1
Sales	1	1	1	1

between vineyards, *market power of large vineyards*, *marketing costs* and *marketing efforts abroad* are much less linked than *costs*, *differentiation*, *personnel costs*, *price of grape*, *price of wine*, *production*, *production costs*, *profits*, *revenues* and *sales*. Visual inspection of the table also reveals that the variables exclusive to G2 (lower half of the table) are no less involved in the paths than are the shared variables. Overall, there are 210 paths included in one single model, 119 contained in two respective models, 37 belong to three and 6 to as many as four out of the six models of this group.

Based on the data shown in Tables 8 and 9, if the question is what the direct and indirect influences of the *price of wine* are for vineyards of groups 1 and 2, the divergence observed in Fig. 3 persists. Table 11 resumes the shared variables and indicates first (columns 2 and 3) which ones can be reached starting from the *price of wine*. As compared to G1, G2 includes *differentiation*, *marketing costs* and in particular the *price of wine*: there is a feedback loop because the *price of wine* has an indirect influence on itself. As far as loops drive the behavior of dynamic systems, the united models of G2 include a representation of one relevant aspect of the wine business which is not included in G1: the fact that any change of the *price of wine* will trigger cascading changes of the *price of wine*.

When looking at which shared variables can be influenced starting at any of the shared variables (columns 4 and 5 in Table 8), only the input variables *alternatives to wine*, *average quality demanded* and *dominance of large vineyards* cannot be influenced in group 2. However, the models of G1 cannot influence *differentiation*, *market power of large vineyards*, *marketing efforts abroad* and *personnel costs*: whereas these are endogenous variables for group 2, they are inputs (externally givens) for G1.

The entire set of data cannot be reproduced on a printed page. The aggregated models consist of 551 attributions, and since many of them are aggregated representations of several paths and of longer paths, there is a set of 2,087 disaggregated paths. Also, the causal maps of the aggregated models are too large to fit into printed pages.

Conflict of Interest

None

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