ORVin-T model description

The model developed for this study, ORVin, employs agent rules that are grounded in the above described theoretical framework. To describe this system, we use Overview, Design, and Details (ODD), a standard protocol developed by Grimm et al. (2006) for documenting and communicating ABMs. It facilities model replicability and reproducibility through supporting complete and understandable descriptions.

Model Overview

Purpose

Based on theoretical and empirical considerations, ORVin is developed to understand consumer purchasing behavior regarding organic wines. To gain insight into the process of wine consumption, the theory of planned behavior is considered along with alphabet theory and goal framing theory. This provides a solid theoretical framework for identifying behavioral factors, including beliefs, attitudes, norms, habits, and goals that may influence organic wine purchases. The model can be used to examine the effectiveness of different interventions for encouraging households to purchase organic wine instead of conventional wine. ORVin provides a dynamic platform to study the individual reaction of the disaggregated, low-level actors of the system to the hypothetical changes in the wine market such as taxation, marketing campaigns, and promotions. The cumulative impacts of changing behavior are also evaluated with respect to the environment. This model improves users' understanding of the complexity of wine purchasing decisions and helps them to interpret further and forecast organic wine market.

Entities, State Variables, and Scales

This model simulates the behavior and interactions between two agent classes: households and wine retailers. It is, in particular, used for exploring household preferences for organic wine in the City of Sydney Local Government Area, Australia. The City of Sydney is approximately 26.15 square kilometers and is home to over 103,844 estimated households with an average size of 2.2 in 2016 (Sydney, 2016).

A number of attributes characterize households[1]: (1) head of household gender, (2) head of household age, (3) household size (i.e., number of household members over 18 years old), (4) average income level, (5) highest education level, (6) head of household ability to learn (i.e., capacity of understanding new concepts, a type of intelligence), (7) geographic coordinates of residence, (8) wine shopping frequency, (9) number of bottles per purchase, (10) willingness to pay for organic wine (considered in dollar value), (11) maximum allocated budget for a bottle of wine, (12) wine knowledge (the health and environmental considerations of organic food and wine), (13) action repetitions which is the number of times an action should be repeated before it becomes a habit, and (14) frequency of revisiting PBC and social norms.

[1] The head of household means a person who normally does the wine shopping in the household.

For shop agents, we only consider two attributes 1) location and 2) wine types on sale and their prices.

For this model, two sets of control variables are defined. Users can change variables such as (1) price of products, (2) tax rate, (3) and, level of informational marketing activities (i.e., awareness and knowledge about organic wine). The production rate of organic and conventional wines and the delivery time of products are static.

ORVin is programmed in AnyLogic Software and will be available for interested researchers upon request. Most of the households report shopping wine at least once per week and thus, the time step in the model is set to one week. The simulation runs for 600 weeks, but this can be easily changed. Snapshots of the model interface at setup and during simulation are illustrated in Figure C1 and C2, respectively. A map of the City of Sydney is displayed in the model environment and all agents are placed on it (marked in orange). The organic and non-organic households are depicted as green and light blue dots, respectively, and blue houses represent five major wine retailers in the region.

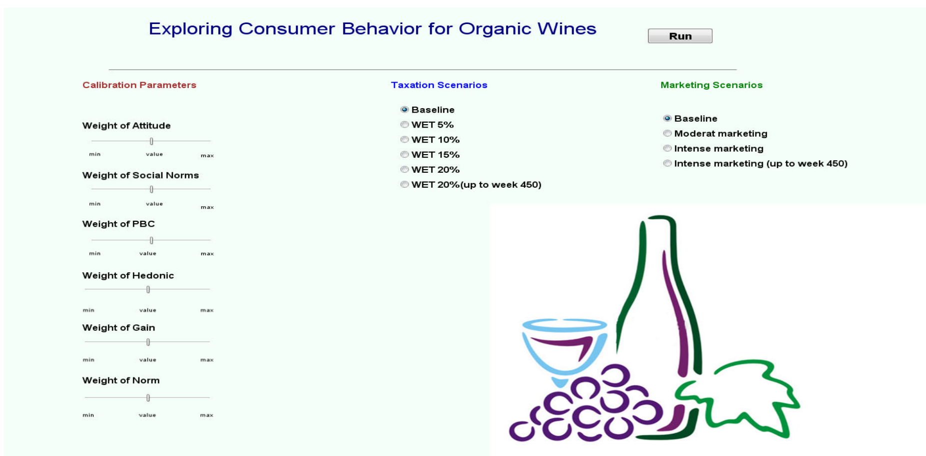

Fig C1. Model interface at set-up. Here, some of the model parameters and scenarios can be defined.

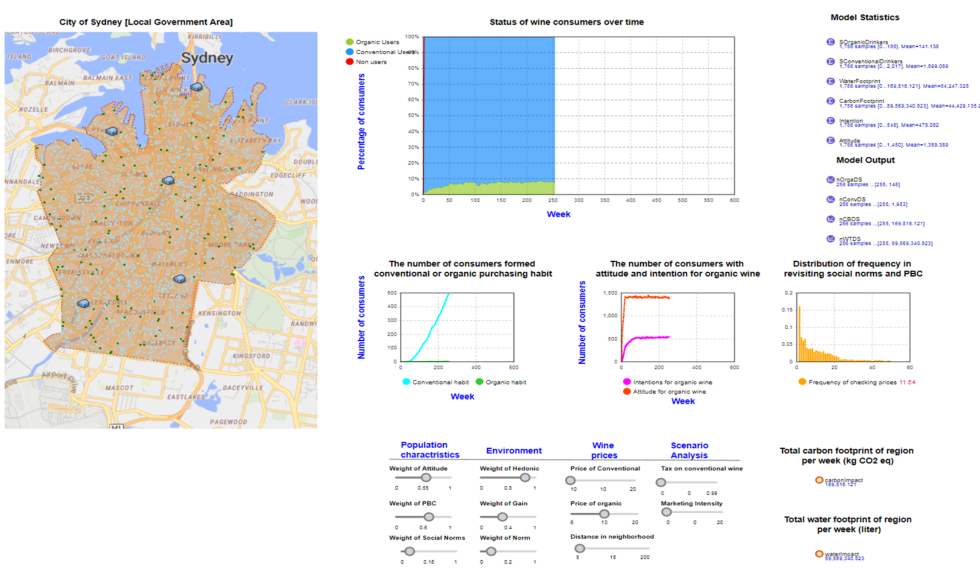

Fig C2. Model dashboard during run time. The map of the area is presented as well as the main model outputs. A number of sliders are provided to change system performance on the fly.

Process Overview

The wine shopping journey for the head of a household is schematically shown in Figure C3. They can either purchase organic or conventional wines. Based on their shopping frequency, shoppers list the available wine retailers and visit the closest one. At the beginning of the simulation, households have no preference for organic or conventional wine. When they arrive at the retailer, they first check which wine types are in stock and then compare their prices with each other and with their maximum allocated budget for wine. They choose a wine type based on a set of behavioral factors that are not based on pure rationality. Within each shopping event, four modules/ phases are processed in the following order: intention, habit, goal, and purchasing behavior (see section C.2 for details). If the price of wine is higher than the households' spending limit or if no suitable wines are in stock, they leave the shop without making any purchase.

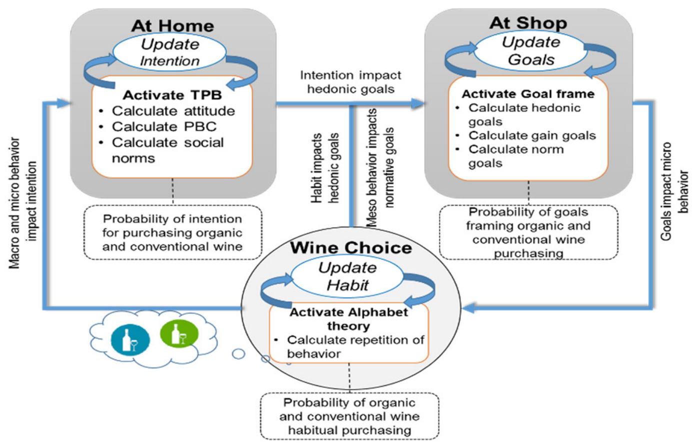

Fig C3. Household wine-related decision-making process.

Households make planned purchase decisions between organic and conventional wines, according to TPB, at home. Every time they go shopping for wine, they list the available wine retailers and visit the closest one. We assume that the retailers always meet the market demand, and no stock-out condition is allowed. The choice is made between organic or conventional wines at the shop according to the goal framing theory. The frequent wine shopping, personal norm, activates alphabet theory to consider habitual purchasing and its effect on decisions. The dynamics of changes in the wine preference of consumers emerge from the household behavior, while we impose probabilistic theoretical/empirical rules on them. Different control factors, such as the price of wines and organic informational-educational campaigns, drive changes in the behavior of wine consumers. Emergence can appear if we find that combining various control factors, we may be producing effects that go beyond adding the impacts in individual factors.

Design Concepts

Emergence

The dynamics of changes in the wine preference of consumers emerge from the household behavior, while probabilistic theoretical/empirical rules are imposed on the behavior of each household. Changes in the behavior of wine consumers are driven by different control factors such as the price of wines, and organic informational-educational campaigns. Emergence can appear if we find that combining various control factors we may be producing effects that go beyond adding the impacts in individual factors. For example, the effect of changing wine pricing while running an educational campaign can be more (or less) substantial than when we enact these strategies separately.

Adaption

On the one hand, households exhibit a set of adaptive behaviors in response to different stimuli. An important adaptive process considered for all households is learning. Once individuals are exposed to informational messages, they tend to increase their awareness about that matter and adjust their attitude accordingly. They will gradually forget newly learned information if it is not repeated. Informational marketing also influences individuals' goal-frame. Changes in price and availability of wines lead to changes in perceived behavioral control (PBC) and eventually intention, and goal-frame. Finally, habit is another adaptive behavior defined for households and is highly dependent on time and context. In the real world, humans learn by repeating an action and gaining experience. This experience emerges as a part of wine purchase decision. On the other hand, wine producers regulate the production amount considering the demand and price of organic and conventional wine. In other words, producers/retailers respond to the households' wine decisions by increasing or decreasing production rates. We assume that the retailers always meet the market demand and no stock-out condition is allowed.

Interaction

The social network of each household includes neighbors, households living up to 400-800 meters away from them, and wine shoppers at the retailer. The defined neighborhood type and buffer may influence the estimation of neighborhood effects (i.e., the effect of a particular neighborhood characteristic on wine choice) (Duncan et al., 2013; Hwang et al., 2016). In social interactions, households exchange information about wine preferences and continuously update their perceived subjective norms about wine types.

Stochasticity

Due to uncertainty in data, the initial conditions of several parameters are determined as stochastic values. The stochastic parameters involved in the model are:

- Wine shopping basket size, which is the number of bottles the household purchases per shopping trip, follows a uniform distribution over the interval [1,5] bottles;
- Maximum money to be spent on a bottle of wine is uniformly distributed in the interval [30,100] dollars;
- Leaning capacity, which indicates memory, attention and the speed of processing data in households is assigned random numbers uniformly distributed over the interval (0.0001,0.005), where 0.0001 indicates a slow learner while 0.005 indicates a quick learner;
- Depending on the number of times a household purchases wine and their habits, three uniform distributions are assigned to the probability that a household revisits their preference for organic wine (i.e., checking the price of substitute wines and observing the wine choice of the neighbors). Within the first 4 shopping events, the frequency of

checking the price of alternatives and the wine preference of neighbors is considered as a random number uniformly distributed between 1 and 4 (i.e., PBC and social norm are updated every 1 to 4 weeks). In the next 5 to 22 shopping events, as agents gain experience with purchasing wine, they check the prices and other preferences for wine less often (a uniform distribution bounded between 5 and 22 is used). Once a household gets used to a particular wine type (i.e., either organic or conventional wine habit is formed), this frequency of updating PBC and social norms reduces to once every 23 to 51 shopping events (a uniform distribution on the interval [23,51]);

- Elements involved in predicting attitude (such as health concerns, awareness about organic wine, and willingness to change) and PBC (perceived value of organic wines) are interpreted as probabilities (refer to section C.3.3 for more details);
- A triangular distribution that takes on numbers between 18 and 254 with mode 66 is assigned to the action repetition attribute indicating the minimum number of times households should purchase a particular wine type before this preference becomes a habit. In addition, a uniform distribution is used for presenting the strength of habits (refer to section C.3.3 for more details).

Observation

During the simulation, the model calculates the statistics (maximum, minimum, average, standard deviation) of organic and conventional wine consumers per week as well as the relevant the overall amount of carbon and water footprints across the period. The number of households with positive attitudes and intentions towards organic wine are presented for calibration and validation purposes. In addition, the number of households who have habitual wine purchasing behavior and the distribution of frequencies households revisit the price of substitutes and other norms are considered.

Model Details

Initialization

For initializing the model, a population of 2099 households is randomly distributed over the City of Sydney. We locate one wine retailer for each of five major suburbs of this area according to a Google map. The shops are assumed to sell similar wines for the same prices (there is no difference between the wine shops in the model). We discuss in C.1.2 the exact values of state variables based on data and in C.2.4 the initial values chosen arbitrarily. Since some of the initial values are set stochastically, the model initialization is not always the same and it varies between simulation runs.

Input Data

For household agent parametrization, we use the results of Ogbeide (2013) field experiment on Australians' interest in organic wine. He used a sample of 2099 responses (representative of the Australian population) to understand the factors affecting the willingness to pay for organic wine. The details of the initial values obtained from field experiments are listed in Table C1. The correlations between gender and household age, income, and education level are considered.

Organic and conventional wine prices are set based on data provided by the Australian Government via Wine Australia Website (https://www.wineaustralia.com/). In order to reap a 50 percent profit margin, conventional and organic wines are retailed at minimum AU$10.00-13.00 (approximately US$8-10) per bottle, respectively (taxes included). These base prices are also used by Ogbeide et al. (2015) for exploring the Australians' willingness to pay premiums. Wine Australia reports that people are willing to pay 20-30% more for a bottle of organic wine. We assume that the selling price of wine at farmer doors and retail stores are the same. In real markets, wines at cellar doors are usually cheaper (by at least 20%) than in bottle shops.

Table C1. Field experiment data from (Ogbeide, 2013)

Gender	**%%**	**Income**	**%%**	**Household size (above 18)**	**%%**
Male	61.5	Less than 50,000	31.8	Single	14.5
Female	38.5	50,001-100,000	62.6	2	56.3
Age	**%%**	More than 100,001	27	3	15.81
18-34	17	**Education**	**%%**	4 and more	13.33
35-54	41.7	School-High school	26.8	**Willingness to pay for organic wine**	**%%**
55 and more	41.3	Diploma-Bachelor	62.6	0-10%	15
Frequency of wine consumption	**%%**	Master-Doctorate	10.6	10%-20%	15
Everyday	16.48	**Wine Knowledge**	**%%**	20%-30%	22
A few times a week	44.35	Relatively low	4	30%-40%	12
Once a week	23.73	Medium	64	40%-50%	8
Once a fortnight	8.48	Relatively high	32		
Once a month and more	6.96				

Sub-Models

Here, we include a more detailed explanation of the decision-making processes of our household agent (an overview is presented in C.1.3). A list of all notations used in sub-models is provided in Table C2.

Table C2. List of notations used in the model and their description

Variables	Definition
F_{Ai1}(t)	Household i health belief at time t
F_{Ai2}(t)	Household i environmental awareness about organic wine at time t
F_{Ai3}(t)	Household i wine drinker types at time t
F_{Ai4}(t)	Household i willingness to change at time t

W_{A1}	Weight of health belief
W_{A2}	Weight of organic awareness
W_{A3}	Weight of type of drinker
W_{A4}	Weight of willingness to change
F_{Ai}(t)	Household i attitude at time t
F_{Pi1}(t)	Household i perceived economic value of organic wine at time t
F_{Pi2}(t)	Household i perceived availability of organic wine for at time t
W_{P1}	Weight of price
W_{P2}	Weight of availability
F_{Pi}(t)	Household i PBC for organic wine at time t
F_{Spoi}(t)	Total number of household i 's neighbors with organic wine preferences at time t
F_{Spi}(t)	Total number of household i 's contact network at time t
F_{Si}(t)	Household i subjective wine norm at time t
W_S	Weight of subjective norms
W_A	Weight of attitude
W_P	Weight of PBC
F_{Ii}(t)	Household i intention for wine at time t
NE_i^o(t)	The number of times household i purchased conventional wines at time t
NE_i^c(t)	The number of times household i purchased conventional wines at time t
H_i^o(t)	Households i habitual purchasing of conventional wine at time t
H_i^c(t)	Households i habitual purchasing of conventional wine at time t
FH_i^o(t)	Household i hedonic goal for organic wine at time t
FH_i^c(t)	Household i hedonic goal for conventional wine at time t
FG_i^o(t)	Household i gain goal for organic wine at time t
FG_i^c(t)	Household i gain goal for conventional wine at time t
F_{Sqoi}(t)	The ratio of conventional wine shoppers to total wine shoppers with household i at shop j at time t
F_{Sqci}(t)	The ratio of organic wine shoppers to total wine shoppers with household i at shop j at time t
FN_i^o(t)	Household i organic wine normative goal at time t
FN_i^c(t)	Household i organic wine normative goal at time t
W_N	Weight of normative goal
W_H	Weight of hedonic goal
W_G	Weight of gain goal
GO_i(t)	Household i organic wine goals at time t
GC_i(t)	Household i conventional wine goals at time t

❖ Intention

As shown by previous research, three main factors, including attitude, social norms, and perceived behavioral control determine the intention of agent i. Agents are different in terms of attitude towards organic food, willingness to pay more for organic wine as well as social network size. According to Squazzoni, Jager, & Edmonds (2013), these differences can generate heterogeneity in the population. WA, WP, WN indicate the relative importance of individual preference, social influence and contextual factors on the intention of agents for wine-related decisions. These weights are determined by model calibration, but this does not mean at all that the agents have the same intention. A similar rationale can be found in the study of Kniveton, Smith, & Black (2012) and Scalco et al. (2017) where these weights are determined by a regression method. In addition, our model focuses only on the City of Sydney Local Government Area, which encompasses only a few suburbs of the great Sydney. This spatial scale (Local Government Area) is one of the smallest socio-economic subdivisions in the Australian Bureau of Statistics. So, we assume that there are no significant differences between the suburbs of this statistical region (with regards to the weights of factors).

Attitude: Schäufele and Hamm (2017) reported demographics and information/knowledge-seeking as two main factors influencing the consumer attitude toward wine with sustainability attributes. Regarding demographics, researchers partially agreed that gender and income are two important characteristics determining the organic wine choice (D'Amico et al., 2016). Females with higher income levels have a more positive attitude towards purchasing organic wine. Regarding the relationship between age and organic wine purchasing attitude, the findings are conflicting. While some researchers reported no correlation between age and attitude to buying organic wine (D'Amico et al., 2016), others found a higher willingness to pay in younger people (Bernabéu et al., 2008; Sogari et al., 2015). Research on the food preference of Australians indicates that millennials are more willing to purchase a range of organic products (including wine). Their growing interest in organics may be explained by their higher concern for individual and family health, diet and food quality (Lawson et al., 2018). Aertsens et al. (2011) showed that highly educated people have a higher level of knowledge about organic farming and environmental/health issues. Therefore, a high level of awareness encourages a positive attitude towards buying organic food.

In a series of exploratory studies, Melo et al. (2010), Melo et al. (2011), and Melo et al. (2012) studied the relationship between wine drinking history and attitude towards wine to predict the future wine consumption pattern. Based on drinking frequency they categorized wine consumers into low, intermediate and high consumption groups. Lower and intermediate consumption groups drink less than 933 ml/week (approximately 5 wine bottles/month) and from 933 to 2000 ml/week (between 5 and 10 wine bottles/month), respectively, whereas, high consumption group takes more than 10 bottles per week (above 2000 ml/week). For low consumption group, personal reasons for drinking (e.g., coping with tension, enhancing mood) are not a priority. They rather consume wine as a part of social life and are inspired by occasions and social events (e.g., gathering, gift giving) (Melo et al., 2010). Boncinelli et al. (2019) highlight that organic attitude of social drinkers is relatively greater than both moderators and high drinkers.

The willingness of people to change their choice is another factor influencing the attitude (Harmon-Jones & Mills, 1999). The theory of cognitive dissonance (Festinger, 1962) explains that once the intention and behavior are inconsistent, a willingness to change will arise. People experiencing an inner inconsistency or discrepancy (a distance between intention and behavior) tend to change either their intention or behavior depending upon their strength. The closer the distance of intention and behavior, the higher the resistance to change a behavior one faces (Jager & Mosler, 2007). In our model, we assume that for households who have a willingness to change, the behavior is stronger than intentions.

Consumer attitude is defined as follows:

$F_{Ai}(\mathrm{t}) = W_{A1}F_{Ai1}(\mathrm{t}) + W_{A2}F_{Ai2}(\mathrm{t}) + W_{A3}F_{Ai3}(\mathrm{t}) + W_{A4}F_{Ai4}(\mathrm{t});$ (Equation C1)

where $0 \le F_{Ai1}(\mathrm{t}), F_{Ai2}(\mathrm{t}), F_{Ai3}(\mathrm{t}), F_{Ai4}(\mathrm{t}), F_{Ai}(\mathrm{t}) \le 1$; $0 \le W_{A1}, W_{A2}, W_{A3}, W_{A4} \le 1$;

$\sum_{i=1}^{4} W_{Aj} = 1$; i=1, …, n.

F_{Ai1}(t) is the health concern of household i at time t, and is a function of their age, gender, and income level. F_{Ai2}(t), organic wine awareness of household i at time t, is a function of education and wine knowledge. F_{Ai3}(t) determines which drinker type household i is at time t by calculating the average number of drinks the household members have per week. F_{Ai4}(t), is the estimation of household i willingness to change at time t. This parameter is utilized to assess the strength of disagreement between intention and behavior. In all presented formulas, n is the total number of households. We assign almost equal weights to health concern (W_{A1}weight of health concern), wine awareness (W_{A2}weight of organic awareness), and drinker type (W_{A3}weight of type of drinker), and a considerably smaller weight to willingness to change (W_{A4}weight of willingness to change). Equation C1 evaluates the attitude of individual i towards organic wine at time t. The values of all attributes and weights used in the formula are set up between 0 and 1, to make the outputs comparable. The sum of the weights is equal to 1.

Perceived behavior control: In predicting the perceived ease and difficulty of organic wine purchase, two critical elements are price and availability. A recent study on the relationship between organic wine and price found no that certified organic does not necessarily receive a price premium (Abraben et al., 2017). Lawson et al. (2018) consider price as the main barrier to purchasing organic products in Australia. The conjoint analysis studies on food revealed that increasing the availability of organic food at shops could create a higher preference for healthy food consumption (He, Tucker, Gilliland, et al., 2012; He, Tucker, Irwin, et al., 2012). Similarly, for organic wine shopping behavior, availability is noted as a comparatively less influential factor in purchasing organic food for Australians (Lawson et al., 2018). Among the entire hindering factors for purchasing organic products, price is the main issue while availability is listed fifth (Lawson et al., 2018).

The described elements interact as in:

$F_{Pi}(\mathrm{t}) = W_{P1}F_{Pi1}(t) + W_{P2}F_{Pi2}(t);$ (Equation C2)

where $0 \le F_{Pi1}(\mathrm{t}), F_{Pi2}(\mathrm{t}), F_{Pi}(\mathrm{t}) \le 1$; $0 \le W_{P1}, W_{P2} \le 1$; $\sum_{j=1}^{2} W_{Pj} = 1$; i=1, …, n.

Here, F_{Pi1}(t), the household i perceived the economic value of organic wine at time t, is a function of organic wine price, conventional wine price, and the willingness to pay a price premium for organic wine. F_{Pi2}(t), household i perceived the availability of organic wine at time t, is a function of the ratio of organic and non-organic wine bottles available in the shops stock.

We assume that the proportion of organic to conventional wines is always equal in all shops. Therefore, the weight of price (W_{P1}) is considered to be 1 and the weight of availability (W_{P2})is set to 0. Equation C2 indicates the household i perception of their ability to purchase wine at time t (F_{Pi}(t)) is bounded between 0 and 1. The sum of price and availability weights should be equal to 1.

Social Norm: Drinking wine with friends, family, or workgroups internalizes the social norms for wine consumption and preferences in individuals. Although researchers have already shown a strong relationship between socio-cultural norms and drinking behavior (Nwagu et al., 2017; Sudhinaraset et al., 2016), there are a few studies examining the influence of social pressures on purchasing organic wine (Thøgersen, 2002). Social desirability can be an impetus for consumers' wine choice, especially when a wine is purchased for particular occasions or as a gift. In these situations, people often seek to satisfy social norms rather than personal preferences. Boncinelli et al. (2019) report that on gift-giving occasions, the probability of choosing organic wine is much higher than personal use. Researchers such as Johe and Bhullar (2016) emphasize that subjective appraisals of a reference group are a crucial predictor of organic wine purchasing intention. Here, we examine the impact of subject norms on buying organic wine.

F_{Si}(t), the household i subjective wine norm at time t, is calculated as:

$$F_{Si}(t)=\frac{F_{Spoi}\,(t)}{F_{Spi}(t)}\,; \qquad \text{(Equation C3)}$$

where 0 ≤ F_{Si}(t) ≤ 1; i=1, …, n;

F_{Spoi}(t) is the number of neighbors with organic wine preferences and F_{Spi}(t) is the total number of household i's contact network at time t. F_{Si}(t) higher than 0.5 represents organic wine as the norm while values less than 0.5 indicate that conventional wine is the perceived subjective norm. Equation C3 determines which norm (i.e., organic or conventional) can guide a household decision to buy organic wine.

Intention: In TPB, factors including attitude, subjective norms, and perceived behavioral control shape the intention. An intention equal or higher than 0.5 refers to the preference for organic wine, while intention less than 0.5 refers to the preference for conventional wine.

F_{Ii}(t), the intention of household i for purchasing either organic or conventional wine is calculated as:

$$F_{Ii}(t)=\frac{(W_A F_{Ai}(t)+W_P F_{Pi}(t)+W_S F_{Si}(t))}{(W_A+W_P+W_S)}\;; \qquad \text{(Equation C4)}$$

where 0 ≤ F_I(t) ≤ 1; 0 ≤ W_A, W_P,W_S≤ 1; i= 1, ..., n.

Here,W_A the weight of attitude,W_P the weight of perceived behavioral control, and W_S the weight of subjective norms on intention are limited between 0 and 1. Equation C4 assesses whether household i purchase to purchase organic wine, where an intention equal or higher than 0.5 is interpreted as organic wine purchase intention.

❖ Habit Formation

Habit concept has high relevance to wine purchasing behavior (Pomarici & Vecchio, 2014; Vecchio, 2013). For many years, habits have been evaluated through the past behavioral frequency of action in a stable context. Recently, researchers have criticized this method because it fails to explain whether a repeated action is deliberate or habitual (Lally & Gardner, 2013). For example, a doctor may prescribe the same medicines to patients frequently, but it is not his habit. Thus, researchers have proposed atomicity, a complementary discourse to distinguish between habitual and non-habitual actions (Lally et al., 2011). Habit formation follows an asymptotic curve, as a remarkable increase can be observed in behavior automaticity in the initial repetitions, and the automaticity growth rate gradually reduces until the behavior approaches its limit of automaticity (i.e., asymptote to be reached). In an experimental study about the impact of habit on promoting healthy eating and drinking behavior, Lally et al. (2010) found that for reaching up to 95% of the asymptote of atomicity, on average, 66 repetitions are required within a range between 18 to 254.

We assume that habitual purchasing behavior can be activated in all households. The behavioral rules for describing the habit formation in individual i is defined as in:

if (NE_i^o(t)> action repetition AND NE_i^c(t)< (0.3*NE_i^o(t))) (Equation C5)

then (H_i^o (t)=uniform (0.7, 0.9, Randomness) AND H_i^c (t)=0); i= 1, ..., n.

Here, the number of times household i purchased organic (NE_i^o(t)) and conventional wines (NE_i^c(t)) up to time t are counted. If NE_i^o(t) is higher than the number of repetitions required to approach behavior automaticity (i.e., action repetition attribute in the model), and if NE_i^c(t) is smaller than 30% of NE_i^o(t), it is highly probable that household i purchases organic wine habitually at time t (presented as H_i^o(t)). The first condition of Equation C5, on the one hand, satisfies that the number of times organic wine purchased by household i is sufficient to drive purchasing automaticity. The second condition, on the other hand, assures that the conventional wine purchasing of household i is occasional and does not interrupt the organic wine habit formation. If both conditions are met, then with a high probability household i purchases organic wine habitually at time t (H_i^o (t)). If the second condition changes to NE_i^c (t) between 30% and 50% of NE_i^o(t), then a weak habitual organic wine purchasing is considered for household i at time t. We apply similar logic for estimating the likelihood of habitual purchasing of conventional wine at time t (H_i^c(t)). Following, we explain how the goal frame is activated, and how does it interfere with habits if any.

❖ Goal-Frame

In the environmental psychology discipline, there are few articles examining the impact of conditional factors on decisions, systematically (Steg & Vlek, 2009). Contextual factors such as price, availability, market forces, trust, grape variety, sales channel, and package can significantly influence organic wine purchasing behavior and mediate the relationship between intention and behavior (Ogbeide, 2013; Schäufele & Hamm, 2017). The goal-framing theory assists us to analyze the mediating effect of context on wine preferences. We discuss this theory in Appendix B.

In ORVin, three overarching goals, which are hedonic, gain and norm guide the wine choice of consumers. At any point in time, a combination of activated goals determines the perception and action of the individual. Personal interests, egoistic values, and enjoyment drive hedonic goals. Predicting the hedonism of households is difficult since measuring the emotions and pleasure is complex. It is not obvious what factors cause immediate pleasure and a sense of leisure in wine consumers. What we know so far is that when a person's decisions and actions are aligned with their intention, they have less internal disagreement (self-discrepancy), more satisfaction and self-fulfillment. Therefore, we assume that the value of hedonic goal for organic (FH_i^o(t)) and conventional wine (FH_i^c(t)) at time t are determined by either intention or habit depending on which one drives the behavior.

If the habit of household i is stronger than his/her intention at time t, then with a high probability, habitual behavior guides the behavior and considered as the value of hedonic goals. Moreover, if a strong habitual behavior exists, only under a stronger intention/motivation or interrupted purchasing pattern, this habit will be changed.

In the gain goal-frame, the individuals choose the most convenient or cheapest options available. For example, Vining and Ebreo (1992) showed that by changing contextual factors such as accessibility to recycling facilities, the individuals' gain goals become stronger. Minimizing expenditure is a popular objective for initiating gain goals for purchasing decisions. Here, we consider price as the main contextual factor influencing the wine preferences of households. By dividing the price of organic wine into the price of conventional wine and normalizing it, we estimate the organic gain goal of household i (FG_i^o (t)) and vice versa for conventional gain goal at time t (FG_i^c(t)). Changing the price of wines is well towards influencing the gain goals of consumers.

For modeling the effect of normative motive, we assess social dynamics based on individuals' observations at the wine shop. For example, observing neighbors sweeping the front door sidewalk increases the cleanness norms which eventually create a stronger normative goal (Steg et al., 2016). In our model, household i observes the wine choice of other shoppers at the wine shop. This observation influences the wine norms of households and their purchasing decisions. F_{Sqoij}(t) and F_{Sqcij}(t) are the ratio of organic and conventional wine shoppers household i notices at shop j at time t. Household i organic ($FN_i^o(t)$) and conventional wine norm goals (FN_i^c(t)) at time t are considered as the average of perceived organic and conventional norms at the shop j and in the neighborhood at time t ($F_{Si}(t)$). Advertising campaigns and marketing guide the preference of consumers through affecting the normative goal of consumers.

A weighted aggregation of described elements is considered for determining how much household i values organic and conventional wine at time t as in:

$$GO_i(t)= \frac{(W_H FH_i^o(t)+W_G FG_i^o(t)+W_N FN_i^o(t))}{(W_H+W_G+W_N)} \qquad \text{(Equation C6)}$$

$$GC_i(t)= \frac{(W_H FH_i^c(t)+W_G FG_i^c(t)+W_N FN_i^c(t))}{(W_H+W_G+W_N)}$$

where $0 \le GO_i(t), GC_i(t) \le 1$; $0 \le FH_i^o(t), FH_i^c(t), FG_i^o(t), FG_i^c(t), FN_i^o(t), FN_i^c(t) \le 1$;

$0 \le W_H, W_G, W_N \le 1$; i= 1, ..., n.

Here, W_H, W_G, W_N denote the weight of hedonic, gain and norm goals, respectively. The values of all equation elements are bounded between 0 and 1. Equation C6 determines the preference of household i at time t by considering organic and conventional wine pay off (GO_i(t) versus GC_i(t)). If the value of organic goal is bigger than the non-organic goals at time t (GO_i(t)≥GC_i(t)), then the household i prefers organic wine over conventional, and vice a versa. Table C3 provides the complete set of rules used to define wine purchasing decisions.

Table C3. Pay-off structure for consuming organic and conventional wine

Goals	**If the planned decision of i is organic wine**	**If the planned decision of i is conventional wine**
FH_i^o**(t)**	If (intention organic i at time t >= habit organic i at time t), then, intention organic i at time t, else 1.	Intention organic i at time t.
FH_i^c**(t)**	Intention conventional i at time t.	If (intention conventional i at time t >=habit conventional i at time t), then, intention conventional i at time t, else 1.
FG_i^o**(t)**	1-[(price of organic wine perceived at time t-willingness to pay more) /(price of organic wine+price of conventional wine)].	1-[(price of organic wine perceived at time t -willingness to pay more) /(price of organic wine+price of conventional wine)].
FG_i^c**(t)**	1-[(price of conventional wine perceived at time t) /(price of organic wine perceived at time t +price of conventional wine perceived at time t)].	1-[(price of conventional wine perceived at time t)/(price of organic wine perceived at time t +price of conventional wine perceived at time t)].
FN_i^o**(t)**	An average of the number of organic shoppers at time t and F_{Si}(t).	An average of the number of organic shoppers at time t and F_{Si}(t).
FN_i^c**(t)**	An average of the number of conventional shoppers at time t and F_{Si}(t).	An average of the number of conventional shoppers at time t and F_{Si}(t).

ORVin-E model description

In contrast, we develop ORVin-E by modifying some of the behavioural assumptions associated with ORVin, given the insights from the survey (Figure 3). Namely, the modifications concern (i) introducing new parameters to the structure of sub-models, in PBC, habit and normative goal functions; (ii) relaxing assumptions of attitude, social norms and gain goals calculations; and (iii) calibrating the model with empirical data for intentions and behavior. For agent parameterization, we use empirical data related to socio-demographics, shopping-drinking patterns and behavioral factors to feed this model (the previous section reported the details of these factors and their values). Below, we provide a brief description of the applied changes in the sub-models. Notably, the equations for estimating intention ($F_{Ii}(t)$) and goal frame ($GO_i(t), GC_i(t)$) remain unchanged in ORVin-T and ORVin-E. For more information, please refer to the ODD protocol in Taghikhah et al. (2020b). In all equations, *i* = 1, … , *n*, where *n* is the total number of consumers and *j* = 1, … , *m*, where *m* is the total number of shops.

- <u>Attitude</u>

In ORVin-T, for estimating attitude ($TF_{Ai}(t)$), we use an average of health concern, environmental belief, and drinker type, all of which are estimated based on age, gender, income level, education, wine knowledge and shopping frequency from our survey. In addition, the willingness to change for agent *i* is approximated by the theory of cognitive dissonance (Festinger 1962; Appendix C.3.3 in Taghikhah et al. 2020).

In ORVin-E, we estimate the attitude ($EF_{Ai}(t)$) of agent *i* based on disaggregated survey data as:

$$EF_{Ai}(t) = Average\ (EF_{Ai1}(t),\ EF_{Ai2}(t), EF_{Ai3}(t)); \qquad \text{(Eq.1)}$$

where $EF_{Ai1}(t)$, $EF_{Ai2}(t)$, $EF_{Ai3}(t)$ are consumer *i*'s health concern, environmental awareness, and trust in organic products at time *t*, respectively. Every time agents leave their house to go wine shopping, they recalculate their current individual attitude, except if they have reported no willingness to change their attitude in the survey.

- <u>Perceived Behavioral Control</u>

In predicting the perceived ease or difficulty of organic wine purchase, price and availability are amongst the most influential factors. In both ORVin-T and ORVin-E, PBC is only a function of perceived price elements (including organic wine price, conventional wine price and the willingness to pay a price premium for organic wine). Therefore, the importance of availability is excluded from both models because no stock-out condition is allowed. While ORVin-T considers the weight of price on PBC is equal to 1, ORVin-E extracts this parameter from the survey. The formulation of PBC ($EF_{Pi}(t)$) in ORVin-E is as follows:

$$EF_{Pi}(t) = \ EW_{Pi}EF_{Pi1}(t); \qquad \text{(Eq. 2)}$$

Here, EW_{Pi} refers to the importance of wine price to consumer *i* and $EF_{Pi1}(t)$ is their perceived economic value of organic wine at time *t*.

- Social norms

Drinking wine with friends, family, or workgroups internalizes the social norms for wine consumption and preferences in individuals.

In ORVin-E, the perceived subjective norm of consumer *i* ($F_{Si}(t)$) is calculated as:

$$EF_{Si}(t) = EW_{Si}\frac{F_{Spoi}(t)}{F_{Spi}(t)}\ ; \qquad \text{(Eq. 3)}$$

where $EF_{Spi}(t), EF_{Spoi}(t)$ are the total number of consumer *i*'s contact network and those of them who are organic consumers at time *t*, respectively. In contrast to the ORVin-T, where consumers interact with neighbors after every shopping journey, in ORVin-E, consumers only update their norm when they talk to others about wine. EW_{Si} is the influence of advice from friends and family on the wine decision of consumer *i* (extracted from the survey), which is excluded from ORVin-T.

- Habit

The *habit* concept is highly relevant to wine-purchasing behavior (Pomarici & Vecchio 2014; Vecchio 2013). Habit formation follows an asymptotic curve, as a remarkable increase can be observed in behavior automaticity in the initial repetitions, and the automaticity growth rate gradually reduces until the behavior approaches its limit of automaticity (i.e., asymptote to be reached). The ORVin-T model assumes all consumers could develop habitual purchasing. A triangular distribution that takes numbers between 18 and 254 with mode 66 is assigned to the action repetition attribute indicating the minimum number of times households should purchase a particular wine type before this preference becomes a habit.

To ensure the estimation of habit function is consistent with the empirical data in ORVin-E, we modify the function as:

$$\begin{Bmatrix} H_i^o(t) = min\,(uniform\,(0.7, 0.9, Randomness), H_i^e); & if\ (NE_i^o(t) > R_i\ and\ NE_i^c(t) < (0.3 * NE_i^o(t))) \\ H_i^o(t) = 0; & else \end{Bmatrix} \qquad \text{(Eq. 4)}$$

Here, H_i^e is the degree of habitual purchasing for consumer *i* derived from the survey to prevent agents from developing habits based only on repetitions of behavior (R_i). NE_i^o(t) is the number of times consumer *i* purchased organic wine and $H_i^c(t)$ is the habitual purchasing of conventional wine for consumer *i* at time *t*. A similar equation is used to update conventional wine-purchasing habits.

- Hedonic goals

Personal interests, egoistic values and enjoyment drive hedonic goals. Predicting the hedonism of households is hindered since it is difficult, if not impossible, to measure emotions and pleasure. In ORVin, we assume the value of hedonic goals for organic and conventional wine is determined by either intention or habit, depending on which one drives the behavior. If the habit of household *i* is stronger than his/her intention at time *t*, then with a high probability, habitual behavior guides the action and is considered the value of hedonic goals. Moreover, if a strong habitual behavior exists, only under a stronger intention/motivation or interrupted purchasing pattern, this habit will be changed.

In ORVin-E, however, we estimate the hedonic goals (FH_i^o(t)) of agent *i* by explicit consideration of survey data as:

$$FH_i^o(t) = F_{Ii}(t)\ Average\ (F_{Hi1}(t),\ F_{Hi2}(t), F_{Hi3}(t)); \qquad \text{(Eq. 5)}$$

where $F_{Hi1}(t),\ F_{Hi2}(t),\ F_{Hi3}(t)$ refer to noticing a distinction between organic and conventional wine, tasting different flavors for them, and enjoying drinking organic, respectively. Based on the concept of 'alternative hedonism' (Caruana et al. 2019) and supported by correlation analysis results (Taghikhah et al. 2020a), we assume hedonistic-driven behavior can be moderated by intention. A similar equation is applied to estimate the conventional hedonic goals.

- Gain goals

In the gain goal-frame, the individuals choose the most convenient or cheapest options available. Minimizing expenditure is a popular objective for initiating gain goals when making purchasing decisions. In ORVin-T, we estimate the organic versus conventional gain goal of agent i by dividing the price of organic wine into the price of conventional wine and vice versa for organic gain goal.

In ORVin-E, to find out the strength of gain goals, our survey asks whether respondents substitute their preferred wine type if its price increases. If consumer i has willingness to switch (WTC_i) to other wine types, we assume that the gain goals actively drive their decisions. Moreover, the correlation analysis conducted by Taghikhah et al. (2020a) highlights a negative relationship between gain goals and habits.

Accordingly, we modify the gain goal function ($FG_i^o(t)$) in ORVin-E as:

$$\left\{\begin{array}{ll} FG_i^o(t) = 1 - \left(\frac{P_o(t) - WTP_i}{P_o(t) + P_c(t)}\right); & if\ (WTC_i \neq 0) \\ FG_i^o(t) = 1 - \left(\frac{P_o(t) - WTP_i}{P_o(t) + P_c(t)}\right)(1 - FH_i^o(t)); & else \end{array}\right\} \qquad \text{(Eq. 6)}$$

Here, $P_o(t)$ and $P_c(t)$ refer to the price of organic and conventional wine at time *t*, respectively. WTP_i is the willingness to pay more for organic wine parameterized from the survey data. An examined factor in updating the function is consumer *i*'s frequency of checking and comparing the price of products when shopping for wine. In some cases, consumers may keep purchasing the same product without noticing the changes in price (especially if the change is small). A similar equation is used to calculate the conventional gain goals.

- Normative goals

For modeling the effect of normative motive, we assess social dynamics based on individuals' observations at the wine shop. In both models, agent *i* observes the wine choice of other shoppers at the wine shop. This observation is linked with the concept of social learning, which can prompt unplanned purchasing decisions. In ORVin-T, we assume the influence of other shoppers' choices on the wine-purchasing decisions of all agents is equal. Nevertheless, in ORVin-E, we consider the empirical data on the importance of other shoppers' choices for consumer *i* (W_{Ni}) by modifying normative goal function ($FN_i^o(t)$) as:

$$EFN_i^o(t) = EW_{Ni}\frac{F_{Noji}(t)}{F_{Nji}(t)}; \qquad \text{(Eq. 7)}$$

where $F_{Noji}(t)$ is the number of organic shoppers at time *t* around consumer *i* in shop *j* and $F_{Nji}(t)$ is the total number of consumers in shop *j* at time *t*. A similar equation applies to conventional normative goals.