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BAE 10th Anniversary paper

The effect of attribute framing on consumers' attitudes and intentions toward food: A Meta-analysis

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Abstract. This paper analyzes the existing literature on the effect of attribute framing on consumers' attitudes and intentions with regard to food products. Attribute framing includes a broader interpretation of gains and losses when a product attribute is presented in a dichotomous way, such as fat vs. lean or harm vs. benefit. Meta-analysis results for the whole sample indicate that product attributes framed as gains have a higher effect on attitudes and intentions than product attributes framed as losses. Grouping studies by outcome variables, the meta-analysis demonstrates a larger effect size for studies that assess consumer attitude while for studies dealing with consumer intention, the effect size is close to zero and insignificant. We observe from the meta-regression results that the gain frame, the use of interaction terms, a specific product, and a student sample significantly influence consumers' attitudes and intentions.

Keywords: attribute framing, food products, meta-analysis.
JEL codes: D91, I12.

INTRODUCTION

The framing effect shows that decisions depend on the way in which outcomes are presented. In their seminal contribution, Kahneman & Tversky (1979) developed the prospect theory that serves the analysis of decisions under risk. According to the evidence they accumulated, choices depend on the gains and losses compared to the current situation rather than to absolute outcomes and the theory postulates that people dislike negative characteristics associated with a choice more than they value positive aspects. That is, the value function in prospect theory is S-shaped and steeper for losses than for gains, meaning that displeasure from a loss is stronger than the pleasure from an equivalent gain (see Figure 1) (Kahneman & Tversky, 1979). Thus, people choose differently depending on which characteristic of the choice is emphasized – gains or losses. This discrepancy creates a framing effect initially introduced in Kahneman and Tversky's 1981 paper with an example of an Asian disease (Kahneman & Tversky, 1981). In the exam-

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ple, participants of the experiment are confronted with the following problem: "Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the program is as follows". Then, participants in one group are presented with choices A and B: "If Program A is adopted, 200 people will be saved. If Program B is adopted, there is a 1/3 probability that 600 people will be saved and 2/3 probability that no people will be saved". And participants in another group are presented with the choices C and D: "If Program C is adopted 400 people will die. If Program D is adopted there is a 1/3 probability that nobody will die, and 2/3 probability that 600 people will die". The choices in the original experiment were distributed as follows: Program A – 72%, program B – 28%, program C – 22%, program D – 78%. Results of the experiment demonstrated that the choice of the program depends on how the outcome is described, in terms of losses (deaths) or gains (survivals), and that people prefer risky outcomes when it comes to losses and certain outcomes when it comes to gains – an effect called loss aversion.

The framing effect serves as a means to describe decision anomalies where people seem to deviate from consistent choice behavior because of various framings of outcome, context and goal. Presenting or communicating attributes of products in diverse ways came to be referred to as attribute framing, and presenting the goal of behavior in diverse ways – as goal framing (Levin et al., 1998). In this study we are particularly interested in attribute framing and thus goal framing is not discussed any further.

Although the framing effect was initially applied to explain decisions under risk, its meaning extended since

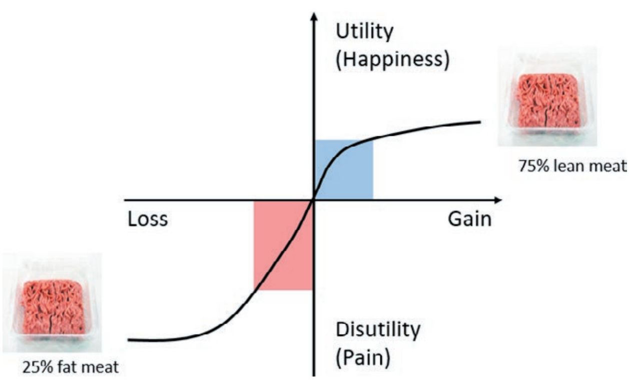

Figure 1. Lean-fat framing of meat products with regard to gain-loss framing.

then to broader interpretations, for example, when meat is presented as lean or fat (Figure 1) (Levin et al., 1998). The concept has, according to some, subsequently come to embody a widely understood, generic definition that stands for the conflicting reactions to information presented in disparate ways (Braun et al., 1997). Several authors stretched the definition and study concepts to merely positive versus negative, strengths versus risks, or even more versus less information framing (Levin et al., 1998). The framing effect has been studied in various fields, including medical decisions, auditing evaluations, public health, environmental valuation, marketing, and consumer choice (Levin et al., 1998; Rothman & Salovey, 1997; Jin & Han, 2014; Kragt & Bennett, 2012; Svenningsen & Thorsen, 2021).

When applied in a marketing context, attributes are often not presented in bipolar, dichotomous ways and emphasize certain aspects to make them salient. For example, the benefits of meat substitutes that are framed in terms of "societal benefits", "high tech", and "same meat" in persuasive appeals are considered as attribute framing (Bryant & Dillard, 2019). Different from risk framing or goal framing which represents loss and gain associated to an expected outcome, attribute framing selects an attribute of a product and describes it in a dichotomous way, such as fat vs. lean, tax vs. offset, and harm vs. benefit. Attribute framing, which is usually delivered in the forms of labels, advertisement, and communications, has considerably influenced people's choice preferences. For example, people are willing to pay more for a burger described as 75% lean than one described as 25% fat (Levin & Gaeth, 1988). They show a higher preference for 80% fat-free chocolate compared to 20% fat chocolate (Braun et al., 1997).

In the area of health-related decisions, framing of the choice outcomes provided some controversial results. Rothman & Salovey (1997) examined a number of framing studies related to the public's health-related decision-making and found evidence of framing effects in hypothetical choice situations. They concluded that the effectiveness of choice frames depends on the illness-detecting or health-affirming function of a message. Gallagher & Updegraff (2012) in their study of message framing in health communication, found that gain-framed messages are more effective in encouraging prevention behaviors than loss-framed messages. Two subsequent meta-analyses of messages regarding disease prevention behaviors also demonstrated conflicting results. O'Keefe & Jensen (2007) reported that the persuasiveness in disease-prevention communication is higher for gain-framed messages than for loss-framed messages. However, their behavior-specific meta-analysis in 2009 reported that loss-framed messages are slightly but significantly more persuasive than gain-framed messages (O'Keefe & Jensen, 2009).

Food choices can be associated with potentially negative consequences for health including the development of obesity and other non-communicable diseases. Public policy interventions that attempt to influence consumer choices in the food domain use different communication methods to inform consumers about potentially damaging consequences of consuming certain kinds of foods. Communicating the nutritional properties of foods can take the form of attribute framing. In this case, product attributes are described in two different ways: a) by emphasizing positive characteristics (e.g., dietary fibers and vitamins), or b) by presenting negative characteristics of foods (e.g., sugar and fat). The effectiveness of different communication strategies is typically measured in the form of consumer behaviors, intentions, or attitudes (Gallagher & Updegraff, 2012).

This paper aims to provide a systematic review of the use of gain-loss attribute framing on food products. We want to investigate and quantify the extent to which other external factors affect the overall framing effect on people's food choices across different countries. We are specifically interested in what kind of framing results in more positive consumer attitudes and increased intention to purchase healthy and environmentally friendly food products. Although our initial approach suggested the inclusion of studies with actual behavior as an outcome, no such studies were identified through our search. We perform a meta-analysis to determine the effectiveness of a gain vs. loss framing and then use a meta-regression to explore study heterogeneity. The remainder of the paper is organized as follows. It starts with a detailed walkthrough of how the literature for the systematic meta-analysis is collected and selected. The next part presents the methods employed to code the data and build the final data frame for analysis. The result section includes the meta and regression analysis results. The major findings and noteworthy points are discussed in the following discussion section and the paper concludes.

METHOD

A systematic screening of existing literature was first performed to collect and analyze published articles in peer-reviewed journals and conference proceedings via four academic search engines (ScienceDirect, Web of Science, EBSCO host, and AgEcon Search), followed by additional random searches on Google Scholar, resulting in a final set of 25 articles published between 1987 and May 2021. The procedure of publication collection and selection is shown in Figure 2.

Given the broad coverage and the various terms associated with the topic, we used a long Boolean search query with an intersection set of "framing", "food", and a union set of "consumer behavior", "consumer decision making", "consumer choice", "consumer preference", "consumer perception", "consumer willingness to buy", "consumer willingness to accept", "consumer willingness to pay", "consumer buying behavior", "consumer purchase intention", and "consumer buying intention". Then, the abstract of each article was first examined in order to include only those articles that cover attribute framing in the food domain. We also set conceptual boundaries to only incorporate dichotomous framings (i.e., promotion vs. prevention, harm vs. benefit) on food choices. In other words, framing effects on other consumer behaviors related to food, such as food-wasting, recycling, and so on, were not considered relevant. Furthermore, to systematically analyze the effect sizes of the main intervention (bipolar framing) and other explanatory factors, we needed the mean and standard deviation of each data point. Hence, we excluded studies that did not report the means of the dependent variables and whose standard deviations of dependent variables are not computable from the information being reported. The final collection of studies included in this review is listed in Table 1.

In preparation of the data, besides extracting means and standard deviations, we also target variables that have been reported to influence consumers' behaviors in the existing systematic reviews in the food realm. The literature review on vegetable consumption by Nørnberg et al. (2016) revealed that an overall main effect might not display. The domain- and individual-specificities of the

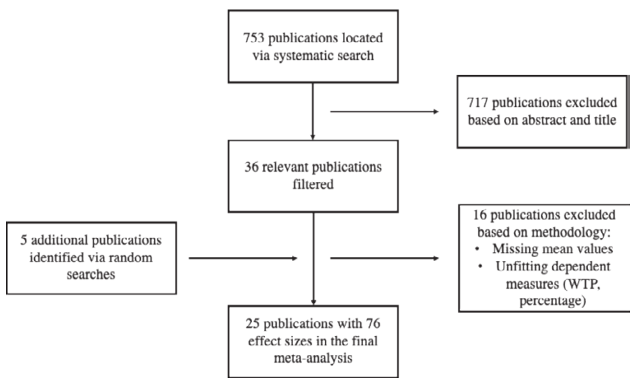

Figure 2. Flowchart of publication gathering and selection process for the meta-analysis

Table 1. Products and attributes of the studies included in the analysis (by year of publication)

N	Author(s) (year)	Product	Attribute	Interaction
1	Levin, I. (1987)	Ground beef	Lean/fat	N/A
2	Levin, I., Gaeth, G. (1988)	Ground beef	Lean/fat	N/A
3	Loke, W.H., Lau, S. (1992)	Hamburger patty	Non-fat/fat	N/A
4	Braun, K. et al. (1997)	Milk chocolate bar	Fat-free/fat	Gender: female vs. male
5	Van Assema, P. et al. (2001)	Low-fat diet/fruits and vegetables	Positive/negative consequences	Dietary behavior: fat vs. fruit & vegetables
6	Levin, I. et al. (2002)	Ground beef	Lean/fat	N/A
7	Orth, U. et al. (2007)	Apples, bottled water	Positively/negatively framed advertisements	Nation
8	Kees, J. (2011)	Healthy/unhealthy food	Advantages/disadvantages of healthy/unhealthy foods	Regulatory focus: promotion vs. prevention; Time orientation: present vs. future
9	Van't Riet, J. et al. (2013)	Fast food	Nutrition information	N/A
10	Jin, H.J., Han, D.H. (2014)	Beef tallow/cow milk	Food safety	Prior knowledge: low vs. high
11	Abrams, K. (2015)	Chicken products	Environmental benefits, animal welfare	N/A
12	Bosone, L. et al. (2015)	Healthy diet	Vitamin and nutrient content	Regulatory focus: promotion vs. prevention
13	Chang, M.-C., Wu, C.-C. (2015)	Organic food	Environmental benefits	Environmental motivation: low vs. high
14	de Bruijn, G.-J. et al. (2015)	Fruit	Fruit intake benefits	Descriptive majority norm: low intake vs. high intake
15	Yan, C. (2015)	Junk food	Advantages/disadvantages of junk food	Attitudinal ambivalence: univalent vs. ambivalent
16	Britwum, K., Yiannaka, A. (2016)	Beef products	E.coli vaccination	Media story: included vs. not included
17	Chen, M.-Y. (2016)	High-fiber oat milk	Health benefits	Self-construal: independent vs. interdependent; Temporal construal: proximal vs. distant
18	Koenigstorfer, J., Baumgartner, H. (2016)	Trail mix	Dietary permitted or dietary forbidden	Fitness label: included vs. not included; Dietary restraint: with vs. without; Gender: female vs. male
19	Tran, V. et al. (2016)	Food products	Benefits/risks of nanotechnology	N/A
20	Hilverda, F. et al. (2017)	Organic food	Advantages/disadvantages of organic foods	Interaction partner: expert vs. peer vs. anonymous
21	Lundeberg, P. et al. (2018)	Variety of food products	Healthfulness	N/A
22	Kuo, K. et al. (2019)	Fat-free yoghurt, ice cream	Advantages/disadvantages of yoghurt/ice cream	Food categorization: virtue vs. vice; Regulatory focus: promotion vs. prevention
23	Vidal, G. et al. (2019)	Snack food	Nutrition information	N/A
24	Cui, H.J. et al. (2020)	Ethnic foods	Advantages/disadvantages of ethnic foods	Regulatory focus: promotion vs. prevention
25	Shan, L. (2020)	Organic food	Benefits/losses of buying organic food	Price anchor: low vs. high; Product knowledge: low vs. high

persuasive effect of loss vs. gain framing are often considered, especially in the food domain (Britwum & Yiannaka, 2016). Due to the lack of evidence of the general effectiveness of the framing effect on consumers' food choices, we decided to also look into other covariates. Frewer et al.'s (2013) systematic review and meta-analysis on genetically modified (GM) food choices suggests that the food type and consumers' geographic region affect the acceptance and prevalence of GM food. In Lusk et al. 's (2005) and Dannenberg's (2009) meta-analysis studies on the valuation of GM food, it was found that geographic location of study and food product characteristics significantly influence the percentage premium that participants are willing to pay for non-GM foods. In addition, a meta-analysis on consumer's willingness to pay for farm animal welfare indicated a significant effect of socio-economic characteristics of participants (Lagerkvist & Hess, 2011). Therefore, our study considers covariates including sample characteristics, geographic location, product characteristics, means of presentation, and control for types of dependent measures

The following final list of variables were extracted from the studies: authors and year of publication, product and attribute in question, sample size, treatment type, means and standard deviations of the dependent variable, if the study included interaction terms, the type of attribute communication, if the study was conducted on a student sample, and if it was conducted online. Table 2 provides an overview of the variability of products and attributes included in the analysis for the whole sample and for the studies on attitudes and intentions. Broadly, the studies discussed attributes related to different health and sustainability issues. Health aspects framed in terms of gains and losses included nutritional information and food safety. Sustainability aspects included environmental benefits, animal welfare, and organic and ethnic foods. The sample sizes of studies included in the analysis differed between 25 and 433, with 32% of studies having a sample size of less than 100 participants. We observed an almost equal distribution of studies on variables such as the use of frames, outcome variables, interaction terms, specific products, and student samples. Thirty-two percent of studies were conducted in the USA, 13% used product labels as means of attribute communication; and 30% of the studies were conducted online.

To determine the overall effect of gain vs. loss attribute framing, we performed meta-analysis, using means and standard deviations obtained from the studies. Missing standard deviations are a common problem in meta-analysis. We employed the computational method recommended by the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins & Green, 2011), which enables the calculation of missing standard deviation from the reported t-value and difference in means according to the following formula:

$$\sigma = \frac{\textit{Difference in Means (DM)}}{t} \quad (1)$$

To explore between-study heterogeneity, we used mean values of attitudes and intentions as a dependent variable (Table 2). Attitudes and intentions measured on a 7-point Likert scale are included directly. When the outcome variable in a study was measured on a 5-point Likert scale, the values were rescaled to the 7-point scale. We use the following random-effects model:

Table 2. Definitions and means and standard deviations of variables included in the analysis.

Variable	Definition	Mean (standard deviation)		
		Whole sample N=76	Attitude N=40	Intention N=36
Mean (dependent variable)	Mean values of attitudes and intentions on a 7-point Likert scale	4.40 (0.86)	4.64 (0.64)	4.12 (0.99)
Frame	1 - gain frame, 0 - loss frame	0.50 (0.50)	0.50 (0.51)	0.50 (0.51)
USA	1 - if the study is conducted in the USA, 0 - otherwise	0.32 (0.47)	0.50 (0.51)	0.11 (0.32)
Outcome	1 - attitude, 0 - intention	0.53 (0.50)		
Interaction	1 - interaction term, 0 - no interaction	0.51 (0.50)	0.48 (0.51)	0.56 (0.50)
Product	1 - specific product, 0 - product category	0.53 (0.50)	0.75 (0.44)	0.28 (0.45)
Label	1 - label is used, 0 - other communication forms	0.13 (0.34)	0.25 (0.44)	0.00 (0.00)
Student	1 - student sample, 0 - other	0.50 (0.50)	0.45 (0.50)	0.56 (0.50)
Online	1 - online study, 0 - other	0.30 (0.46)	0.33 (0.47)	0.28 (0.45)

$$Mean_i = \beta_0 + \beta_1\ Frame_i + \beta_2\ USA_i + \beta_3\ Outcome_i + \beta_4\ Interaction_i + \beta_5\ Product_i + \beta_6\ Label_i + \beta_7\ Student_i + \beta_8\ Online_i + u_i + \varepsilon_i \quad (2)$$

where $Mean_i$ is the mean value of attitudes and intentions elicited from the studies. The two error terms are $u_i \sim N(0,\tau^2)$, where τ^2 is the between-study variance, and a normally distributed $\varepsilon_i \sim N(0,\tau^2)$.

RESULTS

We used the random-effects model to analyze the effect sizes due to the high heterogeneity across participants' characteristics and methodologies in selected studies. The user-written package "metan" in Stata 13 was employed. The forest plot resulting from meta-analysis is presented in Figure 3. The overall effect indicated by the standardized mean difference (SMD) is positive and significant, indicating that the gain frame results

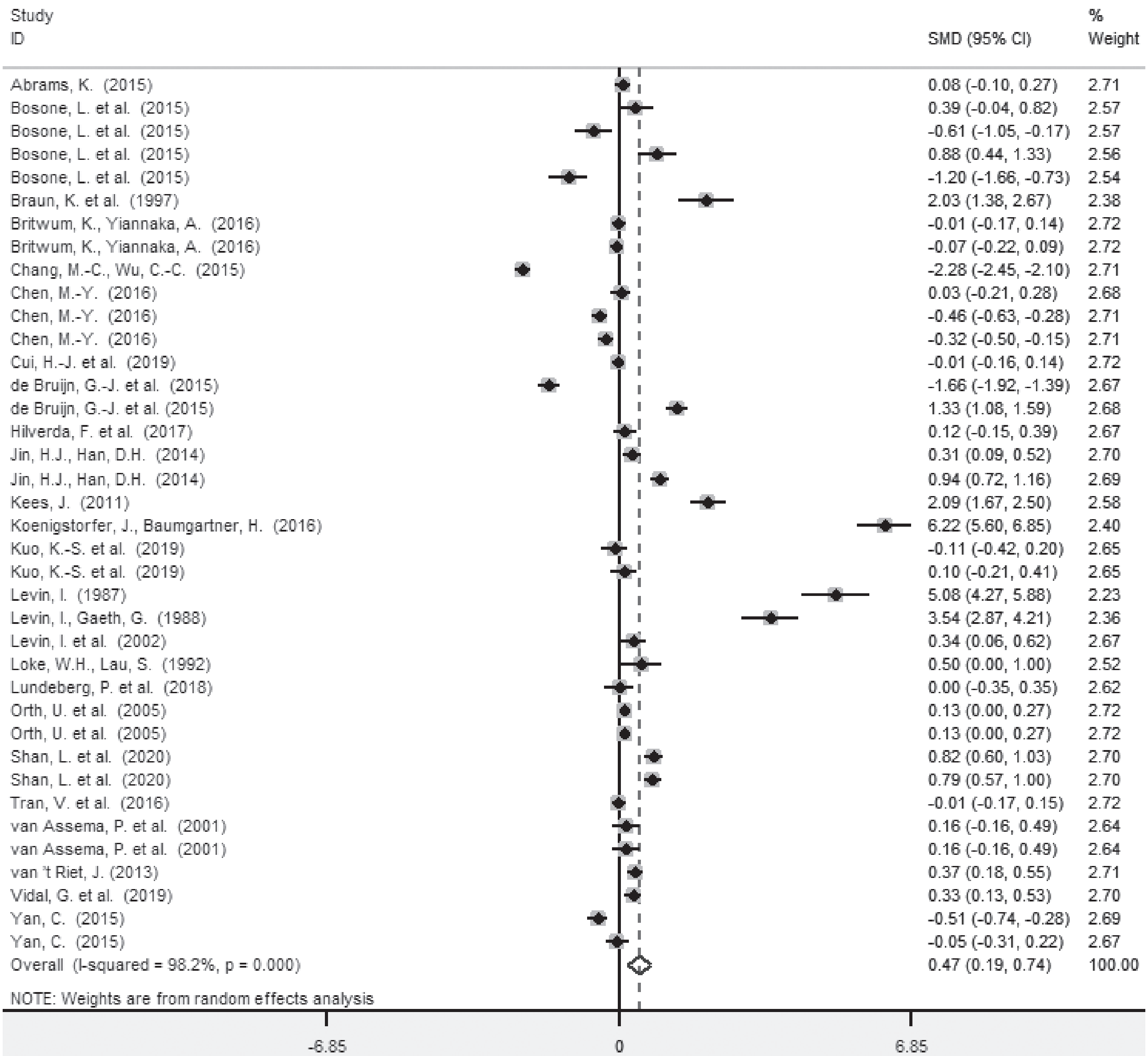

Figure 3. Meta-analysis results (whole sample).

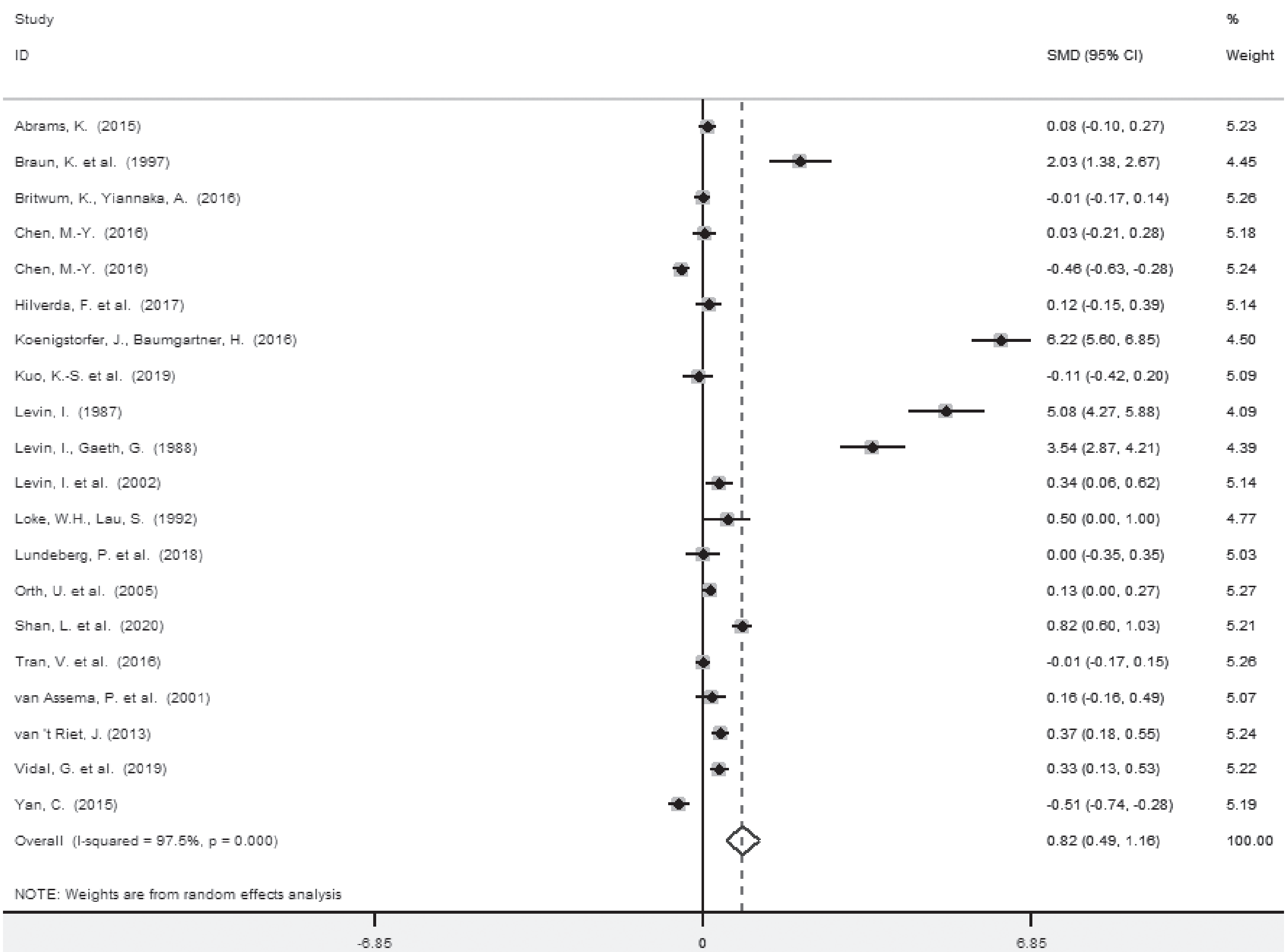

Figure 4. Sub-group meta-analysis results for attitude.

in higher attitudes and intentions than the loss frame. Along with the effect sizes, the meta-analysis reports a measure of study heterogeneity which is attributed to variability in the treatment effect rather than to variation in sample sizes (Higgins & Thompson, 2004). Results demonstrated I^2 = 98.2%, which calls for further investigation into the studies' heterogeneity via a meta-regression and a sub-group analysis (Higgins & Green, 2011). The results of a sub-group meta-analysis showed a larger effect size for studies that assess consumer attitude (Figure 4) than for studies dealing with consumer intention where the effect size is close to zero and insignificant (Figure 5). Also, the variation of the effect sizes for studies that measure consumer intention is considerably bigger than those that measure consumer attitudes. Whereas a majority of the data points from the attitude subgroup lie on the side favoring the gain framing, the data points from the intention subgroup tend to spread out more evenly.

We used a meta-regression specifically designed for meta-analyses (Harbord & Higgins, 2008), which estimates the between-study variance and coefficients using weighted least squares. Stata 13 package "metareg" was used for the estimation. We analyzed the whole sample and then split it into separate estimations for attitudes and intentions. The list of explanatory variables together with coefficients and standard errors is provided in Table 3.

For the whole sample estimation, residual variation due to heterogeneity equaled 17.84%, while the included covariates explained 72.32% of the between-study variance. The I^2 value of 17.84% can be considered as a low level of heterogeneity, according to the classification in Higgins et al. (2003). We observed from the results of this regression that the gain frame, the use of interaction terms, a specific product, and a student sample significantly influence consumers' attitudes and intentions. A gain frame increases consumer attitudes and intentions towards food products with health and environmental

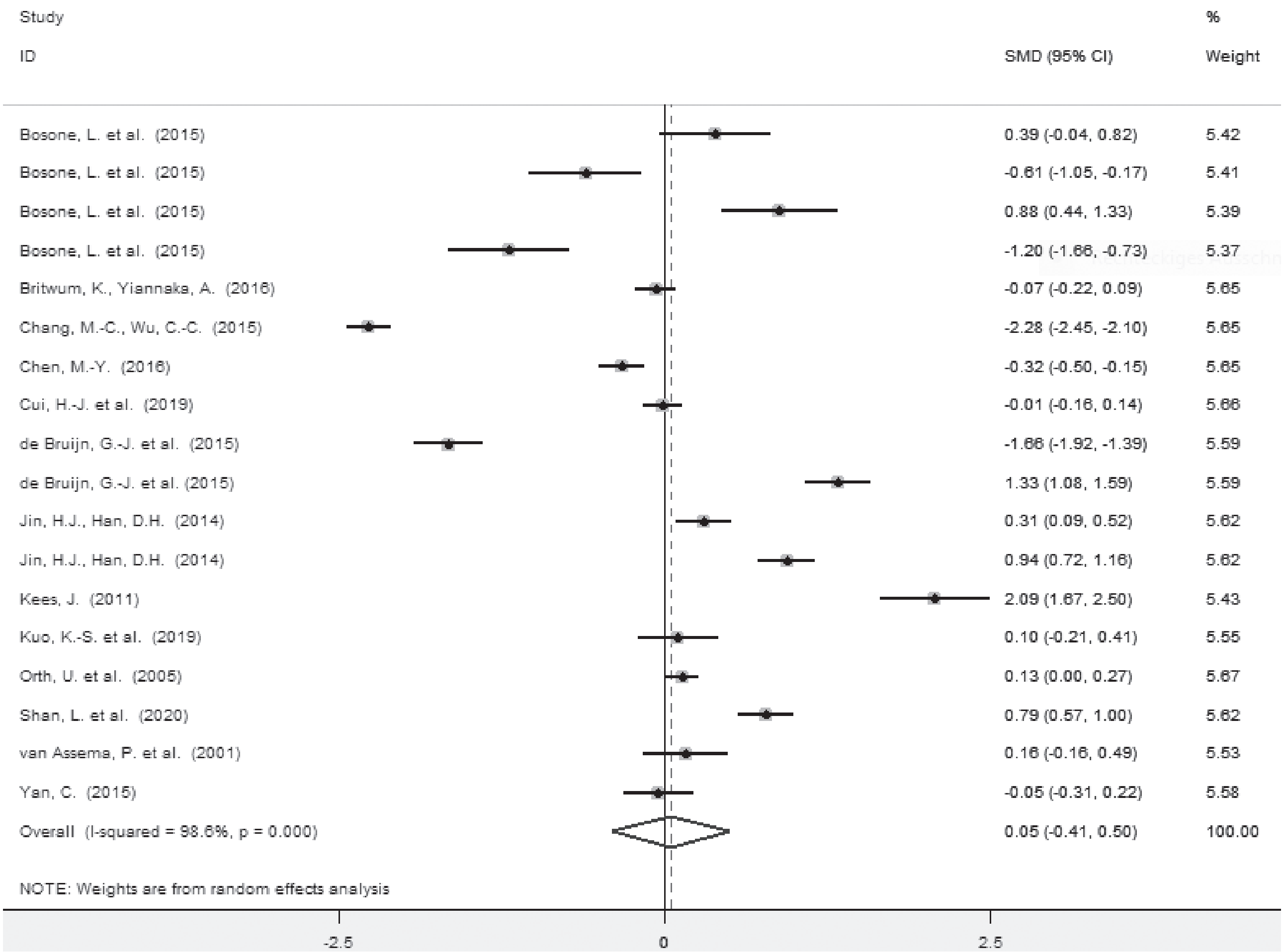

Figure 5. Sub-group meta-analysis results for intention.

benefits. When we split our sample into two sub-groups, depending on whether the papers included investigating attitudes or intentions, we observed that the gain frame is significant for attitudes but not for intentions. Interestingly, the location of the study in the USA has a different effect depending on the outcome variable. When it comes to consumer intentions, the use of an US sample increases the mean value. On the contrary, attitudes decrease when the study is not conducted in the US. The use of interaction terms positively influences the outcome variable; however, this effect is mainly attributed to the studies about consumer intentions. Unlike more general product categories, specific products negatively affect the attitudes to purchase food products with health and environmental benefits. The use of a student sample is marginally significant in the regression for the whole sample; however, this result does not replicate when the sample is split. The use of labels to communicate health and environmental benefits to the consumers is positively associated with consumer attitudes. Studies conducted online increase consumer intention to purchase food products; however, the strength of the association is marginal.

DISCUSSION

Our results demonstrate that when it comes to food products, the use of gain frames elicits stronger responses from consumers than the use of loss frames. Previous research has already indicated that encouraging positive behaviors by evoking loss aversion is not necessarily a guiding principle when it comes to health and environmental benefits (Gallagher & Upbegraff, 2012), especially in the domain of attribute framing. Loss-framed messages are mainly effective when it comes to decisions involving significant risk. Food choices usually serve an illness/environmental harm prevention function and are

Table 3. Results of the meta-regression[1].

Variables	Coefficients (std. err.)		
	Whole sample N=76	Attitude N=40	Intention N=36
Frame	0.27 (0.13)**	0.51 (0.09)***	-0.01 (0.09)
USA	0.10 (0.20)	-0.74 (0.20)***	1.01 (0.34)***
Interaction	0.30 (0.14)**	-0.18 (0.14)	0.33 (0.14)**
Product	-0.32 (0.18)*	-0.93 (0.46)*	-0.09 (0.44)
Label	0.30 (0.20)	0.59 (0.12)***	---
Student	-0.57 (0.31)*	-0.02 (0.45)	-0.71 (0.55)
Online	0.28 (0.29)	0.83 (0.51)	0.88 (0.49)*
Intercept	4.60 (0.30)***	5.27 (0.41)***	4.14 (0.51)***
Adj. R^2	72.32%	100.00%	98.74%
τ^2	0.07	0.00	0.00
I^2	17.84%	0.00%	0.00%

*, **, *** denotes significance at 0.10, 0.05, and 0.01 level, respectively.

[1] In meta-regression R2 indicates the percentage of between-study variance explained by the covariates. The value of 100% indicates that the effect size does not vary substantially across studies.

not associated with an immediate high level of risk (Gallagher & Upbegraff, 2012).

As expected and congruent with existing literature, both types of framing (gain vs. loss) and interaction factors significantly influence the effectiveness of framing overall. Interestingly, the effect of interaction variables is only demonstrated in intentional but not attitudinal measures, whereas it is the opposite for the effect of types of framing. In other words, there is a main overall effect from the framing intervention on people's attitudes toward food choices, but the main effect of the intervention on people's intention does not manifest. The significant change in people's intention of food choices is determined by various moderators, such as individual food product knowledge, regulatory focus, temporal construal, and so on. One possible explanation, according to both the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB), is that all potential external influential factors on intentions and behaviors are thought to be mediated by the attitudes and subjective norms, plus perceived behavioral control for TPB (Ajzen & Fishbein, 1980). Therefore, it is sensible that, as an antecedent factor of intentions, attitudes are more malleable and directly influenced by external interventions than intentions. The effectiveness of framing in changing people's intentions is more scenario- and individual-specific, which is explained by different interaction terms.

Consumer attitudes based on beliefs and values often surpass specific products (Purhoit, 2012). When it comes to product categories, like fast food or organic food, consumers tend to express their attitudes more readily than when it comes to specific products and labels. As consumers often lack specific knowledge about health and environmental benefits (Vermeir & Verbeke, 2006), it is easier for them to express their preferences in terms of general product categories.

The use of labels as means of conveying the attribute framing compared to other communicative vehicles, such as advertisement and text-based marketing messages, shows a significant increment in people's attitudes toward making wiser (be it healthier or more environmentally conscious) food choices. It demonstrates that labels employing few words and visuals that concisely communicate the benefits of healthier or more environmentally friendly food (or the harms of the opposite) are more effective in influencing people's attitudes toward that food. One possible explanation is that consumers are used to obtaining information about food from labels. Therefore, they are more fluent in processing information presented with labels.

Looking at the studies in the meta data by year reveals how the application of attribute framing to food consumption has been gaining research attention and interest. Before 2000, the literature on the framing effect related to food choices was, albeit influential, sparse. Studies in this domain increased considerably after 2010, in terms of both number and diversity. It was only until recently that researchers mostly focused on how framing could be utilized to influence people's food choices for the purpose of nutrition and health. Three decades after the initial study of the framing effect on food choices, topics have been broadened to cover environmental impact, animal welfare, livestock vaccination, nanotechnology, and so on. The origins of the studies also expanded from the United States to the rest of the world and changed from studies based on student samples to more demographically representative ones. The demographical and topical variability enabled examining other factors that influence the effect of attribute framing on food choices.

The benefits and harms resulting from different food choices are not immediate and consequential compared to other decision-making tasks where decisive influences from attribute framing on people's judgements and decisions have been described, e.g., in lottery and medical treatment decisions. According to temporal discounting theories, people are less sensitive to the losses and gains that manifest themselves later in time. Health-benefiting and pro-environmental decisions are typically intertemporal decisions. The disutility that people perceive to experience in the future from eating unhealthy food now does not outweigh the utility or gratification (sensory or hedonic pleasure) they gain in consuming indulgent food (i.e., high fat and sugar). Similarly, the future negative consequences of consuming ecologically unsustainable foods are not perceived to be strong enough to counteract people's predilection for easily accessible, affordable food, which might carry high environmental costs (e.g., greenhouse gas emission and water consumption). Therefore, people are not motivated to avoid those foods that are unfavorable in the long term from a utilitarian perspective. When a time dimension is taken into consideration, people's perception of gain versus loss might not accord with prospect theory.

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BAE 10th Anniversary paper

Rural areas between locality and global networks. Local development mechanisms and the role of policies empowering rural actors

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Abstract. The main objective of this work is to review the recent achievements on the mechanisms explaining local and rural development, which underpin the current definition of rural areas in the European literature. The analysis carried out in this article acknowledges a gap between local development processes and the current representation of rural diversity by international organisations and national/regional authorities. New concepts can be drawn from this comparative analysis: 1) rural diversity cannot be explained exclusively by agglomeration forces and geographical distance from urban centres; b) multiple functions of rural areas, often rooted into sustainable agri-food systems or other forms of territorial capital, contribute to explain more autonomous roles of rural areas; c) organised or relational proximity is emerging in a context of a globalised economy and non-geographical networks, as a critical factor of connection between rural areas and distant regions/markets. This article translates these different disciplinary developments into a practical and integrated conceptual approach, in which local development processes result from three components: local resource systems, networks, institutions and enabling policies.

Keywords: rural development, local development, regional disparities, networks, rural policies.
JEL codes: O13, O18, Q18, R11, R12, R58.

1. INTRODUCTION

Rural development is a topic that still deserves attention both in research programmes and policymaking. Since the key paper on *L'avenir du monde rurale* ("The future of rural society") was published in 1988, European Commission clearly identified, for the first time, the need for a territorial rural policy that went beyond agriculture and included local development and environmental concerns as key elements (European Commission, 1988). Indeed, a key feature of the debate about rural development is the close interaction between research and policy (Bock, 2016), that translates into reciprocal influences over time in a complex relationship that deserves some future analysis (Bryden and Mantino, 2018). In the context of EU mutual relations between research and policy design, the rural development research, especially in rural sociology and agricultural economics, gained social relevance,

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especially for the CAP reform. In contrast, economic geography and development economics contributed notably to the regional cohesion policy revision over time. Still, rigid boundaries among different disciplines have been reduced, and in several research projects we can see examples of interdisciplinary cross-fertilisation.

After forty years of debates about the conceptualization of rural development and its role within the CAP, and more generally the EU framework, it is hard to say that the scientific process brought about a single, unified theory. Nevertheless, the knowledge of the rural development processes has been significantly enriched in these decades by the contribution of different disciplines. In addition, there are different paradigms and visions of rural areas between disciplines as well as within the same discipline. In the vast literature on the topic, there is no consensus about the driving forces of rural development, and multiple development trajectories are possible, resulting from various combinations of local, regional, national and global forces in a given context (Ward and Hite, 1998).

The main objective of this work is to review the recent achievements on the mechanisms explaining local and rural development, which underpin the current conceptualisation of rural areas in the European policy-making and research. This article is structured as follows. First, it begins with exploring how the diversity of rural areas is represented in the most recent literature, both with regards to the urban-rural relations and the differences within the rurality (section 2). In this regard, we think there is a gap between the current representation of rural areas and the recent rural development theories, as achieved by the different disciplinary approaches in rural sociology, rural/economic geography, agricultural economics and development economics. The main problem, in our opinion, is that official definitions and analyses of rural diversity in Europe do not match the complexity of rural processes as they emerge from research and policy analysis (section 3). We conduct an interdisciplinary review of the theoretical approaches to rural development processes (sections 3.1, 3.2 and 3.3) and then we seek to explore how these achievements have influenced policy frameworks, notably place-based policies and policy approaches targeting the most peripheral/marginalised rural areas (section 3.4). The article proceeds, in the light of the development factors examined by the different theoretical approaches, with an exploration of how these approaches can contribute to creating a different theoretical framework (section 4), which re-defines the functions of rural areas, not simply depending on functional relations with urban centres but considering the capacity of rural actors to develop more autonomous networks and development pathways. The article ends with drawing up implications for future research and policy actions (section 5).

2. THE REPRESENTATION OF THE RURAL DIVERSITY AND INCREASING RURAL-URBAN DISPARITIES

The definitions of “rural” and “rurality” has been a hot topic in both scholarly and policy debates for almost 60 years. While trying to define ‘rurality’, researchers have proposed various typologies based on different quantifiable criteria. In recent decades, a series of relevant research projects and activities have provided substantial evidence on the diversity of rural areas. Approaches and methods to analyse and describe rural diversity have changed over time, moving from simple indicators of population density and percentage of rural population to more elaborate criteria, units of reference and thresholds (Copus et al., 2008; Féret et al., 2020). There is consensus on two points across the definitions, approaches, and scientific positions on the subject of rurality. First, rurality is a concept that is difficult to define. Rural areas have undergone profound economic and social changes since the early agricultural policies aimed at modernisation and land management in the 1960s. As a consequence, rurality can no longer be defined solely according to farming activities and associated lifestyles. Second, determining rurality depends on several factors (Féret et al., 2020): 1) the global contexts (i.e. the characteristics of the socio-economic systems of which the rurality is a part); 2) the discourse and political objectives that were pursued; 3) the social representations of the different categories of stakeholders.

In Europe, each country has developed its own definition of rurality, often as a response to a particular political, administrative and the broadest territorial context, and in some cases as an output of national classifications of other factors (e.g. population, accessibility). Approaches and definitions are rarely similar between countries (Depraz, 2007; Bontron, 1996).

Methods combining several criteria have been adopted since rural areas were recognised as complex and unable to be characterised by a single criterion. Six types of approaches can be identified in the literature: 1) the administrative (or statutory) approach, based on the legal-administrative character; 2) the morphological (or demographic) approach, based on population criteria such as population density; 3) the locational approach, based on spatial relationships between urban and rural areas; 4) the functional approach; 5) the landscape approach, based on land-cover and climatic conditions; and 6) the combined approach, which used a combination of at least two of the other approaches (Féret et al., 2020).

The functional approach has been recently used in the OECD Rural 3.0 Policy Note (2018), based on the relationships between rural and urban centres and the proximity to urban centres as factors conducive to economic performance and development potentials. A functional urban area (FUA) includes a town and its surroundings consisting of less densely populated local units which are nevertheless part of the town's labour market due to commuting, i.e. people travelling from their place of residence to the labour market and/or to access services (healthcare, education, culture, shops, etc.) (Dijkastra and Poelman, 2019). This approach has gained particular interest in the last decades due to the transnational (EUROSTAT and OECD) institutional legitimation (OECD, 2018). According to this definition, OCDE has further developed the classical distinction between predominantly urban, intermediate and predominantly rural areas into a new typology: a) rural areas within an FUA, which are an integral part of the commuting zone of the urban centre; b) rural areas close to an FUA, which have strong linkages to a nearby FUA, but are not part of its labour market; c) remote rural areas, distant from an FUA and somehow connected through the market exchange of goods and services. In this model, the proximity of less than 1 hour travel time to a large urban region is an essential predictor of rural growth: "*proximity allows stronger linkages between urban and rural places*" (OECD, 2018) since it allows better access to services, healthcare, education and transports, thus rural areas within or close to an FUA are more advantaged than remote rural areas. Remote areas dwellers, instead, can count on better environmental conditions and more affordable housing. Rural regions close to cities displayed higher productivity growth before the 2008 economic crisis, and higher resilience after the crisis began (Table 1), whilst remote regions were the most badly affected by the crisis, with an annual average drop of GDP per capita of -2.5%, almost ten times worse than rural regions close to cities.

This representation of rural differences masks a more diversified situation and re-defines the functions of rural areas as dependent on the sphere of influence of various types of urban areas and as 'commuting zones'. The OECD model seems to neglect rural areas' capability to develop autonomous functions associated with specific assets and opportunities in terms of local development. Furthermore, as we will see in the following sections, there is an evident gap between the knowledge achievements about rural diversity and the most relevant representations of rural areas in international and national policy documents. In short, the definition of rural areas related to the OECD approach does not seem to respond to the need to effectively understand rural areas diversity and the different opportunities for rural development (ESPON, 2021). Thus, a definition less dependent on the role of urban centres, more appropriate indicators and territorial scales seem to be necessary for policy design (Migas and Zarzycki, 2020).

Even the definition of the rural development concept has changed over time. In the 1970s, rural development was identified with agricultural modernisation, focusing on encouraging labour and capital mobility (Ward and Hite, 1998). By late 1970, this model was criticised, and theories of endogenous development (see section 3.2) emphasised the need for overcoming exclusion through capacity building (skills, institutions, infrastructures) and diversified rural economies. In the first decade of the new millennium, neo-endogenous theories, assuming the need for mixing endogenous and exogenous forces (Shucksmith, 2010), advocated a more holistic approach to address inadequate service provision, unbalanced

Table 1. Trends in population growth, regional GDP per capita and labour productivity.

Type of region	Average annual population growth, %		Annual average GDP per capita growth, %		Annual average labour productivity growth, %	
	2000-07	2008-12	2000-07	2008-12	2000-07	2008-12
Predominantly urban	0.76	0.67	2.39	-0.70	1.65	0.24
Intermediate	0.55	0.45	2.20	-0.28	1.57	0.65
Predominantly rural (total)	0.31	0.38	2.29	-1.11	1.97	0.12
Predominantly rural close to cities*	0.61	0.55	2.29	-0.26	2.15	0.56
Predominantly rural remote	-0.03	0.18	2.30	-2.45	1.69	-0.61
All regions	0.47	0.46	2.29	-0.70	1.74	0.34

Note: *defined as within 1 hour travel time of a large urban centre.
Source: OECD (2018), RURAL 3.0. A framework for rural development, Paris.

communities, remoteness, isolation and lack of critical mass. This approach has to include capacity building and adding value to local resources, enhancing connectivity and promoting innovation. Also, the role of innovation became more and more relevant in many respects (governance, sustainable production, social inclusion, etc.).

3. DIFFERENT APPROACHES IN UNDERSTANDING RURAL DEVELOPMENT PROCESSES: AN INTERDISCIPLINARY ANALYSIS

Different strands of disciplines and theoretical approaches studied rural diversity and related development processes. Rural sociology, regional economics and geography, agricultural economics and development economics have often looked at rural development from different perspectives and adopting different approaches. However, manifold research projects, especially within European Horizon programmes, have been carried out in recent years through multidisciplinary efforts. At least four relevant strands of literature have deepened the knowledge of rural development processes and provided new evidence and arguments in many directions (Figure 1). First, the group of neo-endogenous models, that evolved into networked approaches, studied in rural sociology and economic geography. As we will see, geographical differentiation factors are increasingly counterbalanced by the importance of a system of networks going beyond spatial differences.

Second, regional convergence/divergence models have studied particularly the role of factors explaining increasing territorial disparities in developed countries and rural-urban interlinkages in these diverging trajectories. The third strand of literature, focusing on clusters, territorial milieu and localised systems, explores the importance of relevant spatial processes and the role of endogenous development factors, notably locality and internal networks of actors and firms. This strand also includes the territorial agri-food systems, mainly studied by the French and Italian economic geography and agricultural economics schools.

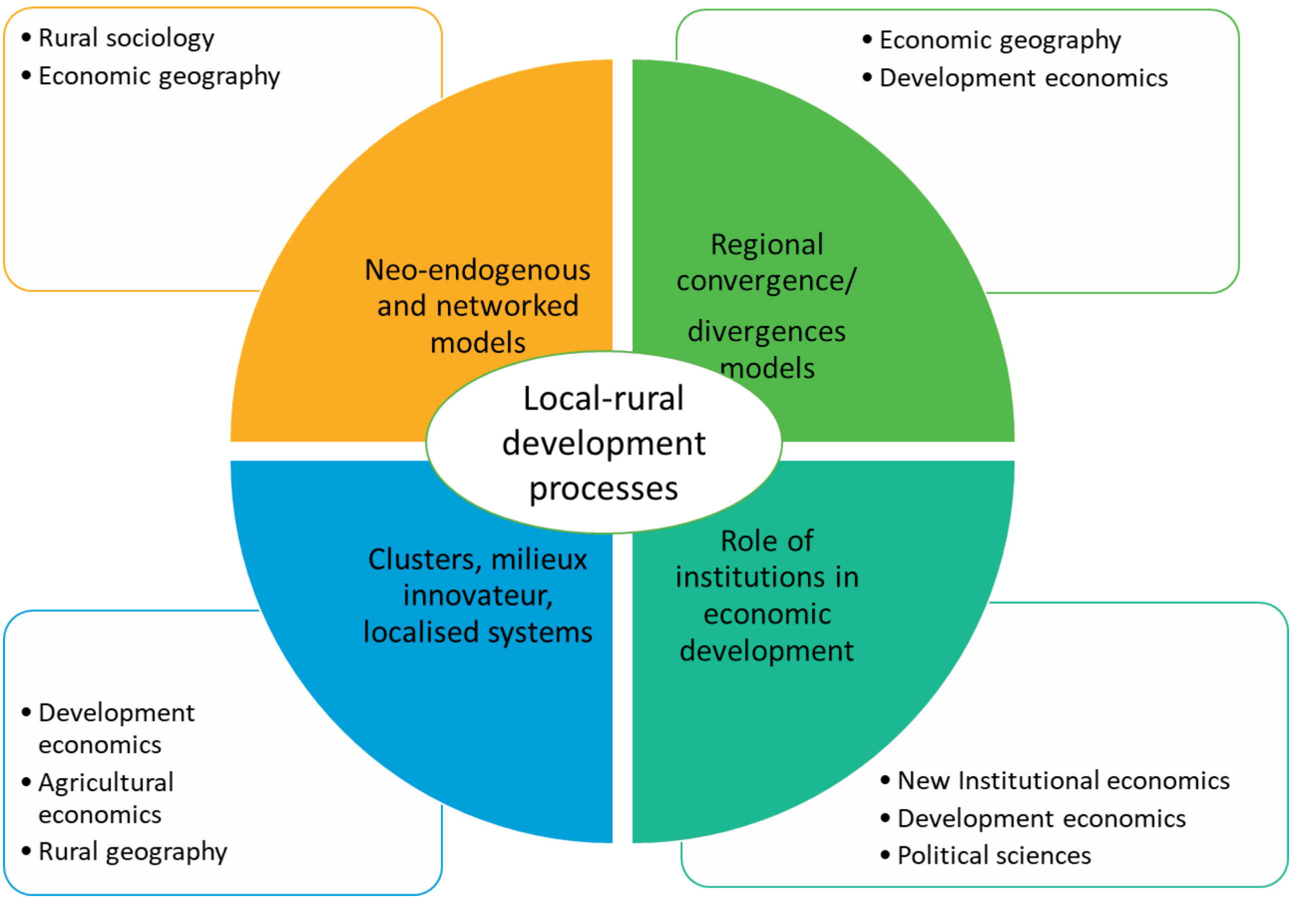

Figure 1. Different disciplinary approaches to local-rural development processes.

Finally, the fourth strand of literature explores to what extent policy institutions play a crucial role in determining the development potential of any territory. This question has been widely studied in development economics theory (North, 1990; Acemoglu and Robinson, 2012).

3.1 Rural areas in regional development models and territorial disparities

The OECD conceptualisation of rural areas diversity heavily relies on theories of agglomeration (McCann and van Oort, 2019), which explain why urban/metropolitan areas accumulate over time comparative advantages and external economies, based on the concentration of physical and financial capital, technological innovation, research and development activities, skills and human capital. Theories of divergent development and cumulative causation models (Myrdal, 1957; Hirschman, 1958; Krugman, 1995) explain why the inter-regional disparities can persist and grow over time. The new economic geography, in particular, highlighted that since 1970 onward, and especially in the new millennium, the technological progress and the long cycle of regional evolutionary features led to increasing regional divergence (Iammarino et al., 2018). According to OECD study (2020), inter-regional disparities grew mainly, in terms of GDP per capita, in France, Italy, Germany, Poland and the US. Still, the polarisation across space is even higher when the gap is measured within the regions (at NUTS3 level). After 2009, regions near metropolitan areas have grown faster than metropolitan regions, but remote rural regions trends do not confirm the traditional divergence cities-rural areas model: they grew faster than regions with the small-medium city (OECD, 2020).

The diversity of rural areas and related wealth disparities make more complex the urban-rural dichotomy and their relationships. In the last two decades, many efforts have been focused on identifying main drivers of territorial disparities, which go beyond agglomeration forces and geographical distance from the centre. There is evidence that the economic relations between urban and rural areas do not follow a one-way functional dominance relation. For example, in-depth research conducted over recent years in the rural regions of Italy, The Netherlands and the UK have pointed out different forms of sustainable rural development (Marsden, 2009). These studies support the idea that rural areas can achieve higher territorial competitiveness and more autonomous roles in different ways: a) through local agri-food systems (LAFS), according to the definitions of the French and Italian schools (Sforzi and Mancini, 2012; Arfini et al., 2012; Vaquero-Piñeiro, 2021); b) alternative food networks, representing more complex and sustainable pathways within the agri-food system (Lamine et al., 2012; Sonnino and Marsden, 2005); c) horizontal networks of economic activities located within an area (Murdock, 2000), based on new synergies between agri-food, tourism, amenity, forestry, renewable energy, waste, information technologies and locality food chain developments (Marsden, 2009). These different processes imply the sustainable valorisation of "territorial capital"[1] (Camagni and Capello, 2012) in many rural areas. More value can be added locally, and more balanced production-consumption relations can occur between rural and urban areas.

Increasing and more complex territorial disparities also emerged in studies on the so-called peripheral territories, in particular within the framework of ESPON research programmes. Peripheralisation has been recently interpreted as a process due to different drivers (Noguera et al., 2017): a) low accessibility to centres of economic activity, in other words, localities geographically disconnected from the centre (conventional peripherality); b) poor access to services of general interest (education, healthcare, transports, etc.), whether this is a consequence of geographic remoteness, or to changing service delivery technologies, or to austerity, or other changes in the provision such as privatisation; c) absence of "relational proximity", and exclusion from the mainstream of economic activity, due to low levels of social and institutional interaction with the broader world. These latter conditions are often associated with disconnection from the centre of political power and a lack of influence in terms of governance, and they may affect even geographically accessible regions. Most areas identified as peripheral seem to be affected by a combination of at least two of the drivers described above (Noguera et al., 2017). The ESPON study (PROFECY) estimated that peripheral areas cover approximately 45% of the European territory and only about half of them lack access to centres and services as key drivers. Another 46% is represented by areas predominantly suffering from poor economic potential and demographic situation, and the remaining 4% covers areas affected by all types of drivers. Peripherality is not a process involving only rural areas (according to the OECD nomenclature) but also a significant share of intermediate and urban and metropolitan regions (table 2), due to increasing unemploy-

[1] The notion of territorial capital defined by Camagni and Capello includes not only physical assets (private and public goods and resources), but also human, social, relational capital and cooperative networks. In this regard, this notion shares relevant theoretical concepts with neo-endogenous approaches to rural development in the section 3.2.

Table 2. Percentage of peripheral areas in European countries by types of driver and types of region (ESPON, 2017).

Types of region	A. Peripherality due to longer travel times from urban centres (%)	B. Peripherality due to poor access to services of general interest (%)	C. Peripherality due to lack of relational proximity and depleting processes
Urban regions	9.6%	18.8%	32.2%
Intermediate regions	48.6%	40.0%	34.1%
Rural regions	41.8%	41.2%	33.7%
Mountain regions	49.5%	38.2%	24.4%
Metropolitan regions	24.0%	23.0%	43.0%

Source: ESPON-PROFECY project. Noguera et al, 2017.

ment, decreasing wealth (GDP per capita) and further impact on out-migration.

Connection or disconnection can also be the result of poor governance of relations between urban and rural areas. New forms of territorial cooperation are emerging between rural and urban areas (rural-urban partnerships) to avoid over-exploitation and depletion of the rural assets (land, soil quality, water, amenities and landscape, ecosystem services, etc.) and foster the valorisation of complementary functions (Copus, 2010). Rural-urban interactions find very different governance solutions across the European countries (Wood and Haley, 2017). However, a series of obstacles hamper the cooperation: absence of trustful relationships, frictions between peripheral municipalities and the urban pole, power imbalances, inadequate financing and capacity constraints about personal and time resources (Oedl-Wieser et al., 2020).

3.2 From exogenous to neo-endogenous and networked models

In the 1970s' and part of the 1980s' rural development thinking was dominated by exogenous development models: rural areas were considered "backwards" and were thought to lack the dynamism of their own, be dependent on urban growth poles, external investment in agricultural modernisation, infrastructural connections, and the transfer of social and technological innovations from dynamic urban centres. Even scientific knowledge was conceived as a mere uptake of technologies produced elsewhere (Lowe et al., 2019). The main functions of rural areas were producing food and primary products for urban economies. This model was criticised mainly for fostering dependent development, reliant on continued subsidies and policy decisions of distant institutions (Gkartzios and Lowe, 2019), for delegitimising local knowledge, and its negative social and environmental impacts (Lowe et al., 2019).

In the late 1980s' and 1990s, rural development theories were enriched by endogenous models, whose main principles were harnessing local potentials of its particular natural, human and cultural assets, including local knowledge and skills, for sustainable development; a territorial rather than sectoral approach, at a small scale; and finally, a focus on the needs, capacities and perspectives of local people (Ray, 1997). The primary function of rural areas was providing diversified activities in the local economies. The LEADER initiative relied on these principles and fully represented the most typical example of a policy instrument empowering people and endogenous potentials within the CAP. However, even this approach became quite simplistic, relying on assumptions of rural areas as self-sufficient and isolated from external forces (Lowe et al., 2019). Furthermore, LEADER experiences demonstrated problems of limited participation of marginal groups (unemployed and young people), the dominance of "*who are already powerful and….enjoy a greater capacity to act and to engage with the initiative*" (Shucksmith, 2000), and limited impact on social inclusion of the most vulnerable population. Finally, specific relevant policies such as the support to farming, public investments for infrastructures and general interest services, and taxation remain strongly exogenous in their design and delivery.

This evolution from the exogenous to neo-endogenous or networked approaches highlights the importance of social, economic, and institutional networks in regional economics and rural sociology/geography. Rural development approaches need to combine endogenous potentials with external forces in the context of a globalised economy, growing mobility of capital and people, substantial national reforms aimed at cutting public costs. Consequently, it was suggested that there is a need to go "*beyond exogenous and endogenous modes*" (Lowe et al., 1995) and focus on strategies that continue to valorise local assets in a multisectoral perspective but are also able to involve actively external actors. Some authors name this different perspective as "neo-endogenous approach" (Shucksmith, 2010 and 2012), but the family of neo-endogenous contributions embrace a series of theoretical frameworks focusing differently on relations and networks between rural actors (rural-rural), between rural and urban actors (rural-urban) or between rural and other relevant actors in the national and international context (rural-global market). These models are referred to in different ways.

The first example of the networked approach is within the "rural web" framework, defined as "*a complex of internally and externally generated interrelationships that shape the relative attractiveness of rural spaces, economically, socially, culturally and environmentally*" (Ploeg et al., 2008, p. vii). The web encompasses a series of multi-actor (including institutions, companies, state agencies, civil society, etc.) dynamic networks of a multilevel character (local and regional, which also influence the relations in other levels). The web also presents six theoretical dimensions (endogeneity, novelty production, sustainability, social capital, institutional arrangements and governance of markets). They can generate multifunctionality and intra-sectoral intertwinement if they interact correctly and thus contribute to the competitiveness of rural development processes.

Shucksmith (2012), Lowe et al. (2019) and Esparcia (2019) refer to a "*networked approach*" to rural development which seeks to link localities "*..into broader interwoven circuits of capital, power and expertise, such as rural professionals, regional agencies, NGOs, companies, universities and research institutes*". They highlighted a vast number of networks in exploring the actors necessary for the setting-off, implementation and development of innovative projects in rural areas: actors involved in the scientific and technical support (provided by research centres, technical staff in government offices, certifying agencies, etc.), knowledge and information (on specific and technical and more generic issues, provided by a wide variety of public bodies), the physical infrastructure (needed for the everyday operation of the project, provided by public bodies, primarily local but, to a lesser extent, also national governments), organisation and marketing (provided by local governments, private organisations and NGOs), and finally implementation of regulatory standards (provided mainly by local and regional governments). Gkartzios and Lowe (2019) describe a series of "*hybrid neo-endogenous*" frameworks where local and extra-local agencies collaborate in rural governance and development processes, mentioning in particular: the role of universities in creating a research-practice rural network; the role of in-migrants in rural areas in terms of employment they might generate for locals, etc.

Copus (2010) outlines the importance of business networks in rural areas to transmit information and promote innovation. In these business networks, innovation depends, on the one side, on both the "*bridging capability*" to channel information from globally significant firms and, on the other side, the "*bonding capability*" to distribute them among the local firms and entrepreneurs. In other words, the role of business networks depends not only upon their local network density, degree of embeddedness and human and social capital but upon their connections to more distant sources of specialist information. In analysing the process of knowledge creation within a geographic cluster, Bathelt et al. (2004) outline that this process relies on both information exchange and learning process within the cluster, achieved through informal day-by-day and face-to-face relations (the "buzz"), on the one side, and more complex channels used in distant interactions (the "pipelines"), on the other side. Finally, co-location and visibility generate potentials for efficient inter-personal translation of important news and information between actors and firms. In contrast, trans-local pipelines allow more information and news about the markets and technologies to be "pumped" into internal networks.

Recently, Bock (2016), focusing on the problems of promoting rural development in the marginal rural areas, outlined that these areas need more collaboration and linkages across space to give access to exogenous resources. In this regard, rural-urban linkages are essential, but broader connectivity and "*virtual proximity*" across the space are also relevant for remote rural areas. Collaborations with nationally operating large business and external companies, third sectors corporations like cooperative movements, the presence of temporary residents, etc., can activate social innovation processes at the local level, including "*the uptake of novel solutions developed elsewhere*" (Bock, 2016, p. 17). This can be necessary, especially in those marginal areas where mobilising citizens, NGOs, third sectors, and business is problematic because "*the local asset basis is too weak*" (Bock, 2016, p.17). Supporting networks in the most peripheral areas is necessary to reduce physical and socio-economic isolation or counterbalance restrictive fiscal policies dismantling regional institutional structures (Shucksmith, 2012). Bock calls this "nexogenous approach" to rural development since it emphasises the importance of reconnection and re-establishing socio-political connectivity, which allows for vitalisation if matched with endogenous forces.

Networks can work at different levels. For example, in a study on rural networks in UK, Miller and Wallace (2012) define a typology of rural networks based on the geographical remit: a) locally-based networks; b) national networks; c) networks that transcend both national and international regions. From the networks identified, those operating within a locality tended to focus mainly on rural issues, whereas national networks were more likely to work on issues affecting both rural and urban areas. Despite finding no substantive differences in why participants accessed rural networks, the three most common reasons for using rural development networks were to obtain advice and information, identify sources of funding, and share local learning and experience. This implies that a lack of funding for rural development networks can have a detrimental effect on communities. Other examples of transnational networks can be found in LEADER (Dwyer et al., 2022): some Local Action Groups (LAGs) were able to promote innovative partnerships within the local area, but also supported the creation of transnational networks under the cooperation measures, lasting well beyond the project duration (as in numerous Italy-Austria transnational projects).

Other types of network, notably food-networks that go beyond the territory where productions are based, have been emphasised in other studies (Lamine et al., 2019; Lamine et al., 2012), identifying the linkages between collective brands, Geographical Indications (GIs) and alternative food networks, on the one side, and groups of urban consumers, on the other side. Some of these networks can transform into encompassing civil society organisations and broader territorial agri-food systems (see the case studies analysed in the Lamine et al. works). The variety of these networks depends upon the diversity of actors involved and their changing nature over time.

In conclusion, various studies confirm the increasing role of social, institutional and business networks in enabling connectivity between rural areas, adjacent urban areas and mainly beyond the geographical proximity. These networks can act as a factor complementary to (or maybe as a substitute for) agglomeration forces in peripheral rural areas[2].

3.3 Clusters and localised systems

The concept of localised agri-food systems (LAFS) focused on the production system and interactions among firms within a given territory: this can explain why it was strongly influenced by the concept of cluster (Porter, 1990; Porter and Ketels, 2009), adopted by Porter to define the spatial proximity of many production units and their reciprocal relationships. Spatial proximity, specialisation of territorial systems and their complex interplay were also at the core of studies on the new economic geography in Krugman (1995), on one side, and in Becattini and his school focusing on the concept of Marshallian industrial district (Beccattini et al., 2009), on the other side. LAFS concept emerged in the mid-1990s and referred to geographical concentrations of specialised farms, food-processing units and distribution networks, private and public entities in a determined place. LAFS appeared in French literature as Systèmes agro-alimentaires localisés (SYAL) (CIRAD-SAR, 1996). Three distinctive features characterise LAFS: a) place, b) social relationships and c) institutions. The place is considered in its broadest meaning as used in the French school, "terroir". Social relationships relate to trust and cooperation among actors. Institutions include all private and public agents promoting actions regulated by formal and informal rules. LAFS is "an agri-food system (production/transformation/services) in a specific territory in which actors try to set up coordination and collaboration processes in partnership terms, with internal management and regulation, but with strong ties to public managers and companies" (Torres Salcido and Muchnick, 2012). This definition outlines the capability of main actors to set up innovative and effective solutions to govern the system and ensure the participation of farmers, processors, services providers and marketing operators.

The contribution of LAFS' approaches to the understanding of sustainable rural development mechanisms relies upon three aspects:

a) there can be broad and intense economic and social linkages between the territorial agri-food systems and the rest of the local economy, as in the case of the bigger agri-food chains (e.g. the case of the processed tomato in North Italy) (Giacomini and Mancini, 2015; Mantino and Forcina, 2018);
b) agri-food systems can have a relevant role in enhancing the local governance. In each LAFS, specific coordination methods can emerge, and governance arrangements to change production, processing and consumption practices and create alternative networks. Better local governance arrangements are supported by collective action that may take different forms and typologies of organisation. The OECD classical definition identifies three types of collective actions, based on the participants (OECD, 2013a): a) farm-led action; b) non-farm-led action; c) government-led action. In practice, multiple actors usually carry out collective action. A good start depends on a sufficiently large number of participants and the management capability of actors taking the lead in the process. Indeed, LAFS is a typical multi-actor situation where farmers are only a component, and the fundamental leading role can emerge either within the supply chain or civil society;
c) finally, there are various cases of territorial alternative food networks in Europe (Lamine et al., 2019),

[2] This concept has been developed by Johansson and Quigley (2004, p. 175): *"…small regions may survive and prosper – to the extent that networks can substitute for geographically proximate linkages, for local diversity in production and consumption, and for the spillouts of knowledge in dense regions".*

contributing to connecting small farmers and peripheral rural areas with urban/extra-local markets and ensuring new development perspectives.

3.4 The role of institutions and public policies

Public rural policies are an essential component of all rural development models. Moving from exogenous to neo-endogenous models implies the need for a differentiated use of policy instruments, decentralisation of policymaking, integration of multi-tiered institutions and sectors, participation of local stakeholders and more emphasis on investments in physical assets rather than mere subsidies. These were the main principles for a new territorial policy put forward by the New Rural Paradigm (NRP) for the OECD countries (OECD, 2006). The NRP was a turning point in the conceptualisation of the rural policy framework since it took on board the ongoing best practices coming from the OECD policy reviews in different countries (Mexico, Spain, Italy, Hungary, Greece, Germany, UK and Canada) and distilled the key lessons to foster rural development in the new millennium. According to the NRP, the LEADER initiative and other territorial approaches in Europe were recognised as success cases due to their innovative character and results, despite the relatively limited budget.

However, despite the increasing number of innovative experiences, policies implemented in rural areas have not achieved significant impacts. On the contrary, in the last decades, some authors included rural areas in the so-called "geography of discontent", which includes rural population left behind by national public institutions, lacking faith in the future, and supporting anti-globalisation and populist movements/parties (Rodriguez-Pose, 2018). Thus, the OECD New rural paradigm needs to be updated, and today the debate on policies for rural areas needs to address three main questions: a) to what extent the place-based approach is effective and should be improved; b) what should be the role of public institutions in enabling/empowering local actors capacity building; c) which policy instruments should be set up to strengthening cooperation and networks (rural-rural, rural-urban and rural-wider markets). We are going to discuss point a) in 3.4.1 section and b) and c) in 3.4.2.

3.4.1 Place-based policies and the CAP

The debate occurring in the late 1900s and first decade of the 2000s was dominated by two radical contrapositions between place-based and spatially-blind (or generalised) policies, on the one side, and bottom-up and top-down approaches, on the other side. This debate strongly concerns the CAP since, in most rural areas, this policy also aims to cover inequalities between rural and urban areas, but in reality, CAP instruments, notably Pillar I, mainly address agricultural incomes. In a recent evaluation study of CAP impact on the balanced territorial objective (Schuh et al., 2020), the most important target groups proved to be farmers and rural young people. Only Pillar II instruments impact low skilled, unemployed people and the population in the most remote areas (Schuh et al., 2020, p. 84-88). According to respondents in the concerned case studies, pillar I instruments (primarily basic and green payments) are not designed to solve territorial needs, and they have controversial impacts. On the one hand, they favour large-scale farms or farms owners not actively involved in agricultural activities (Schuh et al., 2020, p. 90). On the other hand, they can have relevant income support effects in the less developed and marginalised rural areas and areas affected by the environmental and social crisis (e.g. the area hit by the plant pathogen Xylella in the Apulia region). In these areas, Pillar I instruments intervene as income transfers to mitigate the symptoms of economic backwardness and decline of farmers and family's incomes.

Within the CAP, Common Market Organisations (CMO) and rural development instruments seem more appropriate to remove farm structures' weaknesses and enhance competitiveness. Nevertheless, the effects on territorial disparities are uncertain and depend on local institutions and capacity building. For example, innovative approaches foster synergies between CAP instruments, reducing intra-sectoral income disparities and strengthening cooperation in the supply chain (Schuh et al., 2020). This happened in agri-industrial districts that were able to combine schemes targeting specialised production with more generalised CAP instruments (e.g. operational programmes for COM producers).

LEADER is the most typical example of place-based approach within the CAP. Despite the LEADER broader scope in the last programming period (through the adoption of a multi-fund approach), two recent evaluation reports (Schuh et al., 2020; Dwyer et al., 2022) indicate that rural peripheral regions need more robust national policies than LEADER and more diversified supporting systems to face the lack of services of general interest and shortage of employment opportunities. Due to the small budget share (5% of the rural development programmes), LEADER can only provide impulses at the local level. Still, LEADER can generate higher social and economic impact when working alongside other national/regional schemes. Similar impacts have been reported in some Spanish and Italian rural areas, whereby linkages occurred with national programmes for depopulated areas[3].

These case studies provide relevant lessons on place-based policy's effectiveness: the need for combining different types of policies under a common territorial approach. This result has two relevant methodological implications: a) first, to overcome the traditional dichotomy between spatially-blind (or people-based) and place-based development policies and adopt what Iammarino et al. (2018) call "*place-sensitive development policy approach*", whereby agglomeration effects are promoted in as many places as possible through a mix of policy instruments; b) second, to reconcile top-down and bottom-up policies in a "joint" meso-level conceptual framework (Iammarino et al., 2018; Crescenzi and Rodriguez-Pose, 2011). Empirical evidence shows that social marginalisation and low local development opportunities render many place-based policies ineffective and often make them frequently function more as social rather than economic development policies achieving inter-territorial equity. Within a broader perspective, even the World Bank has advocated the need for reconciling policies to enhance institutions, infrastructures, and local interventions, but the right policy mix depends on the types and intensities of interregional disparities (World Bank, 2009).

3.4.2 The role of public institutions in empowering local actors, capacity building and networks

The quality of institutions plays a crucial role in the development processes. Recent research has demonstrated that weak institutions represent a crucial obstacle to the effective use of European Cohesion policies (Rodriguez-Pose and Garcilazo, 2015) and undermine the capacity to innovate (Rodriguez-Pose and Di Cataldo, 2015). Weak institutions imply ineffective regional and local governments, low efficiency in managing public programmes, limits in accountability and voice, and generation of rent-seeking positions, corruption, and lack of confidence in the future. In reality, the quality of institutions also includes the capability to enable local actors and communities "*to make choices and transform those choices into desired actions and outcomes*" (Steiner, 2016). This capability is crucial for two reasons: a) to create an enabling policy environment for community-led initiatives; b) to allow new institutions and groups to emerge in less active places and facilitate the taking action to address social, economic and environmental challenges (Shucksmith, 2012). In other words, enabling policies should help local actors and communities to develop and support resilience (Markantoni et al., 2018). Nevertheless, public bodies remain in most cases unavailable, if not hostile, to these local needs, creating "a not supportive environment" that generate policy barriers in accessing public funding by "hard to reach" communities (Celata and Coletti, 2018).

Many authors outline that local development programmes usually are distributed unevenly across rural areas since the most experienced communities come forward and become increasingly empowered, while others fall further behind (Markantoni et al., 2018). Marginalised communities are less ready to participate in local development processes "*unless explicit attention is given to their inclusion*" (Shucksmith, 2012) and that communities with well-established partnerships and networks are more successful at obtaining funds. In these contexts, we call enabling policies those policies explicitly addressing "*hard to reach*" communities and providing financial, technical, and animation support. A good example of enabling policy is the programme funded in Scotland, *Capacity for Chance* (C4C), under the LEADER funds, since it provides financial support to selected communities that usually do not engage due to lack of human, economic and relational capital. For these reasons, the programme does not require finding match-funding but simply local people voluntary support and offers the support of a project manager to assist the communities in developing their selected projects (Markantoni et al., 2018; Steiner, 2016). This study emphasises how the national, regional and local institutions need to set up rules, organisation and behaviours consistently empowering local actors.

Other examples come from a recent evaluation study of the LEADER implementation in Europe (Dwyer et al., 2022). An enabling environment for the LEADER implementation is determined by two conditions: a) first, reducing the administrative complexity and enhancing coordination, especially in a multi-fund environment (as it happens when all European Funds support LEADER) through a clear definition of tasks and roles between responsible authorities of programme implementation and local agencies; b) establishing a collaborative and mutual learning process between LAGs and programme authorities, through actions such as guidelines, manuals, websites, FAQ sessions, working groups, regular communications and meetings, formal collaborations (for-

[3] These programmes are the National Strategy for Inner Areas in Italy and the regional Strategy against depopulation in Castilla-La Mancha region (Spain). For more details on these programmes see Barca et al., 2014 and Schuh et al., 2020. More recently, these two policies have been presented in a webinar organised by the European Rural Development Network in Brussels (Mantino, 2021; Martinez Arroyo, 2021).

malised in joint committees including local agencies). These conditions are mainly promoted by the public administration bodies.

Regarding networks, the impact of public policies upon networks gained low attention in policy analysis. The need for supporting networks as a specific policy objective is only gradually shaping rural development strategies. In the last decade the attention is much focused on setting up either "networks of networks" (e.g. through funding the European Network of Rural Development and the National Rural Networks) or trans-national networks. It is the case of many cooperation projects supported by transnational cooperation programmes, both within Cohesion policy and the LEADER instrument. Still, many obstacles and institutional barriers undermine their effectiveness (Dwyer et al., 2022).

On the contrary, there is a broad spectrum of studies measuring the influence of networks upon policy design, but some authors highlighted the capacity of rural networks to engage in lobbying activities, providing voice and keeping rural issues on the political agenda (regionally and nationally) (Lamine et al., 2019; Miller and Wallace, 2012; Dwyer et al., 2022).

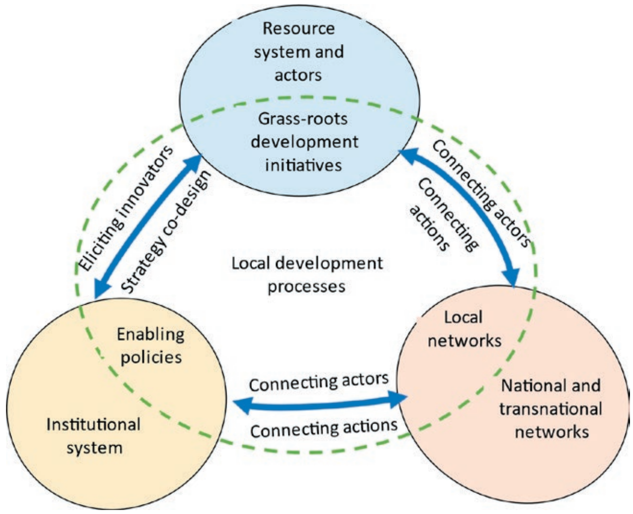

Figure 2. The triple helix model (Wellbrook et al., 2012), adapted to understand local development processes.

4. TRANSLATING RECENT ACHIEVEMENTS INTO A DIFFERENT OPERATIONAL FRAMEWORK

To translate different disciplinary developments into a practical and integrated conceptual approach, we can borrow from the triple helix formalised to study regional learning and innovation (Wellbrook et al., 2012). The model interpreting learning and innovation processes has to be adapted according to the main concepts drawn by our previous analysis. Thus, local development processes can be conceived as the result of what happens in three main domains: local resource systems, networks, enabling institutions and policies (Figure 2). The central dotted circle represents how the specific components of the three domains and how they interact in influencing the local development processes.

The first component includes the territorial resource system, the different actors and their specific capabilities that bring about grassroots development initiatives. According to Wellbrook et al. (2012), "*the [territory]… can thus be regarded as an arena which comprises diverse actors and their different grassroots activities*" (p. 6). Identifying the concept of territory is a crucial step in this framework. Following Camagni and Capello (2013), we can use a notion of a "*system of localised production activities, traditions, skills and know-how*", based on "*cultural elements and values which attribute sense and meaning to local practices and structures and define local identities*" (p. 1387). In practice, this component identifies the physical and human capital underpinning neo-endogenous development in a rural area, focusing on innovative designing and implementing local projects. When designing schemes to support new initiatives, this framework envisages a sort of inventory of local resources and existing initiatives.

The second component is the "*institutional system*", which encompasses a series of public, semi-public and private institutions managing policies for the rural territory and undertaking different tasks (planning, organising, directing, coordinating, monitoring and evaluation). We include in the institutional system the bodies operating at national and regional level, and also institutional actors and rules set up at local level and aiming to deliver EU, national and regional policy instruments to the rural area. Even in this case we replaced the Wellbrook et al. string "*Supporting Policies*" with "*Enabling Policies*" that, in our opinion, has a more pro-active meaning. Thus, more than providing financial and administrative support, "*enabling policies*" for local actors imply at least three other conditions (see figure 2):

a) supporting local development strategies through co-design, whereby public administration or other agencies collaborate with local stakeholders to define long-term actions and possible funding, especially in the areas lacking resources and human capabilities. In these areas, poor access to development policies is strongly correlated to the lack of human capital and poor networks;

b) eliciting innovators to emerge and participate in actions' design and implementation. In the most peripheral areas, conservative groups and socially dominant coalitions often do not allow innovators to voice alternative needs and access policy support. This is detrimental for them to introduce social innovation and get opportunities to play a role in the future of the area;
c) finally, connecting actions and actors, by promoting intersectoral and multi-actor initiatives in the area, either by valorising the current networks or creating new ones.

The third component of the local processes in figure 2 concerns the different types of networking activities. By replacing the string "knowledge support structure", we have adapted the Wellbrook et al. conceptual framework, since networks gained more relevance in the literature concerning more general rural development processes. They include a set of geographical proximity relations (within the rural territory) and "organised proximity" (with distant areas/business systems). Both can generate localised collective learning processes and can be identified as relational capital in Camagni and Capello (2013) definition of territorial capital.

We can further expand the model to include a fourth helix as the new technologies have become more relevant in recent decades. Looking at the model represented in figure 2, external actors or local innovators as providers of internal and tacit knowledge can introduce and develop new technologies in the area. Local and national/international networks can play a relevant role in both cases. New technologies can also be fostered by enabling policies through the institutional system (private and public research and experimental bodies, advisors, trainers, etc.). Public policies have supported digital and broadband infrastructures through regional and rural development incentives and financial resources addressed to peripheral rural areas. In many rural areas, especially the most peripheral, inadequate broadband infrastructures hamper networks and distant market relations. In conclusion, new technologies represent a relevant development factor, but they can enter the model and be diffused in the rural context through different modes.

Local development processes are the result of both the action of each component and of interactions among them. For example, evidence suggests that an enabling policy environment foster grassroots initiatives and new networks, notably at the local level and sometimes (and less evidently) with more distant networks. Vice versa, good grassroots initiatives and local networks can inspire and facilitate a good use of existing policies. It is worth noticing that good local governance is a fundamental ingredient ensuring successful supporting policies, autonomous grassroots initiatives and dense local networks (Mantino and Vanni, 2019).

This conceptual framework can provide a practical outline for development projects at the local scale. A similar framework has been adopted in co-design processes of local strategies in Italy, within the national programme for Inner Areas aiming to support integrated initiatives in the most depopulated areas. The programme entails activating the three components in setting up initiatives through the participation of local actors through: a) an inventory of available infrastructure and service gaps, existing needs and initiatives aiming to overcome these gaps; b) an analysis of policy mix needed to support initiatives in the field of services of general interest and development of local sectors; c) deep and comprehensive scouting of innovators and potential networks to be involved in the project co-design processes. An essential condition for the success of the strategy design is formal governance arrangements signed by partnerships of local municipalities that ensure cooperation among the relevant local institutions (Barca et al., 2014). The Inner Areas approach can solve another relevant failure in the rural development initiatives (World Bank, 2009), that is the appropriate mix of policies addressed to people (education, healthcare, and mobility of population) and policies addressed to places (infrastructures, incentives to economic activities, etc.). This mix allows to strengthen the impact of place-based policies through the support of more general policies, usually falling under the category of macro-economic policies.

5. CONCLUSIONS AND KEY ISSUES FOR FUTURE RESEARCH AND POLICY

The analysis carried out in this article acknowledges a gap between the unfolding of local development processes and the current representation of rural diversity by international organisations and national/regional authorities. This gap is influenced by two relevant factors: a) high heterogeneity in terms of recent and accepted methods and definition criteria of rural diversity; b) a vision of rural areas as strongly dependent on the sphere of influence of urban areas.

In the last two decades, a series of studies, mainly supported by the European Commission (HORIZON, ESPON, evaluation studies, etc.), provided a more complex and diversified vision of rural diversity, regarding theoretical models and practical definitions. Moving from a simplistic definition of rural development processes to more complex frameworks implies taking account of the contribution of different disciplines. New concepts can be drawn from comparative analysis: 1) rural diversity cannot be explained exclusively by agglomeration forces and geographical distance from urban centres; b) multiple functions of rural areas, often rooted into sustainable agri-food systems or other forms of territorial capital, contribute to explain more autonomous roles of rural areas; c) "organised" or "relational proximity" is emerging in a context of a globalised economy and non-geographical networks, as a critical factor of connection between rural areas and distant regions/markets. Thus, the definition of rural peripherality is changing accordingly. Likewise, the dichotomy between exogenous and endogenous models is losing its interpretative appeal, and networks models are gaining interest among rural development scholars.

Which implications do these research achievements get in the directions of future research? First, they call for moving from a functional model to another approach based on the territorial capital endowments of rural areas, whereby territorial capital also includes different forms of "relational capital" and networks. In practice, this requires a detailed analysis of territorial capital variables and deep scouting of relations within the locality and between the locality and markets.

Second, there is a need for developing a rural area concept by revising the current urban-rural typology and introducing criteria based on the variety of functions that rural areas play in the socio-economic and environmental context (ESPON, 2021). The Direction of Agriculture and Rural Development of EC is emphasising this need (Migas and Zarzycky, 2020), but there is also a need to fill persistent data gaps at the correct geographical scale (local in many cases) through the cooperation between different data providers and screening a wide range of possible (including new) data sources beyond conventional indicators such as population density and settlement configuration.

Third, understanding rural diversity across European regions has to be used to read better the dynamics of megatrends, including climate change, environmental crises, and socio-economic and demographic drivers of change. The Commission's Megatrends Hub has identified fourteen global megatrends, and its Strategic Foresight Report (European Commission, 2020a) provides a preliminary systematic analysis of resilience, but we need a significant focus on how different rural areas can face megatrends. In this regard, Bock and Krzysztofowicz (2021) have contributed to the long-term vision for rural areas by drawing four types of scenarios through the combination of diverse future developments ranging from demography and multilevel governance to climate change, economic development and digitalisation (rururbanities, rural renewal, rural connections and rural specialisation).

Within the possible megatrends, particular attention deserves the digital transition as a powerful driver of technological innovation. Digitalisation connected with artificial intelligence (AI), big data, and automation can potentially reshape the economy, which will represent a threat and an opportunity for rural areas. Technology can be a way of overcoming economic disadvantages, notably for rural areas with a shrinking population. New communication technologies can limit the effect of distance. Digital infrastructures will be crucial to facilitate connection, integration, and provision of e-services (e.g. administration, health, education, finance, culture) and enable the digitalisation of agriculture and the bioeconomy (e.g. precision farming, automation). These investments do not require only covering infrastructural needs but also grass-roots initiatives by local communities under the form of "Smart Villages projects" (European Commission, 2020b). This approach encourages rural areas and communities to develop projects, build on their existing strengths and assets, and develop decentralised services, energy solutions, and digital technologies and innovations.

Another relevant question concerns to what extent the current policy framework fits local development needs of the different rural areas. The recent Communication of the European Commission on "A long-term Vision for the EU's Rural Areas" (LTVRA) (EC, 2021) seeks to provide new answers to increasing territorial disparities and the feeling of left behind characterising most rural areas. But, as it was emphasised in the analysis of policies, place-based policy approach is used only for a marginal share of the CAP. To be more effective, territorial lens need to be applied to a mix of different policies, including CAP instruments other than LEADER and cooperation measures. The 2021-27 reform of the CAP offered the opportunities of mixing different instruments in the CAP Strategic Plan (CSP) to prompt sustainable and integrated rural development. Nevertheless, the opportunity to address territorial differences within the CSP and implement a broader place-based approach does not seem realistic, given the dominant visions in the agricultural policies and the traditional barriers and *silos* between the two CAP Pillars.

As part of the Better Regulation Agenda, the LTVRA puts in place a *Rural Proofing* mechanism, notably to assess the anticipated impact of major EU legislative initiatives on rural areas. It will be based on territorial impact assessments and a better monitoring of the situation of rural areas. The way in which rural areas are integrated in the EU's policies will be monitored, notably through regular reports on the implementation of relevant policies. *Rural Proofing* will mean putting more attention to territorial distribution of EU policies before their implementation and potential impacts. This mechanism can become an interesting innovation whether reproduced at national level, but this will strongly rely on political positions of the agricultural world.

A further relevant challenge concerns enabling all individuals to take active part in policy and decision-making processes, involving a broad range of stakeholders and networks as well as all levels of governance. The methodological framework proposed here seeks to activate a process that elicit endogenous capital and innovators through the empowerment of local communities and an enabling policy environment, notably in most peripheral and depopulated rural areas. These types of rural areas need a rather different approach to local development, whereby local institutions and innovators work alongside with regional and transnational actors, and public administrations as well. The provision of public funds is not sufficient to overcome the different obstacles, since empowering local communities requires a radical change in public institutions' objectives, instruments and behaviour. In this regard the contribution of researchers and scholars should be more oriented to multi-actor action research methods, notably in marginalised rural areas and grassroots initiatives by rural communities.

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Understanding the bioeconomy: a new sustainability economy in British and European public discourse

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Abstract. Over the past decade, the term bioeconomy has emerged in both policy and academic discourse. Implying a technology-driven approach to wealth generation from organic materials, the term has taken hold with so far limited critical engagement. It is a contestable rather than contested term. Noting the rise of numerous other 'economies' (blue, green, circular) on a similar timeframe, this paper undertakes a critical discourse analysis of academic literature and UK/EU policy documents using the term 'bioeconomy' to produce a contextualised understanding of how it is used in both theoretical and practical contexts. Our analysis shows that bioeconomy, as with the other 'sustainability' economies, which we term the 'S-economies', prioritises the economy and the markets as the solution brokers for the environmental and economic problems they seek to address. The apparent fragmentation of the theory and policy concerning the environmental sustainability of economic activity is expressed through the variability of terms that aspire to establish multiple economies functioning at the same time. Limited empirical analysis of the existing 'bioeconomy' is symptomatic of the dissociation between theory and practice, emphasizing technological approaches favouring capital intensive approaches over local solutions. The S-economies, including the bioeconomy, are an attempt to bypass economic structural realities that otherwise would need to be addressed.

Keywords: bioeconomy, knowledge-based economy, green economy, circular economy, sustainable economy.
JEL codes: L6, O1, O3, P2, P4, P5, Q1, Q2, Q5.

1. INTRODUCTION

In this study we are critically analyzing the role of the bioeconomy as a term and practice in academia and policy. Broadly, 'bioeconomy' refers to economic activity directly drawing on biogenic material (derived from recently living plants and/or animal matter), to be distinguished from non-biogenic based resources and fossil fuels. Bioeconomy, or bio-based economy, is an expression coined in recent years by experts and policy makers,

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thereby integrating into a single term both the economic significance and awareness of the type of resources to be utilised (Albrecht *et al*., 2010; Begley *et al*., 2011; De Besi and McCormick, 2015; Allen *et al.,* 2017; University of York, 2017; Bell *et al*., 2018; Aguilar and Patermann, 2018; Lewandowski et al., 2018). The bioeconomy has been represented as a way of addressing environmental emergencies and socio-economic challenges at the same time (OECD, 2006, 2009, 2018; Benner and Lofgren, 2007; Birch, 2007, 2017a; Cooper, 2007; Asveld *et al*., 2011; Kitchen and Marsden, 2011; Kircher, 2012; Arancibia, 2013; Hanlin *et al*., 2013; Kautto and McCormick, 2013; *Arts et al*., 2014; Barben *et al*., 2016; Viaggi, 2016; European Commission, 2018a, 2020a, 2020b). The bioeconomy has already had an important economic impact. For example, in 2018 in the UK the bioeconomy amounted to two hundred twenty (220) billion of pounds of Gross Value Added to the economy, supporting more than five million jobs (HM Government 2018). In 2015 the bioeconomy in the European Union reached an added value of 1,460.6 billion euros, which is eleven percent (11%) of overall GDP (Kuosmanen et al. 2020).

It may not be coincidental that the term has become prominent in an era of stagnating economies and high unemployment, following the financial crisis of 2008. Over this same timespan other 'economies' have become prominent too, including the green economy (UNEP, 2009; Pearce and Barbier, 2000; Bina, 2013; Baarsden *et al*., 2014; Antikainen *et al*., 2016; Viaggi, 2016; Ge and Zhi 2016; Ferreira Gregorio et al., 2018; Merino-Saum et al., 2020; Benson et al., 2021) promoted by the UN as an approach to implementing sustainable development (2012); the marine resources-based blue economy (UNCTAD 2014; Smith-Godfrey, 2016; Le Heron and Winder, 2017; Lee, Noh and Kim, 2020); the Circular Economy (promoted by the EU and others as a carbon control and competitiveness enhancing initiative; European Commission, 2015). Other terms such as the low carbon economy (Stern 2007; HM Government, 2009; Zhang, 2010; Foxon, 2011; Lyu, Ngai and Wu 2019) are also seeking to use environmental investments to correct an economic imbalance – i.e., to promote growth and with assumed social benefits (i.e., usually employment). In this paper we examine how the term bioeconomy is used, how it is connected or situated in relation to other terms that represent various types of economic activity with aspirations to deal better with nature and the resources nature offers to human societies, whilst preserving, if not promoting, economic growth.

Drawing on analysis of policy and scientific documents, this paper undertakes a critical discourse analysis of the use of the term bioeconomy in policy documents alongside a comprehensive review of the social science academic literature relating to the bioeconomy in order to gain a contextualised understanding of how the term is being used both theoretically and in practical terms. Research in critical discourse analysis stresses the significance of terms used in policy analysis as representing a social, political and economic context (Jessop, 2004; Farrelly, 2010; Farrelly *et al*., 2019). Certain expressions or forms of expression become accepted as 'normal' or inevitable, and this promotes ease of communication with groups who have the same understandings of the terms used. However, usage and the approach it represents may reinforce the exclusion of other interests or groups, either by representing a barrier to entry in the dialogue or by perpetuating a policy that favours some interests over others. To achieve a contexualisation of the bioeconomy, we examine the concept within the context of the other discursive attempts related to the sustainable types of economies proposed during the last decades, and we also consider the limitations of the scope of existing applications of the bioeconomy.

The following section presents an outline of our approach and methods; section three examines the rise of the term bioeconomy since 1990s. Section four explores how the bioeconomy is used in policy discourse and the fifth section examines critically the academic discourse about the bioeconomy. Section six examines the various (aspiring to be) sustainable forms of economy that emerged in recent decades. The general discussion of our findings is presented in section seven and conclusions are presented in the final section eight.

2. APPROACHES AND METHODS

This paper stems from the THYME project, which is a research consortium comprising the University of York, Teesside University and the University of Hull in order to investigate ways to support the local economy of the North East of England through the mobilisation of bioeconomic processes. THYME project is, in other words, an umbrella project within which several approaches to the bioeconomy are used to develop new understandings, production processes and community engagement. The approaches are employed in sub-projects, of which one example is the research project this paper stems from.

In this paper we draw our methodology from two approaches. One is critical realism as a way to understand discourse and praxis in its historical context. Critical realism is the epistemological approach which acknowledges that 'real' events and processes may only be observable through perceptions; the scholar is committed to what is possible to be known, while having in mind that this knowledge might not be perfect or objective (Sayer, 2002). In critical realism, both the reality we perceive and the knowledge we have access to are thought of as historically constructed through the social, economic and political contexts we live in. Through this approach, we aspire to present a version of discursive reality that is well founded on actual uses of the term of the bioeconomy and we also aspire to think in terms of the actual economic and political conditions that affect the use of the term or made the use of the term possible in the first place (Archer *et al.*, 1998; Birch, 2017b). We are aware that discourse is a political economic endeavour and that, just like the people who have written about the bioeconomy until now, we also have a certain positionality both as researchers and as human beings. This makes us ready to re-visit and refine our approach in the future, discard analyses that we now think are the best we can have given the limitations of our research and interpret both our data and our collection of data through new prisms if what we have at hand does not adequately provide us with the analytical and synthetic tools we need to understand our subject matter.

Our second approach to the examination of the policy documents as sources is informed by grounded theory (Charmaz, 2006; Glaser and Strauss, 2006). Grounded theory is the epistemological approach according to which a research project can start without a pre-established or existing theory. Gathering data with attention to detail and having as a priority to describe reality as it is possible to be approached by the researcher means that theory is chosen while or after the analysis of data. In case there is no theory with analytical capacity to explain the phenomena that the research data reveal, the researcher will attempt to create a theory based on the data, if that is possible. A grounded theory does not aspire to universality, although it can give results that can be widely applied, and is always well connected to research findings. We use this approach to ensure that our arguments stay as connected as possible to the texts we use as sources. This aids the uncovering of social and political context of the documents in order to identify possible understandings and interpretations (as opposed to an interpretation reflecting a theoretical position).

Concerning our sources: we used the existing academic literature, public statements and official documents, where "bioeconomy" as a term is mentioned. We use the search engines of Web Science, Scopus and Google scholar, and also using the snowballing method to find references used in published papers to make sure that we have not missed references that the search engines might miss for technical reasons. We are not addressing the engineering or scientific papers which currently dominate the field. For a recent review of these in combination with the literature of social sciences see Bugge et al. (2016). The search was done in four languages (English, French, Spanish, Greek). All lay articles we found concerning the bioeconomy were written by experts (who were using their expertise credentials in the texts they were writing), and only in one case we found the use of the term to be related to a community practice (in Greece) about which there is no public follow-up or further replication of the use of the term. In addition, we are not incorporating papers that address "bioeconomic" phenomena without mentioning the term. Although we acknowledge the contribution of such papers to the understanding of related issues, this paper is specifically concerned with the use of the term "bioeconomy".

This paper presents a major part of the theoretical or desk-research section of our project. We have also conducted extensive field research about the farmers markets and open-air markets in East Yorkshire, through the use of ethnographic methods (observation, observation by participation, interviews, analysis of public material released by the markets). Our purpose is to document bioeconomic practices that do not belong to big industrial process, yet might be crucial for both environmental sustainability and social sustainability of a region. We are preparing detailed accounts of the field research findings in other studies.

Table 1 shows the range of sources we have used in this paper. We categorised the papers according to their content in terms of discipline and not according to the discipline of the journal they are published in. In many cases, journals focused on technology or environmental sciences publish a study that belongs to another discipline, like a social science. For the table we used only the sources directly related to the bioeconomy and not other sources on peripheral topics.

Our turn to official documents and policy declarations in addition to academic literature was made because it seems that the role of the states and international organisations is fundamental in the history and discourse of the bioeconomy. A governmental role in the development of the bioeconomy also seems to be expected by both the private sector and academics (Brunori *et al.*, 2011; Pavone, 2012; Gustavsson *et al.*, 2013; Barben *et al.*, 2016; BBIJU and SCAR, 2019).

At this stage, we did not use linguistic quantitative methods, like corpus analysis, because we want to focus on notions themselves and how they are used within specific historically perceived political economic con-

Table 1. Bioeconomy literature used in the paper.

Sector of origin	Author role	Type of document	Scope	Number of texts
Policy	State	Report	Normative	6
	International organisation	Report	Normative	4
	Researcher	Report	Normative	2
Academia	Researcher – academic	Paper	Policy-descriptive	16
	Researcher-academic	Paper	Theory-descriptive	44
	Researcher-academic	Paper	Theory-descriptive	1
	Researcher – academic	Paper	Theory-empirical	10
	Researcher-academic	Book or edited book	Theory-descriptive	3
	Research – academic	Paper	Normative	3
Business	Business	Report	Normative	2

texts. In other words, we examine the context of the use of each word, the positionality of the user and the possible or intended effects of that use.

3. BIOECONOMY: RISE OF THE TERM BIOECONOMY IN THE 1990s AND BEYOND

The term bioeconomy is quite new. It appears to have emerged from the pool of ideas and interactions associated with the Biotechnology and the Cell Factory Key Action of the European Union (1998-2002), at least for the countries who were members of the European Union (European Commission, 2007; Aguilar and Patermann, 2018). The term "biotechnology" was associated with policies promoted through the perception of biological knowledge and know-how as a particular type of value in the economy, which were adopted before the emphasis on bio-materials emerged. Biotechnology refers to "the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services" (Arundel and Van Beuzekom, 2006: 7; Miller, 2007).

Biotechnology is broadly used in combination with the terms bio-based economy and knowledge-based economy, explicitly mentioning nowadays bioeconomic sectors like pharmaceutics, well before being combined as the "knowledge-based bio-economy" appeared in EU and OECD documents (OECD et al. 1997; Neef, Siesfeld and Cefola 1998; European Commission, 2002; OECD 2002, 2005). The term (bio-based economy) is also used in OECD documents, but there is no information in OECD archives who or which country first used the term bio-based economy (Begley *et al.*, 2011; Birch, 2017b; Aguilar and Patermann, 2018; Bell *et al.*, 2018). Before that, based on our search in English-speaking literature, we found the term "bioeconomy" only in a biology paper related to the behaviour of the house mouse (Berry and Bronson, 1992). Table 2 provides a timeline for the key terms addressed in this section.

The major emphasis of the EU policy in the late 1990s-decade of 2000s was on biomass to be used as non-fossil fuel and on the production of food (whether through agriculture or pasture/livestock production), including products that were not food but still were based on biological raw materials (Albrecht *et al.*, 2010). A second sector that has been strongly linked to the bioeconomy was pharmaceutical research and production. The documents of the European Union use the latter as an option or direction of bioeconomic activity with increasing momentum after 2010. A special emphasis on pharmaceutical aspects of the bioeconomy is also given by the OECD report on the bioeconomy, especially through the description of future crisis or disaster scenarios that the pharmaceutical bioeconomy would resolve (OECD, 2006, 2009, 2018; Albrect *et al.*, 2010; Styhre and Sundgren, 2011; European Commission, 2012, 2018a, 2020a, 2020b; Benini *et al.*, 2013; Bell *et al.*, 2018). The use of the term bio-economy within the phrase and/or acronym Knowledge-Based Bio-Economy (KBBE) was also linked to sustainability, though not as an inherent characteristic, but as a design element that can be possible, feasible and desirable, under certain policy choices (Albrecht *et al.*, 2010; Allen *et al.*, 2017; Birch, 2017b).

After the European Commission published their communication for sustainable growth in 2012 (European Commission, 2012), the bioeconomy (or bio-economy) became a prominent topic of debate concerning policies that can be related to improved economic pathways for the European Union. The main idea was to use bioeconomy as an engine of economic sustainability, to support innovative solutions in a variety of sectors using policies that are coherent among each other. Bioeconomy would be the umbrella term which would allow this coherence, or at least, this was the plan. Moreover, the bioeconomy was supposed to provide answers to issues or provide opportunities that had emerged as a consequence of waste policies that were restricting the landfilling of biodegradable waste (Girardin and Peigne, 2003; Taiwo, 2011; Cal *et al.*, 2017). The widespread uptake of composting and anaerobic digestion in response to the Landfill Directive pointed to biodegradable residues as a valuable commodity, from which added value could be extracted by the application of science and technology (Boons *et al.*, 2015).

Economically, in the 2000s the bioeconomy was represented as able to provide new investment opportunities for the few who had access to capital and new job opportunities for the many who were experiencing a job market with high long-term unemployment rates and increasing employment instability at the same time (Albrecht *et al.*, 2010; Styhre and Sundgren, 2011; Birch *et al.*, 2012a, 2012b; Dallemand *et al.*, 2015; Goven and Pavone, 2015). This provided an attraction for policy makers similarly to other economically-driven environmental approaches (further discussed in section 6). The widespread concerns relating to the social and environmental consequences of biofuels (displacement of food crops and consequent reduction in the affordability of food) resulted not in the abandonment of biofuels, but in the drive for a technological solution via a "second generation" of biofuels, that would be more sustainable or possible to be sustainably managed although they are more costly to produce (Boody *et al.*, 2007; Jordan et al. 2007; Horlings and Marsden, 2011; Bhandary *et al.*, 2013; Hanlin *et al.*, 2013; Mohr and Raman, 2013; Eggert and Greaker, 2014; Lewandowski, 2015; Bell *et al.*, 2018; Brent *et al.*, 2019).

One should note that up until now (2021), although different sectors of the bioeconomy are described as part of an integrated policy vision, questions of sustainability or the connections with other economic activities are not well developed in the literature or policy statements. In them, the economy is compartmentalised; the bioeconomy is perceived more as an exogenous economic design rather than organic part of economic activity. Nonetheless, there is an implicit assumption that the wider economy can be made use of, with the addition of some technological solution, without an analysis of how the interconnection of the bio- and the wider economy might work or of what the consequences might be. Technology is the assumed solution to problems of human societies; thus the problems faced by human communities can be ameliorated by further technology-drive research.

The use of the term bioeconomy in support of the economy as presently structured and in favour of the bioeconomy-investing companies means that the state authorities had a crucial role not only in shaping bioeconomy as a notion but also in the creation of a bioeconomic market. No doubt, nation states were already in search of possible solutions to the problems and contradictions mentioned above. At the same time, their intervention was supported or even demanded by the bioeconomic industries in a straightforward way (Albrecht *et al.*, 2010; Brunori *et al.*, 2011; Pavone, 2012; Arancibia, 2013; Kautto and McCormick, 2013; Birch *et al.*, 2014; Dallemand *et al.*, 2015; Goven and Pavone, 2015; Barben *et al.*, 2016). A prominent role was also undertaken by international organisations like the OECD and the European Union who were trying to promote bioeconomic policies and support bioeconomic activity within this big business setting (OECD, 2006, 2009, 2018; European Commission, 2012, 2018a, 2020a, 2020b; FAO, 2018; US Department of Energy, 2016; BBIJU andSCAR, 2019). Given the rapid rate of diffusion to the term bioeconomy through national, EU, OECD policy documents, it is difficult now to trace the lines of influence between the different organisations. The following section examines in more detail the recent developments in the use of the term in the EU and the UK.

Table 2. Bioeconomy timeline. This table summarises the key concepts relating to the bioeconomy to provide a timeline. For sources, see the text.

Date	Term	Emphasis
Late 1990s	Biotechnology	Economic benefits from the development of commercial application of biological research
Early 2000s	Biofuels	Carbon reduction and energy security
Later 2000s	Bioeconomy	Biofuels – second generation emerging Options for pharmaceutical industry emerging
2010		Social benefits considered (e.g., employment)
2012		Identified as sustainable growth strategy in the EU – but with economic emphasis focused on capital intensive industry
2010s		Organic waste management potential and biorefining
2018		EC address wider sustainability benefits and refer to small scale bioeconomic activity Link made to circular economy UK re-emphasis the large-scale industry aspect

4. CURRENT USAGE OF THE BIOECONOMY IN POLICY DISCOURSE

Having briefly examined the development of bioeconomy as a policy in the EU, we now apply Critical

Discourse Analysis (CDA) to the text of key EU and UK policy documents.

The original EU policy statement on the bioeconomy was the European Commission Joint Research Centre report (Benini *et al*., 2013), which shows how an international institution steps into the production of knowledge while creating policy at the same time. This report was a study made by the researchers of the Centre, which is a research facility under the auspices of the European Commission. Here we reproduce extracts (pp 18-20) to illustrate the aims and intentions for a bioeconomy [emphasis as in original text]:

> "Towards this end, management of the bio-economy would imply: i) optimizing resource allocation by addressing multi-dimensional and potentially conflicting issues (for example, the "food versus fuel" debate); ii) driving research and innovation in the primary production and processing sectors; iii) developing new industrial concepts and business models, and open new markets, iv) and the creation of new high-skill jobs.
>
> …
>
> While having research and development at its core, EU bio-economy strategy aims also to reconcile sustainable agriculture, forestry and fisheries, food production and industrial use of biological feedstock. In addition, EU Bio-economy Strategy stresses the crucial importance of non-technological factors, such as wide stakeholder involvement and partnering, and the necessity of developing a coherently integrated EU policy framework for the bio-economy, including regional, agricultural, industrial, environmental and energy policy.
>
> The Action Plan focuses on *three key pillars*:
>
> i) Developing new technologies and processes for the bio-economy, by using R&D and innovation to produce renewable raw materials sustainably in agriculture, forestry, fisheries and aquaculture, and to process renewable raw materials into value-added products in the bio-based sectors.
>
> ii) Developing markets and competitiveness in bio-based industries. Concrete actions include support for: development of new markets and bio-based value chains, and commercialization of new bio-based products; demonstration plants and up-scaling facilities, and establishing R&D public-private partnerships.
>
> iii) Collaboration between policymakers and stakeholders by means of a more co-ordinated bio-economy governance mechanism (i.e. including CAP, CFP; RTD[1] and innovation; industrial policy and competitiveness; employment; energy and public health policies; EU environmental policies on: resource efficiency, sustainable use of natural resources and protection of biodiversity)."

In these two passages the bioeconomy is used as a panacea to address and also interconnect other policies of the European Union. The emphasis is on the economy and how the economy can be supported by the bioeconomy (see the frequent use of the word 'competitiveness'). The bioeconomy is expressly seen as being related to and covered by EU environmental policies. There is reference to coordination of policies, e.g., bioeconomy as aiding sustainability (e.g., of agriculture), but the document does not indicate how that might function in an environmental sense. Several references in the text are made to stakeholders – indicating that a common cause is sought with at least the business community, and recognition that although policy makers and scientists may collaborate in research and development for policy priorities, the implementation requires active engagement from other sectors of society. The public is referred to implicitly as consumers, i.e., passive stakeholders who will respond to the policy and buy or use the products, but will not participate in the formulation of the policy. The document is more a future-research-oriented document rather than an appraisal of current bioeconomic processes. Even for the future, the focus is on certain industrial procedures and aims related to industry aspiring to development in biofuels and chemicals. The policy steps undertaken however, induce an effort to protect the food supply, thus tacitly acknowledging the issue of the first generation of biofuels i.e. the risk of competition for land with the potential to increase the price of food (Jordan et al. 2007; Ajanovic, 2011; Baldes *et al*., 2013; Brent *et al*., 2019).

The EU approach to the bioeconomy has, however, changed since that initial report in 2013. In the 2018 report by the European Commission (2018a, A sustainable bioeconomy for Europe) the discourse has greatly changed. We observe some indirect reference to sustainability with respect to production sectors like forestry, fisheries, food, and feedstock as well as to environmental or energy policies. Moreover, within a wider interpretative context the stakeholder engagement can be perceived as including community engagement procedures. The report, however, does not expand beyond a purely economy-focused approach. The wording would allow further sustainability negotiations or contestations, if the politics in the EU member states and institutions were to use this document as a starting point for a debate. In the European Commission (2018b) Staff Working Paper we can see that a major emphasis is given on sustainability and more details concerning how the bioeconomic policy of the European Union can be deployed to support specific environmental and economic activities. However, the disparity of the focus between the two docu-

[1] CAP: Common Agricultural Policy. CFP: Common Fisheries Policy. RTD: Research Training and Development, which is the EU Directorate General for Research and Innovation

ments reveals the internal tensions within the Commission. Some parts of the bioeconomic policy remain at wishful thinking or debate level in the Working Paper. The parts of the debate which are receiving a consensus are those appearing in the main policy document (European Commission, 2018a). The same disconnection we observed between perceptions of farming policies and the role of the bioeconomy and the bio-based economy can also be observed in the more recent Farm to Fork Strategy of the EU (European Commission, 2020a, 2020b).

There is a close association between the bioeconomy and circular economy. The latter refers to the maximisation of value from resources by design of products to promote longevity and recovery of materials at end of product life (European Commission, 2015; 2019). The principle of circularity can be applied to the bioeconomy as well as to non-biogenic resources. The European Commission Report about the sustainable bioconomy in Europe links bioeconomy to sustainability and circularity from the very first part of the Introductory section (European Commission, 2018a, p. 4), where in the box containing the definition of the term we read:

> "Sustainable & Circular: Bioeconomy the European way
> The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. To be successful, the European bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernisation of our primary production systems, the protection of the environment and will enhance biodiversity."

In this document responses to climate change and also the need to protect the economy (notwithstanding environmental constraints) are very visible. In the following sections the linkages to the circular economy concept are represented as more or less overlapping actions that the bioeconomy can deliver better than circular economy or at least more comprehensively than other alternatives (European Commission, 2018a: 5-14). Environmental constraints on the economy are perceived as an argument for more research and data collection for the bioeconomy in order to abide within those constraints (European Commission, 2018a: 15):

> "The Commission will implement an EU-wide, internationally coherent monitoring system (Action 3.2) to track the progress towards a sustainable, circular bioeconomy in Europe and to underpin related policy areas. Knowledge gained will be used to provide voluntary guidance for operating the bioeconomy within safe ecological limits".

Contrary to that declaration, the report by the British Government that very same year (HM Government, 2018) seems to express a more economic orientation, reflecting previous EU policies and statements.

> "What is the bioeconomy?
> The bioeconomy represents the economic potential of harnessing the power of bioscience, using renewable biological resources to replace fossil resources in innovative products, processes and services. The bioeconomy in the UK in 2014 has been estimated to have contributed to £220bn of output across the UK economy, supporting 5.2m jobs. Building a world-class bioeconomy will transform our economy by removing our dependence on finite fossil resources. Bioscience and biotechnology has the potential to create new solutions that are economically and environmentally sustainable as well as resource efficient. These solutions will help to tackle global challenges and create opportunities in agri-food, chemicals, materials, energy and fuel production, health and the environment."
> (HM Government, 2018: 9).

The economic orientation is not just a misrepresentation due to the short length of a definition. In pages 16-17 of the same report we read the goals of the bioeconomic policy [emphasis with bold is in the original text]:

> **"Goals**
> We have set out four high level goals, which are reflected in the actions of this strategy.
> **1. Capitalising on our world class R&D:** We will continue to advance our world class research, development and innovation base, leveraging greater investment to turn our cutting edge ideas into commercial success in the global marketplace.
> **2. Maximising productivity:** We will maximise the potential of our bioeconomy assets right across the UK, making the most of our knowledge, facilities and people to increase productivity from our existing renewable biological resources,
> **3. Delivering benefits:** We will support Industry sectors to ensure that this strategy delivers real, measurable benefits for the UK, creating jobs, increasing productivity and doubling the size of the impact of the bioeconomy to £440bn by 2030.
> **4. Creating the right market conditions:** We will create the right national and international market conditions to allow innovative bio-based products and services to thrive, raising public interest, increasing skills in the workplace and sales to the market."

Searching to see what role has been assigned to sustainability in that same British Government report, we see that it is mostly linked to the plastic packaging policies but apart from that (plastic packaging), it is used in a generic, more aspirational than action-based and rather limited way. Sustainability does not seem to take central role in the design of the UK bioeconomic policy (HM Government, 2018: 4-5,10-12, 16, 24, 35, 37, 48, 51, 53-55). The difference in emphasis between the UK Government and EU documents raises the question of the extent to which other member states have adopted the EU approach as opposed to devising their own variation, and indeed where the push for the EU approach came from. An example is the French bioeconomic strategy as it was announced in 2017 by the Ministère d' Agriculture et Alimentation (2017). Sustainability issues, society's involvement and even agroecology appear in the French Ministry's leaflet. In the report of the German Bioeconomy Council (2019: 72-106) one can see the stark difference between the UK bioeconomic strategy and the strategies of other countries like Spain, Latvia, Italy, France and Norway. The UK focuses on the economy only (plus reduction of waste) while the other countries are explicit in connecting environmental sustainability and/or climate change to the bioeconomic activities. Nevertheless, the Bioeconomy Strategy adopted in January 2020 by the German Government seems to be closer to the 2018 UK strategy, mentioning only the economic sustainability that the bioeconomy can bring and leaving as implicit or assumed any discussion about protection of the environment or environmental sustainability of the bioeconomic processes (Federal Government of Germany, 2020).

As we have mentioned above in Section 3, the major effect of policy-makers and academics both being involved in the promotion and design of the bioeconomy has been that the term itself has been constructed around top-down policies and big corporate structures as the most probable private agents of bioeconomic activity. From the excerpts and examples used in this section, we see that this direction is normalised in official documents. In the European Commission 2018 report, the word "small" referring to small farmers and businesses is used in a way that reflects more an awkwardness that the EU policies have to take into account the small production modes and arrangements that exist in the continent rather than supporting them by priority or as an inherent characteristic of the regional economy. We have to comment, though, that the quest for bioeconomic solutions that can be adapted to small production exists explicitly in the report although most of the details are placed in the Staff Working Paper (European Commission, 2018a: 11; 2018b: 46, 58, 60-62). Conversely, in the British government report the word "small" does not exist at all.

The bioeconomic strategy in the UK seems to have been heavily influenced by industry perspectives and by the perception that it is the economy which is the first priority in the debate about the bioeconomy. It is indicative of this orientation that the British Biotechnology and Biological Sciences Research Council has commissioned a private company named Capital Economics to prepare a report (2015) in order to assess the importance of the bioeconomy for the British economy. This shows that the prioritisation of the economy, especially the large industrial mass-production based economy, in perceiving the bioeconomy is a more or less political trend or medium-term occurrence in British research priorities.

An example of prioritising large industrial mass-production in the bioeconomy is the THYME project itself, in which this paper originates. The project is the only major one that we could find, after searching the projects funded by the UK government until 2020. Sustainability as a goal of the project refers to the industries of the region and this is very understandable given that this industrial sustainability is the most common understanding of the bioeconomy (Goven and Pavone, 2015; Aurambout *et al.*, 2016; Mustalahti, 2018; University of York, 2017).). The local character of entrepreneuship is not taken into account by mainstream economic assessments of the regional economy (Charles and Hodgson, 2008, Viaggi, 2016; University of York, 2017) and our economic understandings/theories for this scale are very limited. The bioeconomic process of food production can thus have various aspects and it can be small scale and follow various routes of generating income for the producers. Those possibilities, however, are very rarely discussed as a possible and viable approach in national or supranational visions of the bioeconomy (Gustafsson *et al.*, 2011).

5. ACADEMIC DISCOURSE ABOUT THE BIOECONOMY: A CRITICAL APPROACH

We now turn to reviewing the academic literature on the bioeconomy, in order to see how the academics, some of whom in one or another advise or influence policy-makers, perceive or develop the notion of the bioeconomy.

In most cases academic discussion of the bioeconomy is normative, i.e., relates to advancing the bioeconomy through technological developments, whilst assuming those to be economically and/or environmentally beneficial (the distribution of those assumed benefits being unquestioned). The term, as we have already mentioned, has been used extensively within a big-business and big-policy framework (OECD, 2006, 2009, 2018; European Commission, 2012, 2018a; HM Government, 2018; BBIJU, 2019). The big-industry orientation of the bioeconomy has been noted by the Food and Agriculture Organisation of the United Nations in their relatively recent report about the bioeconomy (FAO, 2018). Scientific attention has been focused on specific technological advances e.g., the chemical engineering of biofuels, or derivation of high value constituents like pharmaceutical products (OECD, 2006, 2009, 2018; Albrecht *et al*., 2010; Asveld *et al*., 2011; Brown *et al*., 2011; Styhre and Sundgren, 2011; Bringezu *et al*., 2012; European Commission, 2012; Dallemand *et al*., 2015; Barben *et al*., 2016; Cal *et al*., 2017). In particular, the bioeconomy became the byword for people who wanted to believe, or actually believed, that mass production of biofuels would be the most effective solution to the problem of maintaining vehicle-dependence whilst reducing fossil fuel-related carbon emissions and also circumventing fuel security issues (Hilgartner, 2007; Jordan et al. 2007; Gustavsson *et al*., 2013; Lewandowski, 2015; Brent *et al*., 2019). This narrow focus on the bioeconomy as synonymous with technological advancements (i.e., biotechnology) overlooks the perceptions and practices related to the existing economy that it was supposed to be connected with. The connection is seldom analysed, leaving at best a partial understanding of the likely and actual impact of biotechnology on the economy.

For some time, the bioeconomy was perceived by academics precisely in the way that policy-makers do, i.e., an opportunity for capital-intensive economic development, as indicated by the technical literature (whether pharmaceutical or relating to enhancing the efficiency of technologies for extracting value from bio-residues). There are academic writings where the bioeconomy is a framework that is treated as known and non-problematic by the authors (Duchesne and Wetzel, 2003; Dech and Pocharel, 2011; Galt *et al*., 2017). This is also more often observed in papers that have more of a technical or engineering character (Chandra *et al*., 2011; Dech, 2011; Laserre *et al*., 2014; Achury *et al*., 2015; Le Heron and Winder, 2017). There were, however, voices who were critically assessing bioeconomy and were also offering to the debate other perceptions about it that went beyond the big corporation-oriented construction of a bioeconomy (Helmreich, 2008; Pavone, 2012; Mustalahti, 2018). Critique in particular focused on how the bioeconomy was functioning as a discourse to engage broader audiences and various social groups into economic decisions that were made while taking as their first priority the securing of the profits for companies who would invest in research and development of bioeconomic products (Birch, 2006, 2007, 2009, 2012; Larsen, 2007; Fumagalli and Morini, 2010; Brown *et al*., 2011; Birch and Tyfield, 2013; Arts *et al*., 2014; Goven and Pavone, 2015; Bell *et al*., 2018).

The critique of the corporate orientation of the bioeconomy is something we should delve into a bit further. First, the critique shows the impasses of this approach taken by both the private and public sectors with relation to the bioeconomy and its use as a panacea for the environmental and economic problems of 21st capitalist economies (Cooper, 2007; Hilgartner, 2007; Kitchen and Marsden, 2011; Arancibia, 2013; Birch and Tyfield, 2013; Goven and Pavone, 2015; Birch, 2017a). Second, the most important arguments were related to accelerating and intensifying the pace with which nature and knowledge are privatised, commoditised and assetised (Cooper, 2007; Larsen, 2007; Helmreich, 2008; Fumagalli and Morini, 2010; Pavone, 2012; Hendrickx and Reis-Castro, 2013; Goven and Pavone, 2015; Birch, 2017a, 2019). Third, some authors are severely critical about seeing all production processes and all natural materials as part of a scientifically organised profiteering and management process (Brown *et al*., 2011; Goven and Pavone, 2015). This scientised perception of production and nature is considered to turn all activity related to those processes and materials into a profit-making process based on values that have been defined in advance. Those same values are used as the targets and instruments of human activities that aspire to resolve the problems that the profit-making is creating (Larsen, 2007; Birch, 2012, 2019; Kitchen and Marsden, 2011; Hendrickx and Reis-Castro, 2013). Fourth, development of knowledge about nature and re-use of resources is a commodity that needs to be patented to become an asset, so that businesses can invest into that knowledge production by having secured that the knowledge or the practical implications of it will be privately owned by them (Pavone, 2012; Birch 2017a). That this would favour the development of specific types of knowledge and technology and specific ways of using natural resources suggests that the needs of the ecosystems would not be a priority or they would be subjected to the needs of the businesses to profit economically instead of the other way round (Birch 2012; Goven and Pavone, 2015). As a consequence, the entire bioeconomic activity would not be sustainable or it would even harm further degraded ecosystems and problematic economies (Birch, 2007, 2019; Cooper, 2007; Hilgartner, 2007; Fumagalli and Morini, 2010; Arancibia, 2013; Birch and Tyfield, 2013; Delvenne and Hendrickx, 2013; Delvenne et al., 2013; Hendrickx and Reis-Castro, 2013; Bugge *et al.*, 2016; Gawel *et al.*, 2016; Gawel *et al.*, 2019).

Sustainability, especially the environmental part of it, is perceived as being distinct from the bioeconomy. We saw this in policies providing nothing to ensure the short or longer term sustainability of the bioeconomy. And likewise in the academic literature, the bioeconomy is seen as either sustainable or not without this ambivalence being thought of as problematic (Jordan et al. 2007; Baardsen *et al.*, 2014; Dankbaar *et al.*, 2014; Olikainen, 2014; Caivano *et al.*, 2015; Sauvee and Viaggi, 2016; Viaggi, 2016; Allen *et al.*, 2017; Szekacs, 2017; Heijman and Shepman, 2018; OECD, 2018: 25-68). In most cases it is assumed implicitly that the bioeconomy could be sustainable if we do not have not evidence to the contrary (Passet, 2012; Kircher, 2012; Kautto and McCormick, 2013; Goven and Pavone, 2015; Lasserre *et al.*, 2014; Aurambout *et al.*, 2016; Ferreira Gregorio et al. 2018). And we note that there is very little research outside of laboratories and academic spaces that attempts to judge the sustainability of the bioeconomy (Larsen, 2007; Fror *et al.*, 2017). In other cases, the sustainability of the bioeconomy is conflated with the renewability of resources, and those two are both thought to be interchangeable with the sustainability or renewability of capital (Gawel *et al.*, 2019; Birch and Tyfield, 2013). In reality, the sustainability of capital is taken for granted and because capital can renew itself indefinitely in time (or so it is perceived to be able to do), nature and knowledge are also perceived to do the same. If they do not, it is because better (i.e. more intensive) management and resource utilisation is needed (Birch, 2007, 2012; Birch *et al.*, 2010; Dankbaar *et al.*, 2014; De Besi and McCormick, 2015; Gawel *et al.*, 2016; Birner, 2018; Lewandowski, 2018; Pulzl and Ramcilovic-Suominen, 2018) rather than a radically different approach – such as potentially a less intensive use of resources.

However, bioeconomy can be given other meanings than the ones that have been constructed through policy documents and many academic documents. Thus, we suggest it is a contested field for both theoretical debate and economic practice. Contrary to the big-corporation-oriented bioeconomy, there is the organic[2] or agroecological approach. With agroecology we mean that agricultural production is taking place in modes that sustain the local ecosystem and local natural resources with a long-term view (Altieri, 2009; Levidow *et al.*, 2012; Martinez-Torres and Rosset, 2012; Altieri *et al.*, 2015, Bugge *et al.*, 2016; Levidow, 2015). Agroecological practices also seek to provide adequate income to the producers through the production of quality agricultural products, mostly food. Given that agroecology focuses on synergies between the ecosystem as such and the human communities that are producing their food/agricultural products within it, it is more labour intensive than the big bioeconomic industries, but its mode of production is the one of the small farmer or the small producer in general. The specificity of ecosystems (soil, geography, climatic conditions, availability of local seeds, fauna of the region that feeds off or uses agricultural fields for habitat) does not allow sweeping decisions about practices and it requires adaptation of the production processes to the conditions of each place/community. In this framework, the production of food is the core activity of the bioeconomic process. Organic agriculture and agroecology are perceived as methods of cooperating with nature to produce adequately, instead of perceiving nature as a space from which resources are extracted. In that way the mode of production is adapted to this production of food within the context of the local ecosystems (Kitchen and Marsden, 2011; Birch *et al.*, 2012a, 2012b; Levidow *et al.*, 2012; Esposti, 2012; Levidow, 2015; Bugge *et al.*, 2016; Viaggi, 2016; Hausknost, 2017).

We need to note here that bioeconomic processes, such as anaerobic digestion, or value-added approaches to dealing with agricultural waste have proven so far to be quite beneficial to farming and food production on a big scale (De Meester *et al.*, 2012). Farming and the 'official' view of the bioeconomy are not totally divorced from each other and given that policies are constructed through the official corporate-oriented view of the bioeconomy, the bioeconomic influence on farming is also corporate-based. We would need more research and a longer-term experience to have a sound conclusion about the interconnection of bioeconomic processes used to reduce waste and environmental degradation in farming. Moreover, we would need a more holistic approach to assess the potential of the technological bioeconomy to decide whether as a production process is more ecologically sound than other ways of production.

The published critique of the bioeconomy is very much an academic debate; it seems not to have been enjoined by practitioners or social movements. From all online investigations we have conducted (July 2019, October 2019, December 2019, April 2020), it seems that, to the best of our knowledge, the term bioeconomy is not used broadly by grassroots initiatives in their public activity, much less by people who might be small produc-

[2] We do not conflate organic with agroecological. Those are two different approaches to agriculture and even if they sometimes overlap, they can be structured in various ways concerning their economic expression. However, we use them here together in the way they are used in the academic literature, that we examine in this paragraph.

Table 3. Academic discourse on the bioeconomy. This table is a visual presentation of basic perceptions of the bioeconomy as presented in academic literature. For sources, see the text.

Perception	Focuses on	Tries to attract
Normative	Technology	Big businesses, policy-makers
Given-Not discussed	Technology	Big businesses, policy-makers, greater audience
Panacea	Environment Economy Knowledge	Big businesses, policy-makers, greater audience, environmentally aware individuals and groups
Sustainable	Renewability of resources Renewability of capital Efficiency	Big businesses, policy-makers, greater audience
Organic Agroecological	Agriculture Food	Big and small businesses, policy-makers, greater audience, food producers and farmers

ers, even if they practically follow bioeconomic processes in their activities. Furthermore, the academic literature largely overlooks small scale activities which might be construed as part of the bioeconomy. We have found very few mentions of farmers' markets, for example. Thus, so far academic consideration of the bioeconomy is mirroring the policy focus on technology-driven, capital-intensive approaches to the economic opportunities arising from organic resources. We consider this further below, but first address the bioeconomy in the context of other approaches to addressing economic benefits.

6. SUSTAINABILITY ECONOMIES

To understand better the context of the use of the term bioeconomy, we turn to the other types of economies that have emerged during the last decade or two as policy options. These concepts including (the bio-, green, blue, low carbon, and circular economies) we term the sustainability or S-economies (see Table 4 later in this section for a summary of the features of a non-exhaustive list of these economies). The S-economies are named types of economic activity favoured by policy makers as offering potential for a better, or at least different, connection between the natural and human environment via focusing on particular activities as a route to value creation. In many cases, they are represented as attempting to achieve environmental sustainability, although the perceptions of sustainability to which each type of economy is connected might differ. In all cases, the debate that connects those economies to sustainable arrangements is being developed within the confines of the capitalist economy, i.e., to achieve economic growth whilst balancing environmental and social priorities in a manner protective of future generations' abilities to do the same (following on from the WCED in 1987 with Brundtland Report).

We have already mentioned that the bioeconomy emerged initially under the rubric knowledge-based bioeconomy. Knowledge (-based) economy was a term that the European states were using for some decades before the bioeconomy emerged as a term. The term was not just implying that the economy has parts where knowledge, or advances to it, were less significant, but also that people should continuously receive training (for which they should be paying, i.e. they should become clients of educational services providers) in order to adapt to the needs of the markets, i.e. unemployment and low wages were constructed as the result of lack of knowledge on the part of the workers and the businesses (OECD 2002, 2005; Olssen and Peters, 2005; OECD et al. 1997; Jessop and Sum, 2013; Birch *et al.*, 2014; Birch, 2017a, 2017b). Nevertheless, the knowledge-based economy can also be interpreted as an attempt by the capitalist economy to recognise and handle profitably the changes to the economy, brought about by the advance of information and communication technologies and by the creation of new jobs and new demand for advanced or new skills.

By the time the bioeconomy arose as a policy concept, the idea that knowledge itself is a panacea to a stagnating economy was already a well-established one (Godin, 2006; Brine, 2006). The bioeconomy arrives to highlight that with new research and development of more intensive use of biogenic resources we can solve at once both the problem of production costs and job availability and the problems of waste management and environmental degradation. Similarly, the green and blue economies, which were boosted in prominence by the Rio 2012 summit, were seen as means to reignite the faltering global efforts for sustainability. The green economy argues for economic and social benefits to accrue from environmentally focused and social equitable investments, with the blue variant emphasizing marine-based economic opportunities (UNEP, 2009; Bina 2013; UNCTAD, 2014; Smith-Godfrey, 2016; Lee, Noh and Kim 2020; Benson et al., 2021). In practice green economy policies have tended to favour the more mainstream solutions over the more adventurous, socially progressive options (e.g., in building design; Pearce and Barbier, 2000; Gibbs and O'Neill, 2015; Ge and Zhi 2016; Ferreira Gregorio et al. 2018; Merino-Saum et al., 2020). Approaches ostensibly designed to protect the environment by slowing consumption (e.g., bike share schemes) can nonetheless primarily benefit those financially better able to consume (Médard de Chardon, 2019). These outcomes may reflect the contradiction of an apparently anti-consumption policy being driven nonetheless by the profit motive.

The circular economy is a further S-economy, which has risen rapidly to prominence in policy and academic circles in the last few years and which promotes sustainable resource use via design for longevity of product/material use recovery at end of life (Bocken et al., 2016; Geissdoerfer et al. 2017). As discussed above, the bioeconomy and circular economy are closely associated with each other in EU policy debates. The bioeconomy highlights a specific resource type and certain technologies for utilisation, whilst the circular economy proposes principles for using any resources. The circular economy for example favours design for sustainability over marginal improvements to recovery at end of life, but is nonetheless fundamentally seen as a strategy for economic growth by policy makers (European Commission, 2015; 2019). Whilst understandings of the circular economy vary considerably in their degree of social emphasis (e.g., Kirchherr et al., 2017), its origins lie with explicitly corporate-oriented approaches to resource efficiencies such as industrial ecology and industrial symbiosis (Mathews and Tan, 2011; Lieder and Rashid, 2016). The efficient use of raw materials and the recovery of materials from waste, residues and production by-products are the central argument.

Industrial ecology and industrial symbiosis are approaches to economic-environmental benefits that argue for the ability of companies to collaboratively (through networks or business clusters) or collectively (as sectors) produce the necessary technology for avoiding a negative impact on the environment. Business models have to evolve to suit not only changes of technology and social demands but also to be capable of surviving as businesses in a turbulent economic framework (Boons *et al*., 2015; Cecchin *et al*., 2020). Industrial symbiosis therefore can be seen as a transition technology on the way to more profound solutions. By contrast, some understandings of the circular economy (e.g., Ellen Macarthur Foundation, 2015) favour renewable resource use, as opposed to more efficient use of non-renewable resources prominently discussed in industrial ecology. The implied shift towards the bioeconomy is assumed by circular economy discussion to promote sustainability. We have argued, though, that bioeconomy policy and theory does not engage prominently with sustainability debates – leaving the outcome of expanding the use of bio-resources as uncertain. Notably, though, bioeconomy literature has also called the adoption of circular practices (e.g., industrial symbiosis-style use of residues produce other products that could have economic value) (Viaggi, 2016; Sariatli, 2017; Allen *et al*., 2017; Pulzl and Ramcilovic Suominen, 2018).

Lately, the term of smart economy has emerged as a way to show that the economy as we know it can be better organised in order to become sustainable or more sustainable, by using technologies, especially the digital technologies that have been developed during the last decades (Bronstein, 2009; Caragliu et al. 2011; Kumar, 2017; Ruhlandt, 2018). Again, we see the same pattern, of knowledge and advanced technology been assigned the role of the quasi-*deus ex machina* to save both the environment and the economy.

Within the broad remit of sustainability, the relative emphasis of the different pillars of sustainability varies between these different initiatives (Cecchin et al., 2020). The bioeconomy, and mainstream understandings of the circular economy, can be seen as examples of ecological modernisation, the idea that policy-driven technological change can foster economic and environmental benefit (Huber, 2008; Horlings and Marsden, 2011). That is, with a suitable regulatory framework, industry can make profit out of meeting the environmental needs of our societies –creating a win-win situation where the environment would not be harmed and the economic activity would continue unabated. That is, sustainability of the economy and the sustainability of nature are firmly entwined (Pearce and Barbier 2000; Olikainen, 2014; Dankbaar *et al*., 2014; Antikainen *et al*., 2016; Allen *et al*., 2017). Notably the same vision of the green economy is understood differently, along with more radical perspectives on the circular economy, which tend towards the field of degrowth (e.g., Latouche, 2009, Cecchin et al., 2020) increasingly discussed academically though hardly a serious policy contender.

The economies we have described in this section have important differences between them. For example, the knowledge-based economy and smart economy are mostly oriented towards technological solutions that are directly invented in laboratories and research centres. The green economy and ecological modernisation are very much practice-oriented, with a special emphasis on the business activities that will define aims for research and also disseminate the new sustainable technologies through the market. Circular economy and the bioeconomy stand between the two groups, attempting to combine both a strong scientific component with a major role for the business world. Some conceptualisations of the circular economy share the visions of the green economy that seek bottom up, even degrowth, approaches. We argue also that the bioeconomy could be understood as contributing in this area, albeit this aspect has so far been overlooked. Despite these differences, we cannot ignore the similarities among those types of economies and how they emerged at similar historical and geographical points in contemporary economic history, with significantly overlapping aims and intentions. The central aims and economic scope of the various types of sustainable economies are shown in Table 4, along with key policy documents and references to the related academic literature.

From the above we see that the use of the term of bioeconomy, and related ones like green economy, circular economy, or sustainable economy, reveals a commonly accepted, although implicit, assumption that 1) the economy cannot address its own problems but that 2) with some change of emphasis solutions can be found within that same growth-oriented economic approach. The proliferation of terms reveals the pressure to distinguish the contemporary proposals for solutions from recent previous solutions that are facing challenges. Alternatively, the terms imply targeting a different *partial* approach to promoting growth (with sustainability priorities embedded to various degrees), without consideration of the interrelatedness of different aspects of the economy. An analysis of the terminology might reveal the intertwined character of the roles undertaken by state institutions, businesses and academia to promote each and all of those terms/economies and how this intertwinedness can have a potential for both achievements and failures, exactly because the spreading of the use of a certain discourse arguably frames the issues in ways that the various actors and social groups involved with them cannot address effectively from the within the frame/discourse (Birch, 2007, 2012). This is a hypothesis, though, that will be the scope of another paper.

7. DISCUSSION: REFLECTIONS ON THE MEANING(S) OF THE BIOECONOMY

The bioeconomy as a discourse and industrial sector can be credited to the authorities and policy makers who have been steering it over the years since its identification (Benner and Lofgren, 2007; Birch *et al.*, 2010; Birch, 2012, 2017a, 2019; Pavone, 2012; Esposti, 2012; Birch and Tyfield, 2013; Gustavsson *et al.*, 2013; Caivano *et al.*, 2015). Discourse is coming from policy-makers and academics, often in documents that explicitly combine both policy and scientific expertise, i.e. the experts are assigned by the states to provide policy-making advice on the bioeconomy.

From our literature review and to the best of our knowledge it seems that questions like "Why bioeconomy? Why bio-? Why biological? What is new about it? Didn't we have any bioeconomies before 1990?" have not be considered in the literature. The question that any broad definition of bioeconomy raises is whether this type of economy is different from the economy in general, if we accept definitions which state that all biological material is perceived as raw material in the bioeconomy (Albrecht *et al.*, 2010). Apart from seeing such statements as problematic (because they identify all biological substances and all organisms primarily as production inputs), we need to clarify here that not all raw materials are biological materials. Nevertheless, all raw materials are originating in nature ultimately, even if they have been produced in a laboratory or factory. In all cases, human production is based on taking resources from plants and animals. This human production can also be done through the destruction of an ecosystem (e.g. the cutting of a forest) in order to extract minerals from the Earth or the diversion of essential parts of that ecosystem, like water, to benefit human activity instead of the water being available to plants and animals. In other words, whether we choose to deplete or not to overuse the water of a river, we are still (co-)producing the ecosystem.

Although the use of non-biological resources impacts on nature (as above), it could nonetheless still useful to distinguish a specifically 'bio'-aspect as distinct from the wider economy. Destruction is very different to using 'nature' to produce resources. The latter may equally be destructive of habitats but it is not always inherently destructive. The discourse of ecological modernisation has been based on the assumption that more management can be considered as the solution to a lack of sustainable outcomes. The previous section about sustainability economies gave some examples for this use of discourse. The question is whether we need the "bio-" component of the name to stay aware of this use of natural resources.

Furthermore, the bioeconomy, like all S-economies, is vested in the implication that the previous (if recent) economies were based on beliefs and lack of scientific knowledge, or that they were somehow non-, or not adequately, green or sustainable. These hidden critiques concerning the previous economies might have some seeds of truth. But one cannot help recognising that the critiques overlook efforts by several social groups or regions to be less linear and unsustainable through the use of local knowledge and inventiveness. Despite that, the environmental knowledge of those communities has recently begun to be appreciated when the environ-

Table 4. A non-exhaustive list of what we term the Sustainability or S economies. These various expressions have been adopted to promote a particular economic activity as approaches to value generation. The decade of origin and key policy and academic references are provided.

Name	Aims – Vision	Scope	Since	Know-how	Reference
Bioeconomy	Support economic sustainability through capital-intensive use of organic resources	Big industries, biotechnology, pharmaceutics, Energy, waste Efficiency-oriented	Mid-2000s	Edge-research based. Laboratories, industrial applications	OECD 2009, Lewandowski 2018 European Commission 2018 Ferreira Gregorio et al. 2018
Blue economy	Sustainable management of marine resources Profit making from marine nature can be sustainable	Small & big production. Closely associated with to island and coastal economies	2010s	Research & business based Aspects of community economies	UNCTAD 2014 Smith-Godfrey 2016 Le Heron & Winder 2017 Lee, Noh & Kim 2020
Circular economy	Instead of resource depletion & accumulation of waste, design for reuse, repair, upcycling of products and byproducts of each supply chain	All sectors of the economy, but very important for industrial products the raw materials of which are not renewable & after use they cannot be degraded in nature	1990s, but prominent since 2015	Research-based, laboratory-oriented, industrial & consumer orientation	Ellen MacArthur Foundation 2015 European Comission 2015 Bocken et al. 2016 Allen et al. 2016 Geissdoerfer et al. 2017 Cecchin et al. 2020
Green economy	Sustainable solutions that can be profitable – profit making can be sustainable for the environment; some visions emphasise social benefits e.g., via community scale initiatives, and resemble degrowth initiatives	All sectors of the economy	1990s, but prominent since 2000s	Economic & environmental research, industrial applications are preferred, even for the banking sector	Pearce & Barbier 2000 UNEP 2009 Bina 2013 Gibbs & O'Neill 2015 Antikainen et al. 2016 Ge & Zhi 2016 Allen et al. 2017 Ferreira Gregorio et al. 2018 Merino-Saum et al. 2020 Benson et al. 2021
Knowledge-based economy	Make profit out of using advances in research and technology, along with better management of human knowledge	All sectors of the economy, emphasis on industrial sectors and on digital technologies	1990s	Research-based	OECD et al. 1997 Neef, Siesfeld & Cefola 1998 OECD 2002, OECD 2005 Olssen & Peters 2005 Godin 2006 Albrecht et al. 2010 Jessop & Sum 2013
Low carbon economy	Reduce emissions of carbon in production & distribution chains without disturbing profit flow	All sectors of the economy, but mostly industrial plants & other work spaces, food production, transport	2000s	Research-based, business oriented	Stern 2007 HM Government 2009 Zhang 2010 Foxon 2011 Luy, Ngai and Wu 2019
Smart economy	Organise the economy through digital technologies so that costs are minimised and production is more efficient and profitable	All sectors of the economy, emphasis on ICT sector	2010s (or late 2000s).	Research-based, very technology oriented	Kumar 2017 Bronstein 2009 Caragliu et al. 2011 Ruhlandt 2018 (Olikainen 2014)

mental management techniques originating in capitalist economies cannot tackle the implications of the environmental degradation associated with those economies (Berkes and Parlee, 2006; Goodall, 2008). What also needs to be further examined is the variability of types of economies that have been marginalised in the public discourse but still existed and might have been experimenting with smart, green, sustainable and production-symbiotic solutions. The interaction of these marginalised ('grassroots', 'alternative') economies with the mainstream economy, their coordination and potential lessons for sustainability needs much more examination.

8. CONCLUSIONS

For the purposes of this paper, the bioeconomy literature was critically examined in order to investigate how policy-makers and academics perceive economic activity involving the production, use and/or disposal or re-use (whether through upcycling or downcycling) of plant-based products, or products containing substances extracted from plants and animals. We stick with a very broad definition of the bioeconomy and do not assign any inherent sustainability goals to it. Rather than assuming that the bioeconomy is inherently sustainable, we suggest that it can display various characteristics depending on its economic and political context.

What we have seen from the examination of the policy documents and the academic literature is that for the policy-makers and for most academics, the bioeconomy is perceived as a dissociated activity from what everyday people do and from how they understand their relationship to natural materials used for production. At the same time, in cases like the United Kingdom government (or the German government in 2020), the bioeconomy is perceived in a very narrow way which gives emphasis to the economy and sees sustainability as a mainly or only an economic problem. In other words, the corporate direction that the bioeconomy took since its beginning reflected neither the potential of the term nor the bioeconomies that already exist and are largely absent from policy documents and the academic writings relating to the term.

We also showed that the bioeconomy has been developed within a broader context of various named 'economies' (which we call S-economies). These are presented by policy-makers, and analysed by academics, as possibilities for more sustainable economic activity. Ironically, the periodic (if rather frequent) appearance of a new S-economy term in recent decades presents the solutions as something novel, despite that they are all based on common assumptions. Each is aiming to identify a particular field of activity which can generate value within the capitalist economy by offering both a competitive edge and a perceived sustainability advantage (e.g., avoiding fossil fuels).

However, the sustainability credentials may be uninvestigated or in any case contingent on circumstances. Placing the bioeconomy within the broader context of the S-economies makes visible the potential of the bioeconomy to provide at least some environmental benefit, whilst indicating its economic and social limitations. Neither the bioeconomy or other S-economies can overcome the internal contradictions of capitalism. They may generate new opportunities for investment, but also new areas for competition, which may favour some locations/people and may rearrange rather than eliminate inequalities (e.g., Deutz, 2014). It would be the purpose of a future study to investigate 1) how the biotechnology economy articulates with the wider bioeconomy and 2) how the bioeconomy articulates with the wider economy, alongside the other comparable initiatives, which we term the S-economies.

The bioeconomy is generally under-researched as a concept and even more as an economic practice. Some of the literature is descriptive rather than presenting a critical exploration, or incorporates policy-related wishful thinking and academic visions rather than actual findings from the field. We note that there are few policy documents referring to the bioeconomy, and these share a representation of bioeconomic governance as top-down. This lack of extensive academic and political debate and contestation on the concept of bioeconomy obscures the struggle that is taking place among the various social groups who promote and practice the bioeconomy. These we are exploring in further research, especially as relates to small scale, grass-roots practices of the bioeconomy. Our sub-project within THYME investigates the farmers markets in East Yorkshire as small-scale bioeconomic practices on a local collective level. More details about the research findings from that field research will be considered in subsequent papers in order to explore the variety of notions and practices that the bioeconomy can include.

Through our research we have reached the conclusion that the bioeconomy is a contested concept. This is despite fact that it was constructed within a certain geographical and socio-economic framework that was prioritizing corporate and top-down understandings of bioeconomic processes. We also showed that the role of states and international organisations is prominent in this construction of meanings, although a detailed examination of this role should be the focus of future research. Finally, we also showed that evolving perceptions of the bioeconomy, especially in the policy documents, indicate that if we want to develop a *sustainable* bioeconomy, we need to start considering limitations from the side of both ecosystems and our economies. Our paper contributes to a more critical perception and use of the term bioeconomy. which we hope can inform decision-making for both policy-makers and experts.

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Sustainable water resources management under population growth and agricultural development in the Kheirabad river basin, Iran

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Abstract. In this study, an integrated system dynamics model was developed for scenario analysis in sub-sectors of the *Kheirabad River Basin* in southwestern Iran where managing water resources is seriously challenging due to population growth and periodic drought. Afterward, the variability of water demand and supply under baseline scenario and different water demand management policies, including water conservation and water pricing, was evaluated. Findings illustrated that with increasing population and cropland area if no further demand management policies were implemented, the total water demand and withdrawal of water resources increase by more than 0.75% annually. The annual surface water availability during 2018-2030 is expected to decrease by around -1.23%. Under these circumstances, the sustainability index of the water resources system is equal to 0.703, indicating that the water system would not be able to meet the total water demand in the near future. However, the water resource sustainability index increases significantly by improving irrigation efficiency and changing crop patterns at the basin. Also, the reduction in per capita water demand and domestic water pricing under the competition structure would help to improve the sustainability index to 0.963 and 0.749, respectively.

Keywords: Sustainability Index, water system, system dynamics, agriculture, food security, Kheirabad River Basin.
JEL codes: Q2, Q25.

1. INTRODUCTION

Water is essential for people's daily life, agricultural irrigation, fish farming, and manufacturing (UNIDO, 2003). However, this vital resource is faced with several stresses in quantity and quality (Speelman & Veettil, 2013). Among the others, climate variability and increasing population growth have resulted in water scarcity in many countries especially in the arid regions (Hashemi *et al.*, 2019; Mulwa *et al.*, 2021). The water scarcity problem threatens nearly 80% of the world's population (Vallino *et al.*, 2020). Increasing

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water demand in various economic and social sectors exacerbates the problem of water scarcity (Donati *et al*., 2013) and can make the water system more vulnerable (Cai *et al*., 2018). Therefore, the most challenging issue in water resources system in the world is to achieve a balance between supply and demand (Kotir *et al*., 2016; Xiong *et al*., 2020).

The complexity of water systems is familiar to all those studying in the field because of fundamentally their large number of agents and interdependent subsystems (Madani and Mariño, 2009; Balali and Viaggi, 2015). In a water system, there are dynamic feedback relationships among different factors on the supply and demand sides (Kotir *et al*., 2016). Furthermore, the changes in water resource have a dynamics behavior as it is affected by many socio-economic and climatic factors over time (Sterman, 2001). In other words, population growth, climate change, agricultural development, changes in harvesting rate from ground and surface water are factors that affect the water system of a region over time with interaction (Brown *et al*., 2015). The use of water in one sector also affects other sectors, and the agents in the water system are contiguous. These interactions between different water users such as irrigation, drinking water, industrial production, and environmental facilities lead to complexity in the water resources system (Berger *et al*., 2007). These complexities in the water resources system cause policymakers to face policy resistance in managing water resources. Policy resistance occurs when policy actions trigger feedback from the environment that undermines the policy and at times even exacerbates the original problem. Policy resistance is common in complex systems characterized by many feedback loops with long delays between policy action and result (Sterman, 2001). Besides, implementing different policies to manage water resources, depending on the conflict of interest, may have different effects on different stakeholder groups (Darbandsari *et al*., 2020).

Addressing the complexities of water resources system, a holistic approach such as system dynamics (SD) can provide a sufficient water management framework based on conflict resolution approaches. System dynamics consider the interactions among different elements of different stockholders for simulating the behavior of the system and policy analysis (Frank, 2000). This helps decision-makers assess different management policies considering various aspects (e.g., economic, social, environmental, etc.) for simultaneously reducing conflicts and improving water resources conditions (Mirchi, 2013; Darbandsari *et al*., 2020). There are a large volume of published studies that have applied SD modeling to evaluate the effect of changes in some variables such as water demand, population control, water transfer as well as climate change on water availability (Gohari *et al*., 2017; Sun *et al*., 2017; Pluchinotta *et al*., 2018; Mahdavinia and Mokhtar, 2019; Keyhanpour *et al*., 2020). A great deal of previous research into water management has focused on mathematical programing, but they do not pay attention to the feedback processes in the water resources system (Donati *et al*., 2013; Archibald & Marshall, 2018; Zeng *et al*., 2019; Saif *et al*., 2020). Given the significant water consumption in the agricultural sector, these studies emphasize that local water management authorities, in addition to being aware of farmers' possible decisions to allocate farms, should also be able to provide an optimal cultivation pattern commensurate with the potential of each region (Donati *et al*., 2013).

Although good progress has been made in the SD modeling of water resources system in different studies, there are still limitations. Some important limitations of these studies are briefly as follows: (i) in general, less attention has been paid to theoretical foundations in modeling in the agricultural subsystem (Madani and Mariño, 2009; Gohari *et al*., 2017; Mahdavinia and Mokhtar, 2019); (ii) some studies (Kotir *et al*., 2016) considered the crop yields as a stock variable, which contradicts the definitions of the stock variable; (iii) in the population subsystem, few studies (Clifford Holmes *et al*., 2014; Goldani *et al*., 2011) have considered the behavior of consumers to change in water prices; (iv) although most of the above-mentioned studies have focused on the interaction between elements and feedback loops in the water system, a few of them (Madani and Mariño, 2009; Gohari *et al*., 2017) have been designed to analyze various water indicators, for instance, sustainability index that is defined as the ratio of water supply and demand and summarizes the performance of alternative scenarios and policies (Loucks, 1997). It should be noted that the above points are important in studying the behavior of the water system at the basin. Compared to previous studies, to achieve a better result, we used a Nerlove (1956) partial adjustment framework to model the agricultural subsector and simulate cropland area and agricultural water demand. In more detail, farmers' decisions to develop the cropland area were considered in response to changes in crop prices in modeling. It can be an effective effort to more accurately simulate the agricultural water demand. Also in the population sub sector, consumers' responses to water price changes were taken into account. Policies such as taxes and subsidies can change the price of goods and correspondingly the quantity consumed. Thus, various indicators including sustainability (Loucks, 1997), reliability (McMahon *et al*., 2006), vulnerability (Hashimoto *et al*., 1982) and max deficit (Moy *et al*., 1986) indices, were considered to evaluate the effects of water resources management policies and to rank different policies base on their effects on water system behaviour.

Because of increasing complexity and integration of environmental, social, and economic functions, the early water resource models still need to be developed and appropriate policies should be adopted based on the socio-economic and environmental characteristics of basin. Accordingly, this paper develops an integrated SD simulation model for exploring the water resource sustainable index in the *Kheirabad river basin* in southwestern Iran where managing water resources is seriously challenging due to population growth and periodic drought. Put it simply, the present study aims to explore the water supply and demand dilemmas and calculate the water resource sustainability index at the basin.

This paper is organized as follows. The case study and SD model features are presented in the next section. Then, the applied data are described. The simulation results of the model are presented in Section 4 and the conclusions are provided in Section 5.

2. THE STUDY CONTEXT AND SCOPE

Iran is located in the mid-latitude belt of arid and semi-arid regions of the Earth. The arid and semi-arid regions cover more the 60% of the country Iran. The main source of water in Iran is precipitation in the form of 70% rainfall and 30% snow, which is estimated to be about 413 BCM (billion cubic meters). About 71.6% of the total rainfall (295 BCM) is directly evaporated. Considering 13 BCM of water entering from the borders (joint border rivers), the total amount of the country's renewable water resources (long-term averages for 1977 to 2018) is annually estimated to be 124 BCM, of which about 73 BCM go to surface runoff. Groundwater recharge is annually estimated to be about 51 BCM. Currently, total water consumption is approximately 88.5 BCM (Abbasi *et al*., 2015). Agricultural water consumption accounts for about 85% of total water resources in Iran and 90% of them may be allocated in surface irrigation systems with low efficiency and full water supply (Lalehzari *et al*., 2020). According to the latest figures, the average population growth rate in Iran during 1999-2000 was 1.755 percent and lowered to 1.246 percent in 2010-2017. However, in all these periods, Iran's population growth rate is above the global average (UNDATA, 2017). The annual water consumption in the urban areas of the country is about 5.4 BCM, of which 4.3 BCM is related to household consumption that implies to the per capita water consumption of 224 liters per person a day. As far as population growth is considered, the increasing demand is not limited to fresh water use for drinking purposes. The growing population is results in increasing demand for agricultural products as well, especially for some strategic food stuffs such as wheat that are provided at subsidized prices and the Iranian government insists on their domestic supply (The Statistical Center of Iran, 2018). Considering the driving factors of water crisis, the water resources management issue is a national priority and the most important issues among policymakers in Iran (Madani, 2014).

Kheirabad river basin is a part of the *Zohre river basin* in the *Kogiluyeh and Boyerahmad* province, southwestern Iran (Fig. 1). The average annual rainfall of the basin, where the rainfall regime is Mediterranean (with dry and wet season), varies from less than 200 mm to more than 800 mm The average annual temperature also varies from 12°c to 25°c. The water consumption of the *Kheirabad river basin* in the drinking, industrial and agricultural sectors is provided of surface and groundwater resources. This basin is rich in surface water, but the un-normalized utilization of soil and water resources and also the increasing water resources withdrawal have reduced the basin's water potential to meet increasing demands. Most of the surface water resource in the basin is provided by *Kowsar* reservoir dam located in *Zohre river basin* in the west of *Gachsaran* County. Rainfall is extremely seasonal; about 50% of which occurs in winter (concurrently with the smallest water demand), 23% in spring, 23% in autumn, and 4% in summer (concurrently with the greatest water demand). *Kheirabad river basin's* average annual precipitation is estimated to be 331 mm during 2012-2020 while evaporation amount is more than three times that. Not only the climate variability but also the population as an important factor affecting water demand, is continually increasing. While according to the report presented by the Regional Water Organization of Kogiluyeh and Boyerahmad province (2017), the average per capita domestic water consumption of this province is more than 220 liters per day, which is about 20 percent higher than the national average. The combination of these factors led to the water stored in *Kowsar* dam has declined in recent years. Because one of the most important goals of the *Kowsar* dam construction is the supply of drinking water in the southern provinces of Iran and agricultural development in these areas, meeting the growing water demand in this basin is becoming a concern among policymakers.

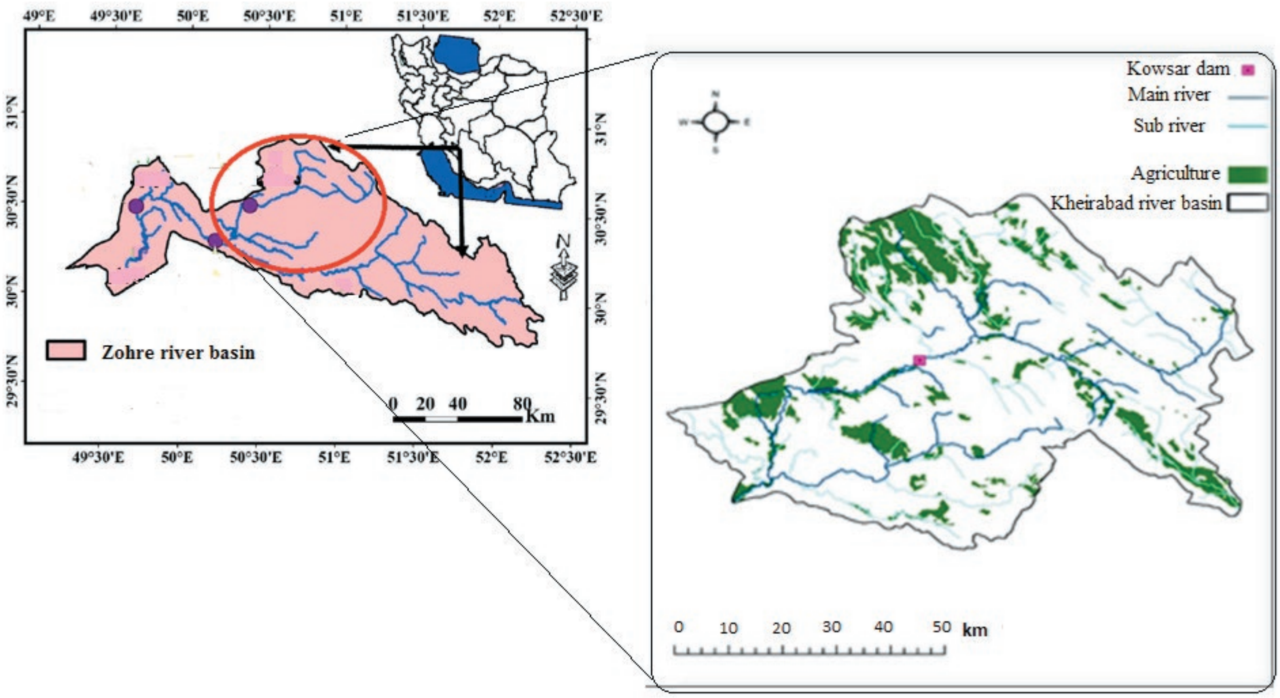

Figure 1. Kheirabad River Basin and Kowsar Dam.

3. SYSTEM DYNAMICS METHODOLOGY

SD modeling is an iterative and feedback process to reach new understanding of how the problem arises and then design high leverage policies for improvement (Davies and Simonovic, 2011). A four-step SD modeling process introduced by Sterman (2001) and Ford and Ford (1999) is used in this study: (1) Problem articulation; (2) Model formulation; (3) Model testing; (4) Scenario design and simulation. The first step in SD modeling is to be specific about the dynamic problem and problem articulation (Ford and Ford, 1999). This step includes defining the problem, identifying the key variables related to the problem, such as stocks, exogenous and endogenous variables, identifying the temporal and spatial scales to be considered (Zhuang, 2014).

The aim of model formulation is representing the structure of the problem and formulating a SD simulation model of the causal theory (Sterman, 2001; Zhuang, 2014). There are several diagram tools to capture the structure of the system, including causal loop diagram (CLD) and stock and flow diagram. CLDs consist of variables connected by arrows for representing the feedback structure of the system (Sterman, 2001). In spite of the fact that stock and flow and feedback are the two central concepts of system dynamic theory, CLDs are not able to capture the stock and flow structure of a system (Ford and Ford, 1999; Sterman, 2001). This is an important reason for using stock and flow diagram to represent the structure of a system with more detailed information that is shown in a CLD. In general, the stock variable is an accumulator variable (Zhuang, 2014). A stock with a single inflow and single outflow can be mathematically formulated as:

$$stock(s) = \int_{t_0}^{t} [Inflow(s) - outflow(s)]ds + stock(t_0) \qquad (1)$$

Where s is any time between t_0 and t. The stocks are the key variables in the model. They represent where accumulation or storage takes place in the system. Stocks tend to change less rapidly than other variables in the system, so they are responsible for the momentum or sluggishness in the system (Ford and Ford, 1999).

Model testing begins as the first equation is written and it is a critical step in SD modeling (Sterman, 2001). Tests to rely on SD model can be divided into two groups, structure tests and behavior tests (Forrester, 1997). Structure tests compare the structure of the SD model with the available knowledge about the real system presented in historical data. Behavior test is to run the model and compare the results to the reference mode[1] (Historical or observed data). When the simulation results match the reference mode, you have reached a major milestone in the modeling process (Ford and Ford, 1999). Following Kotir *et al.* (2016), mean relative errors (*MRE*) and coefficient of determination (R^2) were applied to evaluate the performance of the model. *MRE* indicates the mean possible divergence between the observed and simulated data (Qin *et al.*, 2011), the lower values of *MRE* indicates that the model satisfactory fits the historical values. R^2 describes the proportion of the variance in measured data explained by the model[2] (Kotir *et al.*, 2016).

$$MRE = \frac{1}{n}\sum\left(\frac{Y_i - \hat{Y}_i}{Y_i}\right)\times 100 \tag{2}$$

$$R^2 = 1 - \frac{\sum(Y_i - \hat{Y}_i)^2}{\sum(Y_i - \bar{Y}_i)^2} = 1 - \frac{\sum(e_i)^2}{\sum(y_i)^2} \tag{3}$$

Where Y_i and $\hat{Y}_i$ are the observed and simulated values of tested or variable and $\bar{Y}$ is the average of observed values of variable. After the validation of the model, we can use this model to evaluate the impact of different scenarios designed to solve the problem (Zhuang, 2014).

3.1. SD Modeling of Kheirabad River Basin

3.1.1. Water Supply Subsystem

The water supply subsystem includes feedback relationships between climate variables and water resources. This subsystem is constructed based on the surface and groundwater resources balance equation by taking in to consideration all inflows and outflows at the study area. This subsystem represents the measure of water resources available at the basin (Hjorth and Bagheri, 2006). Surface water resources available are controlled by various factors such as measure of precipitation, runoff, water inflow and outflow of surface water, evaporation, transpiration and infrastructural conditions (Hjorth and Bagheri, 2006; Gohari *et al.*, 2017). As shown in fig. 2, the water supply subsystem includes surface and groundwater resources. It is also worth mentioning that the surface and subsurface water inflows, return flow and precipitation are incoming inflows, and the surface and subsurface water outflows, evaporation, transpiration, water withdraw for kind of uses are outflows. Temperature and precipitation as climate variables affect the measure of available water. As a matter of fact, the increased precipitation can increase water availability. Strictly speaking, part of the precipitation is entered in to the water system as runoff (Eq. 4), taking into consideration of the runoff coefficient reported in the water balance studies of the study areas (Hjorth and Bagheri, 2006). Another part of the precipitation, joins to the groundwater resources considering the average percolation coefficient (Eq. 5). Also evaporation and transpiration was considered as a function of temperature in this study. Therefore, an increase of temperature in the future may affect the behavior of water resources system. Annual evaporation in water supply subsystem is measured into available surface water multiplier in evaporation rate (Eq. 6). At each time step, the evaporation rate is taken from temperature at the basin which is represented as a LOOKUP table[3].

$$\text{Runoff} = \text{Runoff rate} \times \text{Precipitation} \tag{4}$$

$$\text{Percolation} = \text{Percolation rate} \times \text{Precipitation} \tag{5}$$

$$\text{Evaporation} = \text{Evaporation rate} \times \text{Available surface water} \tag{6}$$

Also, the return flow in water system, according to Eq. 7, is as a percentage of the water consumption in different sectors that is added to the surface and groundwater resources. Total water withdrawal from the basin is measured into the sum of agricultural, domestic, environmental and industrial water demands. Following Davies and Simonovic (2011), domestic water demand is expressed as a function of population and per capita water demand in the *Kheirabad river basin* model. Agricultural water demand is expressed as a function of cropland area and water requirement for each crop. Environmental water demand is assumed to be as an exogenous variable. For calculating industrial water demand, per capita industry water use is applied (Balali and Viaggi, 2015), in which industrial water demand equals population multiplier per capita industry water use. The amount of surface water withdraw is equal to the part of total water demand that is supplied from surface water sources. According to the report presented by the Regional Water Organization of Kogiluyeh and Boyerahmad province (2017), 49% of agricultural water demand, 66% of urban water demand and 51% of indus-

1. A reference mode is a pattern of behavior over time
2. The values of R^2 range from 0 to 1, with values closer to 1 indicating that the model well simulates the system.

3. Lookup Tables are typically used in SD modeling to represent nonlinear relationships between two variables. A table function can be defined as a list of numbers whereby input values to a function are positioned relative to the x axis and output values are read from the y axis (Ford and Ford 1999; Vensim Reference Manual 2011).

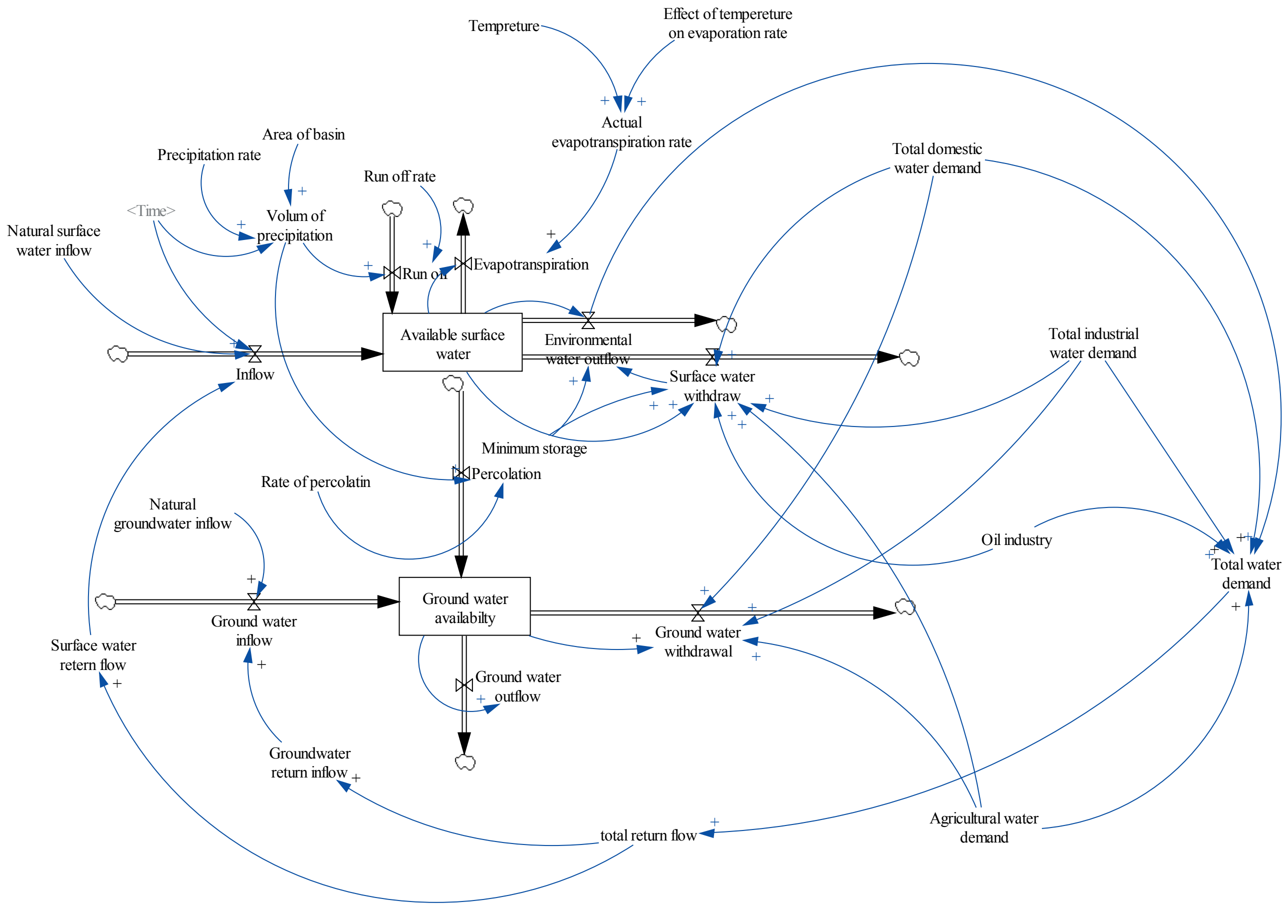

Figure 2. Water supply subsystem stock and flow diagram.

trial water demand at the basin are supplied from surface water sources.

$$\text{Return flow} = \text{Return rate} \times \text{Water demand of each sector} \tag{7}$$

$$\text{Total water demand} = \text{Agriculture D.} + \text{Domestic D.} + \text{Oil industry D.} + \text{Industrial D.} + \text{Environmental D.} \tag{8}$$

$$\text{Surface water withdraw} = \sum_{i=1}^{n} (\text{water demand}_i \times \text{the share of surface water}) \tag{9}$$

$$\text{Ground water withdraw} = \sum_{i=1}^{n} (\text{water demand}_i \times \text{the share of ground water}) \tag{10}$$

3.1.2. Population Subsystem

Population is one of the factors that affect the water demand (Sušnik *et al.*, 2012). Generally, population is the main driving factor in water demand. Population influence the domestic water demand directly and other sources of water demands indirectly (Davies and Simonovic, 2011). There are some towns and villages on the *Kheirabad river basin*. Most of the domestic water demand at the basin is provided by *Kowsar* dam. Also *Kowsar* dam supplied water to the Persian Gulf littoral cities and ports for nearly 20 years. Population sub-model represents the population of the case study including one stock "Population" which is increasing by population growth rate. The population at time t is mathematically represented by Eq. 11 as follows:

$$population(t) = population(0) + \int_{t0}^{t} (population\ growth\ rate)dt \tag{11}$$

In this study, the total population is divided into urban and rural population groups according to urbanization rates (Fig. 3). Therefore, the water demand in the urban sector equals urban population multiplier per capita water consumption in the urban sector and similarly

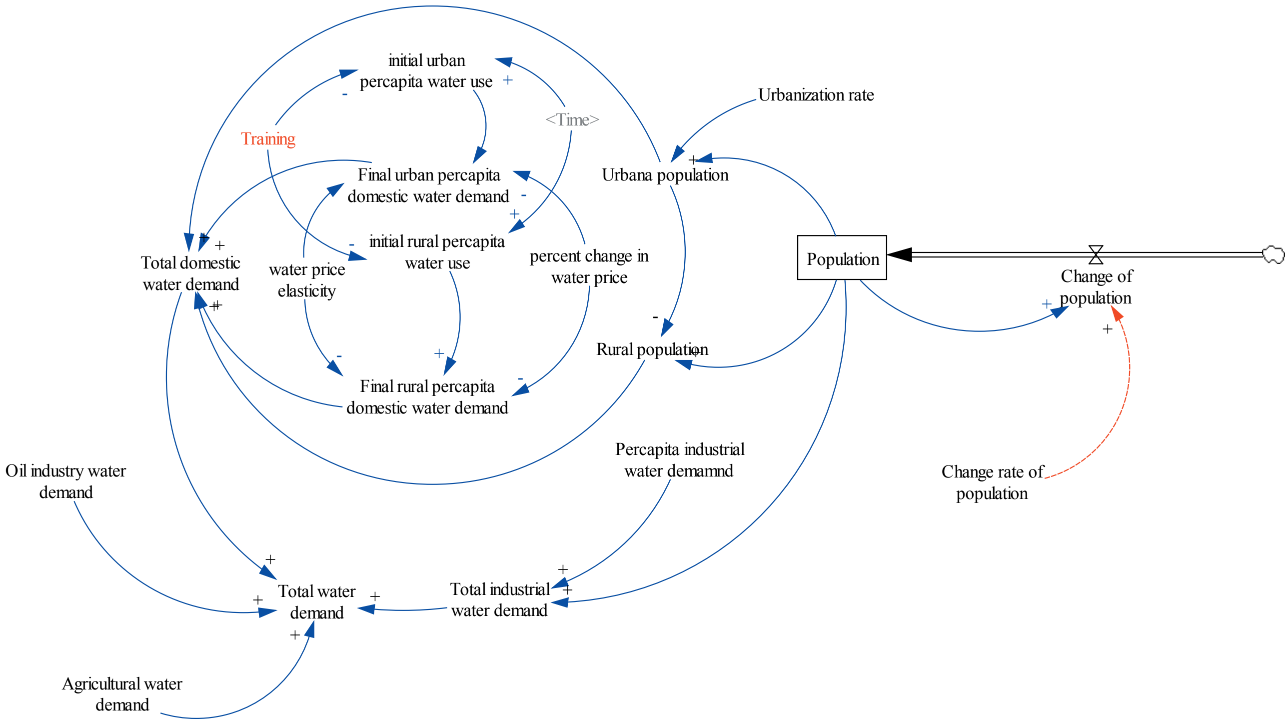

Figure 3. Population subsystem stock and flow diagram.

the water demand in rural sector will be obtained by multiplier of per capita water consumption in the rural sector rural in rural population. The sum of the demand for water in the urban and rural sector constitutes the total domestic demand. It is a fact that water price changes affect water demand. In other words, according to the price elasticity of water demand, we can calculate the feedback of consumer to water price change:

$$E = \frac{\%\Delta Q}{\%\Delta P} = \frac{Q_t - Q_{t-1}}{P_t - P_{t-1}} \times \frac{P_{t-1}}{Q_{t-1}}$$
$$Q_t = Q_{t-1} \times (1 + E \times \frac{P_t - P_{t-1}}{P_{t-1}}) \qquad (12)$$

Where E is the price elasticity of water demand, Q_t is the quantity of demand in period t and p_{t-1} is the price of water in period t-1 (Varian, 1996). Based on the Regional Water Organization of Kogiluyeh and Boyerahmad province (2017), the price elasticity of water demand is considered to be -0.35 in *Kheirabad river basin*.

3.1.3. Agricultural production Subsystem

The agricultural sector is a major consumer of water resources and the change of rivers hydrology conditions, water resources change and climate parameters affect agricultural activities. Climate change affects the water requirement of crops, water consumption and crops yield and consequently agricultural production and farmer's income. Nine crop types are included in the agricultural sub-system, namely wheat, barley, rice, corn, rapeseed, beans, tomato, watermelon and cucumber (Fig. 4). In general, water demand of agricultural sector can be calculated from Eq. 13:

$$\textit{Agricultural water demand} = (\sum_{i=1}^{9} \textit{cropland area}_i \times \textit{water requirement}_i) \,/\, \textit{irrigation efficiency} \qquad (13)$$

Expected agricultural water demand of basin is obtained from sum of calculated demand for all crops. In addition, water requirement has a negative causal relationship with irrigation efficiency. In this research, Nerlove (1956) model was used to model the area under cultivation.

$$Y_t = \gamma\beta_0 + \gamma\beta_1 P_{t-1} + (1-\gamma)Y_{t-1} + \gamma U_t \qquad (14)$$

The model is based on the assumption that farmers determine their optimal cropland area based on the

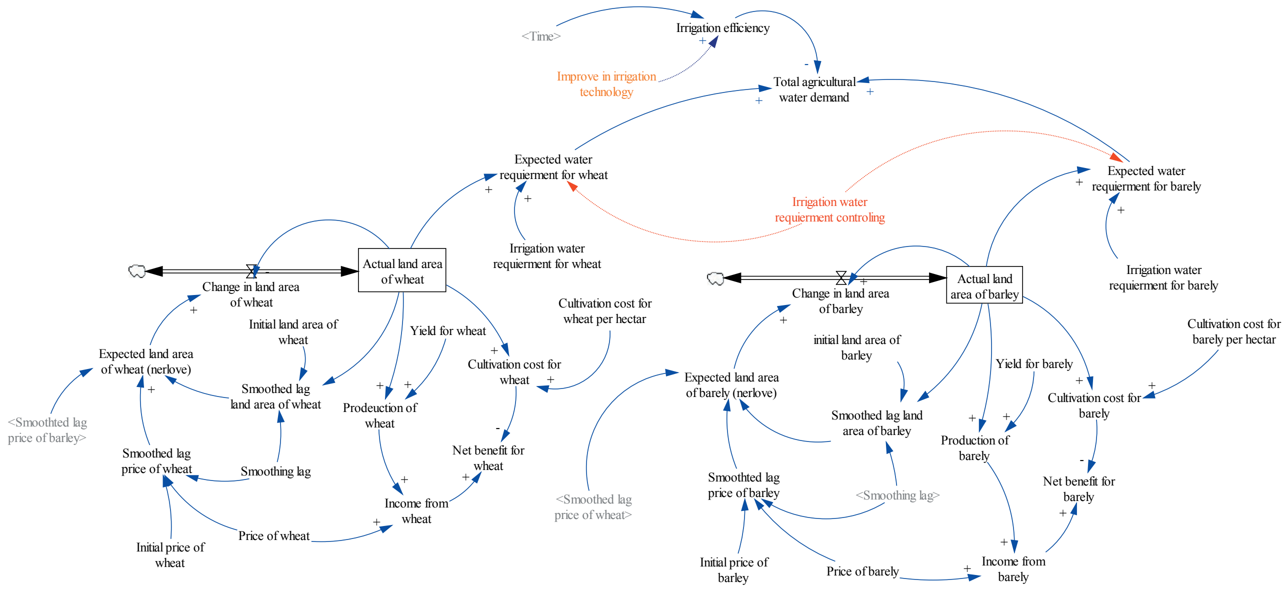

Figure 4. Agricultural production subsystem stock and flow diagram (with two crops).

expected price[4]. In this connection, the price of each crop during the simulation period is predicted applying ARIMA[5] model and entered into the basin SD model as an exogenous variable. As can be seen in equation 14, the lag of dependent variable is considered as an explanatory variable. According to the endogenous nature of this variable, Generalized Method of Moments (GMM) was used to estimate Nerlove model[6].

In the agricultural subsystem production of each crop are calculated based on Eq. 15 via crop yield multiplied by its land area. Following Atherton (2013), population growth due to per capita food consumption increases food demand and the food self-sufficiency index is defined as the ratio of food production to total demand for food. Other possible drivers, for instance international trade, labour productivity and other technological advance, are kept constant during the simulation period.

Food Production = Crop yield × Cropland area
Self-sufficiency index=Food Production / Food Demand (15)
Food Demand = Population × Per capita food consumption

[4] Further research could also be conducted to determine the effectiveness of labor, capital, and other input on cropland area change. but The lag of the cultivated area in the model could represent the farmer behavior and his decisions based on the available facilities.

[5]. Autoregressive Integrated Moving Average – Appendix 1 (Result of real price forecasting)

[6]. We've used the *Eviews9* software to regress this equation.

3.1. Sustainability Index

The sustainability index (SI) is a measure of a system's adaptive capacity to reduce its vulnerability (Loucks, 1997). To evaluate and compare the water management policies Loucks (1997) suggested SI formulated by Eq. 16:

$$SI = [REI \times (1\text{-}VUL) \times (1\text{-}MAX\ DEF)]^{1/3} \quad (16)$$

Where SI is sustainability index, REI, VUL and MAX DEF are reliability index, vulnerability index and maximum deficit, respectively. Water demand reliability is the probability that the available water supply meets the water demand during the period of simulation (Hashimoto *et al.*, 1982; Klemeš *et al.*, 1981). For each time period deficits (D) are positive when the water demand is more than water supplied, i.e.:

$$D = \begin{cases} WD\text{-}WS & if \quad WD>WS \\ 0 & otherwise \end{cases} \quad (17)$$

The reliability REI is calculated by dividing the number of times D=0 by the length of the simulation period (McMahon *et al.*, 2006):

$$REI = \frac{Number\ of\ time\ D = 0}{N} \quad (18)$$

The vulnerability index is the likely value of deficits if they occur (Hashimoto *et al*., 1982). Vulnerability is calculated by dividing the average annual deficit by the average annual water demand in deficit period (Gohari *et al*., 2017; Sandoval-Solis *et al*., 2011):

$$VUL = \frac{(\Sigma D)\ /\ Number\ of\ times\ D > 0\ occurred}{Water\ demand} \tag{19}$$

The maximum deficit, if deficits occur, is calculated by dividing the maximum annual deficit by the annual water demand (Moy *et al*., 1986):

$$Max\ Def = \frac{\max(D_{annual})}{Water\ demand} \tag{20}$$

Table 1 shows the initial values of the stock and some key exogenous variables used for the SD model. This study also uses water shortage index (WSI) to address the interaction between supply (WS) and demand (WD) of water (Fig. 5). The water shortage index defines as the ration of water supply and demand (Zarghami and Akbariyeh, 2012). In order to increase water shortage index, both demand and supply management options should be considered. The interaction between water supply and demand is captured using a water supply and demand balance index (Fig. 5) (Langedale *et al*., 2007). The water balance index (BI) increases with the water availability (WS) and decreases with the water demand. When the index is lower than zero or certain value, the water supply and demand management options will be necessary. The demand management options will decrease the water demand, which in turn the index. The supply management options will increase the water supply, which can offset the freshwater withdrawal and increase the water availability (Zhuang, 2014).

$$WSI = \frac{WD}{WS} \tag{21}$$

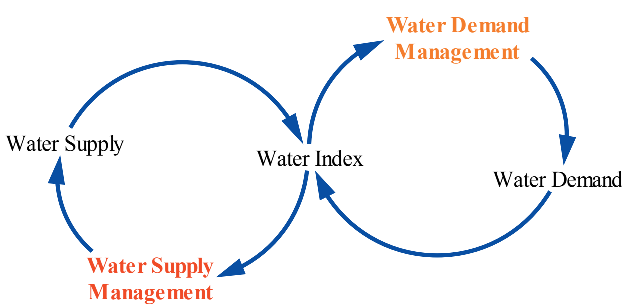

Figure 5. Interaction between water supply and demand.

$$BI = WS\text{-}WD \tag{22}$$

2.2. Policy scenario design

To achieve the high sustainability at the basin, six scenarios is defined based on different levels of irrigation efficiency, water requirement, water price and crops water cropland area. A short description of the scenarios is presented in Table 1.

According to the latest studies conducted into this matter, the average irrigation efficiency in the *Kheirabad river basin* is about 45%. The first policy scenario involves increasing irrigation efficiency as one of the most effective policies for water resources conservation. Therefore, in line with the goals set in the Fifth Development Plan of Iran (Gohari *et al*., 2017) and also the potential irrigation efficiency at the basin, agricultural water use efficiency was increased to 60%. To manage water demand in the agricultural sector, the policy of reduction water requirement of crops by 10% was considered as another scenario. Reducing the water requirement of crops can be achieved by changing irrigation strategies, conservation activities, changing cultivation dates and using drought-tolerant varieties. Since water is the major limiting factor for agriculture production, changing in the crop pattern can be considered as a water resources management policy (Donati, *et al*., 2013). High water requirements of rice and watermelon point out that continued cultivation of these crops may not be justified under climate change from a water management perspective. Therefore, as another scenario we simulate the effect of cropland declining (Excluding rice and watermelon) on water resources availability, water demand and water resources sustainability index at *Kheirabad river basin*. The underlying assumption for this scenario was that current cropland area would decrease.

The Iranian Statistics Center also reports that average per capita water demand in *Kheirabad river basin* is 20 percent higher than the country average. Thus, reduction in average per capita water demand is defined as another policy scenario. As well as, per capita water demand controlling can be achieved through domestic water tariff reform. Based on the goals set in the Fifth Development Plan of Iran, the government was allowed to increase the price of drinking water by 7% annually to promote social justice. Last scenario envisaged water sustainability by decreasing water withdraw of surface and groundwater resources due to applying inter-basin water transfer policy. As more detail, only 70% of the total domestic water demand will come from surface and groundwater resources at the basin, and 30% will be

Table 1. Description of different scenarios.

Policy scenario	Description
Improving irrigation efficiency	Increasing irrigation efficiency parameter to 60% smoothly (50%, 55% and 60%).
Decreasing water requirement of crops	10% reduction in water requirement of crops
Crop pattern	Cultivation of all crops, exclude watermelon and rice
Water price	Increasing price of drinking water by 7% annually
Controlling per capita water consumption	20% reduction in average per capita water demand at the basin
Controlling water withdraw	Only 70% of the total domestic water demand meet from surface and groundwater resources at the basin

met through inter-basin transfer or desalination (Vice-Presidency for Strategic Planning and Supervision, 2017).

Vensim Professional 5 (Ventana Systems, 2009), one of the several software packages available for SD modeling, is applied to develop and run the *Kheirabad river basin* model.

The system dynamics modeling framework of *Kheirabad river* basin water resources management is presented in Fig. 6.

Some key parameters and stock variables used in the model and their corresponding values are describing in Table 2. Typically, long-term intervals from 10 years (Zarghami and Akbariyeh, 2012) to 100 years (Rehan *et al.*, 2011), are used to understand the effects of long-term management options on water system. In this study, a period of 40 years (1992-2031) is considered as the model time boundary and the data of 23 years (1999-2013) are used to validate the designed system dynamics model. According to the available data from water system, time steps are considered annually.

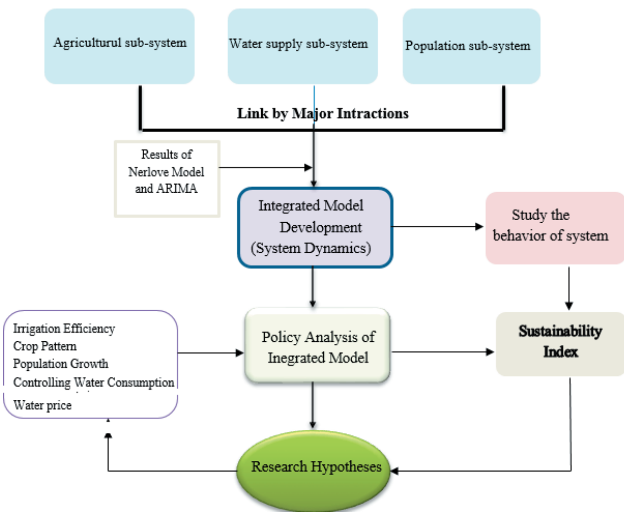

Figure 6. The system dynamics modeling framework of *Kheirabad river basin.*

4. RESULTS

4.1. Model validation

The performance of the model is discussed by comparing model outputs for the selected variables to the corresponding historical data. The surface water availability and population are the key variables demonstrating the performance of the water system. In general, as shown in Fig. 7 and 8, the model performed well in comparison to the historical data.

The simulated results follow the same trend as the observed date, indicating that the model is well calibrated. The statistical values for M and R^2 show that the model satisfactorily fits the historical values. Predictions for surface water have low values of mean relative errors (less than 10%) and the value of R^2 is calculated to be around 0.73 (Table 3).

4.2. Future simulation

For future simulation, the water demand, water availability and water sustainability index were computed for the baseline scenario. Prior to that, simulations of cropland area, the average production, and food self-sufficiency index for the catchment were presented. Finally, the effect of different water demand management policies previously mentioned on water resources indicators was evaluated.

4.2.1. Cropland area and agricultural production

After testing the reliability of the model, the behavior of the system is then simulated over time to assess the availability of water resources and sustainability index. According to the coefficients obtained from the Nerlove model, the simulated trend of the area under cultivation of selected crops at the basin is presented in the table 4. In order to examine this fact in more detail, it should be noted that the total cropland area at the basin increases

Table 2. The stock and exogenous variables of water system.

Variable type	Variable name		Initial value	Unit	Source
Stock Variable	Population		1.993	Million person	The Statistical Center of Iran 2018
	Surface water		996.54	Mm^3	Regional Water Organization of Kohgiluyeh and Boyerahmad Province 2017
	Cropland area	Wheat	7214	Hectare	The Ministry of Agriculture – Jahad 2018 https://www.maj.ir/
		Barley	973	Hectare	
		Corn	653	Hectare	
		Rice	2830	Hectare	
		Bean	169	Hectare	
		Rapeseed	250	Hectare	
		Watermelon	796	Hectare	
		Cucumber	58	Hectare	
		Tomato	40	Hectare	
Exogenous variable	Per capita industry water use		2.13	m^3	Regional Water Organization of Kohgiluyeh and Boyerahmad Province 2017
	Urban per capita domestic water use		64.3	m^3	
	Rural per capita domestic water use		36.6	m^3	
	Runoff rate		16	%	Regional Water Organization of Kohgiluyeh and Boyerahmad Province 2017
	Percolation rate		12	%	
	Oil industry water demand		31	Mm^3	
	precipitation		Time series	mm	Water Balance Reports 2018
	temperature		Time series	c	
	Irrigation efficiency		45	%	Abbasi *et al.* (2015)
	Area of basin		4232.5	Km^2	Water Balance Reports 2018
	Population growth		1.59	%	The Statistical Center of Iran 2018
	Yield	Wheat	2.93	tone	The Ministry of Agriculture – Jahad 2018 https://www.maj.ir/
		Barley	2.25	tone	
		Corn	6.33	tone	
		Rice	4.44	tone	
		Bean	1.66	tone	
		Rapeseed	1.13	tone	
		Watermelon	38.87	tone	
		Cucumber	33.21	tone	
		Tomato	24.26	tone	
	Gross water requirement (net water requirement/ irrigation efficiency)	Wheat	4123	M^3/hectare	NETWAT Software
		Barley	3516	M^3/hectare	
		Corn	6664	M^3/hectare	
		Rice	11862	M^3/hectare	
		Bean	7193	M^3/hectare	
		Rapeseed	4602	M^3/hectare	
		Watermelon	7694	M^3/hectare	
		Cucumber	8989	M^3/hectare	
		Tomato	9708	M^3/hectare	
Endogenous Variable	The other variables seen in the Stock-Flow diagram are endogenous variables. Relationships related to endogenous variables are presented in equations 1-15.				

from 20.077 thousand hectares in 2020 to 21.049 thousands hectares at the end of the simulation period. The results indicate that the average of total cropland area during simulation period will be 20.506 thousand hectares and the annual growth rate of this variable will be 0.585 percent. Changes in the level of cultivation of agri-

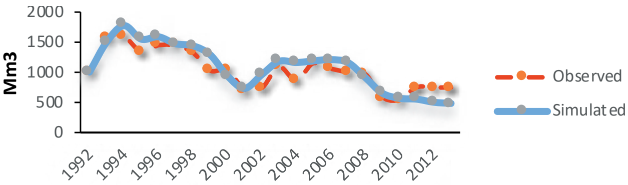

Figure 7. The observed and simulated values of surface water.

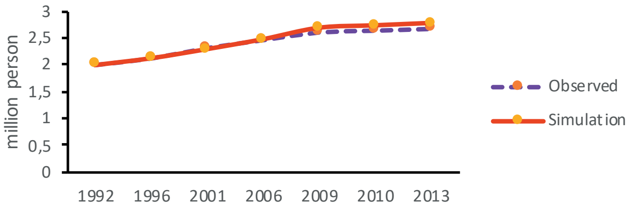

Figure 8. The observed and simulated values of population.

Table 3. Statistical parameters of the model tests.

Variable	R^2	MRE (%)
Surface water	0.73	4.45
Population	0.99	0.86

5. Among selected crops, average production of wheat, watermelon and corn is higher than other crops. The lowest average production is also for beans. The results showed that the average annual production of wheat, watermelon and corn is 34.946, 34.827 and 18.344 thousand tons, respectively. Given this average production, the self-sufficiency index for these crops is equal to 0.597, 1.101, and 0.899, respectively. The self-sufficiency index of greater than 1 for rice and watermelon means that this basin is a potential exporter for these products and there are excess productions available for exporting to adjacent basins.

4.2.2. Water demand

The simulated population at the basin is reported in table 6. According to available reports, the annual population growth rate at the basin was considered to be 1.59 percent that assumed to be constant over the period 2018-2030. Due to this growth rate, total population increases from 3.141 million in 2020 to 3.678 million at the end of the simulation period. According to the SD model, both per capital water consumption in urban and rural areas and population growth affect total domestic water demand in *Kheirabad river basin*. It can be seen

Table 4. Results of cropland area and agricultural water demand (Thousand hectare).

Crops	2020	2022	2024	2026	2028	2030	Average
Wheat	11.653	12.301	12.159	11.589	11.663	12.411	11.927
Barely	1.183	1.180	1.181	1.185	1.185	1.181	1.182
Rice	2.701	2.802	2.714	2.724	2.722	2.711	2.712
Corn	2.819	2.854	2.897	2.945	2.979	2.995	2.898
Bean	0.175	0.175	0.175	0.175	0.176	0.176	0.175
Rapeseed	0.393	0.397	0.396	0.393	0.394	0.399	0.394
Cucumber	0.151	0.163	0.163	0.150	0.149	0.161	0.157
Tomato	0.112	0.113	0.113	0.112	0.112	0.113	0.113
Watermelon	0.889	0.910	0.908	0.885	0.883	0.903	0.896
Total	20.077	20.797	20.706	20.159	20.263	21.049	20.506

Table 5. Average food production and self-sufficiency index at the Basin.

Crops	Average Production (Thousand Tone)	Self-Sufficiency Index
Wheat	34.946	0.597
Barely	2.659	0.350
Rice	12.041	1.078
Corn	18.344	0.899
Bean	0.290	0.325
Rapeseed	0.445	0.315
Cucumber	5.213	0.240
Tomato	2.741	0.188
Watermelon	34.827	1.101

from table 6 that domestic water demand will increase from 173.369 Mm^3 in 2020 to 205.662 Mm^3 at the end of simulation period. The annual average of domestic water demand at the basin will be 184.983 Mm^3 during the 2018-2031. Another important finding is that 22 percent of average domestic water demand is related to rural household and 78 percent of that is related to urban household at the basin. Changes in industrial water demand is also as a function of population in water system designed. Table 6 indicates a slight increase occurring in both industrial and household water demands and thus, total water demand at the basin is likely to increase during simulation period. The results of this research support the idea that the gap between supply and demand for water increases continuously and the water system becomes more vulnerable in the future. The results corroborate the finding of a great deal of the previous work in this field, e.g. Gohari *et al.* (2017) and Kotir *et al.* (2017). Considering available surface water for environmental and oil industry water demand,

Table 6. Results of simulated population (million person) and water demand (Mm^3).

Variables		2020	2022	2024	2026	2028	2030	Average
	Population	3.141	3.242	3.346	3.453	3.563	3.678	
Water demand	Agricultural water demand	306.434	313.562	313.154	308.241	309.320	316.746	311.198
	Domestic water demand	173.369	179.914	186.706	193.754	200.101	205.662	184.983
	Industrial water demand	37.690	37.905	38.126	38.354	38.590	38.833	38.138
	Sum of water demand	517.493	531.381	537.986	540.529	548.011	561.241	534.319

respectively 79 Mm^3 and 31 Mm^3, the amount of total water demand at the basin in 2020 is 627.493 Mm^3 and reach to 671.241 Mm^3 at the end of simulation period.

4.2.3. Water availability

The results of table 7 show that an increase in agricultural water demand along with population growth at the basin can increase the surface water withdraw and decrease surface water availability in the study area. In other words, the amount of available surface water decreases from 487.701 Mm^3 in 2020 to 433.893 Mm^3 at the end of simulation period. The average annual changes of this variable during 2018-2031 will be -1.23 percent. Compared with available surface water, the average annual change of surface water withdraw is estimated about +0.75 percent. As shown in Table 7, withdraw of water at the basin increase by 0.75% on average during 2018-2031 and reaches about 324.176 Mm^3 at the end of the simulation period. An increase in the population and cropland area in the basin increase the total water demand by almost 0.758 % annually. Therefore, the upward trend of total water demand leads to an increase in surface water withdraw. Withdraw of surface water is affected by the demand of the household, industrial and agricultural sectors. Also, water withdrawal for environment uses is considered a constant amount (about 79 Mm^3 yearly), according to Kohgiluyeh and Boyerahmad provincial water organization. Due to population growth (considering the growth rate of 1.59%) and also upward trend of cropland area the demand for household, industrial and agricultural consumption increases directly and the withdrawal of water resources increases eventually. Therefore, it can be concluded that water demand control policy has a positive effect on decreasing in withdraw of water and sustainable water resources management.

The simulated values for the groundwater withdrawal in Figure 8indicate how changes in water demand can affect the behavior of groundwater availability. The volume of groundwater withdrawal at the beginning of the simulation period, equals to 212.809 Mm^3 and with growth of 10.29% reach to peak in 2030 about 234.396 Mm^3. The average annual percentage change of withdrawal of groundwater resources is calculated about 0.837%. As can be seen in Fig. 9, the groundwater balance at the basin is negative during the simulation period, i.e. the trend of groundwater withdrawal is increasing and the outflows are more than the inflows.

4.2.4. Water indices

Figure 10 illustrates the trend of water shortage index and water balance index in *Kheirabad river basin*. As can be seen in the figure, the water shortage index increases and the water balance index decreases over time as water demand goes up as results of population growth and upward trend of cropland area. At the end of simulation period the demand and supply balance index are expected to be negative. It means that, in some years, the value of water demand becomes bigger than water supply at the basin. The downward trend of water balance index triggers the water supply or demand management options. The demand management options can decrease the water demand, which in turn increases the index.

Table 7. Results of available surface water and withdraw simulation - Mm^3.

	2020	2022	2024	2026	2028	2030	Percent average change
Available surface water	487.701	478.543	467.777	455.085	443.311	433.893	-1.234
Surface water withdraw	298.988	306.258	309.956	311.572	316.252	324.176	+0.756

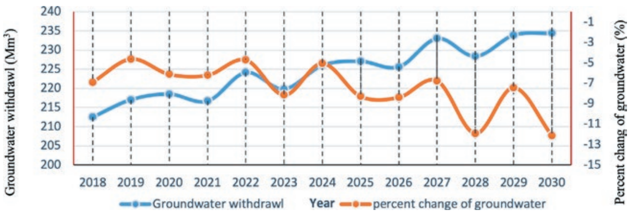

Figure 9. The result of simulated values of groundwater changes.

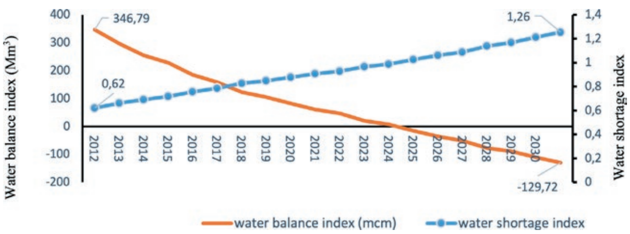

Figure 10. The result of simulated values of groundwater changes.

The next system dynamics model output displayed here is the sustainability index. As introduced in pervious section, this index is computed as combination of three other indices (Reliability index, Vulnerability index, Max deficit). The results in table 8 indicate that the sustainability index at *Kheirabad river basin* will be 0.703 if current environmental conditions within the basin would remain the same without any changes (Baseline). As shown, values of reliability, vulnerability and max deficit indices are estimated to be 0.50, 0.119 and 0.213 respectively. In short, the simulation confirms that the growing demand for water is acting to exacerbate the problems of meeting the growing water demand of Kheirabad river basin.

The results represent the inability of water resources system to meet the increasing water demand in *Kheirabad river basin*. The positive max deficit index indicates that in some years, the value of water demand surpassed its supply value and the system encountered to water shortage. Therefore, according to the results, it is projected the increasing demand for water, due to population growth and upward trend of cropland area, is unlikely to be met using available water resources during the simulation period.

Table 8. Water indices at Kheirabad river basin.

	Reliability Index	Vulnerability Index	Max Deficit Index	Sustainability Index
Water Index	0.50	0.119	0.213	0.703

4.3. Policy scenario analysis

The impacts of water resources management policies on water system can be tracked through the calculation of water resource indices. As showed in Table 9, the implementation of demand control policies likely help meets the growing water demand and the sustainability index for Kheirabad water system increases in comparison with the baseline. As more detail, by increasing irrigation efficiency up to 50%, water resource sustainability index increased to 0.897. Therefore, it can be stated that the effectiveness of this policy on water resource sustainability index within the basin is 27.59%. After increasing irrigation efficiency to 55%, the reliability index increased to 0.857 and vulnerability index decreased to 0.014. Under these circumstances the water resource sustainability index will be 0.940. However, even under this scenario water shortage mater. The highest sustainability index (the lowest vulnerability index) belongs to business as usual conditions along with increasing irrigation efficiency up to 60%. The results also revealed that a 10% reduction in water requirement of crops increases the sustainability water index to 0.857 and decreases vulnerability index to 0.026, compared to business as usual condition without any actions. Although this policy has a significant impact on improving the water system situation in terms of sustainability, it has still been vulnerable in terms of meeting water demand. Therefore, in order to increase the system's ability to respond water demand in the long-term, complementary strategies are needed along with reducing the water requirement of crops at the basin. The results also showed that the reliability and sustainability index of water resources will be 1 after removal of crops with high water requirement. Agricultural water demand decreases as a result of changing crop pattern within the basin. Therefore, it is expected that the gap between supply and demand for water decreases continuously and the water system becomes more sustainable in the future. Therefore, controlling agricultural water demand using water conservation options such as increasing irrigation efficiency or changing crop pattern can help achieve a better balance between supply and demand of water to improve the water sustainability index even under population growth and agricultural development.

The findings also reveal that, by controlling water withdraw as a water management policy at the basin, surface water outflow decreases during the simulation period compared with the baseline condition and the water system can be in a better situation in terms of sustainability. Increasing water storage is expected to increase the ability to meet the demand for water in

Table 9. Water indices under different scenarios.

Policies		Reliability Index	Vulnerability Index	Max Deficit Index	Sustainability Index	Priority
Improving irrigation efficiency	50%	0.786	0.029	0.053	0.897	5
	55%	0.857	0.014	0.015	0.940	3
	60%	1.00	0.00	0.00	1.00	1
Decreasing water requirement of crops		0.857	0.026	0.037	0.930	4
Crop pattern		1.00	0.00	0.00	1.00	1
Water price		0.571	0.104	0.180	0.749	6
Controlling per capita water consumption		0.929	0.020	0.020	0.963	2
Controlling water withdraw		1.00	0.00	0.00	1.00	1

the basin in this condition. According to the Table 9, a reduction in per capita water demand and the economical instruments such as domestic water pricing under competition structure would help to improve the sustainability index to 0.963 and 0.749, respectively.

5. DISCUSSIONS

As mentioned in the literature review, changes in water resources exhibit dynamic behaviors as such resources are affected by many socio-economic and climatic factors over time. Because of complicated interactions and feedbacks among the factors in the water system, a comprehensive and interaction-based approach is needed to understand the consequences of a change in the system. So, in this research, an integrated system dynamics simulation model was developed to examine the feedback processes and interaction among the population, water resources, and agricultural production in sub-sectors of *Kheirabad river basin* in Iran. An initial objective of the project was to identify the behavior of the water system at the basin over time. With respect to the first research aim, it was found that water demand increases as the population growth and agricultural development occur. Under such conditions, the withdrawal of surface and groundwater increases over time which is consistent with the Gohari *et al*. (2017) results for the *Zayandehrud river basin*. The most interesting finding is that population growth contributes to 0.75% annually increase in water demand and 1.23% annually decrease in available surface water during the simulation period. Regarding that the population of the region is expected to increase by 1.87% during 2021-2027, this may put more pressure on the water resources at the basin. A growing population would be a threat for water use sustainability especially if other measures like increasing water use efficiency are not taken into consideration. Another important finding is that the water sustainability index at the basin is 0.703 if the current environmental and socioeconomic condition within the basin would remain the same without any policy change. Therefore, the water supply at the basin can likely be unsustainable and total water demand exceeds the water supply. This finding confirms the results of recent model-based studies and assessments that analyzed the impact of climate change and population growth on water resource availability (e.g., Kotir *el al*., 2016; Gohari *et al*., 2017; Zubaidi *et al*., 2020). It cannot be denied that the water system is vulnerable (vulnerability index is more than zero) due to an imbalanced supply and demand, caused by increasing population and cropland area. This finding is also reported by Madani (2014) and Nkegbe & Shankar (2014). In other words, both of the supply and demand side of the water system is threatening since a growing water demand is accompanied by a possible decrease in water availability caused from more intensive surface and groundwater use. Regarding the widening supply-demand gap, to meet the water demand in the near future, demand management policies are needed. So, the present study is designed to determine the effect of water demand and supply management policies on the behavior of the water resources system at the basin. Especially, given the possible increasing water shortage, water management policies should concentrate on demand side of water use to address the problem. According to the results, a reduction in per capita water demand can play a significant role in decreasing vulnerability and increasing the sustainability indices. This finding is also reported by Stavenhagen *et al.* (2018). However, there is a larger room in agriculture uses where the water use efficiency is much lower than the global ones. It is worth noting that drinking water is supplied by the public sector and the price paid by the consumers' accounts for a slight part of the water costs. Thus, this may indicate that there is considerable room for water demand management even in drinking water demand.

As far as the agricultural use of water is considered, the lower water use efficiency is controversial. In Iran, resource constraints, in particular, water has always been a critical issue in agricultural production while the average irrigation efficiency is less than 35%, and only 5% of the farmed area enjoys modern irrigation system (Madani, 2014). Based on the results, the most effective policy scenario on water management at the basin related to improving irrigation efficiency and crop pattern. In more detail the improving irrigation efficiency up to 60% can bring the water resources system of the *Kheirabad River Basin* to a sustainable state. Besides, the results revealed that crop pattern change and remove rice and watermelon from the cultivation pattern has a positive significant effect on the sustainability index. This study supports evidence from previous observation (e.g. Donati *et al*., 2013 and Hashemi *et al*., 2019). Considering the expected negative effects of adopting this strategy on the production and income of farmers at the basin, the development of non-agricultural activities and small conversion industries in rural areas to compensate for the damage caused by possible variability of weather conditions can be effective.

Under the circumstances that the world as a whole, is facing water crises, many people have little information about how they can preserve water resources. To serve this purpose, the government should provide a context in which people learn to control their daily water consumption. Comparison of water resources sustainability index after the implementation of various policies also confirms the fact that controlling per capita water consumption can be high effective in managing water demand. Moreover, the economical instruments such as domestic water pricing under competition structure, can significantly control water demand toward sustainable management of water. What is surprising is that water pricing has the least efficient in water demand controlling. This is basically because of price inelastic demand at the basin. Therefore, in summary, the effectiveness of water demand management policies in the domestic sector is expected. It doesn't mean that we just focus on domestic water demand. Indeed, it argues that we can conserve water resources in agricultural sector with irrigation water pricing and conservation agriculture (such as zero tillage, mulching and crop rotation). Also, as a policy scenario in this study, it is assumed that 30% of domestic water demand can be met from outside the basin. The results of this study showed that supply-oriented policies such as inter-basin transfer or urban wastewater reuse to reduce the surface and groundwater withdrawal, regardless of the cost of their implementation, can contribute to the sustainability of the water resources system.

6. CONCLUSION

Generally, for managers, a simulation model for the water system is extremely useful. The simulation model allows to look at the interaction of different elements over time and helps you simulate how different management decisions will affect the system. Reducing available water resources is a very serious challenge facing policymakers and planners of water resources in Iran. This mater underlines the need for sustainable management of this vital resource. This study applies system dynamics approach to analyze the behaviour of water system in *Kheirabad river basin* located in southwestern Iran. The study is an attempt to answer this question that can the *Kheirabad river basin* reconcile its available water supply with the growing demand for water. Although many studies have used the system dynamics method to manage water resources, there is a large difference between the structure of the designed model and the variables used in these studies. The differences in studies are in terms of objectives, evaluated policies, and temporal and spatial boundaries. The fact of the matter is that a model can be designed for each basin to suit the economic, social, and environmental characteristics. This is one of the ways to avoid policy resistance in water management. The designed system dynamics model was used to simulate the outcomes of different policy scenario. The results demonstrate that all scenarios reach limits to growth, however, water sustainability index was maximized under improving irrigation efficiency and changing crop patterns at the basin. In other words, the variables of the agricultural sub-sector can be considered as one of the high leverage points in the water resources management system of the *Kheirabad river basin*. It confirms that with system thinking and holistic worldview, policymakers can identify the high leverage points in systems for each basin and avoid policy resistance. Finally, our study is the first attempt at modeling in the *Kheirabad river basin* in Iran that by engaging stakeholders in model development, we have implemented a process compatible with improving stakeholder understanding of the dynamic behaviour of the basin over time. There are, however, some limitations of our study that could be addressed in order to add more precision to our results. This paper has focused on the sustainability index in baseline weather condition. Further research can also focus on climate variability condition along with population growth and agricultural development. Depending on the climatic conditions and the type of cultivation in each region, climate change can have negative and positive effects on agricultural production. Therefore, it is necessary to study the effects of climate change on the yield of strategic crops for regions or provinces (even in different sub-basins) separately in order to obtain the best cultivation pattern for vulnerable areas. Meanwhile, the economic tools for water resources management can also be considered for agricultural sub sector to assess the impacts of agricultural water price reform on system behavior. Considering farmers' behavior under various conditions, including changes in available water resources, may contribute to the flexibility of the model. Last but not least, a decrease in water supply may stimulate immigration from rural and agricultural-dominated areas to urban regions which is accompanied with some social-economic issues, needing to be examined.

DATA AVAILABILITY STATEMENTS

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX

Table A1. Real prices of agricultural products (Rial/Kilogram)-ARIMA forecasting.

Crops	1992	1995	1998	2000	2002	2004	2006	2007	2008	2009	2010	2011
Wheat	43.17	41.78	49.05	44.14	46.46	43.27	47.35	44.72	46.16	44.73	45.97	47.05
Barely	33.54	35.22	37.60	35.43	33.24	33.14	35.05	33.62	36.92	33.68	36.77	35.80
Rice	76.77	106.53	90.74	84.73	75.09	79.98	99.38	84.39	106.95	88.17	90.30	99.59
Corn	37.97	36.97	41.44	38.32	37.55	37.86	38.73	37.66	40.51	37.58	39.67	38.52
Cucumber	42.17	22.58	24.18	33.79	34.03	33.39	34.29	37.28	33.53	36.60	35.19	33.85
Bean	139.82	71.77	90.41	116.57	92.47	76.43	90.54	100.49	104.42	100.40	92.26	85.38
Tomato	43.89	33.13	32.04	28.92	30.17	30.69	31.22	30.10	30.05	31.10	29.54	30.92
Watermelon	19.83	22.91	13.41	19.79	19.95	22.02	18.21	23.78	16.78	19.83	20.31	18.08
Rapeseed	117.14	81.31	89.66	87.88	103.32	94.54	83.68	105.63	95.33	92.56	92.47	83.49
Crops	2012	2015	2018	2020	2022	2024	2026	2027	2028	2029	2030	2031
Wheat	44.13	45.28	46.28	44.68	44.80	46.56	46.80	45.30	45.31	46.83	44.43	46.52
Barely	35.25	37.97	37.40	37.21	34.99	33.04	33.27	35.23	35.41	33.77	37.27	34.05
Rice	77.90	79.41	91.46	80.13	83.06	98.02	100.10	85.17	84.53	97.99	77.28	94.38
Corn	37.97	40.02	39.92	40.23	38.78	37.46	37.65	39.20	39.21	37.66	40.33	37.44
Cucumber	35.06	34.94	32.34	36.38	36.48	32.97	31.78	35.43	35.01	31.94	36.90	32.49
Bean	82.92	96.15	92.03	86.69	90.97	95.14	91.85	89.70	88.82	89.49	91.13	92.75
Tomato	30.38	29.65	29.59	29.88	31.00	31.05	29.95	31.18	29.57	30.78	30.53	29.69
Watermelon	21.80	21.19	18.57	21.54	21.51	17.76	17.30	20.33	20.34	17.27	22.26	17.82
Rapeseed	106.61	94.44	95.64	96.13	105.51	86.34	85.68	103.79	97.18	85.11	97.79	87.45

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The distributors' view on US wine consumer preferences. A discrete choice experiment

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Abstract. This study explored the view that distributors have towards the most valued wine attributes by consumers in the US market, applying the discrete choice experiments technique. Furthermore, to explore the extent to which the distributors' perspective may reflect consumers' preferences, the results are analyzed considering previous evidence with consumers in the same market. The results from a scaled multinomial logit, mixed logit and generalized logit models reveal similarities with consumer studies' findings, especially for the influence of medals/awards, the origin of the wine, grape variety, and price, and it also identifies possible trends in the market. This evidence suggests that data collected using the knowledge and experience of wine distributors generates valuable information through a smaller sample at a lower cost than through applying consumer surveys, which is relevant in large markets with a higher number of consumers.

Keywords: consumer choice, stated choice method, distributors' perspective, wine choice.
JEL codes: C25, D12, D20.

1. INTRODUCTION

Consumer behavior has evolved over the years, and understanding the motivations, thought processes, and experiences of individuals as they make a choice is essential to improve marketing strategies and consumer welfare (Malter et al., 2020). This statement becomes particularly relevant in wine as it is considered a complex "experience good" (Ali & Nauges, 2007; Mueller et al., 2010) described by several intrinsic (e.g., wine-related, variety, alcohol content, flavor, or style) and/or extrinsic (e.g., price-related, packaging, awards, ratings, and brand) attributes.

On the demand side, wine consumption trends are undergoing significant changes (Castellini & Samoggia, 2018) related to consumer spending habits, purchase power, new choice criteria or expectations (such as health-oriented, environmental-oriented, or based on cultural issues, identity/authenticity), and to the existence of substitute products, like beer and

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spirits. This became more relevant in the pandemic crisis (due to Covid-19) where consumer patterns will focus more on sustainability issues, which demands the strength of the greening process of the CAP (Vergamini et al., 2021). Accordingly, the wineries behavior, in terms of management decisions regarding technology, products, marketing, and other factors, is framed in a global market characterized by a monopolistic competition structure, where there exists a large number of firms with different characteristics and sizes; restricted control over price-output; with product heterogeneity; asymmetric information; and freedom to enter or exit the market (Parenti et al., 2017). Despite competition in domestic market, in this industry, firms' competitiveness is increasingly dependent on the ability to trade at an international level (Macedo et al., 2019).

Both changes in market supply and demand have been appealing for a vertical and horizontal wine differentiation based on unique factors such as grape varieties, terroir, quality, and brand or, at the marketing level and distribution channels. Understanding the drivers of wine consumers' purchasing decisions has been the object of a lively debate. As a highly differentiated product, wine preferences are distinctive and country-specific. In this sense, companies need to know consumer's preferences for the attributes of wine to establish marketing strategies, which requires data collection and analysis. Typically, companies use consumer panels through the application of surveys, which can be expensive (Windle & Rolfe, 2011), and whose validity depends on the sample size and randomness (Mitchell & Jolley, 2010).

Over the last few years, there have been a large number of consumer-oriented studies, including in wine research, particularly those using the technique of discrete choice experiments (DCE), a stated preference method, to estimate which attributes are crucial to decision-making by decomposing the good into its attributes or characteristics in light of Lancaster's theory (Lancaster, 1966). The use of the DCE technique has attracted researchers' interest as an alternative to more conventional techniques, as it improves the feasibility of valuation studies, and is relevant for research and policy. This method facilitates obtaining information about the most valued wine attributes in the decision-making process, providing information about how consumers value wine based on their intrinsic and extrinsic characteristics, and assessing a price premium or willingness to pay (WTP) for each wine characteristic. Empirical evidence provides the WTP measures for different wine cues, such as labeling (e.g., Combris et al., 2009; Mueller et al., 2010), wine origin (e.g., D'Alessandro & Pecotich, 2013; Kallas et al. 2013), grape variety (e.g., Corsi et al. 2012; Kallas et al. 2013), awards or medals (e.g., Combris et al. 2009; Corsi et al. 2012), brand and price (e.g., Xu et al. 2014).

For marketing purposes, the results of these studies allow wineries to adjust the definition of their wines to the consumer' profile, gathering the needs of each market and segment. However, to obtain robust consumer knowledge representative samples are required and consider sample selection issues to avoid biased and inconsistent estimators (Heckman, 1979). Solving these issues requires surveying a large number of consumers with high costs. Alternatively, similar information may be collected easily and reliably, by inquiring intermediaries who continuously contact with wine consumers and have knowledge about their preferences and habits.

The distributors make an appropriate linkage between the producer and the final consumer based on consumer insights, playing a pivotal role in choosing the product to sell in each specific market. The distributors decide which products to carry, the market segments to reach, and the prices to charge consumers for each product. Moreover, as Sashi & Stern (1995) attested, in some industries (such as producer goods industries), the intermediaries in the distribution channel are agents of product differentiation. After analyzing the sales of Australian wines on the British retail market, Steiner (2004) found that consumers associate a distribution channel with a specific product quality. In the same sense, Pu, Sun, and Han (2019) state that an increasing number of manufacturers are considering selling differentiated products through different channels as their distribution strategy through quality differentiation.

Regardless of the question of the distribution channel and its relationship with product differentiation, which has been gaining attention [reviewed by Pu et al. (2019)], wine distributors are agents with a deep knowledge of consumer's preferences and behaviors when purchasing wine. Thus, they may act as key players in collecting information for wineries to meet consumer needs, an increasingly complex and challenging demand. This alternative source of information has the advantage of obtaining data through smaller samples of the target markets. Therefore, supported by the DCE theoretical background, the goal of this paper is to test whether the distributors' data may be an alternative source of information to convey consumers' preferences and trends in the target market. Specifically, this article explores wine distributors' perceptions about the most valued wine attributes by consumers using the DCE technique. This information is obtained by administering a survey on wine distributors in the American market (USA), positioned as the world's largest consumer in 2018 (OIV, 2019), but whose background and related studies about wine consumers' preferences are few. As far as we know, this approach has not been conducted before, constituting an innovative research topic capable of promoting helpful knowledge to wineries and wine distributors.

The paper is organized as follows. Section 2 presents the methods comprising the study design, sample, and the methodology employed. Section 3 includes the results and discusses previous evidence on consumer preferences/choices in the US market. The conclusions of this study are presented in Section 4.

2. METHODS

2.1. Data

An online survey comprised of four sections (general characterization of the distributor; ranking of wine characteristics importance; wine valuation scenarios (10 choice sets); business characterization of the distributor) was distributed by a specialized external firm, the Nielsen Consulting company, through distributors that operate in the US market to collect information about the attributes and values in the consumers choice. From the 1109 distributors for US market (bestwineimporters.com in October 2019), a total of 92 valid questionnaires multiplied by the 10 choice sets provides a DCE sample size of 920 observations.

As to the characterization of the data sample (Table 1), the distributors have been on the wine market for 18 years, on average. Red wine is the most important category in terms of market share of wine sales (on average, 53%). For 50% of the distributors, white wine represents up to 25% of wine sales, rosé represents up to 6%, and sparkling wine represents up to 5%. The specialist retailer is the most relevant distribution channel in terms of share of wine sales, followed by the on-trade channel, hypermarkets/supermarkets, and small grocers. Moreover, 62% sell to hypermarkets/supermarkets, and 59.8% to small grocery stores. The wine sales represent the most crucial portion of the distributors' total sales (84%, on average). On average, online sales represent near 7% of the total distributors' business. Nevertheless, for 66% of the distributors, the average share of online sales is zero.

When asking distributors to identify the three most important attributes in the market they serve, the price attribute leads the ranking, followed by other relevant attributes, such as the expert ratings, grape variety, and country of origin (Figure 1).

Table 1. Distributor's business characterization.

	Mean	Median
Years in the market	18	15
Market share		
White	0.25	0.25
Red	0.53	0.50
Rosé	0.93	0.65
Sparkling	0.73	0.50
Others	0.30	0.00
Presence in market channels		
Hyper and supermarkets	0.62	
Small grocers	0.60	
Specialist retailers	0.92	
On-trade	0.94	
Online	0.34	
Share of sales in each channel		
Hyper and supermarkets	0.30	
Small grocers	0.17	
Specialist retailers	0.44	
On-trade	0.39	
Online	0.07	
Share of wine sales in the total sales	0.84	0.98
Less than 50%	0.14	
50 - 75%	0.123	
76% or more, less than 100%	0.25	
100%	0.49	

2.2. Choice experiment

The choice experiment used in this research includes six attributes (see Table 2), representing highly influential cues for wine choice.

Medals/awards: consumers perceive this attribute as an important sign of quality when choosing a wine (Corsi et al., 2012; Lockshin, Jarvis, D´Hauteville, & Perrouty, 2006). A gold medal with a "gold medal winner" description written in the middle was included.

Alcohol level: the growing concern about the effects of overconsumption of alcohol explains the inclusion of this attribute, characterized by three different levels: low (12% vol), medium (13.5% vol), and high (15% vol) alcohol wines.

Origin: wine origin is well documented as one of the most important cues for wine choice (e.g., Kallas et al., 2013). Six levels describe this attribute at the country level: countries with a long history and tradition in wine production – Italy (54.8 mhl), France (48.6 mhl), and Portugal (6.1 mhl) – being in the top 5 in European production (OIV, 2019) and wines from the new producing countries – USA (23.9 mhl), Australia (12.9 mhl), and

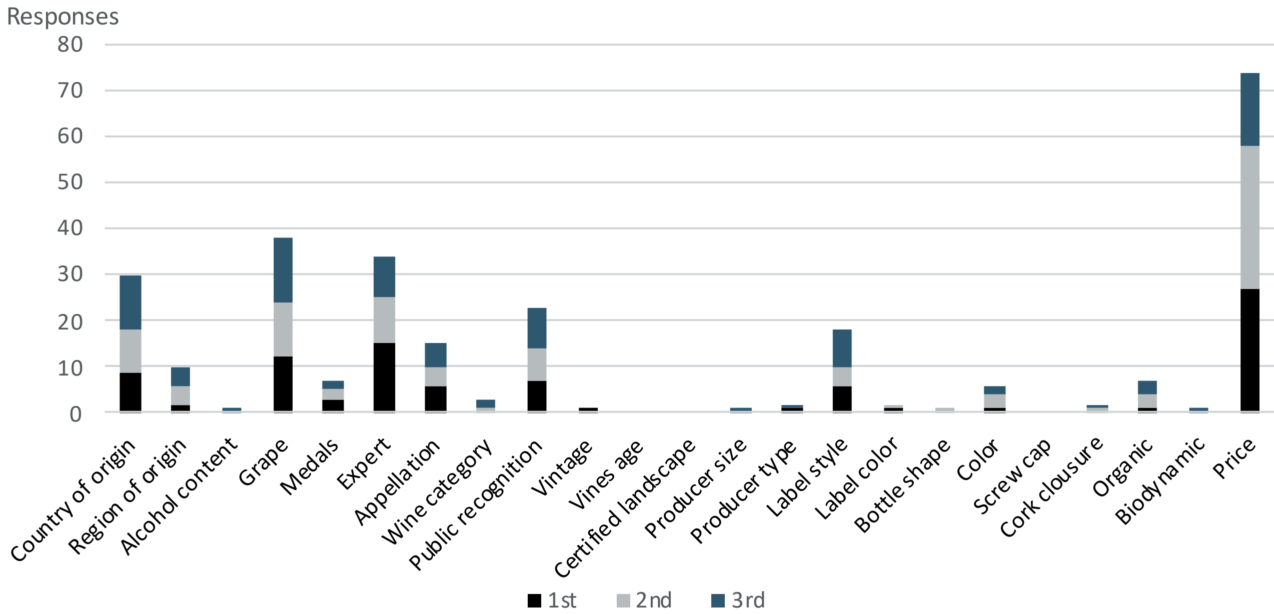

Figure 1. Three most attractive wine attributes in the market in which the distributor operates.

Table 2. Attributes and levels used in the choice experiment.

Attributes	Medals/ Awards	Alcohol level	Origin	Grape variety	Closure	Price
Levels	Yes No+	12% vol. 13.5% vol. 15% vol.	France Italy Portugal USA Australia+ Chile	Cabernet Sauvignon Syrah Red blend No information+	Cork Screw Cap+	$8.99 $12.99 $17.99 $24.99

+ reference level on dummy coding.

Chile (12.9 mhl) – also being in the top 5 in the New World production (OIV, 2019) accounting for the changes in the international wine market.

Grape variety: this factor is a choice driver, especially for the New World wines (Corsi et al., 2012; Kallas et al., 2013). Regarding consumers' preferences for wine varieties, in 2018, the best-selling wine varietals in the US market based on volume included Chardonnay, Cabernet Sauvignon, and Red Blends (Nielsen, 2019). Therefore, two well-known red varieties were selected (Cabernet Sauvignon and Syrah) and a Red Blend.

Closure: this packaging trait may function as a signal of expected quality (Bekkerman & Brester, 2019). Two bottle closure types, screw cap, and cork closure are the most common closures in the wine market. The screw cap closure and the cork closure covered with a capsule were realistically presented in the survey.

Price: it is one of the primary drivers of choice and is commonly used as an indicator of quality (e.g., Lockshin et al., 2006; Corsi et al., 2012). Four price levels were included between the range of $8.99 and $24.99. The choice of price levels was based on the actual price range of red wine in the off-channel in the US market.

A D-efficient design with no priors was obtained using the Ngene software. The attributes' levels were combined into alternative wines and arranged in 10 sequential choice sets[1]. Each choice set was formed by three alternative wines plus a none-option, as displayed in Figure 2. Distributors were asked to select their preferred option or bottle of wine that fits better the market they serve in terms of the consumers' preferences,

[1] The number of choice sets S was selected based on the equation: S≥K/(J-1), where K= #parameters including constant; J=#alternatives (Ngene v1.2.1 software, ChoiceMetrics, 2018).

Figure 2. Example of a choice set.

according to the question: "Imagine you have three different types of wine. Which of the following wines do you find as the most successful in serving wine consumers in your market?".

2.3. Discrete choice model

The method of discrete choice experiments has its roots in the Lancaster (1966) model of consumer behavior, which defines a good in terms of its characteristics, and on the random utility theory (McFadden, 1974), where an individual is a rational decision-maker aiming to maximize her or his utility. Respondent n (n=1, …, N) chooses among different J alternatives in T choice situations. A random utility expression represents each alternative j, according to the following equation:

$$U_{njt} = \beta' x_{njt} + \varepsilon_{njt} \tag{1}$$

x_{njt} is the vector of explanatory variables and includes product attributes and respondents' characteristics, ε_{njt} is the random component. The alternative that gives the highest utility is chosen, such that $P_{nj} = prob(\beta' x_{nj} + \varepsilon_{nj} > \beta' x_{nk} + \varepsilon_{nk})$ $\forall$ j≠k∈C, where C is the choice set of J alternatives, $j=1, …, J$.

In the present application, the utility associated with a particular set of alternatives J can be derived as follows:

$$U_{Jn} = \beta_{medals} * Medals_J + \beta_{alcohol} * Alcohol_J + \beta_{France} * France_J + \beta_{Italy} * Italy_J + \beta_{Portugal} * Portugal_J + \beta_{USA} * USA_J + \beta_{Chile} * Chile_J + \beta_{cabernet} * Cabernet_J + \beta_{syrah} * Syrah_J + \beta_{blend} * Blend_J + \beta_{closure} * Closure_J + \beta_{price} * Price_J + \varepsilon_n \tag{2}$$

In the mixed logit (MIXL) model (Train, 2009), also known as the random parameters logit model, the parameters are assumed to vary from one individual to another, such that:

$$\beta_n = \beta + \Delta z_n + \Gamma u_n \tag{3}$$

in which β, Δ, Γ are parameters to be estimated, Γ is the lower triangular Cholesky matrix, z_n a set of characteristics of individual n, u_n is a vector of random components, capturing non-observable effects, and $\beta + \Delta z_n$ stands for heterogeneity in the mean of the distribution of the random parameters. The choice probabilities from the model are:

$$Prob(choice_n = j | x_{njt}, u_n) = \prod_{t=1} \frac{\exp(\beta'_n x_{njt})}{\sum_{j=1}^{Jn} exp(\beta'_n x_{njt})} \tag{4}$$

Omitting the observed heterogeneity captured in Δz_n, by convenience, the generalized mixed logit model (GMXL) includes scale heterogeneity across respondents through random alternative-specific constants (Fiebig, Keane, Louviere, & Wasi, 2010; Greene & Hensher, 2010). Consequently:

$$\beta_n = \sigma_n \beta + [\gamma + \sigma_n (1-\gamma)]\Gamma u_n \tag{5}$$

where $\sigma_n = exp(\bar{\sigma} + \tau w_n)$ is the individual specific standard deviation of the idiosyncratic error term, τ captures the unobserved scale heterogeneity, and w_n captures unobserved heterogeneity. The mean parameter in the variance, $\bar{\sigma}$, is not identified independently from τ, such that σ_n is normalized to 1 by setting $\bar{\sigma} = -\tau^2/2$. γ is a weighting parameter, bounded between 0 and 1, controlling how the variance in residual preference heterogeneity varies with scale. If $\gamma = 0$, the GMXL model reverts to the scaled mixed logit model (Greene & Hensher, 2010), $\beta_n = \sigma_n[\beta + \Gamma u_n]$; when σ_n ($\tau = 0$), the GMXL reverts to MIXL; and when var (u_n) = 0 it reverts to the scaled multinomial logit model (SMNL).

3. RESULTS AND DISCUSSION

Table 3 presents the SMNL, MIXL and GMXL model results, using maximum simulated likelihood methods with 500 Halton draws in NLOGIT 6. Following Greene, Hensher, and Rose (2006) and Kragt (2013), a constrained triangular distribution was used for the random

Table 3. Results from SMNL, MIXL and GMXL models.

Attributes	SMNL	MIXL		GMXL	
	Mean	Mean	SD	Mean	SD
Medals	0.906*** (0.196)	0.997***	0.691***	1.200***	0.462
Alcohol	-0.014 (0.039)	-0.014	0.147***	0.031	0.151***
Country of origin					
France	1.497*** (0.409)	1.310***	0.633***	2.069***	0.391*
Italy	1.232*** (0.412)	0.672**	0.742***	1.192**	0.763**
Portugal	-0.940*** (0.334)	0.784***	0.794***	1.165**	1.347***
USA	0.958** (0.389)	0.699**	0.069	1.315**	0.408
Chile	0.982** (0.434)	0.499	0.753**	1.350**	0.225
Grape variety					
Cabernet Sauvignon	0.284* (0.162)	0.137	0.987***	0.482*	1.137***
Syrah	-0.062 (0.211)	0.013	0.785***	0.263	1.182***
Red blend	0.598* (0.313)	0.592**	0.010	1.012**	0.947**
Closure	0.176 (0.114)	0.420***	0.801***	0.580***	0.879***
Price	-0.057*** (0.013)	-0.079***	0.079***	-0.095***	0.029**
ASC[1]	-0.434 (0.509)	-1.186**		-0.136	
Variance parameter in scale (τ)	0.821***			0.730***	
Weighting parameter (γ)				0.064	
Sigma:					
Sample mean	0.985			0.933	
Sample standard deviation	0.895			0.670	
Log-likelihood	-1110.9	-1008.2		-997.0	
AIC	2249.9	2064.3		2048.0	
BIC	2317.1	2179.6		2173.0	
McFadden pseudo-R^2	0.11	0.20		0.20	
Observations	920	920		920	

Standard errors in parenthesis; SD = standard deviation; ***, **, * significance at 1%, 5%, 10% level, respectively.
[1] Alternative specific constant – Included for the none-option and it represents the respondent *n's* preference towards the opt-out choice compared to the three alternatives included in our experiment.

price parameter, and a normal distribution was defined for the other attributes (Kragt, 2013).

The scale heterogeneity parameter (τ) was equal to 0.821 and highly significant, indicating the presence of substantial scale heterogeneity, such that respondents varied in terms of certainty/consistency in their choices. Results show that accounting for taste heterogeneity by introducing random parameters provides a better fit than SMNL, with GMXL achieving best performance indicators. The majority of standard deviations for the random parameters are significant, showing taste differences across wine consumers in the perspective of wine distributors, which suggests individual preference heterogeneity. However, while the results from MIXL show preference homogeneity for a red blend wine and American origin, GMXL reveals that preferences are homogeneous for US, Chilean, and awarded wines and contradicts MIXL revealing heterogeneity in preferences for red blend wines. The coefficients on Cabernet Sauvignon and Chilean origin become insignificant when introducing random coefficients in the MIXL. Nevertheless, GMXL suggests that these attributes affect wine choice. Both MIXL and GMXL suggest the relevance of cork closure.

The results show the importance of medals/awards, wine origin, grape variety, closure, and price. In particular, the present study shows that French origin and blended wines are significant and positive drivers for distributors' choice, while Australian origin has the opposite effect. These findings support a DCE's outcomes on wine consumers' preferences (Gonçalves et al., 2020) which also found a positive impact of an awarded wine and the negative influence of price and Australian wines on consumers' choice. Moreover, the coefficient on closure is statistically significant, suggesting that this attribute (cork closure compared to screw cap) positively affects the utility of choosing a wine when introducing

Table 4. Willingness to pay estimates[1], in US$.

	SMNL	MIXL	GMXL
Medals	15.76***	17.33***	15.92***
Alcohol	-0.25	-0.33	0.18
Country of origin			
France	26.04***	22.32***	20.82***
Italy	21.42***	11.94**	12.84***
Portugal	16.34***	13.38***	11.85***
USA	16.66**	12.69**	10.89***
Chile	17.07**	8.34	8.093**
Grape variety			
Cabernet Sauvignon	4.93*	1.41	3.51***
Syrah	-1.07	-0.08	-0.11
Red blend	10.39**	10.78**	8.25***
Closure	3.06	7.57***	6.10***

***, **, * significance at 1%, 5%, 10% level, respectively.
[1] WTP values for SMNL were estimated as $WTP = -(\beta_k / \beta_{price})$, while for the MIXL the WTP were calculated based on unconditional estimates. In the case of GMXL, the model was re-parameterized in "WTP space" to directly produce the WTP estimates.

random coefficients. This finding is in line with Kelley et al. (2015) results, which found that consumers are more willing to increase purchases if bottles have cork closures using the conjoint analysis technique. Additionally, wine distributors perceive red blend varieties as a relevant attribute for consumers' choice.

Regarding willingness to pay measures, presented in Table 4, the results from distributors' perspective suggest the highest price premium for French origin (from \$20.82 to \$26.04 among models), followed by medals (from \$15.76 to \$17.33). There is also a positive price premium for the other origins compared to the Australian one. The results also reveal the importance of red blend variety, with a premium ranging between \$8.25 and \$10.78, and cork closure compared to screw cap (from \$6.10 to \$7.57 among models).

Summing up, despite being a data source from distributors, the results are in line with those obtained from consumers in the same market, using either the same/similar methodology (Gonçalves et al., 2020; Kelley et al., 2015) or with different methodologies (Chrysochou et al., 2012; Lockshin et al., 2015; Pomarici et al., 2017; Thach et al., 2020). Among these, Chrysochou et al. (2012) show the importance of grape variety using the Best-Worst Scaling (BWS) approach. This result was later confirmed by Lockshin et al. (2015) and Pomarici et al. (2017) using the same method. These scholars also reveal the importance of the origin of the wine (Lockshin et al., 2015; Pomarici et al., 2017), price (Pomarici et al., 2017), and medals/awards (Lockshin et al., 2015). Additionally, in line with the present study, Thach et al. (2020) also reported the relevance of blended wines, which might reflect a recent trend among American wine drinkers towards red blends instead of monovarietal.

4. CONCLUSION

This study employs a DCE in the US market, to assess the perspective of wine distributors regarding consumers' preferences. It explores whether the perception of a market distributor, who knows the market well, may reflect the evidence suggested by consumers' preferences studies for wine. This study supports the importance of attributes such as price, medals, country of origin, and grape variety. As first highlighted in the previous questions of scoring an extensive list of attributes and identifying the three most attractive attributes, the alcohol content is not a significant attribute in choosing one bottle of wine over another. When faced with trade-offs between only six attributes, the closure attribute is relevant, suggesting a market trend favoring cork stoppers over screwcaps. We believe that bottle closures may influence the consumers' perception of the quality of a wine and consequently how much they are willing to pay for the product. A recent study (Bekkerman and Brester, 2019) found that, on average, US consumers are willing to pay more for wines with cork closures rather than screw caps. The same study also found that this premium increases for lower-priced wines and decreases for more expensive wines, suggesting that the bottle's closure has an enormous impact on the perceived quality of the wine.

Results from this study reinforce that both price and medals are well-known wine cues for choice in the analyzed market (both in consumer and distributors' views). The red blend is a positive and significant choice driver for wine in the view of distributors, which suggests red blends as an opportunity in the US wine market.

There are important implications based on this study. First, it reflects the view of distributors, who are important players in the wine value chain, about the most valued attributes in the US market, which is relevant for wineries to adapt their supply. Second, this study suggests that distributors know consumer's preferences in the respective market, potentially foreseeing emerging trends. Hence, the distributors can provide robust information on wine consumers' preferences and behaviors, representing a potential alternative to directly obtaining this information from the consumers.

As usual, this research is not free of drawbacks. First, to reach this specific target of respondents, an external consulting company was contacted to distribute the survey. This action has costs, and it was possible because this research was funded. Second, as it is common in similar studies, there is no certainty that all relevant attributes are included in the survey, so the results may not fully capture the market preferences. Additionally, the comparison with results from other consumer studies only indicates preference matching since the survey design, technique, and analysis period are not synchronized. Thus, future research should compare data from these different sources (distributors and consumers) using the same technique and period to obtain more solid conclusions. Additionally, inquiring about this specific target (distributors) with market knowledge and experience may also benefit from a more qualitative study to investigate, for example, barriers and drivers of wine placement.

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