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Modeling hemp as an innovative input: an application of the diffusion of innovations in a sample of hemp aware consumers

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Abstract
After decades of absence, the federal legalization of hemp in the U.S. positions the crop as an innovative, plant-based input for conventional products. Through an application of the diffusion of innovations theory, this study responds to identified research needs made by hemp stakeholders and the existing literature by modeling the influence of innovation characteristics on propensity to use hemp products among Vermont consumers. Findings reveal that attributes associated with relative advantage and trialability significantly influence propensity to use at least one type of hemp product, as well as use multiple types of hemp products. This highlights particularly salient points for hemp stakeholders engaged in the marketing and communication of hemp products. Findings contribute to informed strategy creation for producers, institutions, and other stakeholders operating in this nascent industry, where data and research continue to be limited.

Keywords Hemp · Diffusion of innovations · Consumer behavior

Abbreviations
THC Tetrahydrocannabinol
CBDL Cannabidiol

Introduction

Hemp has been a staple crop throughout human history and was first cultivated as early as 12,000 BCE (Tripathi and Kumar 2022). Hemp fibers were lauded for their strength and resilience as inputs for paper and textiles (Bouloc and van der Werf 2013; Montford and Small 1999) and processed into nautical canvas and rope (Meijer et al. 1995; Robinson 1996). The seeds are rich in healthy oils and proteins (Adesina et al. 2020; Pihlanto et al. 2017), which were used as a therapeutic agent (Adesina et al. 2020; Thompson et al. 1998) and nutritious food source (Borkowska and Bialkowska 2019; Brzyski and Fic 2017). Hemp's oils have been recognized as a source of medicine and healing for hundreds of thousands of years (Fike 2016). Despite the crop's historical significance and versatility, its production was interrupted in the U.S. by regulatory barriers that linked hemp and marijuana (Johnson 2018). Though hemp varieties of Cannabis *sativa* have lower psychoactive tetrahydrocannabinol (THC) concentrations compared to marijuana varieties (Adesina et al. 2020; World Health Organization 2018), hemp was listed as a controlled substance in 1937 (Marihuana Tax Act of 1937 1937). Its production was prohibited in the U.S. for several decades, resulting in limited research investment (Ely et al. 2022b) and consumer access to hemp-based products in the marketplace (Malone and Gomez 2019).

Rising demand for plant-based and environmentally friendly food, textile, and plastic alternatives, coupled with a realization of the crop's potential to contribute to modern economic and sustainability goals, set the stage for hemp's legalization in 2018 (Ahmed et al. 2022; Crini et al. 2020; Ely et al. 2022b; Marihuana Tax Act of 1937 1937). Hemp is perceived to be an environmentally and biodiversity friendly crop that can remediate soil, complement food production,

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and grow quickly (Fortenbery and Bennett 2004; Montford and Small 1999). This perception of sustainable hemp production extends to the crop's resulting products, such as hemp grain for plant-based milk substitutes or textiles made with hemp fiber rather than cotton. Efforts to reduce dependence on petroleum-based products (Babu et al. 2013) stimulated technological progress for conversion of hemp fibers to plastic, construction material, and polymer alternatives (Ahmed et al. 2022; Filimonova et al. 2022). Particular attention was also being paid to another emerging use of hemp: cannabidiol (CBD), a naturally occurring, non-psychoactive compound in the hemp flower used for therapeutic and recreational purposes (Adesina et al. 2020; Mark et al. 2020; World Health Organization 2018). High profit estimations piqued the interest of farmers and entrepreneurs (Mark et al. 2020) who added CBD to edibles, tinctures, and common food and beverage products (Malyshev and McDonough 2019). Hemp's newness in the U.S. is therefore derived from its reintroduction after several decades of absence and its perceived role as a novel plant-based input.

With lucrative prospects for CBD oil and hemp's general untapped potential in mind, national acreage for hemp increased nearly 350% from 2018 to 2019 and largely focused on cultivation for floral biomass for CBD production (Mark et al. 2020). Though the applications of this crop appear endless, hemp is not without limitations. It competes with the cost efficiency of conventional alternatives and new technologies targeting sustainable outcomes, such as flax- and other plant-based bioplastics and building materials (Cherney and Small 2016; Fike 2016; Notaro et al. 2022; Papadopoulou et al. 2015). The production efficiencies championed by cotton and petroleum-based products helped to push hemp out of production in the nineteenth and twentieth centuries (Fortenbery and Bennett 2004; Meijer et al. 1995). Now, too, processing constraints for hemp fiber and oil make them a relatively more expensive alternative (Mark et al. 2020; Mark and Snell 2019; Sterns 2019). Production constraints may also influence the ability of products to make it to store shelves, restricting availability for consumer purchase. Though CBD drove the initial ascent of hemp production, an unknown market and overinflated profit estimates led to CBD's oversupply and price crash in 2019 and 2020 (Mark et al. 2020; Quinton 2021). Exacerbating these barriers to the hemp sector is limited research across the supply chain for informed decision making (Ellison 2021; Ely et al. 2022b, 2022a; Mark and Snell 2019; Schluttenhofer and Yuan 2017).

Changing policy, processing bottlenecks, and price uncertainty (Mark et al. 2020) make knowledge of hemp demand essential to inform producer strategies in a historically turbulent sector. Indeed, hemp's success is conditional on demand for its products (Ely et al. 2022a). Otherwise, investments made by hemp producers could be fruitless, a reality already experienced by many early growers of CBD (Quinton 2021). As the CBD market stabilizes and producers respond to a growing demand for hemp fiber and grain (Grand View Research 2020), understanding consumer perceptions of and demand for these relatively new-to-market products can play a pivotal role in building a resilient hemp sector.

A review of the existing literature finds a handful of consumer studies on hemp products across the globe. Metcalf et al. (2021) model early adopters of newly legal hemp-based food products in Australia and finds that consumer associations with hemp and marijuana do not significantly influence adoption, while consumers do value health and ethical sourcing of hemp food products. Willingness to purchase meat loaf products with hemp ingredients significantly increased when consumers in Poland were provided information about hemp's positive health impacts (Zając et al. 2019). In examining cannabis-based skincare cosmetics, Ribeiro et al. (2022) found that environmental awareness and human values, such as openness to change, influenced purchase intention among a sample of consumers in Portugal. Though consumer studies on hemp products in other countries can offer some insight, the unique context of hemp in the U.S. necessitates specific exploration of its consumers.

A critical consideration for hemp as a product input in the U.S. is its ties to marijuana. Hemp's production restrictions in the U.S. were fueled by fear of marijuana as a drug and public health threat (Micu 2021; Robinson 1996). The two were linked under federal regulation for decades and categorized as controlled substances (Marihuana Tax Act of 1937 1937). Though their differences continue to be demonstrated (World Health Organization 2018), consumers may still confuse hemp and marijuana (Colclasure et al. 2021; Lusk 2017; Rampold et al. 2021). As such, how marijuana perceptions influence hemp product reception is a necessary consideration.

Despite an expressed need for peer-reviewed research on consumer demand for hemp-based products made by stakeholders (Ellison 2021; Mark et al. 2020), available research on hemp in the U.S. is largely limited to industry reports on CBD products that focus on demographic characteristics such as gender and age (New Frontier Data 2020). However, market estimates (Grand View Research 2020) and existing peer-reviewed research (Kim and Mark 2018; Kolodinsky and Lacasse 2021) demonstrate that other, non-CBD, hemp products are of interest to consumers and that demographic data alone provide an incomplete picture of hemp demand (Kolodinsky et al. 2020). There is an absence of consumer behavior research exploring other uses of hemp-based products, such as foods, textiles, personal care products, and cosmetics in the U.S. There is also no examination of consumer acceptance for multiple types of hemp products represented in the literature. The breadth of products hemp can be processed into, as well as efforts to diversify the industry

beyond CBD, necessitate an understanding of consumer response to the totality of hemp offerings, which may offer insight toward sector-wide strategies.

Given hemp's novelty and an absence of information on consumer implications of its use in the U.S., this study models hemp as an innovative product using a survey of Vermont consumers. We use the theory of diffusion of innovations (Rogers 1983) to examine the influence of consumer perceptions on total adoption of hemp-based products to identify salient values that can inform stakeholder decision making and marketing.

Methods

Conceptual framework: Diffusion of innovations

Our empirical work is based on Rogers' (1983) diffusion of innovations: a model of the consumer decision process for adopting innovative products or behaviors. In the case of this study, hemp as an alternative input is the innovation. For example, textiles made from hemp fiber as opposed to cotton, or non-dairy milk substitutes made from hemp grain rather than almonds or soy. The diffusion of innovations identifies five attributes associated with acceptance of an innovation and serve as a proxy for innovative behavior (Fig. 1). Relative advantage refers to the "degree to which in innovation is perceived as being better than the idea it supersedes" (Rogers 1983, p. 214). An innovation with relative advantage may have time, monetary, labor, convenience, or social benefits (Kolodinsky et al. 2004; Rogers 1983; Warner et al. 2020). Based on existing literature, this study measures hemp's relative advantage through perceptions of health benefits (Adesina et al. 2020; Andre et al. 2016), palatability (Hayward and McSweeney 2020; Zając et al. 2019), and durability (Bouloc and van der Werf 2013). If an innovation functions comparably to its alternatives and the way a consumer uses a product, it is compatible. Compatibility can manifest in consumer values, needs, current habits, or prior experiences (Kolodinsky et al. 2004; Rogers 1983). Here, compatibility is measured by whether a respondent perceives hemp-based products to be difficult to find or affordable (Hellwinckel 2020; Sterns 2019). A complex innovation implies that it is difficult to understand, or use, compared to the existing alternatives (Rogers 1983). Alternatively, a simple innovation is easier to understand, or use, compared to its alternatives. For this study, complexity is measured by respondents' perception of whether a hemp product is difficult to use. Trialability refers to the ability of an individual to experiment with the innovation. Trying a new product or behavior limits the uncertainty associated with its newness (Rogers 1983). Trialability is measured by whether the respondent has had an opportunity to try a hemp product. The final attribute is observability, which is the extent to which the innovation is visible to an individual. Observability includes an implication that the product is communicable to buyers and is socially acceptable (Rogers 1983). Here, we measure observability with whether the respondent has seen someone use a hemp product before. Our data measure simplicity, observability and trialability based on previous applications of the diffusion attributes (Rogers 1983). It is expected that each attribute will be positively related with the adoption of hemp as an innovation (Fig. 1).

Data

To operationalize the diffusion of innovations conceptual model, we examine perceptions from a sample of Vermont consumers. Vermont is an appropriate study site for exploring hemp demand. It allowed for hemp production once

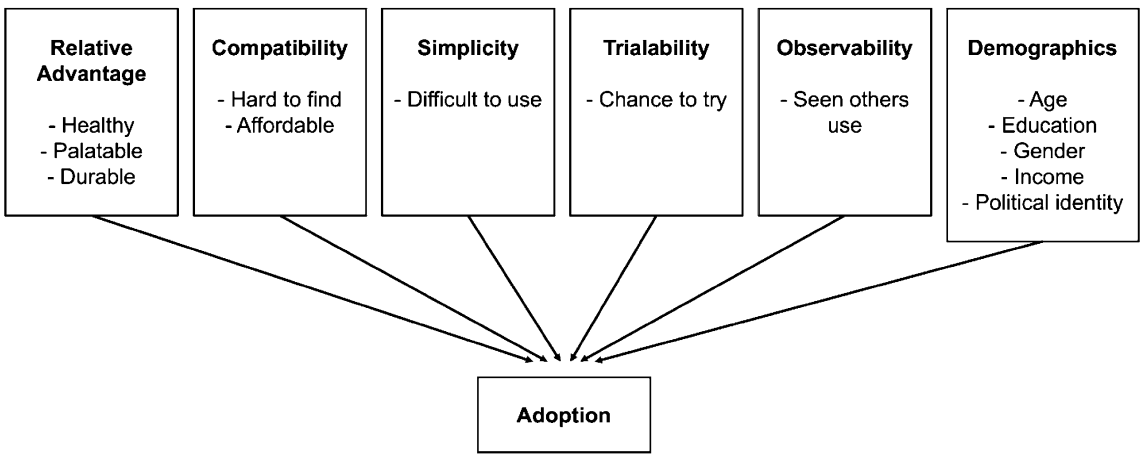

Fig. 1 Conceptual model of the diffusion of innovations adapted from Rogers (1983). Each diffusion characteristic is hypothesized to positively influence adoption

federal legalization allowed in 2018 (Agricultural Improvement Act of 2018 2018), keeping in step with 46 other states that also permitted hemp production by 2019 (Mark et al. 2020). The first few years of hemp production in Vermont (Vermont Agency of Agriculture, Food, and Markets 2020) are comparable to national trends (Vote Hemp 2020). In addition, evidence-based research on consumer behavior towards hemp find that Vermonters are supportive of hemp production and familiar with a wide variety of hemp-based products (Kolodinsky et al. 2020; Kolodinsky and Lacasse 2021), reflecting industry estimates of hemp-product market shares (Grand View Research 2020). Vermont, therefore, can serve an indicator of consumer perceptions of hemp for the rest of the United States.

Specifically, we use data from a statistically representative online survey of 465 randomly sampled Vermont residents conducted state-wide annually. The survey was approved by the Institutional Review Board at the University of Vermont and was conducted in February and March of 2021. Respondents identifying as current Vermont residents over the age of eighteen are eligible to participate. Responses were screened for completion and resulted in a sample size of 398 for our analysis. Results have a margin of error of ± 4% with a confidence interval of 90%. The demographic characteristics of our sample population are compared to the Census Bureau's 2019 American Community Survey (United States Census Bureau 2019) estimates and subject to post process weighting. Demographic weighting ensures that survey responses are representative of the known population characteristics (Mercer et al. 2018). Once weighted, age, education, income, and gender are representative of Vermont within a margin of error of ± 10% (Table 1). IBM® SPSS® Version 27 (SPSS V27 2021) and LIMDEP (Econometric Software Inc. 2021) are used to conduct statistical analyses.

Table 1 Frequency of control variables included in the model (n = 398)

Variable	Percent
Support for medicinal marijuana	84.8
Support for recreational marijuana	66.6
Age	
18–34	27.4
35–54	27.5
55–74	33.4
75 and older	11.8
Education: College degree or more	67.2
Gender: Female	60.6
Income: $50,000 / year or higher	59.8
Political Affiliation	
Republican	14.3
Democrat	21.5
Other	64.2

Analysis subject to weighting

Methods

Our data include questions about eight categories of hemp-based products: CBD; textiles, construction materials, food, paper, personal care products, plastics, and rope. Products are chosen based on recent sales data for hemp-based products (Hemp Business Journal 2018), reflecting products that are available to consumers. Respondents are asked a series of questions related to their awareness of, intention to use, and perceptions of each product category. If a respondent indicates that they are not aware of a given hemp product, they are not asked subsequent questions. Less than 2% of the original survey sample was not aware of any of the hemp products listed. This study is based on a sample of those who are aware of at least one hemp product category.

Awareness of and intention to use hemp categories are aggregated to an 8-point scale representing the total number of product categories a respondent is aware of or will use. Total number of products respondents intend to use serve as a proxy for hemp adoption (Ajzen 1991; Ajzen and Fishbein 1980). Each diffusion characteristic is composed of one or more 5-point Likert scale questions that are specific to each hemp product (Fig. 1); if a characteristic is composed of more than one question, they are averaged. We subsequently create an average measurement of diffusion characteristics by the total number of hemp products a respondent is aware of. The value for each diffusion characteristic is totaled across product type and divided by total product awareness. This results in a maximum average value of five and lowest value of one. For example, a score of five for relative advantage would indicate that a respondent, on average, perceives hemp products overall to have high relative advantage, while a score of one would indicate that they perceive hemp products, on average, to not have relative advantage. A score of 2.5 would indicate that a respondent is neutral about the relative advantage of hemp-based products. In addition, we account for the associations between hemp and marijuana found in previous studies (Colclasure et al. 2021; Lusk 2017) by controlling for the support of medicinal and recreational marijuana legalization. We also control for a series of demographic characteristics, including age, education, income, gender, and political affiliation (Table 1). Those who intend to use zero hemp products represent more than half (52%) of the sample. This introduces potential sample selection bias from a corner solution response, where observations are spread over a range of positive values but have a nontrivial number of observations with a value of zero (Woolridge 2013). To address this, we run a Heckman two-step regression, where a probit regression is used to examine the influence of innovation attributes on propensity to use at least one

hemp product category. We then apply a Poisson regression to examine the count of total hemp product categories used (Greene 2012).

Results

On average, consumers in our sample are aware of 5.6 types of hemp-based products (Table 2). Approximately 70% of our sample are aware of at least five types of hemp-based products (n = 398). Over one-half of our sample do not intend to use any hemp product categories in the future (52%). Respondents are most familiar with CBD (95%), closely followed by hemp clothing (91%), hemp rope (89%), and hemp personal care products (81%). Our sample is least aware of hemp plastics (37.4%). The average total products respondents intend to use in the future is 1.2 (Table 2). Hemp products with the highest incidence of intent to adopt are CBD (39.1%), personal care products (31.5%), and food products (27.7%). Of the innovation attributes associated with hemp products, simplicity has the highest mean score (2.36), followed by compatibility (2.18), observability (2.18), and relative advantage (2.14). Trialability has the lowest mean score (1.89) among our sample. Given that a score of 2.5 indicates a neutral stance, these mean values reflect neutral to negative positions on diffusion characteristics overall.

Table 2 Summary statistics for product awareness and intention to adopt

Variable	Percent	Mean (SD)	n
Total awareness across products[a]		5.6 (2.0)	398
Awareness: CBD	95.2		398
Awareness: Clothing	91.0		398
Awareness: Rope	89.2		398
Awareness: Personal care	81.3		398
Awareness: Food	60.7		398
Awareness: Paper	56		398
Awareness: Construction	51.9		398
Awareness: Plastics	37.4		398
Total intent to adopt across products[a]		1.2 (1.7)	398
Intent to adopt: CBD	39.1		377
Intent to adopt: Clothing	16.7		353
Intent to adopt: Rope	11.8		359
Intent to adopt: Personal care	31.5		297
Intent to adopt: Food	27.7		242
Intent to adopt: Paper	15.7		194
Intent to adopt: Construction	6.6		178
Intent to adopt: Plastics	9.5		98

Analyses are subject to weighting

Total awareness measures the average number of hemp-based products our sample (n = 398) is aware of out of a maximum of 8 possible products. Awareness of individual hemp-based products indicates the percentage of the total sample who are aware of the given product. Total intent to adopt measures the average number of hemp-based products our sample (n = 398) intends to adopt in the future out of 8 possible products. For each hemp-based product, intent to adopt measures the percentage of respondents who intend to adopt among those who are aware of the given product (resulting in varying values of n across products)

[a]Maximum of 8 products possible

The probit regression explains 28% of the variation in whether respondents intend to use at least one type of hemp-based product ($R2 = 0.28$, $p < 0.001$). Given the cross-sectional nature of the data set, this is not an atypical R2 (Eisenhauer 2009; Lu et al. 2013). Examination of the effect of partial effects lead us to reject the null hypothesis that there is no relationship between adoption of hemp products and relative advantage, simplicity, trialability, total awareness, medicinal marijuana support, and being age 18 to 34 (Table 3). Based on the partial effects estimator, age has the largest relative impact on the probability of using at least one type of hemp product, with 18- to 34-year-olds being associated with an increase in the probability of use by 43 percentage points compared to those 75 or older ($p < 0.001$). The second largest relative association with hemp use is relative advantage, where higher perceived relative advantage leads to a 37-percentage point increase in the probability of use ($p < 0.001$). Higher perceived simplicity leads to a 20-percentage point increase in the probability of using at least on hemp product category ($p < 0.001$), while trialability leads to a 15-percentage point increase ($p < 0.001$). The impact of support for medicinal marijuana legalization leads to a 12-percentage point increase in the probability of use ($p = 0.076$). Higher total awareness of hemp product categories leads to a 5-percentage point increase in use ($p < 0.001$).

The Poisson regression explains 8% of the variation in using more than one category of hemp product ($R2 = 0.08$, $p < 0.001$). Relative advantage has the largest relative impact on intensity of use. For a one-point increase in the average perceived relative advantage of hemp products, the difference in the logs of total product categories used increases by 0.55 products ($p < 0.001$) (Table 3). Trialability is significantly associated with total use, where for a one-point increase in the average trialability of hemp products, the difference in the logs of total products used increases by 0.26 products ($p = 0.047$). For every additional product a respondent is aware of, the difference in the logs of total products used increases by 0.23 products ($p < 0.001$). The difference in the logs of total product categories used is expected to be 0.55 higher for respondents who are supportive of medicinal marijuana legalization compared to those who are neutral to or oppose legalization ($p = 0.038$). Compatibility, simplicity, and observability characteristics do not significantly influence the intensity of hemp product use in our sample. Neither medicinal nor recreational marijuana support, nor

Table 3 Results for a probit regression to estimate the adoption of at least one hemp product type (n = 398) and a Poisson regression to estimate the intensity of hemp product use of up to eight product types (n = 208)

Independent Variables	Probit Partial B (SE)	Poisson Parameter Estimate (SE)
Relative advantage	0.37*** (0.07)	0.55*** (0.17)
Compatibility	0.00 (0.06)	− 0.11 (0.13)
Simplicity	0.20*** (0.05)	− 0.04 (0.18)
Observability	0.01 (0.04)	0.09 (0.14)
Trialability	0.15*** (0.04)	0.26** (0.13)
Total aware	0.05*** (0.01)	0.23*** (0.05)
Support for medicinal marijuana	0.12* (0.07)	0.55** (0.27)
Support for recreational marijuana	− 0.07 (0.05)	− 0.03 (0.15)
Age: 18-34[a]	0.43*** (0.07)	0.03 (0.45)
Age: 35-54[a]	0.03 (0.08)	0.09 (0.30)
Age: 55-74[a]	0.00 (0.06)	< 0.00 (0.22)
Education: College degree or more	− 0.10 (0.08)	− 0.23 (0.28)
Gender: Female	− 0.01 (0.05)	− 0.06 (0.13)
Income: $50,000 / year or higher	− 0.06 (0.05)	0.03 (0.14)
Political affiliation: Democrat[b]	0.08 (0.07)	0.13 (0.18)
Political affiliation: Other	0.04 (0.06)	− 0.03 (0.18)
Weight	− 0.05* (0.03)	− 0.06 (0.18)
Constant	–	− 2.72*** (0.72)
Observations	398	208
R-squared	0.28***	0.08***

Heckman selection was run with the Poisson regression to account for sample selection bias. We test for selectivity bias using a t-test comparing ρ between a true Poisson and a selected Poisson (Greene 2012). Results indicate that a selection model accounting for bias is appropriate ($t(3) = 664.7$, $p < 0.002$); *p < 0.10, **p < 0.05, ***p < 0.01; analyses are subject to weighting

[a]Reference variable is age 75 and older

[b]Reference variable is Republican affiliation

socio-demographic characteristics, are significantly associated with intensity of hemp product use.

Discussion

Awareness and use results across hemp categories indicate that consumers are aware of the breadth of products available on the market. They are most aware of and most frequently adopt hemp CBD, which reflects industry focus since hemp's legalization and industry estimates (Grand View Research 2020; Mark et al. 2020). However, consumers are nearly equally aware of hemp clothing, rope, and personal care products, and intend to use hemp personal care products at similar rates to CBD. This indicates opportunities for further research on consumer values or barriers to access for non-CBD hemp products and offers insight to future directions for the industry.

Results of this study find that relative advantage and trialability have significant influence on total use of hemp-based products. Consumers are more likely to adopt an innovation if it possesses advantages compared to its alternatives (Rogers 1983). Results find that higher perceived relative advantage of hemp-based products leads to an increase in total products used. This indicates that the healthier, more palatable, and more durable hemp products are perceived to be, the more likely consumers are to use them, and use them with more intensity. This finding can help direct the hemp industry two-fold. First, they emphasize the importance of continued research exploring the health and nutritional benefits of hemp (Cerino et al. 2021; Wang and Xiong 2019), as well as on how to enhance palatability and durability in innovative products. In addition, findings point to targeted marketing opportunities for hemp stakeholders to continue the diffusion of hemp in the marketplace. To provide expanded segmentation and marketing opportunities, future research should consider modeling relative advantage characteristics as separate attributes to further distinguish the strength of values like health and taste on hemp adoption.

The ability to try a product before adoption allows consumers to gain experience, begin to understand how it would work in their own lives and minimize the hesitation associated with its newness (Rogers 1983). Trialability of hemp products increases the probability of using at least one hemp-based product and the likelihood of using more than one type of hemp product. This finding highlights the

importance of providing opportunities for consumers to try hemp products. This can manifest as company offerings through product coupons and samples or may include institution-led demonstrations at community events to bolster awareness and education. For example, agricultural extension could hold demonstrations of hemp plastics and rope at a community fair. This would provide consumers who have not encountered all types of hemp products, or none, to gain awareness and confidence through trial.

Results for compatibility, observability, and simplicity did not align with hypothesized outcomes; the attributes did not significantly influence the probability of adoption. This study measures compatibility using the extent to which it is easy to find and whether it is affordable. However, compatibility can also reflect existing habits or prior experiences (Rogers 1983), which may be more salient measurements for potential hemp consumers and better reflect willingness to stray from non-hemp product alternatives. Observability was measured based on whether respondents had seen the product being used by other people, but the ability to discern hemp-based products from conventional ones may be difficult. Asking whether respondents know family and friends who use products or if a respondent has received information on hemp may be more appropriate measures of compatibility. Similarly, the absence of simplicity's influence may indicate that hemp products function comparably to their non-hemp alternatives and are neither more nor less complex to use (Rogers 1983). Our finding that not all diffusion of innovation characteristics are correlates of total hemp use may indicate that the variety of potential hemp products have not diffused through the marketplace. Given our results, we recommend further exploration of measures for compatibility, observability, and simplicity for hemp-based products in future studies.

Results of this study indicate that age is an important predictor of hemp use but is not associated with the use of more hemp product types. The youngest in our sample have a greater probability of using at least one hemp product category compared to the oldest. This finding may reflect previous applications of demographic influence, where the oldest age groups are more likely to be unaware of hemp products (Kolodinsky et al. 2020). However, this finding is contrary to industry data that identify older consumers as more likely to consume CBD (New Frontier Data 2020) and points to the importance of avoiding the conflation of CBD findings to the broader hemp consumer. Older consumers may be more frequent users of CBD, but among our sample we find that younger consumers have a higher probability of using hemp overall. Different hemp applications may require separate marketing strategies from CBD. At the same time, hemp more broadly may be more appealing to younger populations, offering potential segmentation opportunities. Overall, significant influence of demographic characteristics was largely not present in our models. Though industry reports frequently focus on demographic characteristics of CBD demand (New Frontier Data 2020), our model highlights that future research should continue to explore hemp perceptions and values.

A common talking point for hemp production is the crop's associations with marijuana. Our study finds that support for medicinal marijuana legalization increases the probability of using at least one hemp product and is associated with higher total product use. This may relate to the background literature's suggestions that hemp and marijuana are linked in the public eye (Colclasure et al. 2021; Lusk 2017), where acceptance of marijuana leads to acceptance of hemp. Given that our findings are contradictory to those of Metcalf et al. (2021) and that our sample is specific to Vermont consumers, the influence of marijuana policy here may highlight the importance of policy and geographic context. In addition, political affiliation did not significantly influence hemp adoption, contradicting earlier studies of Vermont consumers (Kolodinsky and Lacasse 2021) which found that Republican consumers were less likely to be familiar with and adopt hemp-based products. Though this may highlight broad public acceptance of hemp products and diminishing bipartisan views, this study ultimately is unable to tease out the nuance between political affiliation, marijuana policy and support, and hemp legalization. Examining how policy influences hemp acceptance across a range of geographical and government contexts, both within and outside the U.S., may be a valuable contribution to understanding hemp consumption and the influence of policy – particularly marijuana policy—on novel crop adoption.

Our findings reveal that awareness of more types of hemp-based products leads to the use of more total products, which may reflect reduced consumer uncertainty as they gain knowledge about all the ways hemp can be used (Rogers 1983). This indicates the importance of demonstrating the swath of products hemp can be processed into aid hemp's normalization in the marketplace. Though the current market is largely focused on CBD products (Mark et al. 2020) and availability of many product types are limited (Mark and Snell 2019), inclusion of all types of hemp-based products may increase the overall awareness of consumers, leading to greater acceptance and use. This opportunity may increase in the future if producers diverge from CBD and respond to industry estimates of increasing demand for hemp fiber and grain (New Frontier Data 2020).

This study contributes to the growing knowledge base of consumer demand for hemp-based products. Though our Vermont sample can provide a valuable indication of consumer preference for the greater U.S., it should be followed by nationally representative research examining consumer preferences and values towards hemp products. This will allow for greater variation in observed demographic

variables, including race and ethnicity which were unable to be accounted for in this study. Another limitation of our study is the inability to include consumers who are unaware of hemp products and may therefore be a population of interest to hemp producers and other marketers. As such, an understanding of revealed preference for consumer demand may provide a deeper understanding of how demographic characteristics and values influence the decision to purchase hemp products compared to those who do not.

Overall, findings point to salient diffusion of innovation characteristics that can inform stakeholder strategies. Relative advantage and trialability influence both measures of hemp adoption modeled in this paper, while compatibility, observability, and simplicity were not found to significantly influence either measure. We find differences in age and marijuana support between users and non-users of hemp-based products, which may identify hemp as being early in the diffusion process (Metcalf et al. 2021; Rogers 1983). This would reflect hemp's relative nascency in U.S. production and market landscape.

Conclusion

Hemp's legalization in the U.S. positions the crop as a new and innovative input for plant-based product alternatives. This study responds to identified research needs made by hemp stakeholders (Ellison 2021; Mark et al. 2020) and the existing literature (Kolodinsky et al. 2020; Kolodinsky and Lacasse 2021) by modeling the influence of diffusion of innovation characteristics on propensity to use multiple types of hemp products among Vermont consumers. Results lend insight to how innovation attributes influence cumulative hemp use and identify characteristics associated with relative advantage and trialability as salient points for hemp stakeholders to consider. However, given that this model speaks to the context of a single state and that there is variation in hemp policy development across the U.S., expanding the scope of analysis to a national scale for future research would be appropriate. In addition, directly addressing previous recommendations by examining the influence of attributes on specific types of hemp products may improve the model and provide greater insight for stakeholders operating in different areas of hemp production.

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