

The Hass Avocado Board's Program to Fund Research into the Health and Nutrition Benefits of Consuming Avocados

Insights from Google Scholar and Google Trends

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Abstract: This study evaluates the impacts of the Hass Avocado Board's funding and support of research into the health and nutrition benefits of consuming avocados. The Board has funded such research continuously since 2009, spending nearly \$1 million annually on average from 2013 – 2017. We located and reviewed 28 publications supported by HAB funding that have appeared in scientific journals. Fifteen of the papers were published in 2017 and 2018. Most of the papers have appeared in journals with high impact factors (an average five-year impact factor of 4.9). The papers in total have generated 436 citations (an average of 15.6 per paper) in the scientific literature, a commendable number especially given that 10 of the papers were published in 2017 – 18 and have had little time to generate citations.

We also found that the publications generated considerable interest in the popular press with 40 different traditional and on-line media outlets publishing stories based on results in the scientific publications. Further, we found accelerating consumer interest in avocados generally and the health aspects of avocado consumption specifically based on internet search activity in the U.S. and key international markets as measured by Google Trends. This search activity accelerated at a statistically significant rate from 2013 onward, a time frame corresponding to the appearance of most of the HAB-funded publications and the media interest associated with them. We conclude that the Board's funding of research into the health and nutrition benefits of consuming avocados and its efforts to disseminate the findings from this research to key influencers (e.g., physicians, dietitians, and health-related media) and to final consumers is working effectively based on all of the metrics considered in this paper.

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Table of Contents

1	Introduction.....	1
2	Publications from HAB-Funded Research.....	3
3	Academic Impacts of the Publications.....	5
4	General Impacts of the Publications	10
4.1	Measuring Consumer Interest in Avocados Through Google Trends	13
4.2	International Markets.....	18
5	Conclusion	20
6	Appendix: List of HAB-Funded Publications.....	23

List of Tables

Table 1. List of Academic Journals Publishing HAB-Funded Research.....	9
Table 2. Time Trend of Google Search Indices in Five Markets for Two Periods.....	22

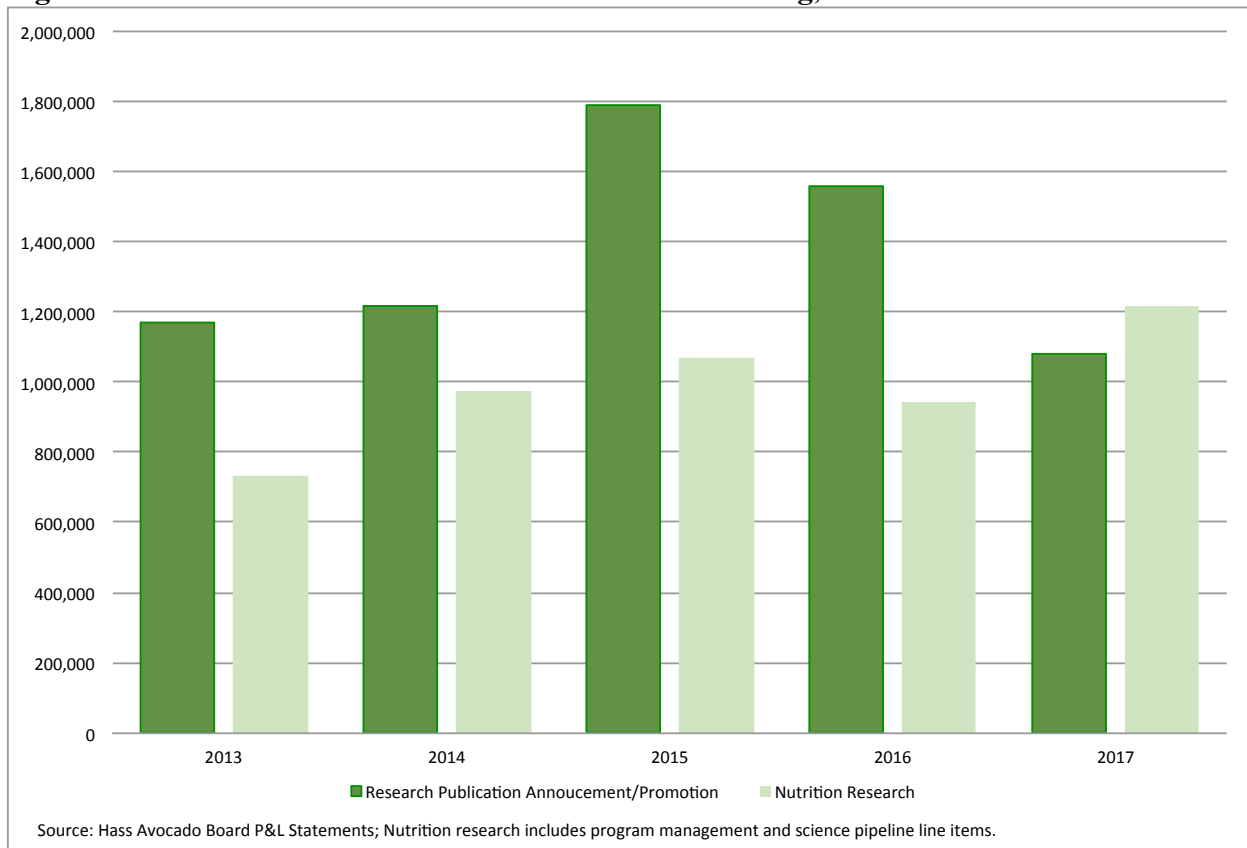
List of Figures

Figure 1. HAB Nutrition Research and Promotion Funding, 2013-2017.....	1
Figure 2. Number of HAB-Funded Publications.....	4
Figure 3. Number of HAB-Funded Publications by Research Topic.....	4
Figure 4. Citations of HAB-Funded Publications by Year of Publication, 2010-2018.....	6
Figure 5. Number of Citations of HAB-Funded Publications.....	7
Figure 6. Number of Versions of HAB-Funded Publications.....	8
Figure 7. Journal Impact Factors for HAB-Funded Publications.....	10
Figure 8. Number of News Reports by First Authors of HAB-Funded Publications.....	11
Figure 9. Number of News Reports by Last Authors of HAB-Funded Publications.....	12
Figure 10. Google Search Index for “Avocado,” 2004-2018.....	14
Figure 11. Google Search Indices for “Avocado,” “Fruit,” and “Berries,” 2004-2018.....	15
Figure 12. Monthly Fixed Effects, Pre-2013 and 2013 - Present.....	17
Figure 13. Google Search Indices for “Avocado” for International Markets, 2004-2018.....	19
Figure 14. Baidu News Reports for the Chinese Market.....	20

1 Introduction

The Hass Avocado Board (HAB) has been funding scientific research on the health and nutrition benefits of avocado consumption continuously since 2009. HAB’s support of health/nutrition research accelerated in 2011 when nearly \$1 million was expended to support this work. The Board’s commitment to fund nutrition research and announce and promote research findings for the most recent five-year period, 2013 – 17, is shown in figure 1. Over this period the Board has spent close to \$1 million per year, an annual average expenditure of \$989,400, to support avocado health and nutrition research and an average of \$1.36 million annually to announce and promote the findings generated from HAB-funded research.

Figure 1. HAB Nutrition Research and Promotion Funding, 2013-2017



This study reviews the impacts of the HAB's support of research into the nutrition and health benefits of avocado consumption. We first examine the publications that have been produced with HAB funding and then look at their impact within the scientific community. Next we turn to an investigation of the published research dissemination to the broader public and its impact on consumer interest in avocados generally and their health and nutrition impacts specifically.

2 Publications from HAB-Funded Research

Our review shows that 28 scientific articles and abstracts have been published with the HAB's financial support (see the appendix for a complete list of the publications). Sixty-six researchers from more than 15 institutions, including Tufts University, Stanford University, UCLA, UC Davis, and the USDA, have contributed to these projects. On average, each publication involved a team of five researchers.

The distribution of numbers of publications by year is shown in figure 2. Publications peaked in 2017 when 7 papers were published. Three were published in 2018 by mid-September. The publications have appeared in 13 different academic journals and covered a wide range of nutrition and health-related topics. Some papers have addressed multiple topics. The distribution of research topics is shown in figure 3. Over half of the publications have focused on the benefits of consuming avocados on the endocrine system and cardiovascular system (organ health and hormones). Over 35% addressed the impacts of consuming avocados on diet patterns and satiety, while 43% of the publications investigated nutrients contained in avocados and the ingestion of the nutrients. Cognitive health, aging, and weight control were other prominent themes of HAB-funded avocado research.

Figure 2. Number of HAB-Funded Publications

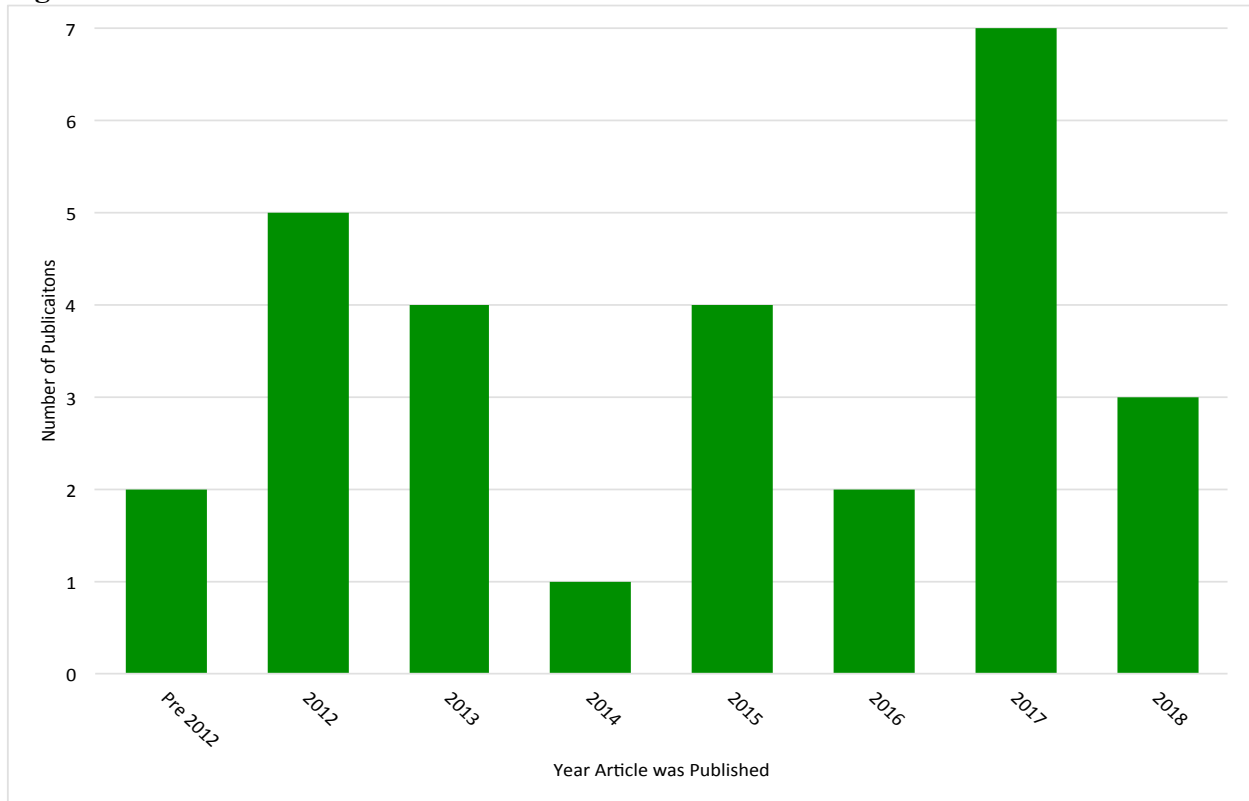
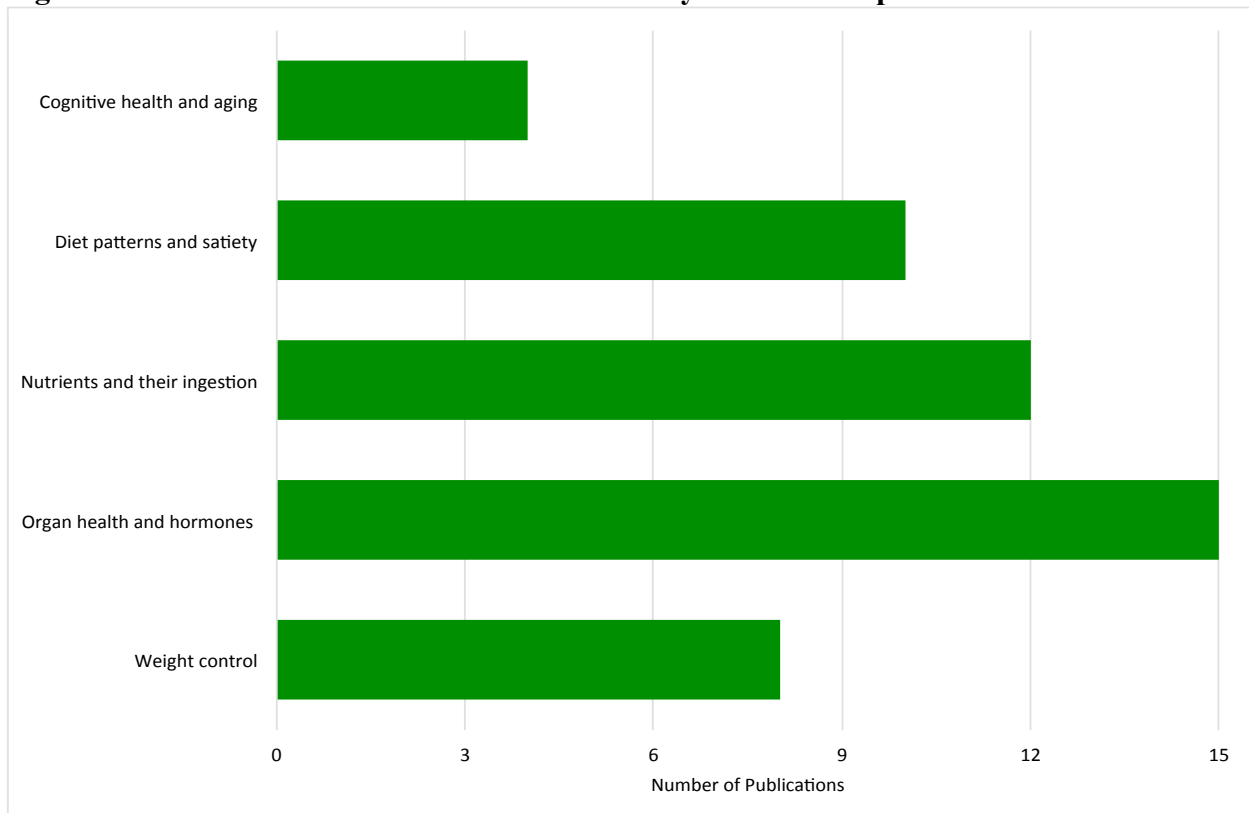


Figure 3. Number of HAB-Funded Publications by Research Topic



3 Academic Impacts of the Publications

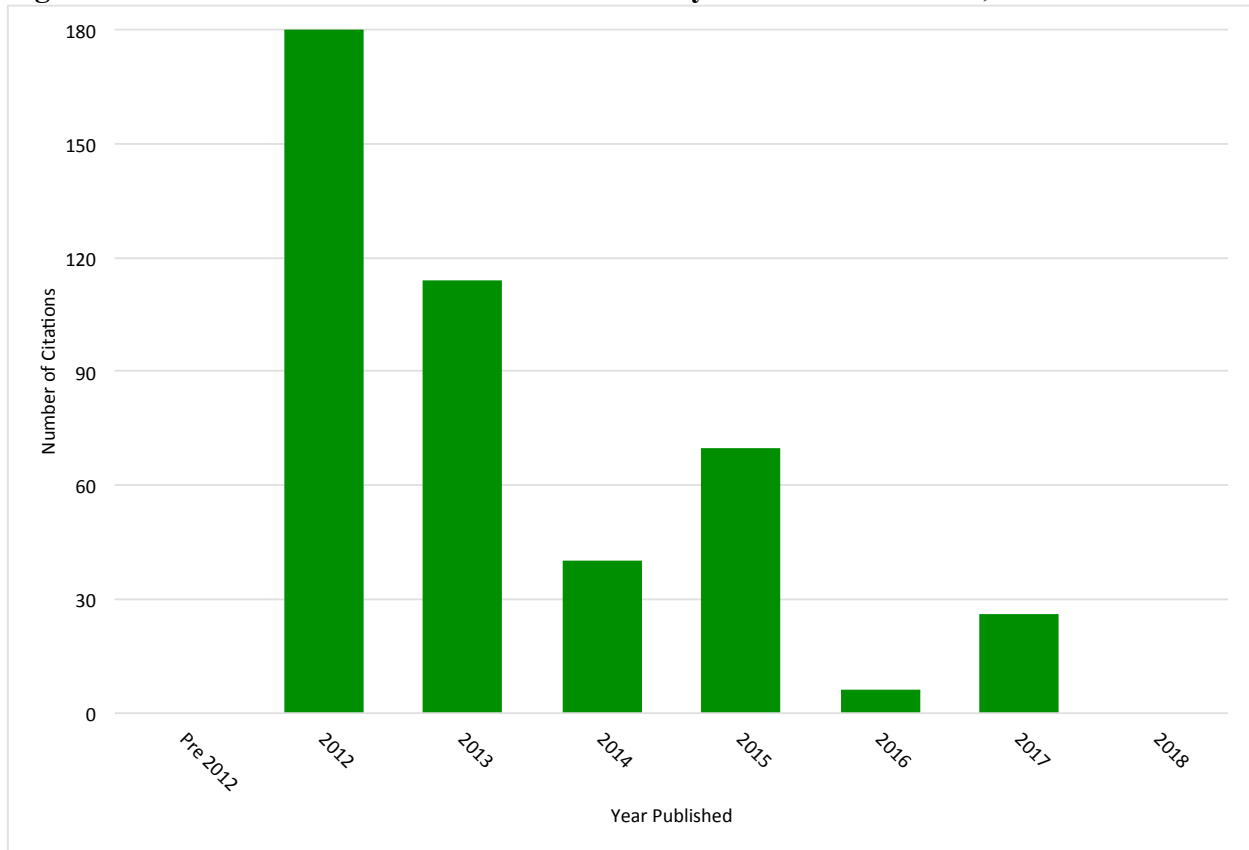
We measured the academic impact of the HAB-funded publications in three ways. First, we used Google Scholar (<https://scholar.google.com>) to estimate the number of citations for each publication through mid-September 2018. Google Scholar is the most widely used search engine for academic articles; it reports the accumulated number of citations for scholarly publications and is a standard measurement of research impact in academia.

It takes time for a publication to be read and cited by peer researchers in their own published work. Thus, the longer a publication has been in circulation, the more citations it tends to acquire. The ten publications in 2017 or 2018 have had little time to accumulate citations. Figure 4 illustrates this point; it summarizes the number of total citations for all HAB-funded publications in a given year (see figure 1). The most citations have been acquired by the publications that appeared in 2012 and 2013, while the substantial number of papers published in 2017 and 2018 have only begun to acquire citations.¹

Figure 5 depicts citation numbers for each of the 28 publications. In total the HAB-funded publications have been cited 436 times in other scientific papers. The most-cited paper has 178 citations, while the average number of citations is 15.6. Half of the papers, with 50% of them published in 2017 or 2018, have yet to acquire citations.

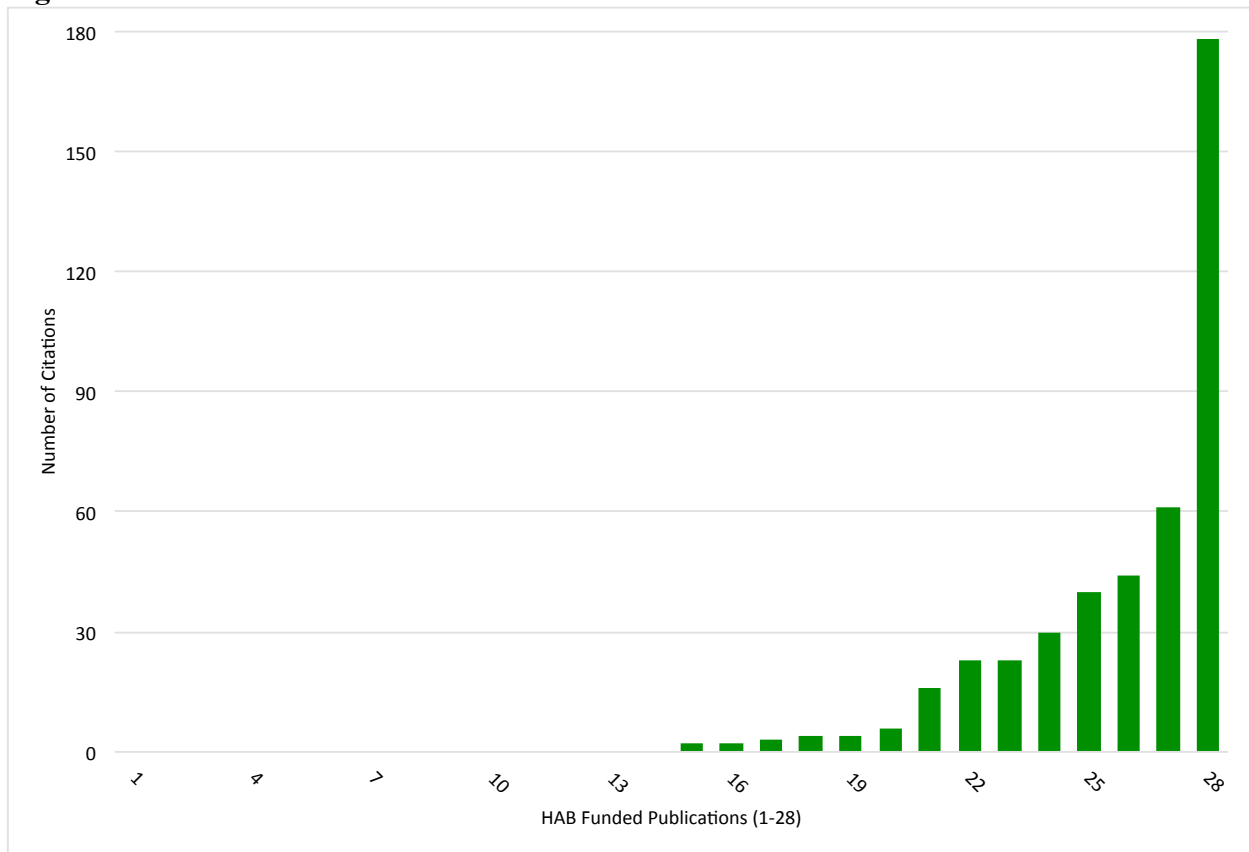
¹ We also collected the citations for the HAB-funded publications reported by Web of Science (<https://clarivate.com/products/web-of-science>), another major collector of citations, but one that is less comprehensive than Google Scholar. The two citation numbers have a correlation coefficient of 0.99, indicating that they agree nearly perfectly with each other.

Figure 4. Citations of HAB-Funded Publications by Year of Publication, 2010-2018



In closing this discussion, we note that citations are a demanding and somewhat narrow measure of a publication’s impact because generating a citation requires that a researcher read a paper, regard it as sufficiently important to incorporate its results into his/her work, and then submit that work into the publication process and have it accepted under the peer-review system and be published. Practitioners in the fields of health and nutrition may be avid consumers of published research, but publish infrequently themselves because they primarily are clinicians or work with patients in other capacities.

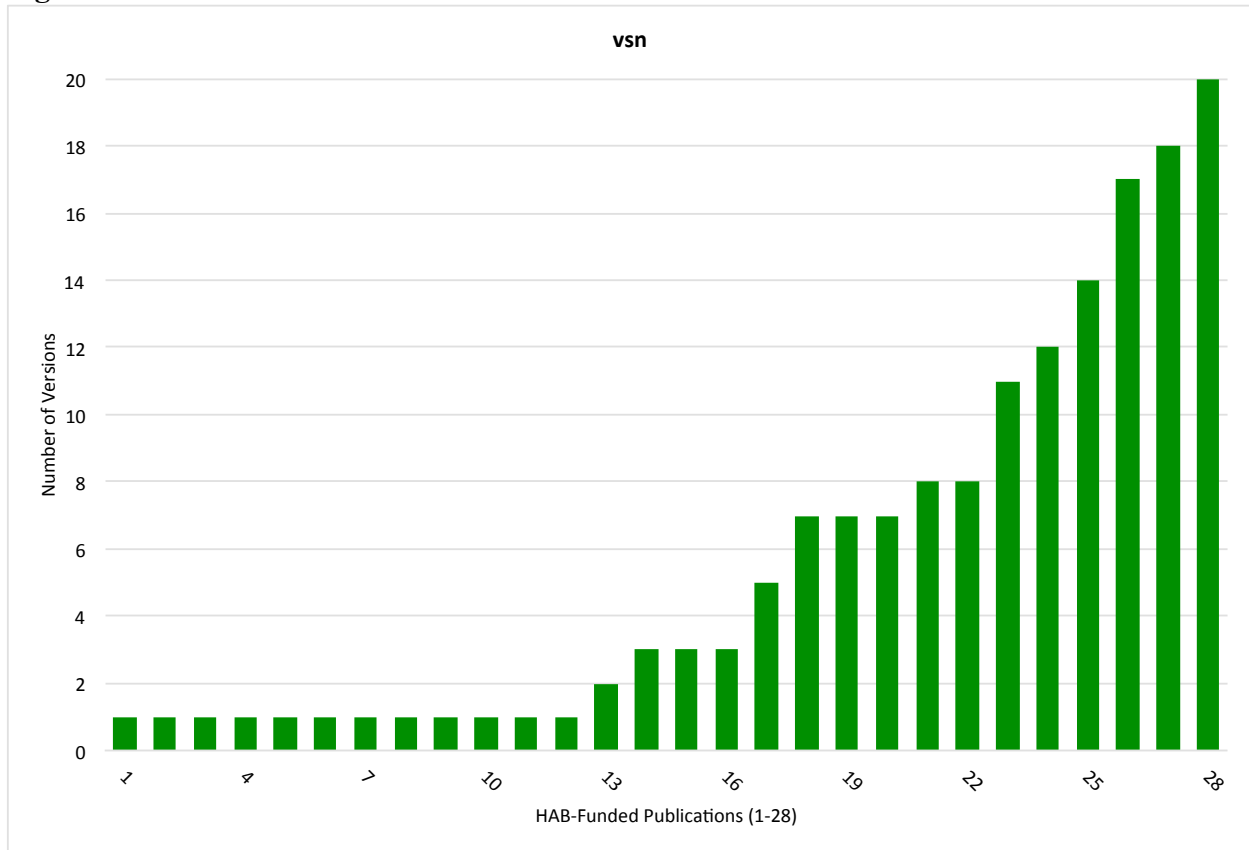
Figure 5. Number of Citations of HAB-Funded Publications



Second, we recorded the number of versions in circulation for each publication. Production of multiple versions of a paper usually reflects research that has been presented at multiple forums or made available through multiple outlets such as conferences, seminars, personal websites, and professional workshops. The more versions of a paper in circulation, the more likely it is to be noticed and read by the scientific community. More importantly, multiple versions of a paper reflect authors' diligence in widely circulating their research results and, in our case of HAB-funded research, disseminating news regarding the health and nutrition benefits of avocado consumption to their professional colleagues.

As shown in figure 6, the majority of the 28 papers have multiple versions; with an average of 5.6, although 12 have only one version that we could locate. Six publications have more than ten versions.

Figure 6. Number of Versions of HAB-Funded Publications



Finally, we measured the quality of the scientific journals in which these papers appear based on the 5-year impact factor of the journal. A journal’s 5-year impact factor measures the average number of citations for publications appearing in the journal in the first five years following publication. Five-year impact factor is a common barometer of the overall quality of scientific journals. The higher the impact factor of the journal, the more influence it has and the more researchers take note of its contents.

Table 1 indicates the journals where HAB-funded publications have appeared and their 5-year impact factors. The average 5-year impact factor of the journals is 4.9, ranging from 2.4 to 6.9. These are mostly favorable impact factors, indicating that HAB-supported researchers are

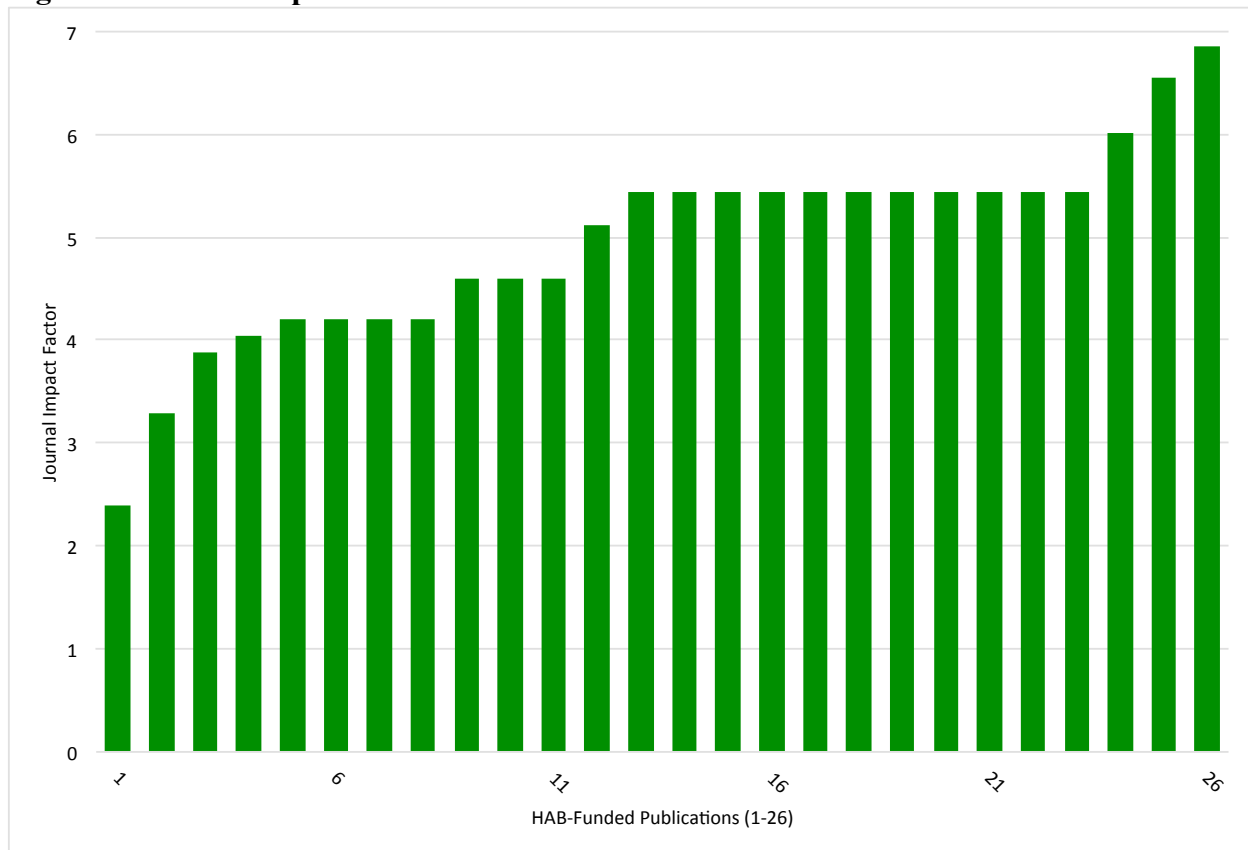
able to place their work in good outlets.² Figure 7 shows the impact factor for each of the 26 HAB-funded papers where we could locate the journal's impact factor.

Table 1. List of Academic Journals Publishing HAB-Funded Research

No.	Journal name	5-Year Impact Factor
1	Advances in Nutrition	6.85
2	Critical Reviews in Food Science and Nutrition	6.02
3	Eating Behaviors	2.40
4	Food and Function	3.29
5	Human Health and Nutrition	N/A
6	Internal Medicine Review	N/A
7	Journal of Natural Products	3.89
8	Journal of the American Heart Association	5.12
9	Nutrients	4.60
10	Nutrition Journal	4.20
11	Obesity	4.04
12	The American Journal of Clinical Nutrition	6.55
13	The FASEB Journal	5.44

² Another point to note regarding these impact factors is that they show most journal papers do not accumulate large numbers of citations, even over a five-year period. Based on the comparative metric of these five-year impact factors, we see that the citations generated by the average HAB-funded publication (15.6) compares favorably with the impact being generated by other papers appearing in these same journals, especially considering that most of the HAB-funded publications have not been in print for five years.

Figure 7. Journal Impact Factors for HAB-Funded Publications



4 General Impacts of the Publications

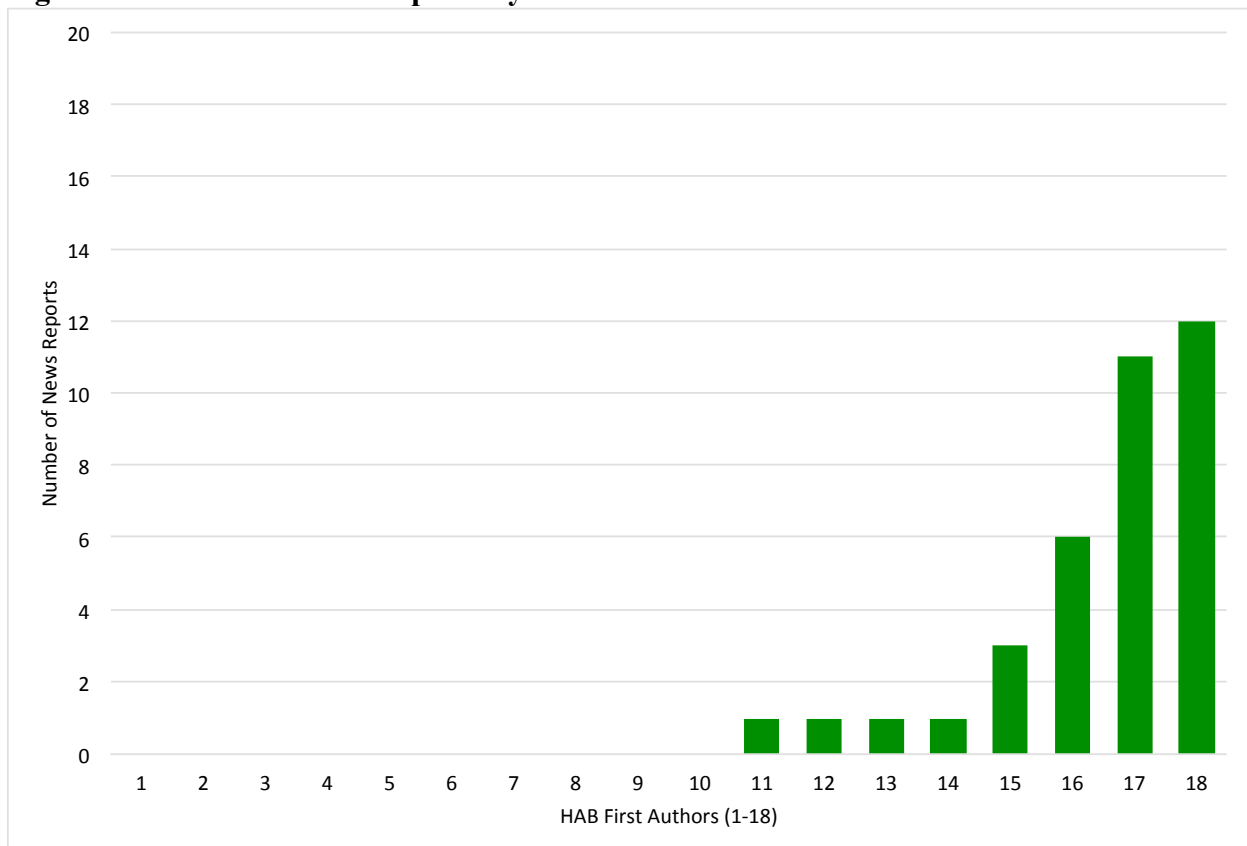
The overall strategy behind the HAB’s support of research into the health and nutrition benefits from consuming avocados is to first document these benefits through peer-reviewed publications, second to disseminate those research findings to key influencers such as dietitians, physicians, and food and health media personnel, and, finally, to get the information into the hands of consumers through this network of influencers and direct marketing to consumers by the HAB and its member associations.

We measured the effectiveness of dissemination to consumers through use of Google News and Google Trends. We were able to use Google News (<https://news.google.com>) to count news reports associated with leading researchers of HAB-funded projects. For this analysis we

searched for news reports by both the first and last authors of research publications. In journals in the health and nutrition field the first author is often a junior author in terms of seniority, but, nonetheless, news media personnel may logically approach the first author for an interview. We also searched for interviews of last authors of the HAB-funded publications. Last authors are likely senior researchers and project leaders who may act as spokesperson for the research team. We read the articles emanating from these searches to confirm that the authors indeed discussed their research on avocados in the news reports.

By September 29, 2018, 39 different traditional and online news media outlets had published news articles based on interviews of first authors of the HAB-funded publications. These results are summarized in figure 8.

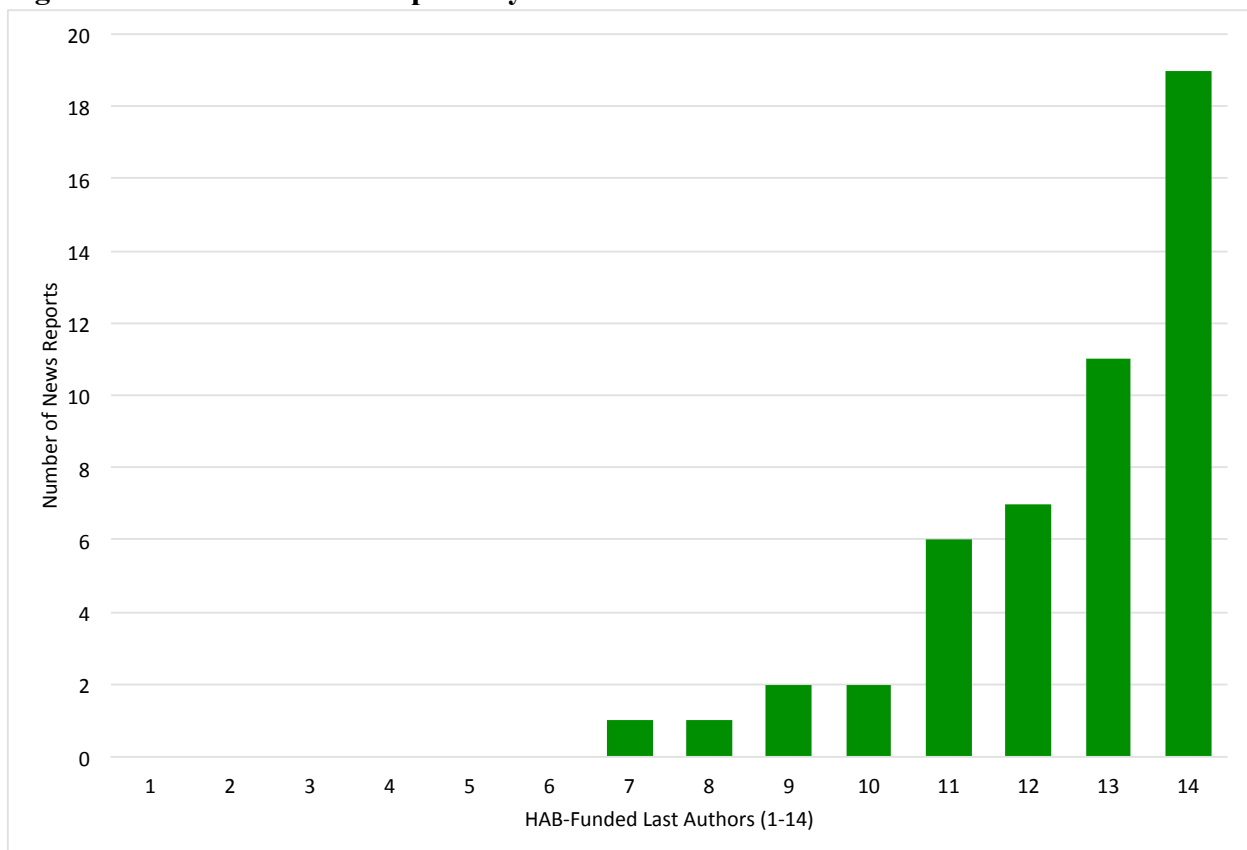
Figure 8. Number of News Reports by First Authors of HAB-Funded Publications



On average, the lead authors have had 2.0 news interviews, with an individual author's number ranging from zero to 12. The time elapsed from the appearance of the first news report to the last for a lead author was on average 5.7 months.³

By November 1, 2018, as many as 40 traditional and online news media outlets, including New York Times, USA Today, Washington Post, and Yahoo News, had published news articles based on interviews with last authors of HAB-funded publications.

Figure 9. Number of News Reports by Last Authors of HAB-Funded Publications



The number of news reports involving the 14 last authors of HAB-funded publications are summarized in figure 9. On average, the last authors have had 3.5 news interviews, with an

³ Eighteen percent of the first authors had at least one interview in an outlet ranked among the 30 most influential in the U.S. (<https://www.allyoucanread.com/american-newspapers/>).

individual author's number ranging from zero to 19. The time elapsed from the appearance of the first news report to the last for an author was on average 14.1 months.⁴

4.1 *Measuring Consumer Interest in Avocados Through Google Trends*

Google Trends (<https://trends.google.com/trends/>) is a search tool that enables researchers to track trends in Google searches over time. The tool reports search results on the topic specified by the researcher, in our case *avocado*, using Google's search engine. The researcher can study searches of a topic in particular categorical areas such as *Food & Drinks*, *Health*, and *Beauty & Fitness*, and also focus on specific geographic areas. Given the topic of this study, we paid special attention to Google searches in the category of *Health*. Hereafter, we use "search term" to refer to a particular combination of topic, category, and geographic scope.

Google searches are increasing over time as access to the internet expands and use of the internet for personal research becomes more common and widespread. The key factor that makes Google Trends such a useful tool to study consumer interest in a topic is that it does not report absolute searches (which most likely are rising for nearly any topic) but instead reports searches on the selected topic *relative* to all other searches in that topic area and from the geographic area if one is specified. Thus, a rising rate of relative searches unequivocally represents increasing consumer interest in a topic.

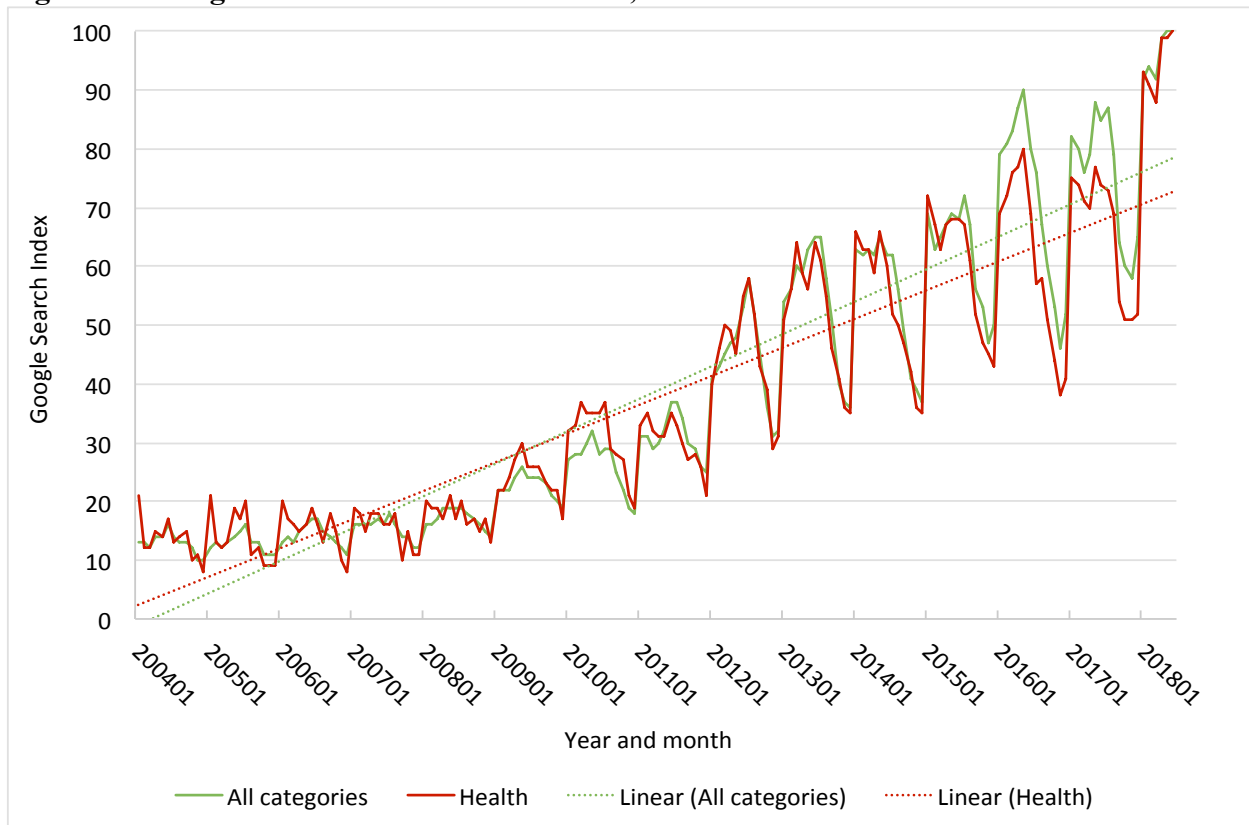
The Google Trends data are reported monthly, with the peak-relative-search month assigned an index value of 100. Every other month within the period of search will then have a search value between 0 and 100 depending on the frequency of searches relative to the peak month. We went as far into the past as possible and collected search information for the United

⁴ Twenty-nine percent of the lead authors had at least one interview in an outlet ranked among the 30 most influential in the U.S. (<https://www.allyoucanread.com/american-newspapers/>).

States and four major international markets of avocados from January 2004 to June 2018. There are 174 monthly observations for each search term.

Monthly searches on avocado for the U.S. market in all categories and in *Health* are illustrated in figure 10. Both search indices started at about 15 and researched the maximum of 100 in the most recent months, meaning that interest in avocados relative to other search topics in *Health* and overall has expanded about six-fold over the past 14 years. Searches in all categories and in *Health* have grown at similar average rates, as indicated by comparing trend lines drawn in the same color of the corresponding curves.

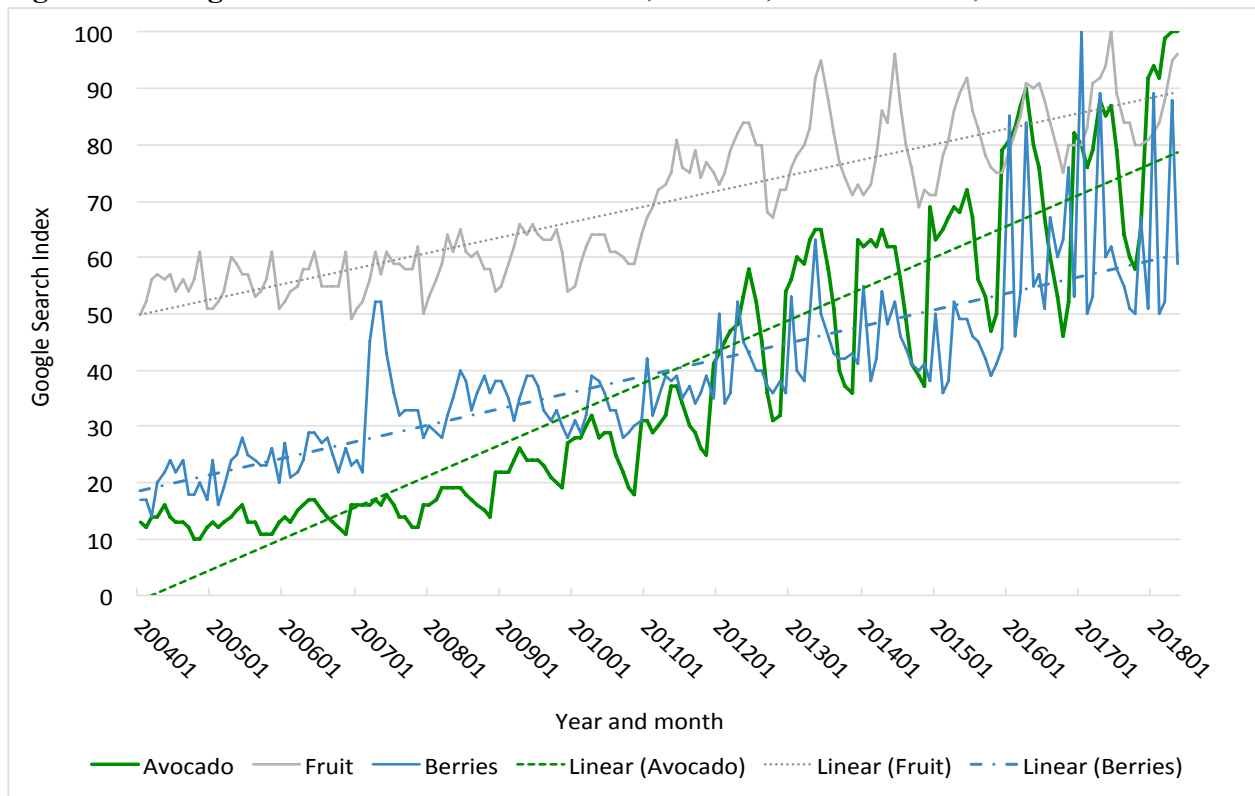
Figure 10. Google Search Index for “Avocado,” 2004-2018



To see the increase in searches of avocado relative to other comparable foods, monthly searches of the terms “fruit” and “berries” are plotted as a comparison in figure 11. Again, trend lines are drawn in the same color of the corresponding curves. Given consumers’ expanding interests in the nutrition and overall healthfulness of specific foods, we would anticipate

increasing relative searches for fruit overall and for most specific fruits. Berries in particular have been experiencing rapid growth within the fruit category. However, figure 11 shows that the trend line of avocado searches has a steeper slope than for fruit or berries, indicating that relative searches of avocado have grown at a faster average rate than searches of fruit in general and searches of berries in particular.

Figure 11. Google Search Indices for “Avocado,” “Fruit,” and “Berries,” 2004-2018



To obtain more precise insights, we specified a linear econometric model to estimate the average monthly increase in searches of avocado over the period. We regressed the relative search index on a time trend and month fixed effects to account for month-to-month differences inherent in the data. The estimates are shown in table 2. Data were split into pre-2013 (108 months from January 2004 to December 2012) and 2013 onward (66 months from January 2013 to June 2018) to allow for potentially different time trends that might be driven by the HAB’s

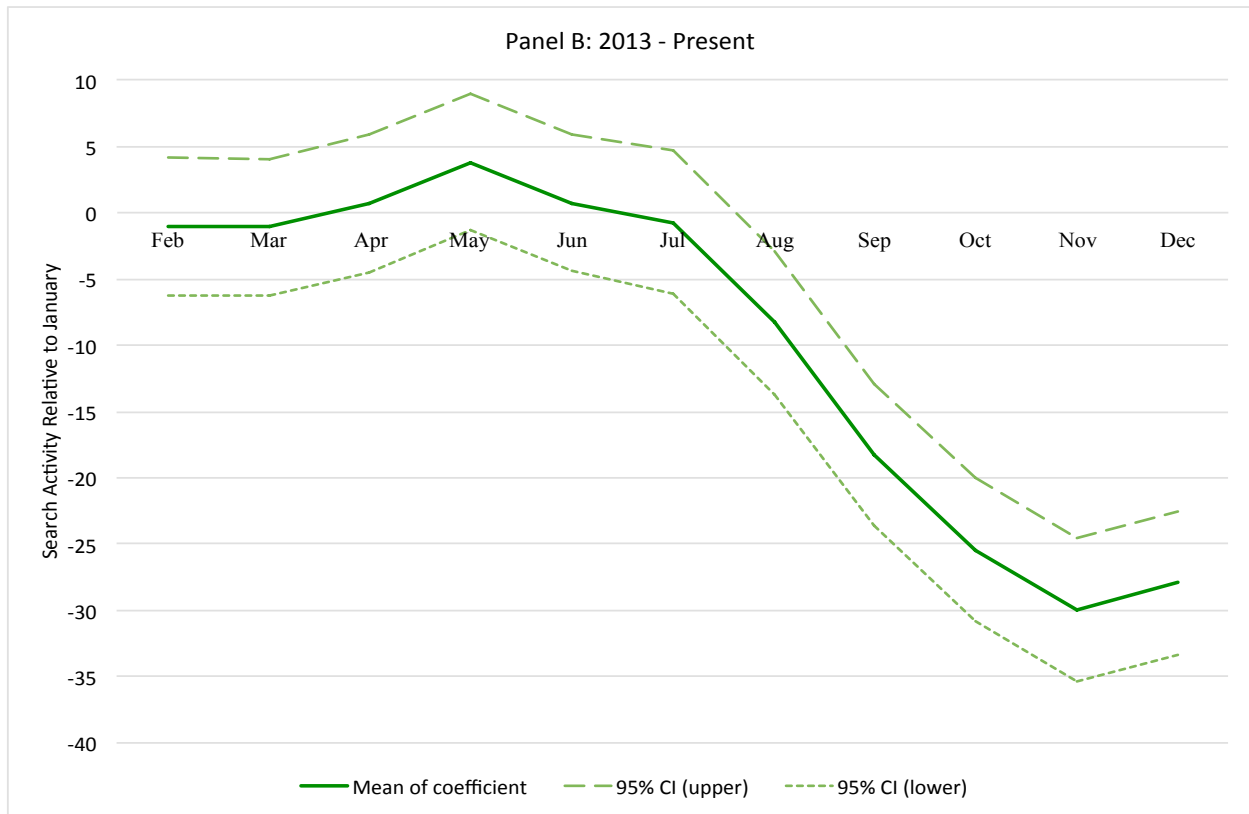
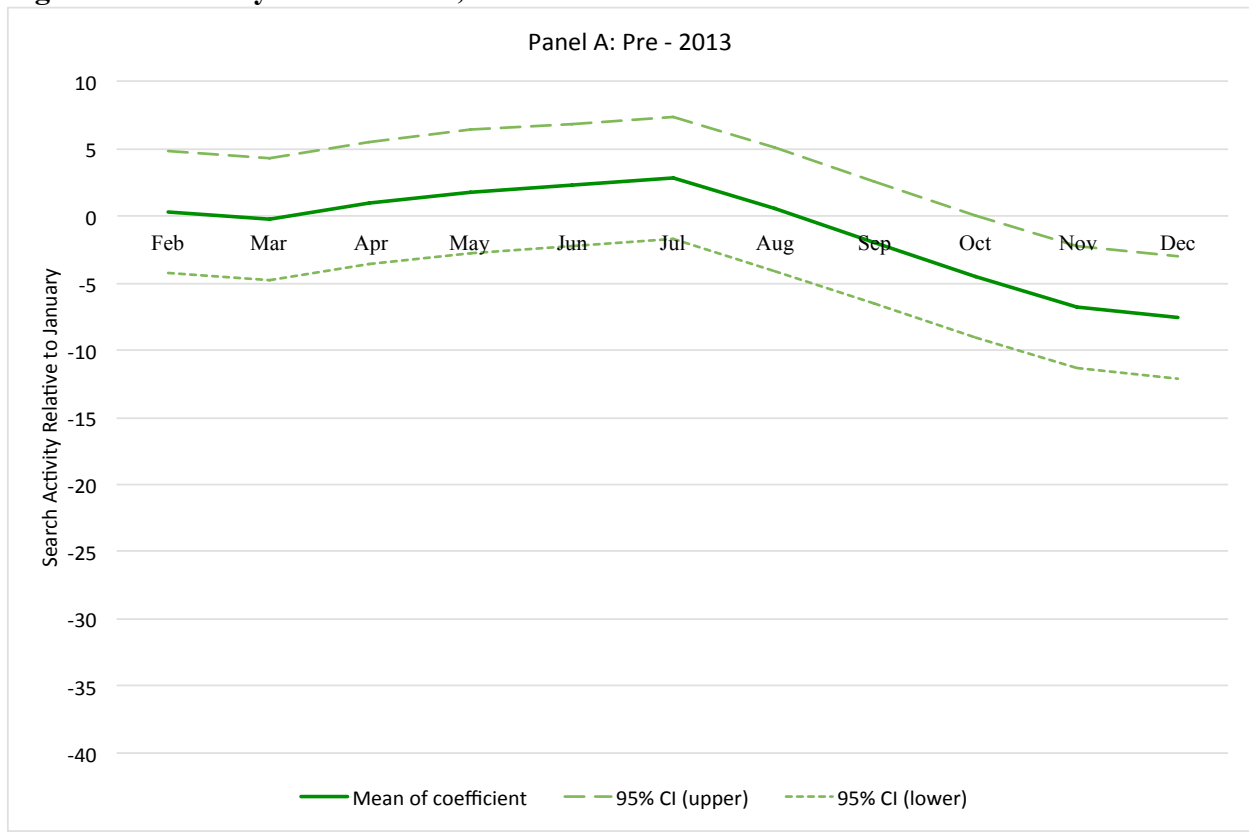
focus on funding avocado health and nutrition research in the immediately preceding years and onward.

The results shown in the upper panel of table 2 reveal that the search index grew considerably faster in this second period. Taking the general search index as an example (columns (1) and (2)), the monthly growth rate is 0.29 percentage points before 2013 and 0.55 for 2013 onward, nearly doubling the growth rate of the preceding period. Category-specific search indices show similar patterns. In particular, the monthly growth rate of the search index in *Health* was 0.30 before 2013 and 0.43 thereafter, a 43% increase.

Figure 12 plots the monthly fixed effects from the regression model for the pre 2013 and 2013 onward periods. In these figures January is treated as a base month, i.e., its value is zero, and then the search activity in all other months can be compared to January's activity. Positive values for a month mean more searches relative to January and vice versa for months with negative values. We see that interest in avocados is relatively constant in the U.S. winter—January through March—and then rises through the spring and summer before declining in the fall and leading into winter. This seasonality in search activity roughly parallels the seasonality in consumption, as depicted and discussed in our main report on promotion activities funded by the HAB. Causality probably runs both ways here—more consumer interest and search leads to more consumption, while consumption also drives search activity.

A somewhat disquieting trend is that the decline in relative search activity through the fall in the U.S. has accelerated in the period from 2013 to the present, i.e., the values for September – December are more sharply negative for this period compared to pre-2013. This fact may be of interest to HAB members who are marketing avocados during this time period.

Figure 12. Monthly Fixed Effects, Pre-2013 and 2013 - Present



4.2 *International Markets*

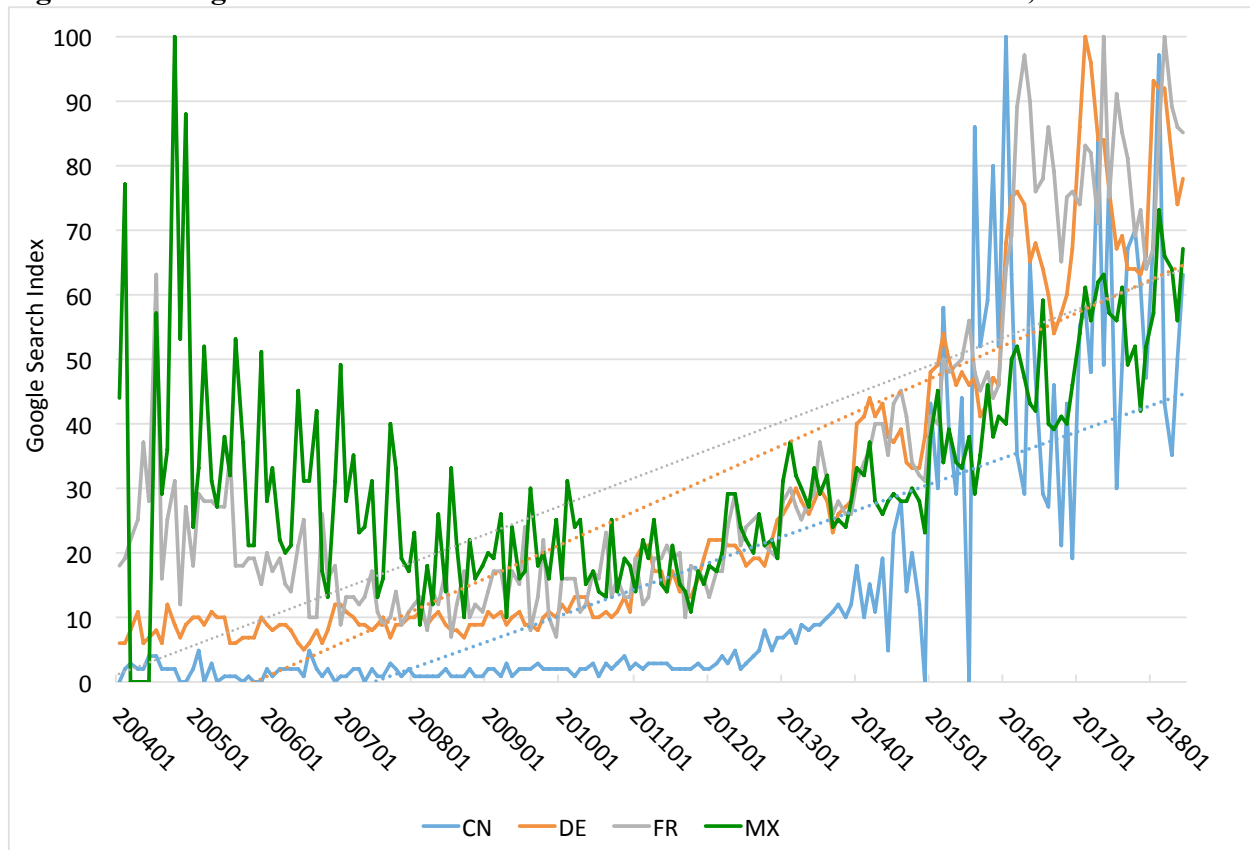
Although the HAB's mandate is to expand the market for avocados in the United States, research results disseminate worldwide. Thus, we also asked how interest in avocados had changed over time in the major consuming countries of China (CN), France (FR), Germany (DE), and Mexico (MX). If international demand for Hass avocados grows as a consequence of the HAB's efforts to support avocado research and disseminate its results, it inures to the benefit of both California producers and importers from the HAB-member countries through the normal workings of the market and the "law of one price."⁵

Figure 13 plots the series of general search indices from 2004 to 2018 for the four markets. France and Germany have experienced the fastest growth rates in the general search indices over the period. The growth rate in China was nearly zero until 2013, at which point it began expanding rapidly. Mexico presents an interesting case. Avocados are a traditional food in Mexico, and most Mexican consumers are very familiar with them. Relative searches on "avocado" actually declined in Mexico for several years before beginning to rise in 2013.

We repeated the regressions used for the U.S. market for the four international markets. The outcomes are summarized in the lower panel of table 2. For all four overseas markets, monthly growth rates of the search index were larger for 2013 onward compared to the prior period. China has a very high growth rate after 2013, though avocados were introduced to Chinese consumers only in early 2000s.

⁵ The law of one price does not mean that prices for a commodity are literally the same everywhere. Prices of course differ across locations for a variety of reasons. The law of one price, however, postulates that, absent barriers to trade, prices for a commodity will move together in the same direction due to normal market forces.

Figure 13. Google Search Indices for “Avocado” for International Markets, 2004-2018



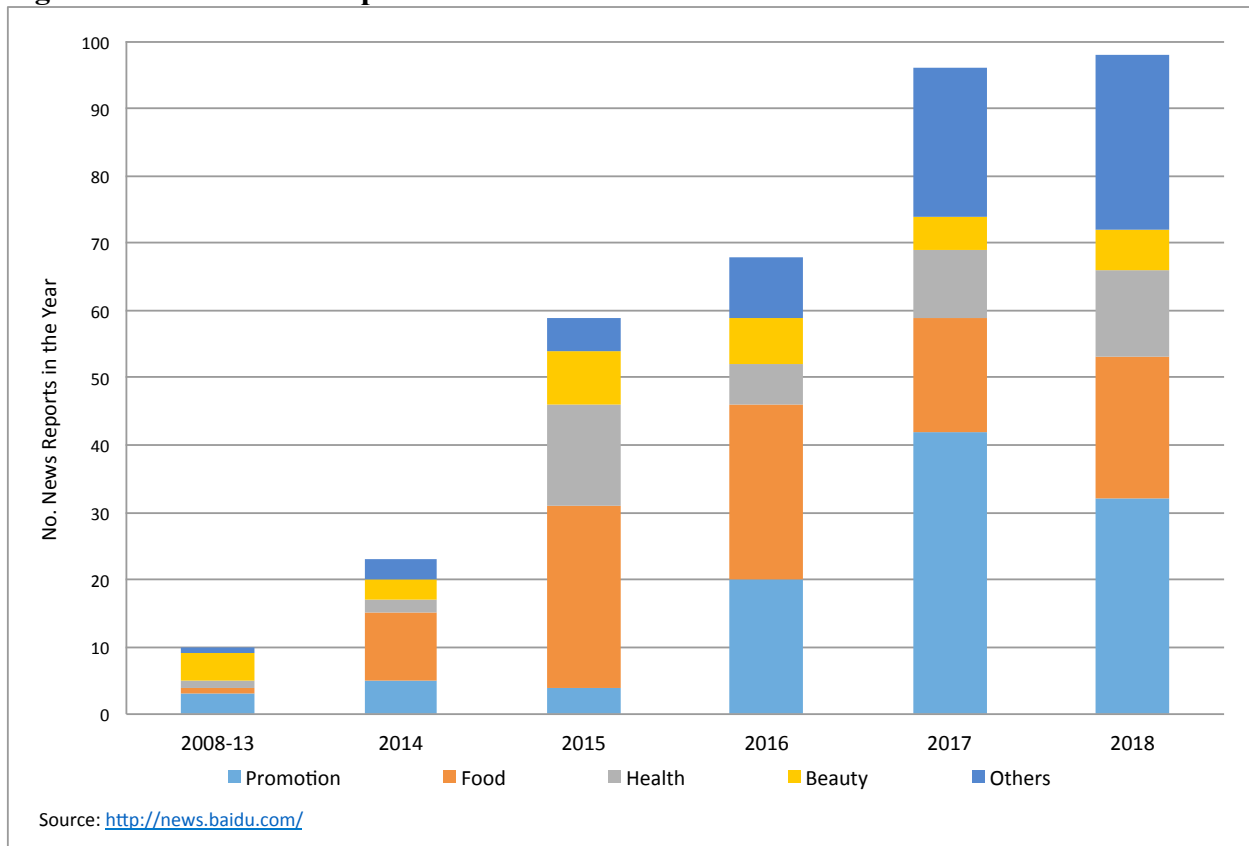
Notes: CN stands for China, DE for Germany, FR for France, and MX for Mexico.

Given that Google is officially banned by the government, most Chinese consumers use the leading domestic searching engine, Baidu (www.baidu.com). On Baidu, we examined all news reports about avocado (*niu you guo* in Chinese) and classified them into five categories according to the theme. The first piece of news was released on September 24, 2008, and the last piece we studied was on August 31, 2018. Evolution in the number of news reports over this period is shown in figure 14.

The number of avocado-related news items took off in 2014 and echoes to the accelerated growth of Google searches in the China market shown in figure 13. The total number of Chinese news reports has steadily increased over time. Almost 30% of the news reports were general

promotion and focused on introducing a new fruit to the consumers. Another 29% focused on teaching Chinese consumers how to use avocados in various dishes, while a quarter of the news reports told readers about health and beauty benefits of avocado.

Figure 14. Baidu News Reports for the Chinese Market



Notes: Promotion refers to news about brand-specific or general promotion and introduction of avocado industry. *Food* refers to news talking about using avocado to make snacks, baby food, and other culinary information of avocados. *Beauty* refers to news about the benefits of eating avocados on weight control and skin and using avocados to make eye cream and masks. *Others* refer to news on the supply, production, and imports quality of avocados.

5 Conclusion

In our view this study shows rather conclusively that the HAB’s strategy of expanding the market for Hass avocados through funding research into the health and nutrition benefits of consuming avocados and disseminating the results of that research to key influencers and, ultimately, to consumers is working well. A first key metric is that at least 28 HAB-funded

research publications (including abstracts) on health and nutrition aspects of avocado consumption have appeared. Given that there is often a substantial time lag between receipt of funding and publications appearing in print or on line, this is a commendable rate of output. Second, most of the papers have appeared in journals with high impact factors, and many of them have generated commendable rates of citation. As noted, there is a considerable lag here as well, so citation rates are naturally low for the papers that came to press in 2017 and 2018.

We also noted that the research had generated a large number of news articles, a key mechanism for transferring results to the general consuming public. Finally, we noted rapidly rising Google search interest in avocados both generally and on the topic of health in the U.S. and key international markets. The rate of increase in search activity has accelerated from 2013 onward, when results from the HAB's funding began to appear in journals and the more general press.

Table 2. Time Trend of Google Search Indices in Five Markets for Two Periods

Category	Relative Google search index							
	All categories		Beauty and fitness		Food and drink		Health	
	Pre-2013	Post-2013	Pre-2013	Post-2013	Pre-2013	Post-2013	Pre-2013	Post-2013
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>U.S. market</i>								
Time trend, US	0.294***	0.551***	0.343***	0.346***	0.316***	0.495***	0.297***	0.426***
	(0.015)	(0.030)	(0.019)	(0.033)	(0.016)	(0.030)	(0.017)	(0.040)
R ² , US	0.809	0.936	0.795	0.907	0.812	0.937	0.795	0.878
<i>International markets</i>								
Time trend, CN	0.020***	0.946***	0.019***	0.234	0.007	0.592***	-0.004	0.406***
	(0.004)	(0.119)	(0.005)	(0.159)	(0.004)	(0.157)	(0.006)	(0.152)
R ² , CN	0.246	0.584	0.198	0.103	0.101	0.307	0.084	0.243
Time trend, DE	0.117***	0.987***	0.154***	0.806***	0.112***	1.096***	0.114***	0.728***
	(0.009)	(0.039)	(0.021)	(0.049)	(0.009)	(0.042)	(0.011)	(0.043)
R ² , DE	0.680	0.934	0.401	0.860	0.663	0.934	0.530	0.886
Time trend, FR	-0.061***	1.101***	0.074	0.811***	-0.028	1.084***	-0.059	0.212***
	(0.022)	(0.060)	(0.070)	(0.111)	(0.034)	(0.049)	(0.046)	(0.037)
R ² , FR	0.210	0.872	0.066	0.516	0.128	0.911	0.075	0.421
Time trend, MX	-0.210***	0.586***	0.016	0.165***	-0.054	0.459***	-0.122**	0.072***
	(0.045)	(0.034)	(0.056)	(0.036)	(0.056)	(0.034)	(0.048)	(0.014)
R ² , MX	0.233	0.866	0.150	0.404	0.134	0.815	0.100	0.389
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Obs.	108	66	108	66	108	66	108	66

Notes: Standard errors are in parentheses; *** implies $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. FE stands for fixed effects. Pre-2013 refers to the period from January 2004 to December 2012, while post-2013 covers January 2013 to June 2018.

6 Appendix: List of HAB-Funded Publications

- Adolphus, K., Bellissimo, N., Lawton, C. L., Ford, N. A., Rains, T. M., Totosy de Zepetnek, J., and Dye, L. (2017). Methodological challenges in studies examining the effects of breakfast on cognitive performance and appetite in children and adolescents. *Advances in Nutrition*, 8(1): 184S-96S.
- Ahmed, N., Smith, R. W., Henao, J. J. A., Stark, K. D., and Spagnuolo, P. A. (2018). Analytical method to detect and quantify Avocatin B in Hass avocado seed and pulp matter. *Journal of Natural Products*, 81(4): 818-24.
- Comerford, K. B., Ayoob, K. T., Murray, R. D., and Atkinson, S. A. (2016). The role of avocados in complementary and transitional feeding. *Nutrients*, 8(5): 1-20.
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