ONLINE APPENDIX: MEASURING THE VALUE OF RECOMMENDATION LINKS ON PRODUCT DEMAND

APPENDIX A

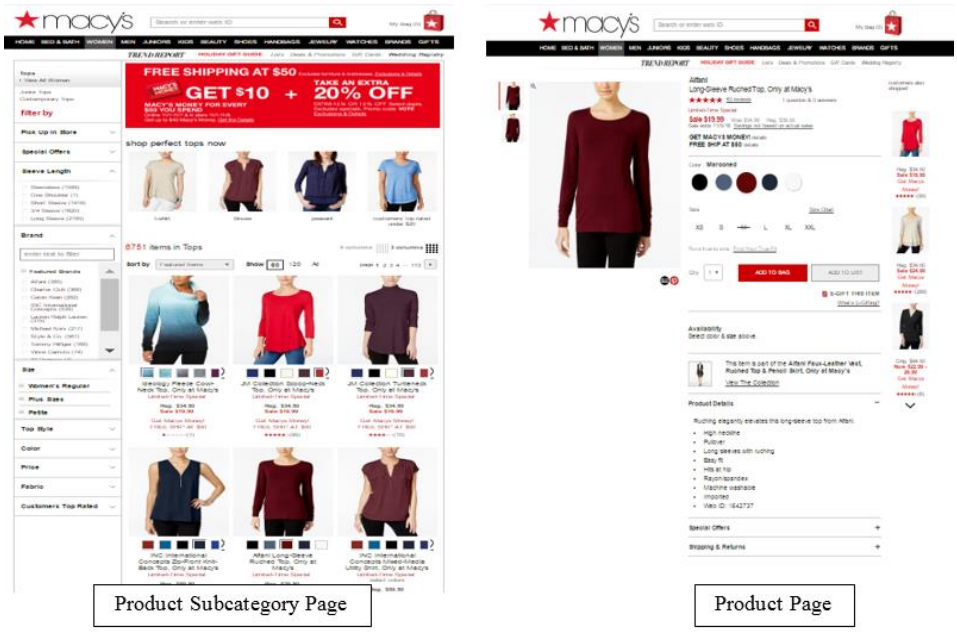

Figure A1: A recommended product appearing with the focal product on both, product subcategory main page and focal product's page

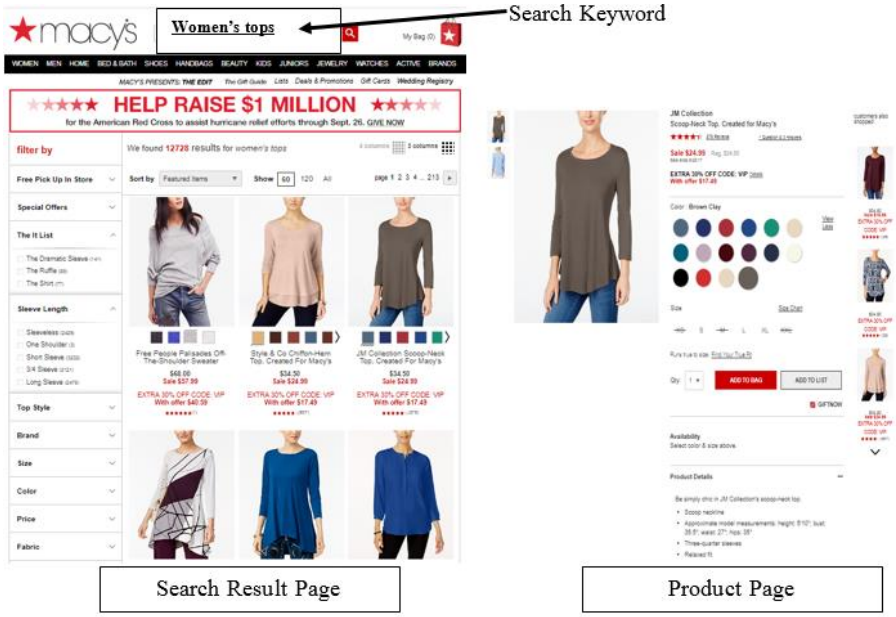

Figure A2: A recommended product appearing with the focal product on both, search result page and focal product's page.

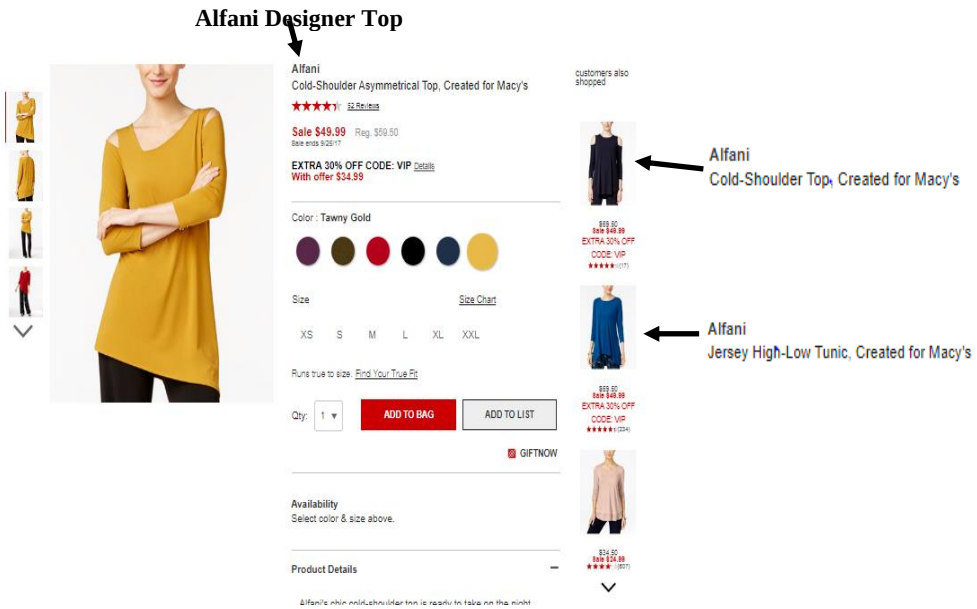

Figure A3: Recommended and focal products have similar style from the same designer

APPENDIX B

We have used Google's PageRank, the most popular eigenvector centrality measure in E-commerce applications, in our main analysis. We further conduct our analysis on all types of network centrality measures: Indegree (degree centrality); closeness (closeness centrality); weighted betweenness (betweenness centrality); and Google's PageRank (eigenvector centrality). Table B1 reports the summary statistics for mean values and range of values for these centrality measures across the 37619 products.

37619 products	Percentile values						
	0	25	50	75	90	95	100
Mean. Indegree	0	0	1.1	3.7	8.1	13	299.5
Range of indegree	0	0	4	8	16	24	452
Mean PageRank	4.6E-06	4.9E-06	7.6E-06	2.7E-05	7.3E-05	1.2E-04	1.4E-03
Range of PageRank	0	5.1E-07	1.5E-05	7.3E-05	1.7E-04	2.6E-04	2.6E-03
Mean closeness	0	0	3.0E-09	1.5E-08	3.4E-08	5.2E-08	3.1E-07
Range of closeness	0	0	1.4E-08	3.9E-08	7.6E-08	1.0E-07	4.3E-07
Mean Wgt. betweenness	0	0	2.5E-08	2.2E-07	1.0E-06	2.4E-06	6.7E-05
Range of Wgt. betweenness	0	0	1.9E-07	1.6E-06	6.9E-06	1.6E-05	2.1E-04

Table B1: Summary statistics for centrality measures

Next, we separately estimate specification (4) with each of these centrality measures to examine whether the coefficient of our interest vary with our choice of centrality measure. Table B2 reports the resulting coefficient estimates. We find that all coefficient estimates remain qualitatively similar with

inclusion of different centrality measures. This shows that our results are robust to the choice of centrality measure.

Coefficient estimates (Std. Errors)	Degree Centrality (Indegree)	Closeness Centrality (closeness)	Betweenness Centrality (Wgt. Betweenness)	Eigenvector Centrality (Google's PageRank)
Dependent variable – Log of daily number of product page views				
Treat	-0.007*** (0.0005)	-0.006*** (0.0005)	-0.005*** (0.0004)	-0.008*** (0.0005)
*Treat * (Centrality Measure)*	0.0015*** (0.0001)	7.5E+05*** (2.7E+04)	2092.2*** (202.8)	346.5*** (10.31)
*Treat * Log avg. incoming affinity score*	0.013*** (0.0003)	0.01*** (0.0003)	0.014*** (0.0003)	0.011*** (0.0003)
Product-day Fixed effects	Yes			
N(No. of product-days)	3958166 (1979083)			

***, **, and * denote statistically significant at α=0.01, 0.05, and 0.10 levels (two-sided test), respectively
Standard errors cluster corrected at product-day level are in parentheses

Table B2: Regression estimates with different centrality measures

We further compute correlations between different centrality measures in Table B3, which indicates a very high correlation of PageRank with closeness and Indegree but a relatively lower value for correlation with Wgt. betweenness.

Correlations	Indegree	closeness	Wgt. Beetweenness	PageRank
Indegree	1			
closeness	0.570	1		
Wgt. Beetweenness	0.233	0.397	1	
PageRank	0.752	0.702	0.196	1

Table B3: Correlation between centrality measures

	Log daily number of product page views
Treat	-0.008*** (0.0005)
*Treat * PageRank*	347.8*** (10.5)
*Treat * Wgt. Betweenness*	1148.1*** (203.03)
*Treat * Log avg. incoming affinity score*	0.011*** (0.0003)
Product-day Fixed effects	Yes
N(No. of products)	3958166 (1979083)

***, **, and * denote statistically significant at α=0.01, 0.05, and 0.10 levels (two-sided test), respectively
Standard errors cluster corrected at product-day level are in parentheses

Table B4: Regression estimates with PageRank and Betweenness centrality

Accordingly, we estimate specification (4) with both PageRank and Wgt betweenness and report the resulting coefficients in Table B4. We find that the coefficient estimates of the treatment variable and its interaction with the PageRank remain qualitatively similar with inclusion of betweenness centrality.

Moreover, the coefficient of interaction of betweenness centrality with treatment variable is also as expected positive and significant.

APPENDIX C

We examine the sessions in which products with reciprocal focal-recommended product relationship are viewed. Let's assume product A appears as recommended product on product B's page and B appear as recommended product on A's page. For such reciprocal product pair A-B, if a visitor first views product A's page, then views product B's page, and then again views product A's page. Such product page views will be included in our specification (3): once as product A's page view with recommended B's page view and once as product B's page view with recommended A's page view. If product B is purchased in this session, it will be counted as recommended product sales in the first inclusion and as focal product sales in the second inclusion in our specification (3). Specification (3) will thus identify the lift in sales of B at the expense of sales of A in the first counting and the opposite in the second counting, and thus estimate the net effect of these two effects.

	Log Product sales | product view		Log Recommended product sales | product view	
	Coeff. Est.	St Err.	Coeff. Est.	St Err.
All sessions				
Treat	-0.019***	0.002	0.09***	0.001
N (No of Product-days)	2326402 (701730)		2326402 (701730)	
Sessions with reciprocal FP-RP relationship products' page views				
Treat	-0.012***	0.003	0.05***	0.001
N (No of Product-days)	1032575 (378398)		1032575 (378398)	
Rest of the sessions				
Treat	-0.024***	0.002	0.12***	0.001
N (No of Product-days)	1293827 (323332)		1293827 (323332)	
Product-days fixed effect	Yes		Yes	

***, **, and * denote statistically significant at α=0.01, 0.05, and 0.10 levels (two-sided test), respectively
Standard errors cluster corrected at product-day level are in parentheses

Table C1: Estimates with reciprocal FP-RP relationship

To check whether our results are robust to such simultaneity issue, we estimate the effect of recommendations for sessions in which focal products with reciprocal focal-recommended products relationship were viewed and rest of the sessions separately. Table C1 reports the resulting estimates as well as the estimates with all sessions for easy comparison. We find that our results are robust to exclusion of sessions with page views of products with reciprocal relationship.

APPENDIX D

We examine whether the effects of recommendations are different across different product categories. The retailer in the present field setup sells over 35,000 different products under the following broad product categories: Home goods (such as luggage, home décor, outdoor and recreational goods, and kitchen and dining); Bed and bath goods (such as bedding, pillows, quilts, bath rugs, curtain, towels and accessories); Women's apparel (such as tops, dresses, pants, jeans, skirts, skorts, shorts, and swimwear); Women's lingerie and sleepwear; Men's apparel and accessories (such as shirts, t-shirts, pants, jeans, shorts, ties, vests and briefs); Apparel and accessories for teenage boys and girls; Baby apparel, toys, and accessories; Shoes and sandals; and Accessories (such as fragrance, cosmetics, handbags, and jewelry). Products in some categories, such as apparel (for men, women, and teenagers), accessories, and shoes & sandals fall under the fashion domain (more hedonic in nature). Products in other categories, such as home goods, bed & bath products, and baby products (baby apparel, toys and accessories) do not fall under fashion domain. Accordingly, we estimate specification (2) and (3) separately for products that fall under and do not fall under fashion domain. We report the coefficient estimates for the full sample and these two subsamples of products in Table D1, which suggests that our results hold for both categories of products.

	Log No. of daily product page views		Log Product sales | product view		Log Recommended product sales | product view	
	Coeff. Est.	St Err.	Coeff. Est.	St Err.	Coeff. Est.	St Err.
Full Sample of products						
Treat	0.075***	0.001	-0.019***	0.002	0.09***	0.001
N (No of Product-days)	3958166 (1979083)		2326402 (701730)		2326402 (701730)	
Products in fashion domain						
Treat	0.098***	0.001	-0.027***	0.002	0.09***	0.001
N (No of Product-days)	2719208 (1359604)		1964605 (524917)		1964605 (524917)	
Products not in fashion domain						
Treat	0.05***	0.004	-0.011**	0.005	0.08***	0.003
N (No of Product-days)	1238958 (619479)		361797 (176813)		361797 (176813)	
Product-day fixed effect	Yes		Yes		Yes	

***, **, and * denote statistically significant at α=0.01, 0.05, and 0.10 levels (two-sided test), respectively
Standard errors cluster corrected at product-day level are in parentheses

Table D1: Estimation results for different product categories