Causal effects of product videos on online apparel sales

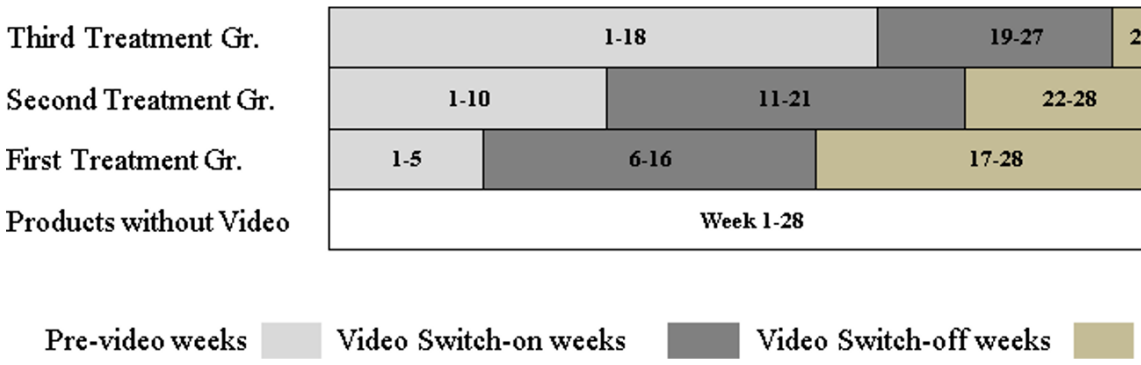
Introduction

A mid-sized apparel firm analysed that the number of total visitors coming to the firm's website was comparable to that of their competitors of similar size. However, the firm's website had a lower click through rate (conversion rate). One plausible reason for lower click-through rates could be that the firm's website does not present products effectively. The firm decided to start using videos to promote products on the website. Even though online product videos have become widely popular among customers, their economic value is not proven. Hence, the firm decided to conduct A/B testing to examine the potential of product videos in increasing the conversion rate at the website.

Experimental Design

The firm decided to design a randomized experiment on its website to measure the true (causal) value of product video. The details of the experiments are as below:

- The firm's website hosted a total of 571 products. Out of the total products, 317 were principal products (tops, bottoms, and dresses), and the remaining were shoes and accessories. It was decided to randomly choose 66 principal products (42 tops, eight bottoms, and 16 dresses) and create short 15-20 second videos for them. In these videos, a human model displays a 360-degree view of the focal product with its matching coordinating products.
- The product videos were shot with a limited number of similar models and similar background settings so that any heterogeneity in product videos was mainly due to differences in product characteristics.
- The firm decided to randomize the timings of the introduction of product videos. It introduced product videos in three phases: 25 videos on February 17, 201X, 30 videos on March 23, 201X, and 11 videos on May 18, 201X. After hosting them on the website for over two months, the team removed these videos in three phases: on May 4, 201X, June 6, 201X, and July 18, 201X.
- The experiment was run during the 28 weeks of spring collection sales on the firm's website from January 13, 201X to July 26,201X.



The retailer sells different product assortments on the website and in retail stores, and there were no product reviews available on the retailer's website. Therefore, the possibility of these factors
confounding the results of the experiment was absent.

Data Collection

The team collected weekly sales in numbers for all products during the experiment period. Besides product videos, other promotions introduced on the website could also influence product sales. Therefore, the team collected information promotions run by the firm during the study period. The joint display of focal and its matching coordinating products in the focal product video could increase the sales of both products. Therefore, the economic value of product video is the total increase in sales of the focal and its coordinating products attributable to their joint display in the video.
Accordingly, two datasets were created for this analysis:
1. Focal product analysis data to check the validity of randomization and to estimate the effect of a product video on focal product sales.
2. Coordinating product analysis data to estimate the effect of a product video on coordinating product sales

Data Dictionary for Focal Product Analysis	
Variable name	**Variable Description**
ProdID	Product ID
ProdPrice	Price of product in USD
Wk	Week number
Month	Month number
Vid	Indicator variable =1 for products that have video and zero otherwise
VidWk	Indicator variable =1 if product's video is switched-on on the website in the week and zero otherwise
PreVidWk	Indicator variable =1 for weeks before the product's video is switched-on on the website and zero otherwise
PostVidWk	Indicator variable =1 for weeks after the product's video is switched-off on the website and zero otherwise
Sales	Weekly product sales in numbers
ProdCat	Category of product (1=accessories, 2=bottoms, 3= dresses, 4= footwear, and 5=tops)
ProdPrice	Sales price of product
PriceDiscWk	Indicator variable =1 if there is a price discount on the product in the week and zero otherwise
EmailWk	Indicator variable =1 if there is an email promotion on the product in the week and zero otherwise
CatalogWk	Indicator variable =1 if there is a catalog promotion on the product in the week and zero otherwise
HomePgWk	Indicator variable =1 if the product is a featured product on the homepage of the website in the week and zero otherwise
CatPgWk	Indicator variable =1 if the product is a featured product on the category front page of the website in the week and zero otherwise
Data Dictionary for Coordinating Product Analysis	
CpordID	Coordinating Product ID
Wk	Week number
VidWk	Indicator variable =1 if focal product's video is switched-on on the website and zero otherwise
PreVidWk	Indicator variable =1 for weeks before the focal product's video is switched-on on the website and zero otherwise
PostVidWk	Indicator variable =1 for weeks after the focal product's video is switched-off on the website and zero otherwise
CpSales	Weekly coordinating product sales in numbers
FpPriceDiscWk	indicator variable =1 if there is a price discount on the focal product and zero otherwise
FpEmailWk	indicator variable =1 if there is an email promotion on the focal product and zero otherwise
FpCatalogWk	indicator variable =1 if there is a catalog promotion on the focal product and zero otherwise
FpHomePgWk	indicator variable =1 if the focal product is promoted on the homepage of the website and zero otherwise
FpCatPgWk	indicator variable =1 if the focal product is promoted on the category front page of the website and zero otherwise
CpPriceDiscWk	indicator variable =1 if there is a price discount on the coordinating product and zero otherwise
CpEmailWk	indicator variable =1 if there is an email promotion on the coordinating product and zero otherwise
CpCatalogWk	indicator variable =1 if there is a catalog promotion on the coordinating product and zero otherwise
CpHomePgWk	indicator variable =1 if the coordinating product is promoted on the homepage of the website and zero otherwise
CpCatPgWk	indicator variable =1 if the coordinating product is promoted on the category main page of the website and zero otherwise

Randomization check

the videos were randomly assigned to products. Hence, the characteristics of the treated and control products should be statistically similar. Moreover, the proportion of treated products in the whole sample should proportionately transmit to the proportions of treated products in each product category (tops, dresses, bottoms).

Product-related data is collected for randomization check:

- price in USD (called *ProdPrice*)
- video treatment status (*Vid*=1 indicates video created for the product and otherwise *Vid*=0)
- products category (called *ProdCat*).

To perform the randomization check, we need to check for statistical similarity between the control group and the treatment group. We need to check the proportions of control group and treatment group corresponding to whole sample and this proportions should be similar to the ones observed in each category as well. To check for statistical similarity, we can perform a t-test to check whether the mean price of the two samples is equal or not. Below is a table for the statistical properties of control and treatment group.

Type	Count	Mean	Median	Stand Dev	25%	75%
Control Group	239	20.41966527	19.9	4.66868746	16.9	24.9
Treatment Group	58	20.71034483	19.9	5.46606111	16.9	24.9

Here, we observe that the statistical properties are almost similar in both the groups. Now, we perform a F-test to check if the variances of the two groups are similar or not.

F-Test Two-Sample for Variances

	Control Group	*Treatment Group*
Mean	20.41966527	20.71034483
Variance	21.8882251	30.40199637
Observations	239	58
df	238	57
F	0.719960125	
P(F<=f) one-tail	0.047764429	
F Critical one-tail	0.723084686	

Here, we observe a p-value of 0.047 which is less than alpha of 0.05, So, we reject the null of equal variances.
Now we perform the t-test for unequal variances to check if the means are statistically similar or not.

T-Test: Two-Sample Assuming Unequal Variances

	Control Group	*Treatment Group*
Mean	20.41966527	20.71034483
Variance	21.8882251	30.40199637
Observations	239	58
Hypothesized Mean Difference	0	
df	78	
t Stat	-0.370433756	
P(T<=t) one-tail	0.356031689	
t Critical one-tail	1.664624645	
P(T<=t) two-tail	0.712063377	
t Critical two-tail	1.990847069	

Here, we observe a p-value of 0.712 which is greater than alpha of 0.05, So, we fail to reject the null of equal means. Thus, these two groups are statistically similar.

Now, we can check for the proportions as well. Below is a table which clearly shows that the proportion of treatment group is similar in the whole sample and in different product categories.

Proportions

Category	Control Group	Treatment Group
2	86.67%	13.33%
3	81.82%	18.18%
5	79.38%	20.62%
Total Sample	**80.47%**	**19.53%**

Difference in mean estimate (Average treatment effect)

The difference in mean estimate is the difference in the average of the mean weekly sales for control group and treatment group. For the full data set the estimate is equal to 22.5 (calculated using pivot table)
Now, we performed a regression on the whole dataset using the below equation.In this equation to account for time variant fixed effects we introduced a factor for week and to account for product
fixed effects we used a "within" model.

plm(formula = Sales ~ VidWk + ProdPrice + factor(ProdCat) + factor(Wk) + PriceDiscWk + EmailWk + CatalogWk + HomePgWk + CatPgWk, data = full, model = "within", index = c("ProdID", "Wk"))

	Estimate	Corrected Std. Error	Correct t-Value
VidWk	16.7058	8.008547	2.085996374
PriceDiscWk	76.6233	8.676391	8.831241008
EmailWk	68.9129	43.675855	1.577826009 (insignificant)
CatalogWk	103.8003	48.877152	2.123697796
HomePgWk	61.0834	15.500825	3.940654772
CatPgWk	29.4373	20.86495	1.410849295 (insignificant)

** We have not included the estimates of factor (Wk) in the tables

We observe an estimate of 16.7058 for VidWk which signifies that the number of weekly sales of the products when they have a video on their product page is 16.7058 greater than the ones with no videos on their product pages.
The difference in mean estimate and the regression estimate differs because the difference in mean estimate doesn't account for the panel effect and the effects of other variables. That is the reason it is higher than the regression estimates.

Establish causal relationship

Now, to infer a causal relation we further divided the data set in three parts. The first is the data set with Pre-Video week where PreVidWk = 1 (Vid will be equal to 1, and VidWk and PostVidWk will be 0) makes the treatment group and Vid = 0 makes the control group. Second is the Video Switch on week data set where, VidWk = 1 making the treatment group (Vid will also be equal to 1, and PreVidWk and PostVidWk will be 0) and Vid = 0 making the control group. And,the third is the post video week data set, where, PostVidWk = 1 (Vid will be 1 and VidWk and PreVidWk will be 0) makes the treatment group and Vid = 0 makes the control group.

If videos have any impact on sales, the estimate of Vid should be higher in the Video Week switch on data set than the other two datasets because, these are the only weeks when the videos were played, in the rest two data sets the videos weren't played, So, ideally the estimates in the other two data sets should be insignificant.

Now we perform the regression on these three data sets. We'll use a pooling model here because we use Vid variables as VidWk values will be same for the whole dataset

plm(formula = Sales ~ Vid + ProdPrice + factor(ProdCat) + PriceDiscWk + EmailWk + CatalogWk + HomePgWk + CatPgWk, data = pre/vid/post, model = "pooling", index = c("ProdID", "Wk"))

Pre-Video Week Data Set Regression

	Estimate	Std. Error	t-value	Pr(>|t|)
(Intercept)	130.97578	9.47113	13.829	< 2.2e-16 ***
Vid	12.38628	5.70167	2.1724	0.0298659 *
ProdPrice	-3.43852	0.37278	-9.2239	< 2.2e-16 ***
ProdCat_3	50.32814	6.70525	7.5058	7.023e-14 ***
ProdCat_5	38.895	6.16049	6.3136	2.927e-10 ***
PriceDiscWk	-19.16888	6.70296	-2.8598	0.0042546 **
EmailWk	124.99096	28.44665	4.3939	1.133e-05 ***
CatalogWk	199.78077	23.2141	8.606	< 2.2e-16 ***
HomePgWk	84.65323	12.63461	6.7001	2.278e-11 ***
CatPgWk	50.52326	14.15972	3.5681	0.0003625 ***

Video Week Data Set Regression

	Estimate	Std. Error	t-value	Pr(>|t|)
(Intercept)	145.315	9.92744	14.638	< 2.2e-16 ***
Vid	26.14197	4.93217	5.3003	1.197e-07 ***
ProdPrice	-3.89101	0.39041	-9.9666	< 2.2e-16 ***
ProdCat_3	42.85147	7.12239	6.0164	1.887e-09 ***
ProdCat_5	31.88504	6.53292	4.8807	1.084e-06 ***
PriceDiscWk	-8.131	6.60618	-1.2308	0.2184
EmailWk	159.3792	34.5488	4.6132	4.047e-06 ***
CatalogWk	239.2123	28.7937	8.3078	< 2.2e-16 ***
HomePgWk	97.12966	13.7645	7.0566	1.897e-12 ***
CatPgWk	136.2011	14.7867	9.211	< 2.2e-16 ***

Post-Video Week Data Set Regression

	Estimate	Std. Error	t-value	Pr(>|t|)
(Intercept)	137.9799	9.51847	14.496	< 2.2e-16 ***
Vid	4.41338	6.24528	0.7067	0.4798
ProdPrice	-3.45159	0.37823	-9.1256	< 2.2e-16 ***
ProdCat_3	42.15473	6.7327	6.2612	4.096e-10 ***
ProdCat_5	30.69243	6.16068	4.982	6.477e-07 ***
PriceDiscWk	-12.85689	6.47933	-1.9843	0.04727 *
EmailWk	140.6393	31.6608	4.4421	9.076e-06 ***
CatalogWk	337.5264	28.1988	11.97	< 2.2e-16 ***
HomePgWk	83.25476	13.2271	6.2942	3.317e-10 ***
CatPgWk	81.78037	16.8066	4.866	1.169e-06 ***

The Estimate of Vid in the pre-video data set is 12.38628, in the video week data set is 26.14197 and in the post-video week is 4.41338. Also, the estimate in the post -video data set is insignificant as suggested above and in the pre-video data set is also marginally significant for alpha 0.05, which is obvious as videos were not on during these weeks.

This clearly suggest the causal relationship of video. As the estimate increases to 26.14197 from 12.38628 when the videos are put on the website and then after they are removed the estimate becomes insignificant in the post-video dataset.

Effect of video on coordinating product sales

To compute the effect (on weekly sales) of coordinating products corresponding to the presence of video on its focal product page, we compared the sales of coordinating products for which the associated focal products have a video (treated products) with the sales of those for which the associated focal products did not have a video (control products).

The regression specification used is: - (factor (Wk) and "within" model to consider for time & product fixed effects)
plm(formula = CpSales ~ VidWk + factor(Wk) + FpPriceDiscWk + FpEmailWk + FpCatalogWk + FpHomePgWk + FpCatPgWk + CpPriceDiscWk + CpEmailWk + CpCatalogWk + CpHomePgWk + CpCatPgWk,data = fullcp, model = "within", index = c("CpordID", "Wk"))

	Estimate	Corrected Std. Error	Correct t-Values
VidWk	20.5732	9.987716	2.05985032
FpPriceDiscWk	-4.1949	6.834573	-0.613776457(insignificant)
FpEmailWk	-6.3294	17.699064	-0.357612131(insignificant)
FpCatalogWk	-9.4168	12.745415	-0.738838241(insignificant)
FpHomePgWk	13.5477	17.562937	0.771380094(insignificant)
FpCatPgWk	6.9409	14.707474	0.471930122(insignificant)
CpPriceDiscWk	89.2036	9.60288	9.28925489
CpEmailWk	70.0027	28.459371	2.459741644
CpCatalogWk	103.8035	51.078375	2.032239671
CpHomePgWk	64.5782	37.223523	1.734876089(insignificant)
CpCatPgWk	50.9331	23.74343	2.145144994

We observe an estimate of 20.5732 for VidWk, that means, for a coordinating product the weekly sales will differ by 20.5732 when its focal product has a video switched on compared to when its focal product doesn't have a video switched on.

Marketing-Mix Decision: Estimating the incremental effect of combining product video with other marketing promotions. To measure the effect of video when they are combined with other kind of marketing promotions, we can do aregression with introducing the interaction terms.

Focal Product

plm(formula = Sales ~ VidWk + ProdPrice + factor(ProdCat) + factor(Wk) + PriceDiscWk + EmailWk + CatalogWk + HomePgWk + CatPgWk + VidWk * (PriceDiscWk + EmailWk + CatalogWk + HomePgWk + CatPgWk),data = full, model = "within", index = c("ProdID", "Wk"))

	Estimate	Corrected Std. Error	Correct t-Value
VidWk	11.0933	7.362257	1.506779782
PriceDiscWk	68.4992	8.341278	8.212074936
EmailWk	70.9036	42.690954	1.660857708
CatalogWk	120.5046	52.182221	2.309303776
HomePgWk	56.1361	15.855595	3.540460008
CatPgWk	12.1435	21.441428	0.566356868
VidWk:PriceDiscWk	60.9777	29.119677	2.09403765
VidWk:CatalogWk	-159.136	50.988754	-3.121001937
VidWk:HomePgWk	72.5836	57.953148	1.252453102
VidWk:CatPgWk	64.3174	31.29315	2.055318816

We can see that the estimates of only VidWk:PriceDiscWk, VidWk:CatalogWk and VidWk:CatPgWk are significant, So,The effects of video change when they are combines with price discounts and category front page promotions. More specifically, we observe an incremental effect when videos are combines with Price discounts and Category front page promotion, specifically an increment of 6 times for both of them. Pertaining to the negative estimate of VidWk:CatalogWk, this shouldn't be the case, it might be due to unavailability of data (has only 3 rows) or due to some other factor as catalog takes time to reach customers, so, we should ignore this.

Coordinating Product

plm(formula = CpSales ~ VidWk + factor(Wk) + FpPriceDiscWk + FpEmailWk + FpCatalogWk + FpHomePgWk + FpCatPgWk + CpPriceDiscWk + CpEmailWk + CpCatalogWk + CpHomePgWk + CpCatPgWk + VidWk *(FpPriceDiscWk + FpEmailWk + FpCatalogWk + FpHomePgWk + FpCatPgWk + CpPriceDiscWk + CpEmailWk + CpCatalogWk + CpHomePgWk + CpCatPgWk), data = fullcp, model = "within", index =c("CpordID", "Wk"))

	Estimate	**Corrected Std. Error**	**Correct t-value**
VidWk	23.93711	10.396474	2.302425803
FpPriceDiscWk	-0.60674	5.435114	-0.111633353
FpEmailWk	-9.87144	27.025588	-0.365262728
FpCatalogWk	-6.51503	15.96519	-0.408077198
FpHomePgWk	13.44155	20.331267	0.661127022
FpCatPgWk	-8.3159	7.767451	-1.070608621
CpPriceDiscWk	90.04179	9.810322	9.178270601
CpEmailWk	85.70153	34.253388	2.501986957
CpCatalogWk	124.7873	63.846127	1.954500701
CpHomePgWk	85.87706	45.691848	1.879483185
CpCatPgWk	58.90202	30.215401	1.949403882
VidWk:FpPriceDiscWk	-23.78164	18.508625	-1.284895015
VidWk:FpEmailWk	2.93113	28.977405	0.10115226
VidWk:FpCatalogWk	-10.624	12.904579	-0.823273661
VidWk:FpHomePgWk	3.06859	34.294151	0.089478524
VidWk:FpCatPgWk	29.46419	26.235333	1.123072842
VidWk:CpPriceDiscWk	-6.47764	17.757131	-0.364790911
VidWk:CpEmailWk	-82.67883	40.960081	-2.018522131
VidWk:CpCatalogWk	-103.37679	67.043152	-1.54194406
VidWk:CpHomePgWk	-98.47164	49.201582	-2.001391744
VidWk:CpCatPgWk	-24.05749	33.578606	-0.716452911

For coordinating products, we see that only VidWk:CpEmailWk and VidWk:CpHomePgWk are significant, but are negative which shouldn't be the case. This might be due to the fact that there is less data (3 & 5 rows respectively) tosupport this case or there might be some other factors which are making this happen. So, generally speaking there is no added effect of promotions for coordinating products.