Evaluation of pilot implementation of nutritional standards for vending in local councils and wider public sector - Supplementary information: Statistical analysis

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Abbreviations

GLM	Generalised Linear Model
ITS	Interrupted Time Series
PS	Pilot Site
SKU	Stock-Keeping Units

List of figures

Supplementary information: Statistical analysis

The following appendix details the results of the statistical analyses which aimed to provide a comprehensive assessment of both intermediate and sustained impacts of the adoption of nutritional standards, accounting for time trends and differences between machines and product types.

All statistical analyses were conducted using R to examine the impact of the nutritional standards intervention on sales and nutritional quality of products sold from the vending machines. Sales and nutritional data were merged for all products at each site, creating datasets for pre- and post-implementation periods. For PS1 alternative pre-implementation periods were defined based on calendar weeks before the intervention, including the eight weeks prior to implementation, the same period from one year earlier, and a full year pre-implementation period, to allow for sensitivity analysis. For PS2 and PS3, pre-implementation periods were defined according to the available data.

Descriptive summary statistics were calculated to describe total and weekly sales quantity, revenue, and nutritional content (calories, sugar) for each period. Data completeness was checked, and exploratory plots including box plots and line graphs were used to visualise trends by period, vending machine, and product category. Mean weekly sales and revenue, as well as mean calories and sugar per unit sold, were computed for pre- and post-implementation periods, with absolute and percentage changes reported.

To inform the choice of statistical tests, the distribution of calories and sugar per unit sold was assessed for normality using Q-Q plots and Shapiro-Wilk tests on a random sample ($n \leq 5000$) weighted by units sold. As distributions were strongly non-normal, non-parametric tests were considered alongside standard paired t-tests. A combination of descriptive, paired, mixed-effects, and interrupted time series (ITS) analyses was used to provide a comprehensive assessment of both immediate and sustained impacts of the intervention, accounting for time trends and differences between machines and product types.

Key outcomes were assessed using both unpaired and paired approaches. For paired analysis, average weekly sales, revenue, calories per unit, and sugar per unit for each vending machine were compared between pre- and post-implementation periods using paired t-tests and Wilcoxon signed-rank tests, treating each machine as its own control. To adjust for machine-level clustering and repeated measures, linear mixed-effects models were fitted for continuous outcomes and negative binomial models for count outcomes at the vending machine × week level, with random intercepts for machine. Models estimated the effect of the intervention on revenue, items sold, calories per unit sold, and sugar per unit sold.

To assess differences by product type, models included fixed effects for product category, and subgroup analyses were conducted for snacks and drinks separately. Interaction models formally tested whether the intervention effect differed by product category. Additional descriptive analyses were performed by product subcategory (e.g., low sugar drinks, confectionery) to examine shifts in the product mix in more detail.

ITS analysis was used to examine trends over time and account for pre-existing trajectories. ITS models assessed changes in weekly revenue and quantity sold at the point of intervention, using negative binomial generalised linear model (GLM) regression for sales counts and linear regression for revenue. Models estimated pre-intervention trends, immediate level changes at intervention, and post-intervention trends, for all products and stratified by snacks and drinks.

PS1

Paired analysis

Paired analyses at the vending machine level indicated that there was no statistically significant change in weekly sales quantity or revenue following implementation, when compared to both the 12-month and 8-week pre-implementation periods. In contrast, sugar per unit sold showed statistically significant reductions. Following implementation, calories per unit sold saw a statistically significant reduction compared to the 12-month pre-implementation period, however the change was not significant when compared to the 8-week pre-implementation period.

Table 1: Paired analysis findings

Variable	12-month pre-implementation (Paired t-test p-value/Wilcoxon p-value)	8-week pre-implementation (Paired t-test p-value/Wilcoxon p-value)
Mean weekly quantity sold	0.544 / 0.625	0.279 / 0.375
Mean weekly revenue	0.633 / 0.625	0.364 / 0.375
Mean calories per unit sold	**0.048** / 0.125	0.075 / 0.125
Mean sugar (g) per unit sold	**0.008** / 0.125	**0.025** / 0.125

Statistically significant results

Mixed models

Model 1

Implementation was associated with a non-significant average weekly revenue increase of £38.42 and an increase of 7% in items sold per week.

Table 2: Model 1 results for sales outcomes

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Estimates	CI	p
(Intercept)	498.66 ***	269.51 – 727.80	**<0.001**	380.76 ***	261.33 – 554.76	**<0.001**
implementation	38.42	-51.84 – 128.69	0.398	1.07	0.85 – 1.35	0.584

*p<0.05 ** p<0.01 *** p<0.001.*

Statistically significant results

Implementation was associated with a significant reduction of 34.9 calories and a non-significant reduction of around 5 grams of sugar per unit sold. Overall, while there was no significant effect of the implementation on revenue or total sales volume, there is clear, strong evidence that the implementation improved the nutritional quality of items sold, reducing both calories and sugar per unit across all vending machines. This demonstrates that healthier products were sold post-implementation, without any significant impact on overall revenue or total sales volume.

Table 3: Model 1 results for nutritional outcomes

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	**CI**	**p**	**Estimates**	**CI**	**p**
(Intercept)	131.62 *	27.88 – 235.36	**0.014**	13.92 ***	6.73 – 21.11	**<0.001**
implementation	-34.94 ***	-42.64 – -27.24	**<0.001**	-4.84 ***	-6.03 – -3.65	-8.16

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Model 2

Model 2 tests the effect of implementation on sales and nutritional outcomes differs by product type (snack or drink).

When adjusted for pre-implementation differences between snacks and drinks, average weekly snack revenue was £116.29 less than drink revenue and snacks sold 32% more units per week compared to drinks during the pre-implementation period. However, the implementation effect for revenue and sales was not significant, as shown by the p-values (p = 0.659 and p = 0.406 respectively).

Table 4: Model 2 results for sales outcomes by product category (snack)

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	**CI**	**P**	**Incidence Rate Ratios**	**CI**	**P**
(Intercept)	556.77 **	182.75 – 930.79	**0.004**	330.93 ** *	204.12 – 536.51	**<0.001**
implementation	38.46	-51.85 – 128.76	0.397	1.07	0.85 – 1.35	0.584

product category [Snack]	-116.29	-640.54 – 407.96	0.659	1.32	0.68 – 2.56	0.406

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Post-implementation, snacks sold contained 179 calories and 12 grams of sugar less than drinks sold on average. This was a highly significant reduction ($p < 0.001$). In terms of product type, snacks remain higher in calories and sugar per unit than drinks, but both categories saw a reduction in these metrics.

Table 5: Model 2 results for nutritional outcomes by product category (snack)

Predictors	**Calories per Unit Sold**			**Sugar per Unt Sold (g)**		
	Estimates	**CI**	**p**	**Estimates**	**CI**	**P**
(Intercept)	41.74 ***	32.14 – 51.34	**<0.001**	7.74 ***	5.92 – 9.57	**<0.001**
Implementation	-34.85 ***	-42.55 – -27.14	**<0.001**	-4.83 ***	-6.02 – -3.64	**<0.001**
product category [Snack]	179.38 ***	167.16 – 191.60	**<0.001**	12.30 ***	9.89 – 14.72	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Model 3: Subgroup analysis by product type

Although Model 2 included product category as a fixed effect, it assumes the implementation has the same impact on both categories. However, descriptive analysis implies that snacks and drinks may have responded differently to implementation. To test whether the effect of implementation differs between snacks and drinks, we ran separate models for each product category. Results for these are shown in Table 6 and Table 7 below.

Table 6: Model 3 results for snack outcomes

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	P
(Intercept)	437.40 ***	360.96 – 513.84	**<0.001**	422.75 ***	358.90 – 497.95	**<0.001**
implementation	44.62	-60.21 – 149.45	0.391	1.13	0.90 – 1.43	0.284

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Incidence Rate Ratios	CI	P
(Intercept)	220.29***	214.37 – 226.22	**<0.001**	19.16***	17.81 – 20.51	**<0.001**
implementation	-35.6***	-44.22 – 27.06	**<0.001**	-5.78***	-7.73 - -3.82	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 6 reveals a non-significant increase in weekly snack revenue of £44.62 and 13% in snacks sold and a significant reduction in 35.6 calories and 5.8g reduction of sugar per snack sold.

Table 7: Model 3 results for drink outcomes

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	P
(Intercept)	561.76*	44.55 – 1078.97	**0.034**	342.40***	184.10 – 636.82	**<0.001**
implementation	53.70	-100.85 – 208.25	0.481	1.06	0.82 – 1.37	0.652

Predictors	Calories per Unit Sold	Sugar per Unit Sold (g)

	Estimates	CI	p	Incidence Rate Ratios	CI	P
(Intercept)	44.77***	34.17 – 55.38	**<0.001**	10.04***	7.88 – 12.20	**<0.001**
implementation	-21.68 ***	-32.25 – -11.12	**<0.001**	-5.20***	-7.77 – -2.63	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 7 shows a non-significant increase in weekly drink revenue of £53.70 and an increase of 6% in drinks sold post-implementation. In terms of nutritional content, there was a statistically significant reduction in 21.7 calories per drink sold and 5.2g of sugar per drink sold.

Model 4

Model 4 tests whether the change in sales post-implementation is statistically significantly different between product categories.

Implementation did not differentially affect overall sales or revenue for snacks versus drinks, with neither showing a significant change (p = 0.889 and p = 0.564 respectively).

Table 8: Model 4 results for sales outcomes (with interaction: implementation × product category)

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	P
(Intercept)	560.35 **	183.04 – 937.65	**0.004**	343.46 ***	208.11 – 566.84	**<0.001**
implementation	31.80	-99.53 – 163.12	0.630	0.99	0.71 – 1.39	0.974
product category [Snack]	-122.95	-655.39 – 409.49	0.645	1.23	0.61 – 2.49	0.560

implementation × product category [Snack]	12.82	-169.56 – 195.20	0.889	1.15	0.72 – 1.83	0.564

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Nutritional quality improved much more in snacks than in drinks, shown by significant interaction effects in Table 9. Compared to drinks, calories per snack sold decreased by 43.99 calories ($p < 0.001$) and sugar per snack sold fell by 3.84g ($p=0.001$).

Table 9: Model 4 results for nutritional outcomes (with interaction: implementation × product category)

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Estimates	CI	P
(Intercept)	29.91 ***	20.91 – 38.92	**<0.001**	6.70 ***	4.84 – 8.56	**<0.001**
implementation	-11.79 **	-19.10 – -4.48	**0.002**	-2.81 ***	-4.39 – -1.24	**0.001**
product category [Snack]	201.68 ***	189.09 – 214.26	**<0.001**	14.26 ***	11.67 – 16.85	**<0.001**
implementation × product category [Snack]	-43.99 ***	-54.08 – -33.90	**<0.001**	-3.84 ***	-6.01 – -1.67	**0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Interrupted Time Series

The ITS analysis shows that pre-implementation, the average weekly revenue was about £2,141 ($p < 0.001$) and revenue was not changing significantly week-to-week pre-implementation (–£5.06/week, $p = 0.13$). There was a statistically significant immediate increase in weekly revenue of £865 post-implementation ($p = 0.021$). Following this, there was a non-significant decrease in revenue of about –£118 per week post-implementation ($p = 0.09$), but the evidence is weak.

Figure 1: Weekly revenue

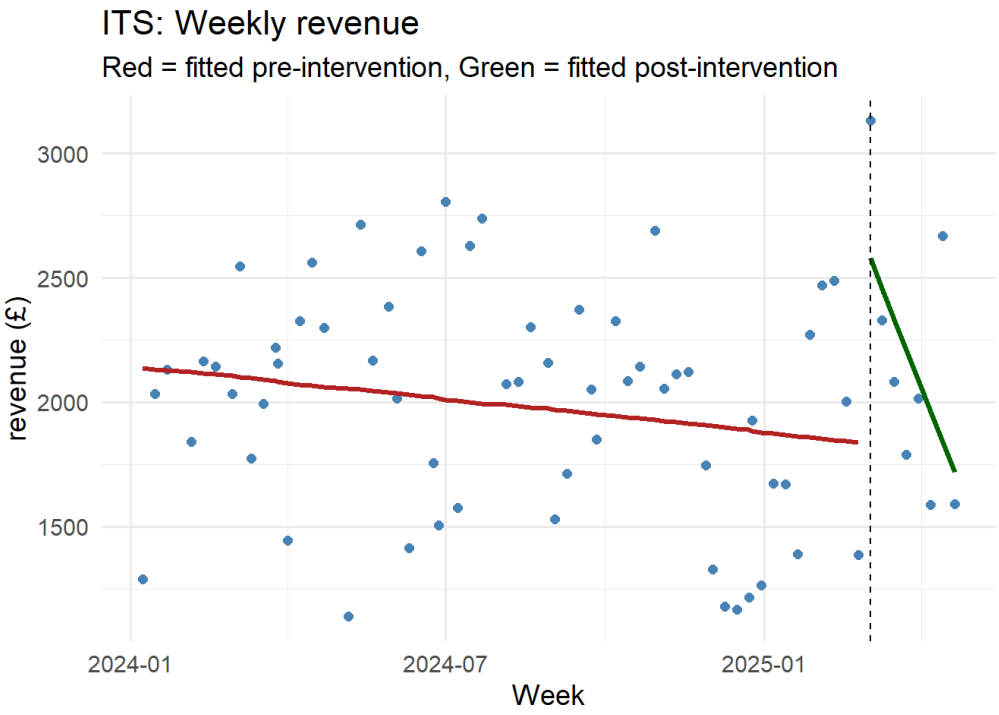


Figure 1 demonstrates a notable and statistically significant immediate increase in the number of items sold per week right after implementation (p=0.023), but this effect was not sustained over time. The subsequent weeks showed a non-significant downward trend in sales (p=0.121). As with revenue, there is no strong evidence for a sustained increase or decrease after post-implementation.

Figure 2: Weekly sales quantity

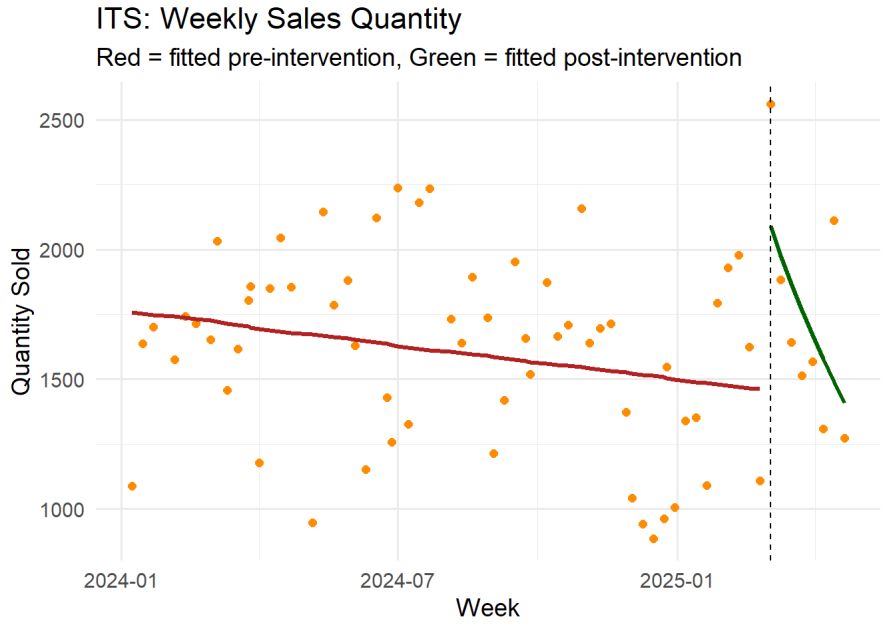


Figure 1 and Figure 2 highlight considerable week-to-week variation of sales and revenue, reinforcing the need for longer-term follow-up to confirm these findings. These results should be interpreted with caution due to several limitations including a short post-implementation period of two weeks, a small sample size and possible confounding factors including bank holidays.

Overall, the ITS analyses confirm that implementation was associated with immediate increases in sales and revenue, particularly driven by snack revenue, that reversed prior declining trends. However, both sales and revenue subsequently showed evidence of a renewed downward trend post-implementation. This highlights the importance of continued monitoring to determine whether these effects are sustained.

Figure 3 and Figure 4 show that implementation was associated with a non-significant decrease in calories per unit sold (p = 0.082) and a significant reduction in sugar content per unit sold (p = 0.012). This downward trend continues to decline post-implementation, however this finding is only significant for sugar per unit sold (p = 0.023).

Figure 3: Average calories per unit sold

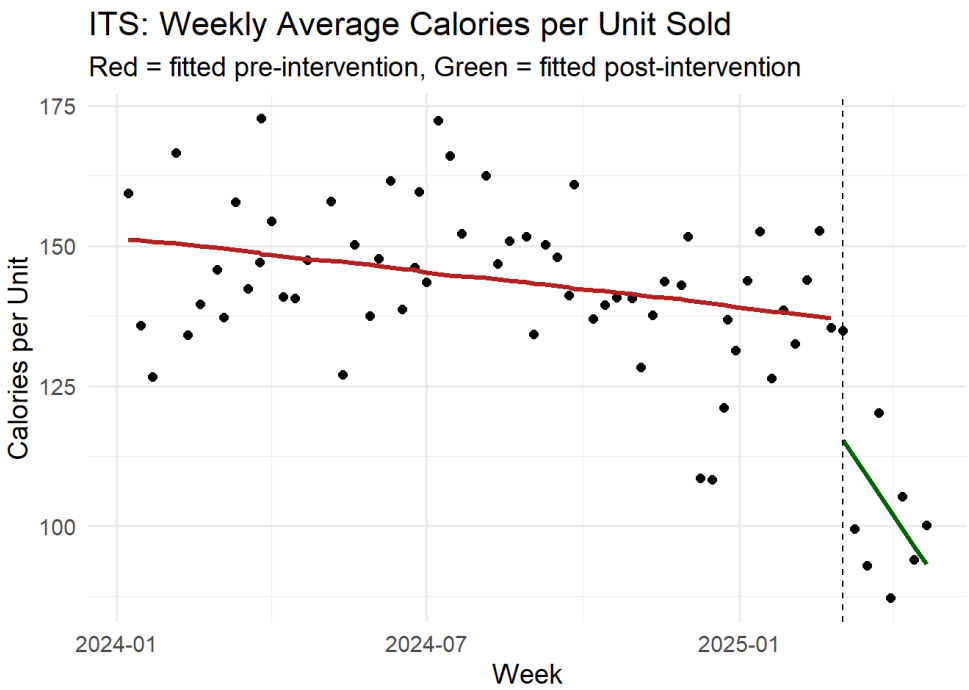
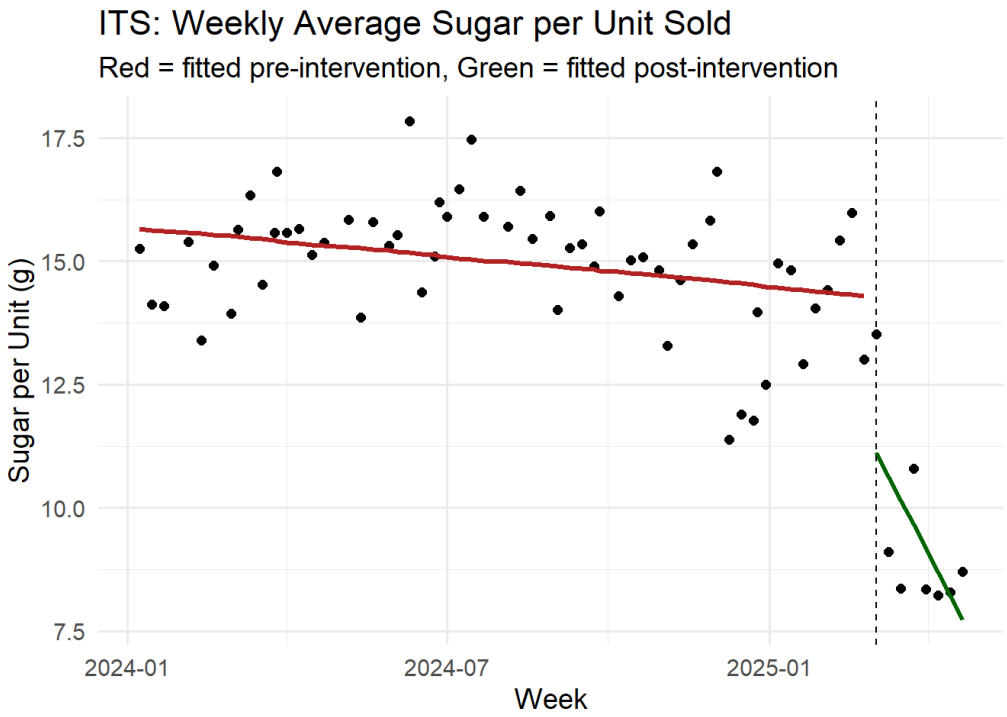


Figure 4: Average sugar per unit sold



PS2

Paired analysis

The Wilcoxon signed-rank test was not informative for PS2 because there are only two machines with both pre- and post-implementation data. The Wilcoxon test requires more pairs to be meaningful; with just two, the result is always p = 0.5, regardless of the direction or magnitude of change. Interpretation of paired analysis findings are therefore based on the paired t-test for PS2.

Table 10: Paired analysis findings

Variable	5-month pre-implementation (Paired t-test p-value)	8-week pre-implementation (Paired t-test p-value)
Mean weekly quantity sold	0.419	0.245
Mean weekly revenue	0.482	0.185
Mean calories per unit sold	0.343	0.353
Mean sugar (g) per unit sold	0.097	**0.044**

Statistically significant results

As shown in Table 10, when compared to both the 5-month and 8-week pre-implementation periods, there was no statistically significant change in weekly sales quantity, revenue, or calories per unit sold post-implementation. There was some evidence of a reduction in sugar per unit sold when compared to the 8-week pre-implementation period (t-test p value = 0.04), but this finding should be interpreted cautiously due to the small number of machines and the limitations of significance testing with such a small sample. Overall, there is little evidence that implementation substantially changed the volume of products sold in this site, however there is some evidence to show an impact on the nutritional quality of products sold based on sugar content.

Model 1

Implementation was associated with a significant average weekly revenue decrease of £73.05 and a decrease of 41% in items sold per week, as shown in Table 11.

Table 11: Model 1 results for sales outcomes

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	p
(Intercept)	204.93 ***	121.21 – 288.66	**<0.001**	152.94 ***	133.11 – 175.72	**<0.001**
implementation	-73.05 ***	-108.66 – -37.44	**<0.001**	0.59 ***	0.47 – 0.74	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

As shown in Table 12, implementation was associated with a statistically significant reduction of approximately 118 calories per unit sold and a reduction of 10.41g of sugar per unit sold.

Table 12: Model 1 results for nutritional outcomes

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Estimates	CI	P
(Intercept)	202.24	-56.09 – 460.57	0.119	13.31 ***	8.98 – 17.63	**<0.001**
implementation	-117.82 ***	-155.41 – -80.23	**<0.001**	-10.41 ***	-11.56 – -9.26	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Model 2

Similar to the findings of Model 1, Model 2 found that implementation led to substantial and highly statistically significant reductions in revenue, items sold, calories per unit, and sugar per unit sold ($p < 0.001$). While pre-implementation differences between snacks and drinks were generally not significant for sales outcomes, snacks had much higher sugar per unit than drinks ($p < 0.01$).

Table 13: Model 2 for sales outcomes by product category (snack)

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	P
(Intercept)	244.76 ***	126.09 – 363.43	**<0.001**	161.65 ***	134.94 – 193.64	**<0.001**
implementation	-73.05 ***	-108.76 – -37.34	**<0.001**	0.58 ***	0.46 – 0.73	**<0.001**
product category [Snack]	-79.65	-246.35 – 87.04	0.332	0.90	0.72 – 1.12	0.348

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 14: Model 2 results for nutritional outcomes with product category (snack)

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Estimates	CI	P
(Intercept)	77.87	-195.54 – 351.28	0.560	11.23 ***	10.28 – 12.18	**<0.001**
implementation	-117.82 ***	-155.52 – -80.13	**<0.001**	-10.41 ***	-11.57 – -9.26	**<0.001**

product category [Snack]	248.74	-137.38 – 634.86	0.195	4.15 ***	2.96 – 5. 34	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*
Statistically significant results

Model 3

Table 15 and

Table **16** show that implementation led to significant reductions in weekly sales, calories per unit, and sugar per unit sold for both snacks and drinks. The reduction in revenue was statistically significant for snacks but not for drinks ($p < 0.001$ and $p = 0.122$ respectively). The nutritional profile of products sold improved across both categories, but also fewer sales, with the effect being more pronounced for snacks.

Table 15: Model 3 results for snack outcomes

Predictors	**Revenue (£/week)**			**Items Sold (log scale)**		
	Estimates	**CI**	**p**	**Incidence Rate Ratios**	**CI**	**p**
(Intercept)	173.53 ***	153.47 – 193. 58	**<0.001**	159.50 ***	135.50 – 18 9.12	**<0.001**
Implementatio n	-94.95 ***	-127.29 – - 62.60	**<0.001**	0.44 ***	0.34 – 0.59	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*
Statistically significant results

Predictors	**Calories per Unit Sold**			**Sugar per Unit Sold (g)**		
	Estimates	**CI**	**p**	**Incidence Rate Ratios**	**CI**	**p**
(Intercept)	57.89***	48.68 – 67.09	**<0.001**	3.99***	3.43 – 4.56	**<0.001**

Implementation	-27.98**	-42.82 - -13.15	**<0.001**	-2.80***	-3.71 – -1.88	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*
Statistically significant results

Table 16: Model 3 results for drink outcomes

Predictors	**Revenue (£/week)**			**Items Sold (log scale)**		
	Estimates	**CI**	**p**	**Incidence Rate Ratios**	**CI**	**p**
(Intercept)	236.34 ***	194.71 – 277.96	**<0.001**	146.38 ***	123.33 – 175.14	**<0.001**
Implementation	-51.16	-118.27 – 15.96	0.122	0.74 *	0.56 – 0.99	**0.042**

*p<0.05 ** p<0.01 *** p<0.001*
Statistically significant results

Predictors	**Calories per Unit Sold**			**Sugar per Unit Sold (g)**		
	Estimates	**CI**	**p**	**Incidence Rate Ratios**	**CI**	**p**
(Intercept)	12.76 ***	11.69 – 13.83	**<0.001**	2.67 ***	2.47 – 2.88	**<0.001**
Implementation	-11.72 ***	-13.44 – -10.00	**<0.001**	-2.57 ***	-2.91 – -2.24	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*
Statistically significant results

Model 4

Implementation was associated with significant reductions in revenue, sales quantity, calories per unit, and sugar per unit, mostly driven by snacks. The effect on sales was significantly stronger for snacks, as shown by the interaction in Table 17 (p=0.012). For calories per unit, snacks also saw a significantly greater improvement post-implementation, containing 146 calories less than drinks on average (p < 0.001).

Table 17: Model 4 results for sales outcomes (with interaction: implementation x product category)

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	p
(Intercept)	236.34 ** *	118.23 – 354.45	**<0.001**	146.38 ** *	123.28 – 173.80	**<0.001**
implementation	-51.16 *	-101.09 – -1.23	**0.045**	0.74 *	0.56 – 0.98	**0.038**
product category [Snack]	-62.81	-229.84 – 104.22	0.442	1.09	0.86 – 1.39	0.487
implementation × product category [Snack]	-43.79	-114.40 – 26.82	0.211	0.60 *	0.40 – 0.89	**0.012**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 18: Model 4 results for nutritional outcomes (with interaction: implementation x product category)

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Estimates	CI	p
(Intercept)	49.85 ***	31.35 – 68.36	**<0.001**	11.51 ***	9.31 – 13.71	**<0.001**
implementation	-44.98 **	-74.82 – -15.14	**0.005**	-11.14 ***	-12.75 – -9.53	**<0.001**
product category [Snack]	304.77 ***	278.60 – 330.94	**<0.001**	3.59 *	0.48 – 6.71	**0.026**
implementation × product category [Snack]	-145.68 ***	-187.88 – -103.48	**<0.001**	1.45	-0.83 – 3.73	0.199

*p<0.05 ** p<0.01 *** p<0.001*
Statistically significant results

ITS Analysis

As shown in Figure 5, average weekly revenue pre-implementation was about £163.49 (p = 0.001) and increasing significantly week-to-week before the implementation, by about £16.45 per week (p < 0.001). There was a statistically significant immediate drop in weekly revenue of £252.90 post-implementation (p = 0.026). In the weeks following, there was no significant change in the upwards trend (p = 0.923).

Figure 5: Weekly revenue

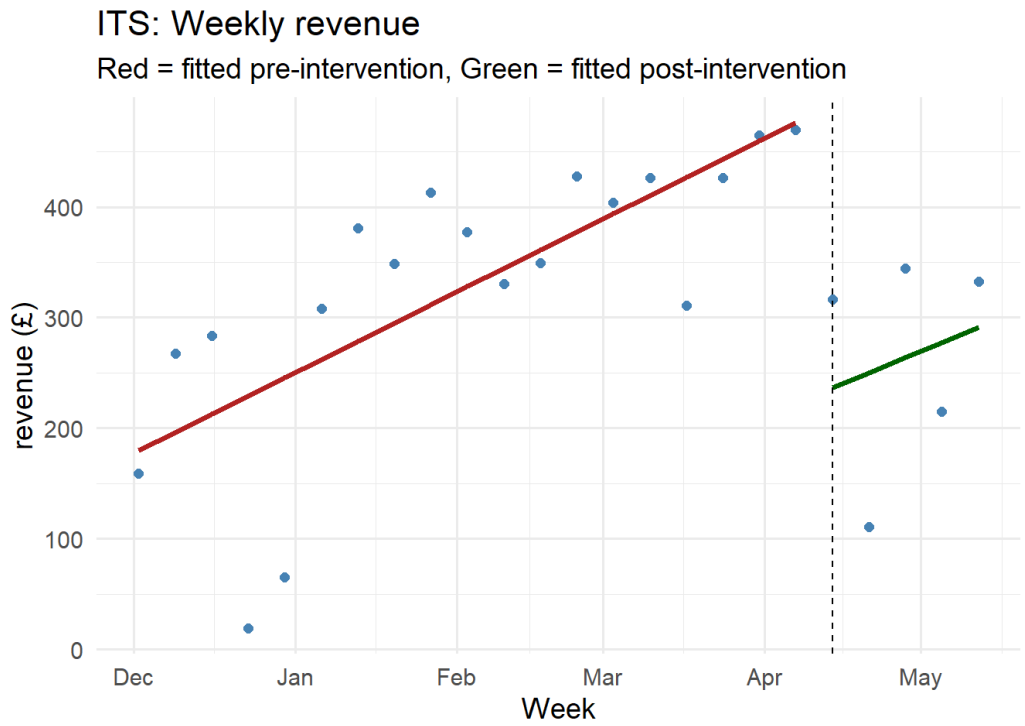
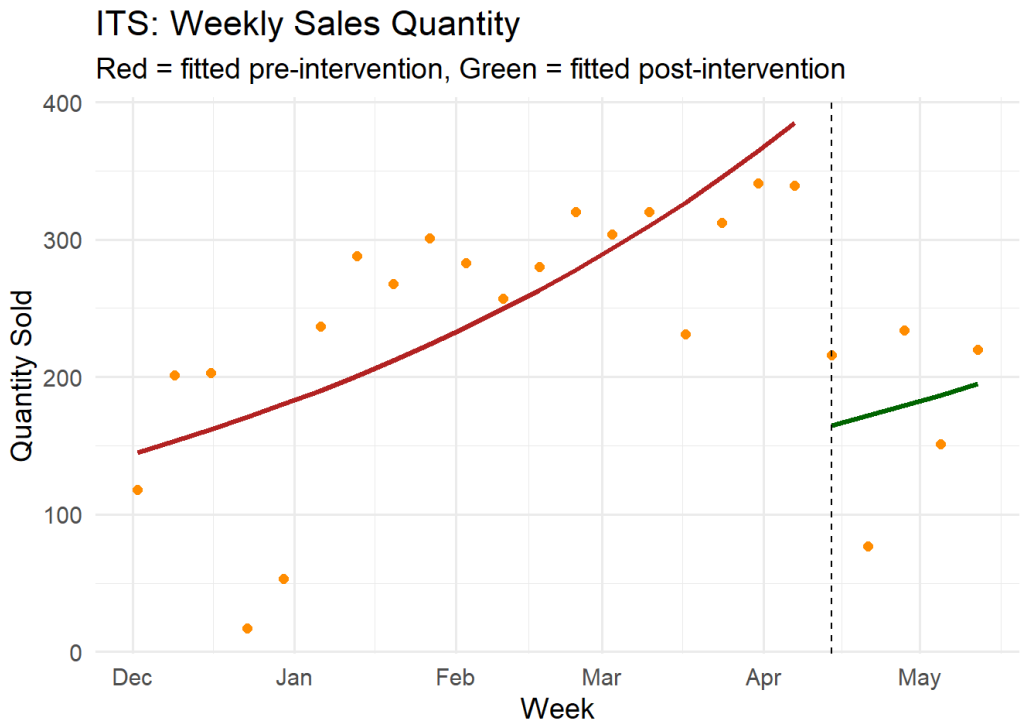


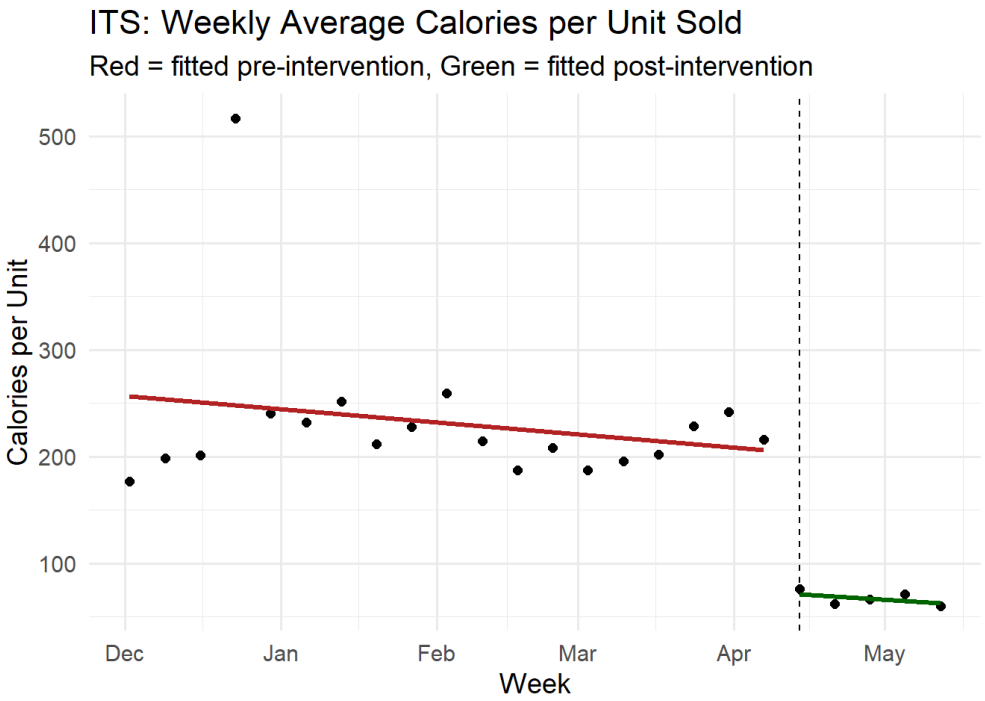
Figure 6: Weekly sales quantity



Weekly sales quantity was significantly increasing prior to implementation ($p < 0.001$). There was a large, but not statistically significant, immediate drop in quantity sold after post-implementation ($p = 0.082$), and no significant change in the post-implementation trend (0.931).

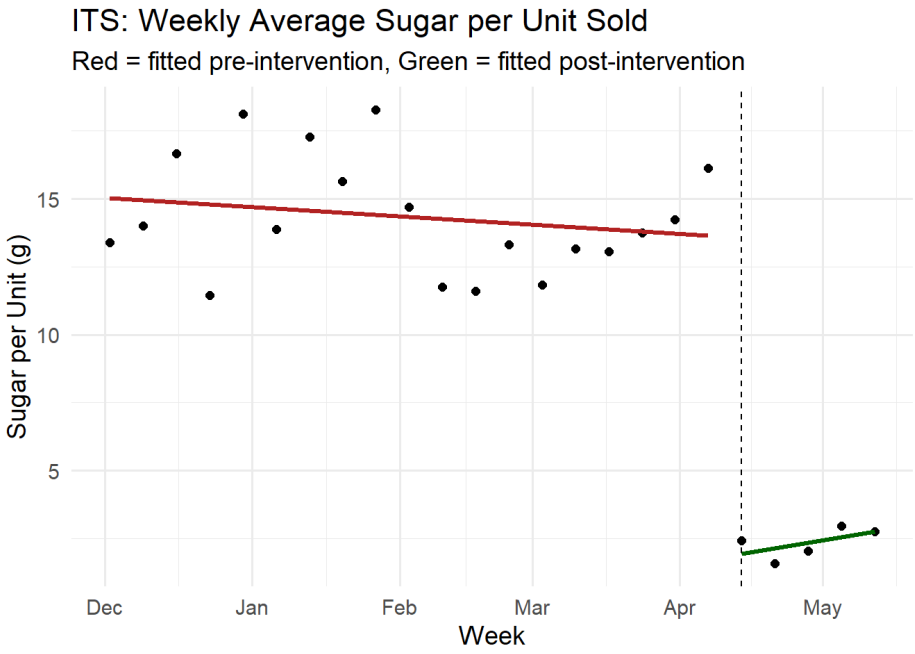
Overall, implementation was associated with an immediate, statistically significant decrease in snack sales and revenue, but the effect on drinks was smaller and not statistically significant. After the initial change, neither product category showed strong evidence for a continuing upward or downward trend.

Figure 7: Weekly average calories per unit sold



Implementation resulted in a large but insignificant decrease in calories per unit ($p = 0.1000$), following the downwards trend observed in the pre-implementation period.

Figure 8: Average sugar per unit sold



Despite the downwards trend in sugar content of products sold in the pre-implementation period, there is an immediate, substantial, and statistically significant increase in the sugar content of products sold post-implementation ($p < 0.001$). However, there was no evidence that these changes continued to increase or decrease in the weeks that followed ($p = 0.665$).

PS3

Paired analysis

There was no statistically significant change in weekly sales quantity or revenue following implementation. However, calories and sugar per unit sold were both significantly reduced compared to both the 10-month and 8-week pre-implementation periods, suggesting a meaningful improvement in the healthiness of products sold.

Table 19: Paired analysis findings

Variables	10-month pre-implementation (Paired t-test p-value/Wilcoxon p-value)	8-week pre-implementation (Paired t-test p-value/Wilcoxon p-value)
Mean weekly quantity sold	0.375 / 0.246	0.234 / 0.25

Mean weekly revenue	0.249 / 0.375	0.199 / 0.25
Mean calories per unit sold	**0.002** / 0.125	**0.010** / 0.125
Mean sugar (g) per unit sold	**0.003** / 0.125	**0.047** / 0.125

Statistically significant results

Mixed models

Model 1

Implementation was associated with an average weekly revenue decrease of £38.60 (p = 0.076) and a decrease of 29% in items sold per week (p = 0.072), however these estimates were not statistically significant.

Table 20: Model 1 results for sales outcomes

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	p
(Intercept)	132.34 ***	108.91 – 155.77	**<0.001**	85.78 ***	72.83 – 101.03	**<0.001**
Implementation	-38.60	-81.51 – 4.31	0.076	0.71	0.49 – 1.03	0.072

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

As shown in Table 21, implementation was associated with a statistically significant reduction of approximately 59 calories per unit sold (p < 0.001) and a reduction of 11.36g of sugar per unit sold (p < 0.001). This suggests a positive impact on the nutritional profile of products offered in vending machines, without strong evidence for a negative effect on overall sales. However, the small sample size for PS3 limits the ability to assess longer-term impact.

Table 21: Model 1 results for nutritional outcomes

Predictors	Calories per Unit Sold	Sugar per Unit Sold (g)

	Estimates	CI	p	Estimates	CI	p
(Intercept)	117.27 ***	86.48 – 148.06	**<0.001**	14.26 ***	8.68 – 19.83	**<0.001**
implementation	-58.93 ***	-73.77 – -44.09	**<0.001**	-11.36 ***	-14.40 – -8.32	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Model 2

Implementation significantly reduced snack sales by £57.34 (p < 0.001) and weekly snack revenue by 45% (p < 0.001) compared to drinks, adjusting for pre-implementation differences between product categories.

Table 22: Model 2 results for outcomes with product category (snack)

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	p
(Intercept)	94.84 ***	81.38 – 108.30	**<0.001**	55.54 ***	45.63 – 67.60	**<0.001**
implementation	-19.30 *	-37.53 – -1.07	**0.038**	0.68 **	0.51 – 0.91	**0.009**
product category [Snack]	-57.34 ***	-71.92 – -42.76	**<0.001**	0.55 ***	0.44 – 0.70	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 23: Model 2 results for nutritional outcomes with product category (snack)

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Estimates	CI	p

(Intercept)	61.90 ***	41.56 – 82.23	**<0.001**	13.95 ***	9.15 – 18.76	**<0.001**
implementation	-50.80 ***	-61.52 – -40.08	**<0.001**	-9.76 ***	-12.68 – -6.83	**<0.001**
product category [Snack]	144.75 ***	136.17 – 153.32	**<0.001**	-0.31	-2.65 – 2.03	0.791

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

There was a highly significant reduction in calories per unit sold post-implementation, with snacks containing much higher calories per unit than drinks (145 calories on average, $p < 0.001$). There was no significant difference in sugar per unit between snacks and drinks pre-implementation ($p = 0.791$). The effect of implementation did not differ substantially by product type, except for the expected pre-implementation differences.

Model 3

Both snacks and drinks showed significant reductions in revenue, items sold, calories per unit, and sugar per unit post-implementation. The magnitude of the reduction was generally larger for snacks, especially for calories which saw a reduction of nearly 40 calories per snack sold compared to a reduction of 14 calories per drink sold.

Table 24: Model 3 results for snack outcomes

Predictors	**Revenue (£/week)**			**Items Sold (log scale)**		
	Estimates	**CI**	**p**	**Incidence Rate Ratios**	**CI**	**p**
(Intercept)	36.91 ***	25.44 – 48.39	**<0.001**	30.70 ***	22.56 – 41.77	**<0.001**
implementation	-16.37 **	-26.57 – -6.18	**0.002**	0.59 **	0.41 – 0.83	**0.003**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Estimates	CI	p
(Intercept)	101.52 ***	76.70 – 126.34	**<0.001**	6.18 ***	3.82 – 8.54	**<0.001**
implementation	-39.50 **	-66.51 – -12.49	**0.005**	-3.73 ***	-5.58 – -1.89	**<0.001**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 25: Model 3 results for drink outcomes

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	p
(Intercept)	95.42 ***	76.40 – 114.45	**<0.001**	53.57 ***	43.29 – 66.29	**<0.001**
implementation	-22.22	-57.46 – 13.01	0.209	0.78	0.52 – 1.19	0.254

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Estimates	CI	p
(Intercept)	16.42 ***	9.74 – 23.09	**<0.001**	3.84 ***	1.94 – 5.74	**<0.001**
implementation	-13.55 **	-22.19 – -4.92	**0.003**	-3.42 **	-5.48 – -1.36	**0.002**

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Model 4

There was no significant difference in the effect post-implementation between snacks and drinks. Both categories declined, but the size of the effect was similar for both

(interaction p > 0.05). The implementation led to a significantly greater reduction in sugar content per unit for drinks than for snacks, with snacks containing 8g more sugar than drinks on average (p = 0.004).

Table 26: Model 4 results for sales outcomes (with interaction: implementation x product category)

Predictors	Revenue (£/week)			Items Sold (log scale)		
	Estimates	CI	p	Incidence Rate Ratios	CI	p
(Intercept)	95.43 ***	81.45 – 109.40	**<0.001**	53.67 ***	43.99 – 65.48	**<0.001**
implementation	-22.23	-48.16 – 3.71	0.092	0.80	0.54 – 1.19	0.277
product category [Snack]	-58.51 ***	-74.92 – -42.11	**<0.001**	0.59 ***	0.46 – 0.77	**<0.001**
implementation × product category [Snack]	5.85	-30.83 – 42.53	0.752	0.70	0.39 – 1.24	0.221

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 27: Model 4 results for nutritional outcomes (with interaction: implementation x product category)

Predictors	Calories per Unit Sold			Sugar per Unit Sold (g)		
	Estimates	CI	p	Estimates	CI	p
(Intercept)	63.02 ***	42.57 – 83.47	**<0.001**	14.78 ***	9.96 – 19.60	**<0.001**
implementation	-56.42 ***	-71.57 – -41.26	**<0.001**	-13.88 ***	-17.82 – -9.94	**<0.001**
product category [Snack]	142.50 ***	132.92 – 152.08	**<0.001**	-1.96	-4.45 – 0.53	0.121
implementation × product category [Snack]	11.23	-10.20 – 32.66	0.300	8.24 **	2.67 – 13.81	**0.004**

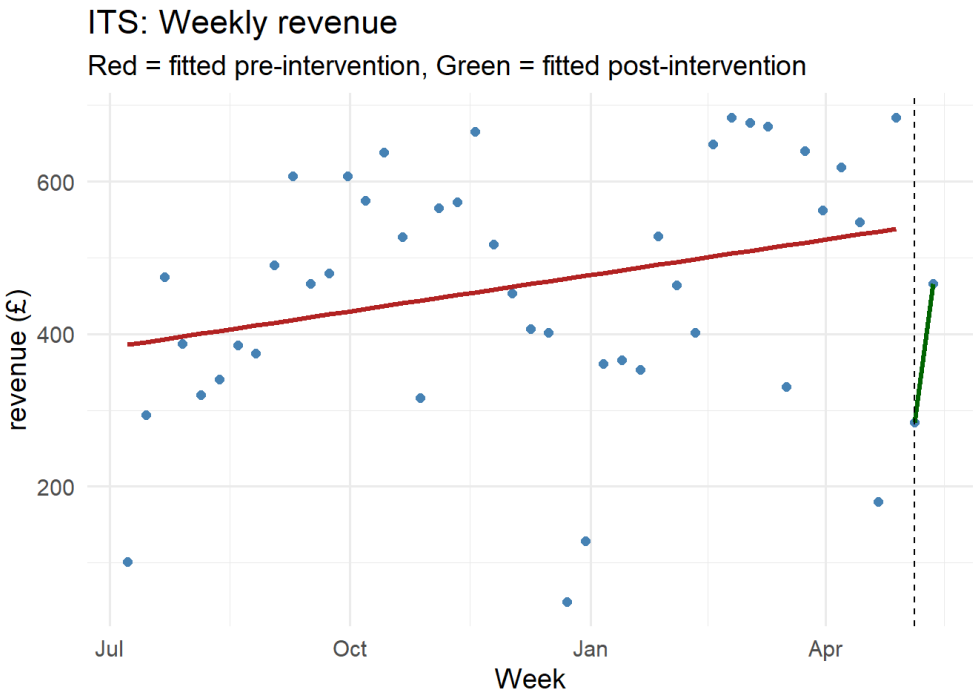
*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

ITS Analysis

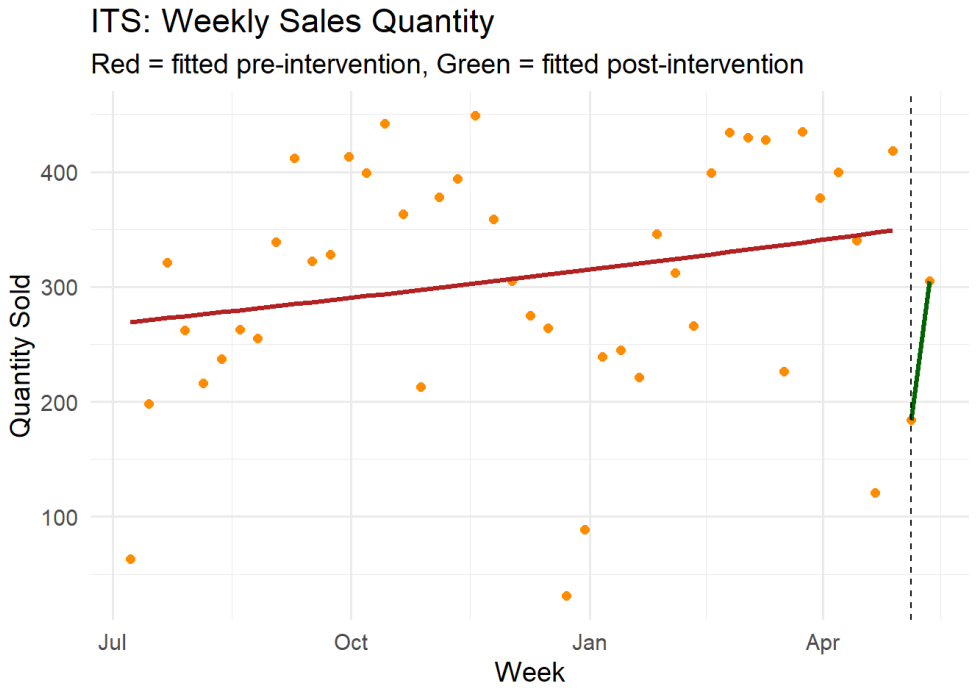
Figure 9 reveals that weekly revenue was rising pre-implementation, but the introduction of nutritional standards led to a significant immediate drop in revenue of £252.90 (p = 0.026). There was non-significant change in the revenue trend both immediately after implementation and in the weeks following (p = 0.230 and p = 0.431 respectively).

Figure 9: Weekly revenue



Weekly sales quantity was increasing pre-implementation (p = 0.0039). Implementation led to a non-significant immediate decrease in sales (step change = −0.89, p = 0.082), and there was no significant change in the trend post-implementation (p = 0.93).

Figure 10: Weekly sales quantity



Overall, there is no statistically significant effect of implementation on total weekly revenue or quantity sold, either for all products together or when snacks and drinks are examined separately. P-values for all post or step-change coefficients were >0.05, meaning changes could be due to random variation rather than a true implementation effect.

Figure 11 shows a slight downwards trend in average calories per unit sold across the pre-implementation period (p <0.001). Post-implementation, there is a large but insignificant immediate reduction of around 60 calories per unit sold (p = 0.067).

Figure 11: Weekly average calories per unit sold

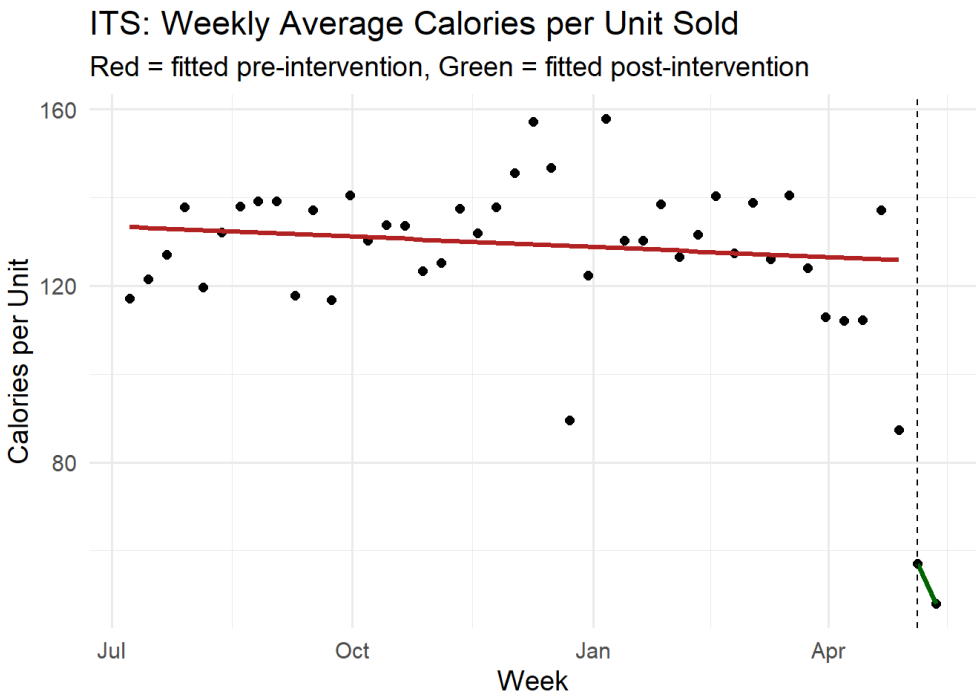
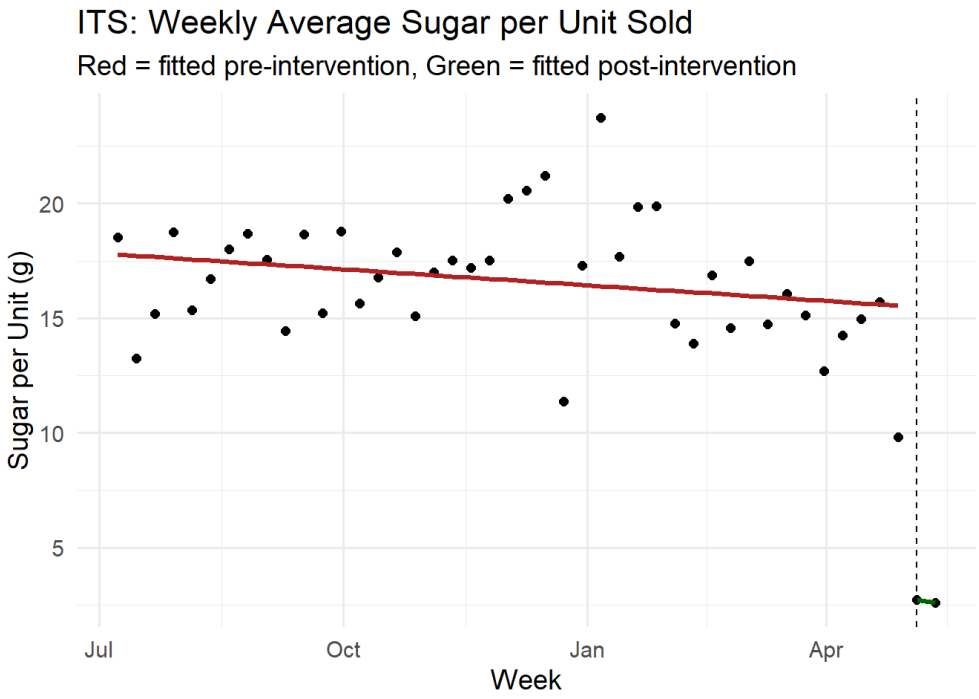


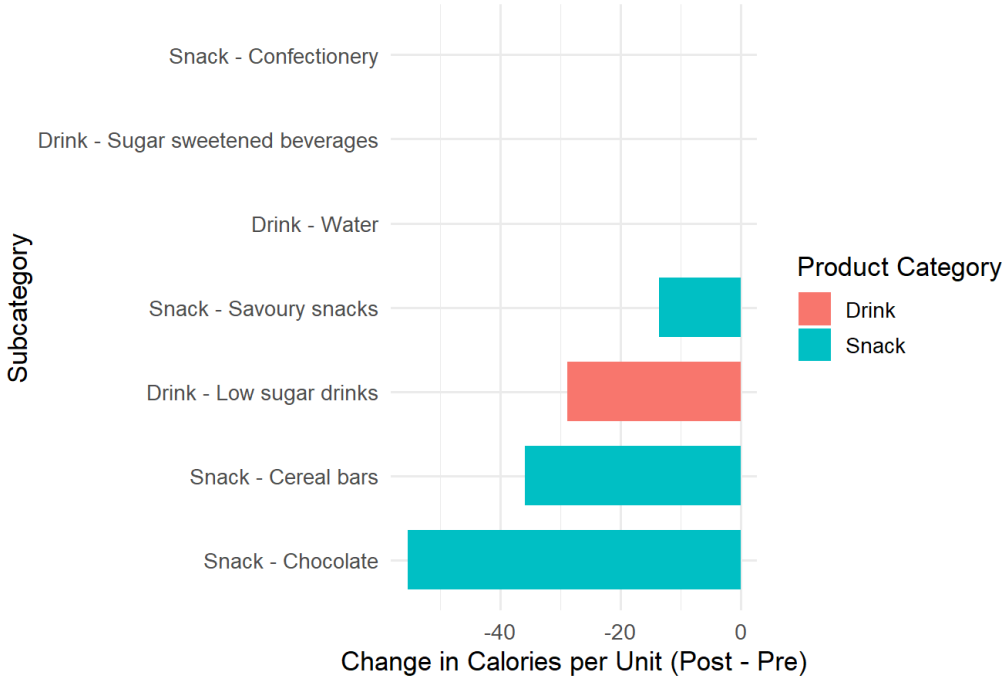
Figure 12 shows a large and significant reduction in the average sugar content per unit sold of 12.7g (p = 0.037). This follows the significant downwards trend seen in the pre-implementation period (p < 0.001).

Figure 12: Average sugar per unit sold



The decrease in water sales by 63% (from 415 to 152 units) suggests that the overall drop in drink sales was not just because unhealthy drinks were removed from vending machines. Instead, it points to a broader decrease in all drink purchases and possible lower use of vending machines post-implementation.

Figure 13: Change in calories per unit sold by subcategory



Snacks saw a greater reduction in calories than drinks post-implementation, with chocolate bars contributing the most to this reduction.

ITS Analysis

PS1

Table 28: ITS model for revenue (£/week)

Predictors	Estimates	CI	p
(Intercept)	2141.33 ***	1907.96 – 2374.70	**<0.001**
week num	-5.06	-11.71 – 1.60	0.134
post	864.81 *	133.03 – 1596.59	**0.021**
weeks after	-118.16	-256.04 – 19.73	0.092
Observations	68		
R^2 / R^2 adjusted	0.091 / 0.049		

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 29: ITS model for sales quantity (Items Sold (log scale))

Predictors	Incidence Rate Ratios	CI	p
(Intercept)	1764.53 ***	1573.62 – 1983.67	**<0.001**
week num	1.00	0.99 – 1.00	0.058
post	1.51 *	1.08 – 2.17	**0.023**
weeks after	0.95	0.89 – 1.01	0.121

Predictors	Incidence Rate Ratios	CI	p
Observations	68		
R^2 Nagelkerke	0.149		

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Figure 14: Weekly snack sales (Negative Binomial GLM)

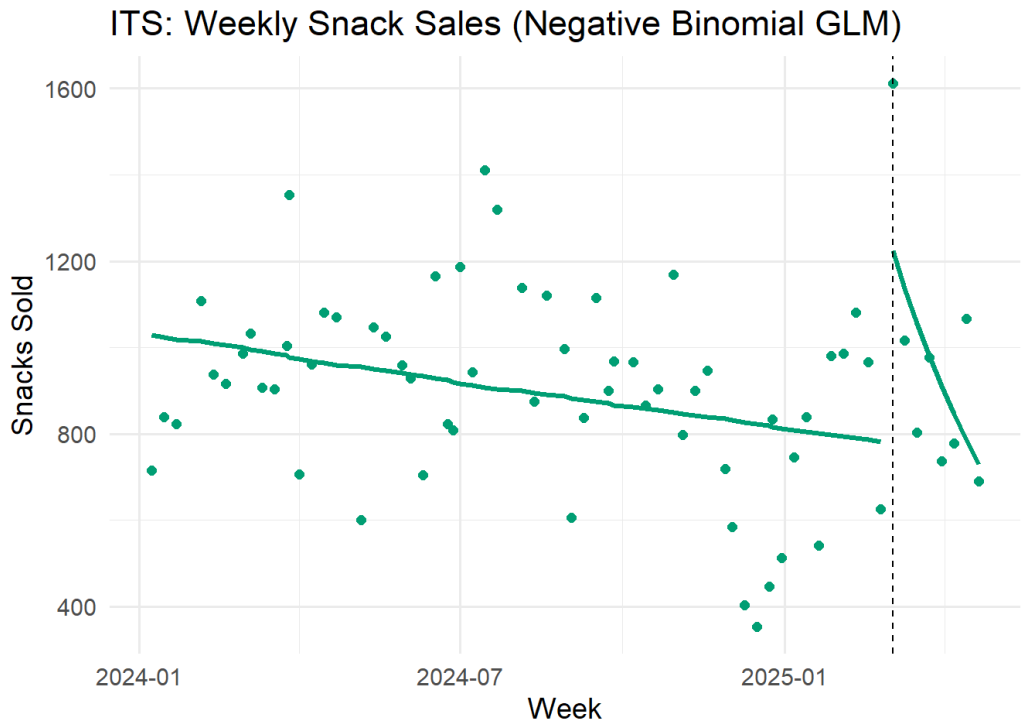


Figure 15: Weekly snack revenue (Linear model)

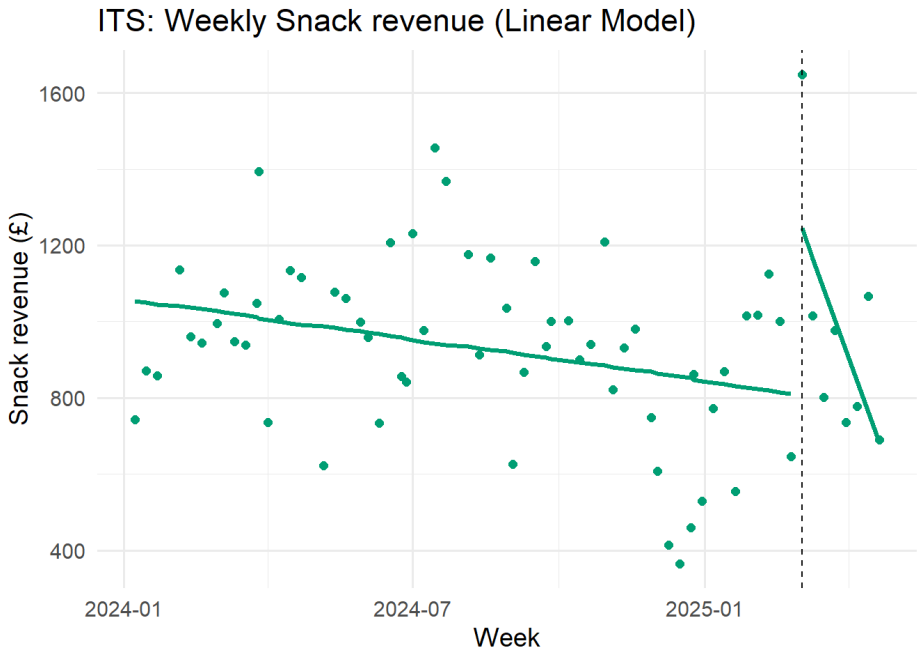


Figure 16: Weekly drink sales (Negative Binomial GLM)

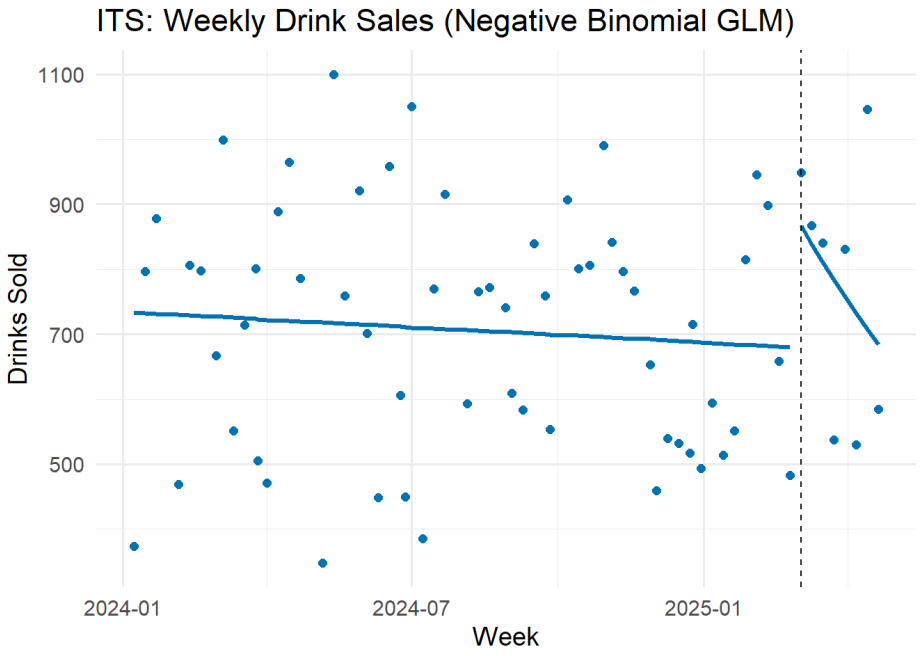


Figure 17: Weekly drink revenue (Linear model)

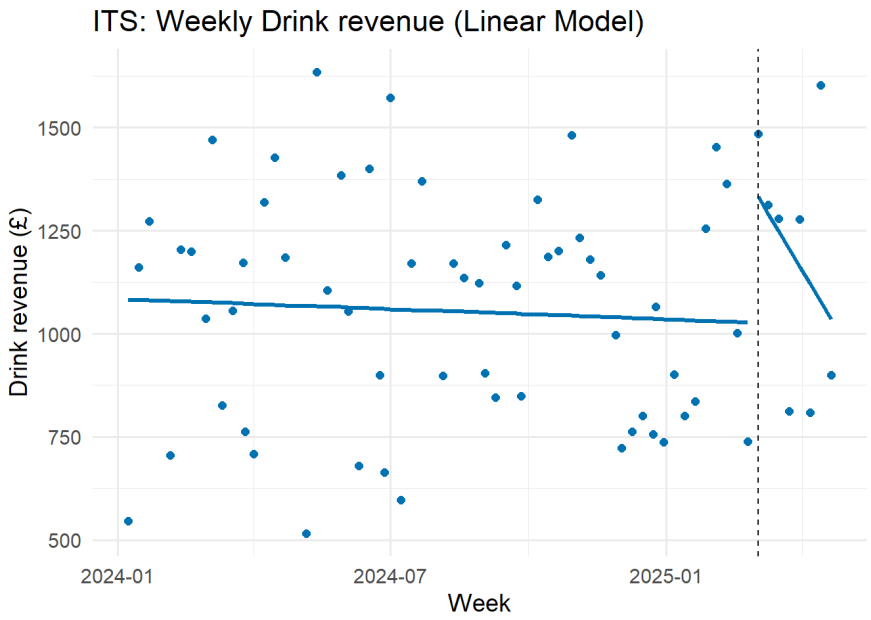


Table 30: ITS model for calories per unit sold

Predictors	Estimates	CI	p
(Intercept)	151.43 ***	144.71 – 158.15	**<0.001**
week num	-0.24 *	-0.43 – -0.05	**0.016**
Post	-18.64	-39.71 – 2.43	0.082
weeks after	-2.93	-6.90 – 1.04	0.145
Observations	68		
R^2 / R^2 adjusted	0.545 / 0.524		

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 31: ITS model for sugar per unit sold

Predictors	Estimates	CI	p
(Intercept)	15.68 ***	15.01 – 16.34	**<0.001**
week num	-0.02 *	-0.04 – -0.00	**0.019**
Post	-2.70 *	-4.80 – -0.61	**0.012**
weeks after	-0.46 *	-0.86 – -0.07	**0.023**
Observations	68		
R^2 / R^2 adjusted	0.693 / 0.679		

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

PS2

Table 32: ITS model for revenue (£/week)

Predictors	Estimates	CI	p
(Intercept)	163.49 **	71.52 – 255.46	**0.001**
week num	16.45 ***	8.38 – 24.51	**<0.001**
Post	-252.90 *	-472.02 – -33.77	**0.026**
weeks after	-2.88	-64.30 – 58.55	0.923
Observations	24		

R^2 / R^2 adjusted	0.503 / 0.428

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 33: ITS model for sales quantity (Items Sold (log scale))

Predictors	Incidence Rate Ratios	CI	p
(Intercept)	137.44 ***	90.32 – 216.21	**<0.001**
week num	1.06 **	1.02 – 1.10	**0.004**
Post	0.41	0.16 – 1.16	0.082
weeks after	0.99	0.75 – 1.29	0.931
Observations	24		
R^2 Nagelkerke	0.426		

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Figure 18: Weekly snack sales (Negative Binomial GLM)

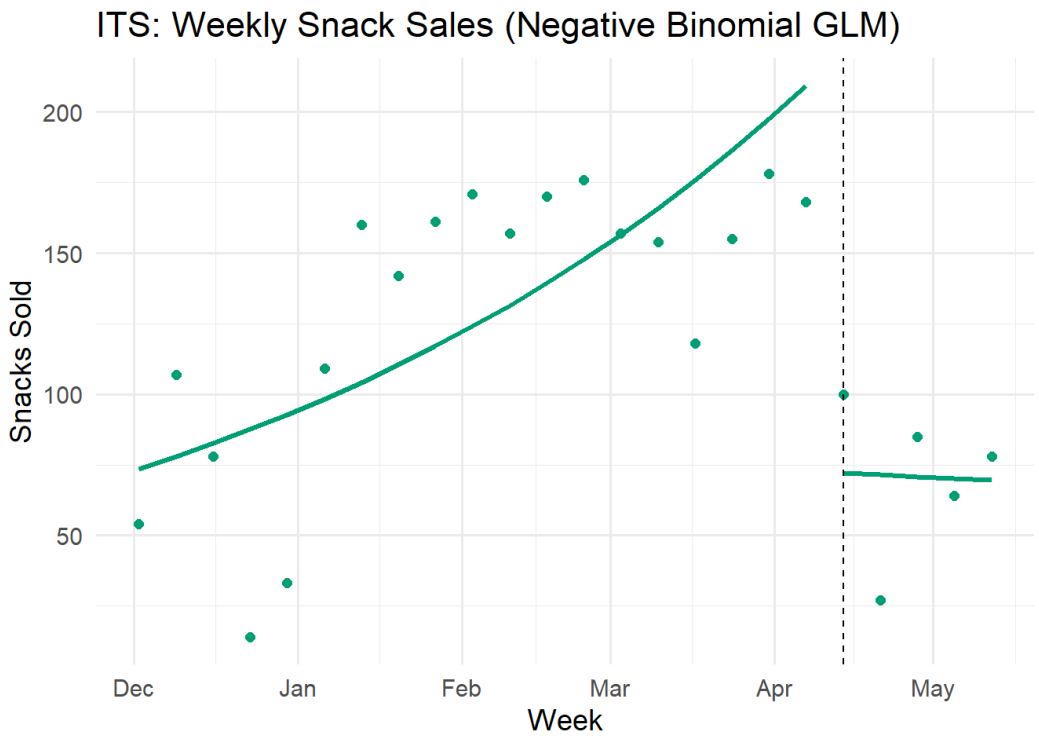


Figure 19: Weekly snack revenue (Linear model)

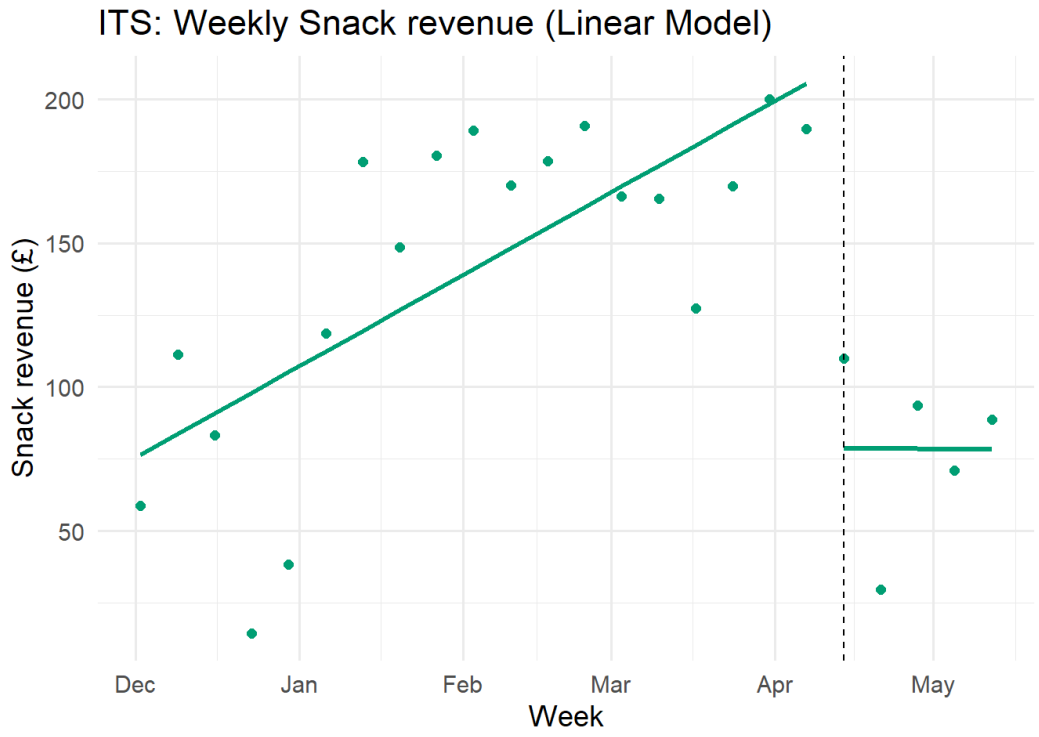


Figure 20: Weekly drink sales (Negative binomial GLM)

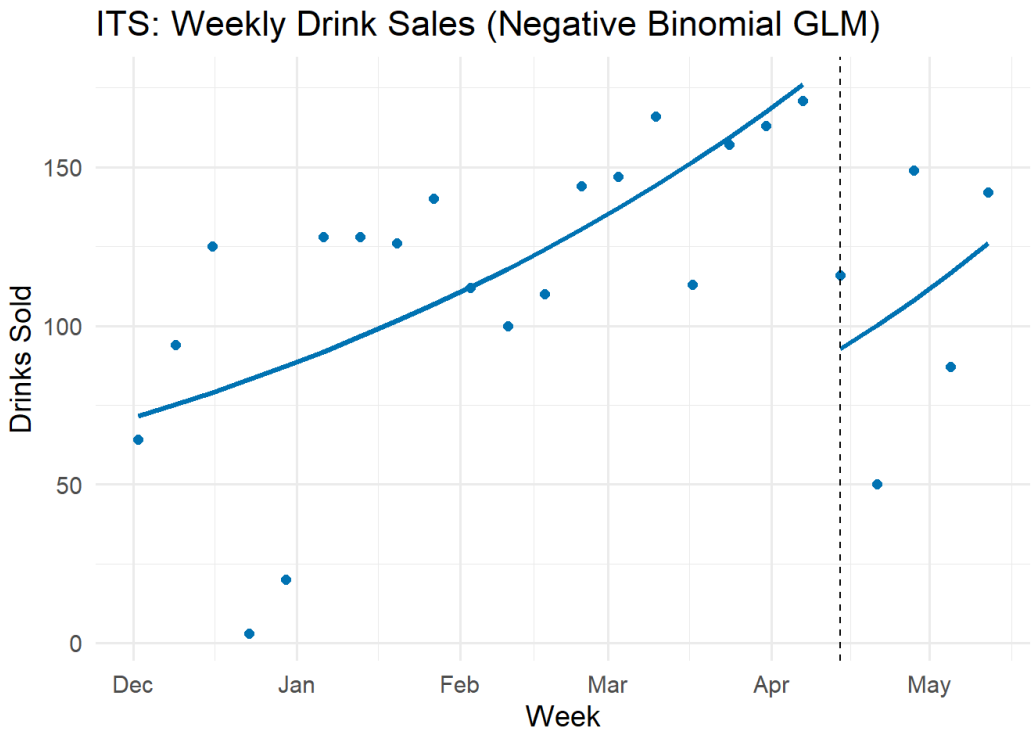


Figure 21: Weekly drink revenue (Linear model)

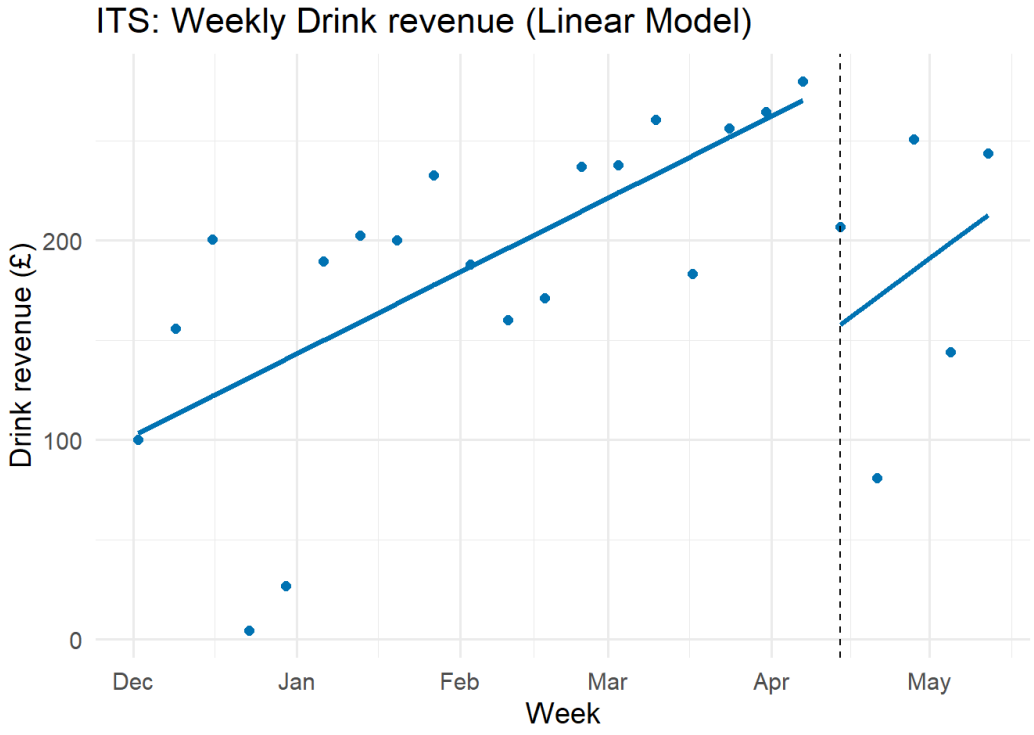


Table 34: ITS model for calories per unit sold

Predictors	Estimates	CI	Statistic	p
(Intercept)	259.44 ***	192.30 – 326.58	8.06	**<0.001**
week num	-2.81	-8.69 – 3.08	-0.99	0.332
post	-132.38	-292.35 – 27.58	-1.73	0.100
weeks after	0.55	-44.30 – 45.39	0.03	0.980
Observations	24			
R^2 / R^2 adjusted	0.551 / 0.484			

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 35: ITS model for sugar per unit sold

Predictors	Estimates	CI	Statistic	p
(Intercept)	15.09 ***	13.09 – 17.10	15.73	**<0.001**
week num	-0.08	-0.25 – 0.10	-0.91	0.375
post	-11.90 ***	-16.67 – -7.13	-5.20	**<0.001**
weeks after	0.28	-1.06 – 1.62	0.44	0.665
Observations	24			
R^2 / R^2 adjusted	0.876 / 0.857			

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

PS3

Table 36: ITS model for revenue (Revenue (£/week))

Predictors	Estimates	CI	p
(Intercept)	382.17 ***	282.89 – 481.45	**<0.001**
week num	3.62	-0.31 – 7.55	0.070
post	-435.53	-1157.12 – 286.05	0.230
weeks after	178.08	-274.26 – 630.42	0.431
Observations	45		
R^2 / R^2 adjusted	0.103 / 0.037		

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 37: ITS model for sales quantity (Items Sold (log scale))

Predictors	Incidence Rate Ratios	CI	p
(Intercept)	267.81 ***	207.86 – 349.21	**<0.001**
week num	1.01	1.00 – 1.02	0.231
post	0.32	0.06 – 2.47	0.227
weeks after	1.65	0.50 – 5.44	0.401
Observations	45		
R^2 Nagelkerke	0.085		

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Figure 22: Weekly snack sales (Negative Binomial GLM)

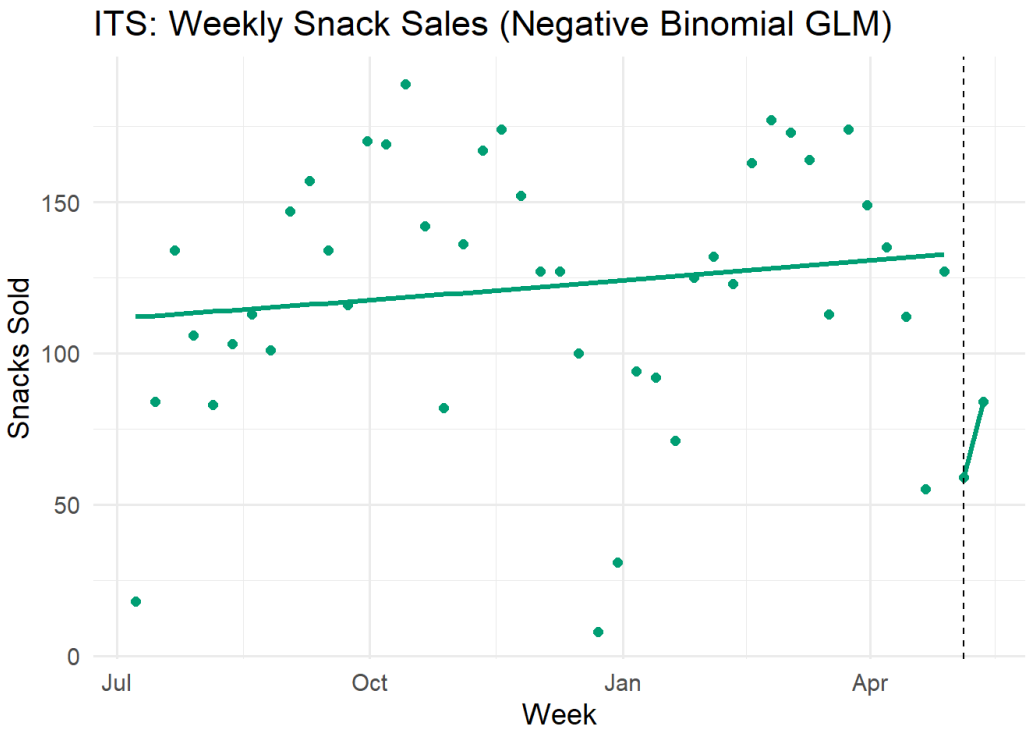


Figure 23: Weekly snack revenue (Linear model)

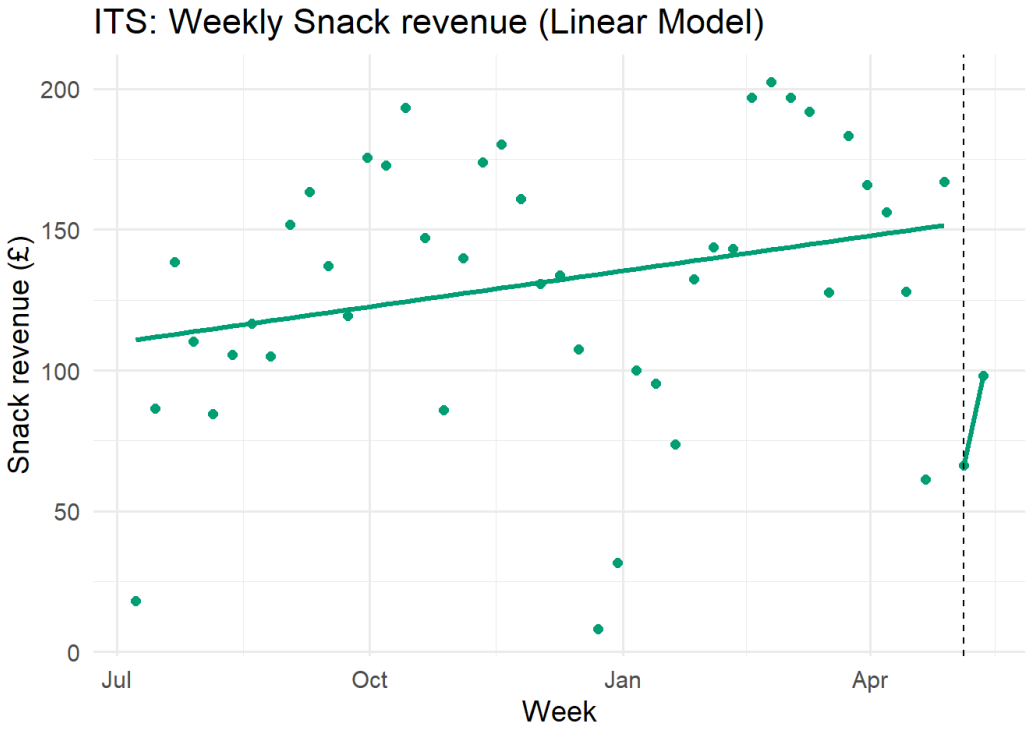


Figure 24: Weekly drink sales (Negative Binomial GLM)

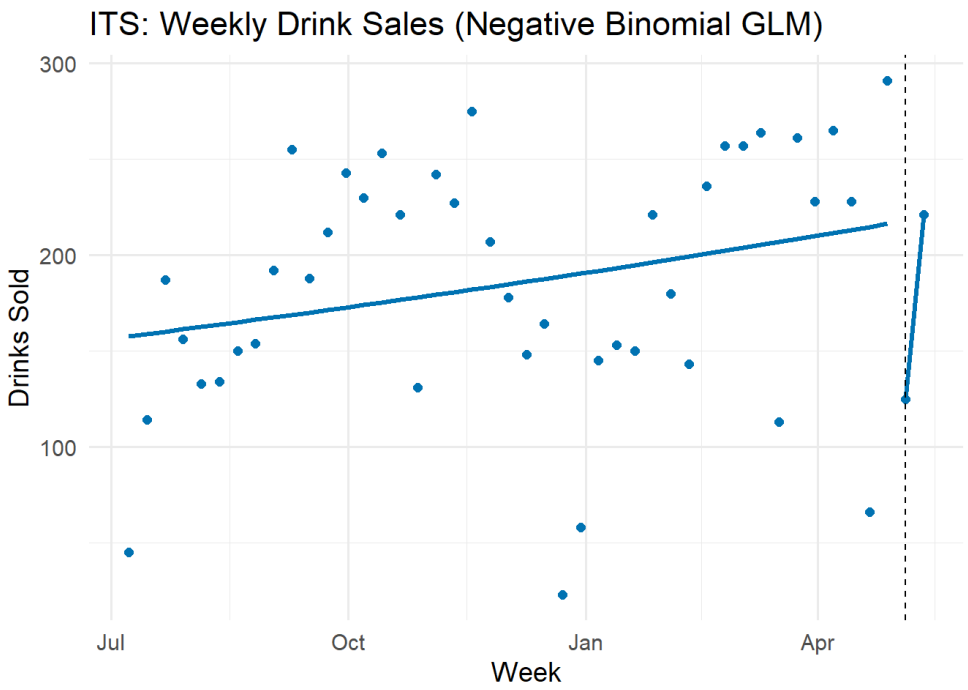


Figure 25: Weekly drink revenue (Linear model)

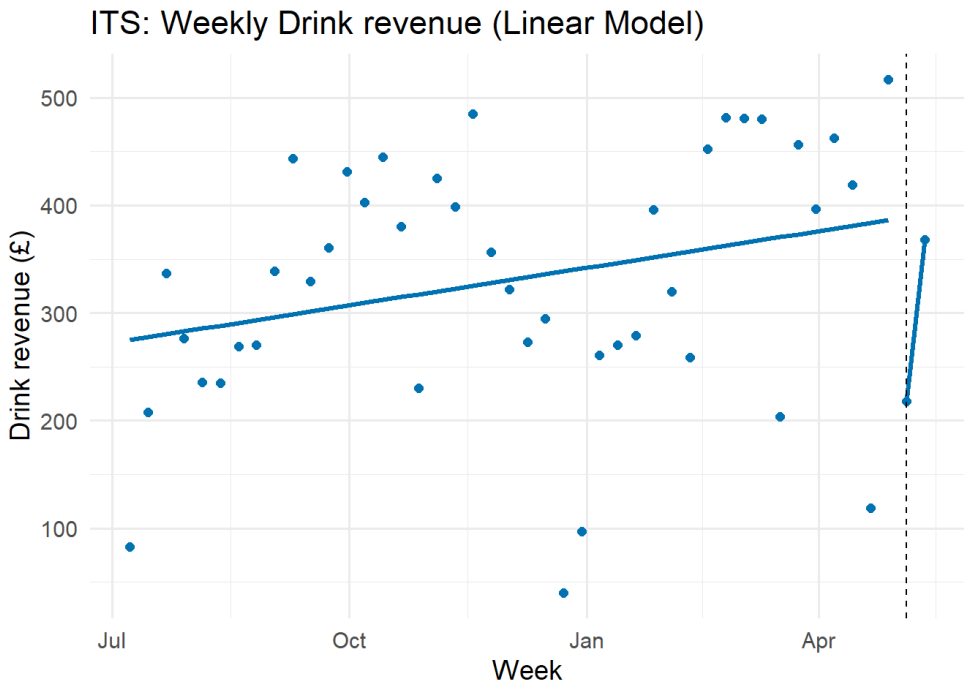


Table 38: ITS model for calories per unit sold

Predictors	Estimates	CI	p
(Intercept)	133.54 ***	124.73 – 142.35	**<0.001**
week num	-0.18	-0.53 – 0.17	0.304
post	-59.61	-123.64 – 4.42	0.067
weeks after	-8.95	-49.09 – 31.18	0.655
Observations	45		
R^2 / R^2 adjusted	0.589 / 0.559		

*p<0.05 ** p<0.01 *** p<0.001*

Statistically significant results

Table 39: ITS model for sugar per unit sold (g)

Predictors	Estimates	CI	p
(Intercept)	17.83 ***	16.20 – 19.46	**<0.001**
week num	-0.05	-0.12 – 0.01	0.105
post	-12.66 *	-24.52 – -0.80	**0.037**
weeks after	-0.10	-7.53 – 7.34	0.979
Observations	45		
R^2 / R^2 adjusted	0.586 / 0.556		

Summary plots

Baseline refers to the pre-implementation period and endline refers to the post-implementation period.

PS1

Machines A and B contain snacks, and Machines C and D contain drinks.

Figure 26: Weekly averages - 12-month pre-implementation

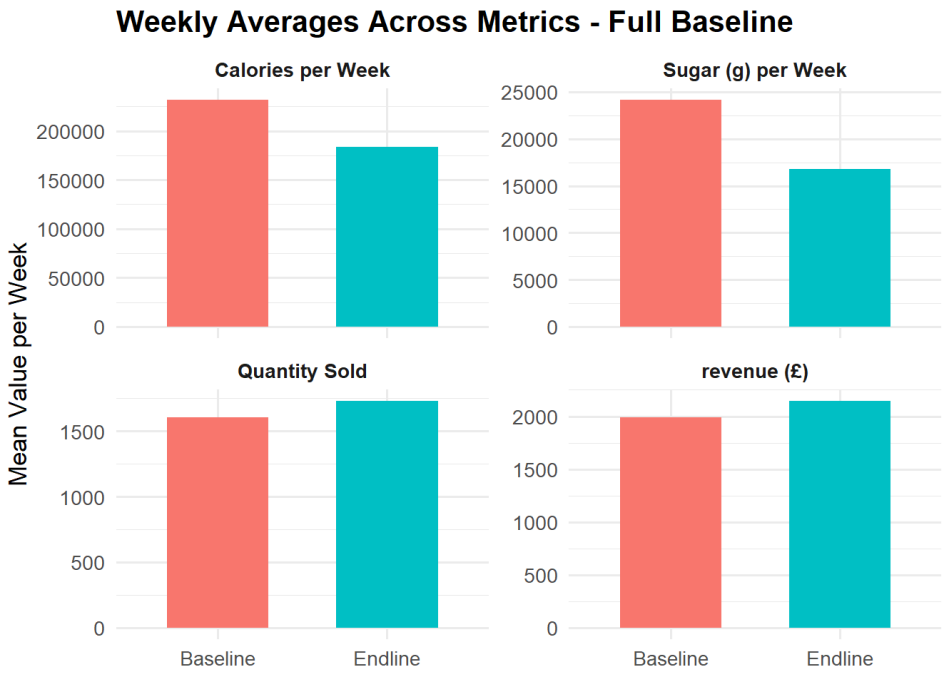


Figure 27: Weekly averages - 8-week pre-implementation

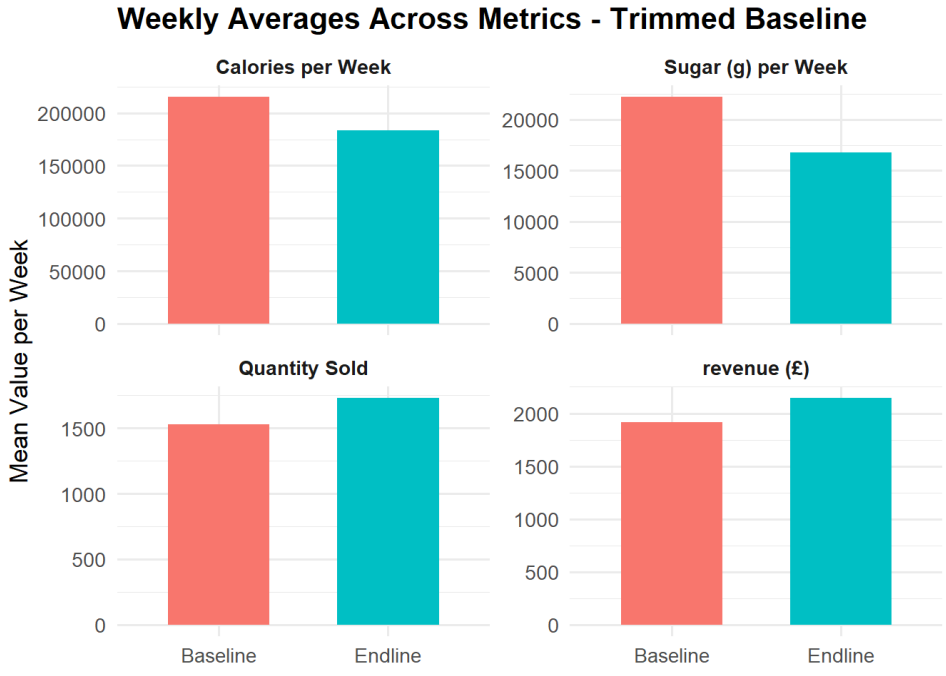


Figure 28: Mean weekly metric by vending machine - 12-month pre-implementation

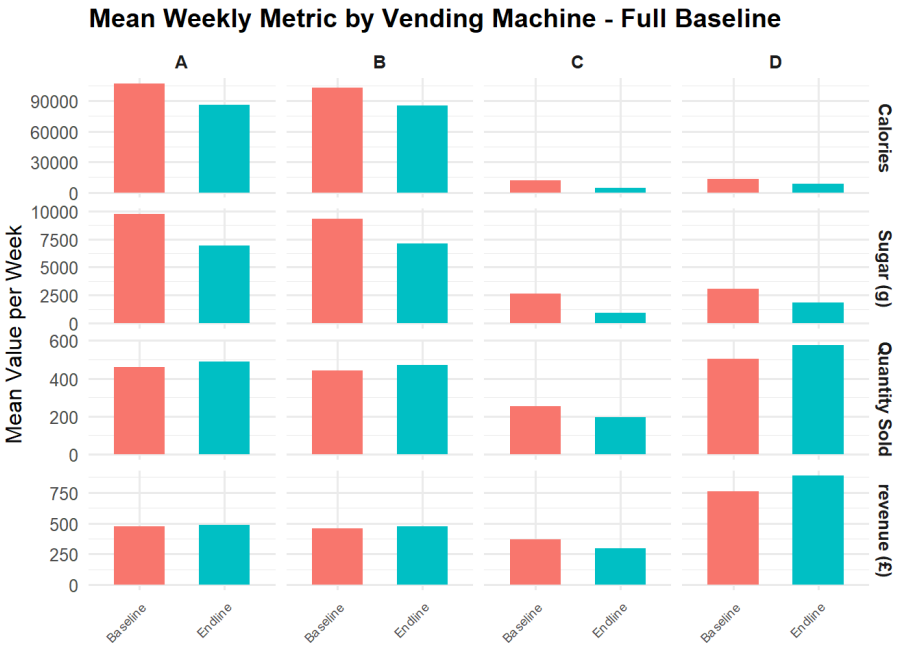


Figure 29: Mean weekly metric by vending machine - 8-week pre-implementation

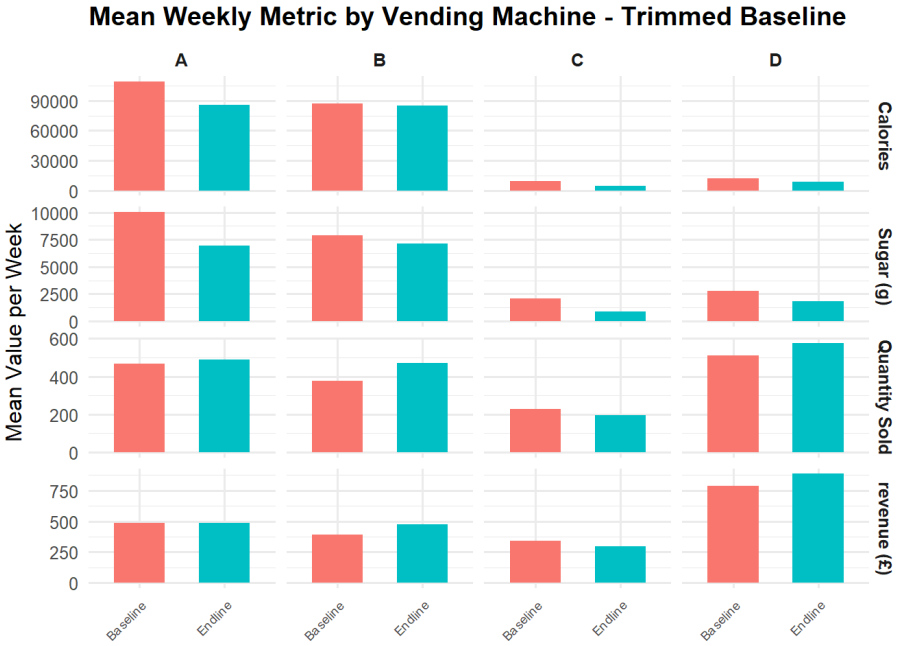


Figure 30: Mean weekly metric by product category - 12-month pre-implementation

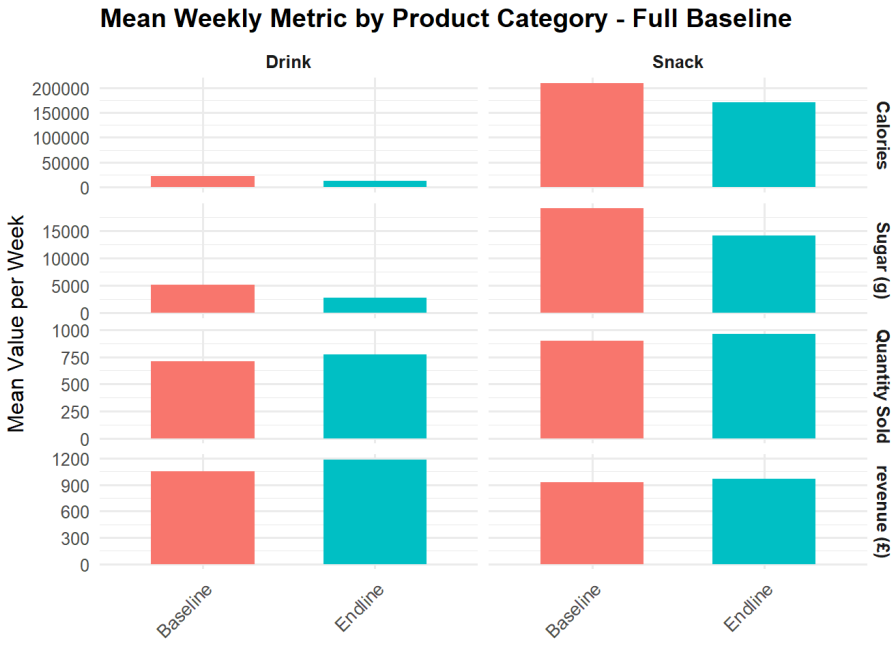
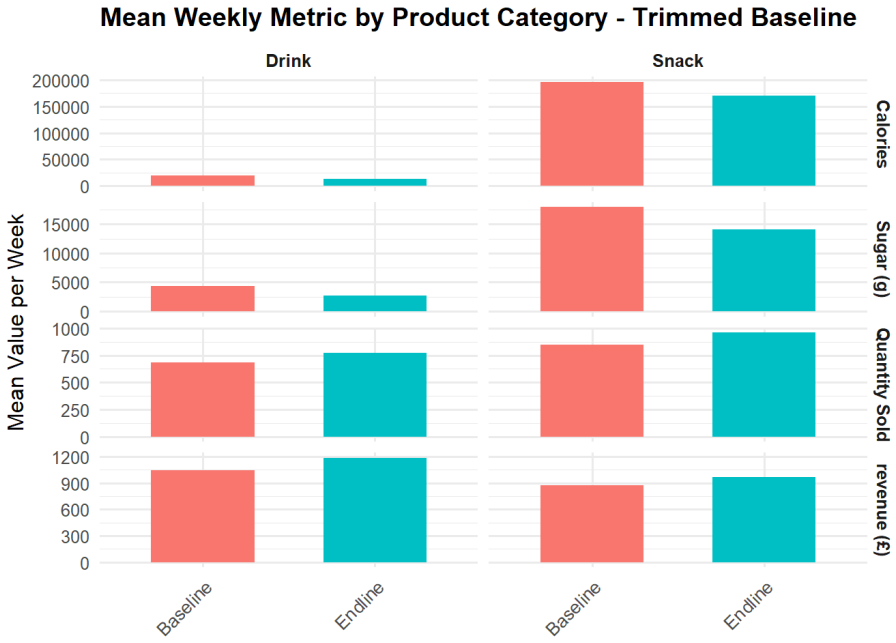


Figure 31: Mean weekly metric by product category - 8-week pre-implementation



PS2

Machine A contains snacks and Machine B contains drinks.

Figure 32: Weekly averages - 5-month pre-implementation

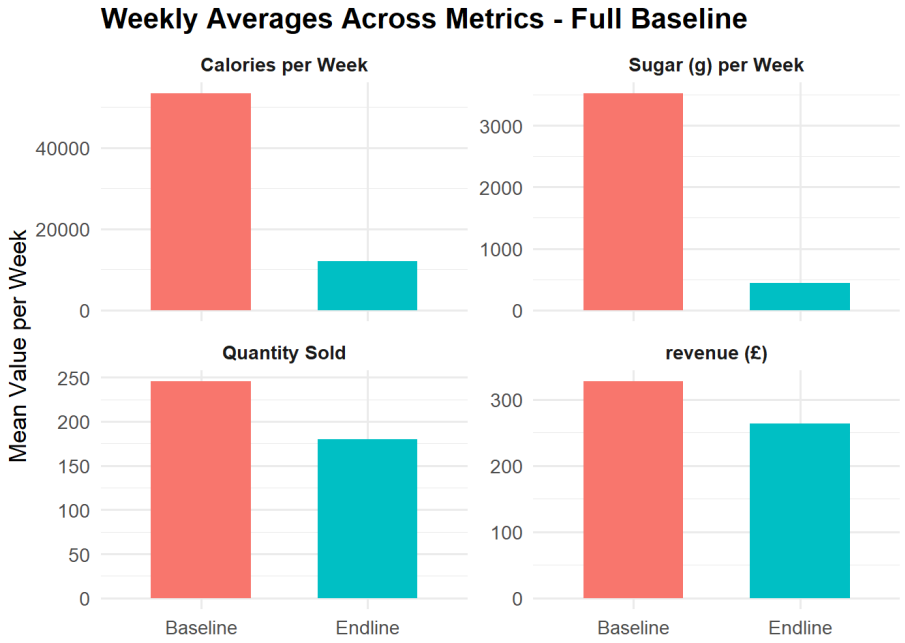


Figure 33: Weekly average across metrics - 8-week pre-implementation

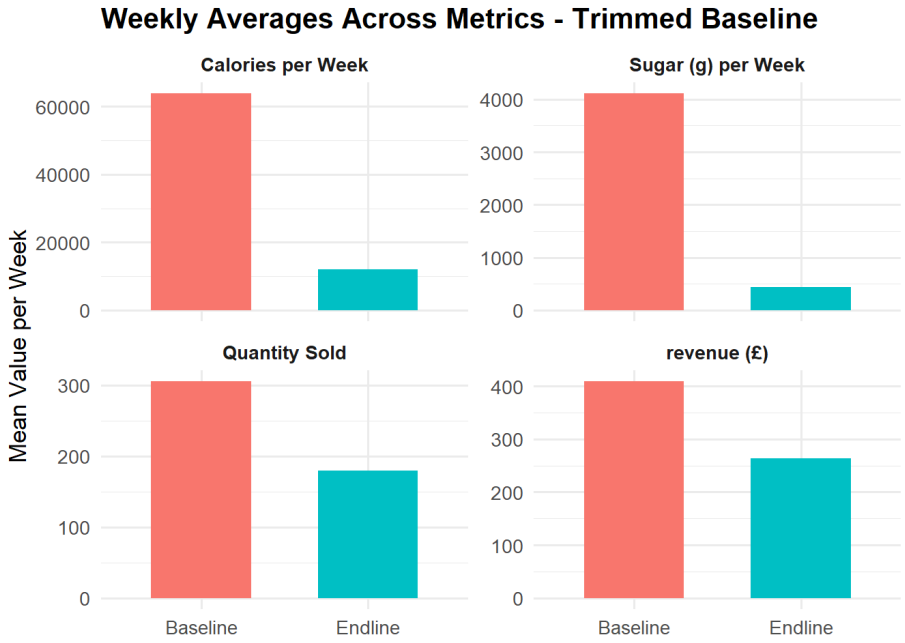


Figure 34: Mean weekly metric by vending machine - 5-month pre-implementation

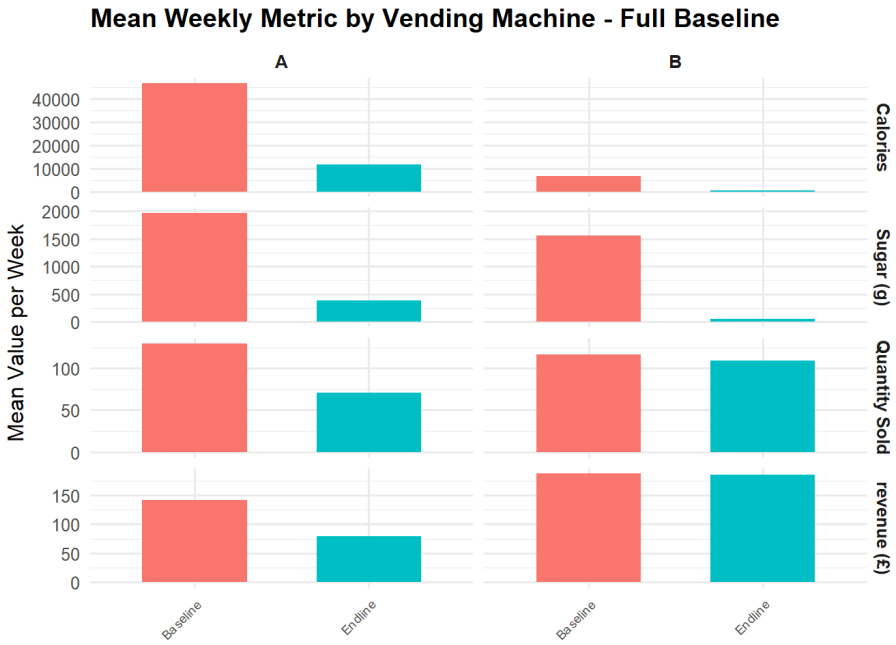


Figure 35: Mean weekly metric by vending machine - 8-week pre-implementation

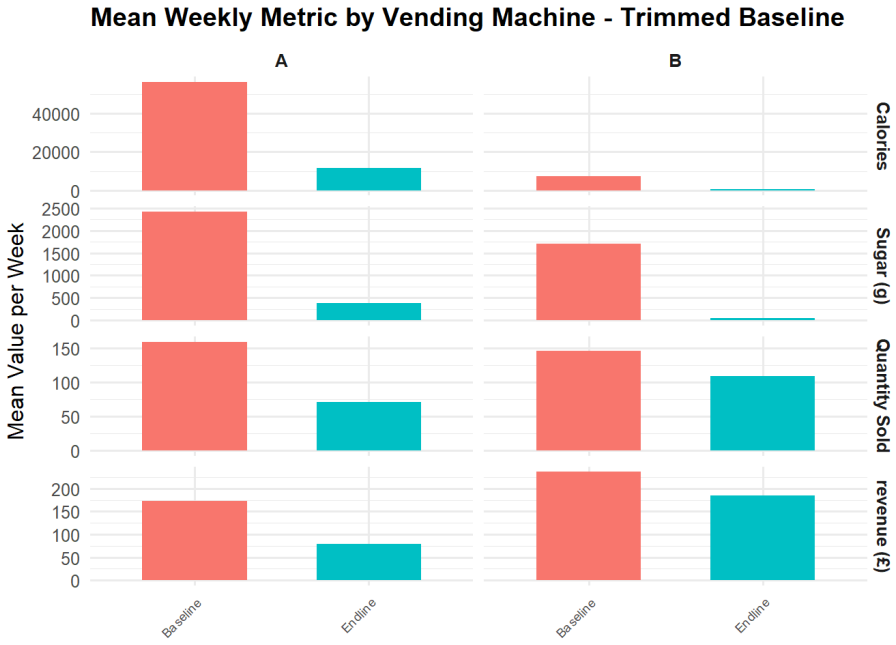


Figure 36: Mean weekly metric by product category - 5-month pre-implementation

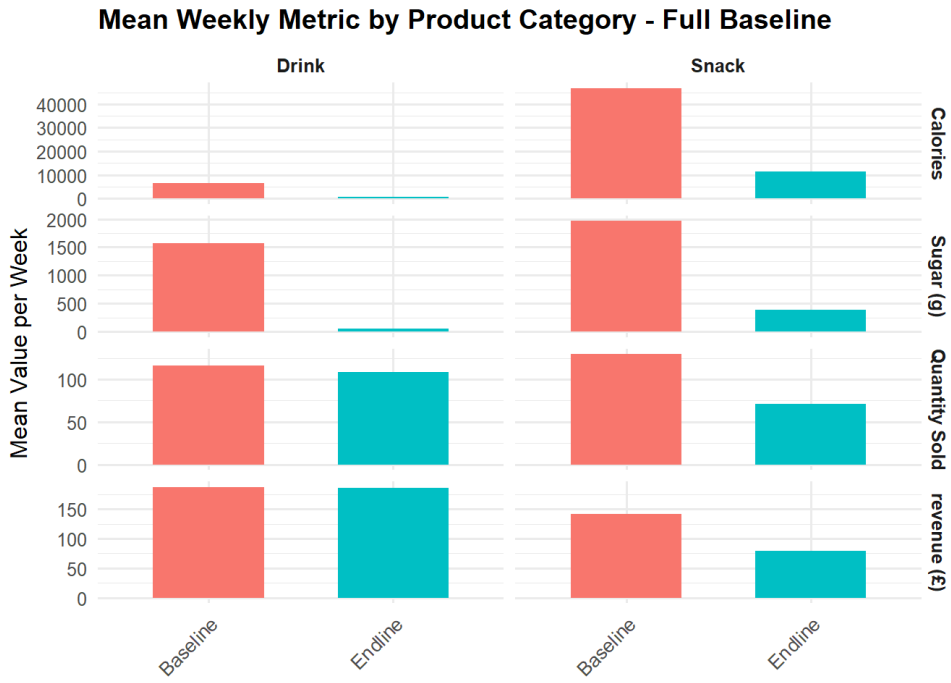
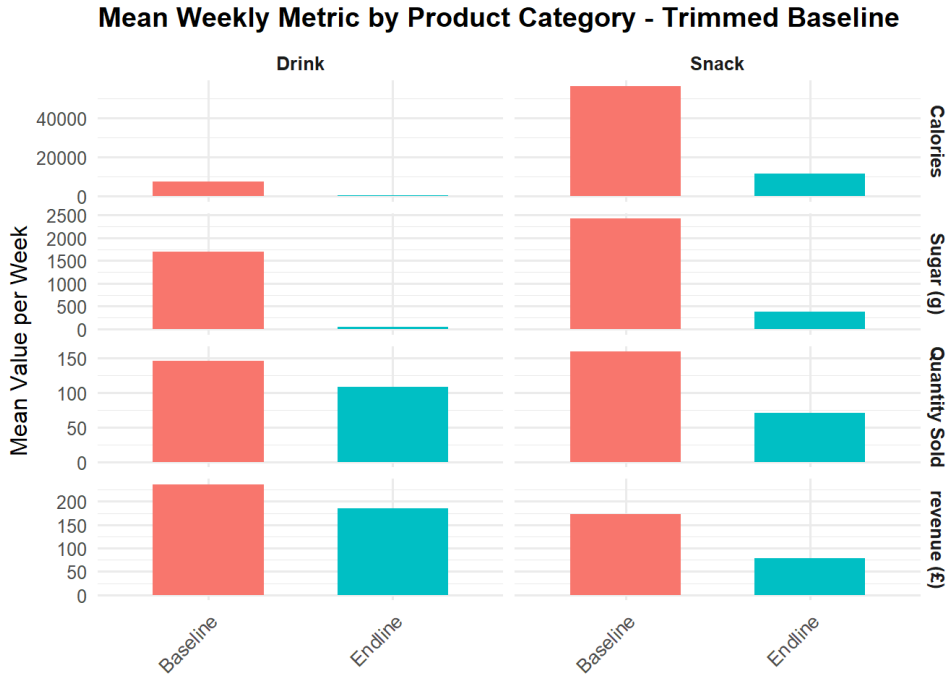


Figure 37: Mean weekly metric by product category - 8-week pre-implementation



PS3

All machines (A, B, C, and D) are mixed snacks and drinks.

Figure 38: Weekly averages across metrics - 10-month pre-implementation

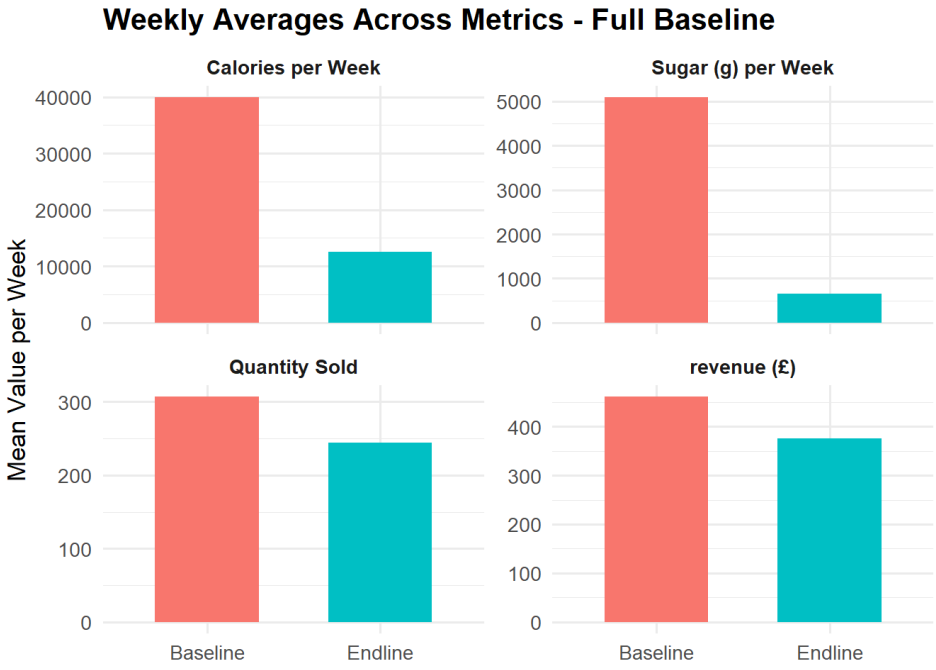


Figure 39: Weekly averages across metrics - 8-week pre-implementation

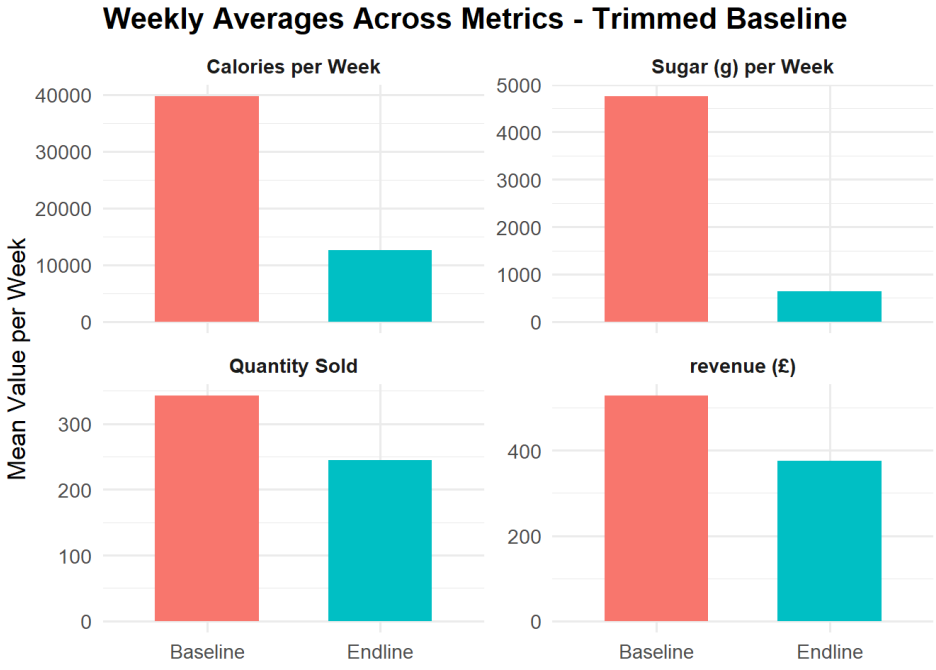


Figure 40: Mean weekly metric by vending machine - 10-month pre-implementation

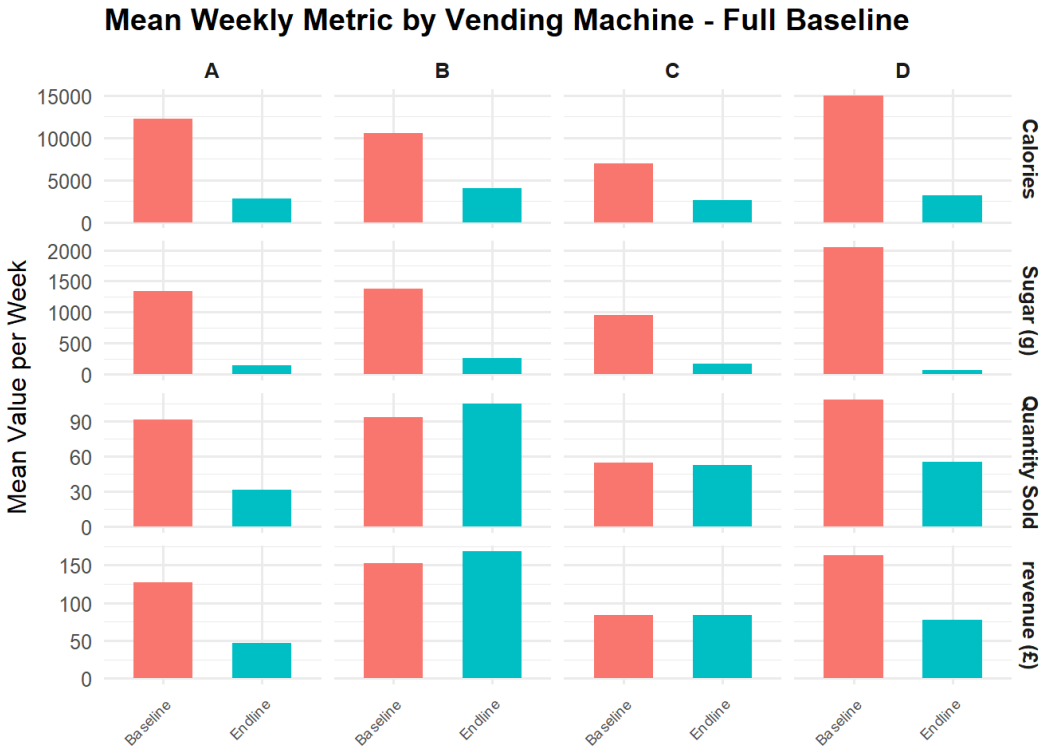


Figure 41: Mean weekly metric by vending machine - 8-week pre-implementation

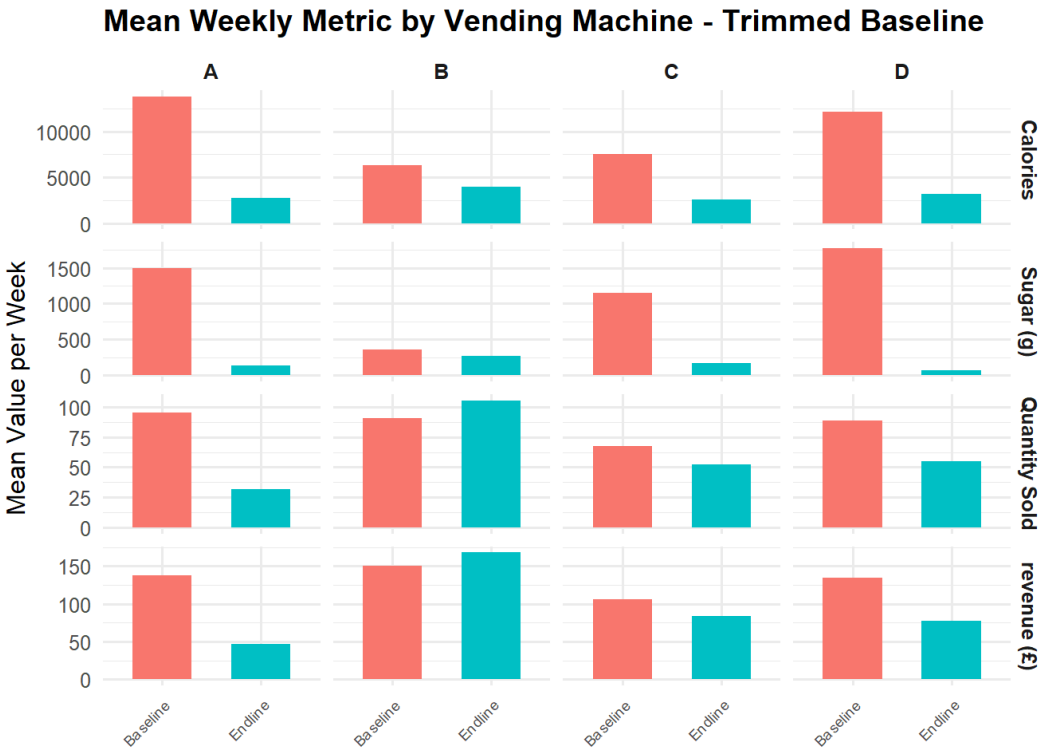


Figure 42: Mean weekly metric by product category - 10-month pre-implementation

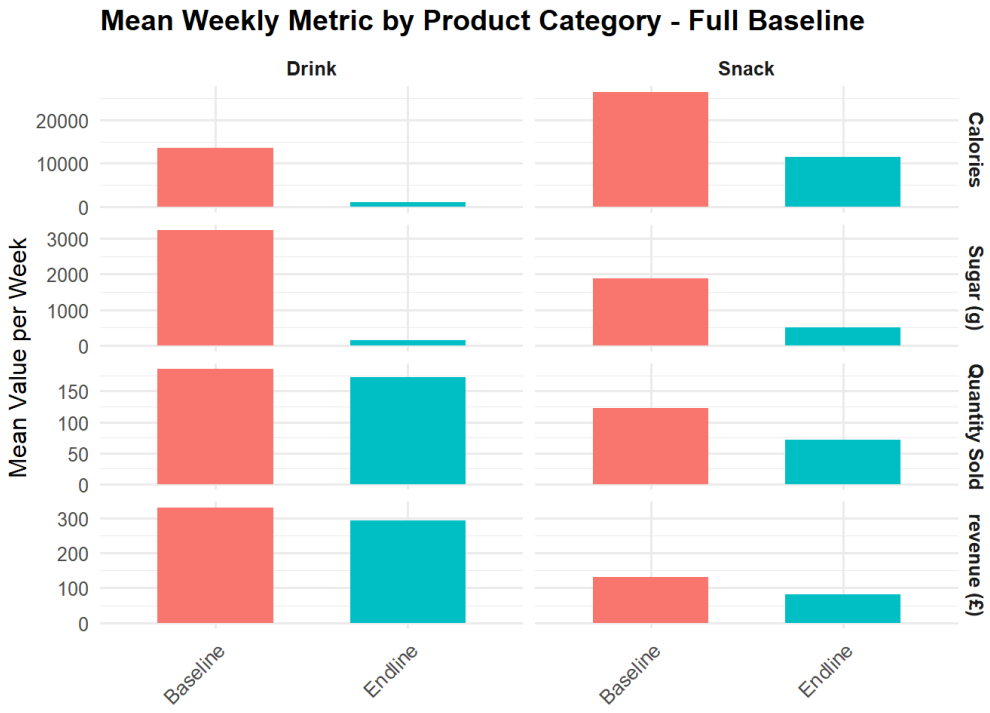
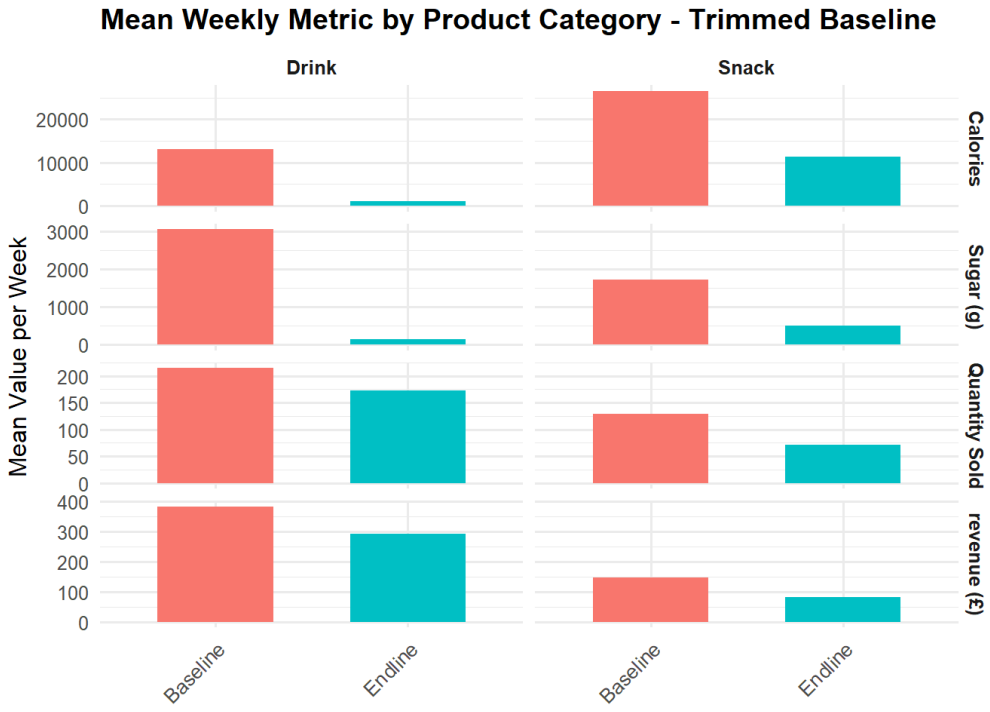


Figure 43: Mean weekly metric by product category - 8-week pre-implementation



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