Exploring Sales on Poshmark

Modeling monthly net earnings collected over
three years from a boutique seller on Poshmark.

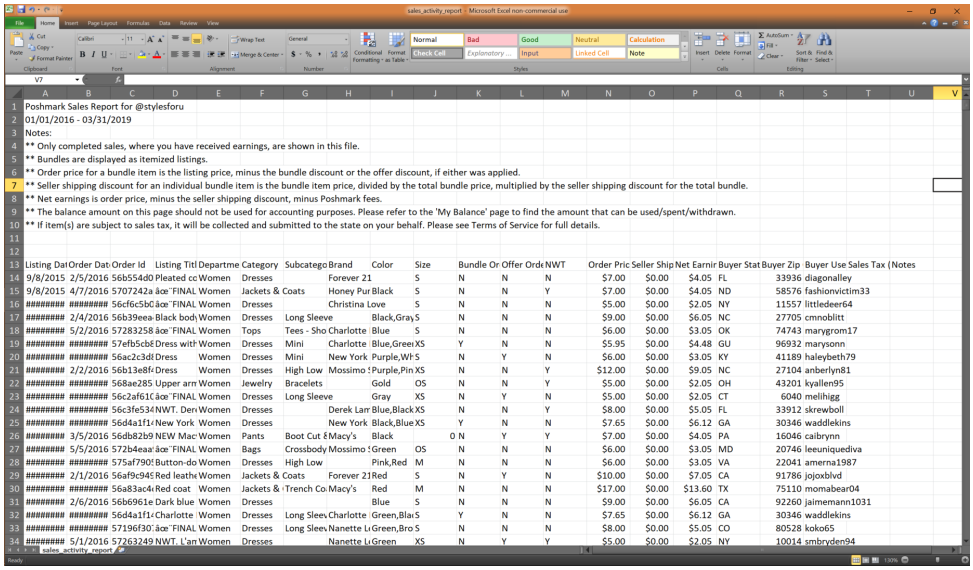
Christian Santizo
STAT 560
Dr. Olga
March 10, 2020

Introduction

What is Poshmark?

Poshmark is a social commerce marketplace established in 2011 where people from United States can buy and sell women's, men's and kids fashion items. The appeal of Poshmark is that you can create your own boutique and shop great deals without leaving the comfort of your own couch!

Motivation



Poshmark Sales Report for @stylesforu
01/01/2016 - 03/31/2019
Notes:
** Only completed sales, where you have received earnings, are shown in this file.
** Bundles are displayed as itemized listings.
** Order price for a bundle item is the listing price, minus the bundle discount or the offer discount, if either was applied.
** Seller shipping discount for an individual bundle item is the bundle item price, divided by the total bundle price, multiplied by the seller shipping discount for the total bundle.
** Net earnings is order price, minus the seller shipping discount, minus Poshmark fees.
** The balance amount on this page should not be used for accounting purposes. Please refer to the 'My Balance' page to find the amount that can be used/spent/withdrawn.
** If item(s) are subject to sales tax, it will be collected and submitted to the state on your behalf. Please see Terms of Service for full details.

Listing Dat	Order Dat	Order Id	Listing Titl	Departme	Category	Subcatego	Brand	Color	Size	Bundle Or	Offer Orde	NWT	Order Pric	Seller Ship	Net Earnir	Buyer Stat	Buyer Zip	Buyer Use	Sales Tax (	Notes
9/8/2015	2/5/2016	56b554d0	Pleated cc	Women	Dresses		Forever 21		S	N	N	N	$7.00	$0.00	$4.05	FL	33936	diagonalley		
9/8/2015	4/7/2016	5707242a	âœ"FINAL	Women	Jackets &	Coats	Honey Pur	Black	S	N	N	Y	$7.00	$0.00	$4.05	ND	58576	fashionvictim33		
########	########	56cf6c5b	âœ"FINAL	Women	Dresses		Christina	Love	S	N	N	N	$5.00	$0.00	$2.05	NY	11557	littledeer64		
########	2/4/2016	56b39eea	Black bod	Women	Dresses	Long Sleeve		Black,Gray	S	N	N	N	$9.00	$0.00	$6.05	NC	27705	cmnoblitt		
########	5/2/2016	57283258	âœ"FINAL	Women	Tops	Tees - Sho	Charlotte	Blue	S	N	N	N	$6.00	$0.00	$3.05	OK	74743	marygrom17		
########	########	57efb5cb	Dress with	Women	Dresses	Mini	Charlotte	Blue,Gree	XS	Y	N	N	$5.95	$0.00	$4.48	GU	96932	marysonn		
########	########	56ac2c3d	Dress	Women	Dresses	Mini	New York	Purple,Wh	S	N	Y	N	$6.00	$0.00	$3.05	KY	41189	haleybeth79		
########	2/2/2016	56b13e8f	Dress	Women	Dresses	High Low	Mossimo	Purple,Pin	XS	N	N	Y	$12.00	$0.00	$9.05	NC	27104	anberlyn81		
########	########	568ae285	Upper arm	Women	Jewelry	Bracelets		Gold	OS	N	N	Y	$5.00	$0.00	$2.05	OH	43201	kyallen95		
########	########	56c2af61	âœ"FINAL	Women	Dresses	Long Sleeve		Gray	XS	N	Y	N	$5.00	$0.00	$2.05	CT	6040	melihigg		
########	########	56c3fe53	4 NWT. Den	Women	Dresses		Derek Lam	Blue,Black	XS	N	N	Y	$8.00	$0.00	$5.05	FL	33912	skrewboll		
########	########	56d4a1f1	New York	Women	Dresses		New York	Black,Blue	XS	N	Y	N	$7.65	$0.00	$6.12	GA	30346	waddlekins		
########	3/5/2016	56db825b	9 NEW Mac	Women	Pants	Boot Cut &	Macy's	Black	0	N	Y	Y	$7.00	$0.00	$4.05	PA	16046	cailbrynn		
########	5/5/2016	572b4eaa	âœ"FINAL	Women	Bags	Crossbody	Mossimo	Green	OS	N	N	N	$6.00	$0.00	$3.05	MD	20746	leeuniquediva		
########	########	575af790	Button-do	Women	Dresses	High Low		Pink,Red	M	N	N	N	$6.00	$0.00	$3.05	VA	22041	amerna1987		
########	2/1/2016	56af9c94	Red leathe	Women	Jackets &	Coats	Forever 21	Red	S	N	Y	N	$10.00	$0.00	$7.05	CA	91786	jojoxblvd		
########	########	56a83ac4	Red coat	Women	Jackets &	Trench Co	Macy's	Red	M	N	N	N	$17.00	$0.00	$13.60	TX	75110	momabear04		
########	2/6/2016	56b6961e	Dark blue	Women	Dresses			Blue	S	N	N	N	$9.00	$0.00	$6.05	CA	92260	jaimemann1031		
########	########	56d4a1f1	Charlotte	Women	Dresses	Long Sleev	Charlotte	Green,Bla	S	Y	N	N	$7.65	$0.00	$6.12	GA	30346	waddlekins		
########	########	57196f30	âœ"FINAL	Women	Dresses	Long Sleev	Nanette L	Green,Bro	S	N	N	N	$8.00	$0.00	$5.05	CO	80528	koko65		
########	5/1/2016	57263249	NWT. L'an	Women	Dresses		Nanette L	Green	XS	N	Y	Y	$5.00	$0.00	$2.05	NY	10014	smbryden94		

Poshmark sales data was made available as of last winter of 2018 to each individual seller. Data such as merchandise category, subcategory, location of purchase by state, and much more are readily available in the sales report. It is left to each Poshmark seller to analyze their data independently. However, the average seller would be overwhelmed with the amount of information the data provides. As a result, most sellers do not take advantage of the data set.

For this analysis, the order date of the when the merchandise was purchased and the net earnings from the sold merchandise were the two variables of interest. The variables were aggregated by months such that monthly net earnings were observed over the months from December 2015 to March 2019. The sales report was provided by Manal Saad, a Poshmark boutique seller (closet handle @stylesforu).

The goal is to see if there is any underlying trends in monthly sales (e.g. seasonal sales). Additionally, it would be in the best interest to find models that give the client an idea of what to expect in the future sales. These models will be constructed by the Locally Estimated Scatterplot Smoothing (LOESS) method and the Thin-plate Smoothing (TPS) Spline method.

Preliminary Analysis

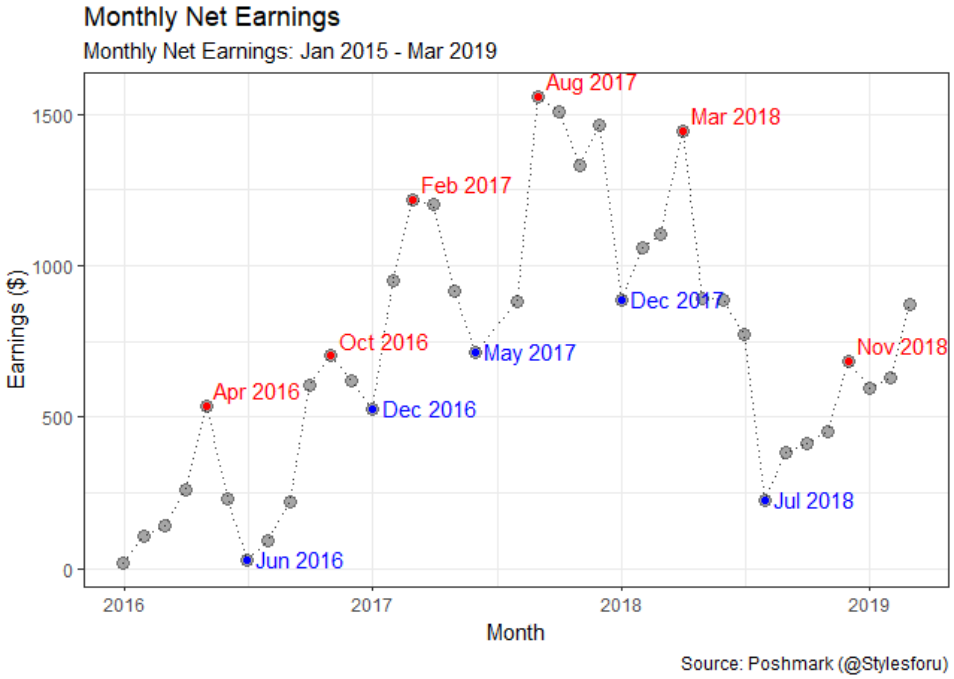
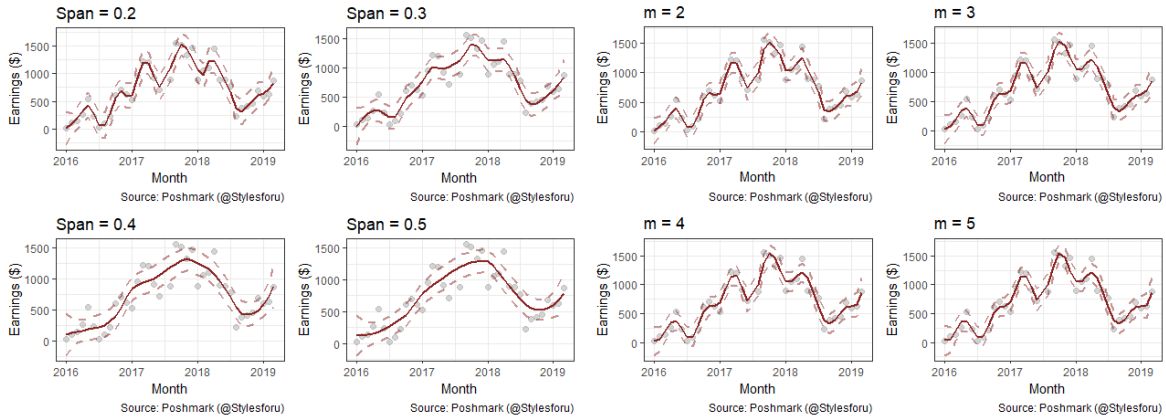


Figure 1: Monthly Net Earnings with lows and highs highlighted in blue and red, respectively.

The scatterplot of Manal's monthly net earnings were plotted against the months from January 2015 to March 2019. It can seen that earnings were volatile; there are several extrema that showcase the buying and selling seasons. Therefore, it would desirable to have a fitted model that captures the periodicity of monthly earnings.

Comparison Between Models



(a) LOESS Regression (b) TPS Spline Regression

Figure 2: Comparison between the two fitted methods.

As it can be seen in Figure 2(a), the LOESS regression produced better results when quadratic functions were fitted versus linear functions. However, the optimal smoothing parameter level was more subject to interpretation. Varies levels of smoothing parameter levels either captured monthly trends (span = 0.2) or yearly trends (span = 0.5).

The different TPS spline curves are displayed in Figure 2(b).The TPS spline regression had little to no change in curvature as the degree of smoothness increased. The curvature of the TPS spline curve is very similar to the LOESS curve with a 20% smoothing parameter level.

Conclusion

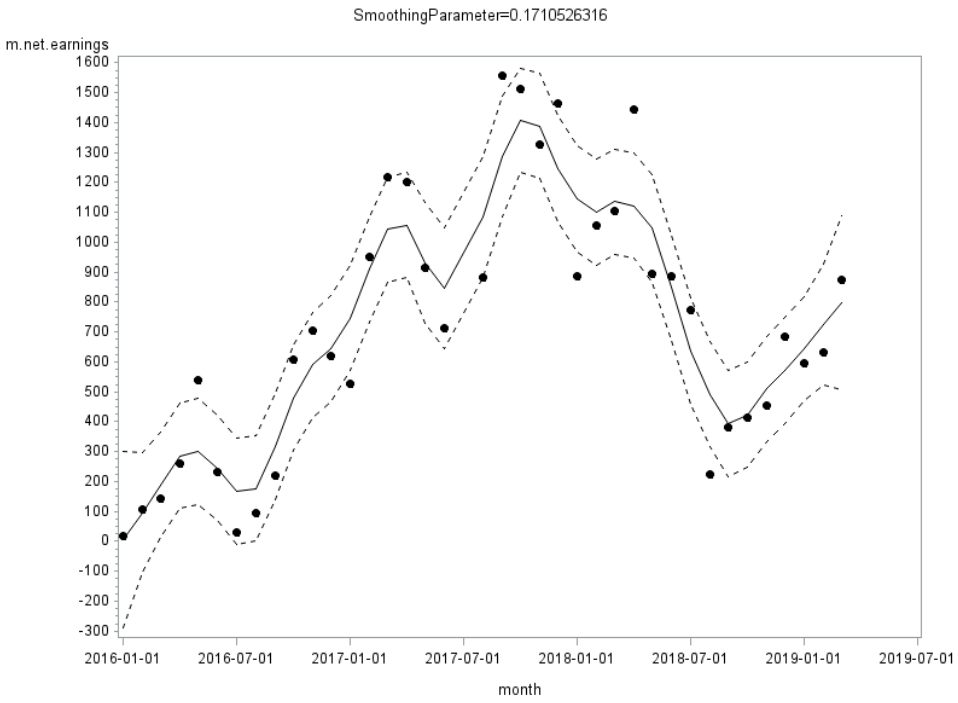
It is difficult to see whether there is a underlying trend monthly sales based on the fitted curves. This can be due to the variability in the seller's sales activity. It for this reason the choice of curve used to predict future sales should be selected by an expert in merchandise sales.

Appendix A: SAS Code and Relevant Output

Here is the code to produce a LOESS regression of degree 1:

```
/* LOESS regression with degree 1 */

proc loess data=rdata;
  model m_net_earnings=month/clm alpha=0.05;
    ods output OutputStatistics=results
run;

symbol1 color=black value=dot;
symbol2 color=black value=none interpol=join line=1;
symbol3 color=black value=none interpol=join line=2;
symbol4 color=black value=none interpol=join line=2;

proc gplot data=results;
  by SmoothingParameter;
    plot (DepVar Pred LowerCL UpperCL)*month/ overlay;
run;
```

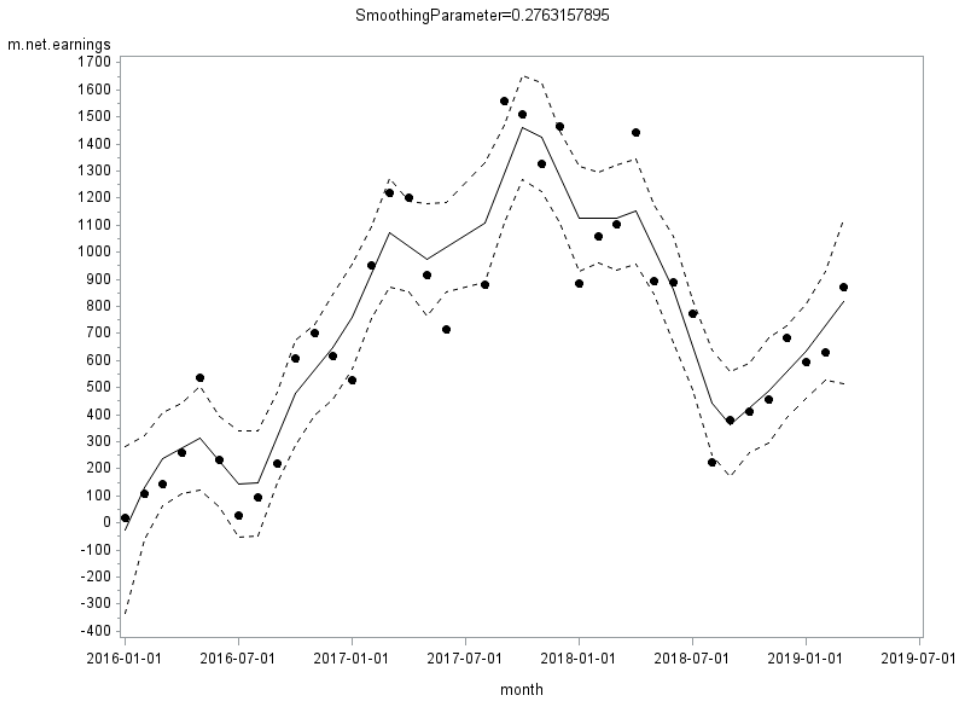
Here is the output:



Here is the code to produce a LOESS regression of degree 2:

```
/* LOESS regression with degree 2 */

proc loess data=rdata;
  model m_net_earnings=month/degree=2 clm alpha=0.05;
    ods output OutputStatistics=results;
run;

proc gplot data=results;
  by SmoothingParameter;
    plot (DepVar Pred LowerCL UpperCL)*month/ overlay;
run;
```

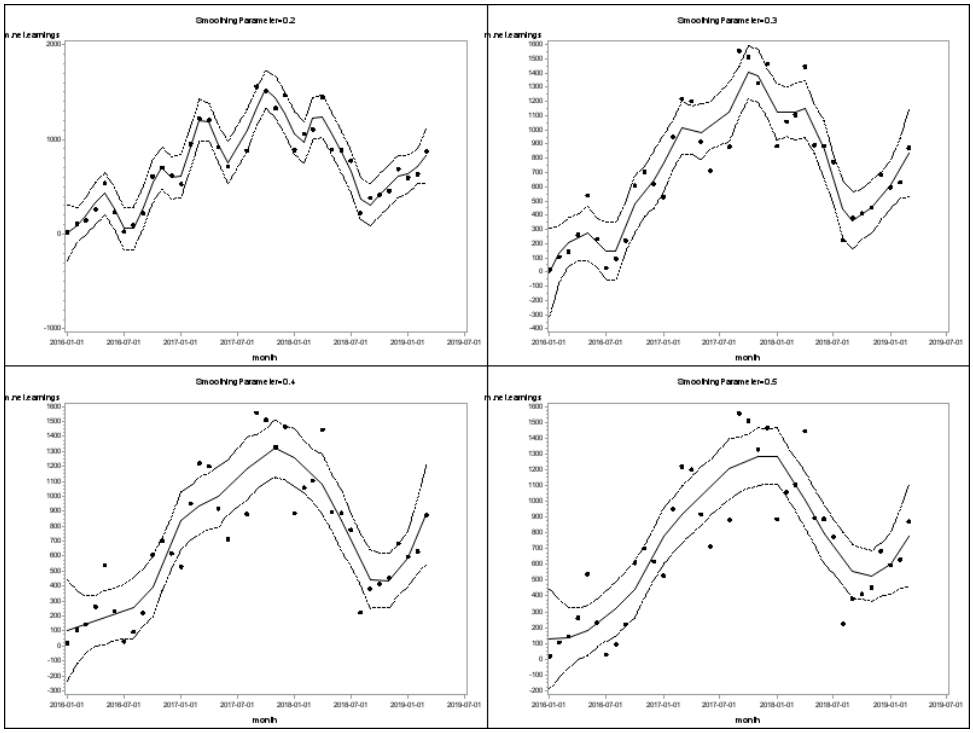
Here is the output:



Here is the code to produce a LOESS regression of degree 2 with different smoothing parameters:

```
/* LOESS regressions (degree 2) with different smoothing parameters */

proc loess data=rdata;
  model m_net_earnings=month/degree=2 clm smooth =0.2 0.3 0.4 0.5;
    ods output OutputStatistics=results;
run;

proc gplot data=results;
  by SmoothingParameter;
    plot (DepVar Pred LowerCL UpperCL)*month/ overlay name='graph';
run;

goption display;
proc greplay nofs tc=sashelp.templt template=l2r2;
  igout gseg;
    treplay 1:graph 2:graph2 3:graph1 4:graph3;
run;
quit;
```

Here is the output:

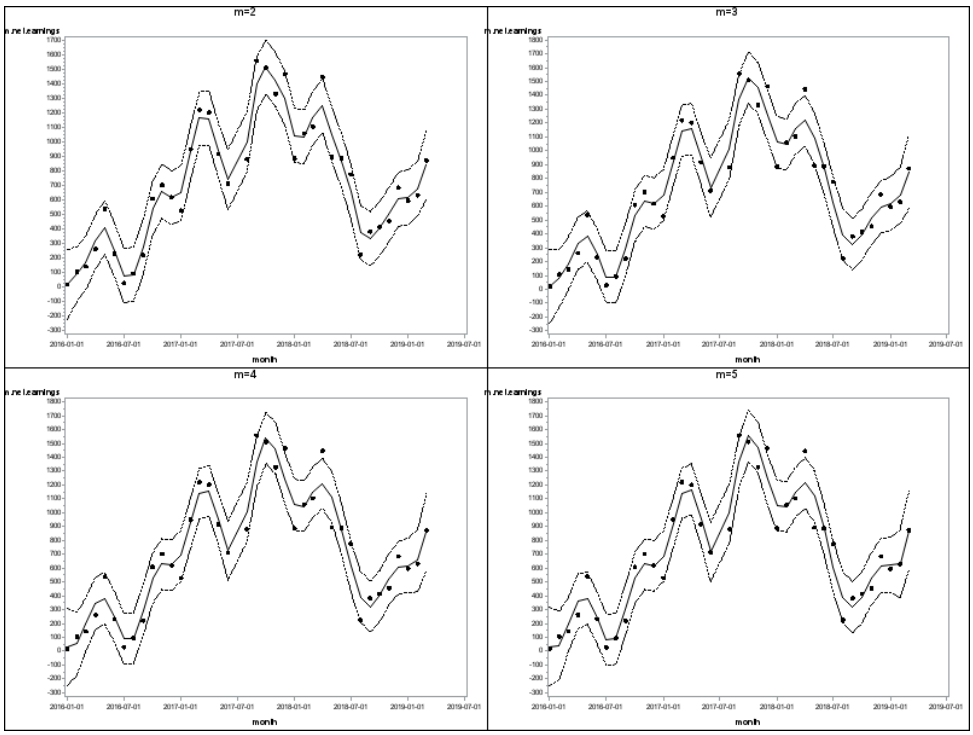


Here is the code to produces TPS spline regressions with different degrees of smoothness:

```
/*SPLINE ESTIMATION PROCEDURE , M=2*/

proc tpspline data=rdata;
  model m_net_earnings=(month)/m=2;
    output out=result pred lclm uclm;
run;

title 'm=2';
symbol1 color=black value=dot;
symbol2 color=black value=none interpol=join line=1;
symbol3 color=black value=none interpol=join line=2;
symbol4 color=black value=none interpol=join line=2;

proc gplot data=result;
  plot (m_net_earnings p_m_net_earnings lclm_m_net_earnings uclm_m_net_earnings)*month/
    overlay name='graph2';
run;

/*SPLINE ESTIMATION PROCEDURE , M=3*/

proc tpspline data=rdata;
  model m_net_earnings=(month)/m=3;
    output out=result pred lclm uclm;
run;

title 'm=3';
proc gplot data=result;
  plot (m_net_earnings p_m_net_earnings lclm_m_net_earnings uclm_m_net_earnings)*month/
    overlay name='graph3';
run;

/*SPLINE ESTIMATION PROCEDURE , M=4*/
```

```
proc tpspline data=rdata;
  model m_net_earnings=(month)/m=4;
    output out=result pred lclm uclm;
run;

title 'm=4';
proc gplot data=result;
  plot (m_net_earnings p_m_net_earnings lclm_m_net_earnings uclm_m_net_earnings)*month/
    overlay name='graph4';
run;

/*SPLINE ESTIMATION PROCEDURE , M=5*/

proc tpspline data=rdata;
  model m_net_earnings=(month)/m=5;
    output out=result pred lclm uclm;
run;

title 'm=5';
proc gplot data=result;
  plot (m_net_earnings p_m_net_earnings lclm_m_net_earnings uclm_m_net_earnings)*month/
    overlay name='graph5';
run;

/* Display the four TPS curves */

goption display;
proc greplay nofs tc=sashelp.templt template=l2r2;
  igout gseg;
    treplay 1:graph2 2:graph4 3:graph3 4:graph5;
run;
```

Here is the output:

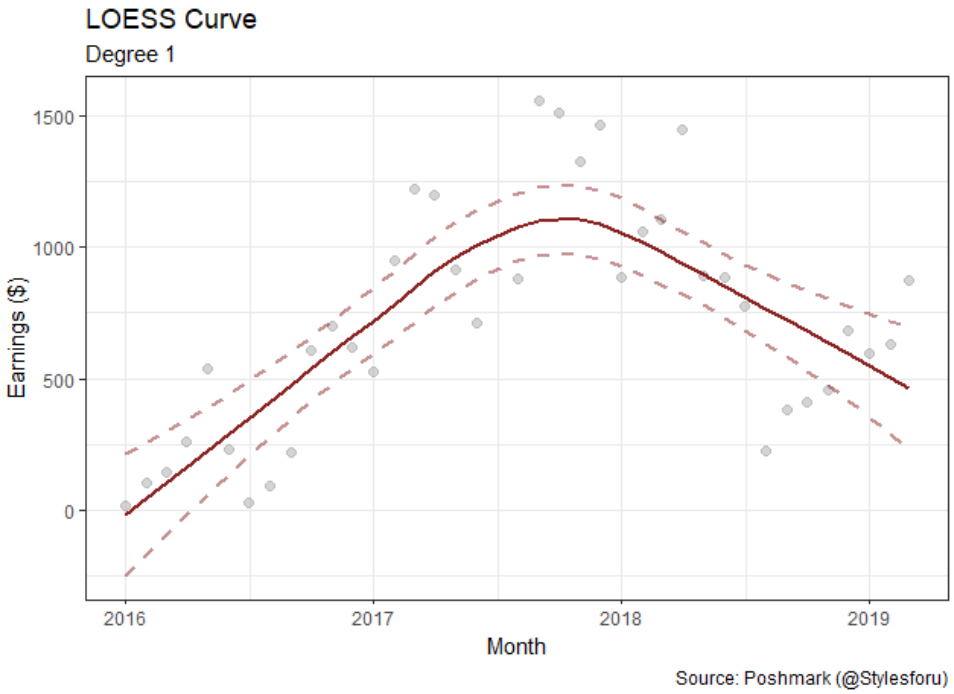


Appendix B: R Code and Relevant Output

Here is the code to produce a LOESS regression of degree 1:

```
## Create LOESS fitted values

library(ggplot2)
library(dplyr)
library('fANCOVA')

p.loess1 = loess.as(dd.m$month, dd.m$m.net.earnings, degree=1, criterion = c("aicc", "gcv")[1],
    plot = FALSE)
aicc_value1 = p.loess1$pars$span
fit1.p = predict(loess(m.net.earnings ~ as.numeric(month), degree=1, span = aicc_value1, data=dd.
    m), se=TRUE)
## Plot LOESS curves (degree 1) with 95% confidence bands

dd.m %>% mutate(smooth_1 = fit1.p$fit, LB = fit1.p$fit - qt(0.975, fit1.p$df)*fit1.p$se, UB =
    fit1.p$fit + qt(0.975, fit1.p$df)*fit1.p$se) %>%
  ggplot(aes(month, m.net.earnings)) +
  theme_bw() +
  labs(title = "LOESS Curve", subtitle = "Degree 1") +
  labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
  geom_point(size = 2, alpha = .5, color = "darkgrey") +
  geom_line(aes(month, smooth_1), color = "brown4",size = 1) +
  geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
  geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)
```

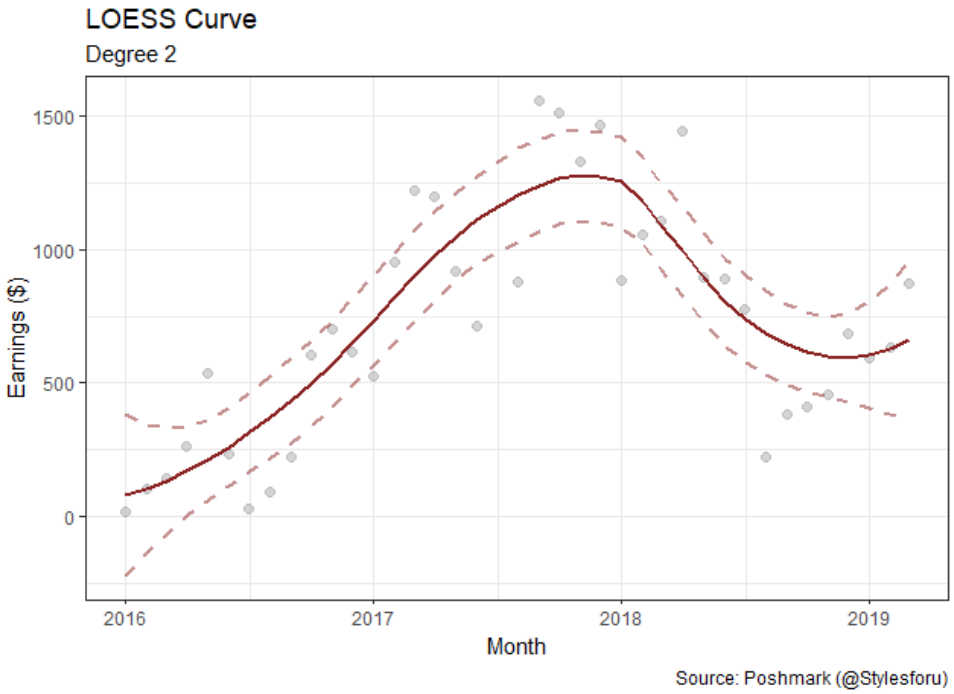
Here is the output:



Here is the code to produce a LOESS regression of degree 2:

```
## Create LOESS fitted values

library(ggplot2)
library(dplyr)
library('fANCOVA')
p.loess2 = loess.as(dd.m$month, dd.m$m.net.earnings, degree=2, criterion = c("aicc", "gcv")[1],
    plot = FALSE)
aicc_value2 = p.loess2$pars$span
fit2.p = predict(loess(m.net.earnings ~ as.numeric(month), degree=2, span = aicc_value2, data=dd.
    m), se=TRUE)
## Plot LOESS curves (degree 2) with 95% confidence bands

dd.m %>% mutate(smooth_2 = fit2.p$fit, LB = fit2.p$fit - qt(0.975, fit2.p$df)*fit2.p$se, UB =
    fit2.p$fit + qt(0.975, fit2.p$df)*fit2.p$se) %>%
  ggplot(aes(month, m.net.earnings)) +
  theme_bw() +
  labs(title = "LOESS Curve", subtitle = "Degree 2") +
  labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
  geom_point(size = 2, alpha = .5, color = "darkgrey") +
  geom_line(aes(month, smooth_2), color = "brown4",size = 1) +
  geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
  geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)
```

Here is the output:

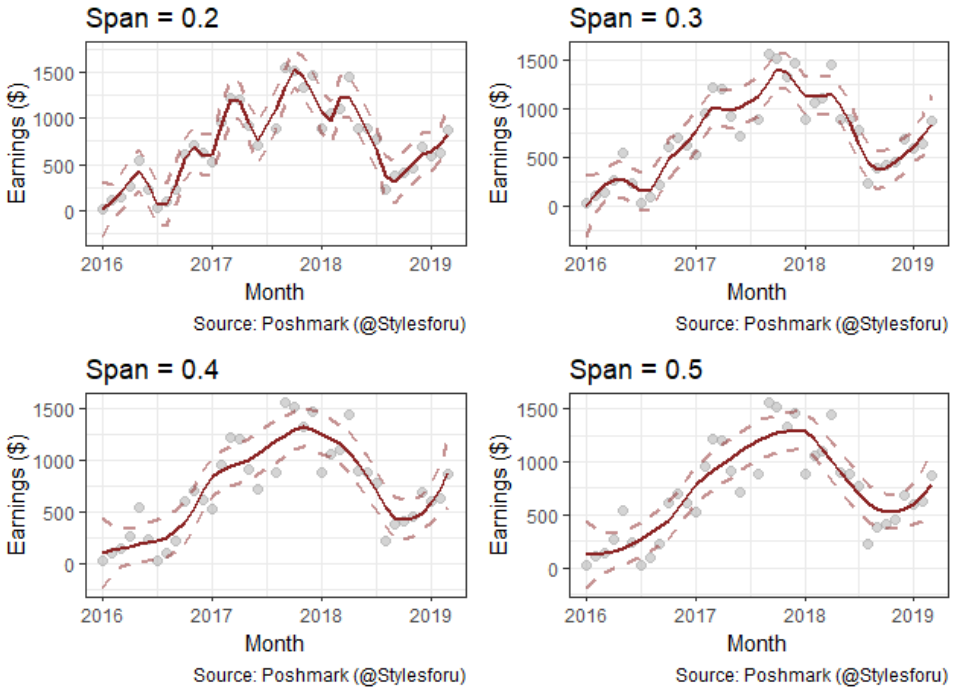


Here is the code to produce a LOESS regression of degree 2 with different smoothing parameters:

```
## Plot LOESS curves (degree 2) with different span values


# span = 0.2

plx1 = predict(loess(m.net.earnings ~ as.numeric(month), degree=2, span = 0.2, data=dd.m), se=
    TRUE)

p1 = dd.m %>% mutate(smooth_2 = plx1$fit, LB = plx1$fit - qt(0.975, plx1$df)*plx1$se, UB = plx1$
    fit + qt(0.975, plx1$df)*plx1$se) %>%
  ggplot(aes(month, m.net.earnings)) +
  theme_bw() +
  labs(title = "Span = 0.2") +
  labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
  geom_point(size = 2, alpha = .5, color = "darkgrey") +
  geom_line(aes(month, smooth_2), color = "brown4",size = 1) +
  geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
  geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)

# span = 0.3

plx2 = predict(loess(m.net.earnings ~ as.numeric(month), degree=2, span = 0.3, data=dd.m), se=
    TRUE)

p2 = dd.m %>% mutate(smooth_2 = plx2$fit, LB = plx2$fit - qt(0.975, plx2$df)*plx2$se, UB = plx2$
    fit + qt(0.975, plx2$df)*plx2$se) %>%
  ggplot(aes(month, m.net.earnings)) +
  theme_bw() +
  labs(title = "Span = 0.3") +
  labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
  geom_point(size = 2, alpha = .5, color = "darkgrey") +
  geom_line(aes(month, smooth_2), color = "brown4",size = 1) +
  geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
  geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)

# span = 0.4

plx3 = predict(loess(m.net.earnings ~ as.numeric(month), degree=2, span = 0.4, data=dd.m), se=
```

```
      TRUE)

p3 = dd.m %>% mutate(smooth_2 = plx3$fit, LB = plx3$fit - qt(0.975, plx3$df)*plx3$se, UB = plx3$
      fit + qt(0.975, plx3$df)*plx3$se) %>%
  ggplot(aes(month, m.net.earnings)) +
  theme_bw() +
  labs(title = "Span = 0.4") +
  labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
  geom_point(size = 2, alpha = .5, color = "darkgrey") +
  geom_line(aes(month, smooth_2), color = "brown4",size = 1) +
  geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
  geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)


# span = 0.5

plx4 = predict(loess(m.net.earnings ~ as.numeric(month), degree=2, span = 0.5, data=dd.m), se=
      TRUE)

p4 = dd.m %>% mutate(smooth_2 = plx4$fit, LB = plx4$fit - qt(0.975, plx4$df)*plx4$se, UB = plx4$
      fit + qt(0.975, plx4$df)*plx4$se) %>%
  ggplot(aes(month, m.net.earnings)) +
  theme_bw() +
  labs(title = "Span = 0.5") +
  labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
  geom_point(size = 2, alpha = .5, color = "darkgrey") +
  geom_line(aes(month, smooth_2), color = "brown4",size = 1) +
  geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
  geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)


multiplot(p1, p3, p2, p4, cols = 2) # Plots the four graphs into one plane
```

Here is the output:



Here is the code to produces TPS spline regressions with different degrees of smoothness:

```
## Plot TPS curve with different smoothing parameters on Monthly Net Earnings against Monthly orders

library(ggplot2)
library(dplyr)
library(fields)


# m = 2

earnings.tps1 = Tps(as.numeric(dd.m$month), dd.m$m.net.earnings, m=2, method="GCV")

earnings.se1 = predictSE(earnings.tps1)

t1 = dd.m %>% mutate(smooth_1 = earnings.tps1$fitted.values,
                LB = earnings.tps1$fitted.values - qt(0.975, earnings.tps1$eff.df)*earnings.se1,
                UB = earnings.tps1$fitted.values + qt(0.975, earnings.tps1$eff.df)*earnings.se1) %>%
      ggplot(aes(month, m.net.earnings)) +
      theme_bw() +
      labs(title = "m = 2") +
      labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
      geom_point(size = 2, alpha = .5, color = "darkgrey") +
      geom_line(aes(month, smooth_1), color = "brown4",size = 1) +
      geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
      geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)

# m = 3

earnings.tps2 = Tps(as.numeric(dd.m$month), dd.m$m.net.earnings, m=3, method="GCV")

earnings.se2 = predictSE(earnings.tps2)


t2 = dd.m %>% mutate(smooth_2 = earnings.tps2$fitted.values,
                     LB = earnings.tps1$fitted.values - qt(0.975, earnings.tps2$eff.df)*earnings.se2,
                     UB = earnings.tps1$fitted.values + qt(0.975, earnings.tps2$eff.df)*earnings.se2) %>%
      ggplot(aes(month, m.net.earnings)) +
      theme_bw() +
      labs(title = "m = 3") +
      labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
      geom_point(size = 2, alpha = .5, color = "darkgrey") +
      geom_line(aes(month, smooth_2), color = "brown4",size = 1) +
      geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
      geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)

# m = 4

earnings.tps3 = Tps(as.numeric(dd.m$month), dd.m$m.net.earnings, m=4, method="GCV")

earnings.se3 = predictSE(earnings.tps3)


t3 = dd.m %>% mutate(smooth_3 = earnings.tps3$fitted.values,
                     LB = earnings.tps3$fitted.values - qt(0.975, earnings.tps3$eff.df)*earnings.se3,
                     UB = earnings.tps3$fitted.values + qt(0.975, earnings.tps3$eff.df)*earnings.se3) %>%
      ggplot(aes(month, m.net.earnings)) +
      theme_bw() +
      labs(title = "m = 4") +
      labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
      geom_point(size = 2, alpha = .5, color = "darkgrey") +
      geom_line(aes(month, smooth_3), color = "brown4",size = 1) +
      geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
      geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)
```

```
63
64 # m = 5
65
66 earnings.tps4 = Tps(as.numeric(dd.m$month), dd.m$m.net.earnings, m=5, method="GCV")
67
68 earnings.se4 = predictSE(earnings.tps4)
69
70
71 t4 = dd.m %>% mutate(smooth_4 = earnings.tps4$fitted.values,
72                      LB = earnings.tps4$fitted.values - qt(0.975, earnings.tps4$eff.df)*earnings.
                            se4,
73                      UB = earnings.tps4$fitted.values + qt(0.975, earnings.tps4$eff.df)*earnings.
                            se4) %>%
74   ggplot(aes(month, m.net.earnings)) +
75   theme_bw() +
76   labs(title = "m = 5") +
77   labs(x = "Month", y = "Earnings ($)", caption="Source: Poshmark (@Stylesforu)") +
78   geom_point(size = 2, alpha = .5, color = "darkgrey") +
79   geom_line(aes(month, smooth_4), color = "brown4",size = 1) +
80   geom_line(aes(month, LB), color = "brown4", size = 1, linetype = "dashed", alpha = .5) +
81   geom_line(aes(month, UB), color = "brown4", size = 1, linetype = "dashed", alpha = .5)
82
83
84 multiplot(t1, t3, t2, t4, cols = 2) # Plots the four graphs into one plane
```

Here is the output: