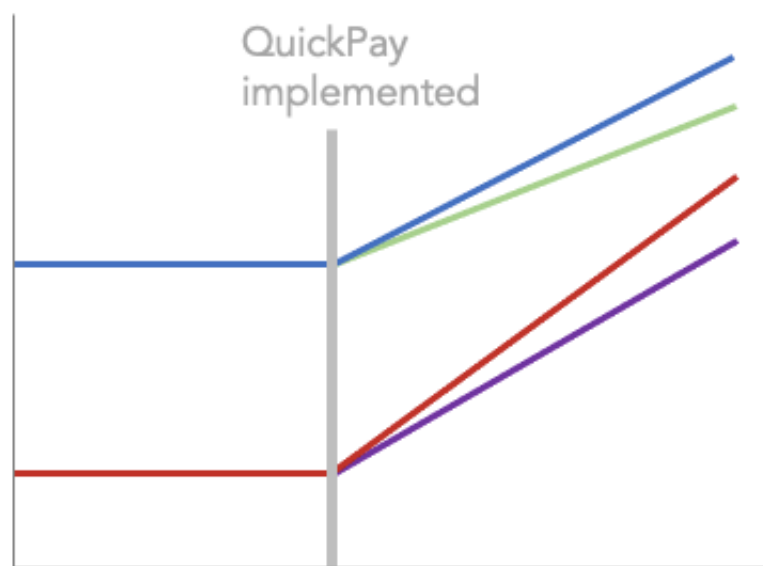


# Effect of Aggressive Competition

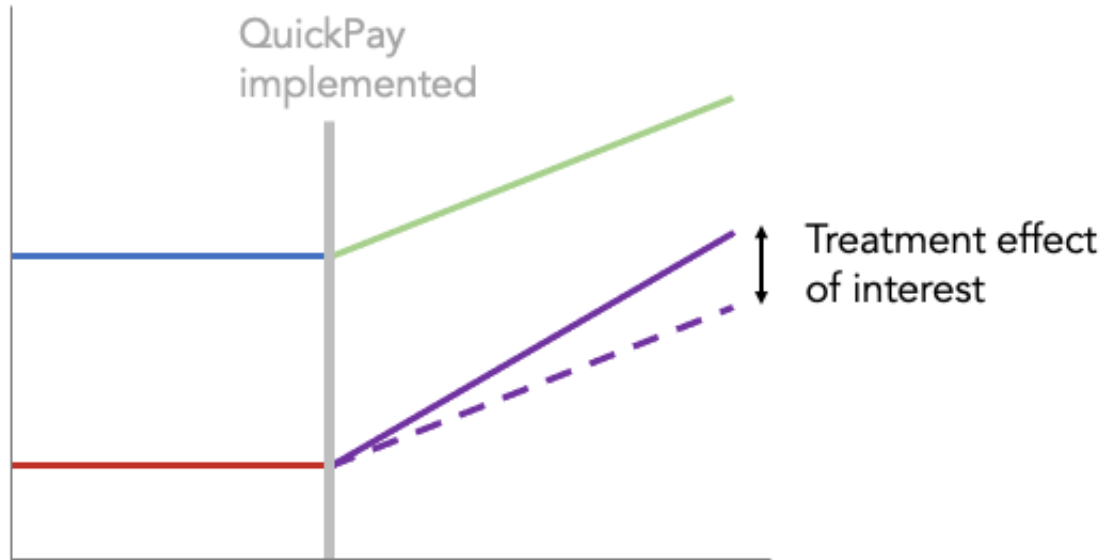
## Hypothesis:

- QuickPay increased competition for small projects.
- This led to more aggressive bids. That is, contractors quoted unrealistically small timelines for the projects.
- As a result, we should see “artificial delays” on these projects as they revert to their realistic timelines later.
- **Note:** This hypothesis only applies to projects that were signed after QuickPay. See Figure below for different groups in the sample.



Large projects signed before QuickPay  
Large projects signed after QuickPay  
Small projects signed before QuickPay  
Small projects signed after QuickPay

- We, therefore, need the effect coming from new projects.



Large projects signed before QuickPay  
 Large projects signed after QuickPay  
 Small projects signed before QuickPay  
 Small projects signed after QuickPay

## Subsample Model

For a subsample of competitive or noncompetitive projects:

$$\begin{aligned}
 Delay_{it} = & \beta_0 + \beta_1 Treat_i + \beta_2 StartedAfterQP_i + \beta_3 Post_t \\
 & + \beta_4 (Treat_i \times Post_t \times StartedAfterQP_i) + \epsilon_{it}
 \end{aligned}$$

- Note:  $Post_t = 0 \implies StartedAfterQP_i = 0$ 
  - These projects don't exist in the period before QuickPay

	Before QP	After QP	Difference
Small Projects	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4$	$\beta_2 + \beta_3 + \beta_4$
Large Projects	$\beta_0$	$\beta_0 + \beta_2 + \beta_3$	$\beta_2 + \beta_3$
<b>Difference</b>	$\beta_1$	$\beta_1 + \beta_4$	<b>Treatment Effect: <math>\beta_4</math></b>

According to our hypothesis,  $\beta_4$  should be positive and significant for competitive projects, and insignificant for non-competitive projects.

## Combined Model

- The model below will give the same result as subsample analysis, but also allow us to test whether difference between the two treatment effects is statistically significant.

$$\begin{aligned}
Delay_{it} = & \beta_0 + \beta_1 Treat_i + \beta_2 StartedAfterQP_i + \beta_3 Post_t + \beta_4 Competitive_i \\
& + \beta_5 (Treat_i \times Competitive_i) + \beta_6 (Post_t \times Competitive_i) \\
& + \beta_7 (StartedAfterQP_i \times Competitive_i) + \beta_8 (Treat_i \times Post_t \times StartedAfterQP_i) \\
& + \beta_9 (Treat_i \times Post_t \times StartedAfterQP_i \times Competitive_i) + \epsilon_{it}
\end{aligned}$$

- Note:  $Post_t = 0 \implies StartedAfterQP_i = 0$ 
  - These projects don't exist in the period before QuickPay

For non-competitive projects:

	Before QP	After QP	Difference
Small Projects	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_8$	$\beta_2 + \beta_3 + \beta_8$
Large Projects	$\beta_0$	$\beta_0 + \beta_2 + \beta_3$	$\beta_2 + \beta_3$
<b>Difference</b>	$\beta_1$	$\beta_1 + \beta_8$	<b>Treatment Effect: <math>\beta_8</math></b>

For competitive projects:

	Before QP	After QP	Difference
Small Projects	$\beta_0 + \beta_1 + \beta_4 + \beta_5$	$\sum_{i=0}^9 \beta_i$	$\beta_2 + \beta_3 + \beta_6 + \beta_7 + \beta_8 + \beta_9$
Large Projects	$\beta_0 + \beta_4$	$\beta_0 + \beta_2 + \beta_3 + \beta_4 + \beta_6 + \beta_7$	$\beta_2 + \beta_3 + \beta_6 + \beta_7$
<b>Difference</b>	$\beta_1 + \beta_5$	$\beta_1 + \beta_5 + \beta_8 + \beta_9$	<b>Treatment Effect: <math>\beta_8 + \beta_9</math></b>

According to our hypothesis,  $\beta_9$  should be positive and significant. That is the difference in treatment effect for competitive and non-competitive projects is significant.

## Combined Model with Old Projects

$$\begin{aligned}
Delay_{it} = & \beta_0 + \beta_1 Treat_i + \beta_2 StartedAfterQP_i + \beta_3 Post_t + \beta_4 Competitive_i \\
& + \beta_5 (Treat_i \times Competitive_i) + \beta_6 (Post_t \times Competitive_i) \\
& + \beta_7 (StartedAfterQP_i \times Competitive_i) + \beta_8 (Treat_i \times Post_t) \\
& + \beta_9 (Treat_i \times Post_t \times Competitive_i) \\
& + \beta_{10} (Treat_i \times Post_t \times StartedAfterQP_i) \\
& + \beta_{11} (Treat_i \times Post_t \times StartedAfterQP_i \times Competitive_i) + \epsilon_{it}
\end{aligned}$$

- Note:  $Post_t = 0 \implies StartedAfterQP_i = 0$ 
  - These projects don't exist in the period before QuickPay

## Started Before QP:

For non-competitive projects:

	Before QP	After QP	Difference
Small Projects	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_3 + \beta_8$	$\beta_3 + \beta_8$
Large Projects	$\beta_0$	$\beta_0 + \beta_3$	$\beta_3$
<b>Difference</b>	$\beta_1$	$\beta_1 + \beta_8$	<b>Treatment Effect: <math>\beta_8</math></b>

For competitive projects:

	Before QP	After QP	Difference
Small Projects	$\beta_0 + \beta_1 + \beta_4 + \beta_5$	$\beta_0 + \beta_1 + \beta_3 + \beta_4 + \beta_5 + \beta_6 + \beta_8 + \beta_9$	$\beta_3 + \beta_6 + \beta_8 + \beta_9$
Large Projects	$\beta_0 + \beta_4$	$\beta_0 + \beta_3 + \beta_4 + \beta_6$	$\beta_3 + \beta_6$
<b>Difference</b>	$\beta_1 + \beta_5$	$\beta_1 + \beta_5 + \beta_8 + \beta_9$	<b>Treatment Effect: <math>\beta_8 + \beta_9</math></b>

## Started After QuickPay

For non-competitive projects:

	Before QP	After QP	Difference
Small Projects	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_8 + \beta_{10}$	$\beta_2 + \beta_3 + \beta_8 + \beta_{10}$
Large Projects	$\beta_0$	$\beta_0 + \beta_2 + \beta_3$	$\beta_2 + \beta_3$
<b>Difference</b>	$\beta_1$	$\beta_1 + \beta_8 + \beta_{10}$	<b>Treatment Effect: <math>\beta_8 + \beta_{10}</math></b>

For competitive projects:

	Before QP	After QP	Difference
Small Projects	$\beta_0 + \beta_1 + \beta_4 + \beta_5$	$\beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 + \beta_7 + \beta_8 + \beta_9 + \beta_{10} + \beta_{11}$	$\beta_2 + \beta_3 + \beta_6 + \beta_7 + \beta_8 + \beta_9 + \beta_{10} + \beta_{11}$
Large Projects	$\beta_0 + \beta_4$	$\beta_0 + \beta_2 + \beta_3 + \beta_4 + \beta_6 + \beta_7$	$\beta_2 + \beta_3 + \beta_6 + \beta_7$
<b>Difference</b>	$\beta_1 + \beta_5$	$\beta_1 + \beta_5 + \beta_8 + \beta_9 + \beta_{10} + \beta_{11}$	$\beta_8 + \beta_9 + \beta_{10} + \beta_{11}$

