

### Question 3

$$\begin{aligned} 3.1) \quad \text{Total Effect (TE)} &= E[Y | do(X=1)] - E[Y | do(X=0)] \\ &= I(14 > 10) - I(0 > 10) \\ &= 1 - 0 \\ &= \underline{\underline{1}} \end{aligned}$$

$$\begin{aligned} 3.2) \quad \text{CDE} &= E[Y | do(X=1, T=0)] - E[Y | do(X=0, T=0)] \\ &= I(8 > 10) - I(0 > 10) \\ &= \underline{\underline{0}} \end{aligned}$$

$$\begin{aligned} 3.3) \quad \text{NIE} &= E[Y | do(X=0, T=T_{X=1})] - E[Y | do(X=0, T=T_{X=0})] \\ &= E[Y | do(X=0, T=3)] - E[Y | do(X=0, T=0)] \\ &= I(6 > 10) - I(0 > 10) \\ &= \underline{\underline{0}} \end{aligned}$$

$$\begin{aligned} 3.4) \quad \text{NIEr} &= E[Y | do(X=1, T=T_{X=0})] - E[Y | do(X=1, T=T_{X=1})] \\ &= E[Y | do(X=1, T=0)] - E[Y | do(X=1, T=3)] \\ &= I(8 > 10) - I(14 > 10) \\ &= \underline{\underline{-1}} \end{aligned}$$

$$\begin{aligned} 3.5) \quad \text{NDE} &= \text{TE} + \text{NIEr} \\ &= 1 + (-1) \\ &= \underline{\underline{0}} \end{aligned}$$

This implies that the thrash related to the new UI is driving the conversion amongst users.

When the time spent familiarizing with the new UI will go down, so will the engagement and user conversion.

3.6) Even if the exogenous variables are not degenerate their sample mean is still 0 and will result in the same conclusions for NDE and NIE.

3.7) Since user features ( $U$ ) is not a mediator or on a causal path between  $X$  &  $Y$  it is not going to effect the approach for computing NDE and NIE.