

ONLINE APPENDIX

Information and Incentives Inside the Firm:
Evidence from Loan Officer Rotation

Online Appendix - TABLE A
Probability of Rotation during High Rotation Quarter

This table presents the estimation of probability models of rotation at the high rotation quarter induced by the three-year rule, on firm observable characteristics and downgrade events that affect loan officer reputation. The probability models are estimated on a cross section of relationships that reach 33 months of duration before December 2001. The dependent variable of interest is a dummy equal to one if the incumbent loan officer is reassigned during months 34 through 36 of the relationship. The explanatory variables are the three reputation event counts used in the career concerns section but where the events are measured relative to actual rotations instead of the high rotation quarter, and the internal risk rating of the firm. All explanatory variables are measured 6 months before the high rotation quarter (month 28 of a relationship). Both linear probability and probit estimates are reported. Models are also reported with and without loan officer dummies. Standard errors reported in parenthesis are estimated accounting for heteroskedasticity and are clustered at the loan officer level. *, ** and *** indicate that the point estimate is statistically significant at the 10, 5 and 1 percent levels respectively.

Neither the loan officer reputation counts nor the internal risk rating of the firm are good predictors of rotation at the rule. The inclusion of loan officer dummies increases the predictive power of the probability models, which suggests the presence of unobserved loan officer heterogeneity.

Probability model	Pr(Rotation Occurred during High Rotation Quarter)			
	Linear		Probit	
	(1)	(2)	(3)	(4)
# events post-rotation loan officer downgrades firm	(0.0022) (0.0013)	(0.0265) (0.0186)	(0.0072) (0.0052)	(0.1041) (0.0676)
# events pre-rotation loan officer's firm experiences post-rotation downgrade	(0.0009) (0.0048)	(0.0060) (0.0040)	(0.0021) (0.0162)	(0.0188) (0.0151)
# events pre-rotation loan officer downgrades firm	(0.0055) (0.0042)	0.0108 (0.0090)	(0.0216) (0.0181)	0.0381 (0.0347)
# of rotations with no reputation event	0.0014 (0.0009)	0.0001 (0.0038)	0.0044 (0.0031)	0.0018 (0.0143)
Internal Risk Rating	(0.0143) (0.0408)	0.0211 (0.0729)	(0.0876) (0.1934)	0.1050 (0.2800)
Loan Officer Dummies	No	Yes	No	Yes
Observations	284	284	284	250
R-Sq (pseudo R-Sq in probit)	0.05	0.23	0.05	0.18

Online Appendix - TABLE B
Other Firm and Bank-Firm Relationship Level Outcomes by Quarter to Rotation

This table provides the results of identification tests based on estimating the following regression of firm level outcomes on quarter-to-rotation dummies, firm fixed effects, loan officer fixed effects and industry-month dummies:

$$Y_{it} = \sum_{s=-8}^2 \varphi_s \cdot 1[s = q_R] + \alpha_i + \alpha_{Loan_Officer} + \alpha_{Industry \times t} + v_{it}$$

The left hand side variables are: ratings assigned by other banks (1), log lending by other banks (2), probability of entering default at t (3), probability of entering default between t+1 and t+12 (4), percentage of debt with less that a year of maturity at t (5). There is no significant difference in the point estimates of any two consecutive quarters to rotation. This indicates that changes in firm creditworthiness and demand for credit, or the timing of loan origination and termination, are not driving the results documented in Section III.

Dependent Variable	External Risk Rating	ln(Debt other Banks)	Dummy=1 if Defaults this Month	Dummy=1 if Defaults in next 12 months	Percentage Debt with Maturity < 1 Year
	(1)	(2)	(3)	(4)	(5)
1(quarter-to-rotation = -8)	-0.017 (0.073)	0.159 (0.221)	0.005 (0.003)	-0.008 (0.027)	-9.089** (4.243)
1(quarter-to-rotation = -7)	0.015 (0.069)	0.192 (0.232)	0.005 (0.003)	-0.055 (0.021)	-8.851* (4.526)
1(quarter-to-rotation = -6)	0.069 (0.076)	0.358 (0.232)	0.000 (0.003)	-0.029 (0.020)	-10.160** (4.466)
1(quarter-to-rotation = -5)	0.068 (0.076)	0.248 (0.231)	-0.001 (0.003)	-0.010 (0.021)	-9.276** (4.497)
1(quarter-to-rotation = -4)	0.050 (0.078)	0.174 (0.234)	0.000 (0.003)	-0.010 (0.021)	-8.636* (4.511)
1(quarter-to-rotation = -3)	0.077 (0.082)	0.306 (0.259)	-0.001 (0.003)	-0.027 (0.023)	-10.181** (4.501)
1(quarter-to-rotation = -2)	0.046 (0.080)	0.279 (0.273)	-0.005 (0.004)	0.002 (0.025)	-10.692** (4.622)
1(quarter-to-rotation = -1)	0.032 (0.092)	0.514 (0.283)	-0.005 (0.004)	0.004 (0.027)	-10.897** (4.798)
1(quarter-to-rotation = 0)	0.082 (0.106)	0.370 (0.297)	0.003 (0.005)	0.001 (0.032)	-10.678** (5.137)
1(quarter-to-rotation = 1)	0.089 (0.144)	0.445 (0.290)	0.003 (0.007)	-0.036 (0.037)	-11.966** (5.568)
1(quarter-to-rotation = 2)	0.141 (0.109)	0.508 (0.325)	0.001 (0.005)	-0.002 (0.049)	-10.121* (5.423)
Firm FE	Yes	Yes	Yes	Yes	Yes
Loan Officer Dummies	Yes	Yes	Yes	Yes	Yes
Industry × Month Dummies	Yes	Yes	Yes	Yes	Yes
Observations	21,477	21,608	21,608	20,080	22,329
R-Sq	0.09	0.14	0.09	0.16	0.60

Online Appendix - TABLE C
Firm Selection Bias Test: Placebo Quarter-to-Rotation

Column (1) shows the estimated coefficients of specification (1) using a placebo quarter-to-rotation measure defined assuming that high rotation quarter occurs during the last quarter of the second year of a relationship, over the subsample of relationships that last at least 21 months. Column (2) reproduces the coefficients in column (2) of Table IV, estimated over the subsample of relationships that last at least 33 months. To facilitate the comparison, the coefficients on column (1) are matched by row so that they refer to the same quarter in a relationship (the coefficient corresponding to placebo quarter-to-rotation 0 is in the same row than the coefficient corresponding to quarter-to-rotation -4). The estimated coefficients indicate that the results are independent of firm selection.

Dependent Variable	Probability of Entering Default in Next 12 Months	
	Placebo High Rotation Quarter: End of Second Year Subsample: relationships that last 21 months or longer	Actual High Rotation Quarter: End of Third Year Subsample: relationships that last 33 months or longer
	(1)	(2)
1(Placebo Quarter-to-Rotation = -4) × Risk Rating	0.791*** (0.268)	1(Quarter-to-Rotation = -8) × Risk Rating 0.555 (0.349)
1(Placebo Quarter-to-Rotation = -3) × Risk Rating	0.700*** (0.270)	1(Quarter-to-Rotation = -7) × Risk Rating 0.670* (0.363)
1(Placebo Quarter-to-Rotation = -2) × Risk Rating	0.922*** (0.246)	1(Quarter-to-Rotation = -6) × Risk Rating 0.834*** (0.290)
1(Placebo Quarter-to-Rotation = -1) × Risk Rating	0.672** (0.274)	1(Quarter-to-Rotation = -5) × Risk Rating 0.347 (0.314)
1(Placebo Quarter-to-Rotation = 0) × Risk Rating	-0.011 (0.244)	1(Quarter-to-Rotation = -4) × Risk Rating -0.216 (0.223)
1(Placebo Quarter-to-Rotation = 1) × Risk Rating	0.28 (0.221)	1(Quarter-to-Rotation = -3) × Risk Rating 0.195 (0.266)
1(Placebo Quarter-to-Rotation = 2) × Risk Rating	0.919*** (0.259)	1(Quarter-to-Rotation = -2) × Risk Rating 1.160*** (0.279)
1(Placebo Quarter-to-Rotation = 3) × Risk Rating	0.786*** (0.230)	1(Quarter-to-Rotation = -1) × Risk Rating 0.957*** (0.271)
1(Placebo Quarter-to-Rotation = 4) × Risk Rating	1.259*** (0.279)	1(Quarter-to-Rotation = 0) × Risk Rating 1.128*** (0.300)
1(Placebo Quarter-to-Rotation = 5) × Risk Rating	1.511*** (0.252)	1(Quarter-to-Rotation = 1) × Risk Rating 1.290*** (0.313)
1(Placebo Quarter-to-Rotation = 6) × Risk Rating	0.743** (0.291)	1(Quarter-to-Rotation = 2) × Risk Rating 0.493* (0.288)
External Rating × Quarter-to-Rotation Interactions	Yes	Yes
Loan Officer dummies	Yes	Yes
Industry × Month dummies	Yes	Yes
Observations	7,560	4,838
Pseudo R-Sq	0.255	0.263

I. Mathematical Appendix

A. Setup and Preliminary Observations

The strategy of x in this game is a mapping from the set of possible private signals at $t = 1$ and $t = 2$ into the set of possible reports at each of these periods (note that absent rotation period $t = 2$ and $t = 3$ are identical so we can limit our attention to her reporting decisions at $t = 1$ and $t = 2$). Written in matrix form a strategy can be written as

$$\left[\{r., r.\}_{nn} \quad \{r., r.\}_{nb} ; \{r., r.\}_{bn} \quad \{r., r.\}_{bb} \right]$$

where in each case $r.$ can be either r_n , or r_b . Under this notation $\{r_n, r_n\}_{nb}$ indicates that when the officer detects s_n at $t = 1$ and s_b at $t = 2$ (as indicated by the subscript for this element) her strategy will be to report r_n at $t = 1$ and $t = 2$. We assume that officers cannot fabricate bad news and hence they only have the choice to report r_b if s_b is detected. This means that the set of feasible strategies are limited to

$$\left[\{r_n, r_n\}_{nn} \quad \{r_n, r_{b/n}\}_{nb} ; \{r_{b/n}, r_n\}_{bn} \quad \{r_{b/n}, r_{b/n}\}_{bb} \right]$$

where $r_{b/n}$ indicates that the officer can either choose to report r_b or r_n . The set of possible equilibrium strategies can be further reduced using the following observations:

- Since x makes her first report at $t = 1$ before observing the second period signal then it must be the case that the first element of $\{r_{b/n}, r_n\}_{bn}$ and $\{r_{b/n}, r_{b/n}\}_{bb}$ is the same.
- Once x has reported bad news there is no incentive to hide news in the future (since the first report is a sufficient statistic for her performance as an active monitor). Thus there cannot be an equilibrium strategy with $\{r_b, r_n\}_{bb}$.
- We can rule out any equilibrium in which r_n is reported at $t = 1$ and where the second element of $\{r_n, r_{b/n}\}_{nb}$ and $\{r_n, r_{b/n}\}_{bb}$ is different since the incentives regarding this choice are identical.
- There cannot be an equilibrium strategy where r_b is reported at $t = 1$ and $\{r_n, r_n\}_{nb}$ since reporting at $t = 2$ will demonstrate that the loan was performing well at $t = 1$ and that x was able to detect the bad news at $t = 2$. This achieves the highest reputation possible for x .

Taken together these observations allow us to limit our attention to three possible equilibrium strategies for x :

$$\begin{aligned} E' &: \left[\{r_n, r_n\}_{nn} \quad \{r_n, r_n\}_{nb} ; \{r_n, r_n\}_{bn} \quad \{r_n, r_n\}_{bb} \right], \\ E'' &: \left[\{r_n, r_n\}_{nn} \quad \{r_n, r_b\}_{nb} ; \{r_n, r_n\}_{bn} \quad \{r_n, r_b\}_{bb} \right], \\ E''' &: \left[\{r_n, r_n\}_{nn} \quad \{r_n, r_b\}_{nb} ; \{r_b, r_n\}_{bn} \quad \{r_b, r_b\}_{bb} \right]. \end{aligned}$$

In words, never reporting bad news, reporting bad news only at $t = 2$ and reporting bad news at both $t = 1$ and $t = 2$. We will use the sequential equilibrium concept to determine out of equilibrium beliefs (Kreps and Wilson (1982)).

B. Equilibrium Without Rotation

First consider the candidate equilibrium E''' where x reports bad news at both $t = 1$ and $t = 2$. Abiding by this equilibrium and reporting r_b at $t = 1$ will generate a final reputation of

$$\widehat{\mu}^{x'''}(r_b^x) = \left(1 + \frac{p(1-q)}{(1-p)q}\right)^{-1} < \frac{1}{2}$$

where the inequality follows from the assumption that $p > q$. Now suppose that x deviates by concealing bad news at $t = 1$ and then reporting bad news at $t = 2$ if possible (i.e., unless the repayment prospects of the borrower change). If she does so her public reputation after $t = 1$ will be

$$\widehat{\mu}^{x'''}(r_n^x) = \left(1 + \frac{1-p(1-q)}{1-(1-p)q}\right)^{-1} > \frac{1}{2}$$

where again the inequality follows from $p > q$. Note that by the law of iterated expectations that in this proposed equilibrium

$$\widehat{\mu}^{x'''}(r_n^x) = (1-\phi)\widehat{\mu}^{x'''}(r_n^x, r_n^x) + \phi\widehat{\mu}^{x'''}(r_n^x, r_b^x)$$

where

$$\begin{aligned}\widehat{\mu}^{x'''}(r_n^x, r_b^x) &= \left(1 + \frac{(1-p)(1-q)}{pq}\right)^{-1} > \frac{1}{2} \\ \widehat{\mu}^{x'''}(r_n^x, r_n^x) &= \left(1 + \frac{(1-p)(1-\phi(1-q)) + pq}{p(1-\phi q) + (1-p)(1-q)}\right)^{-1}\end{aligned}$$

Simple algebraic manipulation using $p > q > \frac{1}{2}$ shows that $\widehat{\mu}^{x'''}(r_n^x, r_b^x) > \widehat{\mu}^{x'''}(r_n^x, r_n^x)$. Thus by deviating x can achieve an expected reputation of

$$\phi\widehat{\mu}^{x'''}(r_n^x, r_b^x) + (1-\phi)\widehat{\mu}^{x'''}(r_n^x, r_n^x) > \widehat{\mu}^{x'''}(r_n^x) > \widehat{\mu}^{x'''}(r_b^x)$$

thus establishing that there cannot be an equilibrium in which x truthfully reveals bad news in both periods (absent rotation).

Next consider the candidate equilibrium E' where x conceals bad news at $t = 1$ and $t = 2$. Under the proposed equilibrium, if x reports r_n at $t = 1$ her reputation will be unchanged at $\frac{1}{2}$ and will remain at this level as long as she continues to report nothing. Thus we can check for deviations from the proposed equilibrium by comparing the resulting expected reputations from that deviations to $\frac{1}{2}$. Consider a deviation where x reports bad news at $t = 1$ whenever possible (i.e., chooses $\{r_b, r.\}_b$). Under this deviation x observes s_b at $t = 1$ her final reputation will be

$$\widehat{\mu}^{x'}(r_b^x) = \left(1 + \frac{p(1-q)}{(1-p)q}\right)^{-1} < \frac{1}{2}.$$

where the inequality follows from the assumption that $p > q$ and ensures that this deviation is not profitable.

Next, consider a deviation where x sets $\{r_n, r_b\}_{nb}$ or $\{r_n, r_b\}_{bb}$. Under either of these scenarios

deviating to report r_b at $t = 2$ will give a final reputation of

$$\widehat{\mu}^{x'}(r_n^x, r_b^x) = \left(1 + \frac{[p - \phi(2p - 1)](1 - q)}{[1 - (p - \phi(2p - 1))]q}\right)^{-1}.$$

Simple manipulation shows that $\widehat{\mu}^{x'}(r_n^x, r_b^x) \leq \frac{1}{2}$ if and only if

$$q \leq \bar{q}^{NR} \equiv p - \phi(2p - 1)$$

This condition is necessary and sufficient to ensure that the proposed equilibrium exists.

Finally consider the last remaining candidate equilibrium E'' in which bad news is reported only at $t = 2$. Under this proposed equilibrium when x reports r_b at $t = 2$ she achieves a final reputation of

$$\widehat{\mu}^{x''}(r_n^x, r_b^x) = \left(1 + \frac{[p - \phi(2p - 1)](1 - q)}{[1 - (p - \phi(2p - 1))]q}\right)^{-1}$$

whereas if she deviates and reports nothing at $t = 2$ she achieves a final reputation of

$$\widehat{\mu}^{x''}(r_n^x, r_n^x) = \left(1 + \frac{1 - [p - \phi(2p - 1)](1 - q)}{1 - [1 - (p - \phi(2p - 1))]q}\right)^{-1}$$

simple manipulation shows that in order for this deviation not to be profitable it must be that

$$\widehat{\mu}^{x''}(r_n^x, r_b^x) \geq \widehat{\mu}^{x''}(r_n^x, r_n^x) \iff q \geq \bar{q}^{NR}.$$

In order for x to follow this candidate equilibrium it must also be the case that she does not want to deviate by reporting bad news at $t = 1$. If she deviates her final reputation will be $\widehat{\mu}^{x''}(r_b^x) = \widehat{\mu}^{x'}(r_b^x) < \frac{1}{2}$. If she follows the proposed equilibrium her expected reputation after $t = 1$ will be

$$(1 - \phi)\widehat{\mu}^{x''}(r_n^x, r_b^x) + \phi\widehat{\mu}^{x''}(r_n^x, r_n^x).$$

This is higher than her public reputation after $t = 1$ of

$$\widehat{\mu}^{x'}(r_n^x) = \left(1 + \frac{1 - p(1 - q)}{1 - (1 - p)q}\right)^{-1} > \frac{1}{2}$$

since $q \geq \bar{q}^{NR}$, combined with the law of iterated expectations for $\widehat{\mu}^x(r_n^x)$ we have that

$$(1 - \phi)\widehat{\mu}^{x''}(r_n^x, r_b^x) + \phi\widehat{\mu}^{x''}(r_n^x, r_n^x) \geq \phi\widehat{\mu}^{x''}(r_n^x, r_b^x) + (1 - \phi)\widehat{\mu}^{x''}(r_n^x, r_n^x) = \widehat{\mu}^{x''}(r_n^x).$$

Hence it follows that $q \geq \bar{q}^{NR}$ is sufficient to ensure that there is no profitable deviation from this candidate equilibrium.

Collecting results, absent rotation, the unique equilibrium is

$$\begin{aligned} E' & : \left[\{r_n, r_n\}_{nn} \quad \{r_n, r_n\}_{nb} ; \{r_n, r_n\}_{bn} \quad \{r_n, r_n\}_{bb} \right] \text{ if } q \in \left[\bar{q}^{NR}, \frac{1}{2} \right] \\ E'' & : \left[\{r_n, r_n\}_{nn} \quad \{r_n, r_b\}_{nb} ; \{r_n, r_n\}_{bn} \quad \{r_n, r_b\}_{bb} \right] \text{ if } q \in [p, \bar{q}^{NR}] \end{aligned}$$

where $\bar{q}^{NR} \equiv p - \phi(2p - 1)$.

C. Equilibrium with Rotation

Begin by noting that since $q > \frac{1}{2}$ it is a dominant strategy for y to report r_b at $t = 3$ whenever possible. This must be the case in any equilibrium. Thus we can focus on the reporting decision of x in $t = 1$ and $t = 2$. As before we must check the three possible candidate equilibria. Begin by considering the candidate equilibrium E''' in which x reports bad news at $t = 1$ and $t = 2$. We can rule out this equilibrium using an argument that is virtually identical to the one used in the case of no rotation. The only difference is that by deviating and concealing bad news at $t = 1$ (and then subsequently revealing bad news at $t = 2$ if possible) x will have an expected reputation of

$$\phi \widehat{\mu}^{x'''}(r_n^x, r_n^x, r_n^y) + (1 - \phi) \widehat{\mu}^{x'''}(r_n^x, r_b^x)$$

where

$$\widehat{\mu}^{x'''}(r_n^x, r_n^x, r_n^y) = \left(1 + \frac{(1-p)(1-\phi + \frac{\phi q}{2}) + p(\frac{q}{2} + \phi)}{p(1-\phi + \frac{\phi(1-q)}{2}) + (1-p)(\frac{(1-q)}{2} + \phi)} \right)^{-1}$$

and $\widehat{\mu}^{x'''}(r_n^x, r_b^x)$ is the same as before. This only increases x 's incentive to deviate since without reputation her expected reputation was

$$\phi \widehat{\mu}^{x'''}(r_n^x, r_n^x) + (1 - \phi) \widehat{\mu}^{x'''}(r_n^x, r_b^x)$$

where

$$\widehat{\mu}^{x'''}(r_n^x, r_n^x) = \left(1 + \frac{(1-p)(1-\phi(1-q)) + pq}{p(1-\phi q) + (1-p)(1-q)} \right)^{-1} < \widehat{\mu}^{x'''}(r_n^x, r_n^x, r_n^y)$$

and the inequality comes from simple algebraic comparison using $p > q > \frac{1}{2}$. Since x 's expected reputation from deviating is strictly higher than before (and her reputation from following the proposed equilibrium is unchanged) then it follows that we can once again rule out the candidate equilibrium in which x reports bad news at both $t = 1$ and $t = 2$.

Next consider the candidate equilibrium E' in which x never reveals bad news. First consider a deviation where x reports bad news at $t = 2$. Doing so will generate a final reputation of

$$\widehat{\mu}^{x'}(r_n^x, r_b^x) = \left(1 + \frac{(1-q)[p - \phi(2p-1)]}{q[1-p + \phi(2p-1)]} \right)^{-1}.$$

Conversely, adhering to the proposed equilibrium and concealing bad news at $t = 2$ will generate an expected reputation of

$$\frac{1}{2} [\widehat{\mu}^{x'}(r_n^x, r_n^x, r_n^y) + \widehat{\mu}^{x'}(r_n^x, r_n^x, r_b^y)]$$

where

$$\begin{aligned} \widehat{\mu}^{x'}(r_n^x, r_n^x, r_b^y) &= \left(1 + \frac{p - \phi(2p-1)}{1-p + \phi(2p-1)} \right)^{-1} \\ \widehat{\mu}^{x'}(r_n^x, r_n^x, r_n^y) &= \left(1 + \frac{1 - \frac{1}{2}[p - \phi(2p-1)]}{1 - \frac{1}{2}[1-p + \phi(2p-1)]} \right)^{-1} \end{aligned}$$

Thus in order it to be an equilibrium for x to always conceal bad news in the presence of

rotation it must be the case that

$$\Psi'(p, q, \phi) \equiv \widehat{\mu}^{x'}(r_n^x, r_b^x) - \frac{1}{2} [\widehat{\mu}^{x'}(r_n^x, r_n^x, r_n^y) + \widehat{\mu}^{x'}(r_n^x, r_n^x, r_b^y)] \leq 0 \quad (1)$$

We need also to ensure that x would not deviate from this equilibrium by reporting bad news at $t = 1$. Such a deviation would give x a final reputation of $\widehat{\mu}^{x'}(r_b^x) < \frac{1}{2}$ (same expression as above). If she follows the proposed equilibrium conditional on having seen the bad signal at $t = 1$ her expected reputation will be

$$\frac{1}{2} [(1 + \phi) \widehat{\mu}^{x'}(r_n^x, r_n^x, r_n^y) + (1 - \phi) \widehat{\mu}^{x'}(r_n^x, r_n^x, r_b^y)]$$

observe that since $\widehat{\mu}^x(r_n^x, r_n^x, r_n^y) > \widehat{\mu}^x(r_n^x, r_n^x, r_b^y)$ then it follows that this expected reputation is strictly greater than

$$\frac{1}{2} [\widehat{\mu}^x(r_n^x, r_n^x, r_n^y) + \widehat{\mu}^x(r_n^x, r_n^x, r_b^y)]$$

which, in order for this equilibrium to exist is greater than $\widehat{\mu}^{x'}(r_n^x, r_b^x)$. However simple comparison shows that $\widehat{\mu}^{x'}(r_n^x, r_b^x) > \widehat{\mu}^{x'}(r_b^x)$ and hence guarantees that this deviation is not profitable. It follows that (1) is necessary and sufficient to ensure the existence of an equilibrium in which x never reports bad news in the presence of rotation.

Finally consider the proposed equilibrium E'' in which x only reports bad news at $t = 2$. First consider the deviation from $\{r_n, r_b\}_{bb}$ to $\{r_n, r_n\}_{bb}$ (an identical argument also holds for deviating from $\{r_n, r_b\}_{nb}$ to $\{r_n, r_n\}_{nb}$). If x follows the proposed strategy and reports r_b at $t = 2$ her final reputation will be

$$\widehat{\mu}^{x''}(r_n^x, r_b^x) = \widehat{\mu}^{x'}(r_n^x, r_b^x) = \left(1 + \frac{(1 - q)[p - \phi(2p - 1)]}{q[(1 - p) + \phi(2p - 1)]} \right)^{-1}.$$

If x deviates and reports r_n at $t = 2$ then her expected reputation will be

$$\frac{1}{2} [\widehat{\mu}^{x''}(r_n^x, r_n^x, r_b^y) + \widehat{\mu}^{x''}(r_n^x, r_n^x, r_n^y)]$$

where

$$\begin{aligned} \widehat{\mu}^{x''}(r_n^x, r_n^x, r_b^y) &= \left(1 + \frac{q[p - \phi(2p - 1)]}{(1 - q)[(1 - p) + \phi(2p - 1)]} \right)^{-1} < \widehat{\mu}^{x''}(r_n^x, r_b^x) \\ \widehat{\mu}^{x''}(r_n^x, r_n^x, r_n^y) &= \left(1 + \frac{(1 - p)[1 - \phi(1 - \frac{q}{2})] + p[\frac{q}{2} + \phi(1 - \frac{q}{2})]}{p[1 - \frac{\phi}{2}(1 + q)] + (1 - p)[\frac{1 - q}{2} + \frac{\phi}{2}(1 + q)]} \right)^{-1} \end{aligned}$$

This deviation will not be profitable if and only if

$$\Psi'(p, q, \phi) \equiv \widehat{\mu}^{x''}(r_n^x, r_b^x) - \frac{1}{2} [\widehat{\mu}^{x''}(r_n^x, r_n^x, r_b^y) + \widehat{\mu}^{x''}(r_n^x, r_n^x, r_n^y)] \geq 0 \quad (2)$$

The other deviation to consider is for x to deviate and report r_b at $t = 1$ after observing s_b .

Such a deviation will not increase x 's expected reputation if and only if

$$(1 - \phi) \widehat{\mu}^{x''}(r_n^x, r_b^x) + \phi \widehat{\mu}^{x''}(r_n^x, r_n^x, r_n^y) \geq \widehat{\mu}^{x''}(r_b^x) = \left(1 + \frac{p(1-q)}{(1-p)q}\right)^{-1}$$

Note that $\widehat{\mu}^{x''}(r_n^x, r_b^x) \geq \widehat{\mu}^{x''}(r_b^x)$ since $\widehat{\mu}^{x''}(r_n^x, r_b^x | \phi = 0) = \widehat{\mu}^{x''}(r_b^x)$ and

$$\frac{\partial \widehat{\mu}^{x''}(r_n^x, r_b^x)}{\partial \phi} = \frac{(1-q)(2p-1)}{q[(1-p) + \phi(2p-1)]^2} \left(1 + \frac{(1-q)[p - \phi(2p-1)]}{q[(1-p) + \phi(2p-1)]}\right)^{-2} > 0$$

Moreover $\widehat{\mu}^{x''}(r_n^x, r_n^x, r_n^y) > \widehat{\mu}^{x''}(r_n^x, r_n^x) > \frac{1}{2} > \widehat{\mu}^{x''}(r_b^x)$ where the second and third inequality again follow from the assumption that $p > q$. Thus this is sufficient to ensure that x would not deviate from this proposed equilibrium to report bad news at $t = 1$.

Taken together we have shown that with rotation there are only two possible equilibria: E' and E'' . When (1) holds there exists an equilibrium in which x always conceals bad news (E'). When (2) holds there exists an equilibrium in which x conceals bad news at $t = 1$ and reports any bad news at $t = 2$ (E''). We now characterize and compare these conditions in more detail.

First consider condition (1). Notice that

$$\frac{\partial \widehat{\mu}^{x'}(r_n^x, r_b^x)}{\partial q} = \frac{1}{q^2} \left(\frac{p - \phi(2p-1)}{1 - p + \phi(2p-1)} \right) [\widehat{\mu}^{x'}(r_n^x, r_b^x)]^2 > 0$$

and the other two terms in that condition are not affected by q . Thus $\Psi'(p, q, \phi)$ is strictly increasing in q . In addition, $\widehat{\mu}^{x'}(r_n^x, r_b^x | q = 1) = 1$ and $\widehat{\mu}^{x'}(r_n^x, r_b^x | q = \frac{1}{2}) = \widehat{\mu}^{x'}(r_n^x, r_n^x, r_b^y) < \widehat{\mu}^{x'}(r_n^x, r_n^x, r_n^y)$. This implies that $\Psi'(p, q, \phi) < 0$ when $q = \frac{1}{2}$ and $\Psi'(p, q, \phi) > 0$ when $q = 1$. Combining these facts we can conclude that for any p and ϕ there exists a $\bar{q}^{R1} \in (\frac{1}{2}, 1)$ such that it is an equilibrium for x to always conceal bad news at $t = 1$ and $t = 2$ (in the presence of rotation) if and only if $q \leq \bar{q}^{R1}$.

Next consider condition (2). As above, $\frac{\partial \widehat{\mu}^{x''}(r_n^x, r_b^x)}{\partial q} = \frac{\partial \widehat{\mu}^{x'}(r_n^x, r_b^x)}{\partial q} > 0$. Next,

$$\begin{aligned} \frac{\partial \widehat{\mu}^{x''}(r_n^x, r_n^x, r_b^y)}{\partial q} &= - \left(\frac{1}{1-q} \right)^2 \left(\frac{p - \phi(2p-1)}{1 - p + \phi(2p-1)} \right) [\widehat{\mu}^{x''}(r_n^x, r_n^x, r_b^y)]^2 < 0 \\ \frac{\partial \widehat{\mu}^{x''}(r_n^x, r_n^x, r_n^y)}{\partial q} &= - \left(\frac{[\phi(1-p) + p(1-\phi)] C_2 + [p\phi + (1-p)(1-\phi)] C_1}{2C_2^2 [\widehat{\mu}^{x''}(r_n^x, r_n^x, r_n^y)]^{-2}} \right) < 0 \end{aligned}$$

$$\text{where } C_1 = (1-p) \left[1 - \phi \left(1 - \frac{q}{2} \right) \right] + p \left[\frac{q}{2} + \phi \left(1 - \frac{q}{2} \right) \right] > 0$$

$$C_2 = p \left[1 - \frac{\phi}{2} (1+q) \right] + (1-p) \left[\frac{1-q}{2} + \frac{\phi}{2} (1+q) \right] < 0$$

Hence

$$\frac{\partial \Psi''(p, q, \phi)}{\partial q} > \frac{\partial \Psi'(p, q, \phi)}{\partial q} > 0.$$

In addition, $\widehat{\mu}^{x''}(r_n^x, r_b^x | q = 1) = 1$ and $\widehat{\mu}^{x''}(r_n^x, r_b^x | q = \frac{1}{2}) = \widehat{\mu}^{x''}(r_n^x, r_n^x, r_b^y | q = \frac{1}{2}) < \widehat{\mu}^{x''}(r_n^x, r_n^x, r_n^y)$. This implies that $\Psi''(p, q, \phi) < 0$ when $q = \frac{1}{2}$ and $\Psi''(p, q, \phi) > 0$ when $q = 1$. Combining these facts we can conclude that for any p and ϕ there exists a $\bar{q}^{R2} \in (\frac{1}{2}, 1)$ such that it is an

equilibrium for x to always conceal bad news at $t = 1$ and reveal any bad news at $t = 2$ (in the presence of rotation) if and only if $q \geq \bar{q}^{R2}$.

We now show that $\bar{q}^{NR} > \bar{q}^{R1}$. Note that \bar{q}^{NR} is, by construction, such that

$$\hat{\mu}^{x'}(r_n^x, r_b^x) = \hat{\mu}^{x'}(r_n^x, r_n^x) = \frac{1}{4}\hat{\mu}^{x'}(r_n^x, r_n^x, r_b^y) + \frac{3}{4}\hat{\mu}^{x'}(r_n^x, r_n^x, r_n^y)$$

where the second equality follows from the law of iterated expectations. Similarly, \bar{q}^{R1} is such that

$$\hat{\mu}^{x'}(r_n^x, r_b^x) = \frac{1}{2}\hat{\mu}^{x'}(r_n^x, r_n^x, r_b^y) + \frac{1}{2}\hat{\mu}^{x'}(r_n^x, r_n^x, r_n^y) < \frac{1}{4}\hat{\mu}^{x'}(r_n^x, r_n^x, r_b^y) + \frac{3}{4}\hat{\mu}^{x'}(r_n^x, r_n^x, r_n^y)$$

where the inequality follows from the fact that $\hat{\mu}^{x'}(r_n^x, r_n^x, r_n^y) > \hat{\mu}^{x'}(r_n^x, r_n^x, r_b^y)$. Thus it must be the case that $\Psi'(p, \bar{q}^{NR}, \phi) > 0$ and hence, since $\frac{\partial \Psi'(p, q, \phi)}{\partial q} > 0$ it must be that $\bar{q}^{R1} < \bar{q}^{NR}$ in order to ensure that $\Psi'(p, \bar{q}^{R1}, \phi) = 0$. It is also the case that $\bar{q}^{R1} > \bar{q}^{R2}$. We establish this numerically by computing and comparing \bar{q}^{R1} and \bar{q}^{R2} across a grid of the allowable (p, ϕ) combinations.