

THE ECOSYSTEM OF SOFTWARE PLATFORM: A STUDY OF ASYMMETRIC CROSS-SIDE NETWORK EFFECTS AND PLATFORM GOVERNANCE

Peijian Song

School of Business, Nanjing University, Nanjing CHINA {songpeijian@nju.edu.cn}

Ling Xue

J. Mack Robinson College of Business, Georgia State University, Atlanta, GA 30303 U.S.A. {lxue5@gsu.edu}

Arun Rai

J. Mack Robinson College of Business, Georgia State University, Atlanta, GA 30303 U.S.A. {arun.rai@eci.gsu.edu}

Cheng Zhang

School of Management, Fudan University, Shanghai CHINA {zhangche@fudan.edu.cn}

Appendix A

Cross-Side Network Effects Before and After Frequent Platform Updates

Table A1. Cross-Side Network Effects Before Frequent Platform Updates

Panel A: User-to-App Effects		
Paths	Short-Term Effect	Long-Term Effect
User Usage → App Number	0.04 (0.22, $p = 0.43$)	0.31 (0.15, $p = 0.03$)*
User Usage → App Diversity	0.01 (0.02, $p = 0.31$)	0.09 (0.02, $p = 0.00$)*
Panel B: App-to-User Effects		
Paths	Short-Term Effect	Long-Term Effect
App Number → User Usage	0.94 (0.49, $p = 0.04$)*	0.20 (1.14, $p = 0.43$)
App Diversity → User Usage	0.64 (0.29, $p = 0.03$)*	0.19 (0.78, $p = 0.41$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Table A2. Cross-Side Network Effects After Frequent Platform Updates		
Panel A: User-to-App Effects		
Paths	Short-Term Effect	Long-Term Effect
User Usage → App Number	0.06 (0.22, $p = 0.39$)	0.03 (0.04, $p = 0.24$)
User Usage → App Diversity	0.01 (0.01, $p = 0.17$)	0.01 (0.03, $p = 0.37$)
Panel B: App-to-User Effects		
Paths	Short-Term Effect	Long-Term Effect
App Number → User Usage	0.37 (0.74, $p = 0.30$)	0.40 (1.08, $p = 0.36$)
App Diversity → User Usage	0.49 (0.24, $p = 0.04$)*	0.19 (0.78, $p = 0.41$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Appendix B

Download as An Alternative Measure of User-Side

Table B1. Cross-Side Network Effects		
Panel A: User-to-App Effects		
Paths	Short-Term Effect	Long-Term Effect
User Download → App Number	0.12 (0.16, $p = 0.24$)	0.45 (0.18, $p = 0.02$)**
User Download → App Diversity	0.00 (0.01, $p = 0.83$)	0.03 (0.01, $p = 0.01$)*
Panel B: App-to-User Effects		
Paths	Short-Term Effect	Long-Term Effect
App Number → User Download	2.05 (0.92, $p = 0.03$)*	0.43 (2.31, $p = 0.43$)
App Diversity → User Download	0.04 (0.91, $p = 0.48$)	0.48 (1.62, $p = 0.39$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Table B2. Influences of App Review Time on Cross-Side Network Effects		
Panel A: User-to-App Effect		
Paths	Short-Term Effect	Long-Term Effect
User Download × App Review Time → App Number	-0.02 (0.01, $p = 0.04$)*	-0.03 (0.01, $p = 0.01$)**
User Download × App Review Time → App Diversity	-0.03 (0.04, $p = 0.24$)	-0.12 (0.05, $p = 0.02$)*
Panel B: App-to-User Effect		
Paths	Short-Term Effect	Long-Term Effect
App Number × App Review Time → User Download	-1.85 (2.79, $p = 0.26$)	-3.62 (4.92, $p = 0.24$)
App Diversity × App Review Time → User Download	-2.49 (2.23, $p = 0.15$)	-3.75 (3.92, $p = 0.18$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Table B3. Influences of Frequent Platform Updates on Cross-Side Network Effects

Panel A: User-to-App Effect		
Paths	Short-Term Effect	Long-Term Effect
User Download × Platform Update Frequency → App Number	0.00 (0.01, $p = 0.71$)	-0.13 (0.03, $p = 0.00$)**
User Download × Platform Update Frequency → App Diversity	0.00 (0.02, $p = 0.79$)	-0.10 (0.04, $p = 0.02$)*
Panel B: App-to-User Effect		
Paths	Short-Term Effect	Long-Term Effect
App Number × Platform Update Frequency → User Download	-1.61 (0.40, $p = 0.00$)**	-0.19 (0.81, $p = 0.41$)
App Diversity × Platform Update Frequency → User Download	-0.07 (0.46, $p = 0.44$)	-0.90 (1.12, $p = 0.22$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Appendix C

Number and Diversity of Developers as Alternative Measures of App-Side

Table C1. Cross-Side Network Effects

Panel A: User-to-App Effects		
Paths	Short-Term Effect	Long-Term Effect
User Usage → Developer Number	0.01 (0.02, $p = 0.31$)	0.07 (0.02, $p = 0.00$)**
User Usage → Developer Diversity	0.01 (0.01, $p = 0.17$)	0.03 (0.01, $p = 0.01$)**
Panel B: App-to-User Effects		
Paths	Short-Term Effect	Long-Term Effect
Developer Number → User Usage	0.39 (0.14, $p = 0.01$)**	0.28 (0.94, $p = 0.39$)
Developer Diversity → User Usage	0.61 (0.19, $p = 0.01$)**	0.68 (0.63, $p = 0.15$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Table C2. Influences of App Review Time on Cross-Side Network Effects

Panel A: User-to-App Effect		
Paths	Short-Term Effect	Long-Term Effect
User Usage × App Review Time → Developer Number	-0.02 (0.01, $p = 0.04$)*	-0.04 (0.02, $p = 0.04$)*
User Usage × App Review Time → Developer Diversity	0.01 (0.01, $p = 0.17$)	-0.03 (0.01, $p = 0.01$)**
Panel B: App-to-User Effect		
Paths	Short-Term Effect	Long-Term Effect
Developer Number × App Review Time → User Usage	0.31 (0.50, $p = 0.28$)	0.47 (1.05, $p = 0.33$)
Developer Diversity × App Review Time → User Usage	0.68 (0.61, $p = 0.15$)	0.62 (1.02, $p = 0.28$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Table C3. Influences of Frequent Platform Updates on Cross-Side Network Effects		
Panel A: User-to-App Effect		
Paths	Short-Term Effect	Long-Term Effect
User Usage × Platform Update Frequency → Developer Number	-0.02 (0.02, $p = 0.17$)	-0.09 (0.02, $p = 0.00$)**
User Usage × Platform Update Frequency → Developer Diversity	0.00 (0.01, $p = 0.50$)	-0.08 (0.01, $p = 0.00$)**
Panel B: App-to-User Effect		
Paths	Short-Term Effect	Long-Term Effect
Developer Number × Platform Update Frequency → User Usage	-1.03 (0.05, $p = 0.00$)**	-0.79 (1.01, $p = 0.23$)
Developer Diversity × Platform Update Frequency → User Usage	-1.14 (0.04, $p = 0.00$)**	-0.61 (0.92, $p = 0.26$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Appendix D

Platform Update Interval as An Alternative Continuous Measure of Frequent Platform Updates

Table D1. Influences of Frequent Platform Updates on Cross-Side Network Effects		
Panel A: User-to-App Effect		
Paths	Short-Term Effect	Long-Term Effect
User Usage × Platform Update Frequency → App Number	-0.01 (0.01, $p = 0.17$)	-0.17 (0.07, $p = 0.02$)*
User Usage × Platform Update Frequency → App Diversity	0.00 (0.01, $p = 0.75$)	-0.02 (0.01, $p = 0.04$)*
Panel B: App-to-User Effect		
Paths	Short-Term Effect	Long-Term Effect
App Number × Platform Update Frequency → User Usage	-0.93 (0.47, $p = 0.04$)*	-1.10 (1.51, $p = 0.24$)
App Diversity × Platform Update Frequency → User Usage	-0.91 (0.43, $p = 0.03$)*	-1.01 (1.58, $p = 0.27$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Appendix E

With the Update Intervals of Competing Platform as An Additional Control

Table E1. Cross-Side Network Effects		
Panel A: User-to-App Effects		
Paths	Short-Term Effect	Long-Term Effect
User Usage → App Number	0.01 (0.02, $p = 0.28$)	0.14 (0.07, $p = 0.04$)*
User Usage → App Diversity	0.01 (0.01, $p = 0.14$)	0.07 (0.03, $p = 0.02$)*
Panel B: App-to-User Effects		
Paths	Short-Term Effect	Long-Term Effect
App Diversity → User Usage	0.65 (0.15, $p = 0.01$)**	0.08 (0.90, $p = 0.47$)
App Diversity → User Usage	0.49 (0.19, $p = 0.01$)**	0.31 (0.64, $p = 0.32$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Table E2. Influences of Frequent Platform Updates on Cross-Side Network Effects		
Panel A: User-to-App Effects		
Paths	Short-Term Effect	Long-Term Effect
User Usage × Platform Update Frequency → App Number	-0.03 (0.03, $p = 0.17$)	-0.12 (0.04, $p = 0.01$)**
User Usage × Platform Update Frequency → App Diversity	-0.01 (0.01, $p = 0.15$)	-0.10 (0.03, $p = 0.01$)**
Panel B: App-to-User Effects		
Paths	Short-Term Effect	Long-Term Effect
App Number × Platform Update Frequency → User Usage	-1.14 (0.45, $p = 0.02$)*	-1.26 (1.30, $p = 0.18$)
App Diversity × Platform Update Frequency → User Usage	-0.91 (0.41, $p = 0.03$)*	-1.94 (2.42, $p = 0.22$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Appendix F

Additional Analyses on App Quality

Table F1. Additional Analysis on App Quality		
Paths	Short-Term Effect	Long-Term Effect
App Review Time → Quality of New Apps	15.13 (2.72, $p = 0.00$)**	11.34 (3.51, $p = 0.00$)**

Notes: * $p < 0.05$, ** $p < 0.01$. The coefficients are percentage values. In parentheses are standard errors and corresponding p-values.

Table F2. App-to-User CNEs for High-Rating and Low-Rating Apps		
Panel A: App-to-User Effects for High-Rating Apps		
Paths	Short-Term Effect	Long-Term Effect
App Number → User Usage	2.41 (0.42, $p = 0.00$)**	0.60 (0.56, $p = 0.16$)
App Diversity → User Usage	0.75 (0.33, $p = 0.02$)*	0.35 (0.59, $p = 0.28$)
Panel B: App-to-User Effects for Low-Rating Apps		
Paths	Short-Term Effect	Long-Term Effect
App Number → User Usage	0.41 (0.15, $p = 0.01$)*	0.15 (0.43, $p = 0.37$)
App Diversity → User Usage	0.78 (0.74, $p = 0.16$)	0.35 (0.41, $p = 0.21$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Appendix G

Additional Analysis on Platform Updates

Table G1. Impact of Frequent Platform Updates on the App-Side		
Paths	Short-Term Effect	Long-Term Effect
Platform Update Frequency → Number of Updated Apps	7.36 (2.26, $p = 0.00$)**	8.94 (2.71, $p = 0.00$)**
Number of Updated Apps → Number of New Apps	-11.36 (2.61, $p = 0.00$)**	-11.33 (2.73, $p = 0.00$)**

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.

Table G2. Influences of Frequent Platform Updates on User-to-App Effect (for New and Updated Apps)		
Panel A: User-to-App Effect for New Apps		
Paths	Short-Term Effect	Long-Term Effect
User Usage × Platform Update Frequency → Number of New Apps	-2.23 (2.89, $p = 0.24$)	-4.60 (1.07, $p = 0.00$)**
User Usage × Platform Update Frequency → Diversity of New Apps	-0.10 (0.15, $p = 0.26$)	-0.25 (0.12, $p = 0.03$)*
Panel B: User-to-App Effect for Updated Apps		
Paths	Short-Term Effect	Long-Term Effect
User Usage × Platform Update Frequency → Number of Updated Apps	2.27 (3.13, $p = 0.24$)	5.62 (1.58, $p = 0.00$)**
User Usage × Platform Update Frequency → Diversity of Updated Apps	0.11 (0.67, $p = 0.45$)	0.08 (0.68, $p = 0.45$)

Notes: * $p < 0.05$, ** $p < 0.01$. Estimated coefficients are in percentage values. In parentheses are standard errors and corresponding p-values.