

Table 1: Definition of variables

| Type                 | Variable name                     | Symbol         | Measurement Method                                                                                                                                            |
|----------------------|-----------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dependent Variable   | Firm Innovation                   | R&D            | R&D expenditure / Total assets                                                                                                                                |
| Independent Variable | Oil Price Uncertainty             | $OPU_C^S$      | Annual <i>std.</i> of CNY-denominated WTI crude oil daily returns                                                                                             |
|                      |                                   | $OPU_C^G$      | Annual mean of GARCH(1,1) conditional <i>std.</i> of CNY-denominated WTI crude oil daily returns                                                              |
|                      |                                   | $OPU_U^S$      | Annual <i>std.</i> of USD-denominated WTI crude oil daily returns                                                                                             |
|                      |                                   | $OPU_U^G$      | Annual mean of GARCH(1,1) conditional <i>std.</i> of USD-denominated WTI crude oil daily returns                                                              |
| Control Variables    | Firm Age                          | Age            | Number of years since firm's listing                                                                                                                          |
|                      | Return on Assets                  | ROA            | Net income / Total assets                                                                                                                                     |
|                      | Tobin's Q                         | TobinQ         | Market value of firm / Total assets                                                                                                                           |
|                      | Leverage Ratio                    | Leverage       | Total liabilities / Total assets                                                                                                                              |
|                      | Operating Cash Flow               | CF             | Operating cash flow / Beginning total assets                                                                                                                  |
|                      | Growth Opportunity                | Growth         | $\frac{revenue_t - revenue_{t-1}}{revenue_{t-1}}$                                                                                                             |
|                      | Tangibility                       | Tang           | Net tangible assets / Total assets                                                                                                                            |
|                      | CEO Duality                       | Dual           | 1 if the chairman and CEO are the same person; 0 otherwise                                                                                                    |
|                      | Price-to-Book Ratio               | PB             | Share price / Book value per share                                                                                                                            |
|                      | Board Independence Ratio          | Indep          | Number of independent directors / Total number of directors                                                                                                   |
|                      | State-Owned Enterprise            | SOE            | 1 if the firm is state-owned; 0 otherwise                                                                                                                     |
|                      | GDP Growth Rate                   | gGDP           | $\frac{realGDP_t - realGDP_{t-1}}{realGDP_{t-1}}$                                                                                                             |
|                      | M2 Growth Rate                    | gM2            | $\frac{M2_t - M2_{t-1}}{M2_{t-1}}$                                                                                                                            |
|                      | Economic Policy Uncertainty       | EPU            | EPU Index developed by <a href="#">Baker et al. (2016)</a>                                                                                                    |
| Mechanism Variables  | Risk-taking capacity              | Risk1<br>Risk2 | <i>Std.</i> of industry-adjusted ROA* over a three-year rolling window<br>Range (max - min) of industry-adjusted ROA* over the same three-year rolling window |
|                      | Government Subsidy                | Subsidy        | Government subsidies / Total assets                                                                                                                           |
|                      | Financing Constraints             | WW             | Financing constraint index constructed by <a href="#">Whited and Wu (2006)</a>                                                                                |
|                      | Market power                      | Lerner         | $\frac{Sales - COGS - SG\&A}{Sales}$ , following <a href="#">Datta et al. (2013)</a>                                                                          |
|                      | Alternative dependent variables   | Invpat         | Log difference of invention patent applications                                                                                                               |
| Robustness variables | Alternative explanatory variables | Invpatqual     | Log difference of the average knowledge breadth index based on invention patents at the firm-year level                                                       |
|                      |                                   | OVX            | CBOE Crude Oil ETF Volatility Index                                                                                                                           |

\* ADJ\_ROA = (EBIT/Total Assets) - industry mean.

Table 2: Mechanism regressions: firm attributes and external conditions

| VARIABLES                                | (1)<br>R&D <sub>t</sub> | (2)<br>R&D <sub>t</sub> | (3)<br>R&D <sub>t</sub> | (4)<br>R&D <sub>t</sub> | (5)<br>R&D <sub>t</sub> | (6)<br>R&D <sub>t</sub> | (7)<br>R&D <sub>t</sub> | (8)<br>R&D <sub>t</sub> | (9)<br>R&D <sub>t</sub> | (10)<br>R&D <sub>t</sub> |
|------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|--------------------------|
| $OPU_{C,t-1}^S$                          | -2.525***<br>(0.486)    | -2.530***<br>(0.487)    |                         |                         | -16.084***<br>(5.808)   |                         | -5.134***<br>(0.725)    |                         | -2.954***<br>(0.459)    |                          |
| $OPU_{C,t-1}^{S,2}$                      | 0.029***<br>(0.007)     | 0.029***<br>(0.007)     |                         |                         | 0.187***<br>(0.072)     |                         | 0.063***<br>(0.010)     |                         | 0.034***<br>(0.006)     |                          |
| $OPU_{U,t-1}^S$                          |                         |                         | -2.375***<br>(0.501)    | -2.379***<br>(0.502)    |                         | -15.725***<br>(5.554)   |                         | -5.026***<br>(0.748)    |                         | -2.797***<br>(0.474)     |
| $OPU_{U,t-1}^{S,2}$                      |                         |                         | 0.027***<br>(0.007)     | 0.027***<br>(0.007)     |                         | 0.183***<br>(0.069)     |                         | 0.062***<br>(0.010)     |                         | 0.032***<br>(0.007)      |
| $OPU_{C,t-1}^S \times Risk1_{t-1}$       | 39.439**<br>(19.126)    |                         |                         |                         |                         |                         |                         |                         |                         |                          |
| $OPU_{C,t-1}^{S,2} \times Risk1_{t-1}$   | -0.479**<br>(0.242)     |                         |                         |                         |                         |                         |                         |                         |                         |                          |
| $OPU_{C,t-1}^S \times Risk2_{t-1}$       |                         | 20.219**<br>(10.238)    |                         |                         |                         |                         |                         |                         |                         |                          |
| $OPU_{C,t-1}^{S,2} \times Risk2_{t-1}$   |                         | -0.245*<br>(0.130)      |                         |                         |                         |                         |                         |                         |                         |                          |
| $OPU_{U,t-1}^S \times Risk1_{t-1}$       |                         |                         | 41.827**<br>(19.753)    |                         |                         |                         |                         |                         |                         |                          |
| $OPU_{U,t-1}^{S,2} \times Risk1_{t-1}$   |                         |                         | -0.514**<br>(0.253)     |                         |                         |                         |                         |                         |                         |                          |
| $OPU_{U,t-1}^S \times Risk2_{t-1}$       |                         |                         |                         | 21.494**<br>(10.576)    |                         |                         |                         |                         |                         |                          |
| $OPU_{U,t-1}^{S,2} \times Risk2_{t-1}$   |                         |                         |                         | -0.264*<br>(0.135)      |                         |                         |                         |                         |                         |                          |
| Risk1 <sub>t-1</sub>                     | 81.665***<br>(29.745)   |                         | 81.243***<br>(29.714)   |                         |                         |                         |                         |                         |                         |                          |
| Risk2 <sub>t-1</sub>                     |                         | 42.296***<br>(16.286)   |                         | 42.082***<br>(16.270)   |                         |                         |                         |                         |                         |                          |
| $OPU_{C,t-1}^S \times WW_{t-1}$          |                         |                         |                         |                         | -13.064**<br>(5.630)    |                         |                         |                         |                         |                          |
| $OPU_{C,t-1}^{S,2} \times WW_{t-1}$      |                         |                         |                         |                         | 0.153**<br>(0.070)      |                         |                         |                         |                         |                          |
| $OPU_{U,t-1}^S \times WW_{t-1}$          |                         |                         |                         |                         |                         | -12.866**<br>(5.377)    |                         |                         |                         |                          |
| $OPU_{U,t-1}^{S,2} \times WW_{t-1}$      |                         |                         |                         |                         |                         | 0.150**<br>(0.067)      |                         |                         |                         |                          |
| WW <sub>t-1</sub>                        |                         |                         |                         |                         | 277.191**<br>(110.407)  | 273.074***<br>(105.151) |                         |                         |                         |                          |
| $OPU_{C,t-1}^S \times Lerner_{t-1}$      |                         |                         |                         |                         |                         |                         | 19.382***<br>(5.041)    |                         |                         |                          |
| $OPU_{C,t-1}^{S,2} \times Lerner_{t-1}$  |                         |                         |                         |                         |                         |                         | -0.253***<br>(0.065)    |                         |                         |                          |
| $OPU_{U,t-1}^S \times Lerner_{t-1}$      |                         |                         |                         |                         |                         |                         |                         | 19.725***<br>(5.202)    |                         |                          |
| $OPU_{U,t-1}^{S,2} \times Lerner_{t-1}$  |                         |                         |                         |                         |                         |                         |                         | -0.259***<br>(0.067)    |                         |                          |
| Lerner <sub>t-1</sub>                    |                         |                         |                         |                         |                         |                         | -264.777***<br>(93.933) | -268.545***<br>(96.005) |                         |                          |
| $OPU_{C,t-1}^S \times Subsidy_{t-1}$     |                         |                         |                         |                         |                         |                         |                         |                         | 1.855**<br>(0.908)      |                          |
| $OPU_{C,t-1}^{S,2} \times Subsidy_{t-1}$ |                         |                         |                         |                         |                         |                         |                         |                         | -0.023*<br>(0.012)      |                          |
| $OPU_{U,t-1}^S \times Subsidy_{t-1}$     |                         |                         |                         |                         |                         |                         |                         |                         |                         | 1.886**<br>(0.938)       |
| $OPU_{U,t-1}^{S,2} \times Subsidy_{t-1}$ |                         |                         |                         |                         |                         |                         |                         |                         |                         | -0.024*<br>(0.012)       |
| Subsidy <sub>t-1</sub>                   |                         |                         |                         |                         |                         |                         |                         |                         | 11.596***<br>(2.086)    | 11.608***<br>(2.087)     |
| Controls                                 | YES                     | YES                     | YES                     | YES                     | YES                     | YES                     | YES                     | YES                     | YES                     | YES                      |
| Constant                                 | 83.704***<br>(28.168)   | 83.090***<br>(28.179)   | 83.186***<br>(28.154)   | 82.577***<br>(28.165)   | 405.498***<br>(119.763) | 398.265***<br>(114.594) | 165.390***<br>(30.392)  | 163.060***<br>(30.457)  | 64.269**<br>(28.245)    | 63.912**<br>(28.229)     |
| Firm FE                                  | YES                     | YES                     | YES                     | YES                     | YES                     | YES                     | YES                     | YES                     | YES                     | YES                      |
| Observations                             | 31,342                  | 31,342                  | 31,342                  | 31,342                  | 31,405                  | 31,405                  | 31,386                  | 31,386                  | 31,407                  | 31,407                   |
| Number of ID                             | 4,582                   | 4,582                   | 4,582                   | 4,582                   | 4,588                   | 4,588                   | 4,583                   | 4,583                   | 4,589                   | 4,589                    |
| R <sup>2</sup>                           | 0.057                   | 0.056                   | 0.057                   | 0.056                   | 0.056                   | 0.056                   | 0.059                   | 0.059                   | 0.058                   | 0.058                    |

This table reports the full-sample regression results for Eq. (5), where mechanism variables  $M_{i,t-1}$  capture internal attributes (risk-taking capacity, Risk1/Risk2; financing constraints, WW) and external conditions (product-market power, Lerner, and government subsidies, Subsidy).

Specifically, cols. (1)–(4) report the results for the mechanism of firms' risk-taking capacity, cols. (5)–(6) for financial constraints, cols. (7)–(8) for external market competition, and cols. (9)–(10) for government subsidies.

Parentheses (·) report robust firm-clustered standard errors of the relevant coefficient estimates. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ , which are associated with the two-tail  $t$ -test.

This table reports results based on realized standard-deviation OPU measures (both CNY- and USD-denominated) only.

## References

- Baker, S.R., Bloom, N., Davis, S.J., 2016. Measuring economic policy uncertainty. *The Quarterly Journal of Economics* 131, 1593–1636. doi:[10.1093/qje/qjw024](https://doi.org/10.1093/qje/qjw024).
- Datta, S., Iskandar-Datta, M., Singh, V., 2013. Product market power, industry structure, and corporate earnings management. *Journal of Banking & Finance* 37, 3273–3285. doi:[10.1016/j.jbankfin.2013.03.012](https://doi.org/10.1016/j.jbankfin.2013.03.012).
- Whited, T.M., Wu, G., 2006. Financial constraints risk. *The Review of Financial Studies* 19, 531–559. doi:[10.1093/rfs/hhj012](https://doi.org/10.1093/rfs/hhj012).