

# **Online Appendix A**

**Attention allocation and return co-movement:**

**Evidence from repeated natural experiments**

Online Appendix Table OA1

Pair-wise correlations of individual firm returns on large jackpot days

For firm  $i$  and firm  $j$ ,  $i \neq j$ , pair-wise  $(i, j)$  time-series Pearson correlation coefficients are calculated on large jackpot days and on non-large jackpot days separately; then we obtain the differences (correlation coefficients on large jackpot days minus those on non-large jackpot days) and the percentage differences (differences divided by those on non-large jackpot days). The percentage change data for all firms are winsorized at the 99% and 1% levels to minimize the effects of extreme values. The paired  $t$ -test is employed for testing the mean difference, and Wilcoxon signed-rank test is used for testing the median differences. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% level, respectively.

		Large jackpot days	Non-large jackpot days	Difference ( $p$ -value)	Percentage change ( $p$ -value)
Correlation coefficient	Mean	0.258	0.246	0.012*** ( $<.0001$ )	0.044*** ( $<.0001$ )
	Median	0.266	0.248	0.018*** ( $<.0001$ )	0.073*** ( $<.0001$ )

Online Appendix Table OA2

Portfolios preferred by retail investors and return co-movement with market

This table shows that those portfolios more preferred by retail investors co-move more with the market. For daily observations, we sort stocks into 25 portfolios according to each stock's average market capitalization in the past 22 trading days (Panel A), or idiosyncratic return volatility in the past 180 trading days (Panel B). Equally weighted and value-weighted portfolio returns are calculated. For each portfolio, we calculate the Pearson correlation coefficients of portfolio excess returns with market excess returns on large jackpot days and on non-large jackpot days and then obtain their differences (the correlation on large jackpot days minus the correlation on non-large jackpot days). Displayed are results from the OLS regressions of those differences on the ranking of market capitalization or idiosyncratic volatility, respectively. We also run the following regression for each portfolio on large jackpot days and non-large jackpot days:

$$PortRet_{j,t} = \alpha_j + \beta_j MktRet_t + \varepsilon_{i,t},$$

where  $PortRet_{i,t}$  is excess return of portfolio  $j$  at time  $t$  and  $MktRet_t$  is market excess return at time  $t$ . Then we obtain the differences in adj.  $R^2$  (adj.  $R^2$  on large jackpot days minus adj.  $R^2$  on non-large jackpot days). Displayed are the results from OLS regressions of the differences on the ranking market capitalization or idiosyncratic volatility, respectively. \*\*\*, \*\* and \* indicate statistical significance at the 1%, 5% and 10% level, respectively.

*Panel A: market capitalization*

	Change in correlation coefficient		Change in adj. $R^2$	
	Equally weighted	Value-weighted	Equally weighted	Value-weighted
Ranking of market capitalization	-0.001*** (-3.93)	-0.001*** (-2.48)	-0.001*** (-2.97)	-0.001* (-1.94)
$R^2$	0.402	0.211	0.277	0.140
Observations	25	25	25	25

*Panel B: Idiosyncratic volatility*

	Change in correlation coefficient		Change in adj. $R^2$	
	Equally weighted	Value-weighted	Equally weighted	Value-weighted
Ranking of idiosyncratic volatility	0.001** (2.61)	0.001*** (3.77)	0.001* (2.05)	0.002*** (3.41)
$R^2$	0.228	0.382	0.154	0.335
Observations	25	25	25	25

Online Appendix Table OA3

The spillover of the large jackpots and investor attention

We conduct panel regression of share turnover (or SVI and abnormal SVI for firm name abbreviation) on large jackpot dummy variable, an indicator variable for two trading days' spillover in Panel A (or four in Panel B, six in Panel C), controlling for firm, year, month, and day of the week fixed effects. Standard errors are clustered at the firm level. We also run time series regression of SVI and abnormal SVI for lottery on the large jackpot dummy variable, an indicator variable for two trading days' spillover in Panel A (or four in Panel B, six in Panel C), controlling for year, month, and day of the week fixed effects. Standard errors are adjusted for heteroskedasticity. Share turnover and SVI are winsorized at the 2.5% and 97.5% levels. We report the *t*-statistics in parentheses. \*\*\*, \*\* and \* indicate statistical significance at the 1%, 5% and 10% level, respectively.

<i>Panel A: Two trading days' spillover</i>					
	Share turnover	SVI for firms	Abnormal SVI for firms	SVI for lottery	Abnormal SVI for lottery
Large jackpot	-0.016*** (-6.66)	-0.050*** (-3.39)	-0.006** (-2.20)	5.849*** (18.11)	0.907*** (17.88)
Spillover day	-0.011*** (-5.52)	-0.035*** (-2.77)	-0.005** (-1.97)	3.063*** (17.02)	0.478*** (17.06)
Fixed effects	Yes	Yes	Yes	Yes	Yes
<i>R</i> <sup>2</sup>	0.224	0.708	0.024	0.470	0.484
Observations	2,403,706	1,967,169	1,896,052	2,849	2,731
<i>Panel B: Four trading days' spillover</i>					
	Share turnover	SVI for firms	Abnormal SVI for firms	SVI for lottery	Abnormal SVI for lottery
Large jackpot	-0.018*** (-6.81)	-0.059*** (-3.91)	-0.007** (-2.21)	5.971*** (18.40)	0.934*** (18.33)
Spillover day	-0.011*** (-5.59)	-0.049*** (-4.12)	-0.004* (-1.76)	2.421*** (17.34)	0.398*** (18.37)
Fixed effects	Yes	Yes	Yes	Yes	Yes
<i>R</i> <sup>2</sup>	0.224	0.708	0.024	0.454	0.474
Observations	2,403,706	1,967,169	1,896,052	2,849	2,731

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*Panel C: Six trading days' spillover*

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	Share turnover	SVI for firms	Abnormal SVI for firms	SVI for lottery	Abnormal SVI for lottery
Large jackpot	-0.017*** (-6.08)	-0.057*** (-3.67)	-0.007** (-2.13)	6.057*** (18.63)	0.950*** (18.62)
Spillover day	-0.008*** (-3.38)	-0.033*** (-2.87)	-0.004 (-1.49)	2.000*** (17.10)	0.336*** (18.39)
Fixed effects	Yes	Yes	Yes	Yes	Yes
$R^2$	0.224	0.708	0.024	0.438	0.459
Observations	2,403,706	1,967,169	1,896,052	2,849	2,731

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Online Appendix Table OA4

Stock returns' co-movement with the market by alternative cutoffs

We define large jackpot days by alternative cutoffs (every 20 million TWD between 400 million TWD and 600 million TWD) and repeat the analysis in Table 3. Large jackpot days are those with a jackpot size bigger than the cutoff. The number of trading days ranges from 215 to 429. The decrease of trading days may add outliers which would deteriorate the mean test, so we winsorize the differences data at the 97.5% and 2.5% levels to minimize the effect of extreme values. Winsorizing them at the 99% and 1% levels gives qualitatively similar results. Reported are the mean and median of differences in correlation coefficient and adj.  $R^2$  on large jackpot days. The paired  $t$ -test is employed for testing the mean difference, and Wilcoxon signed-rank test is used for testing the median difference. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Cutoff	Correlation Coefficient		Adj. $R^2$	
	Mean Difference ( $p$ -value)	Median Difference ( $p$ -value)	Mean Difference ( $p$ -value)	Median Difference ( $p$ -value)
600	0.038*** ( $<.0001$ )	0.050*** ( $<.0001$ )	0.043*** ( $<.0001$ )	0.042*** ( $<.0001$ )
580	0.033*** ( $<.0001$ )	0.043*** ( $<.0001$ )	0.037*** ( $<.0001$ )	0.034*** ( $<.0001$ )
560	0.034*** ( $<.0001$ )	0.043*** ( $<.0001$ )	0.038*** ( $<.0001$ )	0.035*** ( $<.0001$ )
540	0.035*** ( $<.0001$ )	0.043*** ( $<.0001$ )	0.037*** ( $<.0001$ )	0.036*** ( $<.0001$ )
520	0.027*** ( $<.0001$ )	0.031*** ( $<.0001$ )	0.029*** ( $<.0001$ )	0.025*** ( $<.0001$ )
500	0.019*** ( $<.0001$ )	0.023*** ( $<.0001$ )	0.021*** ( $<.0001$ )	0.018*** ( $<.0001$ )
480	0.020*** ( $<.0001$ )	0.027*** ( $<.0001$ )	0.022*** ( $<.0001$ )	0.021*** ( $<.0001$ )
460	0.018*** ( $<.0001$ )	0.022*** ( $<.0001$ )	0.020*** ( $<.0001$ )	0.018*** ( $<.0001$ )
440	0.010*** ( $<.0001$ )	0.015*** ( $<.0001$ )	0.013*** ( $<.0001$ )	0.010*** ( $<.0001$ )
420	0.011*** ( $<.0001$ )	0.015*** ( $<.0001$ )	0.013*** ( $<.0001$ )	0.011*** ( $<.0001$ )
400	0.008*** (0.0002)	0.014*** ( $<.0001$ )	0.011*** ( $<.0001$ )	0.010*** ( $<.0001$ )

Online Appendix Table OA5

Investor attention on large jackpot days and on small jackpot days

Among large jackpot days (i.e., a jackpot size bigger than 500 million TWD) and small jackpot days (i.e., a jackpot size smaller than 64 million TWD), we run panel regressions of share turnover (or SVI and abnormal SVI for firms) on a large jackpot dummy variable, controlling for firm, year, month, and day of the week fixed effects. Standard errors are clustered at the firm level. We also run time series regressions of SVI and abnormal SVI for lottery on the large jackpot dummy variable, controlling for year, month, and day of the week fixed effects. Share turnover and SVI are winsorized at the 2.5% and 97.5% levels. We report the *t*-statistics in parentheses. Standard errors are adjusted for heteroskedasticity. \*\*\*, \*\* and \* indicate the significance level of 1%, 5% and 10% respectively.

	Share turnover	SVI for firms	Abnormal SVI for firms	SVI for lottery	Abnormal SVI for lottery
Large jackpot	-0.012*** (-4.14)	-0.082*** (-3.65)	-0.010*** (-2.72)	4.672*** (11.73)	0.731*** (11.36)
Fixed effects	Yes	Yes	Yes	Yes	Yes
<i>R</i> <sup>2</sup>	0.246	0.729	0.025	0.618	0.607
Observations	400,018	354,687	351,666	511	506

Online Appendix Table OA6

Stock return co-movement with market: by Google search volume index for “lottery”

The sample period is from January 4, 2004, to June 30, 2015. We collect Google weekly search index for “lottery” in traditional Chinese over the sample period in Taiwan and unadjusted Google daily search index over each quarter. We calculate the adjusted daily search index as follows: Adjusted daily search index = (weekly search index to which the day belongs) × (unadjusted daily search index / weekly average of unadjusted daily search index). Large Google search volume days are days with the daily search index bigger than 12.47, which is approximately 90th percentile value of the total sample. Following the same procedures described in Tables 3 and 10, we calculate the change in correlation and adj.  $R^2$  with the market/industry on large Google search volume days. The paired  $t$ -test is employed for testing the mean difference, and Wilcoxon signed-rank test is used for testing the median difference. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% level, respectively.

		Co-movement with market			Co-movement with industry			Market vs. industry
		Large	Non-large	Difference	Large	Non-large	Difference	Difference-in-differences
		SVI days	SVI days	( $p$ -value)	SVI days	SVI days	( $p$ -value)	( $p$ -value)
Correlation coefficient	Mean	0.474	0.448	0.026*** ( $<.0001$ )	0.515	0.495	0.020*** ( $<.0001$ )	0.005*** (0.003)
	Median	0.493	0.462	0.030*** ( $<.0001$ )	0.516	0.493	0.020*** ( $<.0001$ )	0.008*** ( $<.0001$ )
Adj. $R^2$	Mean	0.238	0.215	0.023*** ( $<.0001$ )	0.292	0.272	0.020*** ( $<.0001$ )	0.003* (0.077)
	Median	0.24	0.214	0.025*** ( $<.0001$ )	0.263	0.243	0.018*** ( $<.0001$ )	0.005*** (0.001)



Online Appendix Table OA7

Industry size and differences in the changes in co-movement with market and with industry

First, we compute the differences in changes in co-movement with market and with industry on large jackpot days for all 817 firms. Then, we partition all firms into 3 groups by industry size (i.e., by the number of firms in the firms' corresponding industry in Panel A and by the firms' corresponding industry's market capitalization in Panel B). The number of firms in each group is reported. The cross-sectional tests of the mean and median of the difference-in-differences are conducted for each group. The difference-in-differences are winsorized at the 97.5% and 2.5% levels. The paired *t*-test is used for testing the mean difference-in-differences, and Wilcoxon signed-rank test is employed for testing the median difference-in-differences. \*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% level, respectively.

*Panel A: Partition by number of firms in the corresponding industry*

Industry ranking	Difference-in-differences in correlation coefficient		Difference-in-differences in adj. $R^2$		Number of firms
	Mean ( <i>p</i> -value)	Median ( <i>p</i> -value)	Mean ( <i>p</i> -value)	Median ( <i>p</i> -value)	
1	0.009*** (0.003)	0.011*** (0.001)	0.007** (0.021)	0.009** (0.014)	256
2	0.007*** (0.006)	0.008*** (0.005)	0.007*** (0.002)	0.006*** (0.002)	284
3	0.001 (0.483)	0.003 (0.345)	0.002 (0.428)	0.001 (0.366)	277

*Panel B: Partition by firms' corresponding industry's market capitalization*

Industry ranking	Difference-in-differences in correlation coefficient		Difference-in-differences in adj. $R^2$		Number of firms
	Mean ( <i>p</i> -value)	Median ( <i>p</i> -value)	Mean ( <i>p</i> -value)	Median ( <i>p</i> -value)	
1	0.010*** (0.0005)	0.011*** (0.001)	0.006** (0.027)	0.007** (0.016)	271
2	0.006** (0.019)	0.005** (0.018)	0.005** (0.033)	0.004** (0.024)	300
3	0.004* (0.079)	0.004 (0.126)	0.005** (0.03)	0.003* (0.057)	246

# Online Appendix B

## Attention Allocation and Return Co-Movement: Evidence from Repeated Natural Experiments

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# 1 Our Baseline Model

To articulate the economic mechanisms of our hypotheses, we build a conceptual framework based on Peng and Xiong (2006) and Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016). Our economy has three periods:  $t = 0, 1$  and  $2$ . Investors invest in a large portfolio with financial assets at  $t = 0$  and  $1$ , and asset payoffs are realized at  $t = 2$ . Our model features introducing an exogenous shock that attracts investors' attention away from the financial market. Specifically, we use this exogenous shock to study how investors' attention reallocation affects return co-movements.<sup>1</sup>

The differences between our model and that of Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016) are as follows. First, whereas Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016) study how aggregate uncertainties affect investors' attention allocation, we focus on the study of investors' attention reallocation and asset pricing implications when one exogenous shock attracts their attention away from the financial market. Second, there is one representative investor in our model, whereas Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016) consider a static model with heterogeneous investors. Third, there are only market and firm-specific shocks in Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016), but our extension considers three types of shocks in asset payoffs including market, industry and firm-specific shocks.

Our model is related with but differs from that of Peng and Xiong (2006). Peng and Xiong (2006) consider a dynamic model with one representative investor with a CARA utility. We use a static model and follow Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016) to assume that the representative investor has a mean-variance utility. Moreover, we complement their model by showing how attention shocks affect return co-movements with the market and industries differently.

## 1.1 Model Description

**Structure of asset payoffs** There are  $n$  stocks in the financial market ( $n > 2$ ), and each stock has a net positive supply, which is normalized as 1. Each stock's payoff is realized at  $t = 2$ . In addition,

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<sup>1</sup>In our model, the investors' total attention span does not change, but one exogenous shock decreases investors' attention initially allocated to the financial market. We call this shock "attention shock" in the following analysis. Meanwhile, asset payoffs in the baseline model only have market and firm-specific shocks, but our extension incorporates market, industry and firm-specific shocks.

the risk-free asset provides a constant payoff of one for each unit. Stock  $i$ 's payoff is denoted by  $V_i$ , where  $V_i$  is random and depends on market shock  $m$  and firm-specific shock  $f_i$ . Specifically,  $V_i$  is a linear combination of  $m$  and  $f_i$  as follows:

$$V_{i,j} = \bar{V} + m + f_i, \quad (1.1)$$

where  $\bar{V}$  is the mean of  $V_i$ . The shocks,  $m$  and  $f_i$ , are realized at  $t = 2$  and are unknown for the investor at  $t = 0$ . Asset payoffs are summarized by a vector as follows:

$$V = (V_1, V_2, \dots, V_i, \dots, V_n)^T, \quad (1.2)$$

where  $T$  denotes the matrix transpose. We assume that these shocks are independent of each other, and follow normal distributions as follows:

$$m \sim N\left(0, \frac{1}{\tau_m}\right), \quad (1.3)$$

$$f_i \sim N\left(0, \frac{1}{\tau_f}\right), \quad (1.4)$$

where  $i = 1, 2, \dots, n$ . In this specification, the variance of market shock  $m$  is  $\frac{1}{\tau_m}$ , and the variance of firm-specific shock  $f_i$  is  $\frac{1}{\tau_f}$ . To simplify the analysis, we assume that  $\tau_m = \tau_e = \tau_f$ . Therefore, we have the following assumption.

**ASSUMPTION 1.** *The variances of market and firm-specific shocks are the same. In other words,  $\tau_m = \tau_f = \tau > 0$ .*

**Investor's Utility and Learning** There is one representative investor in this economy. We follow [Kacperczyk, Van Nieuwerburgh, and Veldkamp \(2016\)](#) and assume that this investor has a mean-variance utility over the final wealth. We denote the investor's initial wealth as  $W_0$ , his wealth at  $t = 1$  as  $W_1$ , and his final wealth at  $t = 2$  as  $W_2$ . At  $t = 0$ , the investor has no information. At the beginning of  $t = 1$ , the investor can allocate attention to learning about different shocks in asset payoffs and his information set is denoted by  $\mathcal{F}$ . Moreover, we assume that the investor's

utility from final wealth conditional on his information set  $\mathcal{F}$  is given by the following:

$$E(W_2|\mathcal{F}) - \frac{\gamma}{2} \text{Var}(W_2|\mathcal{F}), \quad (1.5)$$

where  $\gamma$  is the risk aversion coefficient.

The investor can learn about each shock, but his learning capacity is limited. For the learning process, we assume that the investor obtains signals about different shocks as follows:

$$s_m = m + \varepsilon_m, \text{ where } \varepsilon_m \sim N(0, \frac{1}{\kappa_m}), \quad (1.6)$$

$$s_{f,i} = f_i + \varepsilon_{f,i}, \text{ where } \varepsilon_{f,i} \sim N(0, \frac{1}{\kappa_{f,i}}), \quad (1.7)$$

where the signal noises  $\varepsilon_m$  and  $\varepsilon_{f,i}$  are independent of each other.  $\varepsilon_m$  follows a normal distribution with mean zero and precision  $\kappa_m$ ;  $\varepsilon_{f,i}$  follows a normal distribution with mean zero and precision  $\kappa_{f,i}$ . When the investor pays more attention to learning about one specific shock, the signal about this shock becomes more precise. Following the above signal specifications, the investor's information set at  $t = 1$   $\mathcal{F} = \{s_m, s_{f,1}, \dots, s_{f,k}, \dots, s_{f,n}\}$ .

Following [Kacperczyk, Van Nieuwerburgh, and Veldkamp \(2016\)](#), we assume that the investor has limited learning capacity and needs to rationally allocate his attention to learning about different shocks. More importantly, we assume that the investor's total attention span is  $K$ , but he will be potentially attracted by an exogenous event, such as large jackpots lotteries, away from the financial market at the beginning of  $t = 1$ . If there is no large lottery jackpot at the beginning of  $t = 1$ , the investor can devote all his attention to learning about shocks. If there is any lottery large jackpot at the beginning of  $t = 1$ , the investor is distracted from the financial market and can only allocate  $K - L$  to learning about shocks, where  $0 < L < K$ . Specifically, the investor's learning capacity is subject to his attention constraint as follows:

$$\kappa_m + \sum_{i=1}^n \kappa_{f,i} \leq K_F, \quad (1.8)$$

where  $K_F = K$  if no large jackpots occur, and  $K_F = K - L$  if large jackpots occur. Intuitively, the investors' total attention span does not change in this economy, but large jackpots decrease

investors' attention initially allocated to financial markets

## 1.2 The Equilibrium Description

This section describes the equilibrium definition. We denote the vector of asset prices at  $t = 0$  as  $P_0$ , and the vector of asset prices at  $t = 1$  as  $P_1$ , where  $P_0$  and  $P_1$  are  $n \times 1$  vectors given by the following:

$$P_0 = (P_{1,0} \dots P_{k,0} \dots P_{n,0})^T, \quad (1.9)$$

$$P_1 = (P_{1,1} \dots P_{k,1} \dots P_{n,1})^T. \quad (1.10)$$

Assuming that the investor's demand at  $t = 0$  is  $X_0$  and that his demand at  $t = 1$  is  $X_1$ ,  $X_0$  and  $X_1$  are  $n \times 1$  vectors given by the following:

$$X_0 = (X_{1,0} \dots X_{k,0} \dots X_{n,0})^T, \quad (1.11)$$

$$X_1 = (X_{1,1} \dots X_{k,1} \dots X_{n,1})^T. \quad (1.12)$$

Thus, his final wealth  $W_2 = W_0 + X_0'(P_1 - P_0) + X_1'(V - P_1)$ .

At  $t = 1$ , the investor has a two-step optimization problem as follows:

$$\max_{\kappa_m, \kappa_{f,i}} E \left\{ \max_{X_1} E(W_2 | \mathcal{F}) - \frac{\gamma}{2} \text{Var}(W_2 | \mathcal{F}) \right\} \quad (1.13)$$

subject to:

$$W_2 = W_1 + X_1'(V - P_1), \quad (1.14)$$

$$\kappa_m + \sum_{i=1}^n \kappa_{f,i} \leq K_F, \quad (1.15)$$

$$\kappa_m \geq 0, \quad \kappa_{f,i} \geq 0 \text{ for } i = 1, 2, \dots, n, \quad (1.16)$$

where  $\mathcal{F} = \{s_m, s_{f,1}, \dots, s_{f,k}, \dots, s_{f,n}\}$ .

The above optimization problem has two steps. In the first step, the investor optimally allocates his attention to learning about different shocks, subject to the attention constraint. In the second

step, the investor chooses optimal demand  $X_1$  to maximize his expected utility conditional on his information set.

At  $t = 0$ , because there is no information, the investor maximizes his unconditional expected utility as follows:

$$\max_{X_0} E(W_2) - \frac{\gamma}{2} \text{Var}(W_2) \quad (1.17)$$

subject to:

$$W_2 = W_0 + X_0'(P_1 - P_0) + X_1'(V - P_1). \quad (1.18)$$

### 1.3 Equilibrium Characterization

We use backward induction to solve the model. At  $t = 1$ , given attention allocation  $\kappa$ s, the optimal demands are given by the following:

$$X_1 = \frac{1}{\gamma} \text{Var}(V|\mathcal{F})^{-1} \{E(V|\mathcal{F}) - P_1\}. \quad (1.19)$$

In the equilibrium, the market clearing condition is  $X_1 = \mathbf{I}_{n \times 1}$ . Thus, we have the following:

$$P_1 = E(V|\mathcal{F}) - \gamma \text{Var}(V|\mathcal{F}) \cdot \mathbf{I}_{n \times 1}. \quad (1.20)$$

At  $t = 0$ ,

$$P_0 = L_0, \quad (1.21)$$

where  $L_0$  is a deterministic vector.

At the beginning of  $t = 1$ , the investor optimally allocates attention to learning about different shocks. Putting the expressions of  $X_1$  and  $P_1$  into the optimization problem in the equation (1.13), the investor's optimization problem regarding attention allocation is equivalent to the optimization problem as follows:

$$\max_{\kappa_m, \kappa_{f,i}} - \frac{\gamma}{2} \text{Var}(V|\mathcal{F}) \quad (1.22)$$

subject to

$$\kappa_m + \sum_{i=1}^n \kappa_{f,i} \leq K_F, \quad (1.23)$$

$$\kappa_m \geq 0, \quad \kappa_{f,i} \geq 0 \quad \text{where } i = 1, 2, \dots, n. \quad (1.24)$$

Conditional on the information set  $\mathcal{F}$ , the conditional variances of market and firm-specific shocks are  $\text{Var}(m|\mathcal{F}) = \frac{1}{\tau + \kappa_m}$  and  $\text{Var}(f_i|\mathcal{F}) = \frac{1}{\tau + \kappa_{f,i}}$ , respectively. Thus, the optimization problem for attention allocation is equivalent to the following:

$$\min_{\kappa_m, \kappa_{f,i}} \frac{n^2}{\tau + \kappa_m} + \sum_{i=1}^n \frac{1}{\tau + \kappa_{f,i}} \quad (1.25)$$

subject to

$$\kappa_m + \sum_{i=1}^n \kappa_{f,i} \leq K_F, \quad (1.26)$$

$$\kappa_m \geq 0, \quad \kappa_{f,i} \geq 0, \quad \text{where } i = 1, 2, \dots, n. \quad (1.27)$$

We use the Lagrange method to solve the investor's attention allocation problem as follows:

$$L = \frac{n^2}{\tau + \kappa_m} + \sum_{i=1}^n \frac{1}{\tau + \kappa_{f,i}} \quad (1.28)$$

$$- \lambda_K [K_F - \kappa_m - \sum_{i=1}^n \kappa_{f,i}] \quad (1.29)$$

$$- \lambda_m \kappa_m - \sum_{i=1}^n \lambda_{f,i} \kappa_{f,i}. \quad (1.30)$$

Because the objective function in the optimization is a decreasing and convex function of  $\kappa_s$ , its solution is unique. We summarize the uniqueness and existence of the solution as follows.

**PROPOSITION 1.** *There is one unique solution to the investor's attention allocation problem. There are two cases that concern the solutions to the investor's attention allocation problem:*

*Case 1: when the attention capacity is large ( $K_F \geq K^C$ ),*

$$\kappa_m = \frac{n}{\sqrt{\lambda_K}} - \tau, \quad \kappa_{f,i} = \frac{1}{\sqrt{\lambda_K}} - \tau, \quad (1.31)$$

where  $\sqrt{\frac{1}{\lambda_K}} = \frac{K_F + \tau + n\tau}{2n}$ .



Case 2: when the attention capacity is small ( $K_F \leq K^C$ ),

$$\kappa_m = K_F, \kappa_{f,i} = 0. \quad (1.32)$$

In addition, the investor allocates more attention to learning about the market shock than to learning about firm-specific shocks. That is,  $\kappa_m \geq \kappa_{f,i}$ .

Proposition 1 shows that the investor cares more about the market shock than firm-specific shocks. The intuition is clearly shown in the optimization problem of the equation (1.25). There are  $n$  stocks in this economy, where all stocks are subject to the market shock and only one stock is subject to a firm specific shock. Therefore, the market shock plays a more important role than firm-specific shocks in the investor's portfolio. As a result, the investor has incentive to allocate more attention to learning about the market shock than to learning about firm-specific shocks. Moreover, Proposition 1 shows that the investor learn about all types of shocks only when his attention capacity is large. When the attention allocated to the stock market becomes more binding, he starts to decrease his attention initially allocated to firm-specific shocks.

Proposition 1 clearly shows that attention shocks have different impacts on the attention allocated to different types of shocks. To study these impacts in detail, we denote attention allocated to the market shock and firm  $i$ 's shock as  $\kappa_m^{NL}$  and  $\kappa_{f,i}^{NL}$ , respectively, when no large jackpots occur. We denote attention allocated to the market shock and firm  $i$ 's shock as  $\kappa_m^L$  and  $\kappa_{f,i}^L$ , respectively, when large jackpots occur. The impacts of large jackpots in attention allocation to different shocks are summarized as follows.

**COROLLARY 1.** *For the interior solution, large jackpots lead to less attention allocated to all shocks. More importantly, when large jackpots attract the investor away from the financial market, his attention is relatively reduced with to learning about firm-specific shocks than to learning about the market shock. That is,  $|\frac{\kappa_{f,i}^{NL} - \kappa_{f,i}^L}{\kappa_{f,i}^{NL}}| > |\frac{\kappa_m^{NL} - \kappa_m^L}{\kappa_m^{NL}}|$ .*

This result in Corollary 1 is also based on the intuition that the market shock affects more stocks than firm-specific shocks. Corollary 1 has meaningful implications for the variabilities of asset prices. As shown in price functions  $P_1$ , the variabilities of asset prices are driven by signals about two types of shocks in the economy. Moreover, return co-movements depend on the incorporation

of market/firm-specific information. Specifically, when asset prices incorporate more information about the market shock, asset prices are more correlated. Following this intuition, we propose two measures of stock return co-movement with the market: correlation coefficient and  $R^2$ . First, we define the  $i$ th stock's return from  $t = 0$  to 1 as  $r_i$ , where  $r_i = P_{i,1} - P_{i,0}$ . The market index's return is given by:

$$r_m = \frac{\sum_{i=1}^{i=n} P_{i,1}}{n} - \frac{\sum_{i=1}^{i=n} P_{i,0}}{n}, \quad (1.33)$$

We denote stock  $i$ 's correlation coefficients with the market on large jackpot days as  $\rho_{i,m}^L$ , and denote stock  $i$ 's correlation coefficients with the market on non-large jackpot days as  $\rho_{i,m}^{NL}$ , where  $\rho_{i,m} = \frac{COV(r_i, r_m)}{\sqrt{Var(r_i)}\sqrt{Var(r_m)}}$ . Meanwhile,  $R_{i,m,L}^2$  is from the regressions of stock  $i$ 's returns on the market return on the large jackpot days, and  $R_{i,m,NL}^2$  is from the similar regressions on the non-large jackpot days. The following proposition summarizes the effects of large jackpots on return co-movements:

**PROPOSITION 2.** *For the interior solution, large jackpots increase stocks' correlation coefficients with the market index, and increase the variations explained by the market. That is,  $\rho_{i,m}^L > \rho_{i,m}^{NL}$  and  $R_{i,m,L}^2 > R_{i,m,NL}^2$ .*

Proposition 2 shows that stock return co-movements with market are higher on large jackpot days. Intuitively, when the investor is attracted by large jackpots, he decreases his total attention to the financial market. Correspondingly, the attention allocated to firm-specific shocks decreases relatively more than that allocated to market shocks (see Corollary 1). Asset prices thus incorporate relatively more market information. This leads to higher return co-movements with market.

Based on Proposition 2, we do perform comparative statics and study how changes in return co-movement vary with the initial level of attention capacity  $K$ . We denote the impact of large jackpots on stock  $i$ 's correlation coefficient with the market as  $Diff_{\rho,i,m}$ , where  $Diff_{\rho,i,m} = \rho_{i,m}^L - \rho_{i,m}^{NL}$ . In addition, we denote the impact of large jackpots on stock  $i$ 's  $R^2$  as  $Diff_{R^2,i,m}$ , where  $Diff_{R^2,i,m} = R_{i,m,L}^2 - R_{i,m,NL}^2$ . The comparative statics with  $K$  are summarized as follows:

**COROLLARY 2.** *For the interior solution, when the investor's attention capacity is larger, large jackpots have smaller impacts on stock return co-movements with the market. That is,  $\frac{\partial Diff_{R^2,i,m}}{\partial K} < 0$  and  $\frac{\partial Diff_{\rho,i,m}}{\partial K} < 0$ .*

Corollary 2 shows that large jackpots have different impacts on return co-movements for different initial levels of attention capacity  $K$ . Intuitively, for investors with large attention capacities (e.g. sophisticated institutional investors), large jackpots play a minor role in attention reallocation and thus have a small impact on stock return co-movements with market.

## 2 An Extension: Introducing Industry Shocks

Our baseline model shows that stock returns become more correlated when investor's total attention to financial markets decreases (e.g., being attracted by large jackpots in our economy). However, asset payoffs in the main model only have market and firm-specific shocks. In this section, we extend our analysis and assume that assets have three types of shocks including market, industry and firm-specific shocks. This extension not only serves as a robustness check, but also has some new implications (e.g., comparing attention shocks' impacts on return co-movements with the market and industries).

In this extension, we assume that there are  $n$  industries with  $k$  stocks in each industry, where  $n > 2$  and  $k > 2$ . Each stock has a net positive supply, which is normalized as 1. The payoff of the  $j$ th stock in the  $i$ th industry is denoted by  $V_{i,j}$ . Each stock's payoff  $V_{i,j}$  is random and depends on three categories of shocks. That is, market shock  $m$ , industry shock  $e_i$  and firm-specific shock  $f_{i,j}$ . To be more specific,  $V_{i,j}$  is a linear combination of  $m$ ,  $e_i$  and  $f_{i,j}$  as follows:

$$V_{i,j} = \bar{V} + m + e_i + f_{i,j}, \quad (2.34)$$

where  $\bar{V}$  is the mean of  $V_{i,j}$ . The shocks,  $m$ ,  $e_i$  and  $f_{i,j}$ , are realized at  $t = 2$ , and are unknown for the investor at  $t = 0$ . Asset payoffs are summarized by a vector as follows:

$$V = (V_{1,1}, \dots, V_{1,k}, \dots, V_{i,1}, \dots, V_{i,k}, \dots, V_{n,1}, \dots, V_{n,k})^T, \quad (2.35)$$

where  $T$  denotes the matrix transpose. We assume that these shocks are independent of each other,

and follow normal distributions as follows:

$$m \sim N\left(0, \frac{1}{\tau_m}\right), \quad (2.36)$$

$$e_i \sim N\left(0, \frac{1}{\tau_e}\right), \quad (2.37)$$

$$f_{i,j} \sim N\left(0, \frac{1}{\tau_f}\right), \quad (2.38)$$

where  $i = 1, 2, \dots, n$  and  $j = 1, 2, \dots, k$ . In this specification, the variance of market shock  $m$  is  $\frac{1}{\tau_m}$ , the variance of industry shock  $e_i$  is  $\frac{1}{\tau_e}$ , and the variance of firm-specific shock  $f_{i,j}$  is  $\frac{1}{\tau_f}$ . To simplify the analysis, we assume that  $\tau_m = \tau_e = \tau_f$ . Specifically, we have the following assumption.

**ASSUMPTION 2.** *The variances of market, industry and firm-specific shocks are the same. In other words,  $\tau_m = \tau_e = \tau_f = \tau > 0$ .*

For the learning process, we assume that the investor obtains the signals about different shocks as follows:

$$s_m = m + \varepsilon_m, \text{ where } \varepsilon_m \sim N\left(0, \frac{1}{\kappa_m}\right), \quad (2.39)$$

$$s_{e,i} = e_i + \varepsilon_{e,i}, \text{ where } \varepsilon_{e,i} \sim N\left(0, \frac{1}{\kappa_{e,i}}\right), \quad (2.40)$$

$$s_{i,j} = f_{i,j} + \varepsilon_{f,i,j}, \text{ where } \varepsilon_{f,i,j} \sim N\left(0, \frac{1}{\kappa_{f,i,j}}\right), \quad (2.41)$$

where the signal noises  $\varepsilon_m$ ,  $\varepsilon_{e,i}$  and  $\varepsilon_{f,i,j}$  are independent of each other.  $\varepsilon_m$  follows a normal distribution with mean zero and precision of  $\kappa_m$ ,  $\varepsilon_{e,i}$  follow a normal distribution with mean zero and precision of  $\kappa_{e,i}$ , and  $\varepsilon_{f,i,j}$  follows a normal distribution with mean zero and precision  $\kappa_{f,i,j}$ . When the investor pays more attention to learning about one specific shock, the signal about this shock becomes more precise. The investor's information set at  $t = 1$  is denoted by  $\mathcal{F}$ , where  $\mathcal{F} = \{s_m, s_{e,1}, \dots, s_{e,k}, s_{1,1}, \dots, s_{1,k}, \dots, s_{i,1}, \dots, s_{i,k}, \dots, s_{n,1}, \dots, s_{n,k}\}$ . Moreover, the investor's learning capacity is subject to his attention constraint as follows:

$$\kappa_m + \sum_{i=1}^n \kappa_{e,i} + \sum_{i=1}^n \left( \sum_{j=1}^k \kappa_{f,i,j} \right) \leq K_F, \quad (2.42)$$

where  $K_F = K$  if no large jackpots occur, and  $K_F = K - L$  if large jackpots occur at the beginning of  $t = 1$ . We follow Section 1 to solve the investor's attention allocation and equilibrium assets prices at  $t = 0$  and  $t = 1$  ( $P_0$  and  $P_1$ ). Because we have  $nk$  stocks,  $P_0$  and  $P_1$  are  $nk \times 1$  vectors given by the following:

$$P_0 = (P_{1,1,0}, \dots, P_{1,k,0}, \dots, P_{i,1,0}, \dots, P_{i,k,0}, \dots, P_{n,1,0}, \dots, P_{n,k,0})^T, \quad (2.43)$$

$$P_1 = (P_{1,1,1}, \dots, P_{1,k,1}, \dots, P_{i,1,1}, \dots, P_{i,k,1}, \dots, P_{n,1,1}, \dots, P_{n,k,1})^T. \quad (2.44)$$

The optimization problem for the attention allocation is equivalent to the following:

$$\min_{\kappa_m, \kappa_{e,i}, \kappa_{f,i,j}} \frac{n^2 k^2}{\tau + \kappa_m} + \sum_{i=1}^n \frac{k^2}{\tau + \kappa_{e,i}} + \sum_{i=1}^n \sum_{j=1}^k \frac{1}{\tau + \kappa_{f,i,j}} \quad (2.45)$$

subject to

$$\kappa_m + \sum_{i=1}^n \kappa_{e,i} + \sum_{i=1}^n \left( \sum_{j=1}^k \kappa_{f,i,j} \right) \leq K_F, \quad (2.46)$$

$$\kappa_m \geq 0, \quad \kappa_{e,i} \geq 0, \quad \kappa_{f,i,j} \geq 0 \quad \text{where } i = 1, 2, \dots, n \text{ and } j = 1, 2, \dots, k. \quad (2.47)$$

Because the objective function in the optimization is a decreasing and convex function of  $\kappa$ s, there is one unique solution. We summarize the uniqueness and existence of the solution as follows.

**PROPOSITION 3.** *There is one unique solution to the investor's attention allocation problem. There are three cases that concern the solutions to the investor's attention allocation problem:*

*Case 1: when the attention capacity is large ( $K_F \geq K^H$ ),*

$$\kappa_m = \frac{nk}{\sqrt{\lambda_K}} - \tau, \quad \kappa_{e,i} = \frac{k}{\sqrt{\lambda_K}} - \tau, \quad \kappa_{f,i,j} = \sqrt{\frac{1}{\lambda_K}} - \tau, \quad (2.48)$$

where  $\sqrt{\frac{1}{\lambda_K}} = \frac{K_F + \tau + n\tau + nk\tau}{3nk}$ .

*Case 2: when the attention capacity is medium ( $K^L \leq K_F \leq K^H$ ),*

$$\kappa_m = \frac{nk}{\sqrt{\lambda_K}} - \tau, \quad \kappa_{e,i} = \frac{k}{\sqrt{\lambda_K}} - \tau, \quad \kappa_{f,i,j} = 0, \quad (2.49)$$

where  $\sqrt{\frac{1}{\lambda_K}} = \frac{K_F + \tau + n\tau}{2nk}$ .

Case 3: when the attention capacity is small ( $K_F \leq K^L$ ),

$$\kappa_m = K_F, \kappa_{e,i} = 0, \kappa_{f,i,j} = 0. \quad (2.50)$$

In addition, the investor allocates more attention to the market shock than to industry shocks, and more attention to industry shocks than to firm-specific shocks. That is,  $\kappa_m \geq \kappa_{e,i}$  and  $\kappa_{e,i} \geq \kappa_{f,i,j}$ .

Proposition 3 shows that the investor cares more about the market shock than about industry shocks, and care more about industry shocks than about firm-specific shocks. The economic intuition is clearly shown in the optimization problem. Given  $n$  industries and  $k$  stocks in each industry, there are  $nk$  stocks in this economy. Because  $nk$  stocks are subject to the market shock and only  $k$  stocks are subject to a specific industry shock, the market shock plays a more important role than industry shocks in the investor's portfolio. Moreover, because only one stock is subject to the firm-specific shock, industry shocks play more important roles than firm-specific shocks in the investor's portfolio. Therefore, the investor pays more attention to the market shock than to industry shocks, and more attention to industry shocks than to firm-specific shocks. Moreover, Proposition 3 shows that, when attention allocated to the stock market becomes less, the investor initially begins to decrease his attention to learning about firm-specific shocks, and then decrease his attention to learning about industry shocks.

Proposition 3 clearly shows that attention shocks have different impacts on attention allocated to different types of shocks. To examine these impacts in detail, for the case without large jackpots, attention allocated to the market shock, industry  $i$ 's shock and firm  $ij$ 's firm-specific shock are denoted by  $\kappa_m^{NL}$ ,  $\kappa_{e,i}^{NL}$  and  $\kappa_{f,i,j}^{NL}$ , respectively. For the case with large jackpots, attention allocated to the market shock, industry  $i$ 's shock and firm  $ij$ 's firm-specific shock are denoted by  $\kappa_m^{NL}$ ,  $\kappa_{e,i}^{NL}$  and  $\kappa_{f,i,j}^{NL}$ , respectively. The impacts of large jackpots in attention reallocation to different shocks are summarized as follows.

**COROLLARY 3.** *For the interior solution, large jackpots lead to less attention to all shocks. More importantly, when large jackpots attract the investor away from the financial market, he reduces relatively more attention to learning about firm-specific shocks than to learning about industry shocks, and he reduces relatively more attention to learning about industry shocks than to learning*

about the market shock. That is,  $|\frac{\kappa_{f,i,j}^{NL} - \kappa_{f,i,j}^L}{\kappa_{f,i,j}^{NL}}| > |\frac{\kappa_{e,i}^{NL} - \kappa_{e,i}^L}{\kappa_{e,i}^{NL}}| > |\frac{\kappa_m^{NL} - \kappa_m^L}{\kappa_m^{NL}}|$ .

This result in Corollary 3 is also based on the intuition that the market shock affects more stocks than industry shocks, and industry shocks affect more stocks than firm-specific shocks.

Corollary 3 has meaningful implications for the variabilities of asset prices. As shown in price functions  $P_1$ , the variabilities of asset prices are driven by signals about three types of shocks in the economy. Moreover, return co-movements depend on the incorporation of market/industry information. Specifically, when asset prices incorporate more information about market/industry information, asset prices are more correlated. Following this intuition, we propose two measures of return co-movements with market/industry: the correlation coefficient and  $R^2$ . First, we define stock  $ij$ 's return from  $t = 0$  to 1 as  $r_{i,j}$ , where  $r_{i,j} = P_{i,j,1} - P_{i,j,0}$ . The market index and the industry  $i$  returns are given by the following:

$$r_m = \frac{\sum_{i=1}^{i=n} \sum_{j=1}^{j=k} P_{i,j,1}}{nk} - \frac{\sum_{i=1}^{i=n} \sum_{j=1}^{j=k} P_{i,j,0}}{nk}, \quad (2.51)$$

$$r_i = \frac{\sum_{j=1}^{j=k} P_{i,j,1}}{k} - \frac{\sum_{j=1}^{j=k} P_{i,j,0}}{k}. \quad (2.52)$$

We denote stock  $ij$ 's correlation coefficients with the market and industry  $i$  on large jackpot days as  $\rho_{i,j,m}^L$  and  $\rho_{i,j,i}^L$ , and we denote stock  $ij$ 's correlation coefficients with the market and industry  $i$  on non-large jackpot days as  $\rho_{i,j,m}^{NL}$  and  $\rho_{i,j,i}^{NL}$ , where  $\rho_{i,j,m} = \frac{COV(r_{i,j}, r_m)}{\sqrt{Var(r_{i,j})}\sqrt{Var(r_m)}}$  and  $\rho_{i,j,i} = \frac{COV(r_{i,j}, r_i)}{\sqrt{Var(r_{i,j})}\sqrt{Var(r_i)}}$ . Meanwhile,  $R_{i,j,m,L}^2$  and  $R_{i,j,i,L}^2$  are from the regressions of stock  $ij$ 's returns on the market return and industry  $i$  return on large jackpot days, and  $R_{i,j,m,NL}^2$  and  $R_{i,j,i,NL}^2$  are from the similar regressions on non-large jackpot days. The following proposition summarizes the impacts of large jackpots on return co-movements:

**PROPOSITION 4.** *For the interior solution, large jackpots increase stocks' correlation coefficients with market/industry indexes, and increase the variations explained by market/industry indexes. That is,  $\rho_{i,j,m}^L > \rho_{i,j,m}^{NL}$ ,  $\rho_{i,j,i}^L > \rho_{i,j,i}^{NL}$ ,  $R_{i,j,m,L}^2 > R_{i,j,m,NL}^2$ , and  $R_{i,j,i,L}^2 > R_{i,j,i,NL}^2$ .*

Both Proposition 3 and Corollary 3 show that the investor cares more about the market shock than industry shocks. Intuitively, when there are attention shocks, the investor reduces relatively

more attention to industry shocks than to the market shock. As a result, asset prices incorporate relatively more information about the market shock than that about industry shocks on large jackpot days, leading to higher co-movement with the market than that with industries. This implies that large jackpots have larger impacts on return co-movements with the market than that with industries.

To compare large jackpots' impacts on return co-movements with market and that with industries, we construct two measures,  $Diff - In - Diff_{R^2}$  and  $Diff - In - Diff_{\rho}$ . Here,  $Diff - in - Diff_{R^2} = Diff_{R^2,i,j,m} - Diff_{R^2,i,j,i}$  and  $Diff - In - Diff_{\rho} = Diff_{\rho,i,j,m} - Diff_{\rho,i,j,i}$ . In addition, we denote the impact of large jackpots on stock  $ij$ 's correlation coefficient with the market and industry  $i$  as  $Diff_{\rho,i,j,m}$  and  $Diff_{\rho,i,j,i}$ , where  $Diff_{\rho,i,j,m} = \rho_{i,j,m,L} - \rho_{i,j,m,NL}$  and  $Diff_{\rho,i,j,i} = \rho_{i,j,i,L} - \rho_{i,j,i,NL}$ . In addition, we denote the impact of large jackpots on stock  $ij$ 's  $R^2$  as  $Diff_{R^2,i,j,m}$  and  $Diff_{R^2,i,j,i}$ , where  $Diff_{R^2,i,j,m} = R_{i,j,m,L}^2 - R_{i,j,m,NL}^2$  and  $Diff_{R^2,i,j,i} = R_{i,j,i,L}^2 - R_{i,j,i,NL}^2$ . We describe the comparisons in the following corollary.

**COROLLARY 4.** *When the investor's attention capacity is medium, large jackpots' impact on return co-movements with the market is higher than their impact on return co-movements with industries. That is, when  $K^L \leq K_F \leq K^H$ , we have  $Diff - In - Diff_{R^2} > 0$  and  $Diff - In - Diff_{\rho} > 0$ .*

### 3 Testable Predictions

In this section, we discuss testable predictions based on the previous theoretical analysis. We have three empirical predictions as follows.

First, when large jackpot of lotteries attract investors away from the financial market, the amount of investors' attention allocated to the financial market decreases. Consequently, investors reduce relatively more attention to learning about firm-specific shocks than to learning about market/industries. Thus, more information about the market/industry is incorporated into asset prices, generating higher return co-movements. In summary, Proposition 2 and 4 predict that large jackpots lead to higher return co-movements with the market/industry (referring to the first hypothesis and the extension with industries in our main text).

Second, Corollary 2 shows that the impact of large jackpots in return co-movements are higher when the initial level of attention capacity  $K$  is lower. Given that retail investors tend to have lower



attention capacities than sophisticated institutional investors, we predict that large jackpots have a larger impact on stocks traded more by retail investors (referring to the second hypothesis in our main text).<sup>2</sup>

Third, because the market shock affects more stocks than an industry shock, investors reduce relatively more attention to learning about industry shocks than to learning about market shock on large jackpot days. Accordingly, Corollary 4 predicts that large jackpots change return co-movements with the market more than those with industries (referring to the extension with industries in our main text).

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<sup>2</sup>We conjecture that retail investors have low attention capacities for several reasons. First, according to [Kacperczyk, Van Nieuwerburgh, and Veldkamp \(2014, 2016\)](#) and [Nosal, Kacperczyk, and Stevens \(2015\)](#), attention capacity can be interpreted as trading skills. Because retail investors lack professional education or financial knowledge, they have lower attention capacities. Second, most retail investors have regular non-financial jobs and have limited time to analyze financial information.

## 4 Appendix

This appendix provides all proofs omitted above with auxiliary results. In addition, the economy with market and firm-specific shocks (Section 2) is a special case of the economy with market, industry and firm-specific shocks (Section 3). For brevity, we only provide detailed proofs for Proposition 3, Corollary 3, Proposition 4, Corollary 2 and Corollary 4. For the proofs for Proposition 1 and Corollary 1, we only do several notation changes. First, we replace the number of stocks  $nk$  with  $n$  in the optimization problem. Second, we assume that the precision of industry shocks are infinite. That is,  $\tau_f = +\infty$ .

PROOF OF PROPOSITION 1 AND 3. The Proof of Proposition 1 is a special case of Proposition 3. The proof of Proposition 1 is omitted for brevity, and we only focus on the proof of Proposition 3.

The proposition's existence and uniqueness is from the fact that the objective function is a decreasing and convex function of  $\kappa$ s. We use the Lagrange method to solve the investor's attention allocation problem as follows:

$$L = \frac{n^2 k^2}{\tau + \kappa_m} + \sum_{i=1}^n \frac{k^2}{\tau + \kappa_{e,i}} + \sum_{i=1}^n \sum_{j=1}^k \frac{1}{\tau + \kappa_{f,i,j}} \quad (4.1)$$

$$- \lambda_K [K_F - \kappa_m - \sum_{i=1}^n \kappa_{e,i} - \sum_{i=1}^n (\sum_{j=1}^j \kappa_{f,i,j})] \quad (4.2)$$

$$- \lambda_m \kappa_m - \sum_{i=1}^n \lambda_{e,i} \kappa_{e,i} - \sum_{i=1}^n (\sum_{j=1}^j \lambda_{f,i,j} \kappa_{f,i,j}). \quad (4.3)$$

Clearly, when  $K_F$  is large enough ( $\frac{K_F + \tau + n\tau + nk\tau}{3nk} \geq \tau$ , that is  $K_F \geq (2nk - n - 1)\tau$ ), we have interior solutions for  $\kappa$ s. These interior solutions are given by:

$$\kappa_m = \frac{nk}{\sqrt{\lambda_K}} - \tau, \kappa_{e,i} = \frac{k}{\sqrt{\lambda_K}} - \tau, \kappa_{f,i,j} = \sqrt{\frac{1}{\lambda_K}} - \tau, \quad (4.4)$$

where  $\sqrt{\frac{1}{\lambda_K}} = \frac{K_F + \tau + n\tau + nk\tau}{3nk}$ .

When  $(n-1)\tau \leq K_F < (2nk - n - 1)\tau$ ,  $\kappa_{f,i,j} = 0$ , and the interior solutions of  $\kappa_m$  and  $\kappa_{e,i}$  are given by:

$$\kappa_m = \frac{nk}{\sqrt{\lambda_K}} - \tau, \kappa_{e,i} = \frac{k}{\sqrt{\lambda_K}} - \tau, \quad (4.5)$$

where  $\sqrt{\frac{1}{\lambda_K}} = \frac{K_F + \tau + n\tau}{2nk}$ .

When  $K_F < (n-1)\tau$ ,  $\kappa_{f,i,j} = \kappa_{e,i} = 0$ , and the interior solution of  $\kappa_m$  is given by:

$$\kappa_m = K_F. \quad (4.6)$$

Now we denote  $K^H = (2nk - n - 1)\tau$  and  $K^L = (n - 1)\tau$ , and we can obtain the solutions for different regions shown in the proposition. Comparing  $\kappa_m$ ,  $\kappa_{e,i}$ ,  $\kappa_{f,i,j}$ , we get that  $\kappa_m \geq \kappa_{e,i}$  and  $\kappa_{e,i} \geq \kappa_{f,i,j}$ . This concludes the proof.  $\square$

**PROOF OF COROLLARY 1 AND COROLLARY 3.** The Proof of Corollary 1 is a special case of Corollary 3. The proof of Corollary 1 is omitted for brevity, and we only focus on the proof of Corollary 3.

It is clear that when large jackpots occur, the investor pays less attentions to learning about all shocks. For the interior solution, the absolute percentage changes in attention allocated to different shocks caused by large jackpots are given by:

$$\left| \frac{\kappa_m^{NL} - \kappa_m^L}{\kappa_m^{NL}} \right| = \frac{\frac{L}{3nk}}{\frac{1}{\sqrt{\lambda_K}} - \frac{1}{nk}\tau}, \quad (4.7)$$

$$\left| \frac{\kappa_{e,i}^{NL} - \kappa_{e,i}^L}{\kappa_{e,i}^{NL}} \right| = \frac{\frac{L}{3nk}}{\frac{1}{\sqrt{\lambda_K}} - \frac{1}{k}\tau}, \quad (4.8)$$

$$\left| \frac{\kappa_{f,i,j}^{NL} - \kappa_{f,i,j}^L}{\kappa_{f,i,j}^{NL}} \right| = \frac{\frac{L}{3nk}}{\frac{1}{\sqrt{\lambda_K}} - \tau}. \quad (4.9)$$

It is clear that the absolute percentage change in attention allocated to firm-specific shocks is larger than that allocated to industry shocks, and the absolute percentage change of attention allocated to industry shocks is larger than that allocated to the market shock.  $\square$

**PROOF OF PROPOSITION 2 AND PROPOSITION 4.** The Proof of Proposition 2 is a special case of Proposition 4. The proof of Proposition 2 is omitted for brevity, and we only focus on the proof of Proposition 4.

Because  $R^2$  is  $\rho^2$ , we could only focus on  $\rho^2$  in this proof. In addition, the proposition is equivalent to the results that  $\rho_{i,j,m}^2$  and  $\rho_{i,j,i}^2$  are decreasing with  $K_F$ . A calculation of  $\rho_{i,j,m}^2$  and  $\rho_{i,j,i}^2$  shows that:

$$\rho_{i,j,m}^2 = \frac{\frac{\kappa_m}{\tau + \kappa_m} \frac{1}{\tau} + \frac{1}{n} \frac{\kappa_e}{\tau + \kappa_e} \frac{1}{\tau} + \frac{1}{nk} \frac{\kappa_f}{\tau + \kappa_f} \frac{1}{\tau}}{\frac{\kappa_m}{\tau + \kappa_m} \frac{1}{\tau} + \frac{\kappa_e}{\tau + \kappa_e} \frac{1}{\tau} + \frac{\kappa_f}{\tau + \kappa_f} \frac{1}{\tau}}, \quad (4.10)$$

$$\rho_{i,j,i}^2 = \frac{\frac{\kappa_m}{\tau + \kappa_m} \frac{1}{\tau} + \frac{\kappa_e}{\tau + \kappa_e} \frac{1}{\tau} + \frac{1}{k} \frac{\kappa_f}{\tau + \kappa_f} \frac{1}{\tau}}{\frac{\kappa_m}{\tau + \kappa_m} \frac{1}{\tau} + \frac{\kappa_e}{\tau + \kappa_e} \frac{1}{\tau} + \frac{\kappa_f}{\tau + \kappa_f} \frac{1}{\tau}}, \quad (4.11)$$

where  $\kappa_m = \frac{nk}{\sqrt{\lambda_K}} - \tau$ ,  $\kappa_e = \frac{k}{\sqrt{\lambda_K}} - \tau$ ,  $\kappa_f = \sqrt{\frac{1}{\lambda_K}} - \tau$ . Now we focus on  $\rho_{i,j,m}^2$ . Using the

expressions of  $\kappa_m, \kappa_e$ , and  $\kappa_f$ , we have:

$$\begin{aligned} & \frac{\kappa_m}{\tau + \kappa_m} \frac{1}{\tau} + \frac{1}{n} \frac{\kappa_f}{\tau + \kappa_f} \frac{1}{\tau} + \frac{1}{nk} \frac{\kappa_f}{\tau + \kappa_f} \frac{1}{\tau} \\ &= \left( \frac{1}{\tau} + \frac{1}{n} \frac{1}{\tau} + \frac{1}{nk} \frac{1}{\tau} \right) - \frac{3}{nk} \sqrt{\lambda_K}, \end{aligned} \quad (4.12)$$

$$\begin{aligned} & \frac{\kappa_m}{\tau + \kappa_m} \frac{1}{\tau} + \frac{\kappa_f}{\tau + \kappa_f} \frac{1}{\tau} + \frac{\kappa_f}{\tau + \kappa_f} \frac{1}{\tau} \\ &= \left( \frac{1}{\tau} + \frac{1}{\tau} + \frac{1}{\tau} \right) - \left( \frac{1}{nk} + \frac{1}{k} + 1 \right) \sqrt{\lambda_K}, \end{aligned} \quad (4.13)$$

which leads to:

$$\rho_{i,j,m}^2 = \frac{\frac{1}{nk} + \frac{1}{k} + 1}{nk/3} \frac{\frac{1}{\tau} (1 + \frac{1}{n} + \frac{1}{nk}) nk/3 - \sqrt{\lambda_K}}{\frac{3}{\tau} / (\frac{1}{nk} + \frac{1}{k} + 1) - \sqrt{\lambda_K}}. \quad (4.14)$$

When  $n \geq 2$  and  $k \geq 2$ ,  $(1 + \frac{1}{n} + \frac{1}{nk}) nk/3 > 1 / (\frac{1}{nk} + \frac{1}{k} + 1)$ . It is clear that  $\rho_{i,j,m}^2$  is increasing with  $\lambda_K$ , and thus is decreasing with  $K_F$ .

For  $\rho_{i,j,i}^2$ , it is calculated as follows:

$$\rho_{i,j,i}^2 = \frac{\frac{1}{nk} + \frac{1}{k} + 1}{\frac{1}{nk} + \frac{1}{k} + \frac{1}{k}} \frac{\frac{1}{\tau} (1 + 1 + \frac{1}{k}) / (\frac{1}{nk} + \frac{1}{k} + \frac{1}{k}) - \sqrt{\lambda_K}}{\frac{3}{\tau} / (\frac{1}{nk} + \frac{1}{k} + 1) - \sqrt{\lambda_K}}. \quad (4.15)$$

When  $n \geq 2$  and  $k \geq 2$ ,  $(1 + 1 + \frac{1}{k}) / (\frac{1}{nk} + \frac{1}{k} + \frac{1}{k}) > 3 / (\frac{1}{nk} + \frac{1}{k} + 1)$ . It is clear that  $\rho_{i,j,i}^2$  is increasing with  $\lambda_K$ , and thus is decreasing with  $K_F$ . □

**PROOF OF COROLLARY 2.** We take two steps to prove this corollary. In the first step, we prove that both  $Diff_{R^2, i, j, m}$  and  $Diff_{R^2, i, j, i}$  are decreasing with attention capacity  $K$ . In the second step, we prove that both  $Diff_{\rho, i, j, m}$  and  $Diff_{\rho, i, j, i}$  are decreasing with attention capacity  $K$ .

### Step 1

Using the expression of  $R_{i,j,m,L}^2$ ,  $R_{i,j,m,NL}^2$  and  $\frac{1}{\sqrt{\lambda_K}}$ , we have

$$\begin{aligned} Diff_{R^2, m} &= \frac{\frac{1}{\tau} (1 + \frac{1}{n} + \frac{1}{nk}) nk/3 \frac{K-L+(1+n+nk)\tau}{3nk\tau} - 1}{\frac{3}{\tau} / (\frac{1}{nk} + \frac{1}{k} + 1) \frac{K-L+(1+n+nk)\tau}{3nk\tau} - 1} - \frac{\frac{1}{\tau} (1 + \frac{1}{n} + \frac{1}{nk}) nk/3 \frac{K+(1+n+nk)\tau}{3nk\tau} - 1}{\frac{3}{\tau} / (\frac{1}{nk} + \frac{1}{k} + 1) \frac{K+(1+n+nk)\tau}{3nk\tau} - 1} \\ &= \left( \frac{(1 + \frac{1}{n} + \frac{1}{nk}) nk/3}{\frac{3}{\tau} / (\frac{1}{nk} + \frac{1}{k} + 1) \frac{K-L+(1+n+nk)\tau}{3nk\tau}} - 1 \right) \times \\ &\quad \left( \frac{1}{\frac{3}{\tau} / (\frac{1}{nk} + \frac{1}{k} + 1) \frac{K-L+(1+n+nk)\tau}{3nk\tau} - 1} - \frac{1}{\frac{3}{\tau} / (\frac{1}{nk} + \frac{1}{k} + 1) \frac{K+(1+n+nk)\tau}{3nk\tau} - 1} \right) \end{aligned}$$

It is clear,  $\frac{\partial Diff_{R^2,i,j,m}}{\partial K} < 0$ . Following the similar procedure, we could get that  $\frac{\partial Diff_{R^2,i,j,i}}{\partial K} < 0$ .

## Step 2

Using the expression of  $\rho_{i,j,m,L}$ ,  $\rho_{i,j,m,L}$  and  $\frac{1}{\sqrt{\lambda_K}}$ , we have

$$\begin{aligned} Diff_{\rho,i,j,m} &= \sqrt{\frac{\frac{1}{\tau}(1 + \frac{1}{n} + \frac{1}{nk})nk/3^{\frac{K-L+(1+n+nk)\tau}{3nk\tau}} - 1}{\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K-L+(1+n+nk)\tau}{3nk\tau}} - 1}} - \sqrt{\frac{\frac{1}{\tau}(1 + \frac{1}{n} + \frac{1}{nk})nk/3^{\frac{K+(1+n+nk)\tau}{3nk\tau}} - 1}{\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K+(1+n+nk)\tau}{3nk\tau}} - 1}} \\ &= \sqrt{a + \frac{a-1}{\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K-L+(1+n+nk)\tau}{3nk\tau}} - 1}} - \sqrt{a + \frac{a-1}{\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K+(1+n+nk)\tau}{3nk\tau}} - 1}}, \end{aligned}$$

where  $a = \frac{(1 + \frac{1}{n} + \frac{1}{nk})nk/3}{\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K-L+(1+n+nk)\tau}{3nk\tau}}}$ . Then, we have:

$$\begin{aligned} \frac{\partial Diff_{\rho,i,j,m}}{\partial K} &= \frac{1}{2} \frac{3}{\tau} / (\frac{1}{nk} + \frac{1}{k} + 1) \frac{1}{3nk\tau} \times \\ &\{ -(a + \frac{a-1}{\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K-L+(1+n+nk)\tau}{3nk\tau}} - 1})^{-0.5} (\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K-L+(1+n+nk)\tau}{3nk\tau}} - 1)^{-2} \\ &+ (a + \frac{a-1}{\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K+(1+n+nk)\tau}{3nk\tau}} - 1})^{-0.5} (\frac{3}{\tau}/(\frac{1}{nk} + \frac{1}{k} + 1)^{\frac{K+(1+n+nk)\tau}{3nk\tau}} - 1)^{-2} \} \\ &< 0. \end{aligned}$$

Following a similar procedure, we can obtain  $\frac{\partial Diff_{\rho,i,j,i}}{\partial K} < 0$ . □

**PROOF OF COROLLARY 4.** When  $K^L \leq K_F \leq K^H$ , there are no firm-specific information. Thus, both  $Diff_{R^2,i,j,i}$  and  $Diff_{\rho,i,j,i}$  are 0. From Proposition 2, we have  $Diff_{R^2,i,j,m} > 0$  and  $Diff_{\rho,i,j,m} > 0$ . This leads to the results in this Corollary. □

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