# Are fund managers incentivised to ignore stock market jumps?

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**ABSTRACT**

In this paper, we show that the way in which fund managers are compensated can, under plausible conditions, lead them to act in a way that does not maximise the wellbeing of their clients. Due to performance bonuses in fund managers' rewards, there is a highly non-linear relationship between the wealth of the client and the fees that the manager receives. We demonstrate that jumps in equity returns can lead to a conflict of interest between the investor and the manager in such a setting. Specifically, the managers' option-type payment structure can incentivise them to not account for the downside risk induced by jumps, especially if the fund manager is only in post for a few years; thus managers may pursue a more aggressive asset allocation strategy than their clients desire. Our key policy recommendation is that regulators should consider imposing a negative fund fee in times of very poor absolute fund performance to mitigate against suboptimal fund management asset allocation decisions.

**KEYWORDS**

manager incentives; jump-diffusion; portfolio optimisation; risk management; tail risk; clawbacks

**JEL Codes:** G10, G11, G23, G24, C11

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## 1. Introduction

The 2008 financial crisis and the recent volatile period were stark reminders that equity markets periodically experience sudden, severe declines; such behavior can be appropriately modelled using jump processes. In this paper, we demonstrate that principal-agent conflicts of interest in portfolio management can arise in a setting where jumps in asset prices are present but the fund manager has the discretion to select a portfolio allocation that maximises her, not her client's, interest. These conflicts are most acute when the investment horizon of the manager is short, when risk aversion is low, and when investors respond in a symmetrical manner to positive and negative fund performance via transferring their wealth between funds. We identify the mechanisms that mitigate such incentives and make policy suggestions to prevent, or at least dampen, excessive risk-taking behaviour by the manager. Thus, our work innovatively connects two distinct areas of finance; first, portfolio optimisation under jumps in the return process and, second, principal-agent problems when managerial compensation is performance-based. Our work also has potential regulatory implications for the Financial Conduct Authority in the UK and other regulators internationally.

We expand on Hong and Jin (2018) and suggest an approximation that allows the calculation of optimal portfolio weights for stochastic volatility jump-diffusion models (SVCJ) with constant arrival intensity for jumps. An affine jump-diffusion model with a proper jump-size distribution and stochastic volatility can fit equity return data well both before and after the crisis (Kou, Yu, and Zhong (2016)), although the proper selection of a jump distribution is an open issue. The differences in model fit stem from the differences in jump distributions, which appear to be the governing factor behind our results. This mirrors our comparison between a manager using a stochastic volatility model versus one who uses an SVCJ model. We build on and extend prior jump-diffusion literature by examining a novel application to a delegated portfolio management setting.

Our second key contribution is to show how jumps in asset prices and volatility can cause an investor-fund manager conflict when managers receive one-sided performance bonuses. This relates to finance literature on the compensation structure in a delegated portfolio management setting, e.g which compensation structure that leads to a trading strategy with the highest risk-adjusted compensation for the manager (Aivaliotis and Palczewski (2014)). However, equity returns are known to incorporate jumps in both returns and volatility (Kou, Yu, and Zhong (2016)), which introduce negative skewness and kurtosis in their distributions. We extend this to a principal-agent (investor-manager) setting where jumps are present in the returns generating process to examine if and illustrate how conflicts of interest can arise in such a setup. Although option-type compensation is a known source of such conflicts (Goetzmann, Ingersoll, and Ross (2003)), the additional impact of jumps in portfolio management has received little attention. Due to the negative skewness of returns and the negative average magnitude of jumps, such effects are not necessarily symmetric and create distinct technical and management issues that are not addressed in the literature. We provide a new formalisation that embodies those features.

In our model, the fund manager makes a strategic asset allocation decision between an equity index and a risk-free asset on behalf of the investor. The fund manager can choose between one of two portfolios. The first maximises the expected utility of the investor when the volatility of equity returns is stochastic but there are no jumps (Heston (1993)). The second portfolio takes into account jumps in returns and volatility as well as stochastic volatility (Eraker, Johannes, and Polson (2003)); thus, it is optimal in our setting since it maximises investor wellbeing (i.e. utility from portfolio wealth). Nonetheless, a conflict of interest can arise since the fund manager selects the portfolio that maximises her own expected utility, despite knowing that this choice may not maximise her client's expected welfare. Manager utility is based on fee income,[1] which comprises an administration fee plus a performance bonus. A range of simulations demonstrate that there are plausible conditions under which the manager will prefer an allocation that ignores jumps, and so places greater weight in the risky asset. Since the manager receives a performance bonus in both cases, the main factor behind our results is jumps in asset prices, not the option-type compensation. We thus further contribute to the literature by isolating the role of jumps in returns and volatility and suggesting ways to mitigate its impact on conflicts of interest. This aspect is often missing from the literature. For example, Goetzmann, Ingersoll, and Ross (2003), Carpenter (2000) and Rajan (2006) note the potential danger of option-type compensation for the manager to lead to excessive risk-taking, however its explicit connection to returns jumps and a possible resolution have not been fully explored.

Our third important contribution is to show that when investors are able to claw back (part of) past performance fees in the event of very poor absolute performance, then the conflict of

[1] Risk aversion and utility functions are the same for both agents. This ensures that our results are solely driven by jumps in asset prices, which impact differently upon the investor's utility from wealth and the manager's utility from fees.

interest is largely ameliorated. This is intuitive since it better aligns the payoffs of the manager with those of the investor given the investor benefits when the fund performs well but also suffers losses when the fund performs badly. Clawbacks can also be considered as directly exposing the manager to fund performance, akin to having a stake in the fund. Clare et al. (2022) show that when a manager has a stake they tend to choose lower exposure to the main risk factors. The clawback approach has some similarities to portfolio manager ownership which can also serve as an incentive alignment mechanism (Ma and Tang (2019), Kaniel, Tompaidis, and Zhou (2019)). In a bank setup under malus (clawbacks from non-vested bonus escrow accounts), Hoffmann, Inderst, and Opp (2021) show in a recent paper that if the regulator correctly understands unconstrained optimal compensation design, such provisions can, in certain setups, lead bank shareholders to incentivise welfare-superior actions from managers. Our paper's findings on clawbacks have important implications for regulation policy, given their remit to ensure consumers are protected and the integrity of the financial system, as well as for resolving other principal-agent conflicts such as shareholder-manager conflicts.

Based on our results, we recommend that regulators should seriously consider mandating clawbacks to prevent this particular conflict of interest. They are a tool that can be applied to improve managerial decision making and address (excessive) risk taking incentives. The latter can occur in a "heads I win tails you lose" scenario or due to peer pressure amongst managers (Rajan (2006)). Although managers do need to be incentivised by compensation to be better aligned with company objectives (Hoskisson et al. (2017)), convex, upside only compensation can be problematic as it generates incentives to undertake excess risk, e.g. due to peer pressure among managers. It also helps us explain further why although in our model removing bonuses altogether can mitigate the conflict of interests, but also why using clawbacks of past bonuses could be an alternative mechanism that can even better align the objectives of principal and agent by providing appropriate incentives to generate value for the principal. Earlier findings on the relationship between risk and performance incentives are mixed (He et al. (2014), Corgnet and Hernan-Gonzalez (2019)). Our work takes a different perspective and demonstrates that two-sided performance incentives offer better alignment benefits than one-sided performance incentives. This is intuitive, since both principal and agent suffer losses when there is bad performance compared to upside only compensation.

## 2. The equity index return model

### 2.1. *The SVCJ and SV models*

Two ways to model jumps in equity returns are using a fat-tailed distribution (preferably of known probability density function) as in Jondeau and Rockinger (2012) or adding a separate jump term in a diffusion process. Conceptually, imposing a fat-tailed probability density function affects the hump of the distribution as well as the tails, while at the same time it manages to capture only the final outcome in returns - a jump, in this context, is only a drawing from the tail. On the other hand, a "normal" diffusion part plus an "abnormal" jump part offer a more flexible structure that captures a host of properties both in the diffusion and the jumps. Large movements in returns can come from combinations of moderate, or even small, values of the diffusion and jumps components. Therefore, such a structure allows the existence of small, moderate and large discontinuities that can be enhanced or dampened by the diffusion part. This flexibility is key in model fit and capturing subtle effects in the returns process. Stochastic volatility is also needed to capture time variation in the second moment, which leads to volatility clustering. Bates (2000) highlights discontinuities and sudden surges in volatility that correspond to jumps, which call for a separate jump structure in that process, while Cartea and Karyampas (2016) use jumps to predict volatility.

A key notion in our approach is the use of a risk neutral measure. Consequently, we use the Heston (1993) square-root stochastic volatility (SV) model to model returns without jumps:

$$\begin{aligned} dY_t &= \mu dt + \sqrt{V_{t-}} dW_t^Y \\ dV_t &= \kappa(\theta - V_{t-})dt + \sigma_V \sqrt{V_{t-}} dW_t^V \end{aligned} \tag{1}$$

The Euler discretised versions and posterior distributions can be found in Appendix A. The Brownian motions correspond to drawings from $\epsilon_t^{Y,V} \sim N(0,1)$ while the Poisson jump process is discretised to a Bernoulli where jump $J \sim Ber(\lambda)$ times magnitude $\xi_t^{Y,V}$.

Our main model is the Eraker, Johannes, and Polson (2003) continuous time SVCJ model

(EJP) which incorporates both stochastic volatility and jumps:

$$
\begin{aligned}
dY_t &= \mu dt + \sqrt{V_{t-}} dW_t^Y + \xi_t^Y dN_t \\
dV_t &= (\kappa\theta - \kappa V_{t-})dt + \sigma_V \sqrt{V_{t-}} dW_t^V + \xi_t^V dN_t
\end{aligned} \tag{2}
$$

$dY_t$ is instantaneous log returns where $Y_t$ is the log price, $V_t$ is variance and $V_{t-}$ the left limit of $V_t$ (the point in time closest to it). $\{W_t^Y\}, \{W_t^W\}$ are Brownian motions with correlation $\rho$, $\{N_t\}$ is a Poisson process with constant arrival intensity $\lambda$ that is common in the two processes, $\mu$ is diffusive mean returns and is constant, $\xi_t^Y, \xi_t^V$ are jump sizes of returns and volatility with correlation $\rho_j$, $\sigma_V$ is the "volatility of volatility" parameter, $\kappa$ is the speed of mean reversion for $V_t$ and $\theta$ is the diffusive long-run volatility mean. Returns jumps follow a normal distribution $N(\mu_Y + \rho_j \xi_V, \sigma_Y^2)$ and volatility jumps follow an exponential distribution $exp(\mu_V)$ which guarantees positivity of volatility. Some useful transformations can be applied for estimation purposes[2].

The SVCJ model nests many variations of affine jump-diffusion models, including the SV model, and its variety of applications allows wide comparisons of performance and parameters. The first paper to present and estimate the model via Markov Chain Monte Carlo (MCMC) was Eraker, Johannes, and Polson (2003), with a full discussion to be found in Johannes and Polson (2010). It is the best performing model of its class and has been estimated, among others, in Raggi (2004) (technical expansion), Asgharian and Bengtsson (2006) (jump spillovers in international markets), Li, Wells, and Yu (2006) (comparison with infinite-jump Lévy processes), Brooks and Prokopczuk (2013) (application to commodities markets), and Witzany (2013) (expansion to bivariate framework). Stochastic equity premia or arrival intensities can be represented by stochastic processes for $\mu$ and $\lambda$. Additional equity premium terms can be introduced linearly in the mean of the returns process, yet as Eraker, Johannes, and Polson (2003) note a volatility premium for equity returns is negligible. The mean of the diffusive part, $\mu$, does not compensate for jumps and represents a risk-free rate $r$ plus a diffusive equity premium $EP$.

[2]Shorthands $\alpha = \kappa\theta, \beta = -\kappa$ are also used in some formulations. By rewriting the volatility error term in (1) as $\epsilon_t^V = \rho\epsilon_t^Y + \zeta_t\sqrt{1-\rho^2}$, where $\zeta$ is a random normal variable independent of $\epsilon_t^Y$, and $\omega = \sigma_V^2(1-\rho^2)$ and $\phi = \sigma_V\rho$ are defined, then direct Gibbs sampling via conjugate priors is possible. Trivially, $\rho = \frac{\phi}{\sigma_V}, \sigma_V^2 = \omega + \phi^2$. This is a standard statistical transformation and is used in this context by Jacquier, Polson, and Rossi (2004), among others.

## 2.2. *Model estimation and data*

MCMC relies on sampling values for the unknown quantities (parameters and variables) of the model from posterior distributions. The posteriors are derived by multiplying the likelihood of the model with a prior distribution. The prior distribution introduces any beliefs or limits about the parameter or variable. The posterior may or may not be of a known form. By continuously circling through the unknown quantities and sampling, a Markov chain is created for each parameter and variable that converges to a stationary distribution, given that the chain is ergodic. Full derivations are provided in Appendix A.1 and the algorithm in Appendix A.3.

The data consists of 9,132 daily log-returns of the S&P500 index from 2-1-1980 to 29-3-2016. This includes the 2007-2009 financial crisis and the following relatively more tranquil period, which nevertheless features a number of shocks. The results are presented together with parameters from Eraker, Johannes, and Polson (2003), whose sample does not include the financial crisis, and Brooks and Prokopczuk (2013) which does. The parameters are presented in daily percentages and annual decimals. The methodology for annualisation is described in the Appendix and comes from Branger and Hansis (2015). The number of repetitions M is 90,000, the burn-in period G is 45,000 and convergence is observed after about 12,000 repetitions. The derivation of the posterior distributions of each variable and parameter, from which a new value is sampled in every iteration of the algorithm, is shown in the Appendix. All posteriors are conjugate apart from the posterior for volatility, for which a Metropolis - Hastings step is used. Viable candidate choices are random walk Metropolis - Hastings, an ARMS sampling algorithm (discussion in Li, Wells, and Yu (2006)) and the ARMS improvement by Martino, Read, and Luengo (2012), who include an additional Metropolis - Hastings step in the construction of the proposal which allows proper sampling for regions where the proposal lies under the posterior. The choice of the paper is a random walk Metropolis - Hastings step due to its performance in convergence, its wide use and the ease of calibration when the acceptance rate of proposed values is low. The estimated parameters are provided in Table 1 and the descriptive statistics in Table 2.

Table 1.: MCMC parameters for the SVCJ and SV models. Values in daily percentages and annual decimals compared to Eraker, Johannes, and Polson (2003) and Brooks and Prokopczuk (2013).$\lambda$: jump frequency, $\rho_J$: correlation of jump sizes, $\sigma_Y(\sigma_V)$: volatility of returns (volatility) jumps, $\mu_Y(\mu_V)$: mean of returns (volatility) jumps, $\mu$: diffusive mean returns, $\rho$: diffusion correlation, $\kappa$: speed of volatility mean reversion, $\theta$: long-run volatility mean

| | SVCJ (1980-2016) | | SV (1980-2016) | | EJP (1980-1999) | | Br. & Pr. (1985 - 2010) | |
|---|---|---|---|---|---|---|---|---|
| | Daily % | An. Dec. | Daily % | An. Dec. | Daily % | An. Dec. | Daily % | An. Dec. |
| $\lambda$ | 0.0055 | 1.3919 | | | 0.0066 | 1.6632 | 0.0041 | 1.0332 |
| | (0.0013) | | | | (0.002) | | (0.0012) | |
| $\rho_J$ | 0.0030 | 0.0030 | | | -0.6008 | -0.2384 | 0.0519 | 0.0206 |
| | (0.0329) | | | | (0.9918) | | (0.2012) | |
| $\sigma_Y$ | 2.6554 | 0.0266 | | | 2.8864 | 0.0289 | 2.2486 | 0.0225 |
| | (0.3902) | | | | (0.5679) | | (0.5251) | |
| $\mu_V$ | 1.0088 | 0.0012 | | | 1.4832 | 0.0374 | 2.7594 | 0.0695 |
| | (0.1265) | | | | (0.3404) | | (0.7914) | |
| $\mu_Y$ | -2.9251 | -0.0293 | | | -1.7533 | -0.0175 | -4.4478 | -0.0445 |
| | (0.6197) | | | | (1.5566) | | (0.9100) | |
| $\mu$ | 0.0340 | 0.0858 | 0.0289 | 0.0729 | 0.0554 | 0.1396 | 0.0421 | 0.1061 |
| | (0.0081) | | (0.008) | | (0.0112) | | (0.0100) | |
| $\rho$ | -0.6757 | -0.6757 | -0.6096 | -0.6096 | -0.4838 | -0.4838 | -0.5831 | -0.5831 |
| | (0.0259) | | (0.0244) | | (0.0623) | | (0.0395) | |
| $\sigma_V$ | 0.1429 | 0.3601 | 0.1691 | 0.4262 | 0.0790 | 0.1991 | 0.1264 | 0.3185 |
| | (0.0055) | | (0.0086) | | (0.0074) | | (0.0098) | |
| $\alpha(=\kappa\theta)$ | 0.0211 | 0.1337 | 0.0265 | 0.0273 | 0.0140 | 0.0888 | 0.0177 | 0.1125 |
| | (0.0018) | | (0.0018) | | | | | |
| $\kappa(=-\beta)$ | 0.0252 | 6.3561 | 0.0245 | 6.1662 | 0.0260 | 6.5520 | 0.0225 | 5.6700 |
| | (0.0021) | | (0.0026) | | (0.0041) | | (0.0041) | |
| $\theta$ | 0.8347 | 0.0210 | 1.0815 | 0.0273 | 0.5376 | 0.0135 | 0.7874 | 0.0198 |
| | | | | | (0.0539) | | (0.0787) | |

### 2.3. *Parameter estimation results*

For the SVCJ model (Table 1), the parameters for $\lambda, \kappa, \theta$ (jump arrival intensity, speed of volatility mean reversion and long-run volatility mean) show that the model has the tendency to trade jump frequency for volatility. The volatility related parameters are higher when the crisis is included in the sample but jump frequency drops. On an annual basis, 1.66 jumps are expected each year for the pre-crisis period but only 1 to 1.4 jumps when the crisis is included. $\theta$, on the other hand, increases from 0.0135 annually to roughly 0.02. A comparison between the EJP sample and ours shows that when the crisis is included, the mean jump magnitude is

Table 2.: Descriptive statistics and simulations quantiles

| Sample summary statistics | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mean | St. Dev | Skewness | Kurtosis | Min | Max | Length |
| 1980 − 2016 | $3.227 \times 10^{-4}$ | 0.0113 | -1.1435 | 26.2693 | -0.2290 | 0.1096 | 9132 |
| 2007 − 2016 | $1.491 \times 10^{-4}$ | 0.0137 | -0.3008 | 9.2187 | -0.0947 | 0.1096 | 2253 |

| Simulations descriptive statistics | | | | | | |
|---|---|---|---|---|---|---|
| | Mean | St. Dev | Skewness | Kurtosis | Min | Max |
| SVCJ | 4.3953 | 16.7194 | -0.6498 | 3.9077 | -108.8360 | 64.2772 |
| SV | 7.1979 | 16.0640 | -0.6181 | 3.7875 | -84.0969 | 70.3762 |

| SVCJ (top) and SV (bottom) simulation percentiles (%) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.5 | 1 | 2.5 | 5 | 10 | 25 | 50 | 75 | 90 | 95 | 97.5 | 99 | 99.5 |
| -66.34 | -49.84 | -42.88 | -33.11 | -25.58 | -17.59 | -5.42 | 6.11 | 16.07 | 24.08 | 28.54 | 32.37 | 36.71 | 39.73 |
| -59.53 | -44.60 | -37.95 | -28.96 | -21.61 | -13.86 | -2.28 | 8.77 | 18.41 | 26.14 | 30.55 | 34.31 | 38.58 | 41.50 |

lower (-2.92% vs -1.75%) and the jump frequency is slightly reduced. This shows that the model uses higher volatility parameters to match the high variation in the data instead of higher jump frequency or average jump size $\mu_Y$. Large jumps are taken into account, in that fashion, but are treated as more likely to have been generated from higher volatility. Therefore, isolating frequent small jumps may be challenging.

The standard deviations of parameter estimates are very low and similar across the papers, showing that the crisis does not significantly affect the accuracy of estimates. The reason for that is the inclusion of a sufficiently long period before and after 2007-2009. The expectation for the post-2009 period is that it contains a sufficient number of jumps. This establishes that extreme price movements are not overly rare or concentrated and the pre-crisis period does not dominate the sample. The correlation of jump sizes, $\rho_J$ is insignificantly different than zero, which agrees with overfitting and estimation accuracy problems (Broadie, Chernov, and Johannes (2007)) and allows us to relax this assumption. The leverage effect is strong, with a Brownian motion $\rho$ of $-0.67$ that is far higher than the correlation in jump components. As expected, the variance coefficients for jump sizes and returns jump variances demonstrate high standard deviations. This is understandable due to the rarity of jumps and their much different magnitude, leading to a relative lack of precision in parameter estimates. The negative sign of the returns jump follows the literature (Table 1). Compared to the SV parameters, the diffusive part of SVCJ delivers a higher expected return but lower volatility related estimates. This is consistent with the intuition that jumps, especially small and medium sized, can be captured to a very limited extent by SV models due to an increase in estimated volatility. Where the SV model fails is in large movements and outliers, which are captured by the SVCJ model. Finally, Eraker, Johannes, and Polson (2003) show that the discretisation bias is negligible for daily data and establish that SVCJ fits actual data better than SV.

To illustrate the differences between the two models, we simulate 250,000 annual log-returns (each calculated as the sum of 250 daily log-returns) with and without jumps and compare the sample properties. The descriptive statistics and quantiles can be found in Table 2, the (smoothed) empirical pdf and cdf plots in Figure 1a and a histogram of the tails in Figure 1b. It is very clear that the SVCJ model has much greater downside risk than the SV model (Figure 1) with an elongated and thicker left tail (Figure 1b). First, the probability of a negative market return is approximately 35% in the SVCJ model but only 30% in the SV model; this is connected to a mean effect that the distribution of the model with jumps is moved to the left. Second, the downside tail is much longer in the SVCJ model; for example the 2.5 percentile is $-33.11$ for SVCJ compare to $-28.96$ for SV. Although the diffusive mean ($\mu$) in the SVCJ model is higher than the diffusive mean in the SV model, the presence of jumps in the SVCJ model which have a mean of $-2.92\%$ and occur on average 1.4 times per year leads to a lower overall mean in the simulations of the SVCJ model. The SVCJ model also has higher standard deviation, more negative skewness and higher kurtosis.

[INSERT FIGURE 1 HERE]

Theodossiou and Savva (2016) also report negative skewness in the distribution of excess returns, which is in line with our findings, and note that its modelling is important to help recover a positive relationship between risk and returns. Finally, to provide further understanding of the impact of mean jumps we draw 250,000 jumps in returns (Figure 1c) from the conditional distribution using the estimated mean ($\mu_Y$) and standard deviation ($\sigma_Y$) parameters. The shape resembles the normal distribution it is drawn from, but the minimum -14.09 and maximum 10.51 show that very low returns can be generated by the jump component of the model.

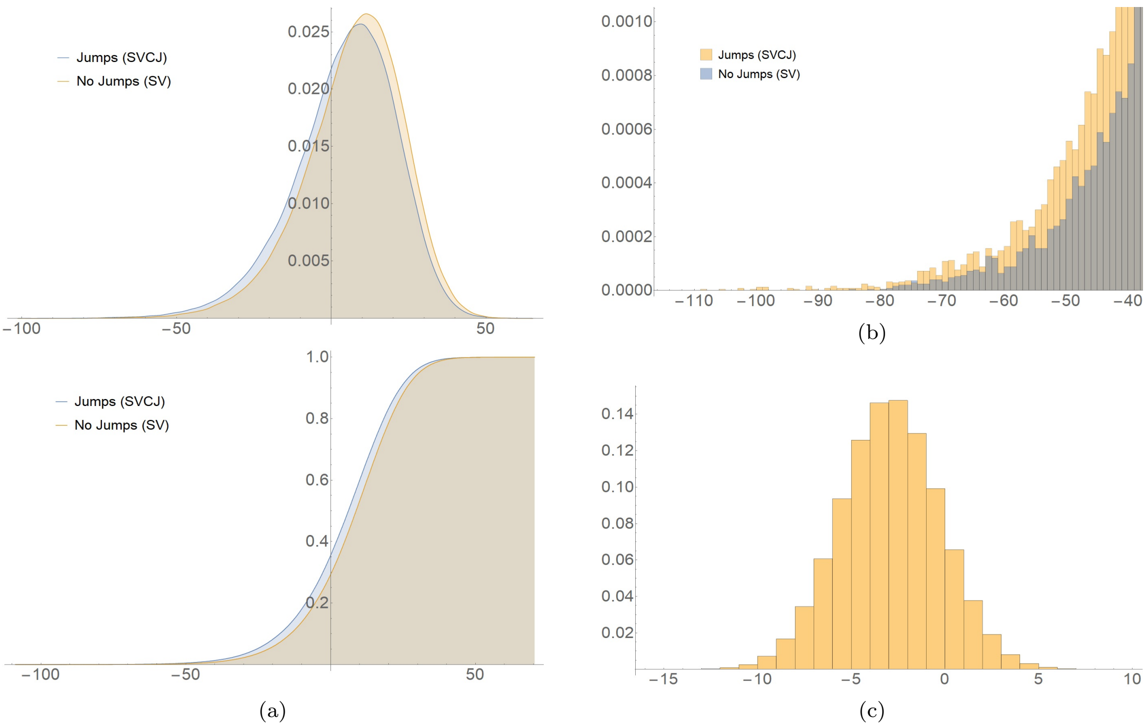


Figure 1.: SVCJ and SV simulations. (a) Empirical Probability Density Functions (top) and Cumulative Density Functions (bottom) (b) SVCJ and SV distribution tails (c) Distribution of return jump sizes (250,000 drawings)

## 3. Optimal portfolio weights

The technical extension of the paper is to provide a solution for the optimal portfolio weights which does not require numerical approximation by simulations. The two types of investors are one that takes jumps into account and optimises using the SVCJ model to replicate the behaviour of the risky asset and one that chooses to ignore them by using the SV model. Each investor allocates wealth to one risk-free asset with a constant annual return of 2% and one risky asset whose return is represented by the SVCJ model. The risk-free rate is an approximation of the average yield of a 1-year bond over the length of the estimation period. The investor has a power utility function $U(W) = \frac{W^{1-\gamma}}{1-\gamma}$ that manages to capture constant relative risk aversion. For $\gamma = 1, U(W) = ln(W)$. Thus, the amount of wealth has no effect on the agent's optimal weights but has an effect on the optimal amounts. The paper assumes $\gamma > 1$.

For wealth $W$, return of the risky asset $Y_t$ and asset weight $\phi$ denoting the percentage of wealth allocated to the risky asset, the wealth process under jumps is

$$dW_t = (r + \phi EP)W_t dt + \phi W_t \sqrt{V_t} dZ_t^Y + \phi W_t E(\xi_t^Y) dN_t \tag{3}$$

To differentiate from notation in (1) and (2), $\{Z_t\}$ is a Brownian motion and $\{N_t\}$ is the Poisson process. The diffusive mean $\mu$ is equal to the risk-free rate plus any risk premium captured by the model ($\mu = r + EP$), and volatility follows the second process in (1). The expression for the SV process omits the last jumps term. An indirect utility function $F(W_t, V_t, t)$ is

$$F(W_t, V_t, t) = \frac{W^{1-\gamma}}{1-\gamma} exp(A(t) + B(t)V) \tag{4}$$

where $A(t), B(t)$ depend only upon t but not W and V. For the optimal weights, the Hamilton-Jacobi-Bellman equation (5) must be solved (full derivation and solution in Appendix B).

$$0 = F_t + max_\phi[L(F)] \tag{5}$$

where $L(F) = (r + \phi EP)WF_W + \frac{1}{2}\phi^2 W^2 V F_{WW} + \kappa(\theta - V)F_V + \frac{1}{2}\sigma_V^2 V F_{VV} + \sigma_V \phi W V \rho F_{WV} + \lambda E[F(W(1 + \phi E(\xi^Y)), V + E(\xi^V), t) - F]$.

The optimal weight $\phi$ for the SVCJ model is the solution to the following system.

$$\phi = \frac{EP}{\gamma V} + \frac{\rho \sigma_V B(t)}{\gamma} + \frac{\lambda E(\xi^Y)(1-\phi E(\xi^Y))^{-\gamma}}{\gamma V} exp(B(t)E(\xi^V)) \tag{6}$$

where B(t) solves the differential equation

$$B'(t) - \frac{1}{2}\gamma\phi^2(1-\gamma) + \frac{1}{2}\sigma_V^2 B^2(t) + (\sigma_V \phi\rho(1-\gamma) - \kappa)B(t) = 0 \tag{7}$$

with initial conditions $A(T) = 0$, $B(T) = 0$. The optimal weights for the SV model are derived in a similar way for

$$\phi = \frac{EP}{\gamma V} + \frac{\rho \sigma_V B(t)}{\gamma} \tag{8}$$

under the same differential equation and conditions as above.

It is useful to compare our result to the solution of the SVCJ specification in Liu, Longstaff, and Pan (2003) (LLP). LLP uses stochastic arrival intensity and is commonly used together with parameters from Pan (2002) in research that discusses optimal weights and portfolio allocation. This is due to its ability to produce tractable portfolio weights. The EJP formulation is commonly used when model estimation is involved but does not yield a convenient expression for optimal portfolia. We clarify how the technical differences affect the types of solutions and show how a semi-closed form result can be derived for the EJP model. This eases the dependency on the LLP formulation when optimal portfolio weights are of interest. LLP models the arrival intenstity of jumps as a linear function of volatility, thus time-varying, and introduces additional jumps premia in the drift. This allows certain terms to be eliminated during the derivation and leads to an ordinary differential equation for $B(t)$ which is not a Ricatti equation and can only be solved numerically. Although the corresponding expression in EJP is a Ricatti equation, the presence of $V_t$ as a variable in the denominator prevents the closed-form solution that class of ODEs produces. The absence of the jump premium in the drift excludes $\lambda V_t$ from appearing and the last jumps related term is multiplied by $\lambda$ only.

To circumvent this issue, V in (6) is replaced by its long-run average $\overline{V} = \theta + \mu_V \lambda/\kappa$. The same approach is used in Branger and Hansis (2012), in order to transform the Eraker, Johannes, and Polson (2003) and Broadie, Chernov, and Johannes (2007) parameters (notably $\lambda$) from the EJP to the LLP formulation. In addition, the value of $\kappa$ indicates that volatility reverts rapidly to its diffusive mean. This allows the elimination of the denominator terms and leads to a tractable semi closed-form solution under constant arrival intensity (a similar discussion can be found in Branger and Hansis (2015)). All calculations are conducted with annualised parameters and rounded up decimals. The resulting weights are based on log returns. The complex expression after substituting (6) in (7) contains the product of a real and an exponential part and does not provide additional intuition, but is the closest to a closed-form solution this model can have. A detailed discussion can be found in Appendix B.2.

Table 3 presents the portfolio weights for the risky asset. We provide results for different levels of risk aversion for the SVCJ and SV models, and compare them to the sample parameters of EJP for 1980-1999. The solution from (6) and (7) implies a buy-and-hold portfolio. There is a very clear difference between the SVCJ and the SV weights, which highlights much more aggressive behaviour by the investor that ignores jumps. For example, for 1980-2016 and a $\gamma$ of 5 the weight in the risky asset is 0.41 for the SV model but only 0.21 for the SVCJ indicating a very large difference in optimal weights once jumps are taken into account. The differences in weights are larger for the full sample than for the Eraker et al. sample due to the inclusion of the financial crisis and a lower mean return (and equity premium).

The solution above is our first extension and the first solution that does not require numerical approximation by simulations. It is semi-closed only due to a product of real and exponential components. This bridges the gap between the solutions derived from the constant and stochastic arrival intensity variations of SVCJ. Commonly, when the LLP model is employed, either the Pan (2002) parameters or arbitrary values are used. On the other hand, EJP is typically

Table 3.: Optimal portfolio weights for the SVCJ and SV models (1980 - 2016) for $r = 2\%$ compared to the weights corresponding to the EJP parameters ($r = 4.5\%$).

| | 1980-2016 | | EJP | |
|---|---|---|---|---|
| $\gamma$ | SVCJ | SV | SVCJ | SV |
| 5 | 0.211 | 0.410 | 0.570 | 0.714 |
| 4 | 0.263 | 0.520 | 0.712 | 0.890 |
| 3 | 0.351 | 0.686 | 0.946 | 1.181 |
| 2 | 0.524 | 1.022 | 1.410 | 1.757 |

estimated anew. Our proposed methodology allows EJP to be used when portfolio optimisation is involved and with newly estimated parameter values. Since the LLP optimal weights solution is known to be mathematically unstable (Korn and Kraft (2004)) and given their ad hoc parametrisation of jumps and the absence of recent parameter estimates in the literature for their model, we opt for our selected approach.

## 4. Investor and fund manager choices, and contract optimality for the manager

This section explains how investor and fund manager choices are modelled. The SVCJ parameters (Table 1) are used to generate the returns of the risky asset. The optimal portfolio weights for the SVCJ and SV models (equations (6) and (8)) show how the investor would wish assets to be allocated under these different scenarios. Given the simulated return distribution is based on both jumps and stochastic volatility being present, then the SVCJ weights are optimal for the investor. Our key analysis introduces a manager who can choose to take jumps into consideration and invest using the SVCJ allocation, or deliberately ignore them and use the SV allocation. Since the manager receives utility from fees rather than portfolio wealth, this can create moral hazard and an associated conflict of interest. The manager has the discretion to offer the SV allocation to the SVCJ client (to whom it is suboptimal).

The manager does not optimise her fee-based utility per se, as both contracts may well be suboptimal for her, but she selects the one of these two which is found to be preferable. For simplicity, there is no differentiation between the fund manager and the fund management company; for our purposes, we treat the manager as the sole beneficiary of the fund. We examine the impact of length of investment horizon, risk aversion and investors switching between funds upon these potential issues. Henceforth, the SVCJ agents will be referred to as "jumps manager (investor)" and the SV agents as "no-jumps manager (investor)".

The option-type compensation of the manager does not allow a closed-form solution for her optimal weights based on her utility from fees. It is, however, important to consider whether the SV weights used by the manager are plausible choices. Thus, we conduct a series of simulations for $\gamma = 2, 3, 4, 5$ and investment horizon $T = 2, 3, 5, 7, 10$ in four different scenarios and calculate the portfolio weights for the risky asset that are optimal for the manager. The full results and process can be found in in Appendix C. Panel A in Table C.1 reports our base case scenario (fees only), which is the manager's equivalent of Table 3. For T = 3 the simulated weights are almost identical to the SV weights for all fee structures and can be considered optimal. For T = 2 they are slightly higher and for longer horizons they gradually decline but remain closer to the SV rather the SVCJ weights. This makes the SV allocation (highly) preferable for the manager, especially at shorter horizons. Even with a 10 year horizon and high risk aversion (with the only exception being for $\gamma = 5$), the optimal weight is closer to the SV than the SVCJ allocation. Overall, using SV weights as a choice for the manager is reasonable. This is especially so for managers with short horizons and lower risk aversion, where ignoring jumps is most plausible. This justifies our approach and our assumption, explained in the next section, that the no-jumps allocation will appeal to the manager in at least some circumstances.

### 4.1. *The jumps investor versus the no-jumps investor*

We show that differences in the way that the principal and agent receive financial reward create an incentive for the fund manager to take on additional risk in the hope that a severe negative outcome(s) will not be realised before the end of her tenure in charge of the fund. For the case of the investor, we compare the performance of an investor that takes jumps into account to one who does not, to verify that taking jumps into account is optimal for the investor. The case of the manager is more complex. Both she and the investor have the same power utility function but the manager receives utility from fees measured at regular (annual) intervals while the investor from the terminal wealth of the investment. We assume that both the fund and the asset manager payments follow the same scheme, which is a flat administrative fee plus a performance fee when portfolio returns exceed a threshold ("hurdle"). This is also the publicly announced fee paid by the investor.

The simulation for investors is arranged as follows. A time series of daily log returns for the equity index is generated by using the SVCJ model and daily percentage parameters. Total returns of the risky asset are then used to calculate annual portfolio returns of a portfolio consisting of the equity index and a risk-free asset with return $r = 2\%$ annually. Jumps are thus present in the path of the risky asset and the portfolio, a fact that is known to the investor. The two types of manager use the SVCJ and SV weights respectively. The measures of win are terminal wealth, average terminal utility and number of wins for each investor. The length of the investment period is $2, 3, 5, 7, 10$, and 15 years, risk aversion $\gamma$ takes values $2, 3, 5$ and starting wealth is $W_0 = 100$. Our conclusions are invariant to the size of initial investment. The duration of the simulation is 5,000 runs[3].

### 4.2. *Investor results in the absence of the manager*

This section examines whether the simulation results confirm that investor prefers jumps to be taken into account. Table 4 contains the simulation outcomes for the two types of investors for risk aversion $\gamma = 2, 3, 4, 5$. The jumps investor always wins in terms of average terminal utility (the UDiff row is always negative); this is exactly as expected since the return generating process contains jumps and the optimal portfolio weights for the jumps investor's preferences are implemented. However, interestingly, the no-jumps investor always wins in terms of average terminal wealth (the WDiff row is always positive). This result confirms that the investor is willing to accept a reduction in expected average return (and terminal wealth) in order to reduce their exposure to jumps, which is achieved by placing a lower weight in the risky asset following the optimal portfolio weights in Table 3. The result is persistent across investment horizons and degrees of risk aversion.

Next, we look at the percentage of wins, which is the proportion of simulations where the terminal wealth (utility) of the no-jumps investor is greater than that of the jumps investor. The percentage of wins for the no-jumps investor ranges from 62% to 80% as the investment horizon ranges from 2 to 30 years, and is very similar across varying levels of risk aversion ($\gamma$)[4]. Thus, in all cases the no-jumps investor wins more frequently than the jumps investor and at longer horizons the no-jumps investor wins substantially more frequently. This helps underline the very nature of the issue that we are examining: that the investor is concerned about suffering several substantial downside jumps during their investment horizon which, should they occur, would lead to a very negative outcome for them. In order to substantially reduce the possibility of such a bad outcome, they reduce their weight on the risky asset, even though in the large majority of cases their terminal wealth would be higher if they (chose to) ignored jumps. The reason why the proportion of wins increases as the investment horizon increases is intuitive. Given that the no-jumps investor has a larger weight in the risky asset, then his expected return is higher and

[3] In unreported results, we conducted test simulations of 20,000, 50,000 and 100,000 runs for 2-10 years and the results did not materially change.

[4] The percentage of wealth and utility wins is the same because wealth is calculated at the end of the investment and used to calculate terminal utility.

Table 4.: Investor simulations. NJW: terminal Wealth for the No Jumps investor, NJU: terminal Utility for the No Jumps investor, WDiff: difference in average terminal wealths, UDiff: difference in average terminal utilities

| | | | $\gamma$=5 | | | | |
|---|---|---|---|---|---|---|---|
| Years | 2 | 3 | 5 | 10 | 15 | 24 | 30 |
| NJW & NJU Wins | 61.74% | 62.04% | 64.06% | 67.62% | 71.86% | 76.04% | 79.84% |
| WDiff (NJ - J) | 0.0234 | 0.0326 | 0.0582 | 0.1372 | 0.2468 | 0.5191 | 0.8209 |
| UDiff (NJ - J) | -0.0085 | -0.0147 | -0.0238 | -0.0326 | -0.0343 | -0.0290 | -0.0219 |
| | | | $\gamma$=4 | | | | |
| NJW & NJU Wins | 60.96% | 62.18% | 66.26% | 69.54% | 71.8% | 75.52% | 77.82% |
| WDiff (NJ - J) | 0.0289 | 0.0453 | 0.0857 | 0.1974 | 0.3460 | 0.7495 | 1.1356 |
| UDiff (NJ - J) | -0.0109 | -0.0182 | -0.0169 | -0.0316 | -0.0435 | -0.0374 | -0.0272 |
| | | | $\gamma$=3 | | | | |
| NJW & NJU Wins | 62.12% | 62.38% | 65.28% | 70.38% | 71.96% | 75.84% | 79% |
| WDiff (NJ - J) | 0.0460 | 0.0673 | 0.1265 | 0.3130 | 0.5560 | 1.2535 | 2.0584 |
| UDiff (NJ - J) | -0.0090 | -0.0180 | -0.0224 | -0.0372 | -0.0578 | -0.0560 | -0.0874 |
| | | | $\gamma$=2 | | | | |
| NJW & NJU Wins | 60.2% | 62.88% | 64.62% | 69.1% | 72.58% | 75.5% | 77.76% |
| WDiff (NJ - J) | 0.0728 | 0.1210 | 0.2294 | 0.6344 | 1.2038 | 3.1237 | 5.5725 |
| UDiff (NJ - J) | -0.0103 | -0.0073 | -0.0073 | -0.0120 | -0.0175 | -0.0214 | -0.0320 |

thus as the horizon increases two effects occur: i) there is more time to recover from a large negative return shock and thus still win in terms of terminal wealth, ii) as the horizon increases the differences in the expected portfolio return to holding the no-jumps weights compared to the jumps weights widen; thus the impact of volatility and jumps is reduced at longer horizons. Thus, even an investor who is interested primarily in terminal wealth has a major motive to ignore jumps in portfolio allocation, which raises the possibility that a fund manager may face a similar issue even more strongly. A utility-maximizing investor, on the other hand, has a motive to take jumps into consideration when allocating wealth, since this will lead them to moderate the amount of risk they take and moderate the effects of severe downsides should they occur.

### 4.3. *The jumps manager versus the no-jumps manager and fee structures*

The crux of this paper is that the manager may have an incentive not to follow the best interests of the investor, i.e. not pursue the course of action which gives him higher expected terminal utility. Specifically, the manager knows that jumps exist but may decide to ignore them in order to achieve higher average fees and to achieve higher average terminal utility of her fees. The performance fee structure implemented is that of a hurdle with a threshold of 6% and the fee is paid on the net excess return above that threshold [5].

The administration fee is calculated on annual portfolio wealth (assets under management) and deducted from profits. Afterwards, the potential performance fee is calculated based on the annual profit, for returns above the hurdle rate, after administration fees are deducted. To avoid complexities with average portfolio wealth during the course of each year, only the start- and end-of-year wealth values are used for each year. The starting wealth of the next period is the terminal wealth of the previous period minus all paid fees, deductions and wealth movements plus any newly added funds, until the investment runs its course. Each year's total fee is used to calculate the utility of the manager summed across the manager's time horizon with a zero rate of time preference. The utility function of the manager is identical to that of the investor. This ensures that any results cannot be attributed to differences in preferences.

For a hurdle $c$, annual return $r$, administration fee rate $a$, performance fee rate $p$ and portfolio wealth for two consecutive periods $W_{t-1}, W_t$, the base $B$ of the performance fee, when present, is calculated as the return above the hurdle rate minus the administration fee, or

$$B = (W_t - W_{t-1} - aW_t) = (1+r-c)W_{t-1} - W_{t-1} - a(1+r)W_{t-1} = (r-c-a(1+r))W_{t-1} \quad (9)$$

Thus, the performance fee is equal to $pB$, for $B \geq 0$. The three schemes of managerial compensation are $2+20\%$, $1+10\%$ and $0.4+3\%$ [6]. They are selected in order to cover as much ground as possible between the high former industry staple, a moderate level and a low level closer to that of mutual funds. The moderate level covers the reductions and discounts recently observed in the industry. Fees between or beyond these limits, such as $1 + 20\%$ or $0.4 + 10\%$ exhibit similar patterns as the fees of choice because the flat administration fee increases compensation horizontally while the performance fee scales smoothly between 10 and 20%. Thus, the results for intermediate schemes are easy to infer from Tables 5 - 7. The combinations used are able

[5] Assuming a threshold of 10% but calculating the performance fee on the entire amount of profits if the threshold is surpassed, yields the same results with slightly more pronounced numerical effects and the winning horizons for $\gamma = 2$ exceeding to 10 years. The same holds if performance fees are calculated on gross (total) rather than net (above the hurdle) profits.

[6] The option-type structure of a flat administration fee plus a performance fee is the most common and simplest compensation scheme. Although it has been enhanced with other types of incentives and payoffs, it is still widely representative. Apart from industry sources such as Preqin (2017) and Barclays (2017), reports show a recent trend for flat reductions and a shift of balance in favour of investors (Fortado (22-12-2016)). The selected fees cover a wide range of empirical values and the middle ground between hedge and mutual funds, who typically do not charge a performance fee or rely on symmetric compensation (fulcrum). The industry staple $2\% + 20\%$ is maintained only by the largest hedge funds.

to accommodate both observed structures and averages across industry as well as fees close to mutual funds, especially when the recent trend of discounts and reductions in the hedge fund industry is considered. The mutual fund structure sets the performance fee equal to zero, which leads the fees deducted at year's end to depend only on a flat scalar, the administrative fee, applied on terminal wealth. Thus, managerial utility also scales by a constant. Preempting our results, the mutual fund case is represented by Table 4 and discussed in section 6.1.

An important feature is the ability of some investors to transfer their wealth from their fund to an alternative at the end of the year. This wealth transfer function is defined as

$$f(x) = \begin{cases} -10, & f(x) \leq -10 \\ -exp(-\delta_1 x) + 1, & x \leq 0 \\ exp(\delta_2 x) - 1, & x \geq 0 \\ 10, & f(x) \geq 10 \end{cases} \tag{10}$$

where $x = r_{NJ} - r_J$ is the relative performance of the funds. $r_{NJ}$ ($r_J$) is the percentage return of the SV (SVCJ) portfolio. f(x) is the percentage of assets transferred between the funds and demonstrates positive inflow (negative outflow) to (from) the no-jumps fund from (into) the jumps fund. The amount is calculated on the basis of the end-of-year assets invested in the under-performing fund. For example, a value of 10 indicates that 10% of the jumps fund's assets under management are transferred to the non-jumps fund. The parameters $\delta_1, \delta_2$ affect the curvature of the function and its economic meaning is the sensitivity of wealth transfers to differences in fund performance. For a symmetric function, $\delta = \delta_1 = \delta_2$ and is set equal to 0.25, while in the case of asymmetry $\delta_1 = 0.5, \delta_2 = 0.25$. This makes investors in the no-jumps fund to be more sensitive to relative bad performance than good performance. The function is truncated at 10% and $-10\%$ to prevent extreme changes of value. For the asymmetric case, the upper bound remains the same but the lower bound is set to $-15\%$. This produces a stronger reaction when relative losses are observed. The introduction, structure and parametrisation of the wealth transfer function are motivated by Getmansky (2012) while the calibration follows fund flows reported in Liang et al. (2019). The 10% threshold ensures that the movement of funds by investors is not sufficiently large so that it ends up as the dominating driver of our results. The moderate level of fund movement that results from this 10% threshold is also consistent with investors having a longer investment horizon than the time that managers are in post: a central feature of our model. Lower (higher) thresholds reduce (increase) the magnitudes of the effects we report. We provide further details on this point in Appendix D.

The asymmetry in this direction can be justified since, given that the no-jumps (SV) fund follows a more aggressive allocation, it underperforms when the market excess return is negative. This is consistent with investors adjusting their holdings more in downturns. Conceptually, this can be seen as introducing downside risk aversion, which has a particularly strong impact when equity returns are low (i.e. lower than the risk-free rate). The flow of capital as a percentage of portfolio wealth allows investors to punish (reward) poor (good) performance. This reduces (increases) the basis upon which managerial fees are calculated, which managers are very aware of. Even without convex compensation, a manager has an incentive to increase assets under management at the expense of performance (Yin (2016)), since fees rely on portfolio wealth.

A fund is considered closed when it loses 95% of its starting wealth. A fund that falls below that level stops operating and no extra fees are collected but its output is maintained in the simulations. This is realistic for a number of reasons. Firstly, closure is a real prospect both for young funds with very high leverage ratios that risk their survival, as well as for old funds which might exhibit a series of negative results over a number of periods. Secondly, excluding the closed funds would introduce survivor bias in the simulations. Thirdly, a fund which has lost almost all its wealth beyond any recovery (i.e. facing a closure threshold equal to $W = 5$ or lower) is defunct for all intents and purposes and the fees it collects cannot cover its operational expenses. However, it will continue to generate extremely low fees and terminal utility for the remainder of the simulation, which would affect expected utility. In practice, the assumption does not affect the results apart from one to 5 simulation runs in two cases: i) for very long investment periods ii) for $\gamma = 2$, where the risk-free asset is sold short, and thus the fund is more susceptible to movements of the index.

## 5. Results

This section presents the main results and highlights where the manager's preferred allocation is not aligned with the investor. The first, most important, result is that the manager has an incentive to ignore jumps for shorter investment horizons. The second result is that this incentive is more pronounced with a symmetric than an asymmetric wealth transfer function. We also find as a third result that a decrease in risk aversion increases the intensity and horizon of the incentive. Our fourth result is that the overall level of fees has very little effect on the incentive. Finally, our fifth result is that expected manager compensation is higher when jumps are ignored.

Due to the large number of subcases, we focus on the most important and representative results [7]. The simulation outcome can be found in Tables 5 - 7 for $\gamma = 3, 5, 2$. Panels labeled I (II) report the case where wealth transfer between funds is symmetric (asymmetric). Panels labeled A (B) [C] report the $2 + 20\%$ $(1 + 10\%)$ $[0.4 + 3\%]$ fee structure. The notation used in the Tables and the Results section is TFJ: Total Fees of Jumps Manager, TFNJ: Total Fees of No-Jumps Manager, TUJ: Average Jumps Investor terminal Utility, TUNJ: Average No-Jumps Investor terminal Utility, TFUJ: Average Total Annual Utility of Jumps Manager from Fees, TFUNJ: Average Total Annual Utility of No-Jumps Manager from Fees. Bold denotes whether the jumps or the no-jumps fund wins by each metric.

### 5.1. *Incentive horizons and compensation schemes*

Panel A.I of Table 5 presents the case of a manager and investor with risk aversion parameter $\gamma = 3$, under a 2+20% fee structure and symmetric wealth transfer. The main variables to consider at this stage are Total Fee Utility of Jumps (TFUJ) and Total Fee Utility of No Jumps (TFUNJ). The numbers in bold denote the higher average realised utility across our simulations. From this, it is clear that the TFUNJ values are higher than the TFUJ values when the investment period is up to five years long and lower for longer periods. This change denotes the time span over which the no-jumps manager is expected to have higher utility than the jumps manager (the winning horizon). For example, for an investment horizon of 3 years, her total utility is -0.3429 (-0.3606) when jumps are ignored (considered) compared to -1.3944 (-1.2744) for a horizon of 10 years. Thus, at the 3 year horizon the manager is incentivised to ignore jumps as demonstrated by the less negative total utility; in contrast, at a 10-year horizon when jumps are ignored the utility is more negative, indicating that the incentive has

[7] For $\gamma$=4, the results for managerial fees and investor utility are the same, while the winning horizon for the no-jumps manager is 3 years for $2 + 20\%$ and $1 + 10\%$ fees, and 2 years for $0.4 + 3\%$ fees

Table 5.: Manager and investor results, $\gamma$=3

TFJ: Total Fees of Jumps Manager, TFNJ: Total Fees of No-Jumps Manager, TUJ: Average Jumps Investor terminal Utility, TUNJ: Average No-Jumps Investor terminal Utility, TFUJ: Average Total Annual Utility of Jumps Manager from Fees, TFUNJ: Average Total Annual Utility of No-Jumps Manager from Fees. Bold denotes the winner.

| | Panel A.I: 2+20% fees, symmetric wealth transfer function | | | | | | Panel A.II: 2+20% fees, asymmetric wealth transfer function | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 2 | 3 | 5 | 7 | 10 | 15 | 2 | 3 | 5 | 7 | 10 | 15 |
| TFJ | 4.2175 | 6.2914 | 10.5611 | 14.5017 | 20.4789 | 30.8059 | 4.2697 | 6.4735 | 10.8965 | 15.3849 | 22.2571 | 34.1901 |
| TFNJ | **5.6556** | **8.5649** | **14.7247** | **21.3233** | **31.2399** | **50.3020** | **5.6915** | **8.4441** | **14.3852** | **20.0822** | **29.5835** | **45.4835** |
| TUJ ($\times 10^{-4}$) | **-1.0023** | **-1.51845** | **-2.57846** | **-3.6563** | **-5.3538** | **-8.3115** | **-1.0053** | **-1.4739** | **-2.4253** | **-3.3469** | **-4.6897** | **-6.8206** |
| TUNJ ($\times 10^{-4}$) | -1.08821 | -1.7030 | -2.9904 | -4.4306 | -7.3276 | -12.1406 | -1.0908 | -1.9619 | -3.4927 | -5.7001 | -10.1857 | -18.8580 |
| TFUJ | -0.2376 | -0.3606 | -0.5911 | **-0.8675** | **-1.2712** | **-1.9058** | -0.2306 | **-0.3388** | **-0.5561** | **-0.7687** | **-1.0766** | **-1.5645** |
| TFUNJ | **-0.2131** | **-0.3429** | **-0.5900** | -0.8722 | -1.3944 | -2.4043 | **-0.2146** | -0.3527 | -0.6869 | -1.1320 | -2.0375 | -3.7195 |
| UJ wins (%) | 33.12 | 32.52 | 31.22 | 30.74 | 31.76 | 31.98 | 32.74 | 36.62 | 40.98 | 45.64 | 48.76 | 53.92 |
| | Panel B.I: 1+10% fees, symmetric wealth transfer function | | | | | | Panel B.II: 1+10% fees, asymmetric wealth transfer function | | | | | |
| TFJ | 2.13797 | 3.2743 | 5.4810 | 7.5619 | 10.8563 | 16.9233 | 2.2030 | 3.3281 | 5.6650 | 8.0955 | 11.9341 | 18.8267 |
| TFNJ | **2.8428** | **4.5252** | **7.8443** | **11.1426** | **16.7128** | **28.6613** | **2.9369** | **4.4302** | **7.5988** | **11.0339** | **16.1726** | **25.7350** |
| TUJ ($\times 10^{-4}$) | **-0.9753** | **-1.4585** | **-2.432** | **-3.3698** | **-4.7774** | **-7.02051** | **-0.9583** | **-1.4178** | **-2.2775** | **-3.0870** | **-4.1899** | **-5.8354** |
| TUNJ ($\times 10^{-4}$) | -1.0540 | -1.4585 | -2.4320 | -3.3698 | -4.7774 | -9.4260 | -1.0707 | -1.7302 | -3.2738 | -5.0613 | -8.2191 | -15.4914 |
| TFUJ | -0.9206 | -1.3499 | -2.2417 | **-3.1730** | **-4.5041** | **-6.4228** | -0.8840 | **-1.3090** | **-2.1036** | **-2.8452** | **-3.8425** | **-5.3434** |
| TFUNJ | **-0.8542** | **-1.3322** | **-2.2338** | -3.2725 | -6.2692 | -7.3952 | **-0.8478** | -1.3677 | -2.6038 | -3.7717 | -6.4867 | -12.1956 |
| UJ wins (%) | 32.24 | 31.40 | 30.24 | 31.42 | 31.74 | 34.02 | 34.58 | 36.82 | 40.94 | 42.36 | 48.58 | 52.44 |
| | Panel C.I: 0.4+3% fees, symmetric wealth transfer function | | | | | | Panel C.II: 0.4+3% fees, asymmetric wealth transfer function | | | | | |
| TFJ | 0.8439 | 1.2702 | 2.1355 | 3.0197 | 4.5678 | 7.0637 | 0.8491 | 1.2912 | 2.2101 | 3.1748 | 4.9145 | 7.9011 |
| TFNJ | **0.9477** | **1.4547** | **2.5343** | **3.7295** | **6.8940** | **11.4467** | **0.9339** | **1.4350** | **2.4737** | **3.5453** | **6.3911** | **10.4341** |
| TUJ ($\times 10^{-4}$) | **-0.9544** | **-1.4236** | **-2.3343** | **-3.2131** | **-4.4505** | **-6.3579** | **-0.9426** | **-1.3798** | **-2.1914** | **-2.9329** | **-3.9213** | **-5.2917** |
| TUNJ ($\times 10^{-4}$) | -1.0092 | -1.5596 | -2.6898 | -3.9852 | -5.6909 | -8.6797 | -1.0812 | -1.6545 | -2.9897 | -4.7503 | -7.6982 | -13.2146 |
| TFUJ | -5.7493 | -8.5758 | **-14.0709** | **-19.3700** | **-25.7350** | **-36.7872** | -5.6867 | **-8.3165** | **-13.2151** | **-17.6902** | **-22.6785** | **-30.5999** |
| TFUNJ | **-5.6646** | **-8.5582** | -15.1193 | -22.4586 | -28.9385 | -43.9368 | **-6.1010** | -9.3003 | -16.7860 | -26.7524 | -39.1105 | -66.8447 |
| UJ wins (%) | 32 | 31.08 | 31.54 | 32.64 | 31.94 | 32.54 | 38.12 | 40.56 | 43.94 | 46.86 | 51.12 | 57.38 |

disappeared at that horizon. This highlights the first result.

Panels B.I and C.I of same table show that this misalignment of incentives occurs at the same horizon under a $1 + 10\%$ and slightly shorter horizon for a $0.4 + 3\%$ fee structure. This highlights the fourth result that the incentive to ignore jumps is not very sensitive to the level of fees. For the 1+10% structure, the value of TFUNJ is -2.2338 for the 5-year period compared to the TFUJ value of -2.2417, while for the 7-year period TFUNJ is -3.2725 compared to a TFUJ of -3.1730. This symmetry between Panels A.I and B.I holds in all the examples we consider. Panel C.I shows that the the no-jumps manager stops winning after 3 years. For a horizon of 5 years, the jumps manager achieves total utility of -14.0709, contrary to the lower value -15.1193 of her competitor. On the other hand, for the 3-year period the TFUNJ value is -8.5582 compared to a TFUJ value of -8.5758. A winning horizon is, therefore, still present but reduced to 3 years for the No-Jumps manager.

The specifics of the fee structure is therefore not central to the conflict of interest, since for high and moderate fees the periods over which the conflict appears are highly comparable. A slight reduction in the incentive is only apparent when the fees become very low.

### 5.2. *Wealth transfer function effects*

We next look at the difference that alternative wealth transfer functions have. This is how the investor moves their money in response to (relative) fund performance. As discussed earlier, we consider a symmetric transfer function and an alternative asymmetric transfer function; the asymmetric transfer function leads to greater money transfer when the equity return is low (i.e. when the no-jumps fund underperforms). We can see the impact of the different transfer functions by comparing Panels II in Table 5, which are based on the asymmetric transfer function, to Panels I, which are based on a symmetric transfer function. For example, comparing the TFUJ/ TFNUJ metrics between Panels A.I and A.II, we notice that as we hold the horizon constant in all cases the TFUJ value has increased (is less negative) while the TFUNJ value is more negative. More importantly, this has the impact of moving the horizon where the incentives of managers and clients are aligned to 3 years compared to 5-7 years with the symmetric transfer function. The same pattern is observed between Panels denoted B and C for the 1+10% and $0.4 + 3\%$ fees.

More severe movements of wealth at losses are still relevant even for the lowest fees in our study (Panels C), where there is a reduction from three to two years. The winning horizons are shorter for all degrees of risk aversion, with the greatest effect manifesting for $\gamma = 2$ (from 7 to 3 years) and are eliminated for $\gamma = 5$; thus, whether the wealth transfer function is symmetric or asymmetric does materially influence our results. Our second result is that asymmetric wealth transfer functions consistently reducing the situations under which there is a principal - agent conflict.

For managerial fees, the metrics TFJ and TFNJ for the jumps and no-jumps manager show that the no-jumps manager always amasses higher average terminal wealth than the jumps manager. For all panels I of Table 5, TFJ is lower than TFNJ across the board. This highlights the fifth result. In absolute wealth, not utility, a manager always has an incentive to ignore jumps. Average total fees are higher when the compensation scheme is more lucrative, when risk aversion is low and when wealth moves symetrically between funds. A comparison across Panels I in Table 5 reveals the effect of fees. The TFNJ values of Panel A.I range between 5.6556 and 50.3020 and are always greater than the TFNJ values of Panel B.I, which range between 2.8428 and 28.6613, and the TFNJ values of Panel C.I, which range between 0.9477 and 11.4467. An example of the effect of wealth transfer can be seen in a cross-comparison of Panels A (B) [C] in Table 6. Under the same fee structure, the TFNJ values of the symmetric case are greater than those of the asymmetric case.

## 5.3. *The effect of varying risk aversion*

The effect of risk aversion can be seen in a panel-by-panel comparison across Tables 5 to 7 for the symmetric (I) and asymmetric (II) cases. Once more we focus on the manager's choice and whether they receive higher utility of fees from the no-jump (TFUNJ) or jump (TFUJ) scenario. Taking symmetry and a $1 + 10\%$ fee structure as an example, we compare Panel B.I across Tables 5 and 6. The movement from high to low risk aversion shows that the horizon over which the incentives of the manager and the investor are aligned is deferred further into the future. In Table 6 the incentives are aligned for a horizon of 3 years or longer, while in Table 5 they are aligned for a horizon of 7 years or longer. Thus, a decrease in risk aversion from 5 to 3 causes the interests of the two agents to become aligned later; a similar delay is also witnessed for the alternative fee structures. When the asymmetric transfer function is used

Table 6.: Manager and investor results, $\gamma$=5

| | Panel A.I: 2+20% fees, symmetric wealth transfer function | | | | | | Panel A.II: 2+20% fees, asymmetric wealth transfer function | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 2 | 3 | 5 | 7 | 10 | 15 | 2 | 3 | 5 | 7 | 10 | 15 |
| TFJ | 4.1134 | 6.1849 | 10.2783 | 14.3471 | 20.4825 | 30.7000 | 4.1370 | 6.2501 | 10.5505 | 14.9629 | 21.7597 | 33.5625 |
| TFNJ | **4.6657** | **7.0535** | **11.9326** | **16.9188** | **25.8152** | **38.5312** | **4.6023** | **6.9755** | **11.6072** | **16.3067** | **23.1441** | **35.0362** |
| TUJ ($\times 10^{-9}$) | **-4.9961** | **-7.4983** | **-12.5940** | **-17.7243** | **-25.4759** | -38.5483 | **-4.8652** | **-7.1328** | **-11.3973** | **-15.2259** | **-20.4980** | **-27.9941** |
| TUNJ ($\times 10^{-9}$) | -5.5440 | -8.5622 | -16.1150 | -24.9694 | -40.4742 | -78.4165 | -5.9447 | -10.1570 | -22.6756 | -42.0754 | -83.2360 | -34.3981 |
| TFUJ | -0.0287 | **-0.0429** | **-0.0724** | **-0.1015** | **-0.1459** | **-0.2207** | **-0.0279** | **-0.0410** | **-0.0655** | **-0.0872** | **-0.1180** | **-0.1603** |
| TFUNJ | **-0.0281** | -0.0433 | -0.0816 | -0.1268 | -0.2070 | -0.3963 | -0.0303 | -0.0516 | -0.1152 | -0.2121 | -0.4129 | -1.8000 |
| UJ wins (%) | 35.96 | 33.68 | 33.42 | 34.52 | 35.54 | 37.28 | 38.36 | 38.92 | 46.72 | 50.53 | 56.04 | 71.39 |
| | Panel B.I: 1+10% fees, symmetric wealth transfer function | | | | | | Panel B.II: 1+10% fees, asymmetric wealth transfer function | | | | | |
| TFJ | 2.0724 | 3.1236 | 5.2519 | 7.4402 | 10.7849 | 16.6039 | 2.0843 | 3.1686 | 5.4177 | 7.7564 | 11.4589 | 18.1896 |
| TFNJ | **2.4334** | **3.6803** | **6.3061** | **9.0492** | **13.4652** | **21.7654** | **2.4278** | **3.6400** | **6.1313** | **8.6183** | **12.7557** | **19.8763** |
| TUJ ($\times 10^{-9}$) | **-4.6863** | **-6.9216** | **-11.1531** | **-15.0707** | **-20.4421** | **-28.1046** | **-4.5770** | **-6.5800** | **-10.1233** | **-13.1076** | **-16.7688** | **-21.1905** |
| TUNJ ($\times 10^{-9}$) | -5.1181 | -7.8263 | -14.3144 | -20.7885 | -34.5753 | -56.2418 | -5.3814 | -9.0194 | -20.0559 | -37.3340 | -73.1603 | -159.7510 |
| TFUJ | -0.4421 | **-0.6532** | **-1.0561** | **-1.4224** | **-1.9290** | **-2.6498** | **-0.4301** | **-0.6205** | **-0.9551** | **-1.2374** | **-1.5808** | **-1.9979** |
| TFUNJ | **-0.4169** | -0.6612 | -1.1757 | -1.6983 | -2.5849 | -4.6522 | -0.4385 | -0.7344 | -1.6474 | -3.0727 | -6.0614 | -13.1634 |
| UJ wins (%) | 32.56 | 32.92 | 34.08 | 33.68 | 34.18 | 33.72 | 34.1 | 38.76 | 44.46 | 50.68 | 54.6 | 66.78 |
| | Panel C.I: 0.4+3% fees, symmetric wealth transfer function | | | | | | Panel C.II: 0.4+3% fees, asymmetric wealth transfer function | | | | | |
| TFJ | 0.8352 | 1.2639 | 2.1373 | 3.0385 | 4.4478 | 6.9468 | 0.8417 | 1.2809 | 2.1989 | 3.1704 | 4.7314 | 7.6309 |
| TFNJ | **0.9528** | **1.4603** | **2.5215** | **3.6390** | **5.5201** | **8.8859** | **0.9508** | **1.4362** | **2.4429** | **3.4744** | **5.1181** | **8.1906** |
| TUJ ($\times 10^{-9}$) | **-4.5317** | **-6.5898** | **-10.3920** | **-13.7576** | **-18.0540** | **-23.7590** | **-4.4113** | **-6.2806** | **-9.4517** | **-11.9924** | **-14.9729** | **-18.2008** |
| TUNJ ($\times 10^{-9}$) | -4.9429 | -7.5250 | -12.5008 | -18.4346 | -26.6534 | -54.1424 | -5.2844 | -8.6666 | -17.4160 | -30.6114 | -62.5063 | -119.3590 |
| TFUJ | -17.0009 | **-24.6860** | **-38.9490** | **-51.5856** | **-67.6276** | **-89.1035** | **-16.5467** | **-23.5689** | **-35.4443** | **-44.9975** | **-56.1410** | **-68.2355** |
| TFUNJ | **-16.2627** | -24.7195 | -40.8931 | -60.2808 | -87.1404 | -175.7580 | -17.2704 | -28.2572 | -57.1591 | -100.8890 | -204.0500 | -389.6650 |
| UJ wins (%) | 34.2 | 31.8 | 31.88 | 33.68 | 34.04 | 35.05 | 36.08 | 38.64 | 43.46 | 50.04 | 55.52 | 58.66 |

Table 7.: Manager and investor results, $\gamma$=2

| | Panel A.I: 2+20% fees, symmetric wealth transfer function | | | | | | Panel A.II: 2+20% fees, asymmetric wealth transfer function | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 2 | 3 | 5 | 7 | 10 | 15 | 2 | 3 | 5 | 7 | 10 | 15 |
| TFJ | 4.6098 | 6.9021 | 11.3284 | 15.4187 | 22.1232 | 32.4729 | 4.6942 | 7.0416 | 11.7170 | 16.5580 | 23.6970 | 36.1586 |
| TFNJ | **6.8496** | **10.5445** | **18.1778** | **25.9447** | **40.0673** | **64.5523** | **6.9736** | **10.5160** | **17.7317** | **25.7030** | **37.2764** | **58.9416** |
| TUJ | **-0.0202** | **-0.0305** | **-0.0515** | **-0.0730** | **-0.1061** | **-0.1636** | **-0.0199** | **-0.0299** | **-0.0500** | **-0.0697** | **-0.0997** | **-0.1473** |
| TUNJ | -0.0211 | -0.0334 | -0.0560 | -0.0824 | -0.1225 | -0.1938 | -0.0214 | -0.0331 | -0.0639 | -0.0907 | -0.1383 | -0.2232 |
| TFUJ | -0.9200 | -1.3883 | -2.3216 | -3.3248 | **-4.8308** | **-7.4449** | -0.9064 | -1.3603 | **-2.2780** | **-3.1715** | **-4.5112** | **-6.7101** |
| TFUNJ | **-0.8727** | **-1.3481** | **-2.2861** | **-3.3172** | -4.9167 | -7.7704 | **-0.8566** | **-1.3274** | -2.2942 | -3.6602 | -5.5446 | -8.9617 |
| UJ wins (%) | 33.24 | 32.28 | 33.46 | 33.52 | 34.44 | 33.02 | 33.06 | 34.54 | 40.02 | 42.86 | 47.24 | 50.16 |
| | Panel B.I: 1+10% fees, symmetric wealth transfer function | | | | | | Panel B.II: 1+10% fees, asymmetric wealth transfer function | | | | | |
| TFJ | 2.4174 | 3.6073 | 5.9962 | 8.4082 | 11.9654 | 18.2031 | 2.4248 | 3.6586 | 6.1931 | 8.8284 | 12.9322 | 20.4003 |
| TFNJ | **3.5198** | **5.4341** | **9.4714** | **14.6697** | **22.3135** | **37.5585** | **3.4959** | **5.2819** | **9.2087** | **13.7643** | **20.0967** | **35.1240** |
| TUJ | **-0.0198** | **-0.0297** | **-0.0498** | **-0.0697** | **-0.1001** | **-0.1494** | **-0.0196** | **-0.0293** | **-0.0483** | **-0.0668** | **-0.0937** | **-0.1346** |
| TUNJ | -0.0207 | -0.0335 | -0.0576 | -0.0776 | -0.1154 | -0.1732 | -0.0217 | -0.0336 | -0.0644 | -0.0846 | -0.1479 | -0.1990 |
| TFUJ | -1.7830 | -2.6862 | -4.5012 | -6.2940 | **-9.0391** | **-13.5053** | -1.7724 | -2.6502 | **-4.3698** | **-6.0325** | **-8.468** | **-12.1443** |
| TFUNJ | **-1.6921** | **-2.5606** | **-4.3891** | **-6.1437** | -9.1448 | -13.8565 | **-1.7042** | **-2.6365** | -4.5656 | -6.7817 | -10.7790 | -15.9058 |
| UJ wins (%) | 34.72 | 33.56 | 32.48 | 32.06 | 32.96 | 32.54 | 34.12 | 33.94 | 40.36 | 43.14 | 46.28 | 46.28 |
| | Panel C.I: 0.4+3% fees, symmetric wealth transfer function | | | | | | Panel C.II: 0.4+3% fees, asymmetric wealth transfer function | | | | | |
| TFJ | 0.9436 | 1.4260 | 2.3816 | 3.3552 | 4.8714 | 7.5451 | 0.9592 | 1.4452 | 2.4606 | 3.5290 | 5.2446 | 8.4344 |
| TFNJ | **1.3249** | **2.0800** | **3.6702** | **5.4692** | **8.6798** | **15.3235** | **1.3381** | **2.0259** | **3.5322** | **5.2060** | **8.0815** | **13.7529** |
| TUJ | **-0.0196** | **-0.0293** | **-0.0488** | **-0.0679** | **-0.0964** | **-0.1409** | **-0.0194** | **-0.0289** | **-0.0473** | **-0.0650** | **-0.0903** | **-0.1278** |
| TUNJ | -0.0206 | -0.0304 | -0.0530 | -0.0757 | -0.1082 | -0.16146 | -0.0207 | -0.0331 | -0.0578 | -0.0819 | -0.1194 | -0.1890 |
| TFUJ | -4.4947 | -6.7082 | -11.1742 | **-15.5464** | **-22.0529** | **-32.2214** | -4.4346 | -6.6167 | **-10.8402** | **-14.8306** | **-20.4514** | **-29.2379** |
| TFUNJ | **-4.2439** | **-6.5197** | **-10.9174** | -15.6221 | -22.3251 | -33.2666 | **-4.2489** | **-6.6011** | -11.8591 | -16.8714 | -24.6747 | -38.9700 |
| UJ wins (%) | 31.9 | 30.5 | 31.9 | 32.48 | 32.88 | 33.92 | 34.66 | 34.02 | 40.66 | 42.32 | 45 | 48.78 |

then the horizon over which the incentive manifests is reduced, to the extent that when $\gamma = 5$ at all horizons managers incentives are aligned with those of investors. If investors are highly risk averse ($\gamma = 5$) and respond more strongly to transfer funds when equity returns are low, then the conflict of interest is eliminated.

Panels I in Tables 5 and 7 ($\gamma$=3,2) for symmetric wealth transfer show that the time at which the incentives are aligned increases to 10 from 7 years as risk aversion decreases (and the period when the conflict of interest manifests increases from 5 to 7 years). The same comparisons for Panels II, representing asymmetry, show that for $\gamma = 3$ the alignment starts at 3 years, which increases to 5 years for $\gamma = 2$. This highlights the third result. Similar results are depicted for all fee structures. There is, therefore, a negative relationship between risk aversion and the winning horizon of the no-jumps manager. As risk aversion decreases, the time horizon of the managerial incentive increases and the interests of the two agents become aligned later in time.

Finally, we consider the percentage of wins for each manager. The incentive (or temptation) to ignore jumps can be illustrated not only on expected utility terms, but also on the probability of a single favourable outcome (e.g "beating the odds"). The "UJ Wins" metric reports the percentage of times the jumps manager ends up with higher terminal utility compared to the no-jumps manager. For all our simulations, the jumps manager has a $30 - 40\%$ win rate across all investment periods under a symmetric wealth transfer function. Under asymmetry, however, the win rate increases from 30% to more than 70% for the longest horizons. Therefore, in the first case the No-Jumps manager has a probability of 60-70% to win a single run, which creates an additional incentive to act against her clients interest, while in the second case the incentive disappears as the investment horizon lengthens. This highlights that an asymmetric reaction to losses acts as a penalising mechanism not only on average terms, but also on a single run. These patterns occur as a direct result of the wealth transfer pattern; for asymmetric transfers, much more wealth is moved when there is poor performance of the fund, which is consistent with investors being more sensitive to losses than gains.

### 5.4. *Managerial incentives in mutual funds*

Although the setup and fee compensation is more representative of hedge rather than mutual funds, the intuition of our results is strikingly similar to the mutual fund tournament effect[8]

[8]We are grateful to an anonymous referee for the suggestion.

(Brown, Harlow, and Starks (1996)). When manager compensation is linked to performance, managers who are more likely to accrue losses are also more likely to increase fund volatility, thus undertaking riskier positions, compared to managers in well-performing funds, who tend to resort to index tracking in order to maintain gains. Chevalier and Ellison (1997) put the tournament effect explicitly in the context of an agency conflict between investors, who want to maximise risk-adjusted returns, and fund companies, who wish to maximise their own profits and value by increased fund flows. They find that young funds have an incentive late in the year to take excess risk if their performance is lagging behind the market; they may also have an incentive to play it safe and act more like an index fund if they are ahead of the market. However, they find an additional, stronger, incentive of funds that are well ahead of the market to gamble. In a parsimonious setting with managers of different skill, Berk and Green (2004) show that investments with active managers do not outperform passive benchmarks because investors competitively supply funds to managers and there are decreasing returns for managers in deploying their superior ability. Similar effects are also detected in mutual fund families (Kempf and Ruenzi (2008)). However, Massa and Patgiri (2009) find that increased incentives increase managerial effort as well as risk-taking, which has a positive effect on fund survival rates. In this context, we show that jumps in asset prices, when combined with convex compensation schemes, create principal-agent conflicts that in some ways mirror those that arise between managers and investors under the tournament effect. We also show that a set of counter-incentives in the form of clawbacks can help mitigate this conflict.

## 6. Methods to align investor-manager incentives

The results thus far support the existence of an incentive for the manager to undertake excessive risk in her positions and, thus, act against her client's interests caused by the existence of jumps in asset prices. This incentive from jumps is distinct from the incentive caused by the manager's option-type compensation, but both operate in conjunction. This entails undertaking positions that do not fully hedge against downside risk or the possibility of a rare catastrophic event. The motive manifests by continuously receiving higher fees on average, having a horizon over which the manager's realised expected utility is higher, and having a higher chance to succeed in a one-off gamble compared to when that risk is taken into account.

This observation is linked to a wider debate on regulation and current shifts in industry norms and practices. From the perspectives of investors and policy makers, the discussion focuses on the clients' loss of welfare and increased accountability and transparency on behalf of the fund. The hedge fund sector is considered to have been charging excessive fees, especially when there is relatively low performance. Competition between financial firms now extends to contract clauses (preferential terms, lock-up periods for fees, fee stratas, discounts) in an attempt to maintain existing clients and attract new ones. Also, many funds charge lower fees than the staple "2 + 20%" scheme and are willing to make concessions to clients, such as favourable terms (Barclays (2017)).

Such contract clauses may provide managers with a motivation to put more weight on market declines in their asset allocation decisions and thus help better align manager and investor objectives. Recent literature highlights issues relating to benchmarking manager performance. Benchmarking may cause mutual fund managers to weigh more heavily riskier, high beta stocks and achieve lower alphas (Christoffersen and Simutin (2017)). Peer pressure may push a manager to follow a performance benchmark (index) instead of trading against overvaluation and to take excessively risky positions, according to Buffa, Vayanos, and Woolley (2014), in a framework very different from ours (linear managerial compensation, CARA utility, constant volatility, multiple risky assets). Agency issues create leverage effects and a situation where deviating from an overvalued index exposes the manager to low performance. In a theoretical paper with a constant volatility model, DeMarzo, Livdan, and Tchistyi (2013) demonstrate that, under disaster risk, a large survival bonus for the manager is not enough to prevent excessively risky investment or remove conflicts of interest.

Instead of a bonus, we consider two possible alternatives to reduce or eliminate this conflict of interest: i) prohibiting performance fees payable to a fund manager and ii) clawbacks. While performance fees are a widely used form of fund manager compensation, clawbacks, in contrasts, are much less established despite their recent adoption by a small number of funds. A clawback is an obligation on behalf of the manager to return to the investor a portion of the past performance fees she has collected when the fund underperforms.

## 6.1. *Performance fee prohibition*

One possible way to align investor and manager preferences is for funds not to charge a performance fee. This can be illustrated by charging only a fixed administrative fee ($\alpha$), which is also the payoff structure of a mutual fund. In that case, fees are $\alpha W_t$ and managerial utility is $\frac{(\alpha W_t)^{1-\gamma}}{1-\gamma} = \frac{\alpha^{1-\gamma}}{1-\gamma}U(W_t) = kU(W_t)$, which is investor utility times a scalar. k is common for the jumps and no-jumps manager, so the relationship between expected utilities follows directly from Table 4. We can see in the third panel ($\gamma = 3$) that the jumps investor always wins in terms of average total terminal utility (TUJ>TUNJ) across all horizons, compensation structures and wealth transfer functions. A change in the fee level merely scales the manager's utility by k, leaving the observed pattern unchanged. This provides a clear motivation and explanation for both investors and fixed fee managers to take jumps into account (when they are known to exist). Since utility is based on portfolio wealth and the allocation is optimised in the presence of jumps, it is reasonable to see the SVCJ weights dominate the sub-optimal SV option even for very short horizons when simulated across a large number of samples. Consequently, this decision will be optimal for both investors and fund managers, as expected, given our approach. We can conclude that mutual funds that do not charge a performance fee do not suffer from a conflict of interest. The complete removal of an option-type compensation scheme for the manager also removes the incentive to ignore jumps, since her reward is a proportion of assets under management. When both managers receive only a flat percentage fee, the No-Jumps manager never wins, similar to the No-Jumps investor. As such, this may appear as a justification to abolish performance fees of that type altogether. While this appears to be one solution to the issue raised in this paper, it may prove to be a controversial policy for the regulator to implement.

## 6.2. *Clawbacks*

Clawbacks enable investors to recoup part of the performance fees they have previously paid and can moderate the incentives for the fund manager to take excessive risks. A clawback acts as a variant of the "fulcrum fee", where high fees (compensation) for good performance are balanced by low fees for bad performance. A key result is that clawbacks substantially ameloriate the conflict between investors and managers. Specifically, they cause a large reduction in the winning horizons, managerial utility and fees across the board, severely reducing instances where manager incentives are mis-aligned and in many scenarios eliminating it altogether. This highlights how such protective provisions are beneficial to the investor and can be a powerful tool for the regulator, if applied correctly. In addition, they have fewer unintended consequences compared to other types of amelioration, such as high watermarks, which are linked to fund closures since the funds lack a strong incentive to continue, particularly after large losses (Ben-David, Birru, and Rossi (2020) for an overview, Masters and Fletcher (2022) for an example[9]).

We selected clawbacks due to their recent post-crisis resurgence as regulatory tools for hedge funds, both for cases of fraud and fund liquidation (Cherry and Wong (2009); Bambach (2014)), as well as their uses by industry practitioners (Lee, Lwi, and Phoon (2004); Smith and Gupta (2017)). We thus extend past literature from clawbacks in the context of bankruptcy and litigation to their much less studied use as an incentives alignment mechanism in normal fund operation. According to Flood and Aliaj (2020), clawback clauses are offered by approximately 16% of hedge funds, up from 10% since 2017, while they are highly sought by one third of investors.

The form of the simulations when clawbacks are introduced is very similar to that of the previous section. We introduce in addition the clawback threshold, which defines the level of losses that activate the clause, and the clawback rate, which defines the amount to be returned to the investor. The mechanism assumes that if portfolio returns fall below the threshold, the manager is bound under contract to return a percentage of the performance fees she has amassed over a given number of past periods back to the investors. We consider two different cases[10]. In the first case, the amount to be repaid is a portion of performance fees collected over a window of 5 years prior to the year of the clawback. The amount "clawed back" is paid at the end of year $t$ by being deducted from annual fees and added to portfolio wealth, and is also

[9] As an example on how our setup can be implemented by a hedge fund, we refer to Aperture Investors, the new firm by the former chief executive of AllianceBernstein Peter Kraus. It implements a 30% performance bonus under a fixed hurdle rate, half of the performance bonus is held in escrow for several years and pays out only if the gains are maintained, and the performance clock is reset annually. According to Kraus, "such [water]marks also push some fund managers to shut down and start over, crystallising losses for current investors and handing any new gains to a different set of investors". The escrow provides managers "time to recover from deep losses while returning money to investors if the gains prove illusory [...] and helps with staff retention". This bears a striking similarity to our setup and provides an example of how past performance fees can be clawed back in practice, covering the concerns of Hoffmann, Inderst, and Opp (2021).

[10] We also considered the case where the amount to be returned is based on the entire length of the investment up to that time (i.e. calculated upon total performance fees collected by the manager during the investment up to time $t$) with a clawback rate of 10%. The winning horizons for the same levels of $\gamma$ followed the same patterns, ranging between 2 and 3 years. Also, for brevity the tables for higher risk aversion are omitted since a winning horizon manifests only in the symmetric case for $\gamma = 4$ with a length of 2 years

subtracted from the sum of performance fees. In the second case, the amount is based on last year's performance fee only (i.e. the window upon which the clawback is calculated is one year instead of 5 years). The clawback threshold that activates the return of fees is when the annual portfolio return falls below -10%. In the first case the clawback rate is 20% of the accumulated performance fees over the last 5 years, while in the second the clawback rate is 33% of last year's performance fee. In this second case, if the manager did not receive a performance fee in year t-1, then the clawback is zero; the implication is that this clawback can only be effective if poor performance is preceded by a year when a performance fee is realized. This makes the clause effective under quite specific conditions, but due to the higher clawback rate of 33% it is expected to have more a severe effect on managerial utility. These structures are combined with symmetric and asymmetric transfer of wealth, leading to four different cases. A threshold of -5% was also considered but yielded almost identical results to those in Tables 8 and 9.

To prevent negative fees but also extremely low managerial utility that would dominate the simulation and distort the outcome when a repayment occurs, it is necessary to include a lower limit in annual fees. The "floors" (fees) are 0.1 (2%), 0.05 (1%) and 0.01 (0.4%). If there is still an amount to be repaid after the floor is reached, it is passed on as balance in the next year [11]. Lower thresholds lead to visibly lower expected utility and winning horizons, as such implementing these "floors" understates the effectiveness of clawbacks.

The trends identified in earlier results remain unchanged under clawbacks. This allows us to focus on the baseline case of a 1 + 10% performance fee. Since the conflict of interest is greater at low and medium levels of risk aversion, only the results for $\gamma = 3$ and $\gamma = 2$ are reported. We start with a risk aversion of 3 and symmetric wealth transfer. A comparison of Panels I in Table 5, where clawbacks are absent, and Table 8, where clawbacks are present and calculated on the sum of performance fees over the past 5 years, reveals a clear reduction of the winning horizons for the No-Jumps manager. Specifically, when the clawbacks are based on the past few years of performance fees, Table 8, Panel A (1+10%) shows that investor-manager incentives are now aligned for horizons of 3 years and above; this is a substantial reduction from the 7-year changing point in Table 5, Panel B.I. When the clawback window is limited to last year only but with a higher clawback rate of 33% (Table 9, Panel A), there is no incentive for the manager since the No-jumps manager always loses for horizons up to 10 years. Therefore,

[11] The values were shown not to be disruptive in terms of expected utility. They are similar to the administration fees paid when the fund has lost 95% of its initial wealth and, according to our conditions in the previous section, becomes defunct.

their incentives are always aligned and the existence of that particular form of clawback clause appears to resolve the conflict of interest.

The punitive effects are even stronger with an asymmetric wealth transfer function, since the manager is burdened not only with the reduction of her own utility but with a further loss of assets under management. The tables to compare are 5 (Panels II), 8 and 9. Without clawbacks (Panel 5.B.II) the winning horizon is 2 years, while for both types of clawbacks (Panels 8.B and 9.B) it is completely eradicated. The result illustrates a dramatic reduction in the incentive of the manager and in her expected utility under a penalising mechanism.

As earlier, an increase in risk aversion reduces the time frame over which the no-jumps manager dominates the jumps manager in terms of utility. For $\gamma = 2$, the manager that ignores jumps wins for investment periods up to 7 years in the symmetric case without clawbacks (Table 5, Panels I), but only up to three years when clawbacks are based on the last 5 years (Panel 8.C) and never wins even at the two year horizon when clawbacks are based on last year (Panel 10.C). When asymmetry is introduced, the respective Panels 5.B.II, 8.D and 9.D show that under the first type of clawbacks the no-jumps manager wins on average for horizons up to two years ($\gamma = 2$), under the second type she always loses, while without them she wins for up to three years. The effect of risk aversion is seen in the reduction for both symmetry and asymmetry when compared with the results for $\gamma = 3$. The new element is that now, with asymmetric movements of wealth, the motive is eliminated for moderate and low risk aversion, contrary to only high risk aversion when clawbacks are absent. This is a clear indication of the ability of such clauses to eliminate the managerial incentive, either on their own or in combination with other policies and factors.

Higher levels of risk aversion have no impact on fees, win percentages and investor utility. Total fees for the No-Jumps manager are clearly lower under clawbacks. The percentage of wins lies constantly between $33 - 36\%$ in the symmetric case, while it steadily increases in the asymmetric case starting from 33% and increasing up to 70% for the 15-year horizon. On fee structures, $2 + 20\%$ is qualitatively identical to $1 + 10\%$ and $0.4 + 3\%$ has slightly lower horizons, mimicking the patterns noted earlier. In that case, however, the manager is penalised even further. Her winning horizon is limited to two years, instead of three, under symmetry and is completely eradicated under asymmetry. A similar, more pronounced, result was observed in the previous set of simulations, yet it is clear that such a punitive mechanism is relevant and

Table 8.: Results under 20% clawbacks over the past 5 years, $1 + 10\%$ fees

| Years | 2 | 3 | 5 | 7 | 10 |
|---|---|---|---|---|---|
| Panel A: $\gamma = 3$, symmetric wealth transfer function | | | | | |
| TFJ | 2.1976 | 3.2870 | 5.5173 | 7.7180 | 11.1190 |
| TFNJ | **2.9776** | **4.4952** | **7.8220** | **11.1701** | **16.9229** |
| TFUJ | -0.8882 | **-1.3393** | **-2.2147** | **-3.1157** | **-4.3987** |
| TFUNJ | **-0.8309** | -1.3437 | -2.4667 | -4.7737 | -9.8253 |
| UJ wins (%) | 33.98 | 34.88 | 38.58 | 44.76 | 45.44 |
| Panel B: $\gamma = 3$, asymmetric wealth transfer function | | | | | |
| TFJ | 2.2046 | 3.3519 | 5.6826 | 8.0967 | 11.9464 |
| TFNJ | **2.8894** | **4.4658** | **7.4969** | **10.4968** | **15.6707** |
| TFUJ | **-0.8816** | **-1.2946** | **-2.0976** | **-2.8491** | **-3.8696** |
| TFUNJ | -0.8859 | -1.4750 | -3.2751 | -5.9698 | -10.0653 |
| UJ wins (%) | 37.98 | 39.88 | 49.62 | 55.12 | 61.96 |
| Panel C: $\gamma = 2$, symmetric wealth transfer function | | | | | |
| TFJ | 2.4005 | 3.6072 | 5.9692 | 8.3967 | 12.0538 |
| TFNJ | **3.5967** | **5.5873** | **9.5904** | **14.1602** | **21.9383** |
| TFUJ | -1.7930 | -2.6921 | **-4.5326** | **-6.3510** | **-9.1048** |
| TFUNJ | **-1.7048** | **-2.6698** | -4.9503 | -7.4477 | -12.7299 |
| UJ wins (%) | 32.16 | 32.14 | 37.62 | 40.48 | 46.44 |
| Panel D: $\gamma = 2$, asymmetric wealth transfer function | | | | | |
| TFJ | 2.4211 | 3.6666 | 6.1947 | 8.8179 | 12.9680 |
| TFNJ | **3.5431** | **5.4881** | **9.2683** | **13.3815** | **20.5961** |
| TFUJ | -1.7773 | **-2.6472** | **-4.3775** | **-6.0583** | **-8.4939** |
| TFUNJ | **-1.7338** | -2.6846 | -5.2561 | -8.3722 | -14.6850 |
| UJ wins (%) | 34.38 | 37.06 | 44.60 | 51.86 | 57.56 |

Table 9.: Results under 33% clawbacks over the last year, $1 + 10\%$ fees

| Years | 2 | 3 | 5 | 7 | 10 |
|---|---|---|---|---|---|
| Panel A: $\gamma = 3$, symmetric wealth transfer function | | | | | |
| 1-6 TFJ | 2.1928 | 3.2865 | 5.5021 | 7.7378 | 11.1102 |
| TFNJ | **2.9156** | **4.4675** | **7.7708** | **11.2976** | **17.1402** |
| TFUJ | **-0.8928** | **-1.3412** | **-2.2225** | **-3.0953** | **-4.3834** |
| TFUNJ | -0.9276 | -1.6600 | -2.9677 | -4.0897 | -6.3781 |
| UJ wins (%) | 36.60 | 36.36 | 37.02 | 37.70 | 38.82 |
| Panel B: $\gamma = 3$, asymmetric wealth transfer function | | | | | |
| TFJ | 2.2097 | 3.3498 | 5.6771 | 8.1107 | 11.9525 |
| TFNJ | **2.9180** | **4.4188** | **7.4643** | **10.8129** | **16.1559** |
| TFUJ | **-0.8796** | **-1.2961** | **-2.0969** | **-2.8328** | **-3.8498** |
| TFUNJ | -1.0568 | -1.6768 | -3.3689 | -4.9712 | -7.8570 |
| UJ wins (%) | 38.50 | 41.56 | 47.44 | 49.16 | 52.52 |
| Panel C: $\gamma = 2$, symmetric wealth transfer function | | | | | |
| TFJ | 2.4217 | 3.6209 | 6.0161 | 8.3958 | 12.0095 |
| TFNJ | **3.6388** | **5.5698** | **9.7542** | **14.2025** | **21.9690** |
| TFUJ | **-1.7899** | **-2.6965** | **-4.5148** | **-6.3554** | **-9.0841** |
| TFUNJ | -1.9632 | -3.1884 | -5.6046 | -8.4066 | -11.9795 |
| UJ wins (%) | 37.42 | 39.60 | 41.48 | 43.98 | 46.88 |
| Panel D: $\gamma = 2$, asymmetric wealth transfer function | | | | | |
| TFJ | 2.4318 | 3.6526 | 6.2102 | 8.8327 | 12.8995 |
| TFNJ | **3.5707** | **5.3613** | **9.3533** | **13.6196** | **20.3224** |
| TFUJ | **-1.7795** | **-2.6694** | **-4.3726** | **-6.0533** | **-8.4991** |
| TFUNJ | -2.0152 | -3.2974 | -5.8223 | -8.7064 | -13.1824 |
| UJ wins (%) | 39.66 | 44.64 | 49.50 | 52.96 | 57.30 |

effective even when fees are very low. The outcome is the same for both clawback mechanisms. A final important point is how even a small performance fee of 3% can motivate excess risk. The effect of an option-type fee is well-documented in the literature and we expand by showing that in order to both maintain such a structure and eliminate the principal - agent conflict, an effective policy mechanism is needed. The complete abolition of performance fees is represented by the investor-only case. Such a policy is highly effective, however it might be too invasive and restrictive. On the other hand, clauses that protect the investor on the downside tend to be almost as effective as the abolition of performance fees.

Further unreported tests (available on request) confirm the robustness of these qualitative conclusions. We can summarize further robustness checks conducted as follows. The results for the fee structure and risk aversion behave in the same manner as when there are no clawbacks. High and moderate fees demonstrate the same qualitative results and only very low performance fees have some effect in mitigating the incentive of the manager. A change in the clawback threshold from $-10\%$ to $-5\%$ yields only a marginal difference. However, as expected, an increase in the clawback rate causes a clear reduction in the winning horizons. If the hurdle threshold, at which performance fees begin to be paid, is increased then this leads to a significant reduction in the winning horizon, particularly in the presence of clawbacks.

### 6.3. *The effect of clawbacks on the manager's preferred allocations.*

Finally, we consider the impact of clawbacks upon the manager's optimal weights. As discussed in Section 4, we simulate portfolio weights for four different cases, explained in detail in Appendix C and Table C.9. Based on our previous results, our main interest is in short and medium investment horizons (T=2,3,5) where the manager's incentive appears more often and more pronounced. We focus on a 33% clawback rate of last year's performance fee, symmetric wealth transfer and a base fee structure of $1 + 10\%$. Our key findings are summarised in Panel C, based on fees and wealth transfer, and Panel D, which additionally includes the impact of clawbacks. First, the optimal weights in Panel C are similar to those in Panel A, indicating that including a wealth transfer function has a limited impact upon the optimal weights for short and medium investment horizons. Notably, the optimal simulated weights match the SV weights in some cases (Panel A, T=3). Second, we examine the impact of clawbacks on the optimal weights; we can clearly see that the optimal weights with a clawback (Panel D) are in many cases substantially lower than without (Panel C). The impact depends crucially on the level of risk aversion and time horizon. For $T = 2$ and $\gamma = 2$ the manager's optimal weights reduce from 100% (Panel C) to 77% (Panel D), whereas for $T = 3$ and $\gamma = 3$ the reduction is from 65% to 52%. Thus, for cases where the manager's and investor's optimal weights are furthest apart, clawbacks can greatly ameliorate but not eliminate, the manager's propensity towards a riskier allocation. For cases without a large difference in weights, such as $T = 10$ and $\gamma = 5$, the clawback still reduces the manager's optimal weight (from 28% to 25%) but by a more modest amount. Also, the weight with clawbacks is much closer here to the investor's optimal (SVCJ) than when jumps are ignored (SV). The manager's incentive is fully removed for $T = 10$, $\gamma = 5$ and $2 + 20\%$ fees, where the simulated and SV weights are equal (21%). We conclude that clawbacks do lead managers to select less risky portfolios, which are more closely aligned with the investor's preferred allocation, compared to an environment where such clauses are absent.

## 7. Conclusion

This paper connects and expands two separate areas of finance; first, portfolio optimisation under jumps in the return process (Hong and Jin (2018)) and, second, principal-agent problems when compensation is performance-based (Ma, Tang, and Gómez (2019)). Specifically, we examine the extent of principal-agent conflicts between an investor and their asset manager in a setting where managers receive performance bonuses and there are substantial but infrequent jumps in equity returns. The key finding of the paper is that an asset manager whose investment horizon is short-term (less than 5 years) and who derives utility from fee income would choose to ignore jump risk and would therefore not invest in a way which maximises the utility of their client. Instead, they pursue a more aggressive asset allocation strategy which leads to higher returns and higher fees but, crucially, more risk than is optimal for the investor. The results are robust across different cases considered including those where investors moved money between funds under differing schemes, differing levels of risk aversion and differing managerial fee levels. The misalignment of incentives is more pronounced when i) there is symmetry in the way investors move money out of losing funds into winning funds, or ii) the manager and investor both have a low level of risk aversion. This incentive is distinct from the incentive caused by asymmetric managerial compensation as in hedge funds.

We demonstrate that when there are negatives fees in times of low performance (”clawbacks”) manager and investor incentives are far more closely aligned; there is a clear reduction across the board in the time horizon when the conflict is manifested. The combination of three features almost resolves the conflict of interest; moderate clawbacks, asymmetric investor reactions and high risk aversion. With a substantial clawback measured over last year’s performance fee, the incentive is eliminated even when there is low risk aversion and symmetry in investor reactions. Notably, the monetary value of the clawback is very low compared to portfolio wealth. As such, the aim is not to cover investor losses but instead to penalise the underperforming manager. Therefore, clawbacks can help align incentives without the disadvantage of diluting the investors’ fund holdings, which occurs when managers become also fund owners (Kaniel, Tompaidis, and Zhou (2019)). When the manager receives only the administrative and not the performance fee (a common feature of mutual funds), then the incentives are fully aligned with the investor and the manager will always take jumps into account. Therefore, removing performance fees is an alternate regulatory solution to clawbacks that solves this agency conflict, but may be more difficult to implement in practice and might have unintended consequences including reduced managerial discipline.

While this paper points to a number of important extensions for future research, two are of particular interest. The first is the sensitivity of management behaviour to different specifications of the utility function within the model. While constant relative risk aversion utility functions, as applied in this paper, are the most prevalent within this type of framework, we have not demonstrated the robustness of our results to other popular choices, such as constant absolute risk aversion. The second is that we have not separated the rewards to the fund from the remuneration paid to the individual fund manager. This relates to concerns on fund and manager liability, regulatory policy implementation and a potential difference in fund survival probabilities between funds with clear or little separation between the fund manager and the fund company. This additional layer of potential agency conflict is a fertile area for further study.

We conclude that regulators should seriously consider mandating clawbacks in performance fees, since regulators have a remit to ensure consumer protection and integrity in the financial system. With proper implementation and regulatory oversight, such policies have the potential to be successful (Hoffmann, Inderst, and Opp (2021)). A clawback linked to last year's performance would be relatively easy to enforce and monitor. Given the large potential benefits and low anticipated costs, the case for such regulatory changes seems compelling.

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## Appendix A. Posterior distributions

### A.1. *SVCJ posteriors*

The discretised version of the SVCJ model described by (2) is

$$\begin{aligned} Y_t &= \mu + \sqrt{V_{t-1}}\epsilon_t^Y + \xi_t^Y J_t \\ \Delta V_t &= V_t - V_{t-1} = \alpha + \beta V_{t-1} + \sqrt{V_{t-1}}\sigma_V \epsilon_t^V + \xi_t^V J_t \end{aligned} \tag{A1}$$

where $\alpha = \kappa\theta, \beta = -\kappa, \epsilon^Y, \epsilon^V \sim N(0,1)$ with correlation $\rho$, log returns $Y_t = log(S_t/S_{t-1})$, $J_t \sim Ber(\lambda)$, $\xi^V \sim exp(\mu_v), \xi^Y \sim N(\mu_Y + \rho_j \xi^V, \sigma_Y^2)$ jump sizes with correlation $\rho_j$. The model can be discretised with either $\alpha = \kappa\theta$ and $\beta = -\kappa$ or directly $\kappa, \theta$. Here the first method is used. In this form, Metropolis - Hastings sampling is needed for $V_t, \rho, \sigma_V$. If the volatility error term is rewritten as $\epsilon_t^V = \rho \times \epsilon_t^Y + \sqrt{1-\rho^2} \times \zeta_t$, where $\zeta_t \sim N(0,1)$ independent of $\epsilon_t^Y$, and $\omega = \sigma_V^2(1-\rho^2), \phi = \sigma_V \times \rho$ are defined, then they can be sampled directly from the resulting posteriors due to conjugacy and get $\rho = \frac{\phi}{\sigma_V}, \sigma_V^2 = \omega + \phi^2$.

The parameters to be sampled are $\theta = (\mu, \alpha, \beta, \rho, \rho_j, \sigma_V^2, \mu_Y, \mu_V, \sigma_Y^2)$, the vectors (sets) to be sampled are $(V_t, J_t, \xi_t^Y, \xi_t^V)$, the notation (...) denotes all other quantities and all sums are from t=1 to t=N. The likelihood function is the bivariate normal

$$p(Y_t, \Delta V_t | V_{t-1}, ...) = \frac{1}{2\pi\sigma_V V_{t-1}\sqrt{1-\rho^2}} Exp\left[-\frac{1}{2(1-\rho^2)}(\frac{A_t^2}{V_{t-1}} + \frac{B_t^2}{\sigma_V^2 V_{t-1}} - \frac{2\rho A_t B_t}{\sigma_V V_{t-1}})\right]$$

where $Y_t - \mu - \xi_t^Y J_t = A_t$ and $V_t - V_{t-1} - \alpha - \beta V_{t-1} - \xi_t^V J_t = B_t$

Volatility yields the most complex posterior. $p(V_t | V_{t-1}, V_{t+1}, Y_t, ...) \propto$

$$\frac{1}{V_t} Exp\left[-\frac{1}{2}\left(\frac{V_t^2 - 2V_t(\alpha + \beta V_{t-1} + J_t\xi_t^V + 2\rho\sigma_V A_t)}{(1-\rho^2)\sigma_V^2 V_{t-1}} + \frac{(B_{t+1} - \rho\sigma_V A_{t+1})^2}{\sigma_V^2(1-\rho^2)V_t} + \frac{A_{t+1}^2}{V_t}\right)\right]$$

It is updated according to a random walk Metropolis - Hastings step. The proposal is $e$ that follows $N(0, \sigma^2)$ centered on the previous value, so $V_{prop} = V_{old} + e$. Setting $\sigma = 0.05$ works well in practice. It has the advantage of being completely agnostic and with a pace $\sigma$ that can be easily calibrated.

The posteriors for $\rho, \sigma_v^2$ are non-standard. The transformation $\omega = \sigma_V^2(1-\rho^2), \phi = \sigma_V \times \rho$ allows the elimination of those terms and separate direct sampling due to conjugacy for $N(0, \frac{1}{2}\omega)$ for $\phi$ and IG(2,200) for $\omega$ as priors. Formally, $p(\phi | V_t, \omega, ...) \propto p(Y_t, V_t | V_{t-1}, ...)p(\phi|\omega)$ and $p(\omega | V_t, \phi, ...) \propto p(Y_t, V_t | V_{t-1}, \phi, ...)p(\omega)$. The results are an Inverse Gamma posterior for $\omega$ with parameters IG(D, C)

$$D = \frac{T}{2} + 2, \quad C = \sum \frac{1}{2}\frac{(V_t - V_{t-1} - \alpha - \beta V_{t-1} - J_t\xi_t^V)^2}{V_{t-1}} + \frac{1}{200}$$
$$- \frac{(\sum \frac{1}{V_{t-1}}(Y_t - \mu - J_t\xi_t^Y)(V_t - V_{t-1} - \alpha - \beta V_{t-1} - J_t\xi_t^V))^2}{2\sum \frac{1}{V_{t-1}}(Y_t - \mu - J_t\xi_t^Y)^2 + 2}$$

and a Normal (Z,X) posterior for $\phi$ with mean

$$Z = \frac{\sum \frac{1}{V_{t-1}}(Y_t - \mu - J_t\xi_t^Y)(V_t - V_{t-1} - \alpha - \beta V_{t-1} - J_t\xi_t^V)}{\sum \frac{1}{V_{t-1}}(Y_t - \mu - J_t\xi_t^Y)^2 + 2}$$

$$\text{and variance } X = \frac{\omega}{\sum \frac{1}{V_{t-1}}(Y_t - \mu - J_t\xi_t^Y)^2 + 2}$$

The prior for $J_t$ is a Bernoulli distribution $Ber(\lambda)$ with J having two states, 0 and 1. Therefore, $P(1) = P(J = 1|Y_t, V_t, ...) = \lambda \times p(V_t, Y_t|J = 1, ...)$ while $P(0) = P(J = 0|Y_t, V_t, ...) = (1 - \lambda) \times p(V_t, Y_t|J = 0, ...)$ and the resulting posterior is $p(J_t|V_t, Y_t, ...) \propto Ber(q)$, where

$$q = \frac{P(1)}{P(1) + P(0)}$$

The remaining posteriors are mostly Normal or Inverse Gamma. With lax notation of $X, Z$ corresponding to N(mean, variance) and IG(shape, scale)

$p(\mu|V_t, ...) \sim N(X, Z)$ with prior $N(k = 2, K = 40)$ for mean and variance, and

$$Z = \left(\sum \frac{1}{(1-\rho)^2 V_{t-1}} + \frac{1}{K}\right)^{-1} \text{ and } X = \left(\sum \frac{Y_t - J_t\xi_t^Y - \frac{\rho}{\sigma_V}(V_{t-1+\alpha+\beta V_{t-1}+J_t\xi_t^V})}{(1-\rho)^2 V_{t-1}} + \frac{k}{K}\right) \times Z$$

For $\alpha = \kappa\theta$, $p(\alpha|V_t, ...) \propto (N, Z)$ where

$$X = \left(\sum \frac{V_t - (1+\beta)V_{t-1} - J_t\xi_t^V - \rho\sigma^V(Y_t - \mu - J_t\xi_t^Y)}{\sigma_V^2(1-\rho^2)}\right) \times Z \text{ and } Z = \sum \frac{1}{\sigma_V^2(1-\rho^2)V_{t-1}}$$

For $\beta = -\kappa$, $p(\beta|V_t, ...) \propto (N, Z)$ where

$$X = \left(\sum \frac{V_t - V_{t-1} - \alpha - J_t\xi_t^V - \rho\sigma_V(Y_t - \mu - J_t\xi_t^Y)}{V_{t-1}\sigma_V^2(1-\rho^2)}\right) \times Z \text{ and } Z = \frac{\sum V_{t-1}}{\sigma_V^2(1-\rho^2)} + 1$$

For $\lambda$ the prior is a Beta $(k, K)$, so $\lambda \sim Beta(X, Z)$ with parameters

$$X = k + \sum J_t \text{ and } Z = K + T - \sum J_t$$

$$\text{For } \sigma_Y^2, p(\sigma_Y^2|V_t,...) \propto p(\xi_t^Y|...)p(\sigma_Y^2) \propto IG\left(\frac{1}{2}T+e, \frac{1}{2}\sum(\xi_t^Y - \rho_J\xi_t^V - \mu_Y)^2 + E\right)$$

with $IG(e=10, E=40)$ as prior. For $\mu_Y, p(\mu_Y|V_t,...) \propto p(\xi_t^Y|...)p(\mu_Y)$ with prior $N(z=0,100)$ , which yields a Normal distribution $N(X,Z)$ with variance

$$Z = \left(\frac{T}{\sigma_Y^2} + \frac{1}{100}\right)^{-1} \text{ and mean } X = \left(\frac{\sum(\xi_t^Y - \rho_J\xi_t^V)}{\sigma_Y^2} + \frac{z}{100}\right) \times Z$$

For $\mu_V$, the pdf of an exponential distribution with mean $\mu_V$ is

$$\frac{1}{\mu_V} Exp\left(-\frac{\xi_t^V}{\mu_V}\right)$$

since the general form is $\lambda Exp[-\lambda x]$ and mean $\lambda^{-1}$

With an Inverse Gamma (d=10,D=20) as prior and ignoring constants,

$$p(\mu_V|...) \propto p(\xi_t^V)p(\mu_V) \propto \left(\frac{1}{\mu_V}\right)^T Exp\left(-\frac{\sum\xi_t^V}{\mu_V}\right)\mu_V^{-d-1} Exp\left(-\frac{D}{\mu_V}\right) \propto IG(T+d, \sum\xi_t^V + D)$$

For $\xi_t^Y$, the posterior is $p(\xi_Y|\Delta V_t, Y, J=1,...) \propto p(Y_t, \Delta V_t|\xi^Y, J=1,...)p(\xi_t^Y)$ which leads to a Normal distribution N(X,Z) with

$$Z = \left(\frac{1}{(1-\rho^2)V_{t-1}} + \frac{1}{\sigma_Y^2}\right)^{-1} \text{ and } X = \left(\frac{Y_t - \mu - \frac{\rho}{\sigma_V}B_t}{(1-\rho^2)V_{t-1}} + \frac{\mu_Y - \rho_J\xi_t^V}{\sigma_Y^2}\right) \times Z$$

When J=0, $\xi^Y$ cones from the unconditional distribution $\xi^Y \sim N(\mu_Y + \rho_j\xi^V, \sigma_Y^2)$

For $\xi_t^V$, the posterior is again standard. $p(\xi_t^V|\Delta V_t, Y_T, J = 1...) \propto p(Y_t, \Delta V_t|\xi_t^V, J = 1)p(\xi_t^Y|\xi_t^V,...)p(\xi_T^V)$. Ignoring the constants, this can be written as

$$\propto Exp\left[-\frac{1}{2(1-\rho^2)}\left(\frac{\sigma_V^2 A_t^2 + B_t^2 - 2\rho\sigma_V A_t B_t}{\sigma_V^2 V_{t-1}}\right)\right] Exp\left[-\frac{(\xi_t^Y - \mu_Y - \rho_J\xi_t^V)^2}{2\sigma_Y^2}\right] Exp\left(-\frac{\xi_t^V}{\mu_V}\right)$$

leading to $N(X,Z)$, where $Z = \left(\frac{1}{\sigma_V^2(1-\rho^2)V_{t-1}} + \frac{\rho_J^2}{\sigma_Y^2}\right)^{-1}$ and

$$X = \left(\frac{(V_t - V_{t-1} - \alpha - \beta V_{t-1}) - \rho\sigma_V(Y_t - \mu - \xi_t^Y)}{\sigma_V^2(1-\rho^2)V_{t-1}} + \frac{\rho_J(\xi_t^Y - \mu_Y)}{\sigma_Y^2} - \frac{1}{\mu_V}\right) \times Z$$

When J=0, the drawing of $\xi^V \sim exp(\mu_v)$ which is again the unconditional distribution. The posterior for $\rho_J$ is a Normal distribution with a prior of N(0,4)
$p(\rho_J|\xi_t^Y,...) \propto p(\xi_t^Y|\xi_t^V,...)p(\rho_J)$, which yields N(X,Z)

$$Z = \left(\frac{\sum \xi_{V,t}^2}{\sigma_Y^2} + \frac{1}{4}\right)^{-1} \text{ and } X = \frac{\sum \xi_t^V(\xi_t^Y - \mu_Y)}{\sigma_Y^2} \times Z$$

### A.2. *SV posteriors*

The easiest way to get the posteriors for the SV model is to take the SVCJ expressions and set the missing parameters equal to 0. This yields exactly the same result as conditioning from the beginning. As a word of caution, this holds only for the model at hand and should not be used in general. To verify, the posteriors were properly derived and then compared to the SVCJ formulas when setting the missing parameters equal to 0.

### A.3. *MCMC algorithm*

The MCMC algorithm employed in the paper is as follows.

- Set initial values for all parameters $\tau = (\mu, \alpha, \beta, \omega, \rho_j, \phi, \mu_Y, \mu_V, \sigma_Y^2, \lambda)$ and vector $V_t$, number of iterations M and burn-in period G.

  For iteration $m = 1, ..., M$
- Sample parameters from their respective distributions $\tau = (\mu \sim N, \alpha \sim N, \beta \sim N, \omega \sim IG, \rho_j \sim N, \phi \sim N, \mu_Y \sim N, \mu_V \sim Exp, \sigma_Y^2 \sim IG, \lambda \sim Beta)$, where $m-1$ the values of the previous iteration or the initial values if $m = 1$. Formally, $p(\tau_i^{(m)}|\tau_{-i}^{(m-1)}, V_t^{(m-1)}, \xi_t^{V,(m-1)}, \xi_t^{V,(m-1)}, J_t)$
- Sample jump occurence vector $p(J_t^{(m)}|V_t^{(m-1)}, V_{t-1}^{(m-1)}, ..., \tau^m) \sim Bernoulli$
- Sample return jump size vector $p(\xi_t^{Y,(m)}|V_t^{(m-1)}, V_{t-1}^{(m-1)}, ..., \tau^m) \sim N$
- Sample volatility jump size vector $p(\xi^{V,(m)}|V_t^{(m-1)}, V_{t-1}^{(m-1)}, ..., \tau^m) \sim N$
- Sample volatility vector $p(V_t^{(m)}|V_t^{(m-1)}, V_{t-1}^{(m-1)}, ..., \tau^m)$ with random walk Metropolis Hastings as described above.

## Appendix B. Optimal portfolio weights

### B.1. *The Bellman equation*

A direct application of the n-dimensional Ito's lemma is applied to the wealth process (3) and the volatility process in (1) with an additional jumps term generated. The result is

$$L(F) = (r + \phi EP)WF_W + \kappa(\theta - V)F_V + \frac{1}{2}\phi^2 W^2 V F_{WW} + \frac{1}{2}\sigma_V^2 V F_{VV}$$
$$+\sigma_V \phi W V \rho F_{WV} + \lambda E[F(W(1 + \phi E(\xi^Y)), V + E(\xi^V), t) - F]$$

The last term comes from the Poisson jump term.

The solution to the Bellman equation (5) is to conjecture and then verify that $F(W_t, V_t, t)$ is of a certain form, namely

$$F(W_t, V_t, t) = \frac{W^{1-\gamma}}{1-\gamma} exp(A(t) + B(t)V)$$

where A(t), B(t) depend only upon t but not W and V. Subsitution of (18) into (7) and differentiation with respect to $\phi$ yields $EP \times WF_W + \phi W^2 V J_{WW} + \rho\sigma_V W V J_{WV} + \lambda K = 0$

$$\text{where } K = \frac{\partial F(...)}{\partial \phi} = E(\xi^Y)W^{1-\gamma}(1 + \phi E(\xi^Y)^{\gamma} exp(A(t) + B(t)V + B(t)E(\xi^V))$$

Solving for the optimal portfolio weight $\phi$ yields

$$EP \times W \times W^{-\gamma} exp\big(A(t) + B(t)V\big) - \phi W^2 V \gamma W^{-1-\gamma} exp(A(t) + B(t)V) + \rho\sigma_V W V B(t) W^{-\gamma} \times exp\big(A(t) + B(t)V\big) + \lambda E(\xi^Y) W^{1-\gamma}\big(1 + \phi E(\xi^Y)\big)^{-\gamma} exp\big(A(t) + B(t)V + B(t)E(\xi^V)\big) = 0 \Leftrightarrow$$

$$EP \times W^{1-\gamma} - \phi\gamma V W^{1-\gamma} + \rho\sigma_V W^{1-\gamma} V B(t) + \lambda E(\xi^Y) W^{1-\gamma}(1 - \phi E(\xi^Y))^{-\gamma} exp(B(t)E(\xi^V)) = 0$$
$$\Leftrightarrow EP - V\phi\gamma + \rho\sigma_V V B(t) + \lambda E(\xi^Y)(1 - \phi E(\xi^Y))^{-\gamma} exp(B(t)E(\xi^V)) = 0$$
$$\Leftrightarrow \frac{EP}{\gamma V} + \frac{\rho\sigma_V B(t)}{\gamma} + \frac{\lambda E(\xi^Y)(1 - \phi E(\xi^Y))^{-\gamma}}{\gamma V} exp(B(t)E(\xi^V)) = \phi$$

The final step is to derive the ordinary differential equations for B(t) and A(t) for which the assumed form of the indirect utility function is indeed a solution. In order for that assumption to hold, the solution for $\phi$ needs to validate the Hamilton-Jacobi-Bellman equation and set it equal to zero. After substituting $\phi$ and $F$ into (7), it is possible to eliminate $\frac{W^{1-\gamma}}{1-\gamma} exp(A(t) + VB(t))$ from all terms. This allows us to separate the terms that contain V from those who do not. The general form is thus D+H×V=0 where both D and H need to be 0, or else

$$H = B'(t) - \frac{1}{2}\gamma\phi^2(1-\gamma) + \frac{1}{2}\sigma_V^2 B^2(t) + (\sigma_V \phi\rho(1-\gamma) - \kappa)B(t) = 0$$

and the expression for A(t) is added below for completeness, although it does not affect the system of equations.

$$D = A'(t) + (1-\gamma)(r + \phi EP) + \kappa\theta B(t) + \lambda E\left(\frac{(1+\phi E(\xi^Y))^{1-\gamma}}{1-\gamma} exp(B(t)E(\xi^V)) - 1\right) = 0$$

## B.2. *Differences in solutions between LLP and EJP*

The returns process in LLP is specified in arithmetic terms, the jumps arrival intensity is $\lambda V_t$, the diffusive parts in the returns and volatility processes become $(r + \eta V_t - \mu\lambda V_t)dt$ and $(\alpha' - \beta' V_t - \kappa'\lambda V_t)dt$ respectively and r is the risk-free rate. The new terms are the volatility premium $\eta V_t$, the stochastic arrival intensity of the Poisson process $\lambda V_t$, the returns jump premium $\mu\lambda V_t$ and the volatility jump premium $\kappa'\lambda V_t$ . Arrival intensity is specified as a Cox process of the general form $\lambda = \lambda_0 + \lambda_1 V_t$. Setting $\lambda_0 = 0$ leads to the LLP formulation while setting $\lambda_1 = 0$ leads to the EJP constant rate specification in (1). The LLP solution for $\phi$ is

$$\phi = \frac{\eta - \mu\lambda}{\gamma} + \frac{\rho\sigma_V B(t)}{\gamma} + \frac{\lambda E(\xi^Y)(1-\phi E(\xi^Y))^{-\gamma}}{\gamma} exp(B(t)E(\xi^V)) \quad \text{(B1)}$$

where B(t) solves the differential equation

$$\begin{aligned} &B'(t) - \frac{1}{2}\gamma\phi^2(1-\gamma) + \frac{1}{2}\sigma_V^2 B^2(t) + (\sigma_V\phi\rho(1-\gamma) - \kappa\lambda - \beta)B(t) \\ &+(\eta - \mu\lambda)(1-\gamma)\phi + \lambda E(\xi^Y)(1-\phi E(\xi^Y))^{-\gamma} exp(B(t)E(\xi^V)) = 0 \end{aligned} \quad \text{(B2)}$$

with initial conditions $A(T) = 0$, $B(T) = 0$

The reason for selecting a Cox process for arrival intensity and including the additional premia in the drift is that they allow the time-varying $V_t$ terms to be eliminated from the denominators. $\lambda V_t$ appears as additional factor in the numerators of each fraction, which leads to (B1) and (B2) after eliminating. Expression (B1) for $B(t)$ is not a Riccati equation and can only be solved numerically. However, setting $\lambda_1 = 0$ (or defining the arrival rate as $\lambda$) leads to constant arrival intensity as in EJP. This leads to expression (7) for B(t), which has the form of a Riccati equation (Branger and Hansis (2015)). Although that class of ODEs does have a closed-form solution, $V_t$ can not be eliminated: the absence of the jump premium in the drift prevents $\lambda V_t$ from appearing and the last jumps related term is multiplied by $\lambda$ only. We thus alleviate the issue by using the long-run volatility mean in the place of $V_t$. The final expression is a complicated product of a real and an exponential function, which constitutes a semi-closed form solution and can only be solved numerically. Using (6) and (7) in the numerical solution after substituting the long-run mean is perhaps the most convenient choice.

**Appendix C. Simulated optimal weights for the manager**

Based on the SVCJ parameters, we simulate a sample of 100,000 annual returns and draw $T = 2, 3, 5, 7, 10$ returns with resampling for each simulation. For the first round, a vector of 0-100% weights in 10 percent increments is constructed and, when the simulation finds which weight yields the highest utility, the second round repeats the process in 1 percent increments around the first weight (e.g. if the optimal weight in the first round was 50%, the vector of the second round will contain 21 weights between 40% and 60%). The wealth transfer function is symmetric and the clawback rate is 33% applied over last year's performance fee. The number of simulations in each case is 100,000 and all the definitions and specifications are identical to the main paper.

For $T = 2, 3, 5$ clawbacks lower the optimal weights of the manager considerably and to a greater extent than wealth transfer, while for $T = 7, 10$ the reduction caused by each mechanism is similar. This pattern is observed for all fee structures for $\gamma = 2, 3$. For $\gamma = 5$, clawbacks and wealth transfer have a similar impact on optimal weights for short horizons but wealth transfer reduces weights more for $T = 7, 10$. The optimal weights are virtually the same across all fee structures for $\gamma = 2, 3$ but somewhat lower for $\gamma = 5, T = 7, 10$ and $2 + 20\%$ compared to the respective values for $1 + 10\%$ and $0.4 + 3\%$.

Table C1.: Simulated optimal weights for the manager

Panel A: Fees only, no clawbacks/ wealth transfer

| | 2 + 20% fees | | | | | 1+10% fees | | | | | 0.4+3% fees | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 2 | 3 | 5 | 7 | 10 | 2 | 3 | 5 | 7 | 10 | 2 | 3 | 5 | 7 | 10 |
| $\gamma = 2$ | 108% | 100% | 92% | 84% | 78% | 107% | 102% | 94% | 85% | 80% | 106% | 102% | 89% | 84% | 81% |
| $\gamma = 3$ | 78% | 61% | 64% | 57% | 53% | 75% | 70% | 64% | 57% | 54% | 71% | 68% | 61% | 59% | 53% |
| $\gamma = 5$ | 46% | 44% | 36% | 33% | 27% | 47% | 45% | 37% | 34% | 33% | 45% | 44% | 38% | 35% | 32% |

Panel B: Fees and 33% clawbacks over last year, no wealth transfer

| Years | 2 | 3 | 5 | 7 | 10 | 2 | 3 | 5 | 7 | 10 | 2 | 3 | 5 | 7 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\gamma = 2$ | 83% | 74% | 69% | 66% | 62% | 80% | 73% | 70% | 66% | 63% | 84% | 79% | 77% | 67% | 66% |
| $\gamma = 3$ | 63% | 57% | 53% | 51% | 48% | 62% | 56% | 51% | 49% | 46% | 65% | 59% | 55% | 51% | 50% |
| $\gamma = 5$ | 42% | 36% | 35% | 30% | 26% | 44% | 39% | 34% | 32% | 31% | 44% | 39% | 37% | 34% | 31% |

Panel C: Fees and symmetric wealth transfer, no clawbacks

| Years | 2 | 3 | 5 | 7 | 10 | 2 | 3 | 5 | 7 | 10 | 2 | 3 | 5 | 7 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\gamma = 2$ | 104% | 98% | 89% | 82% | 72% | 100% | 98% | 92% | 78% | 71% | 98% | 95% | 86% | 78% | 68% |
| $\gamma = 3$ | 75% | 68% | 56% | 47% | 46% | 71% | 65% | 56% | 50% | 46% | 74% | 65% | 54% | 49% | 46% |
| $\gamma = 5$ | 42% | 37% | 28% | 24% | 21% | 43% | 38% | 33% | 29% | 28% | 39% | 38% | 33% | 31% | 27% |

Panel D: Fees, 33% clawbacks over last year and symmetric wealth transfer

| Years | 2 | 3 | 5 | 7 | 10 | 2 | 3 | 5 | 7 | 10 | 2 | 3 | 5 | 7 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\gamma = 2$ | 78% | 70% | 66% | 63% | 59% | 77% | 72% | 65% | 64% | 61% | 79% | 77% | 73% | 65% | 62% |
| $\gamma = 3$ | 58% | 51% | 49% | 43% | 42% | 60% | 52% | 50% | 45% | 43% | 63% | 56% | 47% | 45% | 44% |
| $\gamma = 5$ | 36% | 32% | 27% | 23% | 21% | 38% | 35% | 31% | 28% | 25% | 37% | 36% | 32% | 28% | 26% |

**Appendix D. The wealth transfer function**

In this appendix, we justify the features of the wealth transfer function we employ and examine the effect of different upper and lower bounds in wealth movement between funds. Our key aim is to demonstrate further that our main findings are neither calibration or specification artifacts nor governed by parametrisation. The shape and calibration of the wealth transfer function are motivated by Liang et al. (2019), who find an inverted S-shape relationship between hedge fund asset flows and returns. The flow-performance relationship is upwards sloping with a slight curvature at the edges. To formalise this curvature, we apply a sigmoid function; the main difference is that we use relative performance and fund flows, $r_{NJ} - r_J$, rather than absolute. On calibration, Liang et al. (2019) report quarterly equally weighted (EWF) and asset weighted (AWF) fund flows across different investment styles of hedge funds. The AWF means are around 20% and the EWF means are close to 5% annually. We thus select intermediate values of 10% and 15% for the bounds in our paper.

We examine the robustness of our main results under a higher bound in order to verify that the incentive we detect is not eliminated if larger amounts of wealth are allowed to move between funds. We find that if the bound is increased then the incentive becomes stronger rather than weaker, as it manifests over a longer period in time and leads to more pronounced differences between fund utilities. Table D.1 contains the simulation results when the bound is set according to the higher AWF mean at +/-20% under 2+20% fees, $\gamma = 2$, and a symmetric wealth transfer function for 2- to 7-year investment horizons. Panel A refers to the case without clawbacks, similar to Table 7 in the main paper. Panels B and C refer to the cases of a 5-year 20% clawback and a 1-year 33% clawback, respectively, similar to Tables 8 and 9. Without clawbacks, the manager not only always has an incentive to ignore equity market jumps but the difference in average utilities between the No Jumps and the Jumps manager keeps increasing over time. In Panel A, the difference $TFUNJ - TFUJ$ is positive and increases from 0.0612 for a 2-year horizon to 0.1212 for a 7-year horizon, which shows a persistent and increasingly strong incentive. On the contrary, in Table 7 (10% bound) the same difference would gradually decrease between 2 and 7 years where it would turn negative in year 10, showing that the No Jumps manager would lose for such a long investment horizon and thus an elimination of the inventive. Introducing a 20% clawback applied over the previous 5 years, however, removes the incentive for all horizons apart from 2 years. This is in line with Table 8, where the same finding is repeated for a 10% cap. For a 1-year 33% clawback below, the incentive is also greatly eliminated, as it manifests only over a 2-year horizon. For the same case, it is completely removed in Table 9. Our results are equally robust throughout all other specifications, demonstrating that the main bound values of +/10% lead to a relatively conservative managerial incentive, compared to the one appearing under higher values. Higher wealth transfers between funds, therefore, would give rise to a greater motivation to ignore equity market jumps.

Table D1.: Results under a -/+20% wealth transfer bound

| Panel A: No clawbacks | | | | |
|---|---|---|---|---|
| Years | 2 | 3 | 5 | 7 |
| TFJ | 4.6328 | 6.9293 | 11.3600 | 15.7284 |
| TFNJ | **6.1984** | **9.5790** | **16.3005** | **23.7795** |
| TFUJ | -0.9168 | -1.3825 | -2.3458 | -3.3268 |
| TFUNJ | **-0.8556** | **-1.2951** | **-2.2505** | **-3.2056** |
| Panel B: 20% clawbacks over 5 years | | | | |
| TFJ | 4.6228 | 6.8763 | 11.4179 | 15.7399 |
| TFNJ | **6.1395** | **9.2859** | **16.3562** | **23.0790** |
| TFUJ | -0.9212 | **-1.3969** | **-2.3586** | **-3.3930** |
| TFUNJ | **-0.8820** | -1.4476 | -2.9394 | -6.1152 |
| Panel C: 33% clawbacks over 1 year | | | | |
| TFJ | 4.6622 | 6.9203 | 11.3600 | 15.7820 |
| TFNJ | **6.2473** | **9.4165** | **16.0892** | **23.5875** |
| TFUJ | -0.9171 | **-1.3943** | **-2.3644** | **-3.3426** |
| TFUNJ | **-0.9075** | -1.4208 | -2.5545 | -3.5506 |

Note: Indicative results under a symmetric wealth transfer function, 2+20% manager fees, $\gamma = 2$ and an upper (lower) bound of 20% (-20%) at the amount of portfolio wealth transferred from the losing to the winning fund each year in equation (10). Bold denotes the winning manager.