

# Risk-Taking Channel of Monetary Policy: A Global Game Approach\*

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## Abstract

We explore a global game model of the impact of monetary policy shocks. Risk-neutral asset managers interact with risk-averse households in a market with a risky bond and a floating rate money market fund. Asset managers are averse to coming last in the ranking of short-term performance. This friction injects a coordination element in asset managers' portfolio choice that leads to large jumps in risk premiums to small future anticipated changes in central bank policy rates. The size of the asset management sector is the key parameter determining the extent of market disruption to monetary policy shocks.

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# 1 Introduction

Monetary policy announcements sometimes exert an apparently disproportionate impact on market interest rates. The “taper tantrum” in the summer of 2013 is an example of such an episode, when market interest rates jumped following remarks by the Fed Chairman, Ben Bernanke, on the eventual “tapering” of the pace of asset purchases by the Federal Reserve.

The taper tantrum of 2013 is but a recent case of the general phenomenon in which monetary policy shocks are associated with changes in the risk premium inherent in market prices, over and above any change in the actuarially fair long term interest rate implied by the expectations theory of the yield curve. Shiller, Campbell and Schoenholtz (1983) document the early evidence. Hanson and Stein (2012) and Gertler and Karadi (2013) add to the accumulated evidence that monetary policy appears to operate through changes in the risk premium inherent in asset prices, in addition to change in the actuarially fair long-term rate.

The fact that the risk premium fluctuates so much opens up a gap between the theory and practice of monetary policy. Discussions of central bank communication often treat the market as if it were an individual with beliefs. Transparency over the path of future policy rates is seen as a device to guide long term rates, and crucially, such guidance is seen as something amenable to fine-tuning. The term “market expectations” is often used in connection with central bank guidance. Although such a term can serve as a shorthand, it creates the temptation to treat the “market” as a person with coherent beliefs. The temptation is to anthropomorphize the market, and endow it with attributes that it does not have (Shin (2013)).

However, the “market” is not a person. Market prices are outcomes of the interaction of many actors, and not the beliefs of any one actor. Even if prices are the average of individual expectations, average expectations fail even the basic property of the law of iterated expectations. In other words, the average expectation today of the average expectation tomorrow of some variable is not the average expectation today of that variable (Allen, Morris and Shin (2006)).

In this paper, we explore a global game model of the transmission of monetary policy with

heterogenous market participants. Our model has the feature that monetary policy exerts a direct impact on risk premiums through the risk-taking behavior of market participants.

In our model, risk-neutral investors, interpreted as asset managers, interact with risk-averse households in a market for a risky bond. Although the asset managers are motivated by long-term fundamental asset values, there is an element of short-termism generated by the aversion to coming last in short-term performance rankings among asset managers. We interpret the friction as the loss of customer mandates of the asset managers, consistent with the empirical evidence on the sensitivity of fund flows to fund performance. Thus, the “friction” in the model is that relative performance matters for fund managers.

The importance of relative ranking injects spillover effects across asset managers and an endogenous coordination element in their portfolio choice. The cost of coming last generates behavior that has the outward appearance of shifts in preferences. Just as in a game of musical chairs, when others try harder to grab a chair, the more effort must be expended to grab a chair oneself. The ensuing scramble for the relatively safer option of selling the risky bond in favor of the short-term asset leads to a jump in the yield of the risky bond that has the outward appearance of a sudden jump in the risk aversion of the “market”. The global game approach permits the solution of the trigger level of the floating interest rate when the scramble kicks in. Thus, when the central bank signals higher future rates, the impact on asset prices is often abrupt as the risk-taking behavior of market participants undergoes discrete shifts. We dub this channel of the transmission of monetary policy the “risk-taking channel” of monetary policy, following Borio and Zhu (2009) who first coined the term.

The key parameter for the strength of the risk-taking channel is the size of the asset management sector. Quantities thus matter. When the sector is large relative to risk-averse households, risk premiums can be driven very low by signalling low future policy rates. In return, however, the central bank must accept a narrower region of fundamentals when risk premiums can be kept low, and a larger jump in risk premiums when the policy stance changes.

Our results hold several implications for the conduct of monetary policy, but we postpone discussion of the implications until Section 4. We first present the model and the solution.

## 2 Model

There are two groups of investors. First, there is a continuum of risk-neutral investors interpreted as asset managers. Asset managers are indexed by the unit interval  $[0, 1]$ . They are rewarded with a constant fraction of the terminal value of their portfolio holding and consume once only at the terminal date. Asset managers do not discount the future.

Although asset managers care about long-term asset values, they suffer from “last-place aversion” in that they are subject to a penalty (to be described below) if they are ranked last in the value of their short-term portfolio. We interpret this penalty as the loss of customers suffered by the asset manager, as reflected in the empirical evidence on the positive relationship between fund flows and fund performance.

The second group of investors are risk-averse household investors. They do not discount the future, they consume once only at the terminal date, and behave competitively.

All investors form portfolios between two types of assets - a long-term asset and a short-term asset. The long-term asset is a risky zero coupon bond that pays only at the terminal date, but the payoff is risky. The expected payoff at the terminal date is  $v$  with variance  $\sigma^2$ . There is an outstanding amount of  $S$  units of the risky bond.

The short-term asset is a floating rate money market fund or bank account, and is supplied elastically. There is uncertainty over the interest rate ruling over the next interval of time, but investors have precise signals of the interest rate. However, the interest rate is not common knowledge between investors. The information structure will be described more formally below.

### 2.1 Three Period Model

We first examine the benchmark version of our model where has three dates, 0, 1 and 2. The timeline is depicted in Figure 1.

At date 1, asset managers choose how much of the risky bond to hold. Each have one unit of wealth, which they can allocate between the risky bond and the floating rate account. Asset

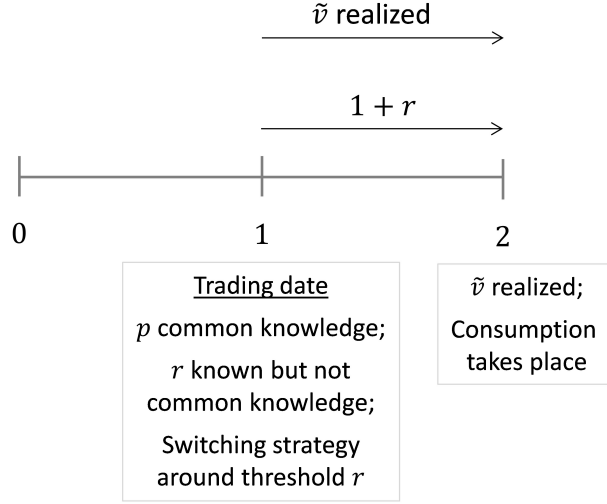


Figure 1. Time line for three period model

managers cannot borrow and cannot take short positions.

The realized value of the risky bond is uncertain, with expected value  $v$ . Investors can earn interest rate  $1 + r$  in the floating rate money market account between date 1 and date 2. The price of the risky bond  $p$  is determined by market clearing.

Households have mean-variance preferences, and at date 1, they submit a competitive demand curve for the risky bond. Household  $h$  has utility function:

$$U_h = vy - \frac{1}{2\tau_h}y^2\sigma^2 + (e - py) \quad (1)$$

where  $y$  is the risky bond holding of the household,  $e$  is the endowment and  $\tau$  is risk tolerance. We assume that the endowment  $e$  is large enough that the first-order condition determines the optimal portfolio. From the first-order condition with respect to  $y$  and summing across households, the aggregate demand for the risky bond for the household sector is

$$\begin{aligned} p &= v - \frac{\sigma^2}{\sum_h \tau_h}y \\ &= v - cy \end{aligned} \quad (2)$$

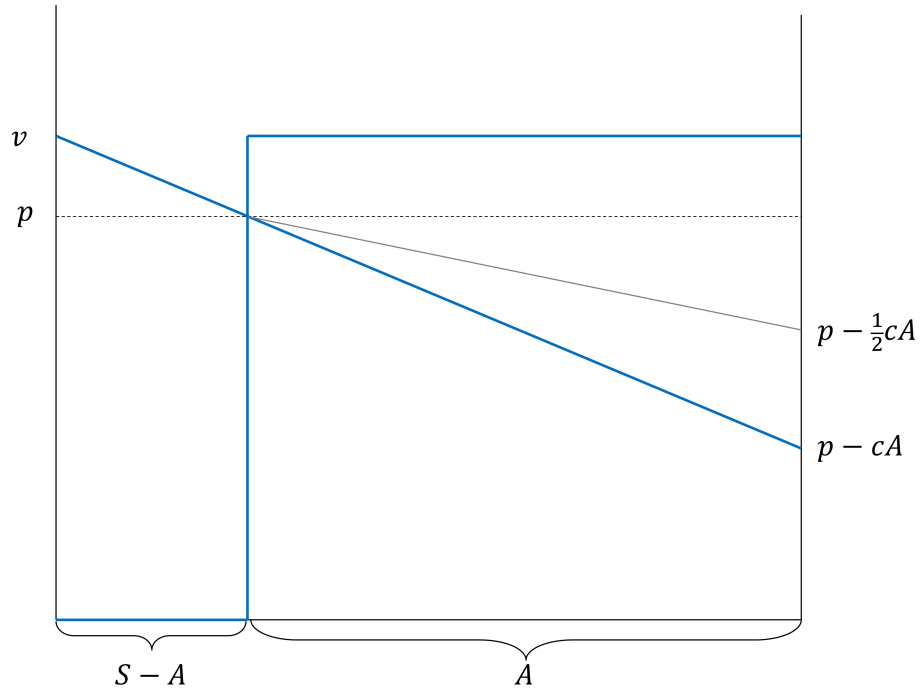


Figure 2. Market Clearing of the long asset. The price of the long asset at date 1 is  $p$ . Asset managers hold  $A$  units and households hold  $S - A$  units.

where  $c$  is the positive constant defined as  $c = \sigma^2 / \sum_h \tau_h$ , and  $\sum_h \tau_h$  is the aggregate risk tolerance for the household sector as a whole.

Figure 2 shows the determination of the price  $p$  of the risky bond from market clearing. Asset managers hold  $A$  units of the bond, where  $A$  is exogenous for now. Households hold the remainder  $S - A$ . The price  $p$  and the resulting risk premium  $v/p$  clears the market by rewarding households for bearing risk.

Although asset managers consume once at the terminal date (date 2), they suffer from last place aversion.<sup>1</sup> We assume that there is a penalty suffered by any asset manager whose portfolio value is ranked last at date 1. The penalty is in the form of a decline in the asset manager's

<sup>1</sup>The term “last place aversion” is taken from Buell, et al. (2013) who have used the concept in the very different context of the welfare economics of social deprivation.

funds under management, interpreted as withdrawals by their customers.<sup>2</sup>

In particular, if any asset manager is ranked last (or equal last) at date 1, and proportion  $x$  of asset managers has a strictly higher portfolio values, then the asset manager's funds under management declines by a factor of  $\phi x$ , where  $\phi$  is a positive constant strictly between 0 and 1. In other words, if the asset manager initially holds 1 dollar of funds under management, but comes last, and proportion  $x$  of fund managers has strictly higher portfolio value, then the asset manager's funds under management shrinks to:

$$1 - \phi x \tag{3}$$

At date 1, asset managers allocate their funds under management between the risky bond and the floating rate account. The asset managers initially start with a holding of  $A$  units of the risky bond. If they choose to hold the bond, each unit of the bond yields expected payoff of  $v$ .

If the asset manager decides to sell the risky bond, their sell order is executed simultaneously with the other asset managers who have decided to sell. The aggregate sale of the risky security is matched with the competitive demand curve of the household investors,<sup>2</sup> and each seller is matched with household buyers.

If proportion  $x$  of the asset managers decide to sell their risky bond holding, the total supply of the risky bond is  $xA$ , and each seller has equal chance of placed in the queue  $[0, x]$  for order execution. Therefore, if  $x$  asset managers sell the risky bond, the expected revenue from sale of one unit is

$$p - \frac{1}{2}cx \tag{4}$$

Figure 2 depicts the expected revenue curve  $p - \frac{1}{2}cx$ , whose slope is half of the competitive demand curve  $p - cx$ .

Given the last place aversion of the asset managers, the expected payoff from holding the

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<sup>2</sup>Chen, Goldstein and Jiang (2010) present evidence that there are strategic complementarities among investors in mutual because of the costs generated by fund redemptions. Our model requires strategic complementarities among fund managers.

risky bond when proportion  $x$  sell the risky bond is

$$u(x) = v(1 - \phi x) \tag{5}$$

Although the asset manager is risk-neutral and has a long horizon, the short-term friction from last place aversion generates element of short-termism.

If the asset manager sells the risky bond at date 1, the proceeds of the sale are put into the floating rate account, where it earns interest rate  $r$ . Hence, the expected payoff of the asset manager from selling the risky bond when proportion  $x$  sell is given by

$$w(x) = (1 + r) \left( p - \frac{1}{2}cx \right) \tag{6}$$

Figure 3 plots the payoffs from the two strategies as a function of  $x$ , the proportion of asset managers who sell. The payoff difference  $u(x) - w(x)$  is indicated by the shaded region. The payoff functions  $u(x)$  and  $w(x)$  are linear in  $x$ , and the payoff difference  $u(x) - w(x)$  is monotonic in  $x$ . If either  $u(x) - w(x)$  is positive for all  $x$ , or negative for all  $x$ , then the problem is trivial as asset managers have dominant actions. Therefore, in what follows, we focus on the case when  $u(x) - w(x)$  crosses the horizontal axis at some point.

## 2.2 Global Game

The floating rate  $r$  ruling between date 1 and date 2 is uncertain, but investors have good information about it. At date 1, asset manager  $i$  observes signal  $\rho_i$  of the true interest rate  $r$  given by

$$\rho_i = r + s_i \tag{7}$$

where  $s_i$  is a uniformly distributed noise term, with realization in  $[-\varepsilon, \varepsilon]$  for small positive constant  $\varepsilon$ . The noise terms  $\{s_i\}$  are independent across asset managers. We further assume that the ex ante distribution of  $r$  is uniform. The assumption that  $r$  and the noise term  $s_i$  are uniformly distributed is for expositional simplicity only. The solution to be obtained below holds under general conditions on the ex ante distribution of  $r$  and the noise structure (Morris and Shin (2003, section 2)).



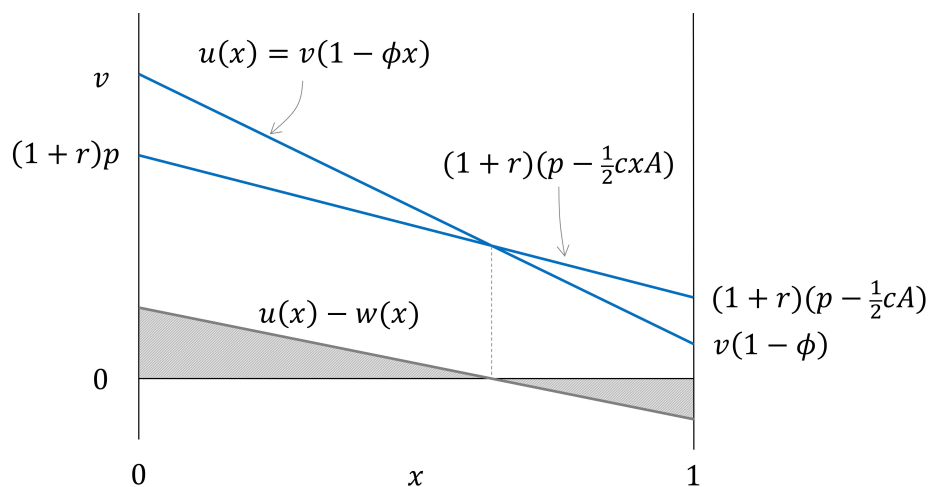


Figure 3. Payoff functions from holding long-dated security and switching to floating rate

Based on their respective signals, asset managers decide whether to hold the risky bond or sell it. Since asset managers are risk-neutral, it is without loss of generality to consider the binary choice of “hold” or “sell”. A *strategy* for an asset manager is a mapping:

$$\rho_i \mapsto \{\text{Hold, Sell}\} \quad (8)$$

A collection of strategies (one for each asset manager) is an *equilibrium* if the action prescribed by  $i$ 's strategy maximizes  $i$ 's expected payoff at every realization of signal  $\rho_i$  given others' strategies.

As the first step in the solution, consider switching strategies of the form

$$\begin{cases} \text{Sell} & \text{if } \rho > \rho^* \\ \text{Hold} & \text{if } \rho \leq \rho^* \end{cases} \quad (9)$$

for some threshold value  $\rho^*$ . We first solve for equilibrium in switching strategies. We search for threshold point  $\rho^*$  such that every asset manager using the same switching strategy around  $\rho^*$ . We appeal to the following result in global games. Recall that  $x$  is our notation for the proportion of investors who sell.

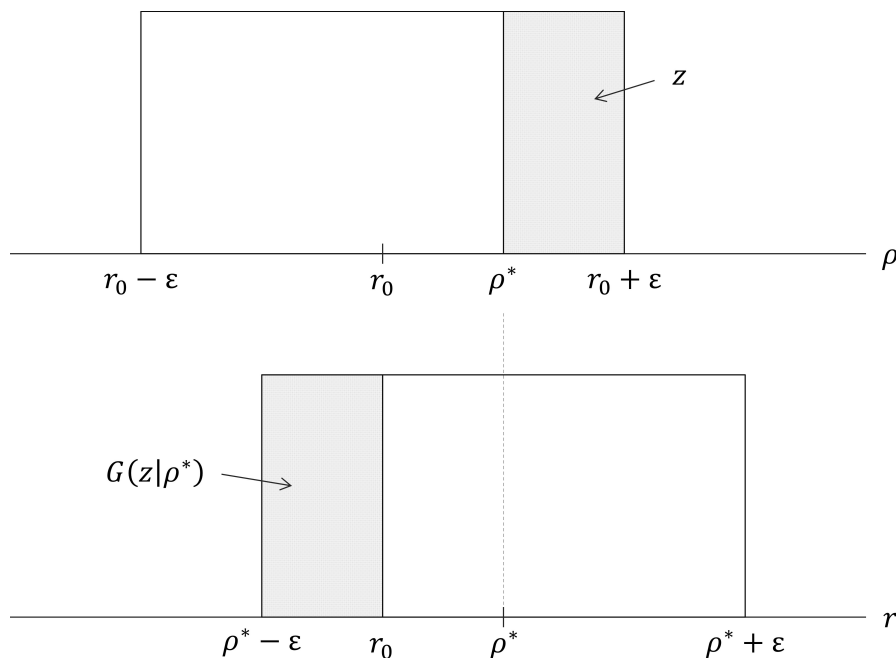


Figure 4. Deriving the subjective distribution over  $x$  at switching point  $\rho^*$

**Lemma 1** *Suppose that investors follow the switching strategy around  $\rho^*$ . Then, in the limit as  $\varepsilon \rightarrow 0$ , the density of  $x$  conditional on  $\rho^*$  is uniform over the unit interval  $[0, 1]$ .*

To make the discussion in our paper self-contained, we present the proof of Lemma 1. For economy of argument we show the proof only for the case of uniformly distributed  $r$  and uniform noise. However, this result is quite general, and does not depend on the assumption of uniform density over  $r$  and uniform noise (Morris and Shin (2003, Section 2)).

The distribution of  $x$  conditional on  $\rho^*$  can be derived from the answer to the following question:

“My signal is  $\rho^*$ . What is the probability that  $x$  is less than  $z$ ?” (Q)

The answer to question (Q) gives the cumulative distribution function of  $x$  evaluated at  $z$ , which we denote by  $G(z|\rho^*)$ . The density over  $x$  is then obtained by differentiating  $G(z|\rho^*)$ . The steps to answering question (Q) are illustrated in Figure 4.

When the true interest rate is  $r$ , the signals  $\{\rho_i\}$  are distributed uniformly over the interval  $[r - \varepsilon, r + \varepsilon]$ . Investors with signals  $\rho_i > \rho^*$  are those who sell. Hence,

$$x = \frac{r + \varepsilon - \rho^*}{2\varepsilon} \quad (10)$$

When do we have  $x < z$ ? This happens when  $r$  is low enough, so that the area under the density to the right of  $\rho^*$  is squeezed. There is a value of  $r$  at which  $x$  is precisely  $z$ . This is when  $r = r_0$ , where

$$\frac{r_0 + \varepsilon - \rho^*}{2\varepsilon} = z \quad (11)$$

or

$$r_0 = \rho^* - \varepsilon + 2\varepsilon z \quad (12)$$

See the top panel of Figure 4. We have  $x < z$  if and only if  $r < r_0$ . We need the probability of  $r < r_0$  conditional on  $\rho^*$ .

For this, we must turn to player  $i$ 's posterior density over  $r$  conditional on  $\rho^*$ . This posterior density is uniform over the interval  $[\rho^* - \varepsilon, \rho^* + \varepsilon]$ , as in the lower panel of Figure 4. This is because the ex ante distribution over  $r$  is uniform and the noise is uniformly distributed around  $r$ . The probability that  $r < r_0$  is then the area under the density to the left of  $r_0$ , which is

$$\begin{aligned} & \frac{r_0 - (\rho^* - \varepsilon)}{2\varepsilon} \\ = & \frac{(\rho^* - \varepsilon + 2\varepsilon z) - (\rho^* - \varepsilon)}{2\varepsilon} \\ = & z \end{aligned} \quad (13)$$

where the second line follows from substituting in (12). Thus, the probability that  $x < z$  conditional on  $\rho^*$  is exactly  $z$ . The conditional c.d.f.  $G(z|\rho^*)$  is the identity function:

$$G(z|\rho^*) = z \quad (14)$$

The density over  $x$  is thus uniform. Finally, note that the uniform density over  $x$  does not depend on the value of  $\varepsilon$ . For any sequence  $(\varepsilon_n)$  where  $\varepsilon_n \rightarrow 0$ , the density over  $x$  is uniform. This proves Lemma 1.

In the limit as  $\varepsilon \rightarrow 0$ , every investor's signal converges to the true interest rate  $r$ . Thus, fundamental uncertainty disappears, and it is without loss of generality to write the investor's strategy as being conditional on the true interest rate  $r$ . Thus, we search for an equilibrium in switching strategies of the form:

$$\begin{cases} \text{Sell} & \text{if } r > r^* \\ \text{Hold} & \text{if } r \leq r^* \end{cases} \quad (15)$$

Figure 4 reveals the intuition for Lemma 1. As  $\varepsilon$  shrinks, the dispersion of signals shrinks with it, but so does the support of the posterior density over  $r$ . The region on the top panel corresponding to  $z$  is the mirror image of the region on the bottom panel corresponding to  $G(z|\rho^*)$ . Changing  $\varepsilon$  stretches or squeezes these regions, but it does not alter the fact that the two regions are equal in size. This identity is the key to the result. The uniform density over  $x$  has been dubbed ‘‘Laplacian beliefs’’ by Morris and Shin (2003), and entails that the strategic uncertainty faced by players in the global game is at its maximum, even when the fundamental uncertainty faced by players shrinks to zero.

### 2.3 Solution

Given Laplacian beliefs, the switching point  $r^*$  is the interest rate that makes each asset manager indifferent between holding and selling. That is,  $\rho^*$  satisfies

$$\int_0^1 [u(s; r^*) - w(s; r^*)] ds = 0 \quad (16)$$

However, since  $u(\cdot)$  and  $w(\cdot)$  are both linear functions of  $x$ , the switching point  $r^*$  can be obtained by solving:

$$u\left(\frac{1}{2}\right) = w\left(\frac{1}{2}\right) \quad (17)$$

which can be written as:

$$v\left(1 - \phi \cdot \frac{1}{2}\right) = (1 + r^*)\left(p - \frac{1}{2}c \cdot \frac{1}{2}A\right) \quad (18)$$

Therefore, the threshold interest rate  $r^*$  is given by

$$1 + r^* = \frac{v(1 - \phi/2)}{p - \frac{1}{4}cA} \quad (19)$$

$$= \frac{v(1 - \phi/2)}{v - cS + \frac{3}{4}cA} \quad (20)$$

It remains to verify that when asset managers strictly prefer to sell when  $r > r^*$ , and strictly prefer to hold when  $r < r^*$ . Both propositions follow from the monotonicity of the payoff difference  $u(x) - w(x)$ . We have  $u(x) > w(x)$  to the left of  $r^*$  and  $u(x) < w(x)$  to the right of  $r^*$ . The switching strategy around  $r^*$  is an equilibrium, and the only switching equilibrium.

The monotonicity of the payoff difference  $u(x) - w(x)$  entails that the switching strategy around  $r^*$  is the unique dominance solvable equilibrium in the sense that it is the only equilibrium that survives the iterated deletion of strictly dominated strategies (Morris and Shin (2003, Section 2)). Therefore, the solution given by (20) is the complete solution in that there is no other equilibrium - whether in switching strategies, or in any other strategies. We summarize the solution as follows.

**Proposition 2** *There is a unique, dominance solvable equilibrium. In this equilibrium, all asset managers use the switching strategy around  $r^*$  defined by (20) and sell the risky bond when  $r > r^*$  and hold when  $r \leq r^*$ .*

We note some properties of the solution. First, the threshold interest rate  $r^*$  is decreasing in  $\phi$ . Thus, the worse is the last-place aversion of the asset managers, the more jittery they become and the lower is the interest rate at which they jump from holding the risky bond to selling out.

Perhaps more important is the effect of changes in  $A$ , the size of the asset management sector. When the asset management sector is large relative to the household investors, the price impact of concerted sales is large. The strategic interaction between asset managers is thus heightened. To use our analogy with the musical chairs game, a larger asset management sector means that the musical chairs game becomes more competitive. There is more at stake

in coming last in the game, so that asset managers are willing to jump ship at a lower threshold interest rate.

The impact of the asset management sector can be seen in several features of our solution. From Figure 2 above which illustrates the market clearing condition, the larger is  $A$  relative to the total stock  $S$ , the higher is the market price  $p$ . Thus, as  $A$  increases, the risk premium of the risky bond becomes more compressed. The risk premium when the size of the asset management sector is  $A$  is given by

$$\frac{v}{p} = \frac{v}{v - c(S - A)} \quad (21)$$

which is decreasing in  $A$ . Thus, a large asset management sector can be used by the central bank to keep the risk premium compressed.

However, there is a tradeoff that comes from the larger asset management sector. We see from our solution for the threshold interest rate  $r^*$  in (20) that the threshold interest rate is also decreasing in  $A$ . This means that the economy will jump to the high risk premium regime at a lower value of interest rates.

Figure 5 illustrates the effect of a larger asset management sector. Large  $A$  entails a lower risk premium in the low risk premium regime, but the jump to the high risk premium regime happens at a lower level of the interest rate. Thus, when the risk premium jumps at the trigger point, the jump will be larger.

Turning the comparison around, for any given interest rate  $r$ , there is an upper bound to the size of the asset management sector that is consistent with the low risk premium regime. From the expression for the critical threshold  $r^*$  given by (20), for the economy to be in the low risk premium regime, we need:

$$1 + r < 1 + r^* = \frac{v(1 - \phi/2)}{v - cS + \frac{3}{4}cA} \quad (22)$$

This gives us an upper bound for  $A$  for the low risk premium regime, namely:

$$A < \frac{4}{3c} \left( \frac{v(1 - \phi/2)}{1 + r} - v + cS \right) \quad (23)$$

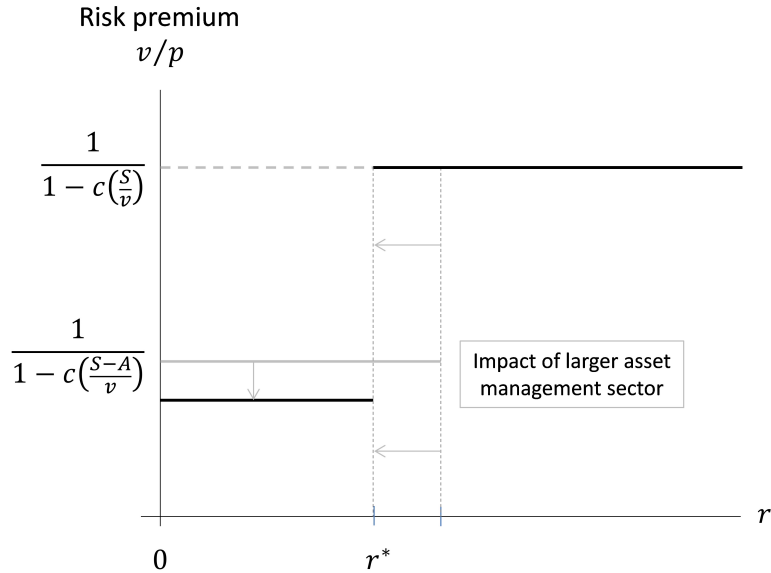


Figure 5. Risk premium and critical threshold  $r^*$  as a function of the size of asset management sector

So far, we have assumed that  $A$  is exogenous. However, if we suppose that  $A$  is growing in the low risk premium regime, then (23) represents the relationship between the feasible size of the asset management sector and the interest rate  $r$ . As  $A$  grows, the central bank can maintain low risk premiums by keeping the interest rate low. However, once the bound is reached, the central bank must reduce interest rates further in order to accommodate the growth in  $A$ . During this process, the risk premium continues to become compressed.

However, by accommodating further increases in  $A$ , the central bank is backing itself into a corner, as shown in Figure 5. The risk premium gets compressed as  $A$  grows, but the threshold point moves down. When, eventually, the central bank has to reverse course and raise interest rates, the jump will happen at a lower interest rate, and the jump in risk premium will be that much larger.

## 2.4 Multi-Period Model

We now consider a multi-period version of our model that is in the same spirit as our benchmark three period model. Time indexed by  $\{0, 1, 2, \dots, T, T + 1\}$ , where date  $T + 1$  is the terminal date, interpreted as the “long run”. We have the same two groups of investors - risk-neutral asset managers, and risk-averse households with mean-variance preferences. Investors do not discount the future, and everyone consumes only at date  $T + 1$ , the “long run”. The risky asset is a zero coupon bond that pays off at the terminal date, and the expected payout is  $v$ , as before. There is late resolution of uncertainty in that the uncertainty in the payout of the risky bond is resolved only between date  $T$  and  $T + 1$ . This assumption of the late resolution of uncertainty means that at the trading dates between date 1 and date  $T$ , the competitive demand curve of the household sector remains unchanged.

We will assume that managers decisions about how to allocate funds  $A_t$  between the risky bond and the safe asset operate as in the earlier model, where managers care about long run returns but also care about relative performance via last place aversion. This assumption is motivated by (unmodelled) process by which investor move funds between managers according to relative performance. However, the quantity of funds  $A_t$  available to managers will depend not on relative performance but on absolute returns in the sector. We will assume that maony moves slowly, with investors responding only to the long run. Since they are risk neutral, they will enter if the long run expected return from the asset exceeds the expected return to holding the short asset. In each period, we assume that the stock of managed funds partially adjusts from its current level to the level that would equate returns in the two markets.

Formally, write  $R_t$  for the expected total return of the short asset at date  $t$  until maturity:

$$R_t = (1 + r_t) E_t [(1 + r_{t+1}) \cdots (1 + r_T)]$$

Now if the supply of risk-neutral investors was elastic, the price  $p_t$  of the risky bond in period  $t$  would solve

$$\frac{v}{p_t} = R_t.$$



But we denote by  $A_t$  the holding of the risky bond by the asset management sector at date  $t$ . If proportion  $1 - x_t$  of risk-neutral managers are invested in the risky bond and proportion  $x_t$  are invested in the short asset, then the period  $t$  price of the asset solves

$$\begin{aligned} p_t &= v - c(S - A_t(1 - x_t)) \\ &= v - c(S - A_t) + cA_t x_t \end{aligned}$$

Now there exists a "capacity" of the market  $A_t^*$  which represents the amount of money which would drive risk premium down to zero if it was all invested in the risky bond, so that it solves

$$\frac{v}{v - c(S - A_t^*)} = R_t.$$

We assume that money enters the managed sector slowly based on how far the market is from capacity. In particular, we let

$$\begin{aligned} A_{t+1} &= A_t + \lambda(A_t^* - A_t) \\ &= \lambda A_t^* + (1 - \lambda)A_t \end{aligned}$$

for some  $\lambda > 0$ . Now the change in price from period  $t$  to period  $t + 1$  is given by

$$\begin{aligned} p_{t+1} - p_t &= (v - c(S - A_{t+1}(1 - x_{t+1}))) - (v - c(S - A_t(1 - x_t))) \\ &= c(A_{t+1}(1 - x_{t+1}) - A_t(1 - x_t)) \\ &= c((\lambda A_t^* + (1 - \lambda)A_t)(1 - x_{t+1}) - A_t(1 - x_t)) \\ &= c(\lambda A_t^* + (1 - \lambda)A_t - A_t + A_t x_t - (\lambda A_t^* + (1 - \lambda)A_t)x_{t+1}) \\ &= c(\lambda(A_t^* - A_t) + A_t x_t - (\lambda A_t^* + (1 - \lambda)A_t)x_{t+1}) \end{aligned}$$

Note that the prices goes up only if

$$x_{t+1} \leq 1 - \frac{A_t}{\lambda A_t^* + (1 - \lambda)A_t} (1 - x_t)$$

Now we assume that in each period, money managers play essentially the game described in the previous section. As in the static model, we assume that the expected price at which

trades are executed is

$$\begin{aligned} & \frac{1}{2}(p_t + p_{t+1}) \\ &= p_t + \frac{1}{2}c(\lambda(A_t^* - A_t) + A_t x_t - (\lambda A_t^* + (1 - \lambda)A_t)x_{t+1}) \end{aligned}$$

Managers care about the (long run) return to investors as well as their last place aversion. The long run value to being in the risky bond is always  $v$  while the long run value of being in the short market is

$$\frac{1}{2}(p_t + p_{t+1})R_t.$$

In addition, managers have last place aversion. Thus if the price of the risky bond declines but they end up in the risky bond, they get a loss aversion term  $\phi v x_{t+1}$ . But if the price of the risky bond increases and they are not holding the risk bond, they get a loss aversion term  $\phi v (1 - x_{t+1})$ . Thus the total payoff to holding the asset if proportion  $x_{t+1}$  are out of the risk bond market is

$$u_t(x_{t+1}) = \begin{cases} v - v\phi x_{t+1}, & \text{if } p_{t+1} < p_t \\ v, & \text{if } p_{t+1} > p_t \end{cases}$$

On the other hand, the payoff to being out of the bond market is

$$w_t(x_{t+1}) = \begin{cases} (p_t + \frac{1}{2}c(\lambda(A_t^* - A_t) + A_t x_t - (\lambda A_t^* + (1 - \lambda)A_t)x_{t+1}))R_t, & \text{if } p_{t+1} < p_t \\ (p_t + \frac{1}{2}c(\lambda(A_t^* - A_t) + A_t x_t - (\lambda A_t^* + (1 - \lambda)A_t)x_{t+1}))R_t - v\phi(1 - x_{t+1}), & \text{if } p_{t+1} > p_t \end{cases}$$

Applying the same methods we applied in the three period model, one can show that the threshold total return above which investors will all move into the short run asset is given by

$$R_t = \frac{v \left( 1 - \phi \left( \frac{1}{2} + \left( 1 - \frac{A_t}{\lambda A_t^* + (1 - \lambda)A_t} \right) \left( 1 - \frac{1}{2} \frac{A_t}{\lambda A_t^* + (1 - \lambda)A_t} \right) \right) \right)}{p_t + \frac{1}{2}c \left( \frac{1}{2} \lambda A_t^* - \frac{1}{2} (1 + \lambda) A_t + A_t x_t \right)}$$

To interpret this, note that when  $A_t = A_t^*$  and  $x_t = 0$ , this reduces to the expression in the previous section. Also observe that this expression is decreasing in  $x_t$ . This is because the more money managers who start out in short run asset, the less likely there is to be a gain to exiting the risky asset. This means that there will be tendency for the market to bounce back after a shock. If we start with a high risk premium, investors will gradually be attracted and

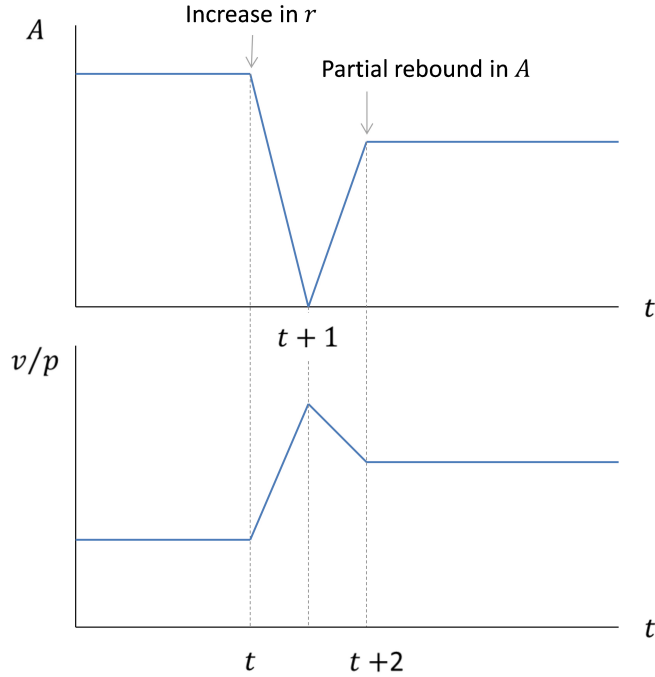


Figure 6. Persistent impact of increase in interest rate above threshold  $r^*$

the risk premium will drop. As the risk premium approaches 0, there will be more tendency for shocks to lead to a market drop. The full solution entails solving out for the prices recursively backwards from date  $T + 1$  in terms of the fundamentals. When the realized floating rate is above the threshold rate  $r_t^*$ , there is a sell-off of the risky bond at date  $t$ , but the asset managers buy back the risky bond at date  $t + 1$ . The typical time path of asset manager holdings and the risk premium following the triggering of the jump of yield will be as in Figure 6. Interest rate shocks then have persistent impact. Even when the asset managers buy back the risky bond at  $t + 1$ , the feasible size of the asset management sector is smaller at the higher interest rate  $r$ , so that the risk premium does not revert back to its previously low level.

### 3 Implications for monetary policy

Monetary policy is a powerful tool for influencing financial conditions. In particular, the commitment to lower interest rates into the future raises the prices of financial assets and compress risk premiums, with consequences for real economic activity. In this respect, our analysis shares the conclusions from orthodox monetary analyses on the impact of forward guidance, and especially on the commitment to lower policy rates into the future (see, for instance, Woodford (2012) for a forceful statement of this argument).

However, our analysis parts company with orthodox monetary analysis on whether forward guidance and commitment to future rates is a policy that can be fine-tuned, or be reversed smoothly when the time comes to change tack. The “market” is not a person, and market prices need not correspond to the beliefs of that person. In our global game analysis, monetary policy works through the “risk-taking channel” through the risk-taking behavior of different sections of the market. Monetary policy affects risk premiums directly, so that the impact on real economic activity flows through shifts in risk premiums, as well as shifts in the actuarially fair long term rates.

One lesson from our analysis is that quantities matter. The size of the asset management sector, as encapsulated by the holding of risky bonds  $A_t$ , determines the risk premium ruling at date  $t$ , as well as the threshold point for the floating interest rate  $r_t$  when a sell-off occurs. To the extent that quantities matter, the lesson is similar to the one from the 2008 financial crisis. Just as we would be concerned with a build-up of leverage and in the size of bank balance sheets, we should similarly be interested in the growth of holdings of fixed income securities of buy-side investors. The central bank can compress risk premiums further by committing to low future interest rates, and accommodating an increase in the size of the asset management sector. However, there is a trade off. By accommodating further growth of the asset management sector, the central bank is trading off a lower risk premium today for a more disruptive unwinding at a lower threshold interest rates when, eventually, the central bank has to reverse course.

On the empirical front, our model suggests that observing the joint movements of price

changes and quantity changes is informative about the risk-taking of market participants. In particular, the model predicts the joint occurrence of price declines and sales of the risky bond. Thus, rather than the demand response being to cushion shocks, the demand response tends to amplify shocks.

Feroli, Greenlaw, Kashyap, Schoenholtz and Shin (2014) find in their VAR analysis of price and valuation changes for risky fixed income categories (such as mortgage backed securities, corporate bonds and for emerging market bonds) that price declines are followed by sales, and sales are followed by further price declines. In this way, the accumulated impulse responses of price and quantity shocks are large.

An implication for the conduct of monetary policy is that the separation between monetary policy and policies toward financial stability is much harder to accomplish than is often suggested. Under the risk-taking channel, monetary policy impacts the economy through shifts in the risk-taking behavior of market participants. As such, any monetary policy shock is also a shock to risk-taking and hence is inseparable from the concern for financial stability.

Discussions of financial stability after the crisis have been conditioned by the experience of the crisis itself. Thus, having neglected the dangers of excessive leverage and maturity mismatch before the crisis, policy makers have given them central importance since the crisis. As is often the case, accountability exercises usually address known past weaknesses, rather than asking where the new dangers are.

However, our analysis suggests that the risk-taking channel may operate through financial institutions that are not leveraged. Asset managers typically have very low effective leverage, and hence do not become insolvent in the way that banks or highly leveraged hedge funds do. However, this does not mean that they do not have an impact on the economy. As the protagonists in financial market dynamics shift from banks to asset managers, more attention is needed on the part of researchers on the market-wide impact of institutional investors. Vayanos and Woolley (2013) show how momentum and reversals result from small agency frictions, even with long-only investors.

The risk-taking channel of monetary policy affects risk premiums directly, with effects on

corporate investment and household consumption. These shocks could have a direct impact on GDP growth through subdued investment and consumption. The potential real economy impact is real, even though no institutions fail, and no financial institutions are bailed out using public funds. Asset managers are not “systemic” in the sense defined in the Dodd-Frank Act as they are not “too-big-to-fail” (TBTF). Nor are there easy regulatory solutions that would substitute for central bank interest rate policy in affecting risk-taking.

Thus, the most important implication of our analysis is that monetary policy and policies toward financial stability cannot be separated. They are, effectively, the same thing.

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