Can central bankers make mistakes?

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Abstract

This paper examines central bankers who might consider a different monetary policy than the generally accepted price stability mandate given to them. In a setting where a global crisis hits, central bankers' differences in types may thus lead to extravagant inflation.

A neoclassical macroeconomic model is used to derive the expectations of private agents, but central bankers are allowed to deviate spectacularly from the predominant Taylor rule-like based monetary policy. A game theoretic analysis shows that unless a central banker is extremely radical (not accepting conventional economic wisdoms) or mistakes his type for inflation inaverse with a large probability, the interest rate setting across borders appears to be coordinated.

The paper analyzes a one period dynamic game of incomplete information between two players, where no prior information is available in dealing with a crisis. Nor is the model pinned against any real-world data.

1 Introduction

The past year and a half has seen turmoil in the financial markets, which appears to be spilling over into the real economy. What have bankers, i.e. central bankers and executives of major financial institutions appeared to do? They have simply tried to cull the turmoil by increasing liquidity, that is, by increasing/making it easier to obtain credit in the financial markets. Recently, we have seen coordinated interest rate cuts[1]. The reason we have seen these **coordinated** moves is that there is implicit (and explicit) knowledge that central bankers are inflation averse.

What do we see in television broadcasts? A man in a gray suit standing behind a podium - what he tries to do is exactly to influence expectations, correcting the public in their assessment if they are wrong, or ensuring them that they believed correctly.

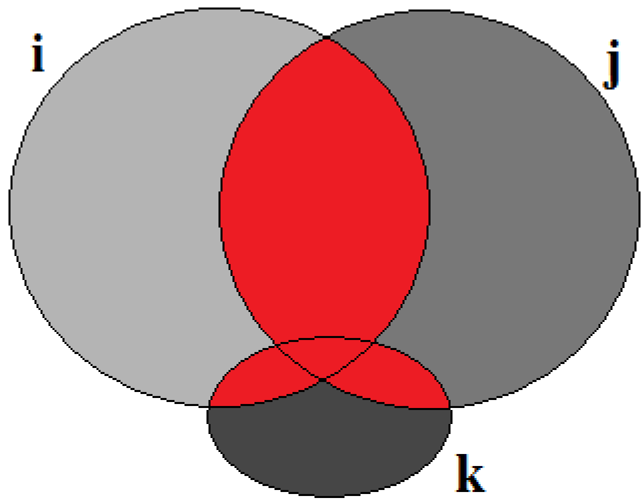
Most recent research focuses on time-consistency problems and the inherent inflation bias of monetary policy. Reputational analyses such as in the seminal paper by Barro and Gordon (1983), multi-period model analyses dominate. Prast (1996) presents an excellent survey of the literature available upto the turn of the millennium. Her main conclusion is that monetary policy institutions have been given too much autonomy. This paper does not follow in her line of criticism of the basic macromodel, but accepts the model, albeit partially. It is fair to say that this paper is more like that of Canzoneri and Gray (1985), though as explained later, drops the microfoundations.

We abstain from analyzing the current tumultous situation, and resolve ourselves to a theoretical world where we do not see the current correction. We therefore believe that capital/credit markets are perfect; for our concern, borrowing and (cross-border) transfer is transfer-cost free. Our model, unlike some classical and recent studies, focuses on interest rate changes across national borders, and is a one-period model. One may think of it as a gathering of central bankers at a conference, each one forced to **write** their new interest rates on a piece of paper to be read up simultaneously by the chairperson at the conference. These central bankers are from the "world" shown in figure 1.

How does this paper differ from the vast literature on this subject? This paper treats central bankers as individuals capable of influencing the real economy even through rash unilateral decisions. Most treat bankers as representatives of private agents ||insert reference here||. Moreover, microfoundations of the economy are not studied, a welfare, or rather social loss minimization function is simply accepted as the central banks mandate. Also, we assume that the central bank is politically autonomous, free from government intervention. However, its role as *market-maker of last resort* is paramount to its ability in dealing with shocks (we

[1] See, the New York times. http://www.nytimes.com/2008/10/09/business/09fed.html

Figure 1: The world modelled



do not explore this role).

Two games will be considered, both standard extensive games of imperfect information. They will be dubbed Γ_E and Γ_ϵ, with Γ_ϵ a particular perturbation of game Γ_E. Reputational effects are not considered, and neither will the model be upheld against real-world data.

2 The model

We consider a dynamic extensive game of private information. The type of the central banker casts doubt on monetary policy. Therefore, we consider monetary policy to be discretionary. The particular macro model we wish to study is the following

$$\min\ SL = (y_t - y^*)^2 + \kappa \cdot (\pi_t - \pi^*)^2 + \psi \cdot (r_t - \bar{r})^2 \tag{1}$$

$$\text{s.t. } \pi_t = \pi^e + \gamma \cdot (y_t - \bar{y}) \tag{2}$$

$$y^* = \bar{y} + \omega \tag{3}$$

$$r_t = \bar{r} + h \cdot (\pi^e - \pi^*) + b \cdot (y_t - \bar{y}) + \nu_{i,j} \cdot \Delta r^{j,e_i} + \nu_{i,k} \cdot \Delta r^{k,e_i} \tag{4}$$

which we solve to arrive at the *expectations dependent solution*

$$\pi_t = \upsilon_1 + \upsilon_2 \cdot \pi^* - \upsilon_3 \cdot \nu_{i,j} \Delta r^{j,e_i} - \upsilon_3 \cdot \nu_{i,k} \Delta r^{k,e_i}. \tag{5}$$

Assuming correct expectations, that is, assuming

$$\Delta r^{j,e_i} = \Delta r^j \text{ and } \Delta r^{k,e_i} = \Delta r^k \tag{6}$$

we conclude that

$$r^{-i} \uparrow \Rightarrow \pi^i \downarrow . \tag{$*$}$$

In the model (1)-(4), y_t is real output, π_t the inflation rate, r_t real interest rate, $\bar{r}$ the world real interest rate, $\bar{y}$ natural output, and y^* and π^* target output and target inflation respectively. κ, ψ, γ, ω h, b, ν_1, ν_2 and ν_3 are parameters. $\Delta r^{j,e_i}$ and $\Delta r^{k,e_i}$ represent the *expected change in foreign interest rate* as expected by i. Instead of incorporating shocks directly into this model, we consider the only type of shock arising from external interest rates.

Hence, the model is a standard text book model of central bank monetary policy; it serves our purpose well. The modification is in the Taylor rule, which has been made directly sensitive to international interest rates rather than just internal pressures.

Why do we solve for inflation? The reason is simply that monetary policy decisions affect inflation, and since we assume that all bankers are inflation averse, (5) is our solution. (Recall that we have accepted price stability as the mandate of the central bank, though being completely autonomous, we allow a central banker to break with this mandate).

Now, the purpose of this paper is to consider the case where bankers types are not common knowledge, rather private information, and must be inferred either subjectively or objectively by the other bankers. That is, we explore the effect of monetary policy, and try to rationalize why a coordinated monetary policy response will be most benificient in a **global** crisis, and indeed we show that such a response is the only rational response. The solution notion will be (weak perfect) *Bayesian Nash* equilibrium.

Since private agents rational expectations have led us to our expectations dependent solution in (5), we turn to the bankers in charge of monetary policy. Since these are influential individuals, and therefore non-aggregated, we study their decisions' impact by allowing them to act in accordance with rational expectations, that is, be inflation averse, but also allow them to deviate from established practice, acting irrationally if one will.

We will consider two types of bankers. These types are

$$\theta = \begin{cases} \textit{type I} \text{ which refers to an } \textbf{inflation averse} \text{ banker,} \\ \textit{type II} \text{ by which we will mean a banker who is } \textbf{not inflation averse}. \end{cases}$$

How does this game play out? The bankers decisions (to raise or not to raise) will reveal their types. However, the decision of say, i will be unknown to j. Therefore, when will non-cooperative players end up in cooperative play? Common sense would posit that cooperation would be achieved when interests are aligned, and in our model when the central banker types are the same.

Let us consider our model: we have a world split up into blocs. We dub the blocs i, j and k. These blocs are trade partners, highly integrated with each other. We assume that two of these have somewhat equal economic influence[2], while the third has less so.

Consider that prices are falling in one of the three blocs considered; consider this bloc temporarily to be a closed economy. What must happen? The central banker must decrease the interest rate making borrowing cheaper for firms and consumers, thus accelerating demand. Prices must then rise since the immediate jump in demand cannot be met by supply, which is relatively more inelastic than demand.

Consider now a different picture. The economy considered is open, decreasing interest rates will cause outflow of capital. We rank the influence of these three economies in the following manner

$$i \geq j > k.$$

Consider a shock arising in i , spilling over into j and k. The only way to minimize the affect of this shock is to act in a coordinated fashion, if all bankers have the same type. If they do not have the same type, the actions will be dissimilar, and the shock will force the economies to a correction. We consider first the case where conventional wisdom, i.e. mainstream neo-classical macroeconomics, requires that interest rates be slashed to stem supply-driven inflation.

The type of banker i is private information, endowed by nature. We assume here that there is no history to infer this type from, no similar crisis has ever before arisen to need a central banker response as is needed now[3]. Remember that we look at a non-cooperative game where the actions appear coordinated.

The game proceeds as follows.

1 Player i's type is private information.

2 Players i and j make their decisions following each other. Player i decides first.

3 Player k makes his decision once the other players' decisions have been revealed.

This is essentially a two-tiered game, if one may call it as such. The first is a game

[2]Consider the blocks to be the Fed, ECB and Riksbank of Sweden if realism must be paralleled.

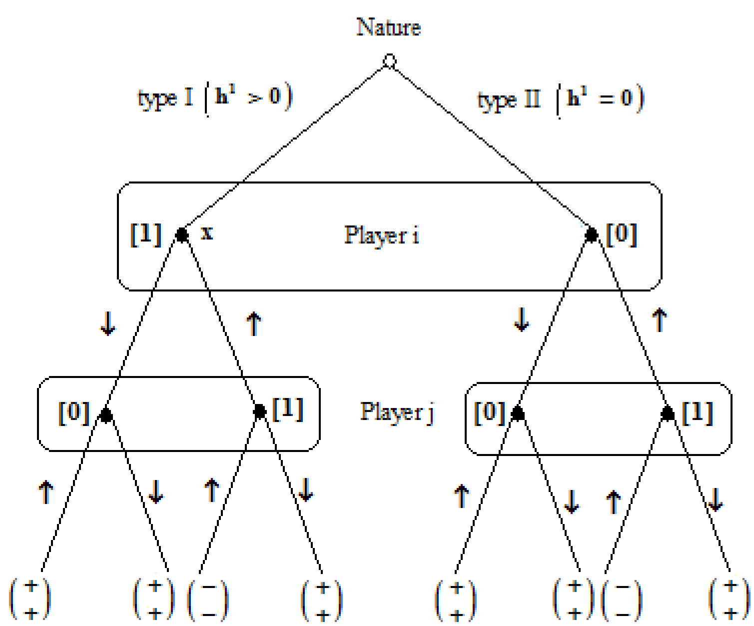
[3]This may be unrealistic, but it serves our purpose nicely since we here model unprecedented times which call for unprecedented measures.

between i and j. The second is a game where only k makes her decision, once the others' decisions have been made. We proceed as follows.

From (4) above we see that type I or type II decides the parameter h. Thus, for a banker to be of type I, the parameter h will be strictly greater than zero - for player i, we will write this as $h^i > 0$. On the other hand, if player i is not inflation averse, it must be that $h^i = 0$. Hence, in our game where types are private information, the player j must form a belief as to what type i actually is. This is where our notion of a perfect Bayesian equilibrium comes into play.

The game tree depicting the game is shown in figure 2. Nature reveals player i's type. As can be seen, j's information set is also non-singleton - she must decide whether or not to raise interest rate without knowledge of i's type and therefore her decision. The payoff vector shows first i's and second j's payoff. The minus sign represents a decrease, whereas the '+' represents an increase in inflation. The goal of the central bankers is to decrease inflation.

Figure 2: Game Γ_E: Players i's and j's decision game



Nature endows i with her type. Based on this type, i decides whether or not to raise interest rates. In this particular setting, player i is of type I with a "big" probability, that is,

$$\text{Prob}(\text{type } I) \geq \text{Prob}(\text{type } II) \tag{\#}$$

. The game tree also shows that if i were to cut interest rates, both would recieve a payoff in the form of further inflation. This is, of course, in line with macroeconomic theory, but not an acceptable outcome since the goal is to reduce inflation.

Since j believes that player i is of type I, (this belief is exogenous but may be updated according to *Bayes' rule* if new information is available) - we have a solution. Moreover, consistent with the belief that i is of type I, j's decision to raise interest rates is *sequentially rational* since from any history that i actually is at, j's response is a best response given her beliefs. Perhaps both i and j went to the same school and have been brainwashed to raise interest rates to stem inflation, and vice versa, have it engraved in them to drop interest rates to fight supply side inflation.

The crucial thing to note in the equilibrium above are player j's beliefs. Player i knows perfectly well his own type (even though it is shown to be non-singleton it need not be since he must know his own type), hence the probability $p = 1$, shown as [1] in figure 2, of being at history x. Player j at the same time *believes* that i is sensible and adheres to mainstream economic theory. Even off the path of (equilibrium) play, we have best responses. Hence, there is a clear path of play.

Fortunately, it is relatively easy to find the Nash equilibrium from the reduced-normal form game, and it is very easily seen to be $\{r^i \uparrow, r^j \uparrow\}$. Why is this optimal? The rising inflation needs an increase in interest rate to alleviate excess demand pressure by increasing the cost of borrowing to consumers, etc.

The equilibrium reached is a *sequential equilibrium*, a refinement of a perfect Bayesian equilibrium. The equilibrium assessment, therefore, is the strategy-belief pair

$$\{\sigma, \mu\} = \{r^i \uparrow, r^j \uparrow |(h^i > 0, \mu^{h^i > 0} = 1)\}$$

As can be seen from the equilibrium, the decision on both players' parts is the same - the resulting action is coordinated even though player j does not know player i's type. We explained the subjectivity of beliefs of j due to indoctrination, though the beliefs may be updated if the decision of i was off the equilibrium path of play.

But is it really true that if i were to play a strategy off the path of (equlibrium) play, j can have no room to maneouver? It seems acceptable - though harsh - that if i were to make a mistake, j would have to suffer. However, this is not the case. For this situation, where i misinterprets natures signal of his type, and indeed forces decisions off the path of play on the part of j, we apply the notion of a *trembling hand perfect equilibrium.*

The general wisdom around trembling hand perfect equilibria is that they force off the path of play strategies to have strictly positive probabilities. Hence, the system of belief's is such that a positive probability must be attached to any possible strategy since a player might "tremble" and put down the wrong decision.

We therefore re-represent the extensive form of the game to take account of this calling it Γ_ϵ, as in figure 3.

Figure 3: Game Γ_ϵ: Players i and j - strictly positive probabilities

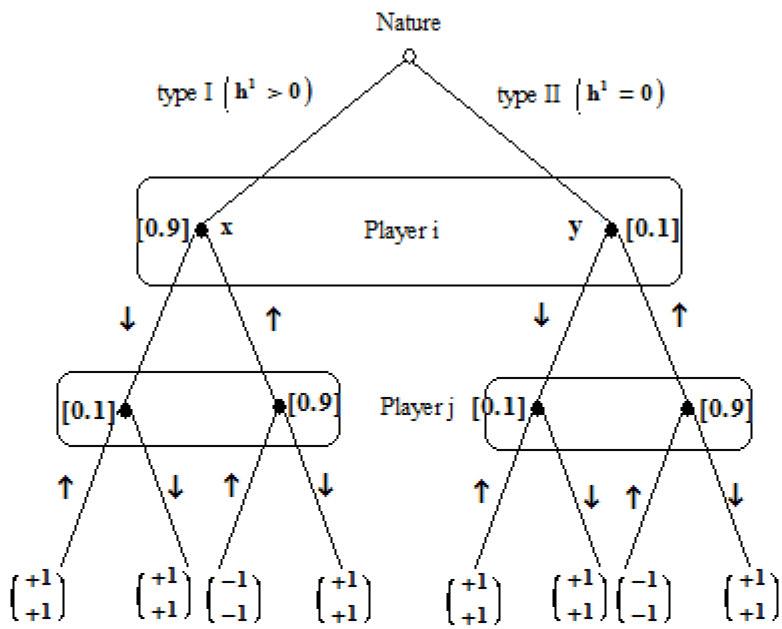


Figure 3 shows that player i might misinterpret her nature-revealed type since she attaches a strictly positive probability to being a type II central banker as well. Since player j is mindful of player i perhaps being radical, he must necessarily consider the possibility that i might act in an unorthodox fashion. A trembling hand perfect Nash equilibrium allows exactly for this scenario.

In essence, a banker may conceivably be not inflation averse, and may announce this. However, we assume that all bankers went to the same school and were indoctrinated likewise, and therefore a type II banker must be a mistake.

Theoretically[4], every trembling hand perfect equilibrium is a sequential equilibrium. However, the opposite is not necessarily the case. Hence, our first candidate for a trembling hand perfect Nash equilibrium should be our Bayesian equilibrium from the last game.

The strictly positive probabilities attached to each node indicate that their must exist completely mixed strategy equilibria. However, even though player j cannot be certain of what player i does, she still attaches a greater probability to i raising the interest rate in this particular scenario of excess demand driven inflation. This belief on the part of j makes i's

[4]Reference to propositions establishing equivalence between sequential equilibria and trembling hand perfect equilibria

type redundant. How? Player i knows perfectly j's type, which is strictly inflation averse (type I, $h^j > 0$. Knowing this, player i also knows that j will raise interest rates no matter her own decision. If her decision is different from j's, both face rising inflation. If her decision matches j's, both face either rising inflation or falling inflation.

Player j knows that player i knows what she knows. Hence, she deters from changing her decision to raise interest rates knowing that the worst case scenario is the same if they differ in their decisions. Hence, she does not find a need to change her decision even though her beliefs are updated in the Bayesian fashion, having taken into account the possibility that i might be type II. It would require a massive shift in beliefs for j to change her decision - we allow only for the slightest possibility of i being type II.

In figure 3, the positive probability attached to i being type II is paramount in determining the equilibrium outcome. Due to her beliefs j must plan for all contingencies. This results in the trembling hand perfect equilibrium, which is clearly also the sequential equilibrium from the last game.

Now, player k being the smallest player and the most *influenced* takes into his decision-making both player 1's and 2's interest rate setting before setting his own. On a small economy's part, we therefore have a very simple game: a dynamic extensive game of perfect information.

The game k faces proceeds as follows.

1 Players i and j make their decisions in Γ_E or equivalently in Γ_ϵ.

2 k the world observes i and j's decisions.

3 Player k comes with the best response to their decisions.

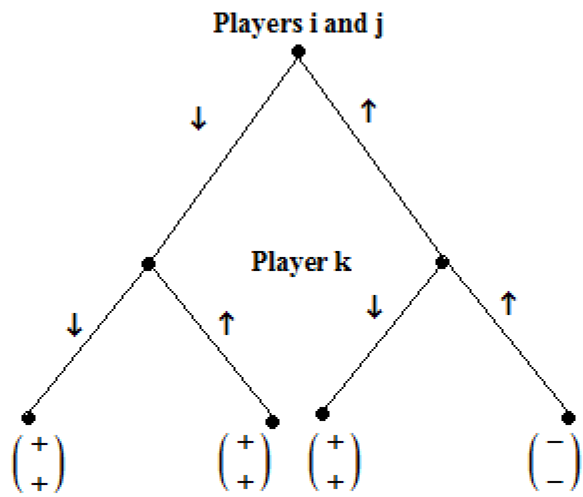
Clearly the game has a Nash equilibrium since k's best response is to raise interest rates to block importing inflation. Hence, all three players have followed suit. Their decisions are the same, even though there existed the small chance that player i might do something unconventional.

The importance of cooperation on the part of players i and j comes to the forefront again here: if the two had different strategies, player k's decision would not be so easy to make. It would require more delicate resolution, perhaps based on trade volume between the two bigger economies (we assumed i at least as influential as j).

3 Conclusion

The fact that both game Γ_E and Γ_ϵ have the same equilibrium verifies our proposition that a shock requiring simultaneous international action on the part of monetary authorities must

Figure 4: Player k following players i and j



result in coordinated action. We have considered the case where a banker may make the mistake of believing himself as an inflation inaverse banker. He will still be forced to play as a type I banker. This was due to the ineffectiveness of opposite actions in the face of a crisis such as the one we model.

The central assumption of the model, or rather, the central *non-assumption* of the model is that central bankers influence expectations. By influence we mean that they can introduce a correction in market expectations by simply announcing a policy which is different than that expected by private agents. In essence, this is the time-inconsistency of monetary policy at play. The main conclusion of the model is therefore that even if a central banker is not trust-worthy, in the sense that he may not adhere completely to conventional wisdom, the optimal decision on the part of both bankers still remains to coordinate interest rate moves by raising interest rates in this setting. In terms of ranking, the equilibrium assessment that both i and j raise interest rates is Pareto efficient compared to the sub-optimal assessment that both coordinate but decrease interest rates.

This too is valid so long as our basic macromodel is true. The most recent example verifying such an equilibrium in the real world is the ASEM7 summit, held in Beijing 24-25 october 2008. The view on the current financial crisis was the same from all members as declared in the **Statement of the Seventh Asia-Europe Meeting on the International Financial Situation**[5] - the premiers' chorus sang of stronger coordination despite hesitation on the part of some.

The policy recommendation arises from here as well. The (refined) Nash equilibrium is

[5] See the full text of the statement at http://www.asem7.cn

coordinated action. The probability that a banker mistakenly raises interest rates rather than decreases when required is minimal, and since the equilibrium requires play of mixed strategies, it is shown that it is a best response of player j to maintain her decision until her beliefs are changed by a very great amount; a belief that i is at node y rather than at history x in the game Γ_ϵ with a probability $\mu(y) > \frac{1}{2}$ would be such a belief.

The implication of this analysis is simple. In an interdependent world, it is extremely hard for central bankers to act independently, even if they are the most influential. Free transfer of financial capital makes interest rate setting a knife-edge policy instrument. In the worst of cases, only a coordinated response will achieve a common goal. If the goals are dissimilar, monetary policy will surely not be optimal. Neither will it be effective, in that if type I, inflation would rise, and if type II, inflation would still rise.

A criticism that may be levelled against the game is that it is modelled as a dynamic game, even though the actions are not revealed until both have decided. Our argument is that even though the actions on the part of i are not revealed, once decided they cannot be changed until announcement has been made. But j must wait before deciding. Moreover, since player i simply decides unconditional on j based on his type, but j must take i's type into account in allocating a system of beliefs, the game is indeed dynamic. Of course, the final stage of the game-theoretic model involving player k is indeed an extensive form dynamic game of complete information.

Appendix: Solving the macromodel

We can simplify our model down to a single equation which we will call the central banker's decision problem. Re-writing equation (2) for y_t in terms of π_t and then inserting it into (4), and hereafter substituting for y_t, y^* and r_t in (1), we reduce the model to

$$\min SL = \left(\frac{1}{\gamma}(\pi_t - \pi^e) - \omega\right)^2 + \kappa(\pi_t - \pi^*)^2 + \psi\left[\frac{b}{\gamma}\pi_t - h\pi^* + \left(h - \frac{b}{\gamma}\right)\pi^e + \nu_{i,j}\cdot\Delta r^{j,e_i} + \nu_{i,k}\cdot\Delta r^{k,e_i}\right]^2 \tag{7}$$

Hence, we have reduced our model (1) - (4) to a single decision problem (7), wherefrom inflation in economy i can be identified.

The first order condition for this problem is given by the derivative $\frac{\partial SL}{\partial \pi_t} = 0$. Of course, this optimality condition is based on the fact that our model is linear, and since SL is a convex function in π_t, there exists an internal solution. Thus, solving for π_t,

$$\frac{\partial SL}{\partial \pi_t} = 0 \Leftrightarrow$$

$$\pi_t = \frac{1}{1+\gamma^2\kappa+b^2\psi}\left((1+b^2\psi - bh\gamma\psi)\pi^e - b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i} + \nu_{i,k}\Delta r^{k,e_i}) + (\gamma^2\kappa + bh\gamma\psi)\pi^* + \gamma\omega\right) \tag{8}$$

Since all private agents have rational expectations, we derive these by taking expectations as follows

$$E(\pi_t | I_{t-1}) =$$

$$E\left(\frac{1}{1+\gamma^2\kappa+b^2\psi}\left((1+b^2\psi - bh\gamma\psi)\pi^e - b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i} + \nu_{i,k}\Delta r^{k,e_i}) + (\gamma^2\kappa + bh\gamma\psi)\pi^* + \gamma\omega\right) \Big| I_{t-1}\right)$$

which, using the definition, $\pi^e = \pi^e_{t,t-1} = E(\pi_t | I_{t-1})$

$$\Leftrightarrow \pi^e_{t,t-1} = \frac{1}{1+\gamma^2\kappa+b^2\psi}\left((1+b^2\psi - bh\gamma\psi)\pi^e - b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i} + \nu_{i,k}\Delta r^{k,e_i}) + (\gamma^2\kappa + bh\gamma\psi)\pi^* + \gamma\omega\right)$$

$$\Leftrightarrow \pi^e - \frac{1}{1+\gamma^2\kappa+b^2\psi}\pi^e = \frac{1}{1+\gamma^2\kappa+b^2\psi}\left(\gamma\omega + (\gamma^2\kappa + bh\gamma)\pi^* - b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i} + \nu_{i,k}\Delta r^{k,e_i})\right)$$

Therefore,

$$\pi^e = \frac{1}{\gamma^2\kappa + b^2\psi}\left(\gamma\omega + (\gamma^2\kappa + bh\gamma psi)\pi^* - b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i} + \nu_{i,k}\Delta r^{k,e_i})\right) \tag{9}$$

Thus,

$$\begin{aligned}
\pi_t =& \frac{1}{1+\gamma^2\kappa+b^2\psi}\left[\frac{1+b^2\psi+bh\gamma\psi}{\gamma^2\kappa+b^2\psi}\left(\gamma\omega+(\gamma^2\kappa+bh\gamma\psi)\pi^* - b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i}+\nu_{i,k}\Delta r^{k,e_i})\right)\right. \\
=& \frac{1}{1+\gamma^2\kappa+b^2\psi}\left(\frac{1+b^2\psi+bh\gamma\psi}{\gamma^2\kappa+b^2\psi}+1\right)\left(\gamma\omega+(\gamma^2\kappa+bh\gamma\psi)\pi^* - b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i}+\nu_{i,k}\Delta r^{k,e_i})\right)
\end{aligned}$$

Defining $\frac{1}{1+\gamma^2\kappa+b^2\psi}\left(\frac{1+b^2\psi+bh\gamma\psi}{\gamma^2\kappa+b^2\psi}+1\right)\equiv\phi$ then the above can be re-written as

$$\begin{aligned}
\pi_t &= \phi\cdot\left(\gamma\omega+(\gamma^2\kappa+bh\gamma\psi)\pi^* - b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i}+\nu_{i,k}\Delta r^{k,e_i})\right) \\
&= \phi\gamma\omega+\phi(\gamma^2\kappa+bh\gamma\psi)\pi^* - \phi b\gamma\psi(\nu_{i,j}\Delta r^{j,e_i}+\nu_{i,k}\Delta r^{k,e_i}) \\
&= \phi\gamma\omega+\phi(\gamma^2\kappa+bh\gamma\psi)\pi^* - \phi b\gamma\psi\nu_{i,j}\Delta r^{j,e_i} - \phi b\gamma\psi\nu_{i,k}\Delta r^{k,e_i}
\end{aligned}$$

Thus,

$$\pi_t = \upsilon_1+\upsilon_2\cdot\pi^* - \upsilon_3\cdot\nu_{i,j}\Delta r^{j,e_i} - \upsilon_3\cdot\nu_{i,k}\Delta r^{k,e_i} \tag{5}$$

where we have the following definitions of the constants

$$\upsilon_1\equiv\phi\gamma\omega \qquad \upsilon_2\equiv\phi(\gamma^2\kappa+bh\gamma\psi) \qquad \upsilon_3\equiv\phi b\gamma\psi.$$

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