Lecture outline

- » An IPO pricing problem
- » IPO pricing II
- » An information model and optimal lying

IPO pricing

- IPO pricing – an information exchange problem
  - » The process begins when an investment bank wants to handle the initial public offering (IPO) for a new company. The bank makes a determination of the value of a company, and issues a number of shares so that the entering share price (*offer* price) is "around" $20 per share. The date at which the shares become available to the market is set, but the initial *market* price remains open.
  - » The bank then begins to call institutional investors, selling the IPO and soliciting commitments to buy at a price the investor feels is appropriate (*counter offer* price).
  - » After collecting information about the interest of the institutional investors, the bank has to choose an opening market price:
    - If too low, the share will quickly rise in price and it will become apparent that the customer (the company receiving money from the sale) has left money on the table.
    - If too high, there may be shares left over at the end of the day. The shares will drop in value, and the bank's reputation will be damaged.

An information exchange model

The IPO pricing game - Version II					
Week	Bank's initial offer	Investor's counter offer	Price bank goes to market with:	Investor buys?	You make
1	20	14	15	1	15
2	22	14	16	1	16
3	18	15	17	1	17
4	14	11	12	1	12
5	19	13	16	1	16
6	22	14	18	1	18
7	17	14	15	1	15
8	22	14	17	1	17
9	23	14	19	1	19
10	21	15	18	1	18
11	17	13	15	1	15
12	19	14	16	1	16
13	23	16	20	1	20
14	21	13	17	1	17
15	18	12	15	1	15
				Total	246

An information exchange model

The IPO pricing game - Version II					
Week	Bank's initial offer	Investor's counter offer	Price bank goes to market with:	Investor buys?	You make
1	20	14	20	0	0
2	22	14	20	0	0
3	18	15	17	1	17
4	14	11	13	1	13
5	19	13	18	1	18
6	22	14	21	0	0
7	17	14	16	1	16
8	22	14	20	0	0
9	23	14	21	0	0
10	21	15	19	1	19
11	17	13	16	1	16
12	19	14	18	1	18
13	23	16	22	0	0
14	21	13	19	0	0
15	18	12	16	1	16
				Total	133

An information exchange model

The IPO pricing game - Version II					
Week	Bank's initial offer	Investor's counter offer	Price bank goes to market with:	Investor buys?	You make
1	20	14			0
2					0
3					0
4					0
5					0
6					0
7					0
8					0
9					0
10					0
11					0
12					0
13					0
14					0
15					0
				Total	0

An information exchange model

- What did we learn about this information exchange?
  - » What was the investor's behavior? Could you figure out the investor's process for taking a price?
  - » How did you respond to this process?

The problem is a lot like the newsvendor problem. If the market price is too low (underage), then all shares will be sold. If the market price is too high (overage), then not all shares will be sold. If the market price is too low, then raising it a bit gets more money, but raises the risk of not selling all shares. If the market price is too high, then raising it futher does not get anything (and the cost of doing the IPO is incurred anyway).

An information exchange model

We need to model the different prices. Our challenge is to capture who knows what information. There is private information and public information.

Let:

$p_b^o =$ The public offer price of the bank (what the bank says the IPO is worth).

$\hat{p}_b^o =$ The private offer price of the bank (what the bank really would like to get).

$p_i^c =$ The public counter offer of the investor (what the investor says it is willing to pay).

$\hat{p}_i^c =$ The private counter offer of the investor (what the investor really is willing to pay).

$p_b^m =$ The price the bank goes to market with (public).

$$X_i^\pi = \begin{cases} 1 & \text{If } p_b^m \leq \hat{p}_i^c \\ 0 & \text{Otherwise} \end{cases} = \text{The investor's decision function.}$$

An information exchange model

What would be a model of our pricing process?

A simple model would be:

Step 1: Bank sets $\hat{p}_b^o$, the price it would like to get.

Step 2: Bank sets public price:

$$p_b^o = \hat{p}_b^o + \hat{\beta}_{bi}^c$$

where $\hat{\beta}_{bi}^c =$ The bank's estimate of the bias in the investor's pricing.

Step 3: Investor looks at public price (and other information) and chooses private price it would like to pay, $\hat{p}_i^c$

Step 4: Investor sets public offer price:

$$p_i^c = \hat{p}_i^c - \hat{\beta}_{ib}^o$$

where $\hat{\beta}_{ib}^o =$ The investor's estimate of the bias in the bank's pricing.

The bank raises its price based on its estimate of the bias of the investor. The investor lowers its offer based on its estimate of the bias of the bank.

An information exchange model

Estimating the bias of the investor:

One way to solve this problem is to try to estimate the bias in the counter offer price of the institutional investor. Let:

$$\omega_{bi}^{c} = \hat{p}_i^c - p_i^c$$

The problem is that the banker does not "see" $\hat{p}_i^c$. An alternative is to use:

$$\omega_{bi}^{c} = p_b^m - p_i^c$$

But what if the market price is too high, and the investor does not accept the offer?

Perhaps a better estimate is to use:

$$\omega_{bi}^{c} = \begin{cases} p_b^m - p_i^c & \text{If } X_i^\pi = 1 \\ 0 & \text{Otherwise} \end{cases}$$

And then the banker can update the estimate of the investor's bias using:

$$\hat{\beta}_{bi}^{c} \leftarrow \begin{cases} (1-\alpha)\hat{\beta}_{bi}^{c} + \alpha\omega_{bi}^{c} & \text{If } X_i^\pi = 1 \\ \hat{\beta}_{bi}^{c} & \text{If } X_i^\pi = 0 \end{cases}$$

This is not perfect, but it may be the best the banker can do.

An information exchange model

Estimating the bias of the bank:

The bias of the bank would be:

$$\omega_{ib}^{o} = p_b^o - \hat{p}_b^o$$

An observation of the bias is the original offer price minus the final market price:

$$\omega_{ib}^{o} = p_b^o - p_b^m$$

The investor can now use this observation to produce an estimate of the bias:

$$\hat{\beta}_{ib}^{o} \leftarrow (1-\alpha)\hat{\beta}_{ib}^{o} + \alpha\omega_{ib}^{o}$$

An information exchange model

- Discussion:
  - » Does this model seem realistic?
  - » What might happen to the biases? Will they stabilize? Will they tend toward zero? Will they get bigger and bigger?

An information exchange model

- How would my behavior change if there was more noise in the process?

Consider the pricing models:

$$p_b^o = \hat{p}_b^o + \hat{\beta}_{bi}^c + \varepsilon_b^o$$
$$p_i^c = \hat{p}_i^c - \hat{\beta}_{ib}^o + \varepsilon_i^c$$

How would the behavior of the game change?

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IPO pricing II

- The banker and investor learning model:
  - » Investment banker initiates an IPO
  - » Calls institutional investors:
    - Institutional investor quotes a public price
  - » Banker chooses a market clearing price
    - Choose the highest public price that would clear the market (assuming that investor will not purchase at price over quoted public price)
  - » Banker reveals market price
    - Learns actual demand
    - Some investors who said they wouldn't buy perhaps did buy
    - If the shares sold out, banker raises his price
  - » The investor adjusts to the new price
    - If the banker raises his price, the investor adjusts his behavior by shifting his own distribution.
- What will happen over the long term?

IPO pricing II

The IPO pricing game - Version III					
Week	Price you would like to offer	My counter offer	You go to market with:	I buy?	You make
1	20	10			0
2					0
3					0
4					0
5					0
6					0
7					0
8					0
9					0
10					0
11					0
12					0
13					0
14					0
15					0
					0

IPO pricing II

The IPO pricing game - Version III					
Week	Price you would like to offer	My counter offer	You go to market with:	I buy?	You make
1	20	10	15	1	15
2	22	11	16	0	0
3	18	10	13	1	13
4	20	9	14	1	14
5	19	11	14	1	14
6	22	10	15	1	15
7	19	12	16	0	0
8	22	11	16	0	0
9	23	13	15	1	15
10	21	14	16	0	0
11	19	13	17	0	0
12	19	13	14	1	14
13	23	9	18	0	0
14	21	12	15	1	15
15	18	8	13	1	13
					128

IPO pricing II

The IPO pricing game - Version III					
Week	Price you would like to offer	My counter offer	You go to market with:	I buy?	You make
1	20	10	13	1	13
2	22	11	14	1	14
3	18	10	13	1	13
4	20	9	13	1	13
5	19	11	13	1	13
6	22	10	14	1	14
7	19	12	14	1	14
8	22	11	15	1	15
9	23	13	16	0	0
10	21	14	16	0	0
11	19	13	14	1	14
12	19	13	14	1	14
13	23	9	13	1	13
14	21	12	14	1	14
15	18	8	12	1	12
					176

IPO pricing II

- Analysis
  - » What was different?
  - » How did your behavior change?

Lecture outline

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Information model and optimal lying

- Information acquisition
  - » The banker calls investors to get information about the price they would be willing to pay.
  - » Before making the call, the banker already has an idea of what the market price should be, but there is some uncertainty in this assessment. Let:

$$\mu_b = \text{What the banker thinks the market price should be.}$$

$$\sigma_{\text{b}}^2 = \text{The variance in his estimate of what the price should be.}$$

  - » Now he calls different investors. Assume that each investor quotes a price that is drawn from a distribution with parameters:

$$\mu_i = \text{The average price that the investors are willing to pay.}$$

$$\sigma_i^2 = \text{The variance in the population of prices quoted by the investors.}$$

Information model and optimal lying

- Information exchange:
  - » Let's assume that there is no bias in this distribution, but there is noise, and the investors can control the noise. That is, assume that each investor quotes a price that is a random perturbation from his private price.
  - » To represent this let:

p_i = The public price that the investor quotes to the bank.

Let's now assume that:

$$p_i = \mu_i + \varepsilon$$

where ε is a noise term with mean 0 and variance σ_i^2. The mean μ_i can be viewed as the average private price of the investors. Adding in a noise term with mean 0 implies that the investors are not going to achieve their goal by simply quoting a lower price (this is a bias that can be estimated over time).

Information model and optimal lying

If (μ_b, σ_b^2) represents what the banker knows, and (μ_i, σ_i^2) represents the information that we are going to get from the investor, how do we combine this information?

We need to create a combined set of parameters. It makes sense to use a weighting that puts less weight on information that we do not know as well. Let:

$$w_i = \frac{\sigma_b^2}{\sigma_b^2 + \sigma_i^2} = \text{Weight that we put on information from the investor.}$$

$$w_b = \frac{\sigma_i^2}{\sigma_b^2 + \sigma_i^2} = \text{Weight that we put on what the banker already knows.}$$

Information model and optimal lying

When we use both sets of information, we create a *posterior* distribution with parameters (μ_p, σ_p^2) which we calculate using:

$$\mu_p = w_i \mu_i + w_b \mu_b$$

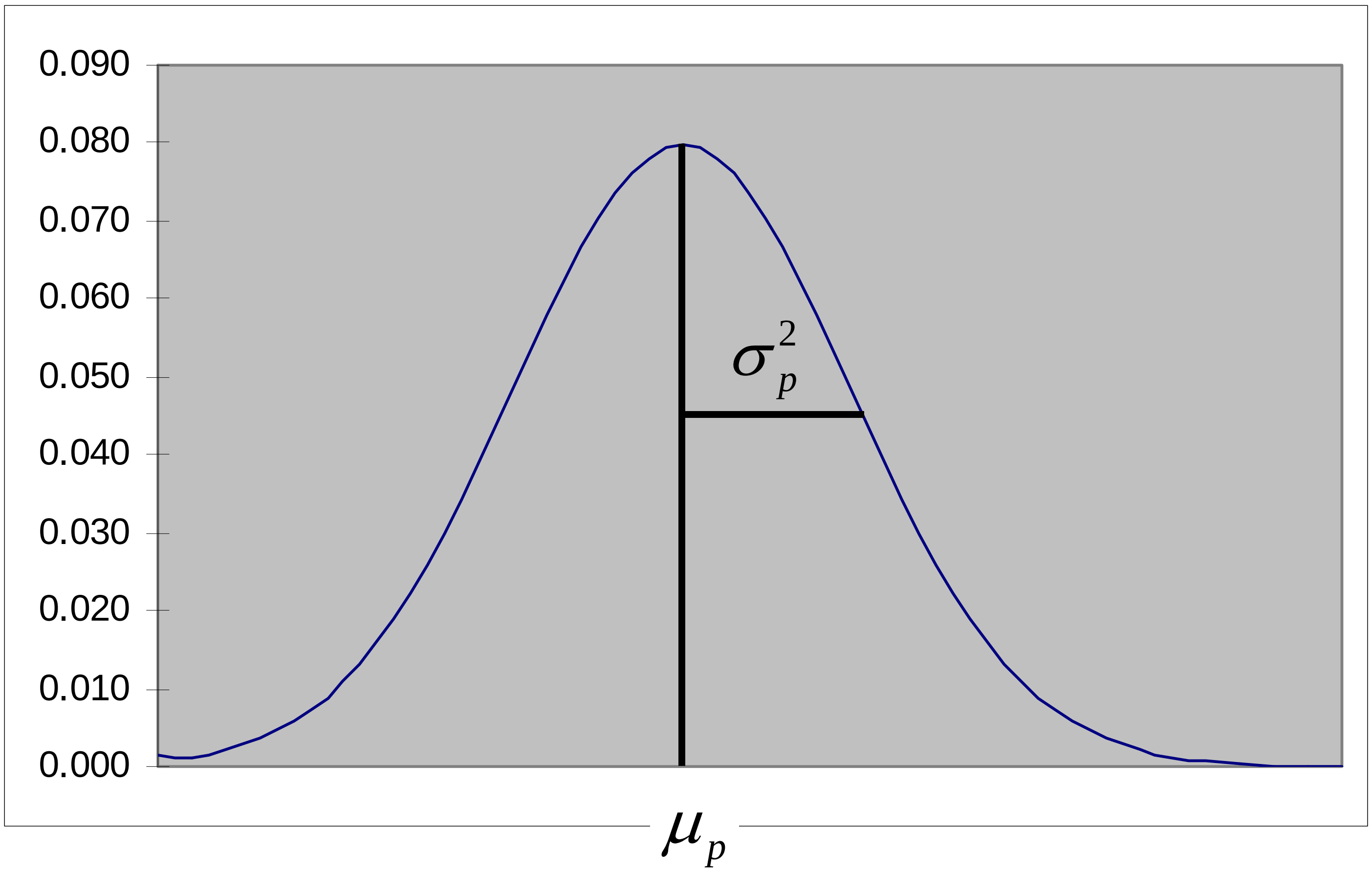
and

$$\sigma_{\mathrm{p}}^2 = w_i \sigma_i^2 + w_b \sigma_b^2$$

So, after getting our information from the investors, we now have a combined distribution.

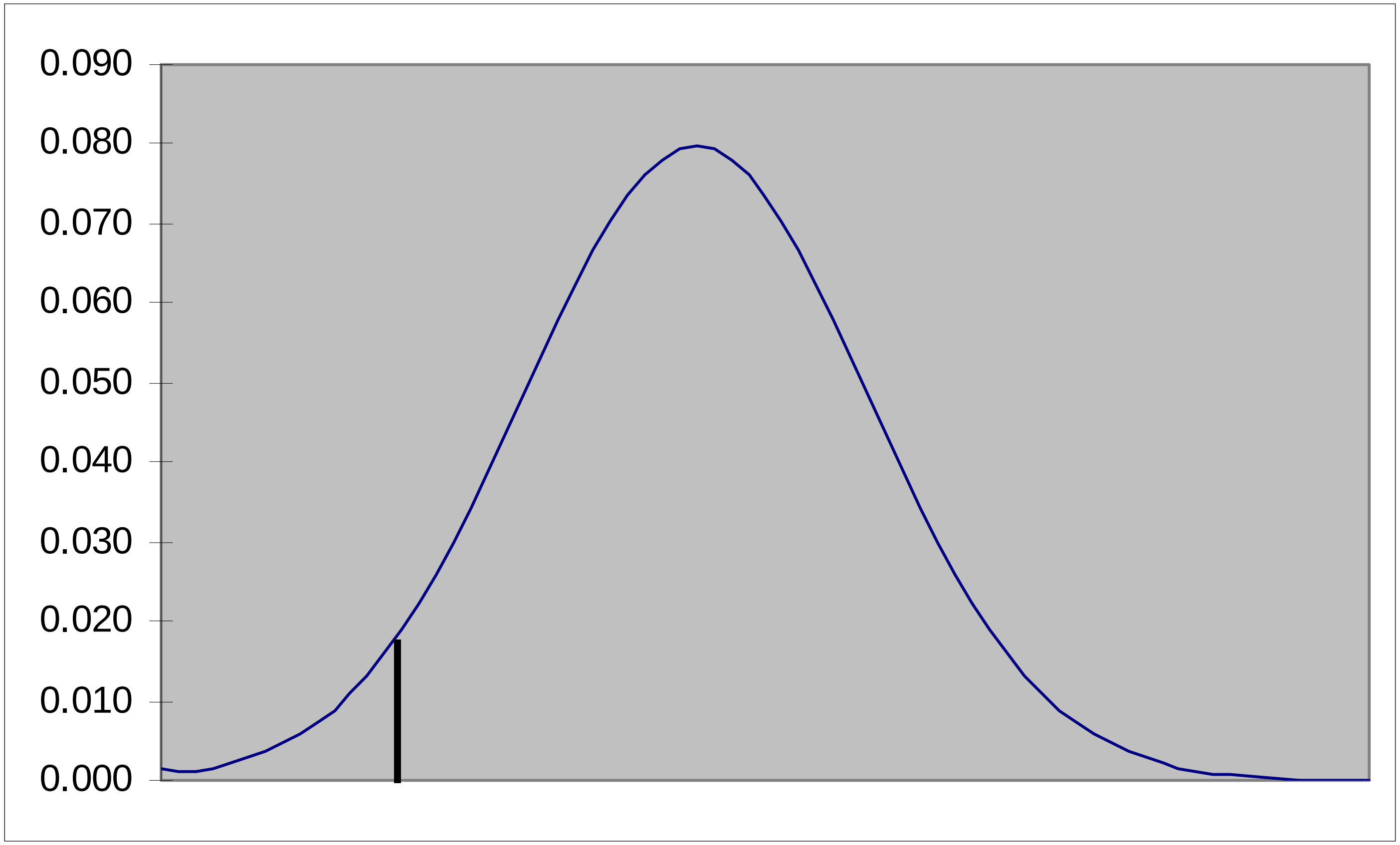
Information model and optimal lying

- Our posterior distribution



Information model and optimal lying

- Pricing and risk aversion
  - » The banker really wants to sell out. If there are shares left over, he takes a hit on his reputation. He would like to pick a price that makes him, say, 90 percent sure that the shares will sell out:



Information model and optimal lying

- But, investors get to choose their variance…
  - » What variance should an investor choose?

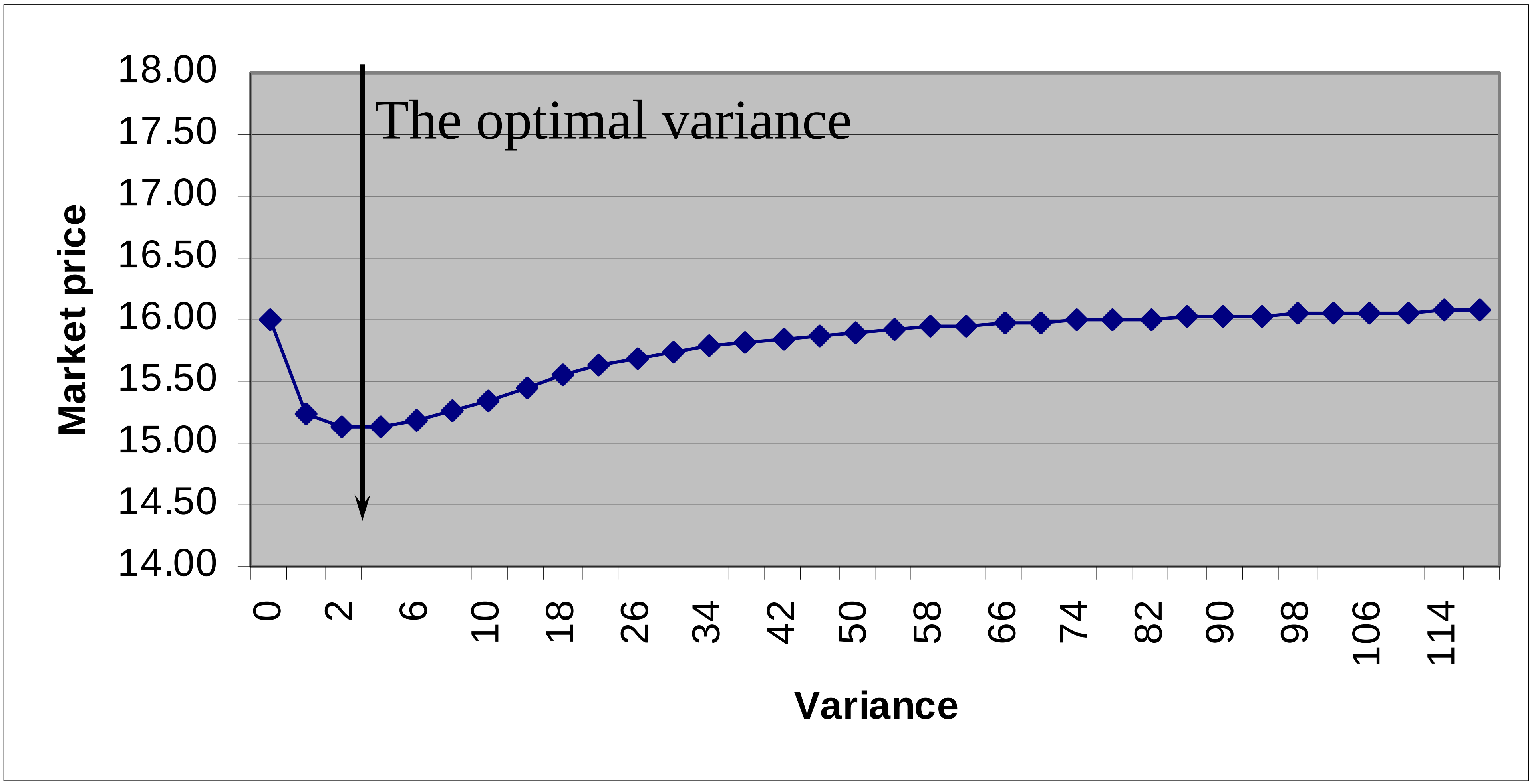
Information model and optimal lying

- Illustration of information mixing
  - » Banker is expecting to receive 20
  - » Investor is willing to pay 16

Banker's information		Investor's information		Weights		Posterior distribution		
Mean	Variance	Mean	Variance	Bank	Investor	Mean	Variance	Optimum price
20	10	16	0	0.00	1.00	16.00	0.00	16.00
20	10	16	1	0.09	0.91	16.36	1.82	15.23
20	10	16	2	0.17	0.83	16.67	3.33	15.13
20	10	16	4	0.29	0.71	17.14	5.71	15.13
20	10	16	6	0.38	0.63	17.50	7.50	15.20
20	10	16	8	0.44	0.56	17.78	8.89	15.27
20	10	16	10	0.50	0.50	18.00	10.00	15.34
20	10	16	14	0.58	0.42	18.33	11.67	15.46
20	10	16	18	0.64	0.36	18.57	12.86	15.55
20	10	16	22	0.69	0.31	18.75	13.75	15.63
20	10	16	26	0.72	0.28	18.89	14.44	15.69
20	10	16	30	0.75	0.25	19.00	15.00	15.74

Information model and optimal lying

- Illustration of information mixing
  - » Banker is expecting to receive 20
  - » Investor is willing to pay 16



Information model and optimal lying

- Observations
  - » Too little noise, and you overpay
  - » Too much noise, and you are ignored
  - » If your estimates are biased, the market will figure out your bias.

- Professor Powell's optimal misinformation policy
  - » Introduce bias and the "right" amount of noise
  - » The market will figure out your bias. It works better if you are always trying to get a higher price. But the bias is a red herring – the real value comes from the noise.