

# 1 Legislative constraint

Legislative constraint as a function of  $e$

- I thought it would be positive at  $e = 0$  and turn negative as  $e$  increases
- What does it mean that for some values it's negative at 0, becomes positive, and then goes negative again?
  - For sure I have to be careful in numerical examples

## 2 Numerical examples

$\delta_L = \delta_{ML} = .95$					
	E=.35	E=.4	E=.41	E=.42	E=.45
$\tau^{tw}$				.074	.0654
$e^{tw}$					.00123
T = 2		.07500			.057407
T = 3		.074716	.070243	.066284	<b>.0570802</b>
T = 4		<b>.074708</b>	<b>.070233</b>	<b>.066275</b>	.0570806
T = 5		.074795	.07033	.06638	.057185
T = 6	.1080	.07492			
T = 7	.1081				.057
T = 8	.10814				

I have another sheet of notes that conflicts with the first column. It just says “ $\delta = .95$ ”:

	E=.35
$\tau^{tw}$	.1213
$e^{tw}$	.006003
T = 3	.1023044
T = 4	<b>.1022411</b>
T = 5	.1022427
T = 6	.10227
T = 7	.102305

This one just says “ $\delta = .99$ ”:

	E=.4	.39
$\tau^{tw}$		
$e^{tw}$		
T = 2	.068510	.06391
T = 3	<b>.068261</b>	<b>.06374</b>
T = 4	.068289	.06378
T = 5	.06841	.06391

This has the note, “This at least works in the direction I thought it would” with “ $\delta_L = .94$ ,  $\delta_{ML} = .95$ ”:

	E=.4
$\tau^{tw}$	
$e^{tw}$	
T = 4	.07464
T = 5	<b>.07421</b>
T = 6	.07481
T = 7	.07492

(“Really want to know if reducing  $\delta_L$  — making future term less important — will give me the  $\sigma$  result I’ve been after; really, no result at all; depends on other parameters.)

Some summaries

- $E = .4$ ,  $\delta_L = .99$ ,  $\delta_{ML} = .95$ ,  $e_{tw} = .00232$ ,  $\tau^{tw} = .08185$ . Optimal  $\tau^a = .07494$  at  $T = 3$ .
- $E = .5$ , assume I kept  $\delta_L = .99$ ,  $\delta_{ML} = .95$ . Optimal  $\tau^a = .04864$  at  $T = 3$ .
- $E = .4$ ,  $\delta_L = \delta_{ML} = .99$ ,  $e_{tw} = .00232$ ,  $\tau^{tw} = .08185$ . Optimal  $\tau^a = .07470$  at  $T = 3$ .
- $E = .4$ ,  $\delta_L = .99$ ,  $\delta_{ML} = .5$ ,  $e_{tw} = .00232$ ,  $\tau^{tw} = .08185$ . Optimal  $\tau^a = .07802$  at  $T = 2$ .
- $E = .4$ ,  $\delta_L = .99$ ,  $\delta_{ML} = .75$ ,  $e_{tw} = .00232$ ,  $\tau^{tw} = .08185$ . Optimal  $\tau^a = .07629$  at  $T = 3$ .

### 3 How does Optimal T vary with political strength?

Trying to understand what is really going on with constraint in terms of  $T$

- Want to get good intuition for why  $T$  can go up as  $\sigma \downarrow$ .
  - Not obvious that it always does; I think it's possible that the direction of  $T$  in response to  $\sigma$  is indeterminant
- I think I need to show effect of  $\sigma$  on  $\bar{e}$  first (I have informally that  $\sigma \uparrow \Rightarrow \bar{e} \downarrow$ )
  - Then, impact of  $\sigma$  on  $\tau^a$ . Next look to see if net profits at  $\tau^a$  increase more than those at  $\tau^{tw}$ , then lobby's future incentives are muted

**Result 1.**  $\frac{d\bar{e}}{d\sigma} > 0$

Proof: Corollary 4 shows that  $\frac{d\bar{e}}{d\gamma} < 0$ . All that is left is to show that  $\frac{d\gamma}{d\sigma} < 0$ .

- The derivative of  $\gamma = 1 + \frac{1}{\sigma}e^\sigma$  w.r.t.  $\sigma$  is

$$\frac{1}{\sigma} \ln \sigma e^\sigma + e^\sigma \left( -\frac{1}{\sigma^2} \right)$$

Both terms are negative given  $\sigma \in (0, 1)$  and  $e \geq 0$ . QED.

Now for the result on  $\tau^a$ . Differentiating the lobby's condition with respect to  $\sigma$ , we have

$$\begin{aligned} \frac{\partial \Pi}{\partial \tau^a} \frac{d\tau^a}{d\gamma} \frac{d\gamma}{d\sigma} + \frac{\partial \Pi}{\partial \bar{e}} \frac{d\bar{e}}{d\gamma} \frac{d\gamma}{d\sigma} + \frac{\partial \Pi}{\partial \gamma} \frac{d\gamma}{d\sigma} &= 0 \\ \frac{d\tau^a}{d\gamma} \frac{d\gamma}{d\sigma} &= \left[ -\frac{\frac{\partial \Pi}{\partial \bar{e}} \frac{d\bar{e}}{d\gamma} + \frac{\partial \Pi}{\partial \gamma}}{\frac{\partial \Pi}{\partial \tau^a}} \right] \frac{d\gamma}{d\sigma} \end{aligned} \tag{1}$$

We know from Corollary 5 that  $\frac{d\tau^a}{d\gamma}$  is positive, and we've just shown that  $\frac{d\gamma}{d\sigma}$  is negative. Thus  $\frac{d\tau^a}{d\sigma} < 0$ .

Write constraint:

$$\bar{e}(\tau^a) - \pi(\tau^b(\bar{e}(\tau^a))) + \pi(\tau^a) - e_a - \frac{\delta_L + \delta_L^{T+1}}{1 - \delta_L} [\pi(\tau^{tw}) - e_{tw} - \pi(\tau^a) + e_a] = 0$$

For now, assume this has an interior solution so calculus works.

First, what does  $T$  do to  $\bar{e}(\tau^a)$ ?

By the Implicit Function Theorem:

$$\frac{d\bar{e}}{dT} = -\frac{\frac{\partial \Omega}{\partial T}}{\frac{\partial \Omega}{\partial \bar{e}}} = -\frac{-\frac{\delta_{ML}^{T+1} \ln \delta_{ML}}{1-\delta_{ML}} [W_{ML}(\gamma(\bar{e}), \tau^a) - W_{ML}(\gamma(\bar{e}), \tau^{tw})]}{\frac{\delta_{ML} - \delta_{ML}^{T+1}}{1-\delta_{ML}} \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^a) - \pi(\tau^{tw})] - \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^b(\bar{e})) - \pi(\tau^a)]} > 0 \quad (2)$$

So if  $T \uparrow$  then  $\bar{e} \uparrow$ .

Now, want to know about effect of  $T$  on  $\tau^a$ .

$$\frac{\partial \Pi}{\partial \tau^a} \frac{d\tau^a}{dT} + \frac{\partial \Pi}{\partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial \Pi}{\partial T} = 0$$

Because  $\frac{\partial \Pi}{\partial T} = \frac{\ln \delta_L \delta_L^{T+1}}{1-\delta_L} [\pi(\tau^{tw}) - e_{tw} - \pi(\tau^a) + e_a]$ , we are looking for

$$\frac{d\tau^a}{dT} = -\frac{\frac{\partial \Pi}{\partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial \Pi}{\partial T}}{\frac{\partial \Pi}{\partial \tau^a}} = \frac{-\left(1 - \frac{d\pi}{d\bar{e}}\right) \cdot \frac{d\bar{e}}{dT} - \frac{\ln \delta_L \delta_L^{T+1}}{1-\delta_L} [\pi(\tau^{tw}) - e_{tw} - \pi(\tau^a) + e_a]}{\left(1 + \frac{\delta_L - \delta_L^{T+1}}{1-\delta_L}\right) \left[\frac{\partial \pi(\tau^a)}{\partial \tau^a} - \frac{\partial e_a}{\partial \tau^a}\right]} \quad (3)$$

The proof of Corollary 3 shows that  $\left(1 - \frac{d\pi}{d\bar{e}}\right)$  is positive, and the above result shows that  $\frac{d\bar{e}}{dT}$  is positive. The second term is positive since net profits are maximized at  $e_{tw}$  and  $\delta_L < 1$  so that its log is negative. With the leading negative signs, the numerator has both a negative and a positive part. This is not changed by the denominator, as the arguments given in the proof of Corollary 1 show that the denominator is positive.

- Remember simplified version where actors are infinitely patient
- Can play around with trick of looking for minimum  $\tau^a$  by setting this equal to zero

As  $\sigma \downarrow$ ,  $\bar{e} \downarrow$  for a given  $\tau^a$ .

- Remember that change in  $\bar{e}$  is really a change in the  $(\tau^a, \bar{e}(\tau^a))$  schedule that derives from legislature's constraint
- So  $\tau^a$  has to be raised to satisfy lobby's constraint

- Net profits are greatest at  $\tau^{tw}$ , so relative gap between net profits at  $\tau^a$  and  $\tau^{tw}$  (future) closes faster than that between break profits and trade agreement profits (present)
- How much  $\tau^a$  adjusts depends on magnitude of  $\frac{\delta_L + \delta_L^{T+1}}{1 - \delta_L}$
- $\pi(\tau^b(\bar{e}(\tau^a))) - \bar{e}(\tau^a)$  is negative, gets less negative when  $\bar{e}$  is reduced.
- $\pi(\tau^a) - e_a$  is positive, becomes larger as  $\tau^a$  rises

$$0 \geq - [\bar{e}(\tau^a) - \pi(\tau^b(\bar{e}(\tau^a))) + \pi(\tau^a) - e_a] + \frac{\delta_L + \delta_L^{T+1}}{1 - \delta_L} [\pi(\tau^{tw}) - e_{tw} - \pi(\tau^a) + e_a]$$

Where present part of constraint is on left and future part is on right. Remember present part must be negative.

Let  $\gamma(e) = 1 + \frac{1}{1-\theta}e^{1-\theta}$ . Or  $\gamma(e) = 1 + \frac{1}{\sigma}e^\sigma$ .

- $\frac{\partial \gamma}{\partial e} = e^{\sigma-1} > 0 \forall \sigma$
- $\frac{\partial^2 \gamma}{\partial \sigma \partial e} = \ln e \cdot e^{\sigma-1} < 0$  for  $e < 1$

i.e. as  $\sigma \downarrow$ ,  $\frac{\partial \gamma}{\partial e} \uparrow$ .

Can I show that the optimal  $T$  can go either way when  $\sigma$  changes? That is, a counterexample to my quasi-result?

- My result says that as lobby gets stronger ( $\frac{\partial \gamma}{\partial e} \uparrow$ , so  $\sigma \downarrow$ ),  $T$  should have to decrease.
- If optimal  $T$  increases when  $\sigma$  decreases (i.e. if  $T$  is decreasing in  $\sigma$ ), this is a counterexample.
- I think it's possible that both cases can happen depending on other parameters, like  $\delta$ .

Look at legislature's constraint:

$$\frac{\delta_{ML} - \delta_{ML}^{T+1}}{1 - \delta_{ML}} [W_{ML}(\gamma(e_b), \tau^a) - W_{ML}(\gamma(e_b), \tau^{tw})] \geq W_{ML}(\gamma(e_b), \tau^b(e_b), \tau^{*a}) - W_{ML}(\gamma(e_b), \tau^a)$$

If  $T$  is too small, future gap can be smaller than current-period gap. So if  $T$  gets too short, can't enforce on legislature.

Note that changing  $\sigma$  changes  $\tau^{tw}$

- $e_{tw}$  is solution to  $\frac{\partial \pi}{\partial \tau} \frac{\partial \tau}{\partial \gamma} \frac{\partial \gamma}{\partial e} = 1$ ; or  $\frac{\partial \pi}{\partial \tau} \frac{\partial \tau}{\partial \gamma} = \frac{1}{\frac{\partial \gamma}{\partial e}}$
- When  $\frac{\partial \gamma}{\partial e} \uparrow$ , RHS  $\downarrow$ , so LHS must go down.

## 4 Optimal T result with perfect patience

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- I know that  $\frac{\partial \tau^a}{\partial T}$  has both a negative and positive part.
  - Shown for the general case where  $\delta$  is anything.
- Now I want to know if/when  $\frac{\partial^2 \tau^a}{\partial T^2}$  is positive so that I could set  $\frac{\partial \tau^a}{\partial T} = 0$  and optimal T (the one that minimizes  $\tau^a$ )
  - Would need to be careful of corner solutions
  - Will do this for case where  $\delta \rightarrow 1$ 
    - \* This means  $\frac{\delta - \delta^{T+1}}{1 - \delta} \rightarrow T$  and  $-\frac{\delta^{T+1} \ln \delta}{1 - \delta} \rightarrow 1$

Start with simplifying result for  $\frac{d\tau^a}{dT}$ .

Again:

$$\frac{\partial \Pi}{\partial \tau^a} \frac{d\tau^a}{dT} + \frac{\partial \Pi}{\partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial \Pi}{\partial T} = 0 \quad (4)$$

$$\frac{d\tau^a}{dT} = -\frac{\frac{\partial \Pi}{\partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial \Pi}{\partial T}}{\frac{\partial \Pi}{\partial \tau^a}} = \frac{-\left(1 - \frac{d\pi}{d\bar{e}}\right) \cdot \frac{d\bar{e}}{dT} + [\pi(\tau^{tw}) - e_{tw} - \pi(\tau^a) + e_a]}{(1 + T) \left[ \frac{\partial \pi(\tau^a)}{\partial \tau^a} - \frac{\partial e_a}{\partial \tau^a} \right]} \quad (5)$$

- $\left(1 - \frac{d\pi}{d\bar{e}}\right)$  is positive
- $\frac{d\bar{e}}{dT}$  is positive:

$$\frac{d\bar{e}}{dT} = -\frac{\frac{\partial \Omega}{\partial T}}{\frac{\partial \Omega}{\partial \bar{e}}} = \frac{W_{\text{ML}}(\gamma(\bar{e}), \tau^a) - W_{\text{ML}}(\gamma(\bar{e}), \tau^{tw})}{T \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^{tw}) - \pi(\tau^a)] + \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^b(\bar{e})) - \pi(\tau^a)]} > 0 \quad (6)$$

- denominator is positive (proof of Corollary 1)

Now, on to  $\frac{d^2 \tau^a}{dT^2}$

$$\begin{aligned} \frac{\partial}{\partial T} \left[ \frac{\partial \Pi}{\partial \tau^a} \frac{d\tau^a}{dT} + \frac{\partial \Pi}{\partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial \Pi}{\partial T} \right] &= 0 \\ \frac{\partial \Pi}{\partial \tau^a} \frac{d^2 \tau^a}{dT^2} + \frac{\partial^2 \Pi}{\partial T \partial \tau^a} \frac{d\tau^a}{dT} + \frac{\partial \Pi}{\partial \bar{e}} \frac{d^2 \bar{e}}{dT^2} + \frac{\partial^2 \Pi}{\partial T \partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial^2 \Pi}{\partial T^2} &= 0 \end{aligned} \quad (7)$$

Going to need:

$$\frac{\partial^2 \Pi}{\partial T \partial \tau^a} = \frac{\partial \pi(\tau^a)}{\partial \tau^a} - \frac{\partial e_a}{\partial \tau^a} > 0$$



$$\frac{\partial^2 \Pi}{\partial T \partial \bar{e}} = 0$$

$$\frac{\partial^2 \Pi}{\partial T^2} = 0$$

To get  $\frac{d^2 \bar{e}}{dT^2}$ , have to do a little more work.

$$\frac{\partial}{\partial T} \left[ \frac{\partial \Omega}{\partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial \Omega}{\partial T} \right] = 0$$

$$\frac{\partial \Omega}{\partial \bar{e}} \frac{d^2 \bar{e}}{dT^2} + \frac{\partial^2 \Omega}{\partial T \partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial^2 \Omega}{\partial T^2} = 0$$

$$\frac{\partial^2 \Omega}{\partial T^2} = \frac{\partial}{\partial T} \left( \frac{\partial \Omega}{\partial T} \right) = 0$$

$$\frac{\partial^2 \Omega}{\partial T \partial \bar{e}} = \frac{\partial}{\partial T} \left( \frac{\partial \Omega}{\partial \bar{e}} \right) = \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^a) - \pi(\tau^{tw})] < 0$$

So,

$$\frac{d^2 \bar{e}}{dT^2} = \frac{-\frac{\partial^2 \Omega}{\partial T \partial \bar{e}} \frac{d\bar{e}}{dT} - \frac{\partial^2 \Omega}{\partial T^2}}{\frac{\partial \Omega}{\partial \bar{e}}} = \frac{-\frac{\partial^2 \Omega}{\partial T \partial \bar{e}} \frac{d\bar{e}}{dT}}{\frac{\partial \Omega}{\partial \bar{e}}} < 0$$

Now we have everything we need for  $\frac{d^2 \tau^a}{dT^2}$ . Rearranging Equation 7, we have

$$\frac{d^2 \tau^a}{dT^2} = -\frac{\frac{\partial^2 \Pi}{\partial T \partial \tau^a} \frac{d\tau^a}{dT} + \frac{\partial \Pi}{\partial \bar{e}} \frac{d^2 \bar{e}}{dT^2} + \frac{\partial^2 \Pi}{\partial T \partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial^2 \Pi}{\partial T^2}}{\frac{\partial \Pi}{\partial \tau^a}}$$

Elements of the last two terms in the denominator have been shown to be zero when  $\delta \rightarrow 1$ , so we have

$$\frac{d^2 \tau^a}{dT^2} = -\frac{\frac{\partial^2 \Pi}{\partial T \partial \tau^a} \frac{d\tau^a}{dT} + \frac{\partial \Pi}{\partial \bar{e}} \frac{d^2 \bar{e}}{dT^2}}{\frac{\partial \Pi}{\partial \tau^a}}$$

The denominator is positive, so as goes the numerator, so goes the whole thing. So let's write out the numerator:

$$\left( \frac{\partial \pi(\tau^a)}{\partial \tau^a} - \frac{\partial e_a}{\partial \tau^a} \right) \left[ \frac{\left( 1 - \frac{d\pi}{d\bar{e}} \right) \cdot \frac{d\bar{e}}{dT} - [\pi(\tau^{tw}) - e_{tw} - \pi(\tau^a) + e_a]}{(1+T) \left[ \frac{\partial \pi(\tau^a)}{\partial \tau^a} - \frac{\partial e_a}{\partial \tau^a} \right]} \right] -$$

$$\left( 1 - \frac{d\pi}{d\bar{e}} \right) \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^{tw}) - \pi(\tau^a)] \frac{W_{\text{ML}}(\gamma(\bar{e}), \boldsymbol{\tau}^a) - W_{\text{ML}}(\gamma(\bar{e}), \boldsymbol{\tau}^{tw})}{\left[ T \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^{tw}) - \pi(\tau^a)] + \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^b(\bar{e})) - \pi(\tau^a)] \right]^2} \quad (8)$$

$$\frac{\left(1 - \frac{d\pi}{d\bar{e}}\right) \cdot \frac{d\bar{e}}{dT} - [\pi(\tau^{tw}) - e_{tw} - \pi(\tau^a) + e_a]}{(1 + T)} - \frac{\left(1 - \frac{d\pi}{d\bar{e}}\right) \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^{tw}) - \pi(\tau^a)] [W_{ML}(\gamma(\bar{e}), \boldsymbol{\tau}^a) - W_{ML}(\gamma(\bar{e}), \boldsymbol{\tau}^{tw})]}{\left[T \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^{tw}) - \pi(\tau^a)] + \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^b(\bar{e})) - \pi(\tau^a)]\right]^2}} \quad (9)$$

## 4.1 Solutions for optimal T

On the solution(s) to  $\frac{d\tau^a}{dT}$ :

- $\frac{d^2\tau^a}{dT^2}$  has one term that is positive, one term that reverses the sign of  $\frac{d\tau^a}{dT}$
- this means if  $\frac{d\tau^a}{dT} = 0$ , it can't be a global max
  - The slope would have to start positive, end negative.
  - The second term in  $\frac{d^2\tau^a}{dT^2}$  would start negative, end positive, so whole term would be positive as  $T$  gets large
  - This means SOC CAN'T be negative everywhere. A contradiction
- It's perfectly consistent to be a global min
  - Let slope start negative, end positive.
  - The second term in  $\frac{d^2\tau^a}{dT^2}$  would start positive, end negative, so whole term would start positive. As  $T$  gets large, either stay positive (global min), or turn negative
  - If start positive and turn negative, would be an inflection point and slope doesn't actually turn positive
- If  $\frac{d^2\tau^a}{dT^2}$  positive everywhere and  $\frac{d\tau^a}{dT}(0) < 0$  then interior min
- We know the negative part of  $\frac{d\tau^a}{dT}$  gets smaller as  $T \uparrow$ 
  - If negative to start out, eventually becomes positive
  - If positive to start out, gets more positive.
    - \* In this case, want  $T$  as small as possible.

In line with last point, must fully explore corner solutions

- What is TRUE? (not just what would be convenient for me)

## 5 Cross Partial w.r.t. $\sigma$

$$\frac{\partial \Pi}{\partial \tau^a} \frac{d^2 \tau^a}{d\sigma dT} + \frac{\partial^2 \Pi}{\partial \sigma \partial \tau^a} \frac{d\tau^a}{dT} + \frac{\partial \Pi}{\partial \bar{e}} \frac{d^2 \bar{e}}{d\sigma dT} + \frac{\partial^2 \Pi}{\partial \sigma \partial \bar{e}} \frac{d\bar{e}}{dT} + \frac{\partial^2 \Pi}{\partial \sigma \partial T} = 0 \quad (10)$$

- Solving for second term
- Already know first (+), fourth (probably convex), fifth (+), eighth (+)
- Leaves four new terms to solve for. Third, sixth, seventh, ninth.

Ninth. Need:

$$\frac{\partial}{\partial \sigma} \left[ \frac{\partial \Pi}{\partial T} \right] = \frac{\partial}{\partial \sigma} \left[ -(\pi(\tau^{tw}) - e_{tw} - \pi(\tau^a) + e_a) \right]$$

- $\sigma$  changes  $\tau^{tw}$
- leave  $\tau^a$  alone as it's an equilibrium object
- also changes how much lobby has to pay for  $\tau^{tw}$  and  $\tau^a$
- Conjecture:
  - When  $\sigma \uparrow$ , the lobby weakens ( $\frac{\partial \gamma}{\partial e} \downarrow$ ). This means  $\pi(\tau^{tw}) - e_{tw} \downarrow$
  - So probably overall gap goes down because lobby can't get as much in the trade war
    - \* i.e. when lobby gets weaker, its future gain is less because it can't exert as much influence in the future (this makes sense)
  - REMEMBER: this enters negatively
    - \* smaller gap means tighter constraint
    - \* a larger gap would mean a tighter constraint

Third. Need:

$$\frac{\partial}{\partial \sigma} \left[ \frac{\partial \Pi}{\partial \tau^a} \right] = \frac{\partial}{\partial \sigma} \left[ (1 + T) \left( \frac{\partial \pi(\tau^a)}{\partial \tau^a} - \frac{\partial e_a}{\partial \tau^a} \right) \right]$$

- For any given  $\tau$ ,  $\sigma$  doesn't affect  $\pi(\tau)$ .
- But it *does* affect how much has to paid to get  $\tau$ .
- When  $\sigma \uparrow$ , have to pay more and more. This is the first derivative.

- As  $\tau^a \uparrow$ ,  $e_a \uparrow$ , so  $-e_a \downarrow$ . As  $\sigma \uparrow$ ,  $e_a \uparrow$  further, so  $-e_a \downarrow$  further. So this term must be negative overall.

Seventh. Note that

$$\frac{\partial \Pi}{\partial \bar{e}} = 1 - \frac{\partial \pi}{\partial \bar{e}} = 1 - \frac{\partial \pi}{\partial \tau} \frac{\partial \tau^b}{\partial \gamma} \frac{\partial \gamma}{\partial \bar{e}}$$

Need

$$\begin{aligned} \frac{\partial}{\partial \sigma} \left[ \frac{\partial \Pi}{\partial \bar{e}} \right] &= \frac{\partial}{\partial \sigma} \left[ 1 - \frac{\partial \pi}{\partial \tau} \frac{\partial \tau^b}{\partial \gamma} \frac{\partial \gamma}{\partial \bar{e}} \right] = - \frac{\partial}{\partial \sigma} \left[ \frac{\partial \pi}{\partial \tau} \frac{\partial \tau^b}{\partial \gamma} \frac{\partial \gamma}{\partial \bar{e}} \right] \\ &= \frac{\partial \pi}{\partial \tau} \left[ \frac{\partial \tau^b}{\partial \gamma} \frac{\partial^2 \gamma}{\partial \sigma \partial \bar{e}} + \frac{\partial^2 \tau^b}{\partial \sigma \partial \gamma} \frac{\partial \gamma}{\partial \bar{e}} \right] + \frac{\partial^2 \pi}{\partial \sigma \partial \tau} \frac{\partial \tau^b}{\partial \gamma} \frac{\partial \gamma}{\partial \bar{e}} \end{aligned}$$

- Since  $\sigma$  is not involved in how  $\tau$  maps to profits,  $\frac{\partial^2 \pi}{\partial \sigma \partial \tau} = 0$  and the second additive term is zero
- We know that  $\frac{\partial \pi}{\partial \tau} > 0$ , so the sign of the seventh term is determined by the sign of what's inside the square brackets
- $\frac{\partial^2 \tau^b}{\partial \sigma \partial \gamma} = 0$ : once  $\gamma$  is determined, it maps directly into  $\tau$  given the form of the welfare function.  $\sigma$  only controls how  $e$  maps into  $\gamma$ .
- So we're left with  $\frac{\partial \tau^b}{\partial \gamma} \frac{\partial^2 \gamma}{\partial \sigma \partial \bar{e}}$ . We know the first term is positive, so just need to investigate  $\frac{\partial^2 \gamma}{\partial \sigma \partial \bar{e}}$ .
  - $\frac{\partial^2 \gamma}{\partial \sigma \partial \bar{e}} = \ln e \cdot e^{\sigma-1} < 0$  for  $e < 1$
  - This means that, although  $\frac{\partial \gamma}{\partial \bar{e}} > 0$ , the positive slope becomes smaller as  $\sigma \uparrow$ . That is, the influence diminishes.

Sixth

$$\frac{d^2 \bar{e}}{d\sigma dT}$$

$$\frac{d\bar{e}}{dT} = \frac{W_{\text{ML}}(\gamma(\bar{e}), \tau^a) - W_{\text{ML}}(\gamma(\bar{e}), \tau^{tw})}{T \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^{tw}) - \pi(\tau^a)] + \frac{\partial \gamma}{\partial \bar{e}} [\pi(\tau^b(\bar{e})) - \pi(\tau^a)]} > 0$$

This looks to be negative (I have lots of notes to type up). Would lead to completely ambiguous result, but even if it's true, maybe something in the intuition.

- What does that mean for overall expression?

At some point, may want to verify via Young's theorem (take derivative of lobby's condition w.r.t.  $\sigma$  first, then w.r.t.  $T$ ):

$$\frac{\partial \Pi}{\partial \tau^a} \frac{\partial}{\partial T} \left[ \frac{\partial \tau^a}{\partial \gamma} \frac{\partial \gamma}{\partial \sigma} \right] + \frac{\partial^2 \Pi}{\partial T \partial \tau^a} \left[ \frac{\partial \tau^a}{\partial \gamma} \frac{\partial \gamma}{\partial \sigma} \right] + \frac{\partial \Pi}{\partial \bar{e}} \frac{\partial}{\partial T} \left[ \frac{\partial \bar{e}}{\partial \gamma} \frac{\partial \gamma}{\partial \sigma} \right] + \frac{\partial^2 \Pi}{\partial T \partial \bar{e}} \left[ \frac{\partial \bar{e}}{\partial \gamma} \frac{\partial \gamma}{\partial \sigma} \right] + \frac{\partial \Pi}{\partial \gamma} \frac{\partial^2 \gamma}{\partial T \partial \sigma} + \frac{\partial^2 \Pi}{\partial T \partial \gamma} \frac{\partial \gamma}{\partial \sigma} = 0$$