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Information Frictions and Tax Inertia

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Abstract

Tax rates tend to be adjusted rarely. This paper proposes information frictions on the side of policymakers as a possible explanation for tax inertia. Information frictions therefore result in sub-optimal tax rates. The implications for two classes of models, namely noisy information and rational inattention, are explored. The paper examines independent as well as interrelated policymakers, who either face independent or common shocks. I find that information frictions can cause tax inertia, which is increasing in the noise of the information content. Furthermore, the degree of strategic complementarity among policymakers can also increase inertia and bunching of tax rates. I also find that investments in information processing technology as well as increased performance incentives on the side of policymakers can decrease inertia.

The views, findings, interpretations, and conclusions expressed in this paper are entirely those of the author and should not be attributed to the World Bank Group, its Executive Directors, or the countries they represent.

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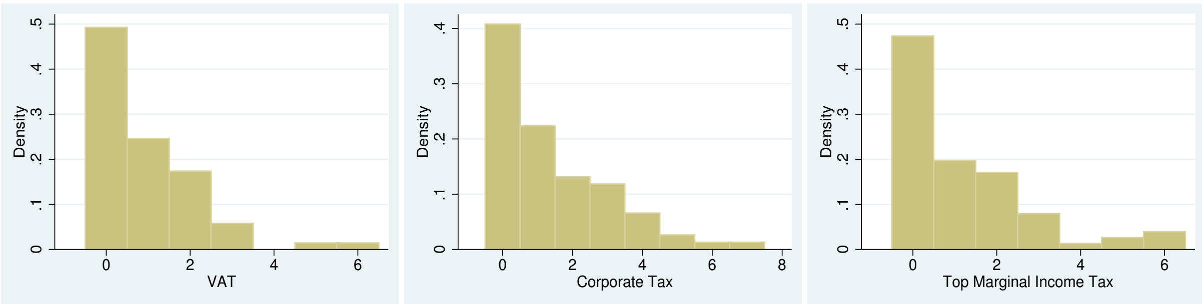
1. Introduction

Tax rates tend to change rarely. Figure 1 illustrates this point, by showing the distribution of the number of tax rate changes in selected countries[1] over the last ten years. The data comes from Vegh and Vuletin (2015), who collect tax rate data for the value-added tax (VAT), standard corporate tax rate and the highest marginal personal income tax rate for 76 countries. In this sample, the mean number of tax rate changes between 2007 and 2017 has been 0.93 for the VAT, 1.4 for the standard corporate tax and 1.2 for the top marginal personal income tax. As the figure shows, nearly half of all countries did not make any change in the VAT rate between 2007 and 2017. Similarly, for the personal income and corporate tax rates, over forty percent of countries made no changes.

Figure 1: Number of Tax Rate Changes by Country, 2007-2017



Source: Own calculations based on data from Vegh and Vuletin (2015)

As a myriad of factors play into optimal taxation[2] formulas, which are subject to shocks, one might expect tax rates to change frequently. Especially since taxes can be used as an instrument to affect business cycles as Vegh and Vuletin (2015) point out, one might expect more variation in tax rates. If taxes cannot react to shocks due to information frictions, then they are set sub-optimally, thereby resulting in welfare losses.

While much attention has been given to sticky prices as they relate to information frictions (see e.g. Mankiw and Reis 2002; Maćkowiak and Wiederholt 2009) the topic of tax inertia, i.e. the rare adjustment and low variation of tax rates due to an underreaction of tax rates to shocks, has not received much attention. Nevertheless, tax inertia, by inducing policy certainty, can have important consequences, as the literature on the uncertainty of fiscal policy shows (Bi et al. 2013; Fernández-Villaverde et al. 2015).

This paper shows that information frictions on the side of policymakers can cause inefficiently sticky taxes. If policymakers cannot perfectly observe the fundamentals that are required to set taxes optimally, then they will adjust taxes more rarely compared to perfect information. In this framework, tax rates under inertia are set optimally from an ex-ante perspective given the information set, but remain sub-optimal compared to perfect information. I first examine the case where policymakers decide taxes independently of each other. This is done in a noisy signal framework, such as in Woodford (2003). I then examine the case where policymakers may have an incentive to partially follow others and strategic considerations can play a

[1]The countries in the sample are listed in the appendix.

[2]See Mankiw et al. (2009) for a recent overview of optimal taxation theory.

role. This can be due to tax competition, as policymakers will not want to have taxes that differ too much from others, out of fear for losing their tax base. Alternatively, this incentive could be due to yardstick competition. I then endogenous the noise terms in a rational inattention framework following Wiederholt (2010).

I find that information frictions cause inertia according to several models. Furthermore, the inertia is increasing in the noise of the information content. With interrelated policymakers, the degree of strategic complementarity plays an interesting role. If jurisdictions set taxes according to common fundamentals, then the degree of strategic complementarity, for example due to the intensity of tax competition, increases tax inertia. If, however, the fundamentals are independent, then there is no effect on the inertia of the average tax rates across municipalities. In that case, a higher degree of strategic complementarity implies that policymakers react less to their own fundamentals, but more to the tax rate changes of others, which can cause bunching. Bunching of tax rates has been empirically established, e.g. in Buettner and von Schwerin (2016), who attribute it to yardstick competition and partial coordination.

The rational inattention framework implies that investments in information processing technology as well as increased performance incentives on the side of policymakers can decrease inertia. Hence, such investments can lead to tax rates that are closer to the optimum. Furthermore, if policymakers suffer from rational inattention and do not operate under tax competition, then tax inertia decreases with the performance incentives of policymakers. In this context, a higher degree of inertia in response to shocks can proxy insufficient performance incentives.

The remainder of the paper is organized as follows. The next section sets up a noisy signal model with tax rates across jurisdictions set independently of each other. Section three extends this model by examining interrelated policymakers. Section four analyzes the extension to rational inattention models, while section five concludes.

2. Independent Policymakers

This section examines policymakers, whose optimal choice of tax rate is independent of the choices of others. While some tax rates can be subject to strategic considerations such as tax competition, this section first establishes inertia, i.e. the sub-optimally low responsiveness of tax rates to shocks, even in the absence of such effects. Interrelated policymakers, on the other hand, are considered in the next section. I examine the tax rate decisions of different municipalities within a country, but the same models can be applied for cross-country analysis.

One way to introduce information frictions is to have the fundamentals of the economy observable with noise, as in Woodford (2003). This section will follow his model.

There is a continuum of policymakers i of measure 1 that set taxes. Suppose the optimal tax rate is driven by a fundamental θ_i that is specific to each municipality. I begin with fundamentals that are independent across municipalities. The case where each municipality is subject to the same fundamental θ will be examined at the end of this subsection.

The optimal tax rate t_i^* is given by a linear function of the fundamental: $t_i^* = f(\theta_i) = a+b\theta_i$, where θ_i has mean 0. This optimal tax function can be interpreted as a first order approximation to a more complicated tax rule, where the fundamental could for example be a tax elasticity. Allowing θ to have a positive mean is straightforward and does not affect the results. Such a case is examined in section 4.

The fundamental cannot be observed directly and instead a noisy signal $Z_i = \theta_i + \epsilon_i$, is observed, where $\theta_i \sim N(0, \sigma_\theta)$, and $\epsilon_i \sim N(0, \sigma_\epsilon)$. Furthermore, θ and ϵ are independent of each other. The average noise observed across municipalities is assumed to cancel out, i.e. $\int_0^1 \epsilon_i di = 0$. Note that $f(\theta_i) \sim N(a, b^2\sigma_{\theta_i})$. Furthermore, $f(\theta_i)$ and Z_i are jointly normal. Sims (2006), in a rational inattention framework, discusses the conditions under which an agent optimally chooses a normally distributed signal.

The policymaker chooses t_i to minimize the quadratic deviation from the optimal tax rate, given her information set Z_i. Formally, she solves:

$$\min E\Big[\beta(t_i - t_i^*)^2 | Z_i\Big] \tag{1}$$

Here β is the discount parameter. A quadratic loss function is chosen for symmetry of sub-optimal rates that are too high or low. The solution to the above problem is:

$$t_i = E[t_i^* | Z_i] \tag{2}$$

From joint normality we have:

$$E[f(\theta_i)|Z_i] = a + \frac{Cov(f, Z_i)}{\sigma_Z^2}(\theta_i + \epsilon_i) \tag{3}$$

Therefore, the policymaker chooses:

$$t_i = E[t_i^*|Z_i] = a + \frac{b\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2}(\theta_i + \epsilon_i) \tag{4}$$

Suppose first that the noise shock ϵ is equal to its expected value of 0. In response to a change of the conditions of the economy, θ_i, the policy maker should optimally change the tax rate by $b\theta_i$. Since $\frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_\epsilon^2} < 1$, however, the policymaker underresponds. Hence, the tax rate does not exhibit as much variation as it should. In the extreme case, where the variance of noise, σ_ϵ^2, approaches infinity, meaning the signal is very imprecise, the tax rate will not react at all, resulting in complete inertia. Of course, the noise shocks will at times cause unwarranted adjustments in individual tax rates. However, as noise is expected to be zero and is generally small, this channel cannot consistently overcompensate the lack of reaction to fundamentals, which causes the inertia.

I now turn to the average tax rates in the economy. Denote the average tax rate across municipalities as t and the average fundamental as $\overline{\theta}$, which is defined as $\int_0^1 \theta_i di$. The average tax rate is then given by:

$$t = \int_0^1 t_i di = a + \frac{b\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2}\overline{\theta} \tag{5}$$

Therefore the average tax rate across municipalities is also sticky. While the tax rates are chosen here ex-ante by optimizing policymakers, they remain sub-optimal from an ex-post perspective.

The insights of this section are summarized in the following proposition.

Proposition 1. *Information frictions can cause tax inertia. Higher noise variance reduces the precision of signals and increases inertia.*

Common Fundamentals

So far, each agent has faced a fundamental that is specific to them. However, since the agents' optimal choices are independent of each other, the solution method is similar for the case with a common fundamental that affects all of them, supposing the signals are independent across policymakers. In that case, the fundamental would be θ, which would simply replace θ_i and $\overline{\theta}$ in the solutions above. Hence, we would still have inertia of the same form.

3. Interrelated Policymakers

The previous section looked at individual policymakers, who decide their tax rates independently of each other. Hence, factors such as tax competition are not necessary to cause tax inertia. This section extends the analysis by examining interrelated policymakers, where strategic considerations can play a role, following Woodford (2003).

3.1. Common Fundamentals

In this model, I will extend the model of section 2 by adding an incentive for policymakers to equalize their tax rates to that of other municipalities. The optimal tax rate will then be:

$$t_i^* = (1-\gamma)t + \gamma\theta \tag{6}$$

Here the optimal tax rate is determined by a fundamental, θ, which is common to all municipalities. The optimal tax rate also reacts to the average tax rate across municipalities, t, to some degree. The dependence on average tax rates shows an incentive for tax competition, as implied by a standard model such as Zodrow and Mieszkowski (1986), or yardstick competition such as in Besley and Case (1995). The weight $(1-\gamma)$ is the degree of strategic complementarity and $0 < \gamma < 1$. If it increases, there is a stronger incentive to follow the tax rate of others. Note that the fundamental here is a random walk and the signals that different policymakers receive are independent from each other. From solving the policymaker's problem, given by equation (1), we now have:

$$t_i = E[t_i^*|Z_i] = (1-\gamma)E[t|Z_i] + \gamma E[\theta|Z_i] \tag{7}$$

A complication of this problem is that each individual choice depends on the expected average choice, which itself consists of individual choices. Therefore beliefs about the decisions of other policymakers become relevant. The problem is solved using higher-order beliefs. The k-order average belief is the average belief of the average belief of ... (repeated k times) of θ

and is defined as:

$$\bar{E}^k[\theta] = \int_0^1 E\Big[\bar{E}^{k-1}[\theta] | Z_i\Big] di \tag{8}$$

where $\bar{E}^0[\theta] = \theta$. Integrating equation (7) over the measure of agents i implies:

$$t = (1-\gamma)\bar{E}^1[t] + \gamma \bar{E}^1[\theta] \tag{9}$$

Solving for the optimal taxes yields[3]:

$$t_i = \frac{\gamma \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2}}{1 - (1-\gamma)(\frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2})} (\theta + \epsilon_i) \tag{10}$$

$$t = \frac{\gamma \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2}}{1 - (1-\gamma)(\frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2})} \theta \tag{11}$$

Similarly to before, there is inertia in the individual and aggregate tax rates. A further implication is that as the degree of strategic complementarity increases, i.e. as $\gamma \to 0$, the degree of inertia increases. Hence, municipalities that are in fiercer yardstick or tax competition exhibit more tax rate inertia.

Proposition 2. *With common fundamentals, the degree of strategic complementarity, e.g. intensity of yardstick or tax competition, increases tax inertia.*

3.2. Specific Fundamentals

The previous section assumes there is a common fundamental to which policymakers react. In this model, municipalities still react to the tax rates of others, but additionally react only to municipality specific fundamentals, denoted θ_i. The optimal tax rate will then be:

$$t_i^* = (1-\gamma)t + \gamma\theta_i \tag{12}$$

This implies:

$$t^* = \overline{\theta} \tag{13}$$

where $\overline{\theta}$ is the average fundamental across municipalities and is defined as $\int_0^1 \theta_i di$.

Proceeding similarly as in the common fundamental case we arrive at the following solutions for the individual and aggregate tax rates:

$$t_i = (1-\gamma)\frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2}\overline{\theta} + \gamma \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2}(\theta_i + \epsilon_i) \tag{14}$$

[3]A derivation is given in the appendix.

$$t = \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2}\overline{\theta} \quad (15)$$

By comparing the chosen tax rates to the optimum, i.e. by comparing equations (12) and (13) to equation (14) and comparing equation (13) to (15), we see that there is inertia. The individual tax rates underreact to the average tax rate of other municipalities as well as to the own fundamental, because $\frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_\epsilon^2} < 1$. As the tax rates underreact to both factors that determine the optimal tax rate, this model produces inertia. Similarly the average tax rate is also sticky.

As before, the model implies that more variance in noise increases stickiness. With regards to the degree of strategic complementarity, however, we now have different results. As it increases, there is more stickiness with respect to changes to own fundamentals, but less with respect to the reactions of others. Hence, as the degree of strategic complementarity increases, i.e. as yardstick or tax competition becomes fiercer, the degree of bunching may increase. For the average tax rate, however, the degree of strategic complementarity no longer matters.

Proposition 3. *Suppose fundamentals are independent across jurisdictions. As strategic complementarity increases, municipalities react less to their own fundamentals and more to the tax rates of others. However, the degree of strategic complementarity has no effect on the average tax rates across jurisdictions.*

4. Rational Inattention

In the models so far, the noise terms were exogenously given. Rational inattention goes one step further by allowing agents to optimally choose the variance associated with the uncertainty about the fundamental. Nevertheless, their attention is constrained and costly, which means they cannot achieve perfect information. Such models will generate stickiness similarly to the simpler noisy information models previously discussed. However, one advantage is that such a framework allows for conclusions regarding the attention of policymakers.

This section largely follows Wiederholt (2010). As it focuses on endogenizing noise, I will only consider the case of independent policymakers. The case of interrelated policymakers follows analogously to the previous section. Here, I also relax the assumption of a fundamental with zero mean. The fundamental is now $\theta_i \sim N(\mu_\theta, \sigma_\theta)$, where $0 < \mu_\theta < 1$. To simplify the terms, I now assume the optimal tax rate simply equals the fundamental, i.e. $t^* = \theta$. Since the problem is symmetric, I suppress the i indices and the solution will hold for each policymaker. Similar to the previous model, the agent cannot observe the fundamental, but only observes the noisy signal $Z = \theta + \epsilon$. Furthermore, θ and ϵ are independent. The agent solves:

$$\min_\kappa \{\frac{w}{2}E[(t-t^*)^2 + c\kappa]\}\; s.t.\; t^* = \theta,\; t = E[t^*|Z], Z = \theta + \epsilon,\; H(\theta) - H(\theta|Z) \leq \kappa$$

Here κ represents the attention paid to the fundamental, while c is the marginal cost of paying attention and w is a parameter governing the cost of mistakes. $H(\theta)$ is the entropy of θ, which measures its uncertainty and the entropy reduction through acquiring information is bounded above by κ, as is standard in such models. The policymaker's problem is solved in lemma 1.

Lemma 1. *The chosen tax rate is given by* $t = [\mu_\theta 2^{-2\kappa^*} + (\theta+\epsilon)(1-2^{-2\kappa^*})]$, *while the optimal attention is given by* $\kappa^* = 0.5log_2(\frac{w\sigma_\theta^2 ln2}{c})$ *if* $\frac{w\sigma_\theta^2 ln2}{c} \geq 0$ *and* $\kappa^* = 0$ *otherwise.*

Proof. See appendix. □

Similarly to before, there will be underreaction to fundamentals and therefore stickiness in the tax rates, which brings us to the following lemma.

Lemma 2. *If policymakers are rationally inattentive, they will under-react to shocks to fundamentals compared to the perfect information scenario and the tax rates will exhibit stickiness with respect to changes in fundamentals.*

Proof. See appendix. □

The conclusions are similar to the previous model. The prediction is that taxes are expected to be sticky and are sticky on average across municipalities. So far this way of modeling policymakers has not provided any real advantage over the simple Woodford (2003) friction. However, this model allows us to make statements about the level of attention, which are summarized in lemma 3.

Lemma 3. *As $\kappa \to \infty$ the information friction disappears and the tax rate approaches that of full information and exhibits no stickiness. The larger the information friction (i.e. the lower κ is) the more stickiness there will be.*

Proof. See appendix. □

From lemma 1 we also know what influences optimal attention allocation. This result together with lemma 3 yields the following proposition.

Proposition 4. *Stickiness increases as the marginal cost of paying attention increases, as the cost of mistakes decreases and as the prior variance of the optimal action decreases.*

Therefore, municipalities with lower attention costs, e.g. through investments in information processing technology, exhibit less inertia. Furthermore, if public policymakers have low performance incentives, due to a low cost of mistakes, then the degree of inertia also increases.

5. Conclusion

This paper is among the first to analyze the issue of tax inertia, which can lead to sub-optimal tax rates. I show that information frictions can cause sticky taxes according to several models. Furthermore, the stickiness increases with the noise of the information content. With common fundamentals across municipalities, the degree of strategic complementarity, as caused for example by tax competition, can exacerbate the inertia. If, on the other hand, fundamentals are independent, then there is no effect of strategic complementarity on the inertia for the average tax rate across municipalities. The rational inattention framework further implies that investments in information processing technology as well as increased performance incentives on the side of policymakers can decrease inertia. Hence, such investments can lead to tax rates that are closer to the optimum. Furthermore, if policymakers suffer from rational inattention, then tax inertia decreases with the performance incentives of policymakers.

An avenue for further research could be to explain the absence of small changes in tax rates and the simultaneous existence of larger adjustments. One approach could be to allow fundamentals to be auto-correlated over time, since policymakers might pay more attention to signals if older ones imply that the current tax rate is sub-optimal. Another approach could also be the use of an inattentiveness framework following Mankiw and Reis (2002), where policymakers can pay a fixed cost to observe information perfectly. In that case, small expected deviations from optimal taxes may not warrant paying the fixed cost of information, whereas large expected deviations could, thereby possibly resulting in infrequent yet large tax rate adjustments.

While inertia in general can be explained by some form of adjustment costs, such models would not be informative of how to exactly address inertia. Information frictions on the other hand offer a clear mechanism, which can be addressed by increasing the capacity of policymakers to process information. In the future, as information becomes more available, policymakers may face an informational overload, which can increase the noise in informational content. Such a development can increase tax inertia, which results in more sub-optimal tax rates and therefore welfare losses. This paper therefore stresses the importance of information frictions in this context.

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Appendix

Countries in the Dataset

The countries in the sample used for Figure 1 are Argentina, Australia, Austria, Azerbaijan, Bahrain, Barbados, Belgium, Bolivia, Botswana, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Czech Republic, Denmark, Dominican Republic, Ecuador, El Salvador, Ethiopia, Fiji, Finland, France, Gabon, Georgia, Germany, Ghana, Greece, Honduras, Hungary, India, Iran, Italy, Jamaica, Japan, Kenya, South Korea, Kuwait, Latvia, Lithuania, Luxembourg, Malta, Mauritius, Mexico, Namibia, New Zealand, Nigeria, Norway, Oman, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Portugal, Qatar, Romania, Russian Federation, Saudi Arabia, South Africa, Spain, Sudan, Sweden, Switzerland, Tanzania, Thailand, Turkey, the United Arab Emirates, the United Kingdom, the United States, Uruguay, Venezuela, Yemen and Zambia.

Deriving equations (10) and (11)

Iteratively substituting and assuming[4] $\lim_{k\to\infty}(1-\gamma)^k \bar{E}^k[t] = 0$ yields:

$$t = \gamma \sum_{k=1}^{\infty} (1-\gamma)^{k-1} \bar{E}^k[\theta] \tag{16}$$

Substituting equation (16) into equation (7) yields:

$$t_i = \gamma \sum_{k=0}^{\infty} (1-\gamma)^k E\left[\bar{E}^k[\theta] | Z_i\right] \tag{17}$$

[4]This assumption is imposed to ensure convergence. It is necessary for the solution and standard in such models, as in e.g. Woodford (2003). The assumption is sensible, as we can expect it to hold for any finite $\lim_{k\to\infty} \bar{E}^k[t]$, since $(1-\gamma) < 1$.

Solving for the expectation, we have:

$$\bar{E}^k[\theta] = \left(\frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_\epsilon^2}\right)^k \theta \tag{18}$$

$$t_i = \frac{\gamma \frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_\epsilon^2}}{1-(1-\gamma)(\frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_\epsilon^2})}(\theta+\epsilon_i) \tag{19}$$

$$t = \frac{\gamma \frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_\epsilon^2}}{1-(1-\gamma)(\frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_\epsilon^2})}\theta \tag{20}$$

Proof of Lemma 1

From the entropy reduction constraint it directly follows that: $\sigma^2_{\sigma|Z} = \sigma^2_\theta 2^{-2\kappa}$. Inserting the optimal choice t^* into the objective function and rearranging yields the objective:

$\min_\kappa\{\frac{w}{2}\sigma^2_{\theta|Z} + c\kappa\}$

Inserting the previously found expression for $\sigma^2_{\theta|Z}$ as a function of κ and solving the first order condition, we arrive at the optimal choice for κ given in the lemma. The equilibrium choice of t is given by $t = E[t^*|Z]$. Computing this expectation as usual using the bivariate normal distribution of θ and Z we arrive at:

$t = \mu_\theta + \frac{Cov(\theta,Z)}{\sigma_Z^2}(\theta + \epsilon - \mu_\theta)$

Using the previous relationship of the conditional variance of θ and κ, we see that:

$\frac{Cov(\theta,Z)}{\sigma_Z^2} = 1 - 2^{-2\kappa^*}$

Inserting this into the expression for t above gives the chosen tax rate stated in the lemma.
□

Proof of Lemma 2

The difference between the tax rate with and without information frictions is:

$t^{Friction} - t^{Full\,Info} = 2^{-2\kappa}[\mu_\theta - \theta] + 2^{-2\kappa}\epsilon.$

If there is bad news, i.e. the fundamental falls below its mean, the tax rate should fall. However, it will be larger than the full information case, meaning it does not fall enough. Similarly, if there is good news, i.e. the fundamental is above its mean, the difference will be negative and the tax rate will not increase enough. Hence we have inertia with regards to the fundamental. □

Proof of Lemma 3

The underreaction is represented by the difference between the chosen tax rate with and without information frictions, which is given by: $t^{Friction} - t^{Full\,Info} = 2^{-2\kappa}[\mu_\theta - \theta]$. This difference is decreasing in κ and goes to 0 as $\kappa \rightarrow \infty$, which means there is no stickiness. $\square$