Discretionary Policy and Multiple Equilibria

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Since the seminal work of Kydland and Prescott (1977), it has been understood that policymaking under discretion can lead to a substantially worse outcome than policymaking under commitment. Many economists believe that discretionary policymaking is important for understanding central issues in monetary policy[1] and fiscal policy.[2] Although there are now many different models of discretionary policymaking, there are two common and essential aspects in all models: (i) private agents make current choices that affect the evolution of state variables on the basis of beliefs about future policy, and (ii) future policymakers take these state variables as historically determined when choosing their optimal actions. Further, within the models of this large literature, there is typically a cost arising from the fact that the discretionary policymaker cannot manage expectations, so that the resulting equilibrium is inefficient relative to that arising with a committed policymaker.

Another potential impact of discretion, however, is that more than one equilibrium may result from the central interaction between private sector choice of state variables, private sector beliefs about future policy, and future policy reaction to state variables. Some of these discretionary equilibria are

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[1] For example, a discretionary monetary policymaker may produce a positive rate of inflation in an economy while a committed policymaker would produce a zero rate of inflation (see Kydland and Prescott 1977 and Barro and Gordon 1983).

[2] For example, a discretionary fiscal policymaker may eliminate private incentives for socially beneficial accumulation by taxing all capital income every period (see Fischer 1980), while a committed fiscal policy may provide ample incentives for accumulation by not taxing capital at all (see Chamley 1986).

better than others in terms of the welfare of the members of the society. An economy may get stuck in a relatively bad equilibrium, so that there can be even greater costs of policy discretion.

Recent work on discretionary monetary policy by King and Wolman (2004) shows how dynamic multiple equilibria can arise in a simple "plain vanilla" New Keynesian macroeconomic model of monopolistic competition and sticky prices of the variety that is now standard in macroeconomic research and policy analysis. In that context, a discretionary monetary authority adopts a policy rule that fosters strategic complementarity between the actions of pricesetters. In turn, that strategic complementarity makes for dynamic multiple equilibria, as in a large literature on the boundary of game theory and macroeconomics concerning coordination games in aggregate economies.[3] In the terminology of Cooper and John (1988), the standard New Keynesian model can give rise to a "coordination failure."

The objective of this article is to construct a very simple and transparent real model in which dynamic multiple equilibria are a consequence of discretionary policymaking for the same economic reasons as in the monetary policy literature. The model is inspired by a brief discussion in Kydland and Prescott (1977) about the interaction of individual location decisions and policy response to disasters such as floods:

> The issues [of time inconsistency arise] in many well-known problems of public policy. For example, suppose the socially desirable outcome is not to have houses built in a particular floodplain but, given that they are there, to take certain costly flood-control measures. If the government's policy were not to build the dams and levees needed for flood protection and agents knew this was the case, even if houses were built there, rational agents would not live in the flood plains. But the rational agent knows that, if he and others build houses there, the government will take the necessary flood-control measures. Consequently, in the absence of a law prohibiting the construction of houses in the floodplain, houses are built there, and the army corps of engineers subsequently builds the dams and levees. (Kydland and Prescott, "Rules Rather Than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy* 85: 477)

[3] Chari, Christiano, and Eichenbaum (2000) describe "expectation trap equilibria" within a monetary policy setting. In these situations, a monetary authority optimally responds to the beliefs of the private sector in ways that are self-confirming so that there is a thematic resemblance to the discussion of the main text. However, the expectation trap equilibria studied by these authors are members of a set of "sustainable plan equilibria" in which great latitude is given to expectation formation and, in essence, a summary of beliefs operates as a state variable. For this class of equilibria to exist, it is necessary that there be no known endpoint to the economy. By contrast, the equilibria described in King and Wolman (2004) are multiple Markov-perfect equilibria in the language of game theory, arising even when there is a fixed endpoint to the dynamic game (as in the example in this article, where the game is essentially static).

The essence of the situation just described is that there is a strategic interaction between the private sector and the government. Accordingly, following much recent literature on policymaking under discretion and commitment, we will make use of game-theoretic constructs to discuss the interaction between private location decisions and the government dam-building decision.

In their analysis, Kydland and Prescott were concerned with understanding the nature of a single discretionary equilibrium and why it would be worse than a single commitment equilibrium. By contrast, this article shows how policy discretion fosters strategic complementarity among private sector decisionmakers in ways that lead to multiple equilibria. In the example studied below, however, the mechanisms are exactly those highlighted in the quotation from their work. An individual knows that the discretionary government will choose not to build a dam if there are only a small number of residents on the floodplain, so that one equilibrium involves the efficient outcome in which no individuals live on the plain and no dam is built. Yet, an individual also knows that the discretionary government will choose to build a dam if there are a large number of floodplain residents, he thus finds it in his interest to locate on the floodplain if a dam is built. Hence, there is another equilibrium that involves a socially inefficient building of a dam and location of individuals on the floodplain. In terms of game theory, it is well understood that multiple equilibria arise when there is sufficient strategic complementarity in a coordination game (Schelling 1960 and Cooper 1999). In the example studied in this article, the strategic complementarity is that an individual's rewards to locating on the plain are higher when other individuals choose to locate there. But the strategic complementarity is present in this setting only when policymaking is discretionary.

1. THE MODEL

There are two locations of economic activity: the floodplain and elsewhere. There are two sets of actors: a government and a private sector. To highlight aspects of the interactions between the government and the private sector, we begin by studying a situation in which there is just one member of the private sector (in Section 2) and then move to the more realistic case in which there are many individuals (in Section 3).

The government and the members of the private sector each have a single action. The private sector must decide to live on the floodplain (call this action $p = 1$) or elsewhere ($p = 0$). The government must decide whether to build a dam ($d = 1$) or not ($d = 0$). Despite the fact public and private decisionmakers take different actions (d and p, respectively), the government's objective is to maximize the welfare of its citizens so that there is no intrinsic conflict between the public sector and private sector. Further, if the government builds the dam, it finances construction via lump-sum taxation, with each member of the private sector paying the same level of taxes.[4]

Individuals derive utility from their location and their consumption of goods. Their utility function takes the form

$$u(c + bp) \tag{1}$$

with $b > 0$. That is, if an individual lives on the floodplain, then it is as if his consumption is raised by an amount, b. Consumption is constrained by after-tax income, which can take on several different values depending on the actions of the government and private sector. The dependence of after-tax income on private and public actions is displayed in Figure 1. The reference level of income is y. If the government builds a dam at cost ψ and finances it with lump-sum taxation, then after-tax income is $y - \psi$. If the government does not build a dam and individuals choose to live on the plain then income is f, which is assumed to be substantially less than y because of floods.

Next, consider the utility level that a single individual receives as it depends on his location decision and the dam-building decision of the government. The various possibilities are shown in Figure 2. We make the following assumptions on the relative sizes of y, b, f, and ψ.

First, we assume that the best situation—the socially optimal situation—is one where individuals do not live on the floodplain and the dam is not built, which requires a pair of restrictions on the parameters of the model. First, it requires that $y > f + b$, which is the idea that effective income is lower when one lives on the plain. Second, it requires that $y > y + b - \psi$ or, equivalently, that $\psi > b$: the dam's cost is higher than the value of living on the floodplain.

Second, we assume that the dam is productive in the sense that $y - \psi > f$. That is, if all individuals are constrained to live on the plain, then there is an economic benefit to building a dam to avoid the low output, f, which arises because of floods.

These assumptions mean that it is easy to determine the optimal choice for an individual. First, if he knows that the government will not build the dam, then it is best for him not to locate on the floodplain since $y > f + b$. Second, if he knows that the government will build the dam, then it is best for him to locate on the floodplain because there are positive benefits from that location choice ($b > 0$ implies that $b + y - \psi > y - \psi$).

Similarly, the optimal choice for the government is easy to describe. As discussed above, the government seeks to maximize the welfare of the individual. If the government knows that the private agent will not locate on the plain, then it is best not to build a dam since it is costly. If the government knows that the private agent will locate on the plain, then it is best to build the dam since it is a productive way of avoiding losses due to floods ($y - \psi > f$).

[4] The Appendix considers the sensitivity of the core results to some alternative financing rules.

Figure 1 Dependence of Income on Individual and Government Actions

		Government Action	
		d=0	d=1
Individual Action	p=0	y	y − ψ
	p=1	f	y − ψ

Notes: The possible government actions are to build a dam (d=1) or not (d=0). The possible individual actions are to locate on the floodplain (p=1) or not (p=0). The income resulting from these actions is given by the entry in the relevant cell of the matrix. For example, if the individual locates on the plain and the government does not build the dam, then the individual receives income "f."

2. A TWO-PERSON GAME

We start by exploring the strategic interactions between a single individual and the government, considering three different cases. First, we assume that the private sector and the government act simultaneously. Second, we suppose that the government acts first, which corresponds to policymaking under commitment. Third, we suppose that the private individual acts first, which corresponds to policymaking under discretion.

Simultaneous Actions

Nash (1951) proposed a definition of equilibrium in games such as the following: a pair of actions (p, d) is an equilibrium if p is the private sector's best

Figure 2 Dependence of Welfare on Individual and Government Actions

		Government Action	
		d=0	d=1
Individual Action	p=0	u(y)	u $(y - \psi)$
	p=1	u $(f + b)$	u $(y + b - \psi)$

Notes: The possible government actions are to build a dam (d=1) or not (d=0). The possible individual actions are to locate on the floodplain (p=1) or not (p=0). The utility resulting from these actions is given by the entry in the relevant cell of the matrix. For example, if the individual locates on the plain and the government does not build the dam, then the individual receives income "f" and utility u(f+b), with "b" measuring the benefits to living on the floodplain.

The model assumes that the dam is costly ($\Psi>0$); that there are benefits to living on the plain (b>0); that there are costs of living on the plain if there is no dam (y>f+b); and that the dam is productive if individuals must live on the plain ($y+b-\Psi>f+b$). These assumptions imply that the diagonal elements of the matrix B are dominant.

response to the action, d, by the government and if d is the government's best response to the private sectors's action, p.[5]

There are, therefore, two Nash equilibria when the private individual and the government move simultaneously. One is that the individual does not locate on the plain and no dam is built by the government ($p = 0$, $d = 0$). The other is that the individual locates on the plain and a dam is built by the government ($p = 1$, $d = 1$). Each of these outcomes is an equilibrium in the

[5] Attention is restricted here to individuals choosing one action or the other. Mixed strategies in which individuals choose one or the other with a specified probability are not considered.

Nash sense since it is optimal for (a) the individual to choose $p = 0$ if $d = 0$ and to choose $p = 1$ if $d = 1$, and (b) the government to choose $d = 0$ if $p = 0$ and $d = 1$ if $p = 1$. One can verify the first of these equilibria by looking at Figure 2. For example, starting at the welfare level corresponding to $d = 0$, $p = 0$, one can see that the individual gets lower welfare if he chooses $p = 1$ (since $f < y$), and that the government's outcome is worse if it chooses $d = 1$ (since $y - \psi < y$). Proceeding similarly, one can also confirm that both diagonal elements are equilibria and that the off-diagonal elements are not.

The two equilibria yield different welfare levels for the individual: the benefit from living on the floodplain is not as large as the cost of building the dam, so that the $p = 0$, $d = 0$ equilibrium is unambiguously better than the $p = 1$, $d = 1$ equilibrium. In terms of the literature on game theory, this is an example of a coordination game, and at least since since Schilling (1960), it has been known that coordination games can display more than one equilibrium.

A Dominant Government

There is symmetry between the individual and the government in the situation just discussed, with each agent deciding on an optimal action taking as given the action of the other. An alternative situation is that the government is dominant, choosing its best action knowing how the individual will respond to government intervention. In our case, the government looks at the various scenarios and recognizes that the individual will respond with $p = 0$ if the government action is $d = 0$ and that the individual will respond with $p = 1$ if the government action is $d = 1$. Since welfare is higher when $d = 0$ and $p = 0$ than when $d = 1$ and $p = 1$, the government will choose not to build the dam.

This situation can be described in other ways. One is to say that the government has a *first mover advantage*, selecting its action and seeing a subsequent response from the private sector, which stresses the timing of actions. The second is to say that the government can *credibly commit* to take the action $d = 0$ even if the private sector chooses $p = 1$, which stresses aspects of feasible government strategies. Either of these perspectives limits the equilibrium solely to the optimal one.

A Dominant Individual

We next consider a setting in which the private sector is dominant. In the current setting, the individual knows that if he chooses $p = 0$ then the government will choose $d = 0$. He also knows that if he chooses $p = 1$ then the government will choose $d = 1$. Since the individual's welfare is highest with

$p = 0$ and $d = 0$, he will choose that action. Hence, a dominant individual will also bring about a socially optimal outcome. That is, the fact that the government cannot commit does not lead to multiple equilibria or to inefficiency when there is a single dominant individual.

3. MANY INDIVIDUALS AND ONE GOVERNMENT

A more realistic situation is that there are many similar private agents and only one government. We study this setting under the assumption that all individuals are identical in their preferences and opportunities, restricting our attention to analysis of symmetric equilibria (those in which all individuals choose the same action).

Each individual makes his location action ($p = 0$ or $p = 1$), taking as given the location decisions of all other individuals: we denote the action taken by all others as $\overline{p}$; the restriction to symmetric equilibria is that $\overline{p}$ is also 0 or 1.[6]

A Committed Government

Suppose that the government can commit to the action $d = 0$. Then, in view of Figure 2, the individual agent will choose $p = 0$. Further, the individual does not really care what other individuals are doing; it is enough for him to know that the government will not be building the dam. The individual will not want to live on the floodplain if there is no dam.

A Discretionary Government

Matters are more complicated when there is a discretionary government. Based on our prior discussion and assuming that the government policy is not influenced by the actions of an individual agent but only by those of the average agent, the optimal decision for the government takes the form

$$d = 0 \quad \text{if } \overline{p} = 0 \text{ and} \tag{2}$$

$$d = 1 \quad \text{if } \overline{p} = 1. \tag{3}$$

That is, a dam is constructed if people choose to live on the floodplain, but not otherwise. This is precisely the same behavior by the discretionary government as in Section 2.

However, the situation for the individual agent is quite different now. He is playing a *simultaneous* game with his fellow agents in which the choice

[6] Equilibria that are not symmetric are studied in the Appendix.

variable is location. Although it continues to be the case that it is the actions of the government that are important for the individual's location decisions, it is now the behavior of all *other* agents that determines how the government acts. The individual has lost his power relative to the case studied in Section 2.

We can again use Figure 2 to determine how the individual will make his location decision. We can represent this as

$$p = 0 \quad \text{if } \overline{p} = 0 \text{ because } d = 0\text{, and} \tag{4}$$

$$p = 1 \quad \text{if } \overline{p} = 1 \text{ because } d = 1, \tag{5}$$

stressing that governmental response depends on the aggregate private sector action. Hence, there are two symmetric equilibria under policy discretion. In one, no individual chooses to locate on the floodplain and the dam is not built. In the other, all individuals choose to locate on the floodplain and the dam is built. As in Section 2, the equilibrium with floodplain location and dambuilding results in lower utility.

Of course, it would be desirable for individuals to coordinate their actions and for each person to choose $p = 0$. But, the $p = 1$, $d = 1$ example is one that involves a "coordination failure" in the sense of Cooper and John (1988). As in the monetary policy analysis of King and Wolman (2004), it is strategic complementarity that leads to coordination failure, making it optimal for any single individual to align his location action with those of his fellow citizens. Further, it is discretionary policy that leads to this strategic complementarity, as was also true in the monetary policy case.

4. DISCUSSION AND CONCLUSIONS

Working with an example discussed by Kydland and Prescott (1977), this article provides a simple model economy in which there is a single, efficient equilibrium under commitment and multiple equilibria under discretionary policymaking. In particular, there are two equilibria that can arise, and one is clearly worse than the other.

As Kydland and Prescott (1977) suggest, it would be desirable for the government to pass a law to restrict individual location choices. If no one was allowed to live on the floodplain, then it would not matter whether a dam would be built by the discretionary government if people did live there. Thus, the model economy displays the property—stressed in the literature on the Samaritan's dilemma that begins with Buchanan (1975)—that limitations on individual choice may be warranted in settings where policymakers lack the ability to commit their future actions.

The analysis has focused on a government that maximizes the welfare of the agent, as is natural when all agents are the same. Yet, the tendency would also arise in more concretely political environments. For example, if agents are allowed to vote on whether a dam should be built *after* their location decisions, then it is clear that there would be unanimous support for the dam if $\overline{p} = 1$ and unanimous opposition if $\overline{p} = 0$. If individuals were allowed to vote on a floodplain prohibition law (of the form suggested by Kydland and Prescott) *before* location decisions, then there would be unanimous support for that rule, even though it limited individual choice. That is, the detailed timing of opportunities for political decisionmaking would be relevant for outcomes in this economy.

We now understand that there is a potential for a multiplicity of equilibrium outcomes in many settings in economic analysis as diverse as monetary policy and flood control. For positive studies of discretionary policymaking, this means that there may be previously unstudied equilibrium outcomes. It is possible, for example, that an extension of the analysis of King and Wolman (2004) might be used to study "inflation scares," as put forward by Goodfriend (1993), in which informational events induce endogenous switches between low-inflation and high-inflation equilibria. In terms of the design of institutions for policymaking in discretionary environments, it is necessary to guard against adverse equilibrium outcomes.

APPENDIX: GOVERNMENT DECISIONMAKING

The focus of the main text is on a situation in which there are many private agents and a government that acts in a discretionary manner (taking its dam-building action after the private sector's location decision). However, the text restricts attention to situations in which there are symmetric equilibria (those with $0 < \overline{p} < 1$) so that it is relatively simple to describe government decisionmaking: it simply acts to maximize welfare as if there was a single agent. Further, the government is restricted to financing the dam (if it builds one) via lump-sum taxes that are common across all agents.

The purpose of this Appendix is to explore how the dam-building decision for a discretionary government is altered when there is an intermediate fraction of agents ($0 < \overline{p} < 1$) that chooses to live on the plain and when there are other financing schemes. In all settings, there is a continuum of agents indexed by i, with $0 \leq i \leq 1$ that are making the location decision between the plain and elsewhere (which we will call the hill in this Appendix).

A1: The Basic Model With Lump-Sum Taxation

In this subsection, we maintain the text assumption that all agents receive a tax bill equal to $d\psi$. (Each agent pays a lump-sum tax equal to government expenditure irrespective of his location decision.) In the main text, attention is restricted to symmetric equilibria so that $\overline{p} = 0$ or $\overline{p} = 1$, but we now relax that assumption.

Since we are studying discretionary equilibria, we assume that the government takes $\overline{p}$ as given and chooses the optimal d. Since agents are heterogeneous by location, we assume here that the government maximizes average utility, $\overline{p}u(c_p + b) + (1 - \overline{p})u(c_h)$, where c_p and c_h are the amounts of consumption by plain and hill residents, respectively. In particular, if $d = 0$, then the welfare of private agents living on the hill is $u(y)$ and that of those living on the plain is $u(f + b)$ so that average utility is

$$\overline{p}u(f + b) + (1 - \overline{p})u(y).$$

By contrast, if $d = 1$, then average utility is

$$\overline{p}u(y + b - \psi) + (1 - \overline{p})u(y - \psi).$$

To understand the optimal choice of the government, consider the function $\Delta(\overline{p})$, defined as the average utility with a dam less the average utility without a dam. It is clear that Δ is linear in $\overline{p}$. It is also clear that $\Delta(0) = u(y - \psi) - u(y) < 0$, and that $\Delta(1) = u(y + b - \psi) - u(f + b) > 0$, so that there is a single value, $\widetilde{p}$, such that $\Delta(\widetilde{p}) = 0$.

Hence, for all $\overline{p} < \widetilde{p}$, then, it is optimal for the government not to build the dam and for all $p > \widetilde{p}$, it is optimal for the government to build it.

Further, suppose that individual i takes $d, \overline{p}$ as given and chooses optimally. Then, his optimal strategy is

$$\begin{aligned} p &= 0 \text{ if } \overline{p} < \widetilde{p} \\ p &= (0, 1) \text{ if } \overline{p} = \widetilde{p} \\ p &= 1 \text{ if } \overline{p} > \widetilde{p}. \end{aligned}$$

If $\overline{p} = \widetilde{p}$ then agents can be viewed as playing mixed strategies, selecting a probability of living on the plain of $\overline{p} = \widetilde{p}$. Alternatively, some agents can simply choose to live on the plain while others don't. But, in any event, consideration of nonsymmetric equilibria indicates that there is a third equilibrium possibility not considered earlier. Since individuals are indifferent to location when $\overline{p} = \widetilde{p}$ and the government is indifferent about whether to build the dam or not, then there is a third equilibrium at which $\overline{p} = \widetilde{p}$ and we are not able to say whether the dam is built. This particular equilibrium seems less interesting, as it is "unstable" in a particular sense: if $\overline{p} = \widetilde{p} \pm \varepsilon$, for a small number ε then it is no longer optimal for an individual to choose the action required by this equilibrium. It is for this reason that we ignore such equilibria in the main text.

The consideration of nonsymmetric equilibria also makes it clear that the Nash equilibria $\overline{p} = 0, d = 0$ and $\overline{p} = 1, d = 1$ are stable with respect to changes in behavior by small fractions of the population. If $\overline{p} = \varepsilon$, the government would continue to choose $d = 0$, and if $\overline{p} = 1 - \varepsilon$, the government would continue to choose $d = 1$.

A2: Taxation Just on Floodplain Residents

Suppose, alternatively, that it is possible to tax only residents of the floodplain, but not the other residents of the community. This fiscal restriction can be understood in two ways. A direct interpretation is that it is just a particular posited fiscal policy. A more subtle implication is that the government chooses this taxation so as to maximize social welfare (as in the next section) subject to the requirement that it must not lower the welfare of any agent and the recognition that individuals can always generate welfare of $u(y)$ by staying on the hill.

In this situation, then, the government maximizes the welfare of floodplain residents:

$$du(y + b - d\frac{\psi}{\overline{p}}) + (1 - d)u(f + b).$$

From the standpoint of these residents, the cost of the dam is now higher because there is a smaller base of individuals subject to the lump-sum tax.

Hence, the government will build the dam if

$$y + b - \frac{\psi}{\overline{p}} > f + b,$$

or if

$$\overline{p} > \frac{\psi}{y - f} = \widehat{p}$$

and it will not if $\overline{p} < \widehat{p}$. (The value of $\widehat{p}$ is positive because $y > f$ and it is less than 1 because $y - f > \psi$, which is the condition that the dam is productive if discussed in the main text.) Hence, the government's decision rule is again to build a dam if there are many floodplain residents and to not build it if there are few. However, relative to the prior case in A1, the "switch point" for the government has changed.

Importantly, the individual private agent's location decision is substantially changed by this alternative tax regime. If he remains on the hill, he gets $u(y)$ while if he moves to the plain he gets something less, irrespective of whether the dam is built. Hence, no rational agent will ever move to the floodplain.

Hence, under discretion with location-specific lump-sum taxes, the only Nash equilibrium is the efficient one in which $\widehat{p} = 0$ and $d = 0$. That is, the change in the structure of taxation has eliminated a "fiscal externality" that is partly responsible for the results in the main text.

A3: Endogenous Taxation

We now consider a discretionary government that chooses the levels of lump-sum taxation so as to maximize the utility of the average agent in the economy, taking as given that there is a fraction of agents, $\overline{p}$, that lives on the plain. As above, this average utility is

$$\overline{p}u(c_p + b) + (1 - \overline{p})u(c_h),$$

where c_p and c_h are the amounts of consumption goods that the government allocates to residents of the plain and hill, respectively. The resource constraint of the economy takes the form

$$\overline{p}c_p + (1 - \overline{p})(c_h) \leq (1 - \overline{p})y + \overline{p}\{dy + (1 - d)f - d\psi\}.$$

That is, the total amount of consumption must be less than the income earned by hill and plain residents, net of any cost of dam building.

A Pareto-optimal allocation mandates that "full" consumption be equated across plain and hill residents:[7]

$$(c_p + b) = c_h.$$

Hence, the amount of consumption available for hill residents is given by

$$\begin{aligned} c_h &= \overline{p}b + y - \psi \text{ if } d = 1 \text{ and} \\ c_h &= \overline{p}b + (1 - \overline{p})y + \overline{p}f \text{ if } d = 0 \end{aligned}$$

Accordingly, the government will maximize consumption and welfare by choosing to build the dam if $\overline{p} > \widehat{p}$ and not to build the dam if $\overline{p} < \widehat{p}$.

The associated taxes by location are

$$\begin{aligned} T_p &= y - c_h - b \\ T_h &= y - c_h \end{aligned}$$

with the amounts of consumption, c_h, depending on the dam-building decision in ways specified above.

Confronted with this government fiscal policy and dam-building decision rule, the individual's behavior is as in the basic model of A1 with lump-sum taxation but with $\widehat{p}$ replacing $\widetilde{p}$: individuals find it desirable to locate on the plain if $\overline{p} > \widehat{p}$ and to locate on the hill if $\overline{p} < \widehat{p}$. Hence, the equilibria are the same as in the main text.

A4: Comparing the Fiscal Regimes

Looking across the three fiscal regimes, we can see that the results of the main text are broadly sustained, except when the government is required to levy location-specific taxes in ways that fully discourage location on the plain. In terms of the discussion of Kydland and Prescott (1977) quoted in the main text, the critical point is that the fiscal policy cannot be equivalent to passing a law "prohibiting construction of houses in the floodplain." That is, the fiscal regime must not fully punish individuals for the action of locating to the floodplain.

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[7] Effectively, floodplain residents have consumption equal to $c + b$, with c being market consumption and b being the consumption value of living on the floodplain.

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