A Dynamic Analysis of Protection and Environmental Policy in a Small Trading Developing Country[1]

by

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Abstract

We analyze a dynamic model of protection and environmental policy in a small trading developing country (DC). The DC government protects the import competing (and the polluting) sector of the economy with a tariff. The employment and output effects of three different pollution taxes are analyzed. These taxes incorporate different assumptions about the DC government's ability to commit to its announced policy. First, we describe the taxes, we study the dependence of these taxes on the tariff, and we show that in general an activist environmental policy is called for, irrespective of the length of time to which the government can commit to its announced policy. Second, we identify a situation in which the conduct of environmental policy raises welfare unambiguously, and the situations in which it does not do so. Finally, we show that the time inconsistency of certain optimal programs can prevent the DC government from achieving its environmental and employment objectives.

Keywords: Commitment, Developing Country, Environmental Policy, Protection

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1. Introduction

Four issues about environmental policy in developing countries (hereafter DCs) have increasingly come to dominate public debate in both the developing and the developed world. As Miller (1995) has noted, the first issue is the perception in many developed countries that DCs are not doing enough to protect their environmental resources. The second issue—see Batabyal (1995)—concerns the potential effects of protection and trade on environmental policy. Specifically, how should a trading DC conduct environmental policy when its protected import competing sector is also the polluting sector?

The third issue concerns the need for creating employment opportunities in DCs. In this connection, Bhalla (1992), Renner (1992), and Mehmet (1995) have argued that DC governments must make a concerted attempt to design and implement policies that generate employment. The fourth issue concerns the apparent tradeoff between employment creation and environmental protection. Several researchers have noted that in addition to implementing employment creating policies, in order to protect the environment, DC governments will also have to implement environmental policies. The developed country experience with environmental policies tells us that these policies can have a negative effect on employment (Christainsen and Tietenberg, 1985; Bonetti and FitzRoy, 1999). This finding has led many to argue that in the face of pressing employment creation needs, DC governments are unlikely to be serious about environmental protection. Put differently, although DC governments may begin the process of instituting environmental policies, their commitment to such policies is likely to be limited.

To address these issues rigorously, we shall analyze a dynamic model of environmental policy in a small trading DC. This model links a DC government's period of commitment to its announced environmental policies. As Lekakis (1991) and Mehmet (1995) have noted, this kind of model, and indeed these issues, have received scant attention in the theoretical literature. Recently, Batabyal (1998) has conducted a dynamic analysis of environmental policy in DCs. Using specific assumptions about the form of the revenue functions, this paper obtains results about the nature of optimal intertemporal environmental policy.

In this paper, we generalize this previous analysis. In particular, we make no assumptions about the form of the underlying revenue functions. We study the conduct of environmental policy by a small trading DC in which a tariff protects the import competing and the polluting sector. The specific question that we address is the following: What are the properties of optimal dynamic environmental policy when a DC government controls pollution by taxing the production of the good manufactured by the protected sector, and when this government is not necessarily able to commit to the pollution tax policy that it announced at the beginning of its tenure in office?

The rest of this paper is organized as follows: Section 2 contains a detailed description of the theoretical framework. Sections 3 through 5 study a dynamic model of environmental policy by the government of a stylized DC, under three different assumptions about the ability of this government to commit to its initially announced policy. Section 6 offers concluding comments and suggests directions for future research.

2. The Theoretical Framework

Our model follows previous papers such as Mussa (1982), Karp and Paul (1994), and particularly Batabyal (1998) that study government policies in a dynamic framework. We use a dynamic version of the Ricardo-Viner model to study a small trading DC. To stress the employment aspect of the underlying story, we suppose that the DC economy is dualistic. That is, the two DC sectors consist of a modern, high wage, environmentally intensive sector in which production causes pollution. This polluting sector is also the import competing sector. The government uses a positive tariff to protect this sector. One possible interpretation of this sector is that it is the DC's "infant industry." The second sector is the traditional, low wage, environmentally benign sector that is free of pollution. This traditional sector—possibly the agricultural sector—is the DC's export sector. The political clout of the import competing sector is such that the government is unable to remove the tariff any time in the foreseeable future. As such, in what follows, we suppose that the tariff is exogenously given.[4]

To earn higher wages, workers migrate from the traditional sector to the modern sector. This migration results in increased employment in the modern sector, increased production, and hence greater pollution. In their role as consumers, workers are adversely affected by pollution. Nevertheless, in this paper, they do not account for pollution in their migration decisions. This means that the marginal migrant pays less than the marginal social cost of migration. In this situation, ideally, one would want to tax pollution directly. However, in many DCs, the government does not possess the means to tax pollution directly. Consequently, we assume that the DC government functions in a second best environment in which it controls pollution with a production tax.

At first, the government does not correct the distorted incentives that producers face as a result of the presence of pollution. This is why the DC economy is initially in disequilibrium. A move toward equilibrium requires that the production of the polluting good decline over time. Seen from a different perspective, a move toward equilibrium involves slowing the rate at which workers migrate from the

[4] Note that the purpose of this paper is to study environmental policy when the polluting sector is protected; we are not interested in the dynamics of trade policy *per se.* This is the reason for treating the tariff as exogenous.

traditional sector to the modern sector. Workers have rational expectations. Because our model is deterministic, this means that workers have perfect foresight.

Each sector of the DC uses a fixed input and a mobile input (labor) to produce a single good with decreasing returns to scale. Superscripts on production variables denote the sector and superscripts on consumption variables denote the agent. Subscripts denote partial derivatives. $L^i(t)$, i=1,2, is the labor used by the ith sector at time t. Time is continuous. $\hat{L}$ is the DC's fixed labor endowment. This means that $L^1(t)+L^2(t)=\hat{L}$. Good 2 is the import competing and the polluting good. Let $\tau_e(t)$ denote the pre-existing tariff that protects sector 2. The government's environmental policy instrument is a pollution tax, $\tau_p(t)$, that is levied on the production of good 2.

Following Karp and Paul (1994) and Batabyal (1998), we use duality theory to model consumption and production decisions in the DC. The production function in the ith sector, i=1,2, is $f^i(L^i)$. The world price of good 2 is $p=p^2/p^1$, where $p^1=1$. Let $L^2=L$, and let $L^1=\hat{L}-L$. Finally, denote the two revenue functions by $R^1(1,\hat{L}-L)$ and $R^2(p+\tau_e-\tau_p,L)$, respectively. From Dixit and Norman (1980, chapter 2) we know that $R_1^i(\cdot)$ and $R_2^i(\cdot)$ are the output supply of good i and the wage in sector i, respectively.

There is a continuum of identical workers in each sector in the DC and a single capitalist is the residual claimant. All agents have homothetic preferences. Then, following Dixit and Norman (1980, p. 326), the expenditure function of agent j, j=1,2,3, is $\bar{E}(p+\tau_e,1,u^j)=U^jE(p+\tau_e)$, where $E(\cdot)$ is the unit expenditure function and U^j is agent j's real income. Our DC's national income is $U\equiv(\hat{L}-L)U^1+LU^2+U^3$. The superscript j stands for the representative worker in sector j=1,2, and j=3 stands for the capitalist.

The private value of migration for a worker at time t is $m(t)$. That is, $m(t)$ denotes the discounted value of the wage differential between the high wage polluting sector and the low wage non-polluting sector.

Formally, we have

$$m(t)=\int_t^{\infty} e^{-r(s-t)}\{R_2^2(\cdot)-R_2^1(\cdot)\}ds, \tag{1}$$

where r is the discount rate. Equation (1) is more conveniently expressed as a differential equation. That equation is

$$\dot{m}=rm+R_2^1(\cdot)-R_2^2(\cdot). \tag{2}$$

A worker will migrate to the high wage sector only when the private value of migration, $m(t)$, is at least as high as the private cost of migration. Nevertheless, because workers do not account for pollution in their migration decisions, the social cost of migration is unequal to the private cost of migration. Let the social cost of migration be quadratic. Then $C(\dot{L})=\alpha(\dot{L})^2$, $\alpha>0$. Here, we are thinking of migration as the rate of change in the sector 2 labor stock. Because the average social cost of migration, $\alpha\dot{L}$, is smaller than the marginal social cost, $2\alpha\dot{L}$, in the absence of government intervention, migration for high wage employment in the polluting sector occurs too rapidly and increases environmental degradation.

To account for the fact that the private cost of migration is less than the social cost, suppose that workers base their migration decision on a fraction δ, $0<\delta<1$, of the marginal social cost $2\alpha\dot{L}$. This means that the migrating workers do not internalize the externality arising in part from their decision to migrate. Let us now equate the private value of migration with the private cost of migration. This gives us the following equation for the dynamics of labor migration:

$$\dot{L}=\frac{m}{2\alpha\delta}. \tag{3}$$

Because we are analyzing a trading DC and because we are disallowing the possibility of international borrowing, in equilibrium, trade must be balanced. In other words

$$D(U,L,m,\tau_e,\tau_p)=UE(\cdot)+\frac{m^2}{4\alpha\delta^2}-R^1(\cdot)-R^2(\cdot)-\tau_e[UE_1(\cdot)-R_1^2(\cdot)]-\tau_p R_1^2(\cdot)=0 \tag{4}$$

must hold. The first term on the right hand side (RHS) of this "balance of trade deficit" equation refers to consumption expenditures. Equation (3) tells us that $C(\dot{L})=m^2/4\alpha\delta^2$. Therefore, the second term on the RHS of equation (4) denotes the social cost of pollution. The third and the fourth terms give the value of production. Finally, the fifth and the sixth terms denote the tariff and the tax revenues. We assume that these revenues are redistributed in lump sum fashion.

Our aim now is to study the DC government's optimal dynamic environmental policy under three assumptions about its ability to commit to a particular course of action. In the first case, the government commits to a tax trajectory or program for an infinite period of time. This infinite period of commitment should be interpreted as a case in which environmental protection is enshrined in the constitution. As noted in Batabyal (1998), if the DC in question were India, then this period would be 1976. This is because until 1976, environmental protection did not appear anywhere in the Indian constitution. Obviously, when environmental protection is enshrined in the constitution, it does not matter which government is in power because the constitution will have to be followed. In the second case, the DC government commits to a tax trajectory for a finite period of time. This finite period of commitment is more plausible and it should be thought of as the length of time during which a particular government is in office. Regrettably, in both these cases, the government's optimal tax policy is time inconsistent. To grasp this, consider the tax trajectory that the government announces at time $t=0$. Time inconsistency means that at some time $\varepsilon>0$, the government will depart from the trajectory it announced at $t=0$. As a result, the government's announced policy at time $t=0$ is not credible. This means that forward looking workers will not believe that the government will actually carry through with its initially announced policy. Therefore this policy will fail to accomplish its intended objectives.

Since the credibility of government policy has been a salient issue in many DCs, *a priori*, it would seem necessary to study the implications of the DC government following a time consistent course of action. This is the third case that we study. In this scenario, the government commits to its tax policy for an infinitesimal period of time. In the limiting case in which the period of commitment approaches zero, the government's tax policy is time consistent. This completes the discussion of our theoretical framework. We now turn to the DC government's problem when it can commit to its tax policy for an infinite period of time.

3. The Infinite Commitment Case

In this case, the DC government makes a binding commitment and chooses its tax trajectory from time $t=0$ to $t=\infty$, at $t=0$. This is the government's open loop tax policy. The open loop pollution tax is a function of calender time only. Recall that workers have perfect foresight and that they are forward looking. Further, because the economy is in disequilibrium at $t=0$, the initial value of L, $L(0)=L_0$, is unequal to its steady state value in the polluting sector of the economy.

The decision to migrate is an investment decision. So, the private value of migration at any time t, $m(t)$, is determined by the current and the future values of the pollution tax. This means that the constraint in equation (2) is a jump state constraint.[5] Formally, this means that the initial value of m, $m(0)$, is endogenous to the problem. In this setting, the DC government solves

$$\max_{U,\tau_p} \int_0^\infty e^{-rs} U ds, \tag{5}$$

subject to equations (2)-(4), with initial condition $L(0)=L_0$. The current value Hamiltonian for this problem is

$$\mathrm{H}=U-\lambda[UE+\frac{m^2}{4\alpha\delta^2}-R^1-R^2-\tau_e UE_1+\tau_e R_1^2-\tau_p R_1^2]+\sigma_1\{\frac{m}{2\alpha\delta}\}+\sigma_2\{rm+R_2^1-R_2^2\}, \tag{6}$$

where λ is the Lagrange multiplier on constraint (4), and σ_1, σ_2 are the costate variables associated with constraints (3) and (2) respectively. The first order necessary conditions are

$$\lambda=\frac{1}{E(p+\tau_e)-\tau_e E_1(p+\tau_e)}, \tag{7}$$

$$\lambda\{(\tau_e-\tau_p)R_{11}^2(\cdot)\}+\sigma_2 R_{21}^2(\cdot)=0, \tag{8}$$

$$\dot{\sigma}_1=r\sigma_1+\sigma_2 h(\cdot)+\lambda\{d(\cdot)+(\tau_e-\tau_p)R_{12}^2(\cdot)\}, \tag{9}$$

5 Many problems in economics are characterized by the existence of jump states. For instance, in monetary economics, the exchange rate is a jump state because it is affected by current interest rates and agents' expectations of the future money supply. For more on jump state constraints, see Karp and Newbery (1993) and Karp and Paul (1994).

and

$$\dot{\sigma}_2 = \frac{\lambda m}{2\alpha\delta^2} - \frac{\sigma_1}{2\alpha\delta}, \tag{10}$$

where $\boldsymbol{d}(\cdot) \equiv \boldsymbol{R}_2^1(\cdot) - \boldsymbol{R}_2^2(\cdot)$, and $h(\cdot) \equiv \boldsymbol{R}_{22}^1(\cdot) + \boldsymbol{R}_{22}^2(\cdot)$. In other words, $-\boldsymbol{d}(\cdot)$ is the current private value of migration, and $h(\cdot)$ denotes the sum of the slopes of the marginal products of labor in the two sectors. Note that $h(\cdot) = \partial\{-\boldsymbol{d}(\cdot)\}/\partial L < \mathbf{0}$.

Our primary interest lies in describing the optimal pollution tax trajectory, and in studying the dependence of this tax on the tariff $\tau_e(t)$. To this end, let us denote steady state values with the superscript S. From equation (3), we get $m^S = \mathbf{0}$. Equation (2) gives $\boldsymbol{d}^S(\cdot) = \mathbf{0}$. Equation (10) implies that $\sigma_1^S = \mathbf{0}$. From equation (8) it follows that $\sigma_2^S = [-\lambda\{(\tau_e - \tau_p)\boldsymbol{R}_{11}^2\}/\boldsymbol{R}_{21}^2]^S$. From equation (9), we get $\sigma_2^S = [-\lambda\{(\tau_e - \tau_p)\boldsymbol{R}_{12}^2/h]^S$. Setting these last two expressions equal, we get $\tau_p^S = \tau_e^S$. From equation (8), it follows that $\tau_p(t) = \tau_e(t) + \sigma_2(t)\boldsymbol{R}_{21}^2/\lambda(t)\boldsymbol{R}_{11}^2$. Because $m(\mathbf{0})$ is free, as Simaan and Cruz (1973) have noted, the right boundary condition for σ_2 is $\sigma_2(\mathbf{0}) = \mathbf{0}$. In other words, the DC government chooses its pollution tax trajectory so that the social shadow value of m at the beginning of the program is zero. Using $\sigma_2(\mathbf{0}) = \mathbf{0}$, we get $\tau_p(\mathbf{0}) = \tau_e(\mathbf{0})$.

3.1. Discussion

Inspection of the expressions for $\tau_p(\mathbf{0})$, $\tau_p(t)$, and τ_p^S from the previous paragraph tells us that in an optimal program, the government's pollution tax depends on the existing tariff τ_e, in a straightforward manner. First, at the beginning and at the end of the program, the magnitude of the optimal pollution tax is equal to the magnitude of the existing tariff and both are positive. Second, in general $\sigma_2(t) > \mathbf{0}$, $\boldsymbol{R}_{21}^2(\cdot) > \mathbf{0}$, $\lambda(t) > \mathbf{0}$, and $\boldsymbol{R}_{11}^2(\cdot) > \mathbf{0}$. This means that $\{\sigma_2(t)\boldsymbol{R}_{21}^2(\cdot)/\lambda(t)\boldsymbol{R}_{11}^2(\cdot)\} > \mathbf{0}$. So the optimal pollution tax at an intermediate point in the program will generally be larger than the existing positive tariff. Putting these two pieces of information together, we conclude that in an optimal program, the government begins with a positive pollution tax that is equal in magnitude to the tariff, then raises this tax, and finally lowers this tax so that in the steady state the pollution tax and the tariff are once again equal in magnitude and positive.

There are two distortions in our DC economy—the tariff and pollution—and the government has available to it a single policy instrument, namely, the pollution tax. Therefore, standard welfare economics tells us that in general, the government will not be able to use environmental policy to raise welfare unambiguously. The results of the previous paragraph should be interpreted in the context of this second best environment in which the DC government operates. At $t=0$, we have $\tau_p(0)=\tau_e(0)>0$. The positive tariff results in excess production of the good manufactured by the import competing sector. Consequently, here, the positive pollution tax simply offsets this excess production effect of the tariff. This tax is unable to simultaneously deal with the pollution distortion. As such, the pollution distortion remains unaddressed.

At $t=\infty$, once again we have $\tau_p^S=\tau_e^S>0$. Now, the situation is different. In the steady state, all adjustments in the economy have taken place and there is no rationale for migrating to the polluting sector because $m^S=0$. In other words, there is no pollution externality and hence the partial internalization of this externality by the workers is not an issue. There is only one distortion in the steady state (the tariff) and as in the $t=0$ case discussed in the previous paragraph, the positive pollution tax offsets the excess production effect of the tariff. Note that in this steady state, and only in this steady state, environmental policy unambiguously improves welfare because it addresses the only distortion in the DC economy.

At any $t\in(0,\infty)$, both distortions are present in the DC economy. Also note that both these distortions affect the output of the polluting good in the same way: they result in over-production. This is why in general we have $\tau_p(t) > \tau_p(0) = \tau_p^S > 0$. The pollution tax at any intermediate point in the optimal program attempts to address both distortions in the economy; however, this single instrument does so only imperfectly. This explains why $\tau_p(t)$ is larger in magnitude than the two pollution taxes at the beginning and at the end of the government's program.

In this open loop case that we have been studying so far, there is no welfare loss to society from the government's inability to commit to its announced policy. This is because the open loop policy incorporates perfect commitment. Consequently, the case for doing nothing, i.e., setting a zero pollution tax, which potentially arises when the government cannot commit, is ruled out. In other words, intuitively, we expect the government's optimal environmental policy to be activist. From the analysis thus far, we see that this is indeed the case because in general $\tau_p(0)$, τ_p^S and $\tau_p(t)$, $\forall t \in (0,\infty)$, are all positive.

From the standpoint of policy credibility, if the DC government's open loop tax policy is believed by the migrating workers, then this policy will achieve its objectives. In particular, this tax will reduce output and employment in sector 2 and slow the rate of migration from the non-polluting sector 1 to the polluting sector 2. However, the government's objectives will not be met because this government will have an incentive to depart from the policy it announced at $t=0$. To comprehend this, note that for any initial value of L, $L(0) \neq L^S$, the optimal initial shadow value of $m(t)$, $\sigma_2(t)$, is zero. However, because $\delta < 1$, on the announced tax trajectory, $\sigma_2(t) \neq 0$. Consequently, at any time $\varepsilon > 0$, the government will want to depart from the tax trajectory it announced at $t=0$, and announce a new trajectory. Put differently, the government's open loop tax policy is time inconsistent. This means that unless there is some mechanism by which the DC government can be bound to its initially announced pollution tax trajectory, this government will fail to achieve its environmental and employment objectives.

From a practical perspective, this case of perfect commitment is clearly farfetched because no government can realistically be expected to commit to its policy for an infinite period of time. Consequently, we now examine the case in which the DC government commits to its announced policy at the beginning of its tenure in office, for a finite period of time. This is the limited commitment case.

4. The Limited Commitment Case

Given that governments are in office for a finite period of time, the most sensible period of commitment matches the length of time during which a particular government is in office. Consequently, let us now analyze the limited commitment case in which the DC government commits to a policy for $T \in (0, \infty)$ time periods.

When the period of commitment is finite, the ensuing equilibrium is a function of the manner in which agents form their expectations. If migrating workers establish their expectations of future taxes on the history of taxes, then there will generally be multiple equilibria. To get around this problem, we shall limit our attention to smooth Markov perfect equilibria. In this context, Markov means that the decision rules of the agents at any time t, depend only on the current value of the stock of labor (the state variable), and not on the manner in which the current stock of labor was attained. A prospect for an equilibrium is perfect if this prospect is an equilibrium for any subgame, i.e., for any level of the stock of labor. Specifically, whether or not some agents have departed from their equilibrium strategies in the past, the continuation of these strategies represents equilibrium behavior on the part of all the agents involved. From a practical perspective, this Markov assumption is of value because it makes the DC government's optimal program unresponsive to agent's mistakes.

Given this restriction of Markov perfection, we are now in a position to describe the equilibrium that emerges when the government commits to its tax policy for T periods. At time periods $0,\ T,\ 2T,...,$ consecutive governments choose their own tax policies. This means that at each $iT,\ i=0,1,2,...,$ the ith government completes its tenure in office and a new government selects its tax policy for the next T time periods. At the end of T periods, each government bequeaths L_T, the current stock of labor, to its successor government. This government then conducts environmental policy for the next T periods, and so on.

With this interpretation of the limited commitment case, let $V(L)$ be the value of the government's program when its period of commitment is T periods and when the initial level of labor in the polluting sector is L. The government now solves

$$V(L)=\max_{\tau_p,U}\int_0^T e^{-rt}U dt+e^{-rT}V(L_T), \tag{11}$$

subject to equations (2)-(4). $V(L_T)$ is a bequest function that denotes the value of the stock of labor in sector 2 bequeathed by an arbitrary government to its successor. Note that problem (11) is the same as the problem in section 3, with the exception that the government's period of commitment is now T and not infinity. This change will alter the boundary conditions at the horizon of the program; however, the first order necessary conditions themselves remain as in equations (7)-(10).

As in section 3, $m(0)$ is free. Hence, it is optimal to select the tax trajectory so that $\sigma_2(0)=0$. Using this last condition in equation (8), we get $\tau_p(0)=\tau_e(0)$. Once again, as in section 3, $\tau_p(t)=\tau_e(t)+\sigma_2(t)R_{21}^2/\lambda(t)R_{11}^2$. Finally, to determine $\tau_p(T)$, let $M(L)$ be the equilibrium current value of m that is determined by the answer to problem (11).[6] In our case, we can write $V(L) \equiv \bar{V}\{L, M(L)\}$, for some function $\bar{V}\{\cdot\}$. At the beginning of a specific time period iT, $i=0,1,2,\ldots$, $\sigma_2(iT)=0$. Further, the assumed smoothness of the value function gives $\sigma_2 = \partial\bar{V}/\partial M$ (Karp and Paul, 1994, p. 1388; Batabyal, 1998, p. 15). This means that the social shadow value of M is equal to the marginal value of M in the bequest. Finally, the transversality condition for σ_2 is $\sigma_2(T) = \partial\bar{V}/\partial M = 0$. Using this condition in equation (8), we get $\tau_p(T) = \tau_e(T)$.

4.1. Discussion

Comparing the three tax expressions in the previous paragraph with the corresponding tax expressions from section 3, we see that a diminution in the length of the government's period of commitment results in no qualitative change in $\tau_p(0)$, $\tau_p(t)$, or in $\tau_p(T)$. Consequently, in general, the analysis of section 3.1 applies to this limited commitment scenario as well. However, there is one point of difference. In section 3, in the steady state $m^S=0$ and hence in this case there is a single distortion in the economy (the tariff) and the pollution tax clearly raises welfare. However, in the limited commitment case, in general, we will not have $m(T)=0$. Consequently, in this case, in an optimal program, the government operates in a second best environment at all points in time. From a welfare perspective, this means that the DC may or may not be better off with the government's activist environmental policy.

Note the significant role played by the endogenous function of the state variable, $M(L)$. This function performs the role of an "expectations" function. When the DC government solves its maximization problem taking this expectations function as exogenous, the optimal program results in an initial value of

6 The properties of this endogenous function of the state have been discussed in detail in Karp and Newbery (1993) and in Karp and Paul (1994). Consequently, we omit an elaborate discussion.

m, $m(0)$, that satisfies $m(0)=M\{L(0)\}$. Put differently, in equilibrium, every agent's point expectations are satisfied. Further, this same optimal program results in a terminal value of m so that $\partial\bar{V}(\cdot)/\partial M=\sigma_2(T)=0$. This means that at the horizon of the program, the shadow value of the state M, equals the marginal value of M in the bequest function, and these two values equal zero.

Even though this limited commitment scenario is believable, the attendant Markov perfect equilibrium is time inconsistent. To see why, think of this Markov perfect case as one in which an infinite sequence of governments conducts environmental policy during a time period of length T. Denote the tenure of each government in this sequence by $\{iT\}_{i=0}^{\infty}$. When $T>0$, each government behaves consistently at each i, but not within a period of length T. In other words, the DC government begins its term of office with the best of intentions, but some time later, it will renege on the policy it announced at the beginning of its term of office. As a result, forward looking agents will not believe that the government will actually carry through with its initially announced policy. From the standpoint of believability, this means that the government will fail to accomplish its policy objectives. In particular, even with an activist environmental policy, pollution and employment in sector 2 will not be reduced, and the government will not succeed in slowing the migration rate from the low wage traditional sector to the high wage polluting sector.

So far we have seen that the time inconsistency of the government's optimal environmental policy can prevent the DC government from attaining its environmental and employment goals. How can the time inconsistency of the government's optimal tax policy be eliminated? We now show how this can be done by studying a case in which the DC government commits to its environmental policy for an infinitesimal period of time. In this setting, we analyze the limiting Markov perfect equilibrium in which the government's period of commitment shrinks to zero.

5. The Infinitesimal Commitment Case

Intuitively, we expect the government's equilibrium pollution tax to be a function of three elements. The first element—the presence of pollution—generally calls for an activist policy that will correct for this negative externality. The second element—the government's inability to commit to its tax trajectory—would appear to favor a "do nothing" course of action. The third element—the presence of the tariff—encourages over-production of the import competing good; consequently, in general, this element also calls for an activist course of action. Given this situation, we now ask the following question: When the government's period of commitment is infinitesimal, is it ever optimal to set a zero pollution tax? In other words, is it possible for the "do nothing" course of action to dominate the activist course of action?

In our study of this infinitesimal case, we shall follow Karp and Paul (1994) and Batabyal (1998). We begin with a discrete stage formulation of the DC government's problem.[7] Denote the government's period of commitment and the length of each stage by ε. Further, suppose that all agents act at the beginning of each time period of length ε. Then, at time t, the government faces constraints (3) and (2). In discrete form, these two constraints are

$$L_t = \left\{\frac{m_t}{2\alpha\delta}\right\}\varepsilon + L_{t-\varepsilon}, \tag{12}$$

and

$$m_t = e^{-r\varepsilon} m_{t+\varepsilon} - d_t(\cdot)\varepsilon, \tag{13}$$

where $d_t(\cdot) = R_2^1(\cdot) - R_2^2(\cdot)$. In equation (12), $\{m_t/2\alpha\delta\}\varepsilon$ stands for the number of migrants in a period of length ε.

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[7] For additional details on the underlying methodology, see Karp and Newbery (1993).

Similarly, in equation (13), $-d_t(\cdot)\varepsilon$ refers to the value of the flow of the wage differential in a time period of length ε. At time t, with period of commitment ε, the government's dynamic programming problem is

$$V(L_{t-\varepsilon})=\max_{U,\tau_p}[U-\lambda\{D(U,L,m,\tau_e,\tau_p)\}]\varepsilon+e^{-r\varepsilon}V(L_t), \tag{14}$$

subject to equations (12) and (13). Observe that the function $D(\cdot)$ represents the "balance of trade deficit" constraint described by equation (4), that $m_{t\cdot\varepsilon}=M(L_t)$, and that the government takes the function $M(\cdot)$ as exogenous. After some algebra, the first order necessary condition to problem (14) w.r.t. τ_p can be written as

$$[\lambda\{(\tau_e-\tau_p)R_{11}^2-\frac{\partial D}{\partial L_t}\cdot\frac{dL_t}{d\tau_p}-\frac{\partial D}{\partial m_t}\cdot\frac{dm_t}{d\tau_p}\}]\varepsilon+e^{-r\varepsilon}\frac{dV}{dL_t}\cdot\frac{dL_t}{d\tau_p}=0. \tag{15}$$

In order to simplify equation (15), let us differentiate equations (12) and (13) totally. We get

$$\frac{dL_t}{d\tau_p}=\frac{\varepsilon}{2\alpha\delta}\cdot\frac{dm_t}{d\tau_p}, \tag{16}$$

and

$$\{-h_t(\cdot)\varepsilon-e^{-r\varepsilon}\frac{dM}{dL_t}\}\frac{dL_t}{d\tau_p}+\frac{dm_t}{d\tau_p}=-\{\frac{\partial d_t(\cdot)}{\partial\tau_p}\}\varepsilon. \tag{17}$$

Now substitute for $dL_t/d\tau_p$ from equation (16) into equation (17) and then simplify the resulting expression. This gives $dm_t/d\tau_p\sim O(\varepsilon)$. Similarly, substituting for $dm_t/d\tau_p$ from equation (17) into equation (16) and then simplifying the resulting expression yields $dL_t/d\tau_p\sim o(\varepsilon)$. Finally, divide both sides of equation (15) by ε, use the preceding two results about $dm_t/d\tau_p$ and $dL_t/d\tau_p$, and then let $\varepsilon\to 0$. The limiting first order necessary condition is

$$\lambda(\tau_e - \tau_p)R_{11}^2 = 0. \tag{18}$$

5.1. Discussion

Equation (18) tells us that the limiting Markov perfect pollution tax $\tau_p = \tau_e$. We see that this limiting tax is also positive and equal in magnitude to the tariff. This result enables us to provide a clear answer to the question that was posed in the first paragraph of this section. In particular, even when the DC government's period of commitment is infinitesimal, it is not optimal for the government to set a zero pollution tax. Put differently, the activist course of action dominates the "do nothing" or passive course of action.

The infinitesimal case that we are studying in this section requires the government to continuously revise its pollution tax. When this government revises its policy instrument continually, the ensuing policy is time consistent. This means that the government's environmental policy is credible. Temporarily, let us set the tariff aside and focus on the believability aspect of intertemporal environmental policy. As Karp and Newbery (1993) have noted, the payoff to an agent is monotonic in his period of commitment. Consequently, reducing the government's period of commitment can never make this government better off. With this remark and the previous discussion of policy efficacy in mind, let us rank the three policies in term's of the government's preference, and the policy's ability to achieve its objectives. From the DC government's perspective, the most desirable policy is the open loop policy because this policy leads to the highest payoff for the government. The second best policy is the Markov perfect tax policy with a finite period of commitment. The least desirable policy is the limiting Markov perfect tax policy. In contrast with this ranking, the ranking in terms of goal attainment is reversed. The limiting Markov perfect tax policy is credible. As such, this policy will be believed by the workers and hence this policy will be able to reduce pollution and slow migration to the polluting sector. The other two policy instruments are not believable; hence they will fail to achieve the government's environmental and employment goals. This discussion highlights the DC government's dilemma. The policy which results in the highest payoff to the government is the one that is least desirable from a credibility perspective.

6. Conclusions

A dynamic version of the Ricardo-Viner model was used in this paper to study a dualistic DC economy in which there is pollution and the import competing sector is protected with a tariff. We examined the conduct of dynamic environmental policy by the DC government under three assumptions about this government's ability to commit to its announced policy. Four significant policy conclusions emerge.

First, our analysis shows that doing nothing, i.e., setting a zero pollution tax, is not an optimal course of action. In every case that we analyzed and no matter what the DC government's period of commitment, we showed that the optimal pollution tax is positive.

Second, the analysis of this paper tells us that the time inconsistency of certain optimal programs may prevent the government from attaining its environmental and employment objectives. Our analysis demonstrated that as long as the private cost of migration is less than the social cost of migration, i.e., as long as $\delta<1$, the limiting Markov perfect tax policy is the only believable environmental policy. Further, we showed that when the import competing sector is protected with a tariff, in general, the government cannot use environmental policy to unambiguously raise welfare in the DC. The conduct of environmental policy raises welfare unambiguously only in the steady state. As discussed in section 3, this is because in the steady state, there is no pollution externality.

Third, from a policy believability perspective, our analysis points to the implausibility of time inconsistent, particularly open loop policies. Such policies will not be believed by forward looking agents with rational expectations. Hence, these agents will successfully thwart the DC government's policy objectives. In contrast to this, the limiting Markov perfect pollution tax policy is time consistent. In this case, the equilibrium is described by an endogenous function of the state variable and the government continuously revises its tax trajectory. Continuous revision implies credibility and this in turn means that the government's environmental policy will achieve its intended objectives.

Fourth, there is a tradeoff between policy payoff and policy believability. Credible policies yield a lower payoff than do incredible policies. This remark provides a likely explanation as to why many DC governments are loath to use time consistent policies that involve continuous policy revision.

The analysis contained in this paper can be extended in a number of directions. In what follows, we suggest two possible extensions. First, one can drop the small country assumption and analyze environmental policy in a DC whose actions affect world prices. Second, one can analyze environmental policy in a setting in which the decision to protect the import competing and the polluting sector is endogenous to the DC government. Studies which incorporate these aspects of the problem into the analysis will provide richer accounts of the connections between protection, time consistency, and dynamic environmental policy in DCs.

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