Death (Machines) and (Optimal) Taxes

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Abstract: In this paper, we consider the social welfare maximization problem facing a government confronting a potential future security threat. The government must choose how much to devote to long lead time military expenditures. The government must also choose whether to run fiscal surpluses or deficits. We show that the government may optimize social welfare by accumulating a precautionary surplus or (more surprisingly) a precautionary deficit. In the event that the government is constrained to maintain budget balance, however, the social optimum is achieved by either increasing long lead time defense expenditures above the level that minimizes expected social costs in the unconstrained case or (more surprisingly) by reducing long lead time expenditures to below the level that would otherwise minimize expected social costs.

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I. **Introduction**

When facing a looming threat of war, it would appear intuitively obvious that responsible leaders should take precautionary measures, such as beefing up defense capabilities or accumulating fiscal surpluses, in order to soften the resultant blow to social welfare should actual conflict break out.

In this paper, we consider the planning predicament confronting a government facing a long term security threat that may develop at some future date into a serious military conflict. We show that a government interested in maximizing expected social welfare may indeed respond to the security threat by enhancing long term military preparations or by accumulating precautionary fiscal surpluses. Surprisingly, however, it may respond by pursuing a diametrically opposite set of policies. Specifically, the government may maximize expected social welfare in the face of a security threat by running precautionary fiscal *deficits* or by *reducing* its long term investment in military capabilities.

In our formulation, we will assume that social welfare is a decreasing function of the total social cost of financing required military and other expenditures, where total social cost includes both direct budgetary costs as well as the welfare losses stemming from the taxation, and its associated dead weight costs, required to finance those expenditures.

We will base our approach to inter-temporal tax efficiency on the seminal analysis offered in Barro (1978) and Lucas and Stokey (1982). Barro (1978) models the dead-weight loss of taxation as an increasing function of the tax rate. This allows him to derive an inter-temporal version of the Ramsey Rule (Ramsey, 1927) known as "tax smoothing" in which tax efficiency is maximized by maintaining a constant marginal tax level over time.

Lucas and Stokey (1982) extend Barro's approach into a stochastic world and demonstrate that tax smoothing holds not only over time but over states of nature. This implies that marginal tax rates should evolve as a random walk process driven by unexpected changes in spending and tax revenue. We will model the government's social welfare maximization strategy as an attempt to implement tax smoothing under uncertainty while maintaining an adequate national defense.

When analyzed through the prism of tax smoothing, the government's problem becomes to assure that each time period and each state of nature bears its "fair share" of the expected burden resulting from the security threat. Normally, this will result in the partial shifting of the costs of conflict from the future to the present. That shift can be accomplished either though increased near term defense expenditure or through the accumulation of fiscal surpluses.

There are credible circumstances, however, where optimization requires that a portion of the spending be shifted from the present to the future, and in particular to the future state of nature in which potential threats fail to materialize. In the absence of complete security markets, the only way to achieve this is through the reduction of near term defense expenditure or through deficit spending. This then is the logic underpinning our results. The benefit from shifting burdens to the future state of nature in which security threats fail to materialize can more than offset the benefit from shifting burdens from the future state of nature in which such threats do materialize over to the present. As we will show below, the actual point at which the former consideration begins to outweigh the latter is determined by the defense utility function (which will be defined below), the probability of future conflict, the efficiency of the tax system, and the time discount rate.

This paper has five sections. In Section II, we model the government's decision making under conditions where fiscal balance is required. In Section III, we model the government's decision making when surplus and deficit spending is unconstrained. In Section IV, we exploit simulation methods to solve for the government's optimal choices of long lead time defense expenditure and budget balance. We solve for the government's choices both under conditions of budget balance and unconstrained fiscal policy. Mathematical simulation is required since the models presented in Sections II and III cannot be solved analytically. We then analyze the simulation results, which clearly demonstrate that choices regarding fiscal balance or defense spending depend critically not only on the efficiency of the tax system, but on the characteristics of the defense utility function as well. Section V concludes the paper.

II. The Government's Optimization Problem with Fiscal Balance

In this model, the government must choose how much money to devote to military preparations for a war that may take place far in the future. Following Feinerman and Lipow (2001), defense planning is modeled as a two-period process, and defense spending is divided into two types of expenditures – "long lead time" expenditures that generate future defense capability, and "short lead time" expenditures that generate near term defense capability.

Examples of long lead time expenditures would include the research of new technologies, the development of new weapons, and investment in new training facilities. Short lead time expenditures would include the actual manufacture of weapons and ammunition, as well as the funding of training and operational activities. Long lead time and short lead time defense spending are treated as inputs into a "military utility function" that models how these differing types of expenditure combine in contributing to national defense.

Expenditures on long lead time military activities must be chosen during the first period. In this version of the model, the government is unable to run fiscal surpluses or deficits. Government fiscal policy could be restrained as the result of formal limitations, such as the need to adhere to Maastricht requirements or to IMF structural adjustment programs. Alternatively, constraints on deficit spending could stem from a situation in which the additional borrowing would lead to a dynamic inconsistency in the management of the national debt. As for fiscal surpluses, it may simply be impossible to resist the political impulse of the legislative branch to fritter away savings on pet projects. As a result of this constraint, all first period expenditures must be funded by first period taxes, while all second period expenditures must be funded by second period taxes.

During the second period, the government chooses the level of short lead time defense spending. Clearly, if national security threats have subsided, little or no resources will have to be devoted to short term preparations for conflict. If, however, security conditions have eroded, short lead time defense expenditures may far exceed the level foreseen during the first period planning exercise.

Let Q equal long term defense expenditures and N represent short term defense expenditures. Let the function D(Q,N) represent the level of military capability produced by a particular combination of expenditures on long lead time and short lead time initiatives. For simplicity and clarity, D will be modeled as a CRS Cobb-Douglas function:

(1) $D(Q,N)=Q^{q}N^{n}$, where $q,n>0$ and $q+n=1$.

It should be emphasized that D is not an objective measure of physical military capability but rather a subjective measure of the social welfare “produced” by national security capabilities. Hildebrandt (1999) offers an excellent discussion of genuine military production functions and how they differ from more abstract defense utility functions of the type exploited in this paper.

There are two possible states of nature during the second period. The first is "war," and the second is "peace." The government correctly believes during the first period that the probability of war during the second period is p.[1] In the event of peace, the level of defense utility required is zero, while in the event of war the level required is D_0. This implies that N equals zero in the event of peace.[2] In the event of war,

(2) $N = D_0^{1/n} Q^{-q/n} \equiv M\, Q^{-\gamma}$, where $M \equiv D_0^{1/n}$ and $\gamma \equiv (q/n)$.

Reflecting the deadweight cost associated with taxation, the excess burden function will be

$$f = kB\left(\frac{c}{B}\right)^2 = \frac{k}{B}c^2,$$

where c denotes the amount spent in any given period on overall government expenditures, and B denotes the tax base and k is the excess burden coefficient. This formulation for excess burden is more or less standard in the public finance literature.

Given the probability of war, what is the socially optimal level of weapon quality? Let $\beta<1$ be the time discount rate, let T represent exogenous spending required to fund civilian activities, and let $\tau \equiv k/B$ represent a measure of the efficiency of the tax system. Then the government's objective is to identify the level of Q that minimizes the expected total costs

[1] Relaxation of this assumption in no way alters the model’s results.
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$$(3)\ c(Q)=T+Q+\tau(T+Q)^2+\beta p[T+MQ^{-\gamma}+\tau(T+MQ^{-\gamma})^2+\beta(1-p)(T+\tau T^2).$$

The first order condition is

$$(4)\ c'=1+2\tau(T+Q)-\gamma\beta pM[1+2\tau(T+MQ^{-\gamma})]Q^{-(1+\gamma)}=0.$$

The value of Q solved from (4) is a global optimum, as is evident from the fact that

$$c''=1+2\tau(T+2Q)+\beta p\gamma^2M\{2\tau MQ^{-(1+2\gamma)}+[1+2\tau(T+MQ^{-\gamma})]Q^{-(1+\gamma)}\}>0 \text{ for } Q>0.$$

Before proceeding to the main result, note that comparative static analysis of (4) yields $(dQ/dp)>0$. Similarly, $(dQ/d\beta)>0$, meaning that if the discount rate increases, so that the present value of future spending increases, present spending will increase.

From (4) we get

$$(5)\qquad (1+2\tau T)Q+2\tau Q^2-\gamma\beta pMQ^{-\gamma}[1+2\tau(T+MQ^{-\gamma})]=0,$$

It is easy to see that this expression cannot be solved analytically for Q. Hence, it will form the basis for the simulations that will be run in Section IV.

III. The Government's Optimization Problem with Unconstrained Fiscal Policy

In this section, we will consider the government's choices when it is able to run unconstrained fiscal policies. The notation used is identical to that exploited in Section II. The only new variable is s, which denotes the government's budget surplus. The value of s will be negative when the government runs a budget deficit. We want to minimize

$$c=T+Q+s+\tau(T+Q+S)^2+\beta p[T+MQ^{-\gamma}-\frac{1}{\beta}s+\tau(T+MQ^{-\gamma}-\frac{1}{\beta}s)^2+\beta(1-p)[T-\frac{1}{\beta}s+\tau(T-\frac{1}{\beta}s)^2].$$

First order conditions are:

$$(6) \qquad \frac{\partial c}{\partial Q}=1+2\tau(T+Q+s)-\gamma\beta pM[1+2\tau(T+MQ^{-\gamma}-\frac{1}{\beta}s)]Q^{-(1+\gamma)}=0.$$

$$(7) \qquad \frac{\partial c}{\partial s}=1+2\tau(T+Q+s)-p[1+2\tau(T+MQ^{-\gamma}-\frac{1}{\beta}s)]-(1-p)[1+2\tau(T-\frac{1}{\beta}s)]=0.$$

It is impossible to establish analytically whether or not the minimand is convex in the neighborhood of (Q,s) that satisfy (6) and (7). It therefore has to be done numerically. From (6) we can isolate s to get

$$(8) \qquad s=\frac{\gamma\beta pM[1+2\tau(T+MQ^{-\gamma})]Q^{-(1+\gamma)}-1-2\tau(T+Q)}{2\tau(1+\gamma pMQ^{-(1+\gamma)})}.$$

Substituting for s in (7) we get

$$2\tau(Q-pMQ^{-\gamma})+$$

$$\frac{(1+\beta)}{\beta}\times\frac{\gamma\beta PM[1+2\tau(T+MQ^{-\gamma})]Q^{-(1+\gamma)}-1-2\tau(T+Q)}{1+\gamma pMQ^{-(1+\gamma)}}=0,$$

from which it follows that

$$(9) \qquad 2\beta\tau(Q-pMQ^{-\gamma})(1+\gamma pMQ^{-(1+\gamma)})+\gamma\beta pM[1+2\tau(T+MQ^{-\gamma})]Q^{-(1+\gamma)}-1-2\tau(T+Q)=0.$$

Equation (9) is the one used for simulation to solve for Q. After that, s is solved from (8).

IV. Simulation Results

In this section, we will apply numerical techniques in an effort to identify the qualitative characteristics of the government's decisions regarding long lead time expenditures and budget balance. First, we will solve (9) and (8), the unconstrained optimization problem, for a variety of situations. We will then solve for (5), the optimum under the assumption of budget balance, under similar conditions. Then, we will compare the results.

In our simulation, we will assume that the level of defense utility required in the event of war, D_0, will equal 14, while D_0, will remain zero in the event of peace. We will further assume that the time discount rate β will equal .7, while exogenous government spending on non-military activities, T, will be set at 100. We will then proceed to solve equations (5), (8), and (9) for three values of the probability of war in the second period p (.2, .4, and .6), two values of the tax distortion parameter τ (.1 and .4), and five values of γ - the ratio of the elasticities of Q and N in "generating" military utility (.2, .5, 1, 2, and 3)

It should be understood that these simulation results are in no way designed to reflect reality, and that the results are of no quantitative significance. One cannot conclude from the size of the effects identified whether the impacts in reality would be large or small. The value of the simulations is qualitative, in the sense that they offer a guide as to the likely direction that relationships would take.

In Table One, the results for the unconstrained optimizations are reported. Having checked second order conditions so as to be certain that we are indeed looking at maxima rather than minima, we report the optimal values of Q and s for each combination of p, τ, and γ.[3] We also report the resultant values for the net present value of expected defense spending (ES), as well as the net present value of expected total costs including the deadweight losses resulting from tax inefficiencies (ET).

[3] Recall from Section III that it was impossible to verify analytically that the SOC for the FOC presented in (6) and (7) were actually negative.

Table One

τ =	0.1				0.4			
	Q	s	ES	ET	Q	s	ES	ET
γ=0.2								
p=0.2	0.818762	1.697098	4.276962	1967.726	0.822488	1.693717	4.277549	7348.072
0.4	1.394807	3.082962	7.612208	2041.548	1.399196	3.078858	7.612691	7633.356
0.6	1.887613	4.386572	10.66611	2108.02	1.8914	4.382942	10.66638	7890.08
γ=0.5								
0.2	2.732905	1.484196	7.169071	2034.819	2.74435	1.474036	7.171256	7607.767
0.4	4.116157	2.557719	11.34559	2127.029	4.127295	2.54739	11.34696	7964.077
0.6	5.208946	3.525589	14.84871	2203.643	5.217564	3.517356	14.84936	8260.023
γ=1								
0.2	5.836868	0.361967	10.54156	2110.461	5.854843	0.346075	10.54156	7900.22
0.4	7.879216	0.85277	14.84438	2205.09	7.893902	0.8391	14.8461	8265.823
0.6	9.394604	1.286032	18.15708	2278.053	9.404831	1.276216	18.15778	8547.544
γ=2								
0.2	9.744691	-1.63279	13.79023	2180.133	9.761582	-1.64798	13.79313	8169.159
0.4	11.91456	-1.72226	17.32691	2257.802	11.92605	-1.73312	17.32798	8469.228
0.6	13.43518	-1.77638	19.81997	2313.209	13.4423	-1.78329	19.82033	8683.377
γ=3								
0.2	11.71617	-2.85717	15.0603	2205.999	11.72905	-2.86894	15.06217	8268.811
0.4	13.65792	-3.14033	17.8799	2268.103	13.66579	-3.14786	17.88048	8508.771
0.6	14.97607	-3.34097	19.77968	2310.585	14.98063	-3.34542	19.77986	8673

Table Two

τ =	0.1			0.4		
	BQ/UQ	BS/US	BT/UT	BQ/UQ	BS/US	BT/UT
γ=0.2						
p=0.2	102.831	100.0918	100.0351	102.9166	100.0977	100.0374
0.4	105.2443	100.1302	100.1106	105.4089	100.1388	100.1179
0.6	107.5669	100.1472	100.2149	107.811	100.1569	100.2291
γ=0.5						
0.2	101.8024	100.1369	100.0255	101.8433	100.1442	100.0269
0.4	103.1972	100.1651	100.0712	103.2802	100.1746	100.0753
0.6	104.4735	100.1642	100.1285	104.5988	100.1739	100.1362
γ=1						
0.2	100.3055	99.99972	100.0014	100.3002	100.0337	100.0014
0.4	100.7525	100.049	100.0075	100.7615	100.051	100.0077
0.6	101.1583	100.0467	100.0141	101.1825	100.0491	100.017
γ=2						
0.2	99.10603	99.89992	100.0283	99.07334	99.89351	100.0307
0.4	98.9967	99.94645	100.0298	98.96209	99.943	100.0321
0.6	98.93675	99.97538	100.0305	98.9021	99.9738	100.0327
γ=3						
0.2	98.80732	99.88599	100.0858	98.76978	99.87924	100.0922
0.4	98.5982	99.95073	100.0994	98.55477	99.94769	100.1063
0.6	98.46576	99.99135	100.1093	98.41886	99.99078	100.1166

We find that for low values of γ, the optimal policy is to run a precautionary surplus. In and of itself, this is not surprising. As γ surpasses 1, however, surpluses transition to *precautionary deficits*.

Why should this be the case? Two factors are sufficient to explain this rather surprising result. First, as γ rises, the proportion of optimal defense expenditure spent during the first period rises. This increases the attractiveness of shifting financial burdens towards the future and away from the present.

Second, tax smoothing seeks to spread out burdens not only between the present and the future, but also between different states of nature that may be realized in the future. The only way to assure that the future state of nature in which there is peace pays its "fair share" of the financial burdens associated with security expenditures is to run a fiscal deficit. Indeed, this second effect is at work even for low values of γ. For optimal fiscal policy to require a surplus rather than a deficit, it is not sufficient for the weighting of expected expenditures to be biased towards the second period. The weighting must be large enough to outweigh the benefits stemming from making sure that any future peace pays its expected share of the financial burden.

In Table 2, the values of Q identified above are compared with the optimal values of Q that result when fiscal policy requires balanced budgets. The numbers reported in Table 2 are the values of Q under balanced budgets as a percentage of the values of Q with unconstrained fiscal policy (BQ/UQ). In addition, we also compare the net present values of expected government spending on defense under balanced budgets with their values under unconstrained fiscal policy (BS/US), as well as the net present values of expected total costs including the deadweight losses resulting from tax inefficiencies (BT/UT). Once again, the numbers reported are the values under balanced budgets as a percentage of the values with unconstrained fiscal policy.

As can be seen, the resultant values of Q are above their unconstrained optimal levels when γ is less than or equal to one. As γ begins to exceed one, and the weight of expected total defense spending begins to shift to the first period from the second, the optimal values of Q begin to decline below their unconstrained optimal levels.

These results mimic those we found for the fiscally unconstrained simulations. Under conditions where a large proportion of the expected defense burden is borne by the first period, the government shifts some of the burden towards the second period by cutting back first period expenditures. The results, however, are substantially less satisfactory than in the unconstrained simulations.

In the absence of deficit spending, it is impossible to find a way to shift some of the expected burden onto the future state of nature in which there is peace. The only policy tool available to the government is to set long lead time expenditures. By reducing such expenditures, it is certainly possible to shift the expected burden to the future, but the entire shift is borne by the state of nature in which there is war. Given that the peaceful state of nature will have a lower marginal cost of taxation than the present or the state of nature in which war breaks out, the inability to shift some of the expected cost towards the peaceful state of nature is a significant lost opportunity. As a result, total social costs are higher when budgets must be balanced.

Section V: Analysis and Conclusions

It seems reasonable to believe that policy makers intent on the maximization of social welfare take the dead weight welfare losses that result from tax distortions into consideration when choosing defense resource allocations as well as funding options. As we have seen, this may lead to the running of budget deficits or surpluses. Alternatively, under conditions where budgets need to be balanced, this may lead governments to allocate either more or less financial resources to long lead time defense expenditures than they would in the unconstrained case.

It is far from clear which of these two fiscal paradigms is the more reasonable. To the best of our knowledge, no national government pursues a strict policy of budget balance. Meanwhile, both political and economic constraints make it extremely difficult for countries to pursue a genuinely unfettered fiscal strategy. It is more likely that most countries pursue asymmetric policies. For most developed countries, it is probably reasonable to assume that they can run large budget deficits, but far fetched to believe that they could run meaningful fiscal surpluses. In the case of countries constrained by Maastricht Treaty requirements, there may be meaningful constraints on both surpluses and deficits. Meanwhile, developing countries that face the strictures of IMF structural adjustment programs and the vagaries of global bond markets, may find it easy to run budget surpluses, while large fiscal deficits are out of the question. Hence, the most credible fiscal paradigm is one in which countries sometimes behave as if they must maintain budget balance, while at other times they behave as if they may run deficits or surpluses.

That said, we believe that this paper’s results may shed some light on four subjects. First, this paper’s results may help clarify an old but unresolved debate in defense economics. During the

1980s, there was widespread support for the notion that the U.S. defense planning was biased towards the allocation of excessive funds to the development of over-sophisticated weaponry at the expense of the procurement of adequate numbers. Rogerson (1990) and Lipow and Feinerman (2001) presented theoretical explanations for such a bias. Both explanations were based on institutional arguments.

A credible case, however, can be made that the inefficiencies inherent in taxation lead welfare maximizing policy makers to allocate a greater level of resources to long lead time activities such as weapon development at the expense of short lead time activities such as procurement. This would be the case for sufficiently low values of γ. Under such circumstances, an observer attempting to evaluate defense allocation decisions ex post would likely, and correctly, conclude that the government was not following a cost minimizing expenditure program, but would incorrectly draw the conclusion that expenditures on long lead time activities were above their optimal level.

Second, this paper offers a potential explanation for the tendency amongst less developed countries (LDCs) to purchase or produce surprisingly sophisticated military equipment. Logically, countries with low capital/labor ratios ought to prefer to purchase larger numbers of simpler weapons. LDCs, of course, are by definition countries with low capital/labor ratios.

Offsetting this, this paper's results suggest that, if γ is sufficiently low and fiscal policy is constrained, countries with relatively primitive and inefficient tax systems may prefer to develop or buy more sophisticated weapons while scrimping on numbers and manpower. [4] Since most LDCs have inefficient tax systems and are often facing either fiscal limitations due either to the strictures of IMF adjustment programs or due to national debt levels high enough to raise

[4] It may be argued that our results do not hold for LDCs since few of these countries design or manufacture their own weapons. This is not the case. Many LDCs actually do produce much of their own weaponry, including Brazil, China, Egypt, India, Iran, Israel, Russia, South Africa, South Korea, and Turkey.

questions of dynamic consistency, it is entirely conceivable that they gain more from the tax smoothing benefits of higher weapon quality than they lose due to the costs associated with spending their relatively scarce capital. In other words, "high tech" may be the appropriate technology for the defense needs of developing countries once considerations of tax efficiency are taken into account.

Third, the analysis conducted in this paper suggests that the benefits of the so-called “Revolution in Military Affairs,” in which information technology and network-centric organizational structures dominate military planning, may be highly exaggerated. Throughout this paper, we have simply assumed that the value of γ is exogenous, yet it is reasonable to assume that a number of different technologies for the combining of Q and N may be chosen. In inspecting Table 1, it becomes clear that there are major benefits in choosing the lowest value of γ that is possible. Lower values of γ allow the government to defer spending to later periods when it has more information regarding evolving security threats. This results in major cost savings.

While it is certainly true that the new digitally equipped militaries are far more efficient than more traditional forces, the resultant cost structure is heavily biased towards long lead time expenditures. Hence, a information technology intensive approach may be the best choice when war is a certainty, but may be extravagant in terms of expected social cost when there is only a 20% probability of conflict ten or twenty years down the road.

Finally, this paper suggests that conversion to a more efficient tax system should lead to reduced defense expenditures. In every case that was checked, the reduction in τ from .4 to .1 led to a reduction in expected defense spending. This is not surprising. As τ declines, considerations of tax efficiency decline in importance relative to considerations of cost minimization. Hence, more efficient taxation not only reduces the welfare cost of raising a given level of revenue, buy may also lower the required level of revenue as well. Failure to take this effect into account could lead to a significant under-estimate of the aggregate welfare gains produced by well designed tax reforms.

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