Taxability and Trade

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Abstract

The trade literature tends to conceive of the relationship between fiscal capacity and trade policy fairly simply: states that have limited fiscal capacity will be more likely to use tariffs to raise revenues given the lack of other means of doing so. This paper presents a model that complicates this story: while greater ability to tax the winners of freer trade makes freer trade more likely, greater ability to tax the losers of freer trade may actually make protectionism more likely. This follows because if both tax and trade policy choices have redistributive implications, and if they are *jointly determined*, then what matters most are the factors that determine the *relative* attractiveness of these redistributive instruments. Indeed, the model predicts that relative taxability of groups should have an even clearer relationship with trade policy than relative political power. This generates a number of empirical implications for patterns of trade policy: for instance, we would expect trade policy to be biased towards factors, industries, and firm sizes that are easier to tax. Moreover, the model provides insight into the conditions under which compensation can be used as a tool to promote freer trade: governments need to be able to tax free trade's winners in order to implement the fiscal bargains that would make trade more politically saleable.

Introduction

Centuries of history link trade policy to issues of state fiscal capacity. In the early years of the United States, for instance, the question of "free trade" was not about whether or not tariffs should be eliminated, but whether or not tariffs should be for protecting industries or "for revenue only" (Irwin 2017 p. 69). Lacking other significant means of collecting revenues, trade tariffs quickly displaced state-imposed direct taxes (poll and land) as the primary source of revenue. Indeed, reforms implemented by Alexander Hamilton in 1790 allowed for a reduction of direct taxation by roughly 85% (Edling and Kaplanoff 2004, p. 731).

At the time, this was considered both politically efficient (it helped reduce unrest over state taxation that had led to protests in the 1780s) and even economically efficient, as the administrative costs of imposing tariffs on foreign goods (which had only a few ports of entry) were

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far less than for direct taxes: an estimated 4 percent versus 20 percent of gross revenue (Balinky 1958, p. 57). Indeed, tariffs continued to provide the majority of US revenues until 1914, when income taxation was introduced (Reamer 2016).

However, despite this long, intertwined history, the political economy of trade literature has not devoted much attention to interrogating the relationship between fiscal capacity - i.e. the ability to tax different groups - and trade policy.[1] While it is the conventional wisdom that tariffs will be implemented in cases where state capacity is relatively low, due to tariffs' relative ease of implementation, there has been little attempt to determine if the situation might be any more complicated than that.

This paper presents a formal model that demonstrates that while this conventional wisdom does capture some of the broader patterns in the use of trade tariffs (Dincecco and Prado 2012, Besley and Persson 2013), it does not tell the whole story. Indeed, what matters is not just the overall levels of fiscal capacity of a state, but which specific groups a government is able to tax.

To see this, consider that trade policy is often treated as being determined by the outcome of some distributive politics game: who wins and loses, and which of these groups are likely to be politically influential due to a variety of factors, are used to predict which groups are likely to receive protection. Taxation and spending decisions are naturally treated in a similar fashion: politically influential groups may be more able to demand reductions in taxation or increases in spending programs that benefit them.

However, if both these claims are true, then what results is a game in which these two quantities are *jointly determined.* A group may, for instance, be willing to accept reductions in trade protection in return for more favorable tax treatment, or vice versa. Moreover, the ability to tax groups varies depending on a variety of characteristics. It may be more costly to implement taxation on certain groups over others due to variation in the degree of deadweight losses generated by taxing different quantities, differing administrative costs across various kinds of taxes, relative ease for such groups to evade taxation, or even the political optics costs to increasing taxation on certain groups. Given this, the extent to which the government can use tax policy as a substitute redistributive policy for tariffs is conditional on the magnitude of these costs.

Put differently, a government's ability to tax and spend creates the possibility that trade liberalization (or even protection) can be the outcome of a larger bargain with the parties implicated by protectionist policies. The losing parties to a policy can be compensated for their losses - and in the case of a move to freer trade, there should typically be a larger pie with which to compensate them. However, what is important for generating these bargains is not just the total fiscal capacity of the government, but whether or not value can be trans-

[1] Recent exceptions include Queralt 2015, 2017 and Betz 2019.

ferred from specific groups to others - i.e. from the winners to the losers. If the winners from a policy are not easily taxable, this reduces the likelihood that such a policy will be politically optimal from the standpoint of governments.

Thus, this paper contributes to our understanding of trade politics in a number of ways. First, it provides a more nuanced understanding of the relationship between fiscal capacity and trade policy: an increase in fiscal capacity may even make protectionist policies more likely if it takes the form of greater ability to tax the beneficiaries of protectionism. This new model of group-specific taxability and trade has significant implications for the empirical trade policy patterns we would expect to observe: in particular, we would expect trade policy to be biased in favor of factors, industries, and firm sizes that are easier to tax.

Second, the paper provides scope conditions for when "compensating the losers" will be a feasible political and economic strategy for achieving more open trade. If freer trade increases the size of the pie being bargained over by generating aggregate gains for a country, one would expect it to be possible to redistribute the surplus so that every party is better off than in a protectionist equilibrium (i.e. to construct a Pareto-improving outcome). However, this paper shows that this is only true conditionally; in some cases, the winners will be taxable in a way that allows their gains to be "monetized" by the government, but in other cases they may be difficult to tax in a way that limits these compensatory bargains. Thus, this paper can provide insight into empirical patterns of trade protection, and can provide insight into an outstanding theoretical question about the seemingly inefficient use of trade protection as a means of redistributing income between groups.

Related Work

As mentioned earlier, political economy scholars have generally treated trade policy as the outcome of political competition between the winners and losers of protectionist policies. As a consequence, much of the literature has focused on identifying who exactly those winners as losers are. Depending on the circumstances, such cleavages might occur along factor lines (Rogowski 1990), industry lines (Scheve and Slaughter 2001, Hiscox 2002), or even between firms of differing sizes and productivities (Osgood 2016, Kim 2017). The literature has also made clear that both importers and exporters are important political actors in the determination of trade policies (Gilligan 1997, Betz 2017).

Beyond determining who the winners and losers are from protectionism, the literature has devoted significant attention to identifying the characteristics that lead governments to value certain groups over others when determining trade policy. This includes work on lobbying (Grossman and Helpman 1994, Goldberg and Maggi 1999, Gawande and Bandyopadhyay 2000, Bombardini 2008, Gawande et al. 2012), and the impact of democratization on trade policy (Mansfield et al. 2000, Milner and Kubota 2005).

This work establishes an important starting point for the analysis of this paper. This paper does not to seek to explain which groups are politically influential, or who benefits from particular trade policies; instead, these characteristics are treated as exogenous parameters in the model. The goal of this paper is instead to show that if we take these characteristics as given, varying the taxabilities of groups can change what we would expect the policy outcomes to be.

The study of public finance in economics also provides important insights that inform this paper. This literature has been active in assessing the characteristics that lead to variation in taxes' deadweight losses, administration costs, and ease of evasion or avoidance (Slemrod and Yitzhaki 2002, Kumler et al. 2013, Best et. al 2015, etc.). This paper also does not attempt to contribute new insight to this literature; instead, costs of taxation are specified exogenously. However, this literature is important for thinking through the implications of the model in practice, and is helpful in clarifying that the costs of taxation derive not only from deadweight losses created by distortions in production and consumption decisions, but also from difficulties associated with the administration and enforcement of taxes.

From political science, the "taxation and accountability" literature is also closely related to this paper. This literature, broadly speaking, suggests that governments provide policy concessions to groups as part of a bargain to encourage compliance with taxation (Bates and Lien 1985, Levi 1988, North and Weingast 1989, Timmons 2005, Martin 2014). Compliance with taxation, in this account, is "quasi-voluntary", with groups threatening to withhold payment in order to extract concessions. Recently, this approach has been applied to trade, where it has been argued that industries in developing countries have exchanged compliance for protection (Queralt 2015, 2017).

Essentially, this literature would argue that providing favorable trade policy to groups makes those groups easier to tax. This paper argues, instead, that greater ability to tax groups leads to more provision of trade policy that benefits those groups; essentially reversing the causal arrow of the taxation and accountability story.

There are several advantages to this paper's explanation. To start, it applies to situations in which taxation is not really quasi-voluntary, but enforced through threat of sanction by the government. Given the extensive efforts that groups and individuals often exert in order to avoid or evade taxation, and the collective action problem associated with it being individually rational not to pay taxes if the trade policy benefits to a group are non-excludable within that group, it is likely that such situations are quite common. For instance, even in Michigan (until recent policy changes), voluntary compliance with self-reporting of sales tax for purchases made online (e.g. through Amazon) was estimated to be about 2.5%.[2]

Even if we accept that taxation is sometimes quasi-voluntary, this paper suggests that the

[2]September 29, 2015. Detroit Free Press

causality could go both ways, reinforcing the link we observe between taxation and favorable trade policies. Moreover, while this paper's argument is equally consistent with the evidence that taxation of industries is correlated with protectionist policies favoring those industries in the developing world (Queralt 2017), the model also produces new empirical implications about the relationship between exogenous features of a factor, industry or firm that affect the costs of taxation (e.g. demand elasticities of products, firm sizes, capital intensity) and trade policy. While a model rooted in quasi-voluntary compliance might predict that low costs to taxing a group would not impact their ability to extract favorable trade policies - or might even predict that low costs would have a *negative* impact by reducing the leverage a group obtains by being able to credibly withhold concessions - this paper suggests that ease of taxation should track with favorable trade policies for reasons that have nothing to do with a "compliance bargain" between the government and various private groups, and everything to do with the government's ability to extract resources via coercion and use them to support its own political agenda.

This paper also relates to a number of papers across subfields in political science and economics that deal with the question of inefficient policy. In the international relations literature, the most prominent example is the work on bargaining models of conflict, which notes that because war is inefficient (i.e. destroys value relative to peace), peaceful bargains should be preferred absent some factor leading to bargaining breakdown, such as a commitment problem, information problem, or indivisibility issue (Fearon 1995, Powell 2004, Powell 2006). Despite the fact that international trade has similar characteristics - protection is also inefficient - there has been little attempt to address similar questions in the international political economy literature.

In the economics literature, a number of explanations for inefficient policy more broadly have been posited, including bargaining models, commitment problems, and information asymmetries (Coate and Morris 1995, Acemoglu and Robinson 2001, Acemoglu 2003, Drazen and Limao 2008). Moreover, the theoretical result that the ability to redistribute income costlessly (i.e. perfect fiscal capacity) should lead governments to maximize national income and then use redistributive taxation is famously shown by Diamond and Mirrlees in a paper on production efficiency (Diamond and Mirrlees 1971). Their result is made in reference to a government maximizing a general social welfare function, but extending the result to a political objective function is straightforward: the main point is that a Pareto improving distribution of resources can always be achieved using production efficiency and redistributive taxation, if taxation is costless.

This paper explores the consequences for international trade of this costless taxation assumption breaking down, and more specifically, breaking down unequally across groups. The literature on this in economics generally assumes that efficient taxation is possible, and is more interested in explaining why less efficient taxes would be used instead of these readily available efficient means (Acemoglu 2003). The limited literature that takes seriously fiscal capacity as a constraint on efficient redistribution in politics focuses on the consequences for government's incentives to invest in public goods or fiscal capacity, but it does not explore the distributive consequences, nor does it consider cases where fiscal capacity may be unequal across groups (Acemoglu 2005, Besley and Persson 2009).

Consequently, this paper provides an explanation for inefficient trade policy that is not only absent from the existing political economy of trade literature, but also largely absent from the broader theoretical literature on inefficient policy.

This answer to a theoretical puzzle allows the paper to speak to a literature in trade politics often referred to as "embedded liberalism", which has broadly argued that government spending can be used to compensate trade's losers in order to make freer trade more politically saleable. This literature originated in work that argued that made the case that the post-war expansion of the welfare state could be understood as an example of this kind of bargain (Ruggie 1982). Rodrik (1998) brought early statistical evidence to bear on the compensation hypothesis, identifying a correlation between public sector size and external openness, which was interpreted as governments insuring voters against "external risk". Later work has provided further evidence that compensation programs can be used to increase support for open trade, using data from trade adjustment assistance in the United States (Margalit 2011), active labor market programs in the OECD (Hays et al. 2005, Hays 2009), and even survey experiments (Ehrlich and Hearn 2014).

This paper identifies limits to the feasibility of such compensatory bargains; a topic that has seen renewed interest in recent years (Frieden 2018, Owen 2019, Mansfield and Rudra n.d.) in the wake of a perceived backlash against globalization. The logic of compensating the losers relies implicitly on the ability to extract such compensation from the winners. Indeed, it is not enough that governments simply have "fiscal capacity" in some broader sense of being able to raise revenues "somewhere" - redistributing income from some party other than trade's beneficiaries would simply entail exchanging one set of trade losers for another. Thus, a necessary condition for the embedded liberalism mechanism to work is that the winners be taxable - a condition that may be violated in a number of important cases. For instance, work seeking to apply the embedded liberalism framework to the developing world has found little evidence of compensation (Rudra 2002, Wibbels and Ahlquist 2011); if open trade's beneficiaries in the developing world are more difficult to tax, then this is precisely what the model would predict.

Model

Set-Up

The model outlined in this paper is a simple distributive politics model in which a government maximizes a weighted sum of the utilities to two groups. The weightings attached to each group represent the degree to which these groups are politically influential, and are specified exogenously. Thus they could be the result of any of a broad variety of factors identified by the trade literature as important to group influence. Indeed, most models of group influence can be thought of as reducing in their conclusions to a weighting across groups, with factors such as lobbying (Grossman and Helpman 1994, 2002), collective action (Olson 1965, 2012), political geography (McGillivray 2004), and more determining the weightings. By assigning these exogenously, the model can be applied generally to a broad variety of situations without imposing significant structure on the underlying politics.

Each group's utility function is strictly increasing and strictly concave in two quantities: their total income $y_i \in \mathbb{R}$ for $i \in \{1,2\}$ and the level of public goods provision $g \in \mathbb{R}^+$. Furthermore, their utility functions are additively separable in these two quantities, with each group's value from public goods provision weighted by a parameter $\beta_i \in \mathbb{R}^+$ to reflect different preferences for or access to public goods, i.e.:

$$U_i(y_i, g) = I_i(y_i) + \beta_i P(g) \; \forall i \in \{1,2\}$$

Where $I_i(y_i) \in \mathbb{R}$, $P(g) \in \mathbb{R}^+$, and we have $I_i'(y_i) > 0$ and $I_i''(y_i) < 0$ for $i \in \{1,2\}$, and $P'(g) > 0$ and $P''(g) < 0$ from the earlier assumptions about concavity and monotonicity.

Each group's total income y_i consists of three parts: (1) earned income $\pi_i(\tau)$, which is a function of the level of protection $\tau \in \mathbb{R}^+$ (which I will call the tariff rate henceforth for simplicity); (2) lump-sum taxes $t_i \in \mathbb{R}^+$; (3) government transfers $r_i \in \mathbb{R}^+$. Group 1 represents the winners of trade protection while Group 2 represents trade protection's losers, so we also have $\frac{\partial \pi_1}{\partial \tau} > 0$ and $\frac{\partial \pi_2}{\partial \tau} < 0$, and I also assume that both functions are strictly concave, so $\frac{\partial^2 \pi_1}{\partial \tau^2} < 0$ and $\frac{\partial^2 \pi_2}{\partial \tau^2} < 0$. I also assume for simplicity that $\lim_{y_i \to 0} I_i'(y_i) = \infty$ and $\lim_{g \to 0} P'(g) = \infty$ to ensure that each group receives a positive income allocation in equilibrium, and the equilibrium public goods allocation is positive. Thus, we have the following form for each group's utility function:

$$U_i(\tau, g, t_i, r_i) = I_i[\pi_i(\tau) - t_i + r_i] + \beta_i P(g) \; \forall i \in \{1,2\}$$

As noted earlier, Government's objective function is simply a weighted sum of each group's utility functions, with the weightings for each group represented by parameters $\alpha_i \in \mathbb{R}^+$. Government chooses the tariff rate τ, the level of public goods provision g, the tax rates t_1, t_2, and the transfers r_1, r_2 to maximize this weighted sum, subject to the constraint that the total revenue collected in taxes must exceed the amount spent on public goods and transfers. Furthermore, some percentage of the income taxed from a group is lost due to various costs from taxation (such as deadweight losses and costs from tax avoidance/evasion). As a consequence, only $\theta_i \in (0,1)$ proportion of the income transferred from group i will end up being available to Government to spend on public goods and transfers. θ_1, θ_2 thus reflect the different "taxabilities" of the different groups, by representing costs to taxation as "leaky buckets". The Government's decision problem can be written as follows: [3]

[3] It is worth noting that this formulation abstracts away from the potential revenue effects of trade policy.

$$\max_{\tau,g,t_1,t_2,r_1,r_2} G(\tau,g,t_1,t_2,r_1,r_2) = \sum_{i\in\{1,2\}} \alpha_i \left(I_i[\pi_i(\tau)-t_i+r_i]+\beta_i P(g)\right) \tag{1}$$

$$\text{s.t. } t_1\theta_1 + t_2\theta_2 \geq r_1 + r_2 + g$$

Analysis

We can now begin to analyze the model. It is helpful to start by demonstrating a result that simplifies the decision problem facing Government substantially.

Lemma 1. *If $t_i > 0$ then $r_i = 0$, for $i \in \{1,2\}$*

Proof. To demonstrate this result, we want to demonstrate that if $r_i > 0$ and $t_i > 0$, Government can construct a Pareto improvement by reducing both r_i and t_i. Recall that $y_i = \pi_i(\tau) - t_i)$ and Government's budget is $B = t_1\theta_1 + t_2\theta_2 - r_1 - r_2 - g$. If $r_i = \chi > 0$, then t_i can be reduced by $\frac{\chi}{\theta_i}$ with no net effect on Government's budget, which since $\theta_i < 1$, has the effect of increasing y_i by $\left(\frac{1-\theta_i}{\theta_i}\right)\chi$ with no other effects on any other y_j, r_j or g. This is a Pareto improvement. If $t_i < \frac{\chi}{\theta_i}$, it will not be possible to fully substitute a tax reduction for the government transfer, but reducing t_i to zero and r_i by a commensurate amount will still yield a Pareto improvement. Thus it cannot be the case that $t_i > 0$ and $r_i > 0$. □

The intuition behind this result is straightforward: if both groups are being taxed at positive rates, a better strategy for Government than explicit redistributive transfers - which destroy value because taxation destroys value - is to *implicitly* redistribute between the two parties by adjusting their relative tax burdens. This result is important in itself, as it reminds us that if all parties are being taxed at positive rates, Government has a very efficient instrument for redistributing income between these parties, i.e. tax credits/reductions.

This result also allows us to continue the analysis of the model in two parts, as we consider two possible cases that could apply: first, the case where both parties are taxed at positive rates (i.e. $t_i > 0$ for $i \in \{1,2\}$); second, the case where one of the two parties is not taxed (i.e. where $t_i = 0$ and $t_j > 0$ for $i \neq j$). However, since most of the results are broadly similar between the two cases, I focus the analysis in the main part of the paper on the first of these two cases, while the second case can be found in the appendix.

If the trade policy instrument in question is tariffs, for instance, then Government collects revenues at the border when they administer the tariff, so this assumption will be false. This version of the model is thus descriptively accurate for many kinds of non-tariff barriers that do not have direct revenue implications, and an unproblematic simplification for cases where trade policy revenue is a relatively small percentage of total revenues. A section of the appendix relaxes this "no-direct-revenue" assumption and discusses under what conditions we might expect this alteration to matter.

Case 1: All Parties Are Taxed

If all parties are taxed at positive rates, by Lemma 1 we have that $r_i = 0$ for $i \in \{1,2\}$. Thus, Government's decision problem simplifies to the following:

$$\max_{\tau,g,t_1,t_2} G(\tau,g,t_1,t_2) = \sum_{i\in\{1,2\}} \alpha_i \left(I_i[\pi_i(\tau) - t_i] + \beta_i P(g)\right) \tag{2}$$
$$\text{s.t. } t_1\theta_1 + t_2\theta_2 \geq g$$

Given that Government does not obtain any value from surplus revenues but has monotonically increasing utility from public goods and each group's income, the constraint is satisfied with equality. Thus, we can substitute $g = t_1\theta_1 + t_2\theta_2$ into the objective function to get the following:

$$\max_{\tau,t_1,t_2} G(\tau,t_1,t_2) = \sum_{i\in\{1,2\}} \alpha_i \left(I_i[\pi_i(\tau) - t_i] + \beta_i P(t_1\theta_1 + t_2\theta_2)\right) \tag{3}$$

If we are at an interior solution, then the unique solution to this objective function will be characterized by the following three first order conditions.

$$\frac{\partial G}{\partial \tau} = \alpha_1 I_1'[\pi_1(\tau) - t_1]\frac{\partial \pi_1(\tau)}{\partial \tau} + \alpha_2 I_2'[\pi_2(\tau) - t_2]\frac{\partial \pi_2(\tau)}{\partial \tau} = 0 \tag{4}$$
$$\frac{\partial G}{\partial t_1} = \alpha_1 I_1'[\pi_1(\tau) - t_1](-1) + (\alpha_1\beta_1 + \alpha_2\beta_2)P'(\theta_1 t_1 + \theta_2 t_2)\theta_1 = 0 \tag{5}$$
$$\frac{\partial G}{\partial t_2} = \alpha_2 I_2'[\pi_2(\tau) - t_2](-1) + (\alpha_1\beta_1 + \alpha_2\beta_2)P'(\theta_1 t_1 + \theta_2 t_2)\theta_2 = 0 \tag{6}$$

The intuition underlying these first order conditions is straightforward. For equation (4), tariffs are increased until the weighted (by Government) marginal value a tariff increase brings to Group 1 is equal to the weighted marginal value lost by Group 2. Equations (5) and (6) show that each tax rate will be increased until the weighted (by Government's weightings for each group and each group's weighting on public goods) effect on public goods provision is equal to the weighted negative effect of increased taxation on a particular group. Without explicitly solving for the optimal τ, t_1, t_2 (which would not be possible without imposing significant structure on the functional forms of several functions), we can rely on the techniques of monotone comparative statics (Milgrom and Shannon 1994) to determine the relationships between these choice variables and the parameters of the model.[4]

To start, we will need to demonstrate that Government's objective function is *supermodular*. The intuition behind this condition is that the choice variables need to be complementary in order for us to derive monotone comparative statics; otherwise, it will not be possible to establish whether the main effects of a parameter on one choice variable are outweighed by indirect effects via other variables' impact on each other. We must thus establish that all

[4] See also Ashworth and Bueno de Mesquita 2006 for an overview of these techniques.

the variables "move in the same direction" in some sense.

To do this, we take the cross partial derivatives for each pair of the arguments of the objective function and sign them, as follows:

$$\frac{\partial^2 G}{\partial\tau\partial t_1} = \alpha_1 \underbrace{I_1''[\pi_1(\tau)-t_1]}_{-} \underbrace{\frac{\partial \pi_1(\tau)}{\partial \tau}}_{+}(-1) > 0$$

$$\frac{\partial^2 G}{\partial\tau\partial t_2} = \alpha_2 \underbrace{I_2''[\pi_2(\tau)-t_2]}_{-} \underbrace{\frac{\partial \pi_2(\tau)}{\partial \tau}}_{-}(-1) < 0$$

$$\frac{\partial^2 G}{\partial t_1\partial t_2} = (\alpha_1\beta_1+\alpha_2\beta_2)\underbrace{P''(\theta_1 t_1+\theta_2 t_2)}_{-}\theta_1\theta_2 < 0$$

Where $I_i''(\cdot)<0$ and $P''(\cdot)<0$ by strict concavity assumptions, and $\frac{\partial\pi_1(\tau)}{\partial\tau}>0$ and $\frac{\partial\pi_2(\tau)}{\partial\tau}<0$ by the assumptions made earlier about how tariffs affect each group. These partial derivatives establish that G is not supermodular in (τ, t_1, t_2) but *is* supermodular in $(\tau, t_1, -t_2)$, so we perform a simple change in variables to establish the required supermodularity condition.

Having established this, we can now determine the comparative statics of the model. It is also worth noting that if the first order conditions from before characterize the solution (i.e. the solution is at the interior), the cross partial derivatives should allow us to determine *strict* comparative statics results (Edlin and Shannon 1998).

To start, let's derive the core results of the paper with regard to taxability. We proceed as follows, starting with θ_1.

$$\frac{\partial^2 G}{\partial\tau\partial\theta_1} = 0$$

$$\frac{\partial^2 G}{\partial t_1\partial\theta_1} = (\alpha_1\beta_1+\alpha_2\beta_2)\left(\underbrace{P''(\theta_1 t_1+\theta_2 t_2)\theta_1 t_1}_{-} + \underbrace{P'(\theta_1 t_1+\theta_2 t_2)}_{+}\right)$$

$$\frac{\partial^2 G}{\partial t_2\partial\theta_1} = (\alpha_1\beta_1+\alpha_2\beta_2)\left(\underbrace{P''(\theta_1 t_1+\theta_2 t_2)\theta_1 t_2}_{-}\right) < 0$$

At this point, we need to impose some additional structure on the shape of the public goods function $P(\cdot)$ in order to proceed. In particular, we want to establish that $\frac{\partial^2 G}{\partial t_1\partial\theta_1}>0$, which requires making the following assumption.

Assumption 1. *It is assumed that:*

$$P'(\theta_1 t_1+\theta_2 t_2) > -P''(\theta_1 t_1+\theta_2 t_2)\theta_i t_i \;\forall i \in \{1,2\}$$

The intuition behind why we need this assumption is essentially analogous to Giffen goods in consumer theory. In consumer theory, a price decrease of a good results in two effects - income and substitution - wherein the fact that a good is cheaper makes one want to purchase more of it relative to other goods, but the increased income from having to spend less on the good may increase or decrease demand depending on whether the good is normal or inferior. For Giffen goods, the overall demand for the good declines as the price decreases because the good is so inferior that the income effect swamps the substitution effect; a theoretical possibility for which credible empirical examples may not exist.

Similarly, what we are concerned with ruling out here is the possibility that a decrease in the "price" of taxing a particular group leads to a decrease in the taxation of that group. This is theoretically possible depending on the shape of $P(\cdot)$ because a reduction in the costs of taxation reduces the amount of taxation required in order to return the same amount of revenue, such that if $P'(\cdot)$ declines steeply enough (i.e. if $P''(\cdot)$ is sufficiently negative), that "income effect" may dominate the substitution effect of it becoming more attractive to tax that group as it becomes cheaper to do so. However, as with Giffen goods, it requires a rather unusual functional form for this result to occur, and thus we can rule it out with minimal loss of generality. As an example, if we were to impose the functional form $P(\cdot) = ln(\cdot)$, Assumption 1 would hold, as demonstrated below.

$$P'(\theta_1 t_1 + \theta_2 t_2) > -P''(\theta_1 t_1 + \theta_2 t_2)\theta_1 t_1$$
$$\frac{1}{\theta_1 t_1 + \theta_2 t_2} > \frac{\theta_1 t_1}{(\theta_1 t_1 + \theta_2 t_2)^2}$$
$$\theta_1^2 t_1^2 + \theta_2^2 t_2^2 + 2\theta_1\theta_2 t_1 t_2 > \theta_1^2 t_1^2 + \theta_1\theta_1 t_1 t_2$$
$$\theta_2^2 t_2^2 + \theta_1\theta_2 t_1 t_2 > 0$$

If Assumption 1 holds, we now have the following:

$$\frac{\partial^2 G}{\partial\tau\partial\theta_1} = 0, \; \frac{\partial^2 G}{\partial t_1 \partial\theta_1} > 0, \; \frac{\partial^2 G}{\partial\text{-}t_2\partial\theta_1} > 0$$

And furthermore, we can invoke the symmetry of the model to determine the following:

$$\frac{\partial^2 G}{\partial\tau\partial\theta_2} = 0, \; \frac{\partial^2 G}{\partial t_1 \partial\theta_2} < 0, \; \frac{\partial^2 G}{\partial\text{-}t_2\partial\theta_2} < 0$$

Which allows us to establish the following proposition:

Proposition 1. *The tariff rate τ is increasing in the taxability of trade protection's winners and decreasing in the taxability of trade protection's losers. Furthermore, when τ, t_1, t_2 are at an interior solution, these relationships are strict. Thus, trade policy exhibits bias towards more taxable groups.*

Proof. We have shown above that $G(\cdot)$ is supermodular in $(\tau, t_1, -t_2)$ and that the parameters θ_1, θ_2 have the same sign cross-partials with each of these variables, and thus by Milgrom and Shannon (1994) have established that $\frac{\partial \tau}{\partial \theta_1} \geq 0$ and $\frac{\partial \tau}{\partial \theta_2} \leq 0$, and by Milgrom and Edlin (1998) have established that these relationships are strict when $(\tau, t_1, -t_2)$ is at an interior solution characterized by the previously stated first order conditions. □

To understand the intuition underlying this proposition, it is worth noting that there is no direct effect of θ_i on τ in this model; instead, the result derives from an indirect effect, in which an increased θ_i increases t_i, lowering the income of group i and thus increasing the value to Government of pursuing trade policy that favors that group.

More generally, this proposition captures the idea that Government would want to pursue trade policies that favor the groups that are most easily taxable so that it could use those revenues to fund public goods and transfers to other parties, which is the core argument of this paper. Also worth emphasizing is that this implies that greater ability to tax the *losers* from open trade actually makes protection more likely - unlike most existing arguments in the literature, higher fiscal capacity does not necessarily lead to lower levels of trade protection.

The remaining comparative statics can be summarized in the following proposition:

Proposition 2. *When τ, t_1, t_2 are at an interior solution, the effects of all other parameters (i.e. β_i, α_i for $i \in \{1,2\}$) are ambiguous.*

Proof in appendix. To explain the intuition: increasing the weighting placed on either group (α_i) has the direct effects of decreasing the amount they are taxed, increasing the amount the other party is taxed, and providing them with more favorable trade policy. Since taxation of the two groups are substitutes, and trade policy is a substitute with more favorable tax treatment, the overall magnitude of these direct and indirect effects is ambiguous: it could theoretically be possible, for instance, that the group receives more favorable trade policy and is taxed more highly, even though we would expect their total income to increase.

This null effect has important substantive implications. The trade literature has focused its attention on the relative influence of interest groups and coalitions, suggesting that this is the primary explanatory factor for trade policy, but Proposition 2 suggests that it is not necessarily the case that the most influential groups will obtain trade policy that benefits them. The key logic is that it is not at all clear how well the use of any particular policy instrument will track with group influence when Government uses multiple instruments simultaneously to provide value to a group. Indeed, this paper suggests that relative taxability of groups should have a much clearer relationship with the specific instrument of trade policy than the relative political power of those groups because taxability directly pertains to the relative attractiveness of the instruments.

Finally, because an increase in either β_i simply increases the weighting that Government ultimately places on public goods, it is difficult to sign these comparative statics as well; the direct effect is both t_1 and t_2 increase, but because they are substitutes it is theoretically possible that this indirect substitution effect will dominate the direct effect. I suspect this is unlikely for most functional forms, but it is not possible to definitively reject this possibility without imposing more structure on the model.

Having derived the comparative statics for this case of the model, we can now turn our attention to another important question: when can differential taxability across groups be an explanation for trade protection, given that protection is widely understood to be an inefficient instrument for redistributing income? This is the core question underlying the "embedded liberalism" literature, which outlines that compensatory bargains can be a means of making liberalization more politically achievable by ensuring that the losers of open trade share the gains. However, given that we still regularly observe protection, it is clear that compensation is not *always* possible or effective, which raises questions about why and when these bargains fail to materialize, given that they should theoretically allow for open trade to be a Pareto improvement.

This paper helps provide answers to these questions by identifying the role that taxabilities can play in impeding these bargains. To start, it is worth flagging that this case of the model - in which both groups are taxed at positive rates - is the least conducive to protectionism, because there implicitly exists a perfectly efficient redistributive instrument: adjusting the relative tax burden of the two groups (e.g. increase $t_2 - t_1$ to compensate free trade's losers). If trade protection destroys value, one might then expect that it would be strictly dominated by a strategy of liberalizing and then compensating via the tax system (i.e. we would expect a corner solution of $\tau^* = 0$). However, it turns out that even when both parties are taxed at positive rates, taxabilities can be an explanation for trade protection - but only when trade's losers are more taxable than trade's winners.

Proposition 3. *If trade protection is inefficient (i.e. destroys value), then $\theta_1 > \theta_2$ is a necessary condition for the level of trade protection to be positive (i.e. $\tau^* > 0$) when $t_1, t_2 > 0$.*

Proof. Consider a move from $\tau = 0$ to some $\tau' > 0$. We can write $\chi \equiv \pi_1(\tau') - \pi_1(0)$ and $\omega \equiv \pi_2(0) - \pi_2(\tau)$. If trade protection is inefficient, then it must be the case that $\omega > \chi$. Now let's consider what happens if we try to fully compensate Group 1 for their losses from liberalization while retaining the same level of public goods provision, i.e. we will try to construct a Pareto improvement. To fully compensate Group 1, we need $\Delta t_1 = \chi$. If $\Delta g = 0$, then $\Delta \theta_2 t_2 = \theta_1 \chi \leftrightarrow \Delta t_2 = \frac{\theta_1 \chi}{\theta_2}$. This means that if we fix $\Delta y_1 = 0$ and $\Delta g = 0$, we have $\Delta y_2 = \omega - \frac{\theta_1}{\theta_2}\chi$. Given that we have assumed that $\omega > \chi$, this implies that $\Delta y_2 > 0$ whenever $\theta_2 \geq \theta_1$; this implies that a Pareto improving bargain is possible, and thus it should be the case that $\tau^* = 0$. Therefore, a necessary (but not sufficient) condition for there not to be a Pareto improving bargain is $\theta_1 > \theta_2$. □

One immediate implication of this result is that if taxation can be done perfectly efficiently (i.e. if $\theta_1 = \theta_2 = 1$) then protection should not be possible; this comports with standard results about Pareto-improving bargains in the face of inefficiency. However, Proposition 3 is substantially more powerful than that: it suggests that when all parties face positive tax rates, *everything else* about the situation besides relative taxabilities *cannot* matter as an explanation for inefficient protection, including how highly trade protection's winners are weighted relative to the losers. Indeed, even the "overall" fiscal capacity of the Government does not matter much here: if both groups are difficult to tax but equally taxable, then we still will not get trade protection. Proposition 3 ultimately provides compelling support for the core claim of this paper: that a focus on *relative* taxabilities of groups is at least as important for explaining trade policy as "fiscal capacity" in general.

Applications

Taking as a given the conclusions of the political economy literature about who wins and loses from particular trade policy choices and which groups are likely to hold the most sway over governments, this paper's model suggests significant modifications to the policy outcomes we would expect to emerge. In particular, we should expect trade policies to be biased towards whichever side of a trade-related political cleavage is easier to tax. While a more sustained empirical investigation of these implications is left for future work, a summary of how we might expect the model to alter our predictions for trade policy outcomes is as follows.

Factor Cleavages

Political economists have often argued that political cleavages over trade may occur along factor lines, especially if we are considering the longer term patterns of trade policy (Rogowski 1990, Hiscox 2002). This follows from the economic predictions of Heckscher-Ohlin (HO). This paper would thus lead us to ask: which is more taxable, capital or labor? Land or labor? Skilled or unskilled labor?

The answers to these questions may depend on a number of factors, such as capital mobility, per-capita income (especially if there are fixed costs to taxation), or even the legal institutions of a country in question. As such, this is a subject worthy of a more systematic empirical inquiry than is within the scope of this paper. Nonetheless, we can speculate about the degree to which certain stylized facts seem to fit the story described by this model.

For instance, trade protection is generally more extensive in the developing world than the developed world (Moutos 2001). Given that poorer countries are usually relatively abundant in unskilled labor, an HO model would lead us to expect that freer trade in developing countries would broadly benefit unskilled labor relative to skilled labor. Naively, we might initially expect this to make trade liberalization an easier sell in the developing world, given that in developed countries much of the opposition to globalization has been structured around issues such as increased inequality, or the degree to which the wealthiest capture the gains, while we might expect the poorest to capture most of the gains of open trade in the developing world.

However, in many developing countries, the informal sector makes up a significant fraction of the economy, especially amongst unskilled workers. As such, the model suggests that we should expect trade policy to be biased against such workers. Indeed, recent survey experimental work by Rudra (n.d.) shows a divide between formal and informal workers in India in their beliefs about the impact of international trade, with the former more likely to believe that foreign engagement will benefit them; this paper suggests that they may be correctly perceiving a bias in government policy. All of this could help to explain why developing countries are broadly more protectionist than developed countries.

Conversely, land may be one of the easiest factors to tax, given that it is immovable (unlike often highly mobile capital) and, as far as assets go, fairly difficult to hide. Commensurate with what this model would predict, we also see that agriculture often receives much higher levels of protection than other commodities, in what is often described as a puzzle by political economists (Thies and Porche 2007). This paper may help to explain this regularity.

Industry Cleavages

Especially in the short term, however, political economists have argued that cleavages might instead occur along industry lines, as predicted by Ricardo-Viner (Scheve and Slaughter 2001, Hiscox 2002). It is also certainly the case that industries vary in the degree to which they are taxable. Oil and many other natural resource industries, for instance, are easily observable, highly immobile, and capital intensive in a way that makes them especially easy to tax. Contrastingly, much of the service industry, and especially the freelance industry, is much more difficult to tax given that it can be diffuse and intangible. Thus, the model would predict that trade policy would be biased towards industries like oil and possibly biased against certain subareas of the service sector.

Indeed, in some of the only extant work linking trade and tax policy, Queralt (2017) provides evidence that industries in developing countries that receive higher levels of protection are also taxed more significantly. While Queralt interprets this as evidence for a "protection for tax compliance" bargain in line with the taxation and accountability literature from comparative politics, it is equally consistent with this paper's story about trade policy bias towards taxable industries.

Capital Mobility

One particular source of taxability - asset mobility - has been the subject of significant discussion in the political science literature (Garrett 1995, Oatley 1999, Clark 2002, Clark et al. 2017). Given that this literature broadly argues that higher asset mobility should provide such asset holders with the ability to extract greater concessions from the government due to their better exit options, it is worth discussing why this paper might come to different conclusions.

Clark, Golder, and Golder (2017) consider asset mobility explicitly within the Exit, Voice, and Loyalty (EVL) framework proposed by Hirschman (1970). While they focus on the importance of exit options, equally important within this framework is the value the government places on "loyalty", often described as the "dependence" of government. This paper essentially argues that this component of the EVL framework is determined in part by taxabilities; if a government cannot tax you, then they have less of a stake in your success.

What then should we predict about the impact of increased asset mobility for a group on trade policy favoring that group? We might expect the effect to be ambiguous: on the one hand, exit options provide a group leverage to extract concessions, but on the other hand the government loses a reason to care about whether that group exits or not. Likely to be important in this case is α_i, i.e. the weighting the government places on a group for reasons outside of their taxability. If a group is especially politically influential for independent reasons - e.g. if they are an important part of a government's winning coalition (Bueno de Mesquita et al. 2005) - then the ability to tax their gains to redistribute to others may not be as important a consideration for the government when deciding on trade policy.

Firm Cleavages

Trade-related cleavages might also occur along firm lines, given that a move to more open trade tends to lead to market consolidation around a smaller number of larger, highly-productive firms (Melitz 2003). This can lead to political divisions around trade agreements between these larger firms, who are also much more likely to be exporters, and smaller firms who may only sell their products in domestic markets, and who may be more likely to go out of business with an expansion of the size of the market (Osgood 2016, Kim 2017).

Whether larger or smaller firms are more easily taxable is not immediately obvious. On the one hand, smaller firms might be more difficult to tax, as they might have an easier time flying under the radar of tax auditors who may not see the value in investing significant fixed costs to track and assess the tax compliance of relatively "small fish". On the other hand, larger firms may have more resources to invest in complicated strategies of tax avoidance, relocating to tax havens, etc. and might be better able to move their assets abroad to lower tax jurisdictions. This would lead us to expect that larger firms would be more difficult to tax.

Evidence presented by Hanlon, Mills, and Slemrod (2005) appears to suggest that larger firms engage in more tax avoidance. If this is the case, the model would predict that trade policy should be biased against larger firms in favor of small businesses. However, if political influence is also related to firm size (see Bombardini 2008, Kim 2017) then this relationship is likely to be observationally confounded, making it difficult to assess empirically. Nonetheless, this paper's model gives us reason to believe that taxability could be an important part of the relationship between firm size and trade policy, whether or not we can empirically identify these effects.

Besides cleavages over firm sizes/productivities, we might also expect firm structure to matter both for the policies demanded by particular firms, and for the ability to tax those firms. Vertically-integrated multinational firms, for instance, would be likely to demand *lower* tariffs on input goods (Osgood et al. 2017, Osgood 2018), and may be differentially taxable from other firms (such as non-MNCs). Horizontally-integrated firms, on the other hand, may prefer protection from foreign competitors, and may be somewhat indifferent towards tariff reductions in foreign countries, given their ability to circumvent these tariffs with foreign subsidiaries. Further complicating the story is that firm structure is endogenous to tariff structure, and thus so too may be certain dimensions of taxability.

This paper does not have any easy answers for how to disentangle these complications. However, if the paper is right that tax and trade policy are substitute redistributive instruments, then the tax implications of global supply chains will be an unavoidable part of the political story of trade liberalization going forward. Indeed, we may already be observing some of the political implications of these changes in the structure of international trade in the form of a backlash against globalization. In a world in which supply chains and firm consolidation simultaneously make firms more politically influential and less taxable, the model might lead us to expect that we would observe greater liberalization of trade in ways that benefit larger firms, but without the concomitant increases in taxation that would allow the gains from open trade to be more broadly shared. In such circumstances, it seems likely that open trade would be a relatively brittle equilibrium, and thus especially vulnerable to shifts in the environment that might empower the actors that have lost most significantly as a consequence of the open trading system.

Conclusion

In this paper, I have identified how the typical story about fiscal capacity and trade policy - that lower fiscal capacity leads to greater reliance on trade tariffs due to lack of other means of raising revenues - provides us with useful insight into the broader patterns of trade protection, but does not tell the entire story. Instead, a model that looks at the relative taxability of different factors, industries, or firms can provide a good deal of new insight into the particular trade policies we would expect to be implemented under different circumstances. Moreover, this paper's model provides insight into why inefficient trade protection might emerge despite the fact that it destroys value; namely, because the beneficiaries of aggregate-income improving open trade policies may not be taxable in a way that would allow their gains to be used by governments to buy off the groups that lose from freer trade.

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Appendix

Case 2: Only One Party is Taxed

Because we assumed earlier that $\lim_{g\to 0} P'(g) = \infty$, it must be the case that at least one of the two parties is taxed. However, it is not necessarily the case that both groups will be assigned a positive tax rate; for instance, if one group was much more easily taxable than the other or significantly wealthier than the other, it is possible that Government would only draw revenues from that party. Formally, the condition for this is as follows:

$$\frac{\partial G}{\partial t_i}(t_i = 0) = \alpha_i I_i'[\pi_i(\tau)](-1) + (\alpha_1\beta_1 + \alpha_2\beta_2)P'(\theta_j t_j)\theta_i < 0 \text{ for } i \neq j$$

If $t_i = 0$, then Lemma 1 will not apply, and it becomes possible that $r_i > 0$. So, for instance, if $t_2 = 0$, Government's decision problem would now be the following:

$$\max_{\tau,t_1,r_2} G(\tau,t_1,r_2) = \alpha_1 U_1(\pi_1(\tau) - t_1) + \alpha_2 U_2(\pi_2(\tau) + r_2) + (\alpha_1\beta_1 + \alpha_2\beta_2)P(\theta_1 t_1 - r_2)$$

Now to make things a little more interesting, I will add in "spendability" parameters $\eta_i \in [0,1]$ for $i \in \{1,2\}$) into the model, which characterize value lost in the process of transferring revenue to a group, given that spending programs also entail administrative costs and can be inefficient in numerous other ways. This makes the version of the model discussed up until now a special case where $\eta_1 = \eta_2 = 1$, but does not change any of the existing results, given that up until now we have been discussing cases where $r_i = 0\ \forall i \in \{1,2\}$. Government's decision problem when $t_1 > 0$ and $t_2 = 0$ thus changes slightly to the following:

$$\max_{\tau,t_1,r_2} G(\tau,t_1,r_2) = \alpha_1 U_1(\pi_1(\tau) - t_1) + \alpha_2 U_2(\pi_2(\tau) + \eta_2 r_2) + (\alpha_1\beta_1 + \alpha_2\beta_2)P(\theta_1 t_1 - r_2)$$

Before proceeding further, we can establish another result which demonstrates that if trade protection is inefficient, compensatory spending programs can only exist in a relatively narrow subset of cases. Specifically, I show the following:

Lemma 2. *If $t_2 = 0$, which implies $t_1 > 0$, either $\tau^* = 0$ or $r_2 = 0$.*

Proof. We assume $\tau^* > 0$ and $r_2 > 0$ and then construct a Pareto improvement. If $\pi_1(\tau^*) - \pi_1(0) = \chi$ and $\pi_2(0) - \pi_2(\tau^*) = \Omega$, we can ensure $\Delta y_1 = 0$ by fixing $\Delta t_1 = \chi$. Then, if we wish to ensure $\Delta g = 0$, we have $\Delta g = 0 = \theta_1\chi - \Delta r_2 \leftrightarrow \Delta r_2 = -\theta_1\chi$. Substituting into the expression for Δy_2 we get $\Delta y_2 = \Omega - \theta_1\eta_2\chi$, which if $\Omega > \chi$ (i.e. protection is inefficient), it must be the case that $\Delta y_2 > 0$ (given that $\theta_1, \eta_2 < 1$). Thus we have constructed a Pareto-improvement. □

This result establishes that spending programs designed to compensate the losers from protection - which destroy value both on the taxation side and the spending side - cannot be an optimal choice for Government if they are also taxing the group that benefits from protection. Since this model is designed to explain trade policy, I will assume going forward that if $t_2 = 0$ then $r_2 = 0$ such that it is possible that $\tau^* > 0$. This ultimately rules out the possibility of spending programs that compensate open trade's winners in exchange for greater protection, since $r_2 = 0$ when $t_2 > 0$ (via Lemma 1) and now $r_2 = 0$ when $t_2 = 0$.[5]

[5] Of course, we do observe some rare examples of these kinds of policies, as with President Trump's compensation of farmers amidst his trade war with China (New York Times, Nov. 19 2018). Two possible explanations for this are: (1) protection with compensation for the losers is an out-of-equilibrium strategy over the long-term, but can be employed in the short-term as a means of extracting welfare-enhancing concessions over the long-term (this is ultimately the argument provided by officials in the Trump administration); (2) President Trump may not be exhibiting equilibrium behavior.

This simplifies the objective function when $t_2 = 0$ to the following:

$$\max_{\tau,t_1} G(\tau,t_1) = \alpha_1 U_1(\pi_1(\tau) - t_1) + \alpha_2 U_2(\pi_2(\tau)) + (\alpha_1\beta_1 + \alpha_2\beta_2)P(\theta_1 t_1)$$

Similarly to with Case 1, we can now determine the first order conditions that will characterize the solution when we are at an interior solution. However, due to the asymmetry induced by protection's inefficiency (as detailed in Lemma 2), this leads to two possible systems of first order conditions, i.e. the following when $t_2 = 0, t_1 > 0$:

$$\frac{\partial G}{\partial \tau} = \alpha_1 I_1'[\pi_1(\tau) - t_1]\frac{\partial \pi_1(\tau)}{\partial \tau} + \alpha_2 I_2'[\pi_2(\tau)]\frac{\partial \pi_2(\tau)}{\partial \tau} = 0 \tag{7}$$
$$\frac{\partial G}{\partial t_1} = \alpha_1 I_1'[\pi_1(\tau) - t_1](-1) + (\alpha_1\beta_1 + \alpha_2\beta_2)P'(\theta_1 t_1)\theta_1 = 0 \tag{8}$$

And the following when $t_1 = 0, t_2 > 0$.

$$\frac{\partial G}{\partial \tau} = \alpha_1 I_1'[\pi_1(\tau) + \eta_1 r_1]\frac{\partial \pi_1(\tau)}{\partial \tau} + \alpha_2 I_2'[\pi_2(\tau) - t_2]\frac{\partial \pi_2(\tau)}{\partial \tau} = 0 \tag{9}$$
$$\frac{\partial G}{\partial t_2} = \alpha_2 I_2'[\pi_2(\tau) - t_2](-1) + (\alpha_1\beta_1 + \alpha_2\beta_2)P'(\theta_2 t_2 - r_1)\theta_2 = 0 \tag{10}$$
$$\frac{\partial G}{\partial r_1} = \alpha_1 I_1'[\pi_1(\tau) + \eta_1 r_1](\eta_1) + (\alpha_1\beta_1 + \alpha_2\beta_2)P'(\theta_2 t_2 - r_1)(-1) = 0 \tag{11}$$

Here it should be reasonably clear that equations (7) and (8) are symmetric with (9) and (10), except that they reflect the special case when $r_2 = 0$. As none of the proofs for when $t_2 > 0$ rely on $r_1 \neq 0$, we can focus on proving results for when $t_2 > 0$ and then invoke symmetry to prove the analogous results for when $t_1 > 0$. Thus, the next step is to establish the required supermodularity condition for when $t_2 > 0$, proceeding as follows:

$$\frac{\partial^2 G}{\partial \tau \partial t_2} = \alpha_2 I_2''[\pi_1(\tau) - t_2]\frac{\partial \pi_2(\tau)}{\partial \tau}(-1) < 0$$
$$\frac{\partial^2 G}{\partial \tau \partial r_1} = \alpha_1 I_1''[\pi_1(\tau) + \eta_1 r_1]\frac{\partial \pi_1(\tau)}{\partial \tau}(\eta_1) < 0$$
$$\frac{\partial^2 G}{\partial t_2 \partial r_1} = (\alpha_1\beta_1 + \alpha_2\beta_2)P''(\theta_2 t_2 - r_1)\theta_2(-1) > 0$$

Therefore, $G(\cdot)$ is supermodular in $(-\tau, t_2, r_2)$ when $t_2 > 0, t_1 = 0$. Invoking symmetry, this also demonstrates that $G(\cdot)$ is supermodular in (τ, t_1) when $t_1 > 0, t_2 = 0$. We can now proceed to deriving the comparative statics. As with Case 1, we need to start with an analogous assumption with a similar intuition.

Assumption 2. *It is assumed that:*

$$P'(\theta_i t_i - r_j) > -P''(\theta_i t_i - r_j)\theta_i t_i \;\forall i \neq j$$

With this assumption, we can now prove the following proposition that replicates the core result from Case 1.

Proposition 4. *The tariff rate τ is increasing in the taxability of trade protection's winners and decreasing in the taxability of trade's losers. Furthermore, when $t_1 > 0$, $t_2 = 0$, and τ is at an interior solution this relationship is strict for θ_1, and when $t_2 > 0$, $t_1 = 0$ and τ, r_1 are at an interior solution, the relationship is strict for θ_2.*

Proof is in the appendix. The proof has a similar structure to Proposition 1, and the intuitions are fairly similar.

Now we can derive the comparative statics results with respect to $\beta_i, \alpha_i \; \forall i \in \{1,2\}$.

Proposition 5. *When τ, t_2, r_1 are at an interior solution, the effects of $\beta_1, \beta_2, \alpha_1, \alpha_2$ are all ambiguous. When τ, r_1 are at an interior solution, the effects of α_1, α_2 are ambiguous, but τ^* and t_1 are increasing in β_1, β_2.*

Proof in appendix. As emphasized in the discussion of Proposition 2, the null effects with respect to the α_i ultimately provide compelling evidence for the importance of relative taxability on trade policy over the more conventional focus on relative political power. The only alternation from Proposition 2 is that because when $t_2 = 0, t_1 > 0$ the only parameter affecting public goods provision is t_1, we can get a clearer comparative static on $\beta_i \; \forall i \in \{1,2\}$.

Now we can derive the comparative statics for the "spendability" parameters that were introduced for this case of the model. As we have established that if $t_2 = 0$ then $r_1, r_2 = 0$, spendability is only relevant in the case where $t_1 = 0, t_2 > 0$. We require an analogous assumption on the shape of $I_1(\cdot)$ to the assumptions made on $P(\cdot)$.

Assumption 3. *It is assumed that:*

$$I_1'\left[\pi_1(\tau) + \eta_1 r_1\right] > -I_1''\left[\pi_1(\tau) + \eta_1 r_1) r_1 \eta_1\right]$$

This assumption ensures that a decrease in the "price" of providing transfers to the losers from open trade does not lead to a reduction in the transfer level to that group, with a similar logic to Assumptions 1 and 2. This allows us to demonstrate the following proposition:

Proposition 6. *The tariff rate τ is decreasing in the "spendability" of open trade's losers. Moreover, this relationship is strict when τ, t_2, r_1 are at an interior solution.*

Proof. Proof is in appendix. □

In other words, trade becomes more open as the ability to compensate the losers increases. As a concrete example, consider that welfare spending has often been treated as a means of compensating the factor-level losers from more open trade; this proposition suggests that trade will become more open as welfare programs become more efficient or easier to expand. [6]

Finally, we can reexamine the "inefficiency puzzle" question; when can taxabilities and spendabilities be an explanation for trade protection when only one party is taxed? Lemma 2 establishes that there are narrow conditions under which inefficiency can be sustained where $t_1 > 0, t_2 = 0$; namely, it must be the case that θ_1, η_2 are sufficiently low that:

$$\frac{\partial G}{\partial r_2} = \alpha_2 U_2'(\pi_2(\tau) + \eta_2 r_2)\eta_2 + (\alpha_1\beta_1 + \alpha_2\beta_2)P'(\theta_1 t_1 - r_2)(-1) < 0$$

When $t_2 > 0, t_1 = 0$ we can put a bit more structure on this question, leading to the following result:

Proposition 7. *If trade protection is inefficient (i.e. destroys value) a Pareto-improving compensatory bargain in favor of fully open trade will still not be possible whenever the ability to tax trade's winners and the ability to spend on (i.e. compensate) the losers is sufficiently low. Specifically, if the efficiency loss from a tariff τ is defined as $\Lambda(\tau)$ and the value to open trade's winners of liberalization is defined as $\Omega(\tau)$, protection can only occur when:*

$$\exists \hat{\tau} \ s.t. \ \Omega(\hat{\tau})(1 - \eta_1\theta_2) - \Lambda(\hat{\tau}) > 0$$

Proof. Similarly to earlier proofs, for $\tau^* > 0$ we define $\pi_1(\tau^*) - \pi_1(\tau) = \chi$ and $\pi_2(0) - \pi_2(\tau^*) = \Omega$. Thus, if $\Delta y_1 = 0$ we have $\Delta r_1 = \frac{\chi}{\eta_1}$, and then if $\Delta g = 0$ we have $\Delta t_2 = \frac{\chi}{\eta_1\theta_2}$. Thus a Pareto-improving bargain will be possible whenever $\Delta y_2 > 0$, i.e. when $\Omega - \frac{\chi}{\eta_1\theta_2} > 0$. If we define the efficiency loss of a tariff rate τ as $\Omega(\tau) - \chi(\tau) = \Lambda(\tau)$, we can substitute into the expression for Δy_2 and rearrange to get the inequality in the proposition. □

Trade Policy as a Revenue Instrument

One extension worth considering, given the long history of tariffs as the primary revenue generator in many countries, is what happens if trade policy also generates revenue for the government. This would occur most straightforwardly with tariffs, as revenues are collected at the point of entry, but could also be the case for certain other kinds of trade policies such as quotas, if the government sells access to those quotas.

If we define a strictly increasing and strictly concave revenue function $R(\tau)$, i.e. $R'(\tau) > 0$ and $R''(\tau) < 0$, we can incorporate the revenue component of trade policy into the existing model with few alterations. I will focus on Case 1 (where all parties are taxed) to illustrate

[6] A careful observer might note that in this model, "spendability" only appears when tax rates are zero on the losers from trade. It is therefore worth noting that welfare programs often apply when workers lose their jobs or are otherwise sufficiently low-income as to pay zero taxes.

how this revenue component comes into play in the model. Government's decision problem becomes the following:

$$\max_{\tau,t_1,t_2} G(\tau,t_1,t_2) = \sum_{i\in\{1,2\}} \alpha_i \left(I_i[\pi_i(\tau)-t_i] + \beta_i P[t_1\theta_1 + t_2\theta_2 + R(\tau)]\right)$$

The first order conditions are largely similar to those from Case 1, with the exception of the following:

$$\frac{\partial G}{\partial \tau} = \alpha_1 I_1'[\pi_1(\tau)-t_1)]\frac{\partial \pi_1(\tau)}{\partial \tau} + \alpha_2 I_2'[\pi_2(\tau)-t_2]\frac{\partial \pi_2(\tau)}{\partial \tau} + (\alpha_1\beta_1+\alpha_2\beta_2)P'[\theta_1 t_1+\theta_2 t_2+R(\tau)]R'(\tau) = 0$$

Which illustrates that now tariffs are chosen in such a way that trades off the increased income to Group 1 *and* the increased revenue against the loss of income to Group 2.

This one change disrupts the ability to derive clear comparative statics from the model without imposing further structure on the model, leading to the following proposition.

Proposition 8. *If trade policy has revenue effects, the effect of all parameters in the model are ambiguous.*

Proof. The proof is straightforward: the supermodularity in $(\tau, t_1, -t_2)$ condition breaks down. This follows immediately from the fact that:

$$\frac{\partial^2 G}{\partial \tau \partial t_1} = \underbrace{\alpha_1 I_1''(\pi_1(\tau)-t_1)\frac{\partial \pi_1}{\partial \tau}(-1)}_{+\text{, income effects}} + \underbrace{(\alpha_1\beta_1+\alpha_2\beta_2)P''(t_1\theta_2+t_2\theta_2+R(\tau))R'(\tau)\theta_1}_{-\text{, revenue effects}}$$

□

In order to understand the scope conditions for this result, we need to think carefully about what gives rise to it. We get ambiguity because the direct impact of an increase in τ on the tax rate levied on Group 1 - the protectionist group - is ambiguous. This is because although the increase in income from protection for Group 1 leads it to be more attractive to raise revenues from Group 1, it also decreases the need to raise taxes by generating revenues directly. If this revenue effect dominates the income effect, the required complementarity condition between the variables breaks down, and we can't sign the comparative statics.

The requirements for this to matter are narrowed even further by an additional consideration: as a tariff increases revenues while *decreasing* the income of Group 2, there are two channels leading to a reduction in the tax rate t_2 on Group 2. However, because t_1 and t_2 are substitutes, this further increases Government's incentive to increase the tax rate on Group 1, which reduces the likelihood that the revenue effects of the tariff will dominate here. Indeed, if t_2 is reduced by an amount equivalent to the revenue effects of the tariffs, then the effect of the taxability of Group 1 on trade policy is once again unambiguously positive.

Nonetheless, it is possible to imagine how this might occur in cases where the ability to raise revenues from domestic taxation is heavily constrained. Alexander Hamilton's 1790 tax reforms, for instance, entailed a case where the revenue effects of tariffs so dominated the income effects for each group that domestic tax rates could be decreased even for the groups that benefited directly from trade protection.

However, when tariff revenues are a relatively small percentage of total revenues - as is currently the case for most countries worldwide and all developed countries [7] - then we would expect the income effects to dominate the revenue effects. In these cases, it should be possible to safely ignore the revenue effects for the analysis and instead treat trade policy as a purely redistributive instrument, as was done in the main variant of the model.

It is also possible to be more precise about the specific magnitude of these countervailing effects by using the more standard implicit function theorem approach to deriving the comparative statics, assuming that all choice variables are at an interior solution. However, this quickly produces complicated expressions that are difficult to interpret meaningfully. I apply this approach to derive an explicit expression for $\frac{\partial \tau^*}{\partial \theta_1}$ when the solution is at an interior in order to illustrate this issue. Implicit function theorem produces the following system of equations:

$$\begin{pmatrix} \Upsilon_{11} & \Upsilon_{12} & \Upsilon_{13} \\ \Upsilon_{21} & \Upsilon_{22} & \Upsilon_{23} \\ \Upsilon_{31} & \Upsilon_{32} & \Upsilon_{33} \end{pmatrix} \begin{pmatrix} \frac{\partial \tau}{\partial \theta_1} \\ \frac{\partial t_1}{\partial \theta_1} \\ \frac{\partial t_2}{\partial \theta_1} \end{pmatrix} = \begin{pmatrix} (\alpha_1\beta_1 + \alpha_2\beta_2)R'(\tau)P''(\Theta)t_1 \\ (\alpha_1\beta_1 + \alpha_2\beta_2)(P'(\Theta) + P''(\Theta)\theta_1 t_1) \\ (\alpha_1\beta_1 + \alpha_2\beta_2)P''(\Theta)\theta_2 t_1 \end{pmatrix}$$

$$\Upsilon_{11} = \alpha_1\left(\left(\frac{\partial \pi_1}{\partial \tau}\right)^2 I_1''(\Lambda_1) + I_1'(\Lambda_1)\frac{\partial^2 \pi_1}{\partial \tau^2}\right) + \alpha_2\left(\left(\frac{\partial \pi_2}{\partial \tau}\right)^2 I_2''(\Lambda_2) + I_2'(\Lambda_2)\frac{\partial^2 \pi_2}{\partial \tau^2}\right) + (\alpha_1\beta_1 + \alpha_2\beta_2)\left[(R'(\tau))^2 P''(\Theta) + P'(\Theta)R''(\tau)\right]$$

$$\Upsilon_{12} = \Upsilon_{21} = -\alpha_1 \frac{\partial \pi_1}{\partial \tau} I_1''(\Lambda_1) + (\alpha_1\beta_1 + \alpha_2\beta_2)R'(\tau)P''(\Theta)\theta_1$$

$$\Upsilon_{13} = \Upsilon_{31} = -\alpha_2 \frac{\partial \pi_2}{\partial \tau} I_2''(\Lambda_2) + (\alpha_1\beta_1 + \alpha_2\beta_2)R'(\tau)P''(\Theta)\theta_2$$

$$\Upsilon_{22} = \alpha_1 I_1''(\Lambda_1) + P''(\Theta)\theta_1^2(\alpha_1\beta_1 + \alpha_2\beta_2)$$

$$\Upsilon_{23} = \Upsilon_{32} = (\alpha_1\beta_1 + \alpha_2\beta_2)P''(\Theta)\theta_1\theta_2$$

$$\Upsilon_{33} = (\alpha_1\beta_1 + \alpha_2\beta_2)P''(\Theta)\theta_2^2 + \alpha_2 I_2''(\Lambda_2)$$

$$\Lambda_1 = \pi_1(\tau) - t_1, \Lambda_2 = \pi_2(\tau) - t_2, \Theta = \theta_1 t_1 + \theta_2 t_2 + R(\tau)$$

Solving this system of equations produces complicated algebraic expressions that are difficult to sign. Indeed, we get the following expression for $\frac{\partial \tau^*}{\partial \theta_1}$, where $d = (\alpha_1\beta_1 + \alpha_2\beta_2)$

[7] Tariff revenue is 3.63% of world government revenues, and <2% in the US, even in the wake of the recent trade war. See: `https://data.worldbank.org/indicator/GC.TAX.INTT.RV.ZS`

and the arguments of many functions are suppressed for (relative) readability:

$$\frac{\partial\tau^*}{\partial\theta_1} = \left(-\left(\alpha_2 I_2'' + \theta_2^2 \mathrm{dP}''\right)\left(-dP' - \theta_1 t_1 P''\right) - \theta_1\theta_2^2 t_1 \left(\mathrm{dP}''\right)^2\right)\left(\theta_1\theta_2\mathrm{dP}''\left(\theta_1\mathrm{dR}'P'' - \alpha_1\pi_1' I_1''\right) - \left(\alpha_1 I_1'' + d\theta_1^2 P''\right)\left(\theta_2\mathrm{dR}'P'' - \alpha_2\pi_2' I_2''\right)\right) -$$
$$\left(\theta_1^2\theta_2^2\left(\mathrm{dP}''\right)^2 - \left(\alpha_2 I_2'' + \theta_2^2\mathrm{dP}''\right)\left(\alpha_1 I_1'' + d\theta_1^2 P''\right)\right)\left(-\left(-dP' - \theta_1 t_1 P''\right)\left(\theta_2\mathrm{dR}'P'' - \alpha_2\pi_2' I_2''\right) - d\theta_1\theta_2 t_1 \mathrm{dP}''P''R'\right) \text{ divided by}$$
$$\left(\left(\alpha_2 I_2'' + \theta_2^2\mathrm{dP}''\right)\left(-\left(\alpha_1\pi_1' I_1'' - \theta_1\mathrm{dR}'P''\right)\right) - \theta_1\theta_2\mathrm{dP}''\left(\theta_2\mathrm{dR}'P'' - \alpha_2\pi_2' I_2''\right)\right)\theta_1\theta_2\mathrm{dP}''\left(\theta_1\mathrm{dR}'P'' - \alpha_1\pi_1' I_1''\right)$$
$$-\left(\alpha_1 I_1'' + d\theta_1^2 P''\right)\left(\theta_2\mathrm{dR}'P'' - \alpha_2\pi_2' I_2''\right) + \left(\theta_1^2\theta_2^2\left(\mathrm{dP}''\right)^2 - \left(\alpha_2 I_2'' + \theta_2^2\mathrm{dP}''\right)\left(\alpha_1 I_1'' + d\theta_1^2 P''\right)\right)$$
$$\left(\theta_1\theta_2\mathrm{dP}''\left(\alpha_1\left(\left(\pi_1'\right)^2 I_1'' + \pi_1'' I_1'\right) + \alpha_2\left(\left(\pi_2'\right)^2 I_2'' + \pi_2'' I_2'\right) + d\left(P''\left(R'\right)^2 + P'R''\right)\right) + \left(\alpha_1\pi_1' I_1'' - \theta_1\mathrm{dR}'P''\right)\left(\theta_2\mathrm{dR}'P'' - \alpha_2\pi_2' I_2''\right)\right)$$

Finally, the revenue model also alters in an interesting way the analysis of when trade protection can occur despite its inefficiency. Here, if we define the value of an increased tariff $\tau' > 0$ to Group 1 as $\chi \equiv \pi_1(\tau') - \pi_1(0)$, the value lost from the tariff to Group 2 as $\Omega \equiv \pi_2(0) - \pi_2(\tau')$, and the revenue effect of the tariff as $\Theta = R(\tau') - R(0)$, then the assumption that trade protection is inefficient can be summarized with the following assumption:

Assumption 4. *It is assumed that:*

$$\Omega > \chi + \Theta$$

The magnitude of each of these components is determined by market characteristics such as import demand elasticities and export supply elasticities, as these features determine both the overall efficiency loss from a tariff, and *tariff incidence* (i.e. who ultimately pays for a tariff). As an example, *perfectly inelastic import demand* would imply *zero* efficiency loss - as domestic consumers would continue to import the same amount of the quantity despite the increase in price - with the effects of a tariff implying an efficient transfer from Group 2 to Government as revenue. In practice, tariffs tend to generate some combination of efficiency losses, revenue increases, and distributive effects across groups, so all of the components of Assumption 4 come into play and vary significantly depending on the tariffs in question.[8] Assumption 4 also implies a "small country" assumption, in the sense that tariffs are assumed not to be welfare-increasing via their terms-of-trade effects. This leads to the following proposition:

Proposition 9. *When trade policy has revenue effects in addition to income effects, trade protection can only occur whenever:*

$$\Omega < \frac{\theta_1\chi + \Theta}{\theta_2}$$

Proof. Having defined notation as above, we proceed as usual: $\Delta y_1 = 0$ means $\Delta t_1 = \chi$. $\Delta g = -\theta_1\chi - \Theta + \theta_2\Delta t_2$, such that if $\Delta g = 0$ we have $\Delta t_2 = \frac{\theta_1\chi+\Theta}{\theta_2}$. Then, substituting, we get $\Delta y_2 = \Omega - \frac{\theta_1\chi+\Theta}{\theta_2}$, which establishes the statement in the proposition. □

[8] See, for instance, Amiti et al. 2019, for an incidence analysis of the Trump Administration's 2019 tariffs.

Proof of Proposition 2

Let's start by deriving comparative statics with respect to α_1.

$$\frac{\partial^2 G}{\partial\tau\partial\alpha_1} = I_1'[\pi_1(\tau)-t_1]\frac{\partial\pi_1}{\partial\tau} > 0$$
$$\frac{\partial^2 G}{\partial t_1\partial\alpha_1} = I_1'[\pi_1(\tau)-t_1](-1)+\beta_1 P'(\theta_1 t_1+\theta_2 t_2)\theta_1$$
$$\frac{\partial^2 G}{\partial t_2\partial\alpha_1} = \beta_1 P'(\theta_1 t_1+\theta_2 t_2)\theta_1 > 0$$

Here, the signs of all but the second cross-partial derivative are immediately clear. However, using the first order conditions that characterize an interior solution (specifically equation 5), we can also establish that:

$$I_1'[\pi_1(\tau)-t_1] = \frac{\alpha_1\beta_1+\alpha_2\beta_2)P'(\theta_1 t_1+\theta_2 t_2)\theta_1}{\alpha_1}$$

Which if we substitute into the expression for $\frac{\partial^2 G}{\partial t_1\partial\alpha_1}$, gives us:

$$\frac{\partial^2 G}{\partial t_1\partial\alpha_1} = \left(\beta_1-\beta_1-\frac{\alpha_2}{\alpha_1}\beta_2\right)P'(\theta_1 t_1+\theta_2 t_2)\theta_1$$
$$= -\frac{\alpha_2}{\alpha_1}P'(\theta_1 t_1+\theta_2 t_2)\theta_1 < 0$$

Thus we have:

$$\frac{\partial^2 G}{\partial\tau\partial\alpha_1} > 0,\ \frac{\partial^2 G}{\partial t_1\partial\alpha_1} < 0,\ \frac{\partial^2 G}{\partial\text{-}t_2\partial\alpha_1} < 0$$

And thus we cannot establish a clear monotone comparative static. This is because an increase in α_1 has the direct effect of increasing t_1 but also increases τ; which of these effects dominates is unclear.

Now, let's consider the effects of β_1. We have:

$$\frac{\partial^2 G}{\partial\tau\partial\beta_1} = 0$$
$$\frac{\partial^2 G}{\partial t_1\partial\beta_1} = \alpha_1 P'(\theta_1 t_1+\theta_2 t_2)\theta_1 > 0$$
$$\frac{\partial^2 G}{\partial t_2\partial\beta_1} = \alpha_1 P'(\theta_1 t_1+\theta_2 t_2)\theta_2 > 0$$

Given that $G(\cdot)$ is supermodular in $(\tau, t_1, -t_2)$, this does not allow us to establish a clear comparative static.

Proof of Proposition 4

The approach here is similar to the proof for Proposition 1. We start by taking the relevant crosspartials.

$$\frac{\partial^2 G}{\partial \tau \partial \theta_2} = 0$$
$$\frac{\partial^2 G}{\partial t_2 \partial \theta_2} = (\alpha_1\beta_1 + \alpha_2\beta_2)\big(P''(\theta_2 t_2 - r_1)t_2\theta_2 + P'(\theta_2 t_2 - r_1)\big) > 0 \text{ (by Assumption 2)}$$
$$\frac{\partial^2 G}{\partial r_1 \partial \theta_2} = (\alpha_1\beta_1 + \alpha_2\beta_2)P''(\theta_2 t_2 - r_1)(-1)(\theta_2) > 0$$

Thus, from this we have established that $\frac{\partial \tau^*}{\partial \theta_2} < 0$ via Edlin and Shannon 1998, for the case where $t_2 > 0$ and $t_1 = 0$ while r_1, τ are at an interior solution. $\frac{\partial \tau^*}{\partial \theta_1} > 0$ is obtained by invoking symmetry when $t_2 > 0$ and $t_1 = 0$ and τ is at an interior solution.

Proof of Proposition 5

To start, let's determine the comparative statics for β_i.

$$\frac{\partial^2 G}{\partial \tau \partial \beta_1} = 0$$
$$\frac{\partial^2 G}{\partial t_2 \partial \beta_1} = \alpha_1 P'(\theta_2 t_2 - r_1)\theta_1 > 0$$
$$\frac{\partial^2 G}{\partial r_1 \partial \beta_1} = \alpha_1 P'(\theta_2 t_2 - r_1)(-1) < 0$$

This establishes that the impact of β_1 is ambiguous when $t_2 > 0, t_1 = 0$. However, when $t_1 > 0, t_2 = 0$, only the symmetric versions of the first two expressions appear, which establishes that $\frac{\partial \tau^*}{\partial \beta_i} > 0$.

Now, let's examine the impact of α_2 when $t_2 > 0$. We get:

$$\frac{\partial^2 G}{\partial \tau \partial \alpha_2} = I_2'(\pi_2(\tau) - t_2)\frac{\pi_2(\tau)}{\partial \tau} < 0$$
$$\frac{\partial^2 G}{\partial t_2 \partial \alpha_2} = I_2'(\pi_2(\tau) - t_2)(-1) + \beta_2 P'(\theta_2 t_2 - r_1)\theta_2$$

Substituting in from Eq. (10) gives

$$\frac{\partial^2 G}{\partial t_2 \partial \alpha_2} = \frac{\alpha_1\beta_1 + \alpha_2\beta_2}{\alpha_2} P'(\theta_2 t_2 - r_1)\theta_2(-1) + \beta_2 P'(\theta_2 t_2 - r_1)\theta_2$$
$$= -\frac{\alpha_1\beta_1}{\alpha_2} P'(\theta_2 t_2 - r_1) < 0$$
$$\frac{\partial^2 G}{\partial r_1 \partial \alpha_2} = \beta_2 P'(\theta_2 t_2 - r_1)(-1) < 0$$

Given that when $t_2 > 0, t_1 = 0$ we have $G(\cdot)$ is supermodular in $(-\tau, t_2, r_1)$, this establishes that the impact of α_2 when $t_2 > 0$ is ambiguous, and by symmetry of the first two expressions (from which we can establish that $\frac{\partial^2 G}{\partial \tau \partial \alpha_1} > 0$ and $\frac{\partial^2 G}{\partial t_1 \partial \alpha_1} < 0$), we can establish that the impact of α_1 when $t_1 > 0$ is also ambiguous.

Finally, let's examine the impact of α_1 when $t_2 > 0$.

$$\frac{\partial^2 G}{\partial \tau \partial \alpha_1} = I_1'(\pi_1(\tau) - t_1)\frac{\pi_1(\tau)}{\partial \tau} > 0$$
$$\frac{\partial^2 G}{\partial t_2 \partial \alpha_1} = \beta_1 P'(\theta_2 t_2 - r_1)\theta_2 > 0$$
$$\frac{\partial^2 G}{\partial r_1 \partial \alpha_1} = I_1'(\pi_1(\tau) + \eta_1 r_1)(\eta_1) + \beta_1 P'(\theta_2 t_2 - r_1)(-1)$$

Substituting in from Eq. (11) gives us:

$$\frac{\partial^2 G}{\partial r_1 \partial \alpha_1} = \frac{\alpha_2}{\alpha_1}\beta_2 P'(\theta_1 t_2 - r_1) > 0$$

Thus establishing that the impact of α_1 when $t_2 > 0$ is ambiguous, which by symmetry of the first two expressions implies that the impact of α_2 when $t_1 > 0$ is also ambiguous.

Proof of Proposition 6

The approach here is similar to the proof for Proposition 1 and 4. We start by taking the relevant crosspartials.

$$\frac{\partial^2 G}{\partial \tau \partial \eta_1} = \alpha_1 I_1''\left(\pi_1(\tau) + \eta_1 r_1\right)\frac{\partial \pi_1(\tau)}{\partial \tau}(r_1) < 0$$
$$\frac{\partial^2 G}{\partial t_2 \partial \eta_1} = 0$$
$$\frac{\partial^2 G}{\partial r_1 \partial \eta_1} = \alpha_1\left[I_1''(\pi_1(\tau) + \eta_1 r_1) r_1 \eta_1 + I_1'(\pi_1(\tau) + \eta_1 r_1)\right] > 0 \text{ by Assumption 3}$$

Thus, from this we have established that $\frac{\partial \tau^*}{\partial \eta_1} < 0$ via Edlin and Shannon 1998, for the case where $t_2 > 0$ and $t_1 = 0$ while r_1, τ are at an interior solution.