Terrorism, Trade and Public Policy*

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Abstract

Are bigger markets safer? How should government policy respond to terrorist threats? Trade draws potential terrorists and economic predators into productive activity, but trade also draws terrorist attacks. Larger trade reduces the risk of terrorist attack when the wage elasticity is high, associated with low ratios of predators to prey and high wages; but it may increase the risk of terrorist attack when the wage elasticity is low, associated with high ratios of predators to prey. Anti-terrorist trade policy should always promote trade in simultaneous play. Government first mover advantage and inelastic wage may imply trade restriction. Tolerance of smuggling may improve security. Better enforcement should ordinarily be provided for bigger, inherently safer and higher wage markets.

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Are bigger markets safer from terrorism? How should governments respond? Informal economic thinking yields conflicting answers. Protectionists think that less trade lowers vulnerability. Liberals think that bigger markets increase legitimate employment and thus dry up the wellsprings of terrorism.

The liberal vs. protectionist debate has important policy implications. Should trade be concentrated and fostered in bigger, more well-protected markets or dispersed in smaller markets? Sensible public policy should be derived from a model of the costs and benefits of trade and enforcement policy, accounting for the reactions of traders and terrorists.[1]

This paper sets out the key elements in a model of rational terrorism, trade and public policy. It features interaction between trade, terrorism and policy through a common labor market supplying trade workers, enforcement patrols, economic predators and terrorists. Think of market towns with labor and capital markets partially segmented from the wider economy. Government and a terrorist executive 'Al Qaeda' (AQ) set defense and attack strategies.

The model is most applicable to thinking about public policy and terrorism in a market and across markets within a country. Since economic predation plays a key role, the model may be less applicable to rich secure countries. Thinking about transnational terrorism suggests linkages between countries that are shut down here — terms of trade effects, migration, and competing national governments, some of which may be complicit with the terrorist movement. The current model may nevertheless be a platform on which to build these added structures.

Is bigger safer? Destruction of bigger markets is probably more valuable to a terrorist executive — bang for the buck. In contrast, trade expansion raises wages, making it more costly for AQ to hire terrorist agents — cost push. Higher wages also draw off economic predators, increasing the shipment success rate of traders against predators of both types — safety in numbers. When safety in numbers and cost push dominate bang for the buck, bigger is safer. This occurs when the elasticity of the wage with respect to trade volume exceeds one and the value to AQ per unit of trade destroyed falls with volume.

The wage elasticity condition is met in high wage low predation markets,

[1]Irrational policy examples include the current US law mandating that 100% (!) of all containers shipped to the US must be inspected by 2010. Some expensive steps have already been taken, in the US and many other locations. Yet delay in ports adds to shipment costs more significantly than most current tariffs.

but it may be violated for low wage markets. 'Underemployment' equilibrium — low wage elasticity with respect to trade — is associated in the model with insecure property rights and a large sectoral share of informal employment. It contrasts with surplus labor models that impose low wage elasticity economy-wide.

Public policy includes both tax or subsidy to trade (via lower access charges) and enforcement by patrols or inspections. Anti-terrorist trade policy should promote trade if the government plays simultaneously with AQ. Trade promotion is efficient whether bigger is ultimately safer or not because the strategies of government and AQ cannot exploit knowledge about their opponents' response. With a government first mover advantage, trade-reducing policy may be beneficial if bigger is less safe; i.e., only if the wage is inelastic and/or AQ's value per unit destroyed is increasing in volume. Considering interaction between government and AQ across many markets, simultaneous play seems more plausible. Liberal optimism is probably justified in most circumstances.

Enforcement frustrates predation of both types by 'patrols' or 'inspections'. The comparative statics of efficient trade and enforcement policy imply that the rich get richer: less trade and enforcement and thus less security the smaller and more low wage the market is.

An important externality arises when a grey (smugglers) market exists alongside a legal market. Smuggling draws off potential predators of both types, so anti-terrorism motives increase tolerance. If smuggling strengthens AQ, intolerance is indicated.

Across market towns linked through the labor market, so long as better enforcement raises the wage, better enforcement anywhere makes all markets safer, a positive externality. When wages are low it is possible that better enforcement reduces the wage (the greater number of cops is offset by the number of economic predators switching to legitimate employment), inflicting a negative externality on other markets. Cooperative enforcement ordinarily treats markets unequally. At a constant wage, bigger markets get more protection. But incorporating the wage response to enforcement effort, in high wage economies the effect is to reduce protection to bigger markets. In low wage economies the wage response can amplify the tendency to protect bigger markets more intensively. Thus efficient enforcement in poor economies may be more unequal than in rich economies.

The analysis provides a structure for future empirical work.[2] The model indicates a non-linear relationship in the reduced form among the determining factors. Bigger markets are safer in some parameter ranges leading to high wages while bigger markets are less safe in other parameter ranges leading to low wages. The endogenous response of trade policy amplifies these effects while the response of enforcement to variation in underlying determinants of trade can amplify or offset these tendencies.

A related literature analyzes the impact of trade on contests over resources (Garfinkel, Skaperdas and Syropoulos, 2008a,b). Opening to trade shifts the value of the resource and hence the level of forces committed to the contest for control. Autarky may dominate free trade in a 'resource curse' regime — protectionist pessimism for a different reason.

Section 1 provides a sketch of the analytic elements. Section 2 sets out the model. Section 3 analyzes trade policy. Section 4 considers the implications of smuggling alongside legitimate markets. Section 5 analyzes enforcement policy. Section 6 concludes.

1 Analytical Elements

The government and AQ play their strategies in an economic environment with trade carried on by a merchant guild, all three actors hiring agents from a common labor pool. AQ recruits agents to attack markets by infiltrating shipments with explosives or toxins. The government protects markets by hiring cops to intercept attacks or inspect shipments, and through 'trade' policy to promote or restrict trade.

"Rational" terrorism is assumed.[3] The deep goal of terrorism is to accomplish political and social regime change in some region or country. Destruction of markets by terrorist attack is instrumental, for reasons outside the model.[4]

[2]Empirical work by Mirza and Verdier (2006) finds links between international trade volume and terrorism. The present model suggests that wo way causality between trade, terrorism and enforcement may be confounding attempts to understand the link between economic forces and terrorism. Expanding the model suitably to analyze international trade is a task for the future.

[3]Some authors argue against rational structure; see Krueger and Laitin, 2007, and Krueger and Maleckov, 2003. Mirza and Verdier (2006) argue in favor.

[4]Massacre or murder are alternative instrumental objects of some prominent recent terrorist attacks. The model's focus on q might still provide useful analysis because de-

AQ's preferences play a role in determining whether bigger is safer. The observable combination of a few massive attacks on big targets and a large number of smaller attacks on smaller targets can be explained within the model by the instrumental role of terrorism. In seeking regime change locally (e.g., the insurgency in Iraq and its counterpart in Afghanistan and the neighboring part of Pakistan), soft targets serve nearly as well as hard ones to demonstrate the incompetence of the regime. The value of goods destroyed to the consumers is a natural measure. AQ thus presumably has non-increasing value per unit for most terrorist attack. In contrast, the value to 'AQ' from huge attacks is potentially in the form of increased resources for carrying on its campaign, especially in the long run from provoking harsh reactions by the government that that will increase resources in the future. Examples are the attack on the Askariya mosque in Samarra in February 2006 and the Mumbai attack of November 2008. This rationale for AQ behavior may imply a range of increasing value per unit destroyed for at least some targets.[5]

The market model abstracts from unnecessary detail. The focus is entirely on the trade activity and its attackers and defenders, so the gross arbitrage margin is exogenous. The traders, attackers and defenders all are drawn from a common labor pool. Trade is subject to attack by economic predators (extortionists or thieves) as well as terrorists. Besides being realistic, the presence of economic predators yields a closed form solution to the rational expectations equilibrium success rate of shippers that is a key element in deriving the equilibrium interaction of traders, predators and cops. The objective success rate of shipments is a decreasing logistic function of the ratio of predators to prey and increasing in the number of cops, while the terrorist objective success rate is an increasing logistic function of the expected number of successful terrorist infiltrations. The combination of economic interaction through the labor market and noneconomic interaction

struction of q is highly correlated with loss of life. A deeper model of rational massacre requires heterogeneous agents and a theory of which agents are targeted.

[5] AQ is taken to be a single actor in the model, hence it internalizes the change in value per unit destroyed. Competitive terrorist organizations correspond to price taking firms that would not internalize the change in value per unit, while oligopolistic competition falls somewhere in between. The market organization of terrorism might be worth developing in the future. Entry involves a the terrorist group that is relatively unknown and needs to advertise its program. Particularly large or imaginatively horrific attacks capture media attention and can serve to increase the flow of resources to the terrorist chiefs. Entry and competition for resources among terrorist groups may thus be associated with increasing returns preferences in the reduced form setup of the model.

of attack/elude/defend activity comprises the mechanism of the model.

Terrorists are hired by AQ at the going wage rate. AQ's payoff is the product of the value (to AQ) of the goods destroyed and the probability of destruction. AQ does not micro-manage the terrorist attacks, but sees through the interaction of predators and prey to internalize the effect of terrorist numbers on the probability of their success. Terrorist agents are hired up to the point where the value of their marginal effect on the probability of destruction is equal to the wage.

Merchants set volume to maximize expected profits, paying trade services workers the equilibrium wage. Increases in trade volume push up the wage, affecting profits in two ways. A merchant monopoly internalizes the due to cost push and also due to the effect of the wage on the shipment success rate, called safety in numbers by Anderson and Bandiera (2006). The rational expectations equilibrium probability of successful shipment is increasing in the wage because economic predation yields an expected return equal to the wage. Monopoly merchants may also possibly internalize the externality that links trade volume to the probability of destruction by terrorists.

The probability of destruction in this setup is reduced directly by increases in the volume of trade, due to safety in numbers. Indirectly, the probability of destruction is changed by the endogenous response of terrorism. On the one hand, safety in numbers implies that the probability of successful attack by any predator is lower. Also, the wage paid to hire a terrorist from the common labor pool rises due to increased demand for labor in trade services, the cost push effect. Both safety in numbers and cost push reduce the probability of destruction. In contrast, bigger markets have more bang for the buck, inducing AQ to commit more resources to terrorism.

The elasticity of the wage with respect to trade volume is critical to determining whether bigger markets are safer with respect to terrorism, and also to characterizing the optimal trade and enforcement policies. A key implication of the model is that the equilibrium wage rate is inelastic with respect to trade volume at high predation rates (and low wages) while it is elastic with respect to trade volume at low predation rates (and high wages). Thus the model endogenizes a source of 'surplus labor' behavior with a simple microeconomic foundation.

2 The Model

The first subsection sets up the model of trade and the labor market while the second subsection develops rational terrorism. The third subsection draws the implications for terrorist incidence.

2.1 Merchants, Traders, Cops and Predators

Goods are purchased by traders at exogenous price c, and if successfully shipped, resold in the destination market at exogenous price $b; b > c$. The gross margin per unit $b - c$ offsets the cost of trade and the expected loss to predation.

The costs incurred in the trade activity include labor and capital costs. Trade is carried on by a monopoly shipper (a merchant guild), except for competitive smugglers when smuggling is introduced. Labor is hired at the equilibrium wage, but the monopsony merchant guild internalizes the effects of trade on the wage. Capital is supplied to the trade sector at a service price that the merchants take as given, though the model allows for endogeneous response between the extremes of sector specific capital and infinitely elastic supply at fixed service price. The focus of the model being on interactions in the labor market, the asymmetric treatment of capital just serves to generalize the treatment of labor demand in trade services.

Merchants hire labor from the same pool as potential predators, paying wage w. Constant returns trade technology and cost minimizing behavior imply a unit cost of trade services $c(w, r)$ where r is the service price of capital. Using Shephard's lemma, capital is emloyed such that $qc_r(w, r) = K(r)$ where $K(r)$ is the capital supply function. Solving for the equilibrium service price $r(q, w)$ and substituting into the unit cost function yields the unit trade cost function $t(q, w) = c(w, r(q, w))$. With Cobb-Douglas technology and sector specific fixed capital, $t = kwq^{1/\alpha}, \alpha \in (0, 1)$, where α is the labor share parameter and k is a parameter reflecting the fixed capital stock and other parameters.

Risk neutral[6] economic predators choose to predate based on equal expected returns to their best alternative, the wage w paid to labor by merchants or AQ. Predators of mass B succeed in their attack on trade with

[6] The consequences of allowing for predators' risk aversion make no essential qualitative difference. Predation is likely to be a far riskier activity than shipping, so risk aversion acts to suppress predation.

probability $1-\pi$, and sell their gains in a thieves market with price normalized to 1. Predators are indifferent when

$$w = \frac{(1-\pi)q}{B}\frac{B}{B+T} = \frac{(1-\pi)q}{B+T}. \tag{1}$$

This setup imposes that no predator attacks the prey of another predator, a plausible simplification.

The objective interaction of traders and predators reflects a game of hide and seek. The success rate of traders in evading predators is modeled as a logistic function of the ratio of predators to prey,

$$\frac{1}{1+\theta(B+T)/q}; \theta > 0.$$

Enforcement by the cops saves a fraction M of encounters between predators and prey from resulting in loss of the goods. M can also reflect the share left to the shipper by extortionists, possibly also due to the shadow of the cops. The objective success rate of shipments is thus

$$\pi = M + (1-M)\frac{1}{1+\theta(B+T)/q}.$$

Considering the success rate of predators,

$$1-\pi = (1-M)\frac{\theta(B+T)/q}{1+\theta(B+T)/q},$$

where the second ratio on the right is the probability that a predator meets a shipment. This formula clarifies the role of patrols: the predator succeeds when there is both a successful meeting with a shipment combined with not being intercepted by a patrol.

The rational expectations equilibrium probability of successful shipment is given by $\pi = M + w/\theta$, resulting from the equal returns condition in the labor market $w = (1-\pi)q/(B+T)$ combined with the logistic objective success rate. Intuitively, enforcement acts independently of the predator/prey interaction, while higher wages crowd out predators. θ is a parameter reflecting the relative effectiveness of predators relative to prey.

Enforcement of quality M requires labor for patrols or inspections $F = aqM$. Here M is the proportion of shipments that are inspected and a is the labor requirement per unit inspected.

The demand for labor in predation is given by $B + T = (1 - \pi)q/w$ due to the equal expected returns condition. The demand for labor in trade services is $E(q, w) = qc_w(w, r(q, w))$. For a Cobb-Douglas technology and fixed capital, employment is given by $E = \alpha k q^{1/\alpha}$.

Labor market clearance requires that the fixed supply[7] N is equal to the total demand $E + F + B + T$. The market clearing wage is given by $w = W(q, M)$. The Appendix presents the details and develops the wage elasticity $W_q q/w$ and also W_M/w. For low volume and low wages, associated with relatively high ratios of $(B + T)/(E + F)$, $0 < W_q q/W < 1$ while for high volume and high wages, $W_q q/W > 1$.

The profits of merchant capital (producers' surplus) are given by

$$S(q, w) = \int_0^q [\pi b - c - t(w, x)]dx.$$

Competitive merchants (smugglers) enter trade to the point where

$$S_q = \pi b - c - t(w, q) = 0. \tag{2}$$

Monopoly trade endogenizes the dependence of the wage on the volume of trade, understanding also the rational expectations equilibrium dependence of the success rate on trade. Thus when the probability of destruction is taken by the merchant as exogenous

$$S_q + S_w W_q = 0. \tag{3}$$

Anderson and Bandiera (2006) analyze the existence of equilibrium in essentially this model.[8] If the gains from trade are large enough, the technology of trade good enough, the technology of predation poor enough, the technology of enforcement good enough or the supply of labor small enough relative to demand in trade services, then trade is secure. Reversing these conditions, autarky may be the only stable equilibrium. For intermediate ranges of parameters, an insecure stable equilibrium exists. This paper assumes an insecure stable equilibrium. It will be one of two types: a weak enforcement equilibrium characterized by $S_w = q[(\pi - M)b - wt_w] > 0$ or a strong enforcement equilibrium characterized by $S_w < 0$. Anderson and Bandiera supply necessary and sufficient conditions for weak or strong enforcement in terms of parameters of the model.

[7]The implications of variable labor supply for the mechanics of the model are obvious — the wage elasticity is reduced. See the Appendix.

[8]In their model a monopoly enforcer internalizes the externalities but the qualitative behavior is much the same.

2.2 Rational Terrorism

Terrorist attacks, if successful, destroy the market (or a portion of it), resulting in expected losses to the merchants equal to DS where D is the expected proportion of surplus lost. Rational terrorism in the model implies a useful relationship between the probability of destruction D and the equilibrium trade volume. This relationship is developed here and then in the next subsection it is used to make predictions about the incidence of terrorism.

It is plausible that destruction of the market requires the infiltration of a substantial number of shipments, literally or metaphorically containers. This would be true for conventional explosives, biological agents and most toxins, considering distribution systems and the uncertain destructiveness of these products. Thus it is reasonable to model the probability of destruction D as a logistic function of the expected number of infiltrated containers:[9]

$$D = d(T) = \frac{(1-\pi)T/\delta}{1+(1-\pi)T/\delta}, \delta > 0. \tag{4}$$

D is increasing in T, $d_T > 0$. The higher the parameter δ the less the chance that a mass mass of terrorist infiltrations can destroy the market. δ represents either the technology, or the society's propensity to report infiltration to the cops.

Next, manipulate the probability of destruction into a form useful for the analysis of simultaneous play between AQ, merchants and the government. Rational expectations shipment success is given by

$$\pi = M + w/\theta.$$

Using labor market equilibrium

$$\pi = \Pi(q, M) = M + W(q, M)/\theta. \tag{5}$$

Using (5) in(4) yields

$$D = D(T, q, M) = \frac{1}{1 + \delta/T[1 - \Pi(q, M)]}. \tag{6}$$

The derivative properties of D are given by

$$D_T = D(1-D)/T \geq 0,$$

[9]The logistic distribution is a good approximation for the distribution of independent dichotomous phenomena such as the individual container being contaminated or not.

$$D_q = -D(1-D)\frac{(\pi - M)W_q/w}{1-\pi} \leq 0,$$
$$D_M = -D(1-D)\frac{1 + (\pi - M)W_M/w}{1-\pi} \leq 0.$$

The sign of D_M is guaranteed by $W_M/w \geq -1$, which is required for interior equilibrium enforcement, as will be shown below. Finally,

$$D_\delta < 0.$$

Next, consider rational terrorist demand T. AQ is assumed to benefit from destruction of the market by $Dh(q)q$, where D is the probability of destruction and $h(q)$ is the value to AQ of destroying a unit of trade. $h_q = 0$ is a natural benchmark because market valuations b and c are constant, while $h_q < 0$ is also natural based on downward sloping demand.

AQ must pay each hired terrorist the equilibrium wage.[10] Thus the rational terrorist AQ hires an efficient number of terrorists such that

$$hqd_T = w.$$

The efficient number of terrorists hired by AQ when facing D function (4) is given by

$$T = (hq\delta/(1-\pi)w)^{1/2} - \delta/(1-\pi). \tag{7}$$

This yields the expected number of infiltrations as

$$(1-\pi)T = (\frac{hq(1-\pi)}{\delta w})^{1/2} - 1/\delta.$$

Substituting back into (4) and simplifying yields

$$D = 1 - (\frac{\delta w}{hq(1-\pi)})^{1/2}.$$

Substituting $W(q, M)$ for w and $M + W(q, M)/\theta$ for π yields the reduced form probability of destruction

$$D = \bar{D}(q, M; \delta) \equiv 1 - \left(\frac{W(q, M)\delta}{hq(1 - M - W(q, M)/\theta)}\right)^{1/2} \tag{8}$$

[10] An exogenous discount or premium has obvious effects. Endogenizing the wage differential requires modeling workers' decisions and their connections to AQ and the government, an important but distracting project.

The direct and indirect effects of a rise in trade volume on the probability of destruction D is given by differentiating (8):

$$\frac{q\bar{D}_q}{D} = \frac{1-D}{2}\left(-\frac{1-M}{1-\pi}\frac{W_q q}{W} + 1 + \frac{h_q q}{h}\right). \tag{9}$$

If $W_q q/W > (1 + h_q q/h)(1-\pi)/(1-M)$, increases in trade lower the probability of destruction. $h_q q/h \leq 0$ seems plausible for most AQ attacks. Noting that $\pi > M$, $W_q q/w$ need not be very large to satisfy the sufficient condition for $\bar{D}_q < 0$.

Proposition 1 *With decreasing unit payoffs to AQ, the terrorist threat is decreasing in trade volume whenever the wage is elastic in trade volume.*

The rise in the wage reduces the terrorist threat through two mechanisms that are combined in the coefficient $(1-M)/(1-\pi) = 1 + (\pi - M)/(1-\pi)$. The first term on the right is cost push, raising the price of hiring terrorists. The second term is safety in numbers: higher wages reduce the number of predators.

2.3 Implications for Terrorist Incidence

Across segmented labor markets, equilibrium trade volume varies directly with key underlying parameters. For example, markets with higher prices b will have larger sales volume and higher wages, all else equal. (9) reveals that larger markets may or may not be safer. A key role is played by the wage elasticity $W_q q/W$. The Appendix shows that $W(q)$ has elasticity less than one with a high ratio of informal to formal employment, associated with low w and elasticity greater than one with low ratio, associated with high w. Thus it is useful to sort segmented labor markets into high and low wage markets, or low and high informal/formal employment markets.

AQ's payoff per unit destroyed is plausibly diminishing in volume for many terrorist groups, $h_q \leq 0$. In combination with the sorting of markets into wage-elastic and -inelastic groups, the implication is that high wage, high elasticity markets that are relatively secure from predation will be more secure from terror attack the larger they are. In contrast, markets that have relatively low wage and wage elasticity will be *less* secure against terror attack the larger they are. Of course, this is an *all else equal* implication. It incorporates two opposing effects of market size, the bang for the buck effect that makes bigger markets less safe for given wages and a 'general equilibrium' effect that runs from trade to wages. Over a cross section of markets the volume effect is combined with other forces that differ by market.

Succeeding sections take up optimal trade and enforcement policies. If these realistically reflect the actual policies, the endogeneity of policy will complicate statistical inference about the incidence of terror, but the structural model of this paper will offer guidance on econometric strategies to identify the key effects. An important complication in thinking about a set of markets is the possibility of cross effects. Cross effects in enforcement policy are treated below. For trade policy cross effects in the absence of terrorism, see Anderson (2008).

3 Trade Policy

A difference in knowledge about AQ between government and merchants opens a role for trade policy. If the merchants are assumed to have knowledge equal to the government, then they internalize the effect of trade volume on D and no public policy is needed. The government knowledge advantage is plausible in situations where government provision of enforcement provides information about AQ.

The merchants collectively internalize the effect of q on their profits through the labor market via both cost push and safety in numbers. Thus $S_q + S_w W_q = 0$.[11]

The government's objective function is assumed to be the sum of expected merchant surplus and the tax revenue (which is negative for trade subsidy):

$$[1 - D(T, q, , M)]S[q, W(q) + (c - c_0)q].$$

Here, c is the tax or subsidy inclusive cost of the goods to the merchants and c_0 is the free trade cost. 'Trade policy' here is defined broadly to include potential encouragements or discouragements to trade such as access charges to infrastructure.

By lowering c the government will raise q[12] and alter D. The interaction between the government and AQ has two possible structures. Simultaneous play implies that the government takes T as given. (6) implies that increases

[11] Anderson (2008) analyzes the implications of competitive trade, in which there is a role for government to internalize both safety in numbers and cost push externalities.

[12] See Anderson (2008) for proof of this intuitive result.

in q lower D through lowering the success rate of predators $1-\pi$, $D_q < 0$. The government's first order condition implies

$$c - c_0 = -\frac{S/q}{1-(1-D)/D_q q}. \tag{10}$$

If the government has a first mover advantage over AQ, $\bar{D}_q$ replaces D_q in (10). The policy implications follow from manipulating the resulting expressions.

Proposition 2 *Assume an interior maximum. With simultaneous play, the optimal anti-terrorism subsidy is*

$$\frac{c-c_0}{c_0} = -\frac{S}{qc_0}\frac{D(\pi - M)W_q q/w}{D(\pi - M)W_q q/w + 1 - \pi} \in (-S/qc_0, 0]. \tag{11}$$

With a first mover advantage the optimal policy is a tax if

$$\frac{D}{2}\left(1 + h_q q/h - \frac{1-M}{1-\pi}W_q q/w\right) > 1. \tag{12}$$

When D is very small, there is no case for intervention. For finite D, *the subsidy rises in proportion to the profit margin S/qc_0. Also, the subsidy is larger the higher is the wage elasticity, all else equal.* The rich get richer. The contrasting protectionist tax requires (see (12) sequential play and a low wage elasticity or increasing per unit payoffs to AQ . The tax rises in proportion to S/qc_0.

Either game structure is plausible for a single market. Simultaneous play is much more plausible in the realistic context where government and AQ play in many markets. Simultaneous play is assumed henceforth.

Trade policy has externalities traveling through the labor market to markets drawing from the common labor pool (Anderson, 2008). Anti-terrorism adds to these, with details left to the interested reader.

4 Smuggling

Smuggling is often tolerated in markets that are insecure. On anti-terrorist grounds, tolerance is always beneficial, assuming that smuggling has no direct negative disutility for the government.[13] Anderson (2008) rationalizes tolerance in the absence of terrorism as increasing the security of legitimate trade when enforcement is weak, associated with low wages. When enforcement is strong, in contrast, smuggling should be suppressed.

Assume that the government cares only about surplus earned in the legitimate market, so it maximizes $(1-D)[S+(c-c_0)q]$.[14] The government has two instruments of trade policy: it can affect c with trade taxes or subsidies and it can affect c^* with allowing or preventing access to its infrastructure.

The optimal own trade policy (assuming a monopoly trader in the legal market) shifts rents to the legal market, exploiting the government's first mover advantage over the smugglers, while also lowering the probability of destruction.

The first order condition of government welfare with respect to own trade policy implies

$$c - c_0 = -\frac{S/q}{1-(1-D)/\widetilde{D}_q q} + \frac{S_{q^*} R_q^* (1-D)/\widetilde{D}_q q}{1-(1-D)/\widetilde{D}_q q} \tag{13}$$

Here $R_q^* > 0$[15] denotes the response of competitive smugglers to a change in legal trade volume q and $\widetilde{D}_q = [D_q + D_{q^*} R_q^*] < 0$. The first term on the right hand side of (13) gives the anti-terrorist motive and is negative. The second term on the right hand side of (13) reflects the rent-shifting policy that operates in the absence of terrorism. This term is also negative, acting toward a subsidy, when $S_{q^*} = S_w W_{q^*} = [(\pi - M)b - wt_w]qW_{q^*}/w > 0$. An increase in smuggling raises wages, and confers a safety in numbers benefit larger than the cost push hit when enforcement is weak (see Anderson, 2008). Then legal trade should be subsidized. When enforcement is strong, $S_{q^*} < 0$ and the anti-terrorism motive offsets the rent-shifting motive.

The government can raise smugglers' costs (though not collecting revenue directly), showing up in the model as a rise in c^*. The first order condition

[13] Disutility attaches to the smuggling of arms and illicit drugs, but recognizing it adds no significant insight. More significantly, no-disutility means that AQ is indifferent to smuggling. A model of interaction between AQ, smugglers and the government might yield new insights.

[14] If the government cares just as much about expected surplus in the smugglers' market, the analysis closely resembles the interdependent markets case analyzed above.

[15] See Anderson (2008) for proof.

is given by

$$[S + (c - c_0)q]\frac{dD}{dc^*} = (1 - D)S_{q^*}dq^*/dc^*.$$

Here, $dq^*/dc^* < 0$ while $dD/dc^* > 0$ due to both the fall in q^* at constant terrorist levels and due to the accompanying fall in q if strategic complementarity obtains. The optimal policy is given by

$$\frac{c - c_0}{c_0} = -\frac{S}{qc_0} + (1 - D)S_{q^*}\frac{dq^*/dc^*}{dD/dc^*}.$$

The first term is always negative and isolates the antiterrorist subsidy. The second term is positive when $S_{q^*} < 0$, enforcement is strong and $dD/dc^* > 0$, which is guaranteed when$dq/dc^* < 0$; smuggling is strategically complementary to legal trade. Formalizing the discussion:

Proposition 3 *Government anti-terrorist objectives are served by tolerance of smuggling. On balance smuggling should be tolerated when enforcement is weak and smuggling is a strategic complement to legal trade.*

5 Enforcement Policy

Enforcement policy M acts on the proportion of trade that is 'inspected' or 'protected' by 'cops' in random interactions with predators. Enforcement provision by the government is rationalized by the combination of free rider problems and perfect substitution between government and private enforcement. Also, coordination of enforcement efforts across the economy requires government provision.[16]

aqM units of labor are required by enforcement rate M with trade volume q, a being the labor requirement per defended shipment. $F = aqM$ is a patrol force sufficient to defeat predator attacks on shipments q with probability M. aqM can also be interpreted as including a cost due to the delay as shipments are inspected. Congestion costs could easily be reflected in aquadratic function of $a(qM)$.

[16]A richer model of political economy and enforcement provision is needed to shed light on imperfect substitution between public and private enforcement and situations where both types of enforcement would be provided. Taking the setup of the model literally, private enforcement can be efficient in an isolated market. But free rider problems arise if a merchant guild finds it easier to monitor agreements by members on trade volume than on enforcement effort. Once cross-market externalities are admitted, coordinated public enforcement is potentially more efficient than private enforcement.

The most plausible game structure is simultaneous play between enforcement and trade strategies on the one hand and terrorist predators on the other hand.

The merchants' expected value of surplus is $H(q; M, T) \equiv [1-D(T, q, M)]S(q, M)$. The efficient level of trade set by a merchant guild satisfies

$$H_q = (1 - D)(S_q + S_w W_q) - D_q S = 0. \quad (14)$$

If merchants are assumed to take D as given, $-D_q S$ represents the efficient government subsidy that internalizes the volume effect on the probability of destruction, as in Section 3. Alternatively, the merchants internalize the externality themselves.

AQ continues to select terrorist employment according to

$$T = (hq\delta/(1 - \pi)w)^{1/2} - \delta/(1 - \pi). \quad (15)$$

The reduced form $T(M, q)$ used for comparative statics below substitutes for w, π the functions $w = W(q, M)$ and $\pi = \Pi(q, M)$ given by (5).

The government objective function is $G(M; q, T) = (1-D)S-aqW(q, M)M$. The funds to pay for enforcement (and any needed subsidy to trade) are assumed to be raised with a lump sum tax.[17] The socially optimal level of enforcement is determined by the first order condition $G_M = 0$:

$$(1 - D)S_M/q - D_M S/q = wa(1 + W_M/w). \quad (16)$$

$W_M/w > -1$ is required for there to be positive marginal cost of enforcement, a condition of interior equilibrium. The Appendix shows that $W_M > 0$ for high wage economies while $W_M < 0$ is plausible for low wage economies. The second order condition requires that $G_{MM} < 0$.

The comparative statics of enforcement follow from differentiating the first order conditions (14)-(16). See the Appendix.

Proposition 4 *(a) Higher value markets are larger and ordinarily get more protection: $dq/db > 0, dM/db > 0$. (b) Markets with less local support for terrorists are larger and ordinarily get more enforcement: $dq/d\delta > 0, dM/d\delta > 0$. (c) Markets that are more difficult to defend are smaller and get less enforcement, $dq/da < 0, dM/da < 0$.*

[17] This assumption simplifies the analysis in a relatively harmless way. a can be regarded as incorporating the marginal cost of public funds in addition to the unit labor requirement of patrols. Requiring enforcement to be paid for with a tax on trade would be perverse because trade taxes tend to defeat the goal of enforcement.

Also, targets with more value to AQ (higher h) raise T, all else equal, and lower q, M. The comparative static structure is essentially the negative of $dq/d\delta, dM/d\delta$ above. The unpleasant conclusion can be reversed if the government has a first mover advantage in enforcement. Thus it can make sense to commit more enforcement to a known high value target among many. Sequential play makes more sense when the rise in h is big, going outside the comparative static derivative logic.

5.1 Enforcement in Multiple Markets

Enforcement has cross-market externalities when the labor market links predators and legitimate employment across the various trading locations. The second market again is denoted with a *.

$$\frac{dD^*}{dM} = -D^*(1-D^*)\left[\frac{\pi^* - M^*}{1-\pi^*}\frac{W_M}{w} + \left(\frac{W_q}{W} + \frac{W_{q^*}}{W}R_q^*\right)\frac{dq}{dM}\right] \tag{17}$$

where R_q^* is the best response change in $q^*$to a change in q. If enforcement raises the wage, security improves in all markets, a positive externality. There is a presumption that this is so for high wage economies, for which $W_M > 0$ and $W_q q/W > 1$. The second term under the square brackets is the ordinarily positive net effect of greater global trade on the wage. When trade strategies are substitutes, it is possible that the second term is negative but this is a special composition effect that goes against the usual presumption that a rise in $q + q^*$ will raise the wage. For low wages, $W_M < 0$. Low wage is associated with low wage elasticities, so the wage can fall on balance. Then improvements in security in one market reduce security in other markets, a negative externality.

With a negative externality, uncoordinated enforcement efforts will overprotect while positive externality means under-protection. National coordination within countries potentially provides more efficient enforcement. Political economy considerations can of course dominate the efficiency considerations analyzed here.

The efficient pattern of enforcement across linked markets resembles the preceding analysis of the comparative statics of enforcement that implies a cross section pattern of enforcement for independent markets. The government objective function is $\sum_i (1-D^i)S^i - \sum_i awM^i q^i$. The first order conditions are:

$$(1-D^i)S^i_{M^i}/q^i - D^i_{M^i}S^i/q^i = wa(1 + W_{M^i}/w). \tag{18}$$

Making full use of the properties of S, (18) can be rewritten as

$$(1-D^i)[b^i + D^i S^i/q^i(1-M^i)] + [(1-D^i)S^i_w w/q^i - aw]W_{M^i}/w = aw,$$

where $S^i/q^i = \pi^i b^i - c^i - \alpha t^i$ and $S^i_w w/q^i = (\pi^i - M^i)b^i - \alpha t^i$.

In the cross section of markets, all else equal (including wage effects), *higher value markets get more protection.* This follows from the second order condition: each first order condition in (18) is decreasing in own enforcement, so the effect of higher b^i is higher M^i in the cross section. Also, *safer markets get more protection, all else equal.* These results resemble Proposition 4.

The effects of variation in W_{M^i} on the efficient level of enforcement pattern across markets likewise closely resemble those for independent markets. Viewed from the standpoint of positive economic description, endogenous enforcement tends to amplify the tendency for bigger markets to be safer. The tendency is offset by the wage effects of enforcement in most parameter ranges.

6 Conclusion

This paper offers a formal model of terrorism and trade that effectively juxtaposes two important opposing forces — larger markets tend to be safer but larger markets also are more attractive targets. Based on this, the paper makes predictions about the incidence of terrorism and it draws prescriptions for trade and enforcement policy. It is a simple enough platform to build on in future work. This concluding section will point out desirable directions.

The model as it stands is limited by its focus on trade as the only economic activity. The extension of economic activity to include production and consumption follows the familiar line from partial equilibrium to general equilibrium, and is unlikely to produce very surprising new insights. But predation and terrorism logically (and realistically) also extend to production and consumption. Here, new methods of describing the interaction of legitimate and predatory activity will be needed. The basic idea that legitimate and predatory activity draw from the same economic resource base remains but the properties of the linkage will not be the same.

A richer description of enforcement is likely to be useful. The model gets a lot of leverage from the simple way that enforcement enters; seemingly simple variants rapidly make the analysis extremely complicated. Nevertheless, its simplicity prevents getting hold of some essential aspects of enforcement.

Some kinds of enforcement activity discourage terrorism without doing much (or even helping) other predatory activity. Enforcement effort can be predatory, who shall guard the guardians?

A richer description of government and of political economy is desirable. The interaction between government and AQ in the paper is extremely limited. More realistically, in many situations (such as Afghanistan, perhaps, or the Northwest frontier provinces of Pakistan) government and AQ are competitors for the allegiance of 'labor'. Their objective functions are presumably more complex than those assigned in this paper. It is more realistic and may be useful to suppose that there are several kinds of labor in terms of 'natural' allegiance with a manipulable group in the middle. AQ may provide services, such as enforcement against ordinary predators. Ordinary predators might usefully play a larger role in the model, such as having manipulable allegiance and getting organized for 'political' participation. Finally, it is realistic to suppose that there may be several AQ's competing for allegiance. The version of the model with a legal and an illegal market side by side looks like a good platform on which to build analyses involving some or all of these complications.

Extensions to consider transnational terrorism appear to require modeling terms of trade effects and migration. Rival national governments may also make use of AQ to advance their competing goals.

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8 Appendix: Technical Details

8.1 Wage Function Properties

Labor market equilibrium is such that the wage elasticity is low when wages are low and predation is high, and high when predation is low and wages are high. Also, the wage responds differently to a rise in enforcement effort depending on whether the wage is high or low.

Trade services employment E is derived from the technology of trade combined with the conditions of supply of capital. At one extreme, the merchant capital K is fixed while at the other extreme the service price of capital r is fixed and merchant capital is available in infinitely elastic supply. Intermediate cases are represented with an increasing supply function $K(r)$. A neoclassical cost function $c(w, r)q$ represents the technology combined with cost minimizing behavior, where $c(w, r)$ is increasing concave and homogeneous of degree one in its arguments. Shephard's lemma implies that the capital market clears with $qc_r(w, r) = K(r)$. This implies a service price of capital to the trade services market $r(q, w)$, increasing in both its arguments. The demand for labor $E(q, w) = qc_w(w, r(q, w))$, using Shephard's lemma again along with capital market clearance. Then differentiating $E(q, w)$ using the homogeneity properties of $c(w, r)$:

$$-E_w w/E = \epsilon(1 - r_w w/r),$$

$$E_q q/E = 1 + \epsilon r_q q/r$$

where $\epsilon \equiv -c_{ww} w/c_w > 0$.

Economic predators choose to predate based on equal expected returns to their best alternative. Risk neutral predators are indifferent when

$$w = \frac{(1-\pi)q}{B}\frac{B}{B+T} = \frac{(1-\pi)q}{B+T}. \tag{19}$$

This setup imposes that no predator attacks the prey of another predator, a plausible simplification. Then the demand for labor from predators of both types is

$$B + T = (1-\pi)q/w. \tag{20}$$

The existence of economic predators and the equal expected returns setup in (19) is crucial to getting clean results from the model. With this setup, the rational expectations success rate is $\pi = M + w/\theta$ (Anderson and Bandiera, 2006) and the predator demand for labor is (20).[18]

The fixed supply of labor N is equal to labor demand in equilibrium. Labor demand L is the sum of trade services employment $E(q, w)$, enforcement employment $F = aqM$, and predators of both types $B + T = q(1 - \pi)/w$.

Totally differentiate L with respect to w and q to form $dw/dq = -L_q/L_w$. Using $\pi = M + w/\theta$, taking the partial derivatives and simplifying yields

$$\frac{q}{w}W_q = \frac{1 + [E/(E+F)]\epsilon r_q q/r + (B+T)/(E+F)}{\epsilon(1 - r_w w/r) + [1 + (\pi - M)/(1-\pi)](B+T)/(E+F)}. \tag{21}$$

$W_q q/w > (<) 1$ as

$$1 + [E/(E+F)]\epsilon r_q q/r > (<) \epsilon(1 - r_w w/r) + \frac{B+T}{E+F}\frac{\pi - M}{1-\pi}.$$

Either sign is possible, but higher predation relative to legitimate employment, associated with low wages, always lowers the wage elasticity. The two special cases of infinitely elastic capital supply (fixed r) and fixed capital stock ($r_q = 0, r_w w/r = 1$) simplify the condition. If labor supply is increasing in w, the denominator in (21) includes a term $N_w w > 0$, reducing $W_q q/w$.

The response of the wage to enforcement is given by $dw/dM = -L_M/L_w$ leading to

$$\frac{W_M}{w} = \frac{aq/(E+F) - [(B+T)/(E+F)][1/(1-\pi)]}{\epsilon(1 - r_w w/r) + [1 + (\pi - M)/(1-\pi)](B+T)/(E+F)}. \tag{22}$$

The right hand side can have either sign. The first term of the numerator is the ratio of the unit labor requirement in patrols a to the unit labor requirement in shipping and patrolling combined $(E + F)/q$. This term is less than one but positive, as better enforcement increases demand for labor. Indirectly, the lower success rate of economic predators reduces their numbers. The impact is captured in the second term of the numerator. For insecure markets with high ratios of predators to legitimate employment, $W_M < 0$, while higher wage, more secure economies have $W_M > 0$.

The extension to multiple markets is straightforward. B^i, E^i, T^i are defined for each market. Labor market clearance holds where the demand for

[18] With no economic predators, the terrorist demand function (7) is used to simultaneously determine the rational expectations success rate, the volume of trade and the equilibrium wage. The economic predators serve to decompose the model with $\pi = M + w/\theta$.

labor is aggregated. For the analog to the derivatives above, the analog to the numerator of (21) and (22) is L_{M^i}, signed by the same conditions as in the preceding paragraph. The analog to the denominator of (21) and (22) is the sum of the individual market demand derivatives $-\sum_i L^i_w$.

8.2 Comparative Statics

The terrorist best response to q, M is given by

$$T(q,M) \equiv \left(\frac{hq\delta}{W(q,M)[1-M-W(q,M)/\theta]}\right)^{1/2} - \frac{\delta}{1-M-W(q,M)/\theta}. \tag{23}$$

The comparative static analysis embeds $T(q,M)$ into the first order conditions of the merchants and government and then differentiates totally with respect to q, M, x where x is an exogenous variable. Redefining G_M on a per unit of q basis, the first order condition for M becomes $G_M = (1-D)S_M/q - D_M S/q - wa(1+W_M/w) = 0$. The first order condition for q is $H_q = (1-D)(S_q + S_w w W_q/w) - SD_q = 0$. The comparative static derivatives are solved from

$$\begin{pmatrix} G_{MM} + G_{MT}T_M & G_{Mq} + G_{MT}T_q \\ H_{qM} + H_{qT}T_M & H_{qq} + H_{qT}T_q \end{pmatrix} \begin{pmatrix} dM \\ dq \end{pmatrix} = \begin{pmatrix} -G_{Mx} \\ -H_{qx} \end{pmatrix}.$$

Let J denote the matrix above. The second order conditions guarantee that $G_{MM} < 0, H_{qq} < 0$ while it is readily seen that $H_{qT} < 0$ while $T_q > 0$. G_{MT} can have either sign but is positive for high wage economies while $T_M < 0$. Thus ordinarily the diagonal elements of J are negative. The lower left element $H_{qM} + H_{qT}T_M > 0$ but the upper right element $G_{Mq} + G_{MT}T_q$ can have either sign. A standard stability condition implies that $|J| > 0$.

When $x = b$, $G_{Mb} > 0, H_{qb} > 0$. The sign pattern of J^{-1} guarantees that $dq/db > 0$. A rise in M is guaranteed by $G_{Mq} + G_{MT}T_q > 0$. When this sufficient condition is violated, whether M rises or falls depends on how strong the trade increasing effect dq/db is; M may rise if the effect of the rise in q in reducing G_M is not too large. Call $dM/db > 0$ the 'ordinary' case. When $x = \delta$, $G_{M\delta} > 0, H_{q\delta} > 0$, and $dq/d\delta > 0$ while the same arguments obtain for the sign of $dM/d\delta$. The 'ordinary' case is $dM/d\delta > 0$. When $x = a$, $G_{Ma} < 0, H_{qa} = 0$, and both q and M fall with a rise in the labor requirement of enforcement.