A Microeconomic Approach to the Economic Impact of Terrorism in Developing Countries

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Abstract

Recent empirical literature dealing with the economic impact of terrorism has not come to clear-cut results. While Abadie and Gardeazabal (2003, 2008) find a severe negative influence of terrorist attacks on economic growth and FDI via an open-economy channel, others, such as Enders et al. (2006), estimate the detrimental effect of violent terrorism to be very limited in both size and country prevalence. Amongst others, they also find that developing countries are more vulnerable, but no conclusive explanation for this result is given.

Utilizing a CES production model with inputs labour and capital, I show that the influence of terrorist attacks on capital usage, which for developing countries is synonymous with FDI, and output depends on the characteristics (labour/capital intensity, substitutability of inputs) of the targeted economic sector. Terrorist organizations are economic actors who engage in kidnapping, capital destruction or both, as motivated by their particular goals. By perpetrating attacks, they raise the cost of labour and capital and therefore change the capital-labour ratio, the size of inputs and total output. Depending on a terrorist organization’s aims and funding, governments of terror afflicted countries may find it beneficial to spend part of the taxes levied on foreign firms on anti-terror measures which raise the cost of engaging in terrorist activities. Developing countries, whose main attraction for foreign firms is the resource extraction business, turn out to suffer the strongest from terrorist activity. Furthermore, the model shows that FDI is an inexact proxy for the economic impact of terrorism as labour is substituted for capital.

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1 Introduction

“Terrorism takes us back to ages we thought were long gone if we allow it a free hand to corrupt democratic societies and destroy the basic rules of international life.” Jacques Chirac as Prime Minister of France in a speech to the UN General Assembly, Sept. 24, 1986

Terrorism, without any doubt, is one of the big challenges of the 21st century to be overcome by developed Western democracies, emerging nations and developing countries alike\(^1\). In 2009, about 11,000 terror attacks took place worldwide, resulting in the death of injury of almost 58,000 people (US Department of State 2010). Apart from very salient attacks in large and developed countries such as 9/11, the bombings in the public transport systems of Madrid and London and the recent attack on the Domodedovo airport in Moscow, most acts of terrorism are perpetrated in developing regions and go largely unreported in Western media. Their effects on the lives and happiness of affected people and political and economic outcomes are immense, nevertheless. Terrorism in countries as diverse as Pakistan, Indonesia, Afghanistan and Iraq proves to be a severe danger to the stability of the political system and seriously hampers economic growth\(^2\). Terrorism also harms individual firms and forces governments to divert spending to prevent acts of terror\(^3\).

Starting with the New York terror attack, economic research into the economic causes and consequences of terrorism has intensified\(^4\). In a trade context, terrorism has been modelled as a strategic game played between rational and utility-maximizing governments and terrorist organizations, in which governments decide on protective and counter-terrorism measures while terror organizations accordingly choose what and how to attack (Mirza and Verdier 2008). A different game theoretic approach has been taken to determine the investment decisions of terrorist organizations and subsequent conflict outcomes (Konrad 2004). Sandler and Arce (2003) present a variety of game theoretic applications to the issue of terrorism, including choice of targets, deterrence

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\(^1\)As Frey and Luechinger (2003) point out, there is no universally accepted definition of terrorism. In this paper terrorism is thus considered to be any obviously illegal action (like kidnapping) taken by an organization classified as terrorist.

\(^2\)The impact of terrorism on individual happiness has been the subject of research by Frey et al. (2006). Abadie and Gardeazabal (2003) for the Basque country and Gupta et al. (2004) for a panel of countries find terrorism to be severely detrimental to GDP growth. And terrorism in Israel has led to a significant shift of parties’ political stances towards accommodation of Palestinian interests and “left” policies (Gould and Klor 2010).

\(^3\)As measured by market capitalization, Royal Dutch Shell, BP and Coca Cola alone have lost over $20 billion by terror attacks between 1995 and 2002 (Karolyi and Martell 2006). Between 2001 and 2011, the USA has spent $1.3 trillion on its self-proclaimed “War on Terror” (Belasco 2010).

\(^4\)For a very extensive overview over terrorism-related economic research, see Schneider et al. (2010).
vs. pre-emption and others. The macroeconomic consequences of terrorism and particularly its impact on foreign direct investment (FDI) have also been treated empirically by various authors, but with differing results.

Abadie and Gardeazabal (2008) present a model in which the investment decisions of individuals are affected by a random terror shock which lowers the mean and increases the variance of their expected investment returns. Thus, in a world sufficiently open to capital movements, investors diversify and reallocate their capital from terror-stricken countries to safe ones. As estimated by a panel dataset of 98 countries, this “open economy” channel leads to a 5% reduction in FDI positions if terror intensity increases by one standard deviation in a country. The authors consider this estimate to be too low for countries with a high prevalence of terrorism. In a study focusing on the Basque country, they also find that this area’s GDP is 10% lower than it would have been without terrorism, pointing to a significant detrimental effect of terrorism on growth (Abadie and Gardeazabal 2003).

Enders et al. (2006), however, who examine US FDI flows into 69 countries by utilizing an augmented gravity model, find that attacks against US interests such as firms have only a small impact on US FDI positions due to the diversified nature of the targeted economies, but in turn conclude that developing countries should disproportionately suffer from terrorism as their economies are undifferentiated	extsuperscript{5}. Using a similar model, Blomberg and Mody (2005) find that terrorism has the strongest effect on FDI in developing countries. But they also note that within the observed time period (1981-1998) strong trends such as globalization, technological change, better integration into supranational organizations such as the WTO etc. were at work which makes it hard to determine the exact size of the influence of terrorism within that period.

As indicated by the last two studies and Blomberg et al. (2004), terrorism seems to disproportionately affect FDI and thus economic performance and growth in developing countries, but there is no agreement on its extent and the channel through which it works. Enders et al. (2006), for instance, suspect that more diversified economies are better able to shift economic activity to sectors not affected by terrorism, but one would expect terrorists to follow this shift with their focus of attacks. Blomberg and Mody (2005) propose that risk premiums on investment costs in developing countries react more strongly to violence, including terrorism, than in developed countries.

Also, none of the studies considers terrorist organizations to be economic actors: While in Abadie and Gardeazabal’s (2008) model terror attacks are just a random exogenous shocks, Enders et al. (2006) and Blomberg and Mody (2005) utilize standard

	extsuperscript{5}Gravity models try to explain cross-border phenomena like trade, migration etc. by country characteristics such as proximity to each other, country size, GDP and so on.
gravity models augmented with a measure of terrorism and no microeconomic foundation.

The contribution of this paper is to present a microeconomic model which can explain the FDI and economic impact of terrorism mainly by endogenous variables and the actions of rational actors. As pointed out above, there is, to my knowledge, no microeconomic model of terrorism which explains why developing countries should be disproportionately affected by acts of terror. Thus, the model in this paper comprises governments which decide on counter-terrorism measures, terrorist organizations which choose what to attack and in which intensity and firms which utilize labour and capital to maximize their production. This allows me to assess the terrorism impact on output, factor allocation and counter-terrorism spending. In particular, I will consider the case where firms produce according to a constant elasticity of substitution (CES) production function with diminishing returns to scale. As most terror attacks take place in developing and emerging countries such as Nigeria and Colombia and as these nations mainly host resource-extracting foreign firms, the assumption of diminishing returns to scale is well justified (see Figures 1, 2 and 3 and Section 3)\textsuperscript{6,7}. The model can account for constant and increasing returns to scale but would not create interior solutions for the resource allocation decision\textsuperscript{8}.

As has been noted by several researchers, the immediate and short-run impact from terror, i.e. the destruction of physical and human capital, may be minor in comparison to long-run effects like additional transactions costs and changes in behaviour and factor prices\textsuperscript{9}. Therefore, the channel through which terror works in this model is factor prices: Terrorist attacks put a risk premium on wages and capital interest rates.

The model is able to explain the severity of economic impacts by several factors: First, the intentions of the terrorist organization. Terrorists may either see attacks on foreign firms as a business from which money is to be made and thus engage in kidnappings for ransom or political gains, or they may wage an all-out war against their own government and foreign firms perceived to be hostile. In this case, their aim, achieved by destroying capital and killing or kidnapping labour, is to reduce foreign economic activity which generates employment, taxes and possibly positive externalities like im-

\textsuperscript{6}This specialization of emerging and developing countries is also noted in Mirza and Verdier (2008).

\textsuperscript{7}Al-Mutairi and Burney (2002), for instance, find diseconomies of scale in Kuwait’s crude oil industry. Economies of scale are singularly hard to measure, though, and estimates differ widely according to the used method. Exemplarily, the reader is referred to the measurement attempts by Haldi and Whitcomb (1967), Silberston (1972) and Ringstad (1978). The common finding is that economies of scale are generally either constant or decreasing.

\textsuperscript{8}The firm will either choose to produce nothing or an infinite amount if it is not constrained by an exogenous budget, and thus employs no resources or an infinite amount of capital and labour.

\textsuperscript{9}See, for instance, Krugman (2004) and cost calculations of the 9/11 aftermath by Penn et al. (2004). The economic impact of terrorism-induced fear is the subject of recent work by Becker and Rubinstein (2011).
proved infrastructure and professional training. Possible international spillover effects, such as the disruption of supply lines for oil and other essential materials, can also serve as motivation for terrorists to target a country’s industries, but are not explicitly captured in the model.\footnote{Al-Qaeda explicitly stated that the oil industry is a major target for attacks as it is particularly vital for Western economies (Washington Post 2004).}

Second, the sector a firm operates in, as characterized by the mix of capital and labour employed in this sector. Highly capital intensive sectors are harder hit by attacks on their facilities, while labour intensive industries suffer more if their employees become the focus of the terrorist’s attacks.\footnote{Sector specific stock market effects of terror attacks are noted by Chesney et al. (2010). E.g., defense industry firms' stocks benefit from recent terror attacks, while the airline industry suffers.}

And third, the flexibility of the production process. A low substitutability between inputs makes it harder to use more of the less terrorism-affected production factor, but the utilization of inputs is more even to begin with. It turns out that the resource extraction sector, which is the main economic factor in many developing countries, shows just the characteristics which make it the most vulnerable to terror-induced factor price increases.

In the next section, I will present the model in a technical form. The third section will discuss the analytical results in the context of developing countries, followed by the in the fourth section conclusion.

## 2 The Model

In this section, the model will be presented in various stages. First, the simplest version of a world consisting only of a firm is considered. Then, a terrorist organization is added, and finally the possibility of counter-terrorism measures by a government is introduced. Note that this model constitutes a one-shot game, so there is no lock-in effect from factor allocation. It also abstracts from the demand side, so a firm cannot compensate for higher factor costs by setting a higher price for the output.

### 2.1 Without Terrorism

This section establishes the basic model without terrorism and counter-terrorism, and shows under which conditions an increase in the price of an input factor has the worst impact on factor usage and output. This result is important for the following sections in which terrorism is added to the model.
Assume that the world consists of only one country with one industrial sector. In this sector, one firm is active and produces according to the following CES production function,

\[ Y(K, L) = (\alpha K^r + (1 - \alpha) L^r)^{\frac{1}{r}} \]  

where \( Y \) is output, \( K \) and \( L \) are the inputs of capital and labour and \( 0 \leq \alpha \leq 1 \) is the share parameter of capital. \( r = \frac{(s-1)}{s} \) with \( 0 < s < \infty \) is the elasticity of substitution and thus \(-\infty < r < 1\). Finally, \( 0 < h < \infty \) measures the returns to scale: if \( h \) is smaller/larger than 1, the firm’s sector exhibits decreasing/increasing returns to scale; if \( h \) is equal to 1, returns to scale are constant\(^{12}\).

The firm has to pay a price of \( i > 0 \) and \( w > 0 \) per unit of capital and labour. Capital and labour can be employed at any desired amount with no effect on wages and interest rates, so \( w \) and \( i \) in the absence of terrorism are fixed. The firm thus maximizes

\[
\max_{K, L} \left( (\alpha K^r + (1 - \alpha) L^r)^{\frac{1}{r}} \right) - \alpha K \cdot i - L \cdot w \tag{2}
\]

The optimal values for \( K \) and \( L \), denoted by an asterisk, are given by

\[
K^* = \left( \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{\frac{h-r}{r}}} \right)^{\frac{h-r}{r}}} \right)^{\frac{1}{r}} \tag{3}
\]

\[
L^* = \left( \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{\frac{h-r}{r}}} \right)^{\frac{h-r}{r}}} \right)^{\frac{1}{r}} \tag{4}
\]

The derivatives of \( K^* \) and \( L^* \) with respect to their input prices take the form

\[
\frac{\partial K^*}{\partial i} = \left( \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{\frac{h-r}{r}}} \right)^{\frac{h-r}{r}}} \right)^{\frac{1}{r}-1} \frac{1}{r} \tag{5}
\]

\[
\frac{\partial L^*}{\partial w} = \left( \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{(1 - \alpha) + \alpha \frac{\frac{1}{r}}{\frac{h-r}{r}}} \right)^{\frac{h-r}{r}}} \right)^{\frac{1}{r}-1} \frac{1}{r} \frac{h-r}{r} \tag{5}
\]

\(^{12}\)For a discussion of the properties of CES production functions, see Arrow et al. (1961).
The functions (5) and (6) do not have closed-form solutions for their derivatives w.r.t. $i$, $w$, $\alpha$, $h$ and $r$. It is therefore not possible to derive general analytical expressions for the thresholds at which these variables switch from having a negative influence on (5) and (6) to a positive influence or vice versa. In the remainder of this paper, several restrictions are put on the variables which have been obtained by simulation and partial examination of the functions. These restrictions are sufficient, but not necessary, to rule out several ambiguities in the reactions of (5) and (6) to the exogenous variables; yet, the exact necessary restrictions, as explained, cannot be determined. It is henceforth assumed that $1 > h \geq r$ and that, initially, $i = w^{13}$. The main interest now lies in seeing how the price reaction functions of the production factors respond to changes in $\alpha$ and $s$, and how this will affect the reaction of output to input price changes.

For low $r$ and high $h$, (5) first increases (becomes less negative), then decreases (becomes more negative) in $\alpha$. This amounts to $\frac{\partial K^*}{\partial i}$ having an interior maximum. For higher $r$, it is possible that raising $\alpha$ first increases, then decreases, then again increases the negative impact of higher factor costs, such that a local minimum occurs. The shape of the reaction function and the range of values for $r$ and $h$ for which such a maxima and minima exist are shown in Figure 4. However, the interior minimum will never be a global minimum as well.

The same reasoning holds for (6) and $1 - \alpha$.

Under these caveats, given the production function (1), the optimal factor allocation (3) and the price reaction function (5), one can see that $K^*$ will show the strongest negative reaction to an increase in $i$ if $\alpha$ is equal to 1: In this case, only capital is used in the production process, and no substitution between factors to compensate for a higher cost of capital is possible. If the share parameter of capital is equal to zero, the opposite is the case: As no capital is used, $i$ does not affect $K^*$ at all. Between these two extremes, the reaction of capital to an increasing $i$ is becoming more negative. The same relationship holds for $L^*$ and $w$ if $\alpha$ decreases. Consider the analytically feasible case of $r = h = 0.5^{14}$: (5) reduces to

$$\frac{\partial K^*}{\partial i} = -2 \cdot \frac{2w}{1 - \alpha} \cdot \frac{1 - \alpha}{w + \alpha} \cdot (\frac{i^* (1 - \alpha)}{w + \alpha})^{-3} = -\frac{\alpha^2}{2i^3} \tag{7}$$

These restrictions rule out interior global minima for the derivatives of (5) and (6) w.r.t. $\alpha$ and $s$.

In this case, the marginal productivity of one factor is no longer dependent on the amount used of the other factor.
This function is strictly monotonously decreasing in $\alpha$ and has its global minimum at $\alpha = 1$. Thus, the reaction of $K$ to $i$ is the strongest if $\alpha = 1$. Due to symmetry, the same holds for the reaction of $L$ to $w$ if $\alpha = 0$. In the more general case of $r \leq h < 1$, one can see from (5) that the second line of the equation has the same sign as the first one, so that increasing $\alpha$ unambiguously makes $\frac{\partial K}{\partial i}$ more negative.

It also becomes visible in output $Y$ that factor price increases have the worst effect if $\alpha$ is either very high or very low. The sum of the negative effects of rising factor prices is the largest for the exclusive use of one production factor. This again is due to the fact that substitution between factors is more costly with $\alpha$ moving away from $\alpha_m\text{in}$. whose value is implicitly determined by solving the function

$$\frac{\partial (\frac{\partial Y(K^*,L^*)}{\partial \alpha})}{\partial \alpha} + \frac{\partial (\frac{\partial Y(K^*,L^*)}{\partial w})}{\partial \alpha} = 0 \quad (8)$$

for $\alpha$. Also, as $r < 1$, the first derivatives of $K^r$ and $L^r$ with respect to $K$ and $L$ are concave, so that, given a low usage of capital (labour), even for very small (large) $\alpha$ the marginal benefit from an additional unit of capital (labour) will be higher than that of the other factor. The total negative output reaction is increasing in the parameter share of capital (labour) if $\alpha$ is to the right (left) of $\alpha_m\text{in}$. Note that corner solutions are possible, i.e. $\alpha_m\text{in}$ can take the values 0 and 1.

To illustrate this result, it is again helpful to consider the case of $r = h = 0.5$. (1) now reduces to

$$Y(K^*,L^*) = \frac{\alpha^2}{2i} + \frac{(1 - \alpha)^2}{2w} \quad (9)$$

so the expression in (8) is explicitly given by

$$\alpha_m\text{in} = \frac{i^2}{i^2 + w^2} \quad (10)$$

A rise in factor prices has the lowest effect on output for the $\alpha_m\text{in}$ determined by (10). Also, $\alpha_m\text{in}$ moves towards the factor with a higher initial price.

**Proposition 1:** The negative reaction of $K^*$ ($L^*$) to an increase in its factor price rises as $\alpha$ increases (decreases). The negative effect of rising factor prices on output increases as $\alpha$ deviates from $\alpha_m\text{in}$.

See Figure 5 for a graphical depiction of Proposition 1, where it is also shown that the sum of the marginal effects of higher factor prices on output increases as $\alpha$ deviates from $\alpha_m\text{in}$. 8
Furthermore, as the elasticity of substitution increases the negative effect of higher factor prices on factor use and output is also becoming more severe. Even though a higher elasticity of substitution increases the interchangeability of factors, it mainly leads to the more important factor being used more extensively. This in turn worsens the effect of an increase in that factor’s price on its usage and total output. Additionally, as \( r \) moves from \(-\infty\) towards \( h \) (i.e. the elasticity of substitution increases), the increase of the marginal productivity of one production factor due to an increased usage of the other first increases, then falls in \( r \). As soon as \( r \) surpasses \( h \), i.e. when inputs are substitutes rather than complements, increased usage of one production factor reduces the marginal productivity of the other. This effect is also increasing in \( r \). To verify this, one can exemplarily consider the first derivative of (1) w.r.t. \( K \) and again differentiate it w.r.t. to \( L \):

\[
\frac{\partial (\frac{\partial Y}{\partial K})}{\partial L} = (h-r) \cdot L^{r-1} \cdot (1-\alpha) \cdot K^{r-1} \cdot \alpha \cdot h \cdot (K^r + \alpha + L^r \cdot (1-\alpha))^\frac{1}{r} \quad (11)
\]

Under the assumption that \((K, L) \geq 1\), the factors \( L^{r-1} \) and \( K^{r-1} \) are increasing in \( r \), while \((h-r)\) is becoming smaller in \( r \). \((K^r + \alpha + L^r \cdot (1-\alpha))^\frac{1}{r} \) is ambivalent: As long as \( \frac{1}{r} - 2 > 0 \), the change in value of the expression is unclear for rising \( r \), but as soon as this condition is violated, the value falls in \( r \). Starting from a low \( r \), \( L^{r-1} \) and \( K^{r-1} \) dominate, but for further increases \((h-r)\) and the last mentioned factor will eventually determine the size of the reaction of input productivity to an increase in the other production factor. Due to symmetry, the same holds for the marginal productivity of labour and an increase in capital usage.

The aforementioned effect will dampen the impact of a factor price increase, as can be seen for example if one considers the case of a rise in capital costs: Labour will be substituted for capital, but the increased usage of labour will in turn make capital more productive as long as the inputs are complements. As this effect is stronger for low elasticities of substitution, industries characterized by such a production function should suffer less in terms of lost output from factor price increases.

In the analytically feasible case of \( r = h \), where, according to (11), the marginal productivity of one input factor no longer depends on the amount employed of the other, (5) becomes

\[
\frac{\partial K^*}{\partial i} = \frac{1}{r-1} \cdot (\frac{\alpha + r}{i^2 - r})^{\frac{1}{r-1}} \quad (12)
\]

The first factor is negative and becomes more negative in \( r \), while the second factor is positive and increasing in \( r \). As the exponent of the second factor is larger than 1 and increasing in \( r \), the whole term is strictly monotonously decreasing in \( r \) for a
sufficiently high $\alpha$ and low $i$. The necessary condition for this is $\alpha \geq i^{15}$. Thus, a higher elasticity of substitution increases the negative impact of a capital price increase on capital usage. The same holds, due to symmetry, for labour if $(1 - \alpha) \geq w$. As the marginal productivity of labour does not depend on capital usage, the optimal amount of employed labour is also not dependent on the price of capital. Therefore, the reaction of $Y$ is only determined by $\frac{\partial K}{\partial i}$.

In the more general case of $r \leq h < 1$, for $s$ to increase the reaction of output to rising factor prices, it is required that the sum of the marginal reactions of the usage of input factors, weighted by the share parameters, is increasing in $s$. One could imagine that even though the more important production factor reacts more strongly to price changes with higher $s$, this is offset by a smaller reaction of the less important input, so that in total the output loss from a simultaneous marginal increase of both capital and labour costs shrinks in $s$. However, it has been ascertained by simulation that this is never the case for a wide range of values, so that $s$ is very likely to increase the total sensitivity of output to prices$^{16}$.

**Proposition 2:** The negative reaction of $Y$ to a price increase of the more important input as measured by $\alpha$ rises as $s$ increases. $\frac{\partial K^*}{\partial i} (\frac{\partial L^*}{\partial w})$ becomes more negative in $s$ if $\alpha \geq i ((1 - \alpha) \geq w)$.

See Figure 6 for a graphical depiction of Proposition 2, where it is also shown that the weighted sum of the marginal effects of higher factor prices on output increases in $s$.

### 2.2 With Terrorism Against Labour

I now introduce a terror organization which acts after the firm’s resource allocation decision. Terrorist attacks against a factor drive up its relative cost and thus lead to a substitution towards the other factor. The firm anticipates the terrorists’ behaviour and alters its factor allocation accordingly. The terrorist organization does not need to be based in the country where it carries out its attacks, so it does not matter whether terror is “home grown” or transnational. However, transnational terrorism would have

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15This appears to be a rather bold restriction, but as shown in Section 3, real world elasticities of substitution are usually lower than 3, which in turn would translate into an $r$ of 2/3. Even if $\alpha < i$, $\frac{\partial K^*}{\partial i}$ is still decreasing in $r$ up to a certain point which may lie above 2/3. Furthermore, in CES functions factor prices can be freely scaled as it is not exactly determined what constitutes one unit of labour and one unit of capital.

16$\frac{\partial Y}{\partial i} + \frac{\partial Y}{\partial w}$ is strictly decreasing in $s$ for any combination of $0.001 \leq s \leq 10$, $0.001 \leq w \leq 10$, $0.001 \leq i \leq 10$, $0.001 \leq \alpha \leq 0.999$ and $0.001 \leq h \leq 0.999$
do deal with border controls which are not incorporated in the model.

To begin with, it is assumed that this organization only engages in kidnapping activities against foreign firms to raise money for the fight against the government’s institutions. An abundance of employed labour (i.e. a host of possible targets) facilitates kidnapping operations, and thus the target function of the terror organization is given by

$$\max_{T_L} T_L \cdot L \text{ s.t. } T_L \cdot C_L \leq M$$

(13)

where $0 \leq T_L$ is the terror intensity against labour (i.e. the frequency of abductions), $0 < C_L < \infty$ the (monetary or manpower) cost of carrying out kidnappings and $0 \leq M$ the amount of available exogenously given manpower or endogenously determined funds. In the latter case, $M = T_L \cdot L$. The terror intensity directly affects the wages a firm has to pay its employees: It is assumed that higher wages have to be paid to compensate employees for the risk of getting abducted and/or that higher wages reflect the ransom that has to be paid if a kidnapping occurs. Thus, a firm no longer pays $w$ for a unit of labour, but $w + T_L$. As the terrorist threat constitutes a lump-sum premium on the regular price of inputs, the additional cost is not related to the marginal productivity of labour and capital. The optimality condition for an endogenous budget constraint is

$$L + T_L \cdot \frac{\partial L}{\partial T_L} - C_L = 0$$

(14)

while the optimality conditions for an exogenous budget constraint are given by

$$L + T_L \cdot \frac{\partial L}{\partial T_L} = 0 \text{ s.t. } T_L \cdot C_L \leq M$$

(15)

By (6) a higher wage drives down the amount of employed labour. Therefore, a terror organization will want to set $T_L$ such that the positive effect on an increase in $T_L$ and the negative effect of the induced decrease in $L$ balance. If $M$ is an exogenous manpower constraint, it could be the case that the terror organization does not want to employ all

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17 An example for this kind of terrorism can be found in the Niger delta where in recent years local terror groups fought for a larger share of their region’s oil proceeds by kidnapping foreign workers for ransom. In Colombia, kidnappings perpetrated by terrorist organizations also abound and seriously hamper investment activities (Psathas and Suarez 2006). Of course, proceeds from drug trafficking and other illegal activities play a major role in financing terrorism, as, for instance, shown by Schneider (2009). But these sources of income are incorporated in the next section where an exogenous budget constraint is assumed throughout.

18 The specification of M rests on the assumption that either kidnappings are cheap in monetary terms as scarce unemployed or ideologically motivated personnel without expensive gear is used, or that the money spent on gear and personnel is significant and has to be financed by the kidnappings themselves. Sandler et al. (2009) point out that the cost of effective terror attacks can be very low, which makes assuming a zero monetary cost of kidnapping plausible.

19 This working mechanism of terrorism is also depicted in Schneider et al. (2010).
available personnel due to the reaction of $L$, so the constraint does not bind.

The terror effect on the capital use depends on the specific form of the production function: For sufficiently high $s$, an increase in the wage rate could actually increase the amount of capital employed as capital is a good substitute for abduction-threatened labour. Thus, depending on the model’s parameters, the reaction of capital can be positive or negative to varying degrees.

Output reduction depends on the economies of scale and the substitutability of production factors. The negative impact of terror, as measured by the output reaction to an increase in $w$, falls in $s$ if capital is the more important production factor and increases in $s$ if labour is more important as measured by its share parameter. This is the effect put forward in Proposition 2. The logic behind this is immediate: An economy that mainly employs capital is not very susceptible to a terrorism-induced rise in wages, while a labour-based economy suffers extensively.

Proposition 3: If terrorism only targets labour, the impact on capital use falls as $s$ and $\alpha$ increase. The impact on output falls with a rising $\alpha$ and, for $\alpha > 0.5$, also with an increasing elasticity of substitution.

2.3 With terrorism against capital and labour

It is now assumed that the terror organization tries to accomplish its goal by targeting both personnel and capital. The objective in this case is assumed to be the minimization of economic activity which hurts the government of this particular country and the resident firms20. Terror against labour now takes the form of assassinations and kidnappings without pecuniary ransom, so this form of terror no longer positively enters the terror organization’s budget constraint. Higher capital and labour levels do not facilitate attacks as this could be merely represented in a terror effectiveness parameter which does not add much to the analysis21. The terror target function is now given by

$$\min_{T_K, T_L} Y = (\alpha K^r + (1 - \alpha)L^r)^{\frac{1}{r}} \ \text{s.t.} \ T_K \cdot C_K + T_L \cdot C_L = M$$  \ (16)$$

where $0 \leq T_K$ and $0 < C_K < \infty$ are the intensity and cost of terror against capital. Terror against capital raises the risk premium that has to be paid for employing

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20 This kind of terrorism can be found in Iraq and Afghanistan, for instance.
21 However, introducing terror effectiveness could be interesting to see whether the improvement of resilience against terror attacks generates better outcomes than raising terrorism’s costs (see Schneider 2010).
capital and thus a unit of capital no longer costs \( i \) but \( i + T_K^{\alpha_{KC}} \). Again, wages increase to compensate employees for the risk of getting abducted or killed. \( M \) is now an exogenously given amount of either manpower or funds, generated by recruiting new terrorists or gathering funds from drug trafficking, state sponsors and so on\(^{23}\). It is of course also possible to endogenize \( M \) if one assumes that a terror organization’s budget depends on the amount of publicity they can create. Thus, if terrorist group is highly effective, it will be able to attract more recruits, raise more money through voluntary contributions and so on. But, analytically, endogenizing \( M \) does not change the results derived below: Terrorists will have a higher incentive to engage in violent activities as it increases their budgets, but governments will, by protecting production factors, also have the benefit of decreasing the terrorists’ funds as less inflicted economic damage will lower the attractiveness of the terrorist organization for potential donors. So only the magnitude, but not the signs, of effects should vary with an endogenous \( M \).

The optimality conditions for an exogenous \( M \) as laid out above are

\[
\begin{align*}
\frac{h}{r} & (\alpha r \frac{\partial K}{\partial T_L} * K^{r-1} + (1 - a) r \frac{\partial L}{\partial T_L} * L^{r-1} ) * (\alpha K^r + (1 - a) L^r)^{\frac{1}{r} - 1} \leq \lambda C_L & (17) \\
\frac{h}{r} & (\alpha r \frac{\partial K}{\partial T_K} * K^{r-1} + (1 - a) r \frac{\partial L}{\partial T_K} * L^{r-1} ) * (\alpha K^r + (1 - a) L^r)^{\frac{1}{r} - 1} \leq \lambda C_K & (18)
\end{align*}
\]

\[T_L * C_L + T_K * C_K = M\]  \( (19)\)

The terror organization will choose an optimal “terror” mix in which the marginal effects on output of the two types of terror, weighted by their respective costs, balance, i.e.

\[
\frac{\partial(-Y)/\partial T_L}{C_L} = \frac{\partial(-Y)/\partial T_K}{C_K}
\]  \( (20)\)

. The more heavily employed production factor, i.e. the more important one as determined by factor costs and the production function, will be more attractive as a terrorism target, as will be the one that is cheaper to attack. This is because rational terrorists will make use of the relationships laid down in (5), (6) and (8): They will cause the input price increases which hurt the economy the most. As an example, I again consider the case of \( r = h = 0.5 \). The optimal terror levels are then given by

\[
T_L = \frac{M \sqrt{C_K}}{C_K (1 - a)} i + \sqrt{C_K (1 - a) - w a \sqrt{C_L}}
\]

\[
\frac{\alpha \sqrt{C_L} + (1 - a) \frac{C_L \sqrt{C_K}}{C_K}}{\sqrt{C_L} + (1 - a) \frac{C_L \sqrt{C_K}}{C_K}}
\]  \( (21)\)

\(^{22}\)This „flight to quality“ of capital which raises risk premiums has also been noted by Johnston and Nedelec (2005).

\(^{23}\)The US currently considers Cuba (FARC), Iran (HAMAS and others), Syria (HAMAS and others) and Sudan (HAMAS and others) to be state sponsors of terrorism (US Department of State 2010).
\[ T_K = \frac{\alpha \sqrt{C_L (w + T_L)}}{(1 - \alpha) \sqrt{C_K}} - i \]  

(22)

If one assumes that both types of terrorism are equally expensive, (21) becomes

\[ T_L = M(1 - \alpha) + i(1 - \alpha) - w\alpha \]  

(23)

which is clearly decreasing in \( \alpha \), increasing in the terror organization’s budget and increasing (decreasing) in \( \alpha \) (\( w \)). The last effect is related to the fact that adding a premium through terrorism to an already high wage will have a lower effect than if wages are low to begin with. Due to symmetry, the inverse relationships hold for \( T_K \). Although, from (21), one can see that the level of one kind of terror is negatively related to its price, it is not clear whether a higher cost of the other terror type increases or decreases its use. This depends on whether the “substitution” effect of the two kinds of terror outweighs the “income” effect for the terrorists’ budget.

The exact size of the capital use reduction will again depend on the industry sector characteristics: The effect will be higher if capital is the more important production factor and substitutability between factors is high. Proposition 4 below is directly related to Propositions 1 and 2: These propositions have established the conditions under which factor price increases have the worst impact on output and factor usage, and terrorist activity drives up these prices.

Proposition 4: If \( s \) and \( \alpha \) are both high, the impact of terrorism on capital use is the strongest. Output suffers the most if \( s \) is high and \( \alpha \) either very low or very high.

A graphical example for Proposition 4 can be found in Figures 7, 8 and 9. Due to the possibility of substituting labour for capital and vice versa, the loss in employed capital will not be equal to the loss in output. With high \( s \) and \( \alpha \), the reduction in capital use will be larger than the loss in output.

2.4 With counter-terrorism measures

I now introduce counter-terrorism measures by the government which drive up the cost of perpetrating terrorist attacks. After the firm has made its factor allocation decision and before the terrorists choose their targets and attack intensity, the government can spend funds on protective measures. The government anticipates the terrorists’ decision and sets its counter-terrorism levels accordingly. The firm foresees both the protection and terror decisions when making its factor allocation choice.
It is assumed that the government can raise a tax \( t \) on total output and use the revenues for its own consumption and protective measures for capital and labour, \( P_K \) and \( P_L \), which can both be zero or greater and bought at a price of 1 per unit. The size of \( t \) is restricted to \( \bar{t} \) by external factors such as increasing cost of taxation, the need of firms to at least cover costs, the possibility of firms to relocate abroad etc. Counter-terrorism measures increase the cost of terror by itself, so a unit of terror against capital or labour now costs \( C_K + P_K \) or \( C_L + P_L \), respectively.

The target function of the government is thus

\[
\max_{P_K, P_L} R = \bar{t} \cdot Y - P_K - P_L \tag{24}
\]

where it has to be kept in mind that \( Y \) is a function the protective measures. By maximizing net tax revenues \( R \) after protective spending the governments implicitly maximizes the funds it has available for its own consumption. Protection levels will be set such that

\[
\frac{\partial Y}{\partial P_K} = \frac{\partial Y}{\partial P_L} = \frac{1}{\bar{t}} \tag{25}
\]

If the terror organization only aims to raise money by kidnapping employees of foreign firms and if the scarce resource is available manpower, one can see by (15) that the government might not be interested in spending money on counter-terrorism measures if the manpower constraint is not binding. In the latter case, counter-terrorism expenditure up to a certain level will not affect terror intensity, and above that level protective measures may cost more than they gain in tax revenues. The same applies with an endogenous \( M \) if terrorists have to fund their kidnappings by ransom proceeds, or if terrorists target both capital and labour. A government may choose not to fight terrorism if terrorism does not sufficiently harm output and thereby tax revenues or if counter-terrorism spending does not sufficiently deter terrorism to warrant the expenditure, an outcome that depends on the sector specific parameters for \( s \) and \( \alpha \). From (25), this is the case if the derivative of output with respect to protective measures is always smaller than one divided by the tax rate, that is if even a marginal protection level generates less additional tax revenues than it costs. As the exogenous variables are bounded within sensible intervals, i.e. input share cannot be higher than 1 or lower than 0, economies of scale are less than 1 and elasticity of substitution is smaller than infinity, it follows that (5) and (6) have a lower limit, and thus protective measures lowering terror levels which in turn affect factor prices and input levels can be inefficient even at the lowest margin.
Proposition 5: If terror organizations only perpetrate kidnappings, if the output effect of terror or if the deterring effect of counter-terrorism are low, governments may find it beneficial not to spend any tax revenues on counter-terrorism measures.

If terrorist attacks are directed against both capital and labour, the government will protect the more important factor of production, as determined by factor costs and the production function, more strongly. It will thus balance the marginal output effects of capital and labour protection while maximizing available tax revenues after counter-terrorism spending as put forward in (24) and (25). Protection of the more important production factor can lead terrorists to shift their attacks towards the easier target, as can be seen from the optimal terror levels in (21) and (22) where the cost of a “unit” of terror, $C_L$ or $C_K$, increases with the amount of protective measures. If, for instance, capital is put under more protection, terror against labour will increase relatively to terror against capital. These effects are illustrated for varying $\alpha$ in Figure 10.

Due to the various counteracting effects of $s$ present in the optimization problems of the government and terrorist organization, the main focus of attacks varies greatly over small $s$. While the government will find it optimal to always put the emphasis on the protection of the more important production factor, terrorists may choose to primarily target the less important, but also less defended input. However, for higher elasticities of substitution, the battleground will shift to the main factor of production. I.e., if the share parameter of capital is high, as it is in the resource extraction industry, spending on counter-terrorism measures and terrorist attacks will mainly target capital. This is illustrated in Figure 11.

Proposition 6: Terrorist organizations primarily target and governments primarily protect the more important production factor. Protective measures induce a terrorism shift towards the less defended factor.

3 Discussion

Having laid down a framework in which terrorism affects firms’ and governments’ decisions, I will now turn to a discussion of the implications the derived results have for developing economies.
As pointed out in the introduction and visible in Figure 3, developing countries host mainly resource extraction industries, many of which are foreign multinational firms\textsuperscript{24}. The resource extraction sector is highly capital intensive, as for instance can be seen in Germany where mining and mineral oil processing are respectively the 4th and 3rd most capital intensive industries (Löbbe 2009). Arrow et al. (1961) find that metal mining, petroleum and natural gas production and their further processing have the highest capital intensity in the US, with capital-labour ratios between roughly 10 and 40. In a CES production function framework, this characteristic is captured by a high $a$.

Furthermore, resource extraction displays a high elasticity of substitution between capital and labour. Salem (2004), looking at the Tunisian economy, estimates $s$ to be 2.575 for the oil and gas and 0.906 for the ores and minerals sectors. Arrow et al. (1961) find the elasticities of substitution for these two sectors in the US to be 1.71 and 1.41, respectively\textsuperscript{25}. Al-Mutairi and Burney (2002) also arrive at the conclusion that capital and labour are substitutes in Kuwait’s crude oil industry, which implies an $s$ larger than 1. It is reasonable to assume $s$ to be even higher in developing countries than in developed ones, because safety measures and working conditions are worse and thus tie up less capital\textsuperscript{26}. Additionally, many menial tasks are not mechanized.

It has been put forward in Propositions 1, 2 and 4 that industrial sectors with a high share parameter of capital and a high elasticity of substitution between inputs suffer the most from capital- and labour-targeted terrorism in terms of lost capital input/FDI and output, as factor price increases cause the most detrimental effect under these circumstances. Thus, the model offers an explanation why developing countries should experience worse economic effects from terrorism than developed ones: As developing countries host mainly industries with such characteristics as described above they are particularly vulnerable. More diversified or non-resource based economies which have on average lower elasticities of substitution and/or more equal factor shares do not react as strongly to terrorism-induced factor price increases. Taking into account that employed capital in developing countries mainly constitutes FDI, the results of Enders et al. (2006) and Blomberg and Mody (2005) are replicated by the microeconomic model, but the model also offers an analytical explanation for their empirical observation. Additionally, the model shows that FDI is only a proxy for the output effect of

\textsuperscript{24}In Nigeria, for instance, 18 international oil companies and many subsidiaries and auxiliary services firms are present (Nigeria Oil&Gas 2011).

\textsuperscript{25}Balistreri et al. 2002 provide more recent estimates using a variety of estimation techniques. Their results do not rule out an elasticity of substitution which is larger than 1.

\textsuperscript{26}A recent Economist article mentions that workers in Chinese copper mines in Zambia have to work for two years before they are issued protective gear as basic as a helmet (The Economist 2011).
terrorism, as factor substitution takes place to react to terrorism. In the resource extraction sector, FDI loss overstates the total loss in output, as can be seen in Figures 7 and 8.

Proposition 3 states the conditions under which labour-directed terrorism has the lowest impact on capital usage and output. If the terrorists’ attacks on the economy are only motivated by ransom payments, which in reality is seldom the case, one should thus see the most severe economic impact in countries with a primarily labour-based economy.

Another result of the model, laid down in Proposition 5, is that it might not be in the economic interest of a government to engage in a wide-ranging counter-terrorism campaign as the gains from higher economic activity can be smaller than the costs of fighting terrorism. Many countries afflicted by terrorism find it viable to endure a certain amount of terrorism instead of diverting huge funds to put a decisive end to terrorist activity once and for all. The Tamil Tigers, for instance, waged a war against the Sri Lankan central government between 1983 and 2009, but only in 2006 did the Sri Lankan government finally start the huge military effort which led to the ultimate defeat of the Tamil Tigers. However, a factor that is not captured by the model, or only implicitly if one considers the parameter \( \tilde{t} \) to encompass a broader range of government benefits from economic activity, is the political dimension of terrorism. If the aim of the terrorists is to topple the government or achieve secession, terrorism will of course also be fought for non-economic reasons, and political constraints may hamper the support for effective counter-terrorism measures.

Finally, the model proposed in this paper also shows the outcome of the strategic game played between governments and terrorists (Proposition 6). Terrorists, ceteris paribus, want to primarily attack the input that is more important to the economy, but this input will also be the better-protected one. The terrorists might thus partly shift their focus on the other input, which corresponds to the real-world equivalent of a change in terrorist tactics. This adaptive behaviour of terrorists has been recently observed in Iraq and Afghanistan, for instance\(^{27}\).

### 4 Conclusion

This paper has developed a microeconomic framework with rational actors to model the impact of terrorism on capital and labour usage, output and the interactions between firms, governments and terrorist organizations. As pointed out in the introduc-

\(^{27}\)Jackson et al. (2007) describe numerous instances of terrorist groups changing their strategies and tactics in response to counterterrorism measures.
tion, the main industry of developing countries and therefore the main target of incoming FDI is the resource extraction business. Although the reduction in FDI overstates the loss in output, terrorism, which drives up factor prices, proves to be most effective in developing countries which can afford setbacks to economic activity the least. This result of the model is in line with the findings of Blomberg and Mody (2005). It is also congruent with Blomberg et al. (2004) and Enders et al. (2006) who come to the conclusion that developed countries with diversified economies show a higher economic resilience against terrorism. Therefore, promoting economic growth in developing countries should not only come down to good governance initiatives and free trade, but also to active help in the fight against terrorism as its economic impact in these countries is the strongest.

References


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Appendix

Figure 1: Resource exports in % of total exports (left Y axis) and terrorist incidents 1999-2008 (right Y axis) in Colombia and Nigeria. Source: Global Terrorism Database (2011) and Germany Trade and Invest (2010).
Figure 2: Terrorist incidents per region, 1991-2008. Source: Global Terrorism Database (2011).
Figure 3: Main exports per region. Source: WTO (2010).
Figure 4: a) Reaction of $K_i$ to an increase in $\alpha$. b) Blue area shows combinations of $h$ and $s$ for which a local maximum/minimum exists for $K_i$.

Figure 5: Input factor and output reactions to a change in factor costs for varying $\alpha$. $i = w = 2$, $h = 0.5$, $s = 0.5$. 
Figure 6: Input factor and output reactions to a change in factor costs for varying $s$. $i = w = 0.5$, $h = 0.2$, $\alpha = 0.75$.

Figure 7: Output, $K^*$, $L^*$ (left Y axis), output loss, $K$ loss and $L$ loss (right Y axis) from terrorism for varying $s$. $i = w = 0.5$, $h = 0.9$, $\alpha = 0.9$, $C_L = C_K = 0.1$, $M = 0.2$. 
Figure 8: Output, $K^*$, $L^*$ (left Y axis), output loss, $K$ loss and $L$ loss (right Y axis) for varying $\alpha$. $i = w = 0.5$, $h = 0.9$, $s = 2$, $C_L = C_K = 0.1$, $M = 0.2$.

Figure 9: Output loss for varying $s$ and $\alpha$. $i = w = 0.5$, $h = 0.9$, $C_L = C_K = 0.1$, $M = 0.2$. 

28
Figure 10: Protection of/terror against capital and labour (left Y axis) and output (right Y axis) for varying $a$. $i = w = 0.1$, $s = 2$, $h = 0.6$, $C_L = C_K = 0.1$, $M = 0.2$, $\bar{t} = 1$.

Figure 11: Protection of/terror against capital and labour (left Y axis) and output (right Y axis) for varying $s$. $i = w = 0.1$, $\alpha = 0.75$, $h = 0.6$, $C_L = C_K = 0.1$, $M = 0.2$, $\bar{t} = 1$. 

29