# A Microeconomic Approach to the Impact of Terrorism on Foreign Direct Investment and Output*

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## Abstract

Recent empirical literature dealing with the impact of terrorism on FDI has not come to clear-cut results. While Abadie and Gardeazabal (2008) find a severe negative influence of terrorist attacks on 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.

Utilizing a simple two country production model with inputs labour and capital, I show that the influence of terrorist attacks on FDI and output depend 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 in one country, they raise the cost of labour and capital and therefore change the capital-labour ratio and drive investment abroad. 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. This model is especially applicable to developing countries such as Columbia and Nigeria in which foreign firms are mainly engaged in resource extraction, but can be generalized to other countries and sectors. Developing, resource extracting countries 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[2]. In 2009, about 11.000 terror attacks took place worldwide, resulting in the killing or injuring 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 Domodedowo 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[3]. Terrorism also harms individual firms and forces governments to divert spending to prevent acts of terror[4].

Starting with the New York terror attack, economic research into the economic causes and consequences of terrorism has intensified[5]. In a trade context, terrorism has been modelled as a strategic game played between rational and utility-maximizing governments and terror organizations, in which governments decide on protective and counter-terrorism measures while terror organizations accordingly choose what and how to attack[6]. A different game theoretic approach has been taken to determine the investment decisions of terrorist organizations and subsequent conflict outcomes (Konrad 2004). 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.

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[2] 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.

[3] 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).

[4] 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).

[5] For a very extensive overview over terrorism-related economic research, see Schneider et al. (2010).

[6] See, for instance, Mirza and Verdier (2008).

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. Enders et al. (2006), however, who examine US FDI flows into 69 countries by utilizing an augmented gravity model[7], find that attacks against US interests such as firms have only a small impact on US FDI positions, and only in OECD countries. 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 these three studies, terrorism seems to affect FDI, but there is no agreement on its extent and the channel through which it works. Also, none of the studies considers terrorist organizations to be economic players: While in Abadie and Gardeazabal's (2008) model terror attacks are just a random exogenous shock, Enders et al. (2006) and Blomberg and Mody (2005) utilize standard gravity models augmented with a measure of terrorism and no microeconomic foundation.

In this paper, I set out to present a microeconomic model which can explain the FDI impact of terrorism mainly by endogenous variables and the actions of fully rational actors. FDI measures only capital investment in foreign countries, not utilization of native or imported labour, and therefore only provides an incomplete proxy for the economic impact of terrorism. Thus, the model in this paper comprises governments which decide on taxation and counter-terrorism measures, terrorist organizations which choose what to attack and in which intensity and firms which utilize labour and capital in two countries to maximize their production. This allows me to assess the terror impact on output, factor allocation, taxation 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

[7] 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.

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) [8]. The model can account for constant and increasing returns to scale but would not create interior solutions for the resource allocation, taxation and counter-terrorism decisions[9].

The model is able to explain the severity of FDI 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 taxes for the government. Second, the sector a firm operates in[10]. Highly capital intensive sectors are harder hit by attacks on their facilities. 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.

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[11]. 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.

In the next section, I will present the model in a technical form. The third section will discuss simulation results, while the fourth section concludes.

## 2. The model

In this section, the model will be presented in various stages. First, the simplest version in a world consisting only of a government and a firm is considered. Then, a terrorist organization is added, and finally the possibility of counter-terrorism measures is introduced. Note that this

[8] Economies of scale are singularly hard to measure 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.

[9] Firms would always base their production in just one country and governments would increase their counter-terrorism spending to the point where it is equal to tax revenues. Also, the firm's location decision becomes dependent on the budgets of the firm and the terrorist organization.

[10] Sector specific stock market effects of terror attacks have also been found by Chesney et al. (2010).

[11] See, for instance, Krugman (2004) and cost calculations of the 9/11 aftermath by Penm et al. (2004). The economic impact of terrorism-induced fear is the subject of recent work by Becker and Rubinstein (2011).

model constitutes a one-shot game, so there is no time inconsistency of tax policy and no lock-in effect from factor allocation. It also abstracts from the demand side, so higher factor costs cannot be compensated by setting higher prices.

## Without terrorism

Assume that the world consists of only two countries: Country 1, comparable to a Western country, in which labour is expensive and capital can be bought at the world interest rate without risk premium. There is only one industrial sector with the same production technology in both countries. Furthermore, as the particular case of raw material extraction is considered, the productivity in country 1 is low due to costly extraction techniques and dispersed deposits (e.g. oil sands in Alaska). In country 2, which is alike to resource-rich developing countries, capital can also be bought at the world interest rate in the absence of terrorism, but (unskilled) labour is cheaper than in the developed country. Also, the productivity in the raw materials sector is higher than in country 1 due to the abundance of deposits and their easy accessibility (e.g., coal, oil and gas in Nigeria and Colombia).

The production function of a firm operating in country *j* is given by

$$Y_j = \varphi_j\left(\alpha {K_j}^r + (1-\alpha){L_j}^r\right)^{\frac{h}{r}} \tag{1}$$

where $Y$ is the output, $0 < \varphi < \infty$ the productivity, $K$ and $L$ the inputs of capital and labour and $0 \leq \alpha \leq 1$ the share parameter of capital. $r = \frac{s-1}{s}$ where $0 < s < \infty$ 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]. It is assumed that the firm has its main seat in country 1, so capital that is employed in country 2 is considered to be FDI.

The firm is constrained by an exogenously given budget constraint (e.g. an exploration and exploitation budget in a multi-sector trust) which has the form

$$B \geq K_1 * i_1 + L_1 * w_1 + K_2 * i_2 + L_2 * w_2 \tag{2}$$

where $0 \leq B$ is the available amount of money and $0 < i$ and $0 < w$ are the country-specific costs 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 $w_j$ and $i_j$ are fixed.

[12] For a discussion of the properties of CES production functions, see Arrow et al. (1961).

A firm's output is taxed by the government of country $j$ by $t_j$ with $0 \leq t_j \leq 1$. For simplicity's sake it is assumed that $t_1 = 0$, so only the government of the less developed country charges taxes[13]. Taking country 2's taxation decision into account a firm allocates its budget on capital and labour in both countries. The optimal values for $K_j$ and $L_j$, denoted by an asterisk, are derived by

$$\max_{K_1,K_2,L_1,L_2} \varphi_1(\alpha {K_1}^r + (1-\alpha){L_1}^r)^{\frac{h}{r}} + (1-t_2)\varphi_2(\alpha {K_2}^r + (1-\alpha){L_2}^r)^{\frac{h}{r}} \; s.t.(2) \tag{3}$$

This gives the following optimal values:

$$K_1^* = \left(\frac{i_1}{\alpha}\frac{(1-\alpha)}{w_1}\right)^{\frac{1}{r-1}} L_1 \tag{4}$$

$$K_2^* = \left(\frac{i_2}{\alpha}\frac{(1-\alpha)}{w_2}\right)^{\frac{1}{r-1}} L_2 \tag{5}$$

$$L_1^* = L_2\left(\alpha\left(\frac{i_2}{\alpha}\frac{(1-\alpha)}{w_2}\right)^{\frac{r}{r-1}} + (1-\alpha)\right)^{\frac{h-r}{hr-r}} * \frac{\left(\frac{(1-t_2)*\varphi_2*w_1}{\varphi_1*w_2}\right)^{\frac{1}{h-1}}}{\left(\alpha\left(\frac{i_1}{\alpha}\frac{(1-\alpha)}{w_1}\right)^{\frac{r}{r-1}} + (1-\alpha)\right)^{\frac{h-r}{hr-r}}} \tag{6}$$

$$L_2^* = B * \left[ i_1\left(\frac{i_1}{\alpha}\frac{(1-\alpha)}{w_1}\right)^{\frac{1}{r-1}}\left(\alpha\left(\frac{i_2}{\alpha}\frac{(1-\alpha)}{w_2}\right)^{\frac{r}{r-1}} + (1-\alpha)\right)^{\frac{h-r}{hr-r}} * \frac{\left(\frac{(1-t_2)*\varphi_2*w_1}{\varphi_1*w_2}\right)^{\frac{1}{h-1}}}{\left(\alpha\left(\frac{i_1}{\alpha}\frac{(1-\alpha)}{w_1}\right)^{\frac{r}{r-1}} + (1-\alpha)\right)^{\frac{h-r}{hr-r}}} + i_2\left(\frac{i_2}{\alpha}\frac{(1-\alpha)}{w_2}\right)^{\frac{1}{r-1}} + w_1\left(\alpha\left(\frac{i_2}{\alpha}\frac{(1-\alpha)}{w_2}\right)^{\frac{r}{r-1}} + (1-\alpha)\right)^{\frac{h-r}{hr-r}} * \frac{\left(\frac{(1-t_2)*\varphi_2*w_1}{\varphi_1*w_2}\right)^{\frac{1}{h-1}}}{\left(\alpha\left(\frac{i_1}{\alpha}\frac{(1-\alpha)}{w_1}\right)^{\frac{r}{r-1}} + (1-\alpha)\right)^{\frac{h-r}{hr-r}}} + w_2 \right]^{-1} \tag{7}$$

Thus, $Y_j = f(B, \varphi_1, \varphi_2, i_1, i_2, w_1, w_2, \alpha, h, r, t_2)$.

Anticipating the labour and capital allocation decisions of the firm, the government of country 2 decides on an optimal tax rate to maximize

[13] Introducing a positive tax in country 1 will just have the effect of lowering this country's productivity.

$$R_2 = t_2 * Y_2 \tag{8}$$

where $R_2$ are the tax revenues. This will obviously be set so as to balance the positive effect on tax revenues of an increase in $t$ with the negative effect of a reduced $Y$. As there is no easily tractable closed-form solution to the country's optimization problem, simulation results to illustrate the outcomes of the model will be presented in the simulation section[14].

## With terrorism against labour

I now introduce a terror organization in country 2 which acts after the government's taxation decision but before the firm's resource allocation. Governments anticipate and firms observe the intensity of terrorist activities. Terror affects the resource allocation decision in two ways: First, terrorist attacks against a factor drive up its relative cost and thus lead to a substitution towards the other factor. Second, as factor prices rise in one country, the other country becomes relatively cheaper and attracts more of the firm's budget which lowers utilization of both factors in the afflicted country.

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[15]. 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

$$\max_{T_L} T_L * L_2 \quad s.t. T_L * C_L \leq M \tag{9}$$

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 manpower or funds[16]. In the latter case, $M = T_L * L_2$. The terror intensity directly affects the wages a firm has to pay its employees in country 2: It is assumed that higher wages have to be paid to compensate employees for the risk of getting abducted and/or that higher

[14] Some of the exponents in (6) and (7) change signs depending on the absolute and relative values of *s* and *h* which would make it necessary to present reaction functions for each particular case. Also, due to the exponential nature of (4) to (7), the number of solutions for *t* and other variables of interest varies with different parameter values.

[15] 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 (Pshisva and Suarez 2006).

[16] 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.

wages reflect the ransom that has to be paid if a kidnapping occurs[17]. Thus, a firm no longer pays $w_2$ for a unit of labour in country 2, but $w_2 + T_L$. By (7) a higher wage in country 2 drives down the labour employed in country 2. 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 $L_2$ balance. If $M$ is an exogenous manpower constraint, it could be the case that the terror organization does not want to employ all available personnel due to the reaction of $L_2$, so the constraint does not bind.

The terror effect on the capital use in country 2 depends on the specific form of the production function: For sufficiently high $s$ and α, an increase in the wage rate could actually increase the amount of capital employed in country 2 as capital is a good substitute for abduction-threatened labour. Analytically, this is the case if in (5) the first multiplier reacts more strongly to an increase in $w_2$ than the second. Thus, depending on the model's parameters, the reaction of FDI can be positive or negative to varying degrees. Also, the effect of varying *h* on FDI is ambiguous depending on *s* and the share parameters.

Output reduction in country 2 depends on the economies of scale and the substitutability of production factors. The negative impact of terror falls in *s* if capital is the more important production factor and first increases, then falls in *s* if labour is more important as measured by its share parameter. A higher *h* (i.e. an *h* closer to 1) will always lead to a higher drop in output, albeit total output will still be higher.

These results will be illustrated in the simulation section.

*Proposition 1: If terrorism only targets labour, the impact on FDI and output falls as s increases. Terror organizations will set an optimal level of terror that may not make full use of a manpower constraint.*

## 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 of foreign firms. The objective in this case is assumed to be the minimization of economic activity in country 2 which hurts the government of this particular country and the resident foreign firms[18]. Terror against labour now takes the form of assassinations instead of kidnappings, so this form of terror no longer positively enters the terror organization's budget constraint. Higher capital and labour levels do not facilitate

[17] This working mechanism of terror is also depicted in Schneider et al. (2010).
[18] This kind of terrorism can be found in Iraq and Afghanistan, for instance.

attacks as this could be merely represented in a terror effectiveness parameter which does not add much to the analysis[19]. The terror target function is now given by

$$\min_{T_L,T_K} Y_2 = \varphi_2(\alpha K_2^r + (1-\alpha)L_2^r)^{\frac{h}{r}} \; s.t. T_L * C_L + T_K * C_K = M \tag{10}$$

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 capital in country 2 and thus a unit of capital no longer costs $i_2$ but $i_2 + T_K$[20]. 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.

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:

$$\frac{\partial Y_2/\partial T_L}{C_L} = \frac{\partial Y_2/\partial T_K}{C_K} \tag{11}$$

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. The exact size of the FDI reduction will again depend on the country and sector characteristics: Across the range of *h*, the effect will be higher if capital is the more important production factor and substitutability between factors is high.

Output is generally decreasing in *s*, and more strongly in a sector with high $\alpha$ where the competitive advantage in wages of country 2 is not as important to begin with.

These results will be shown in the simulation section.

*Proposition 2: If s and α are both high, the impact of terrorism on FDI and output in country 2 is the strongest.*

## With counter-terrorism measures

I now introduce counter-terrorism measures by the government of country 2 which drive up the cost of perpetrating terrorist attacks. The government can spend the taxes levied from the foreign firm on 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. These measures increase the

[19] 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).

[20] This „flight to quality" of capital which raises risk premia has also been noted by Johnston and Nedelescu (2005).

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

$$\max_{t_2, P_K, P_L} R_2 = t_2 * Y_2 - P_K - P_L \tag{12}$$

where it has to be kept in mind that $Y_2$ is a function of both the tax rate and the protective measures.

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 (9) and (12) that the government might not be interested in spending money on counter-terrorism measures if tax revenues are not sufficiently reduced to warrant counter-terrorism spending or 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 tax revenues may react more strongly to higher taxation than to a reduction in terrorist activity. The same applies with an endogenous *M* if terrorists have to fund their kidnappings by ransom proceeds. 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 $\alpha$.

The same result occurs if terrorists attack both labour and capital, only that here a low level of terrorism, resulting from a small budget, will always be fought.

*Proposition 3: 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 of country 2 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 taxation (negative) with those of capital and labour protection (positive) while maximizing available tax revenues after counter-terrorism spending. Protection of the more important production factor can lead terrorists to shift their attacks towards the easier target.

*Proposition 4: Terrorist organizations primarily target and governments primarily protect the more important production factor. Protective measures induce a terrorism shift towards the less defended factor.*

The magnitude of the resource allocation effect in this setting is dependent on several mechanisms: A high substitutability between inputs allows firms in the terror-stricken to use more of the unaffected or less affected production factor. At the same time, more use can be made of the cheaper labour in country 2. However, as factors in country 2 become more expensive with more terrorism, it also allows the firm to more efficiently shift production to country 1 where it can substitute capital for the relatively more expensive labour.

A higher $h$ increases the output, and thus the government's incentive to fight terrorism, for low factor parameters of capital. For high share parameters of capital, output and counter-terrorism spending is first increasing and then decreasing in $h$.

## 3. Simulation results

As the interplay of the various variables of the model is quite involved, it is easier to illustrate the results of the model by simulation than by presenting ratios of the variables for which certain effects prevail. The parameter setting for the following simulations can be found in Table 1. Factor and terror costs, levels of productivity, the firm's budget and particularly the degree of economies of scale are held constant throughout. Changing these parameters shifts certain thresholds within the model which makes the presentation of salient results more difficult but does not affect the general outcomes.

### No terrorism

First, I will present simulation results depicting the optimal capital and labour allocation and optimal taxation in the absence of terrorism in Table 2. The best situation for the government of country 2 ensues if the industrial sector is characterized by a large share parameter of labour and high substitutability between inputs. This is because country 2 has a comparative advantage in using labour due to its lower wage rate, and a high substitutability allows more of the more important factor of production to be used[21].

[21] As $s$ approaches infinity, $r$ converges towards 1, so labour and capital become perfect substitutes. Then, of course, only the cheaper production factor or the one with a higher share parameter is used.

The lowest output and tax revenues are achieved under a share parameter of one half, as country 2 cannot emphasize on its wage advantage in this case. This is aggravated as the elasticity of substitution increases.

In the case of a high share parameter of capital, the government of country 2 can expect average output and tax revenues. Interestingly, average levels of substitutability of inputs make for the worst outcomes. Several counteracting effects are at work here: A lower substitutability makes labour more important (beneficial for country 2), but it also prevents massive employment of the more important production factor (detrimental). Also, country 1 cannot profitably substitute much capital for labour and thus will not attract much business (beneficial). As $s$ rises, the beneficial effects of a low substitutability at first decrease faster than the detrimental effect. But at a certain point, productivity gains from being able to employ more capital outweigh the bad effects of increasing competitiveness of country 1 and waning importance of labour. Note that with increasing α, country 2's cost advantage is eroded away which leads to lower taxes but not necessarily lower tax revenues.

Unsurprisingly, FDI as measured by the size of $K_2$ is decreasing in $s$ and smaller in a sector with α lower or equal to one half than in a sector with a higher share parameter of capital. In such a sector, raising $s$ first increases FDI. Then, above a certain threshold, FDI falls again until $s$ hits another threshold after which FDI increases again. The higher α, the lower all of these thresholds are. This effect is related to the counteracting forces laid out in the last paragraph: Starting from a low $s$, it first becomes more profitable to substitute capital for labour, but as $s$ rises further country 1 becomes more attractive for investment. Finally, for high $s$, the advantage of being able to replace labour with capital again prevails.

## Terrorism against labour

Now it is assumed that terrorism (in the form of kidnappings) is only directed against labour and country 2 can choose to fight terrorism. Figure 5 shows the simulation results for an endogenous budget constraint, i.e. if terrorist organizations try to raise as much money as possible from kidnappings but have to fund kidnappings from these proceeds. As can be seen from the graphs, the optimal level of terror against labour from the point of view of the terrorist organization declines in substitutability and the share parameter of capital. This makes sense as a higher elasticity of substitution makes firms less dependent on labour, and thus the labour input reacts more strongly to an increase in wages. The case of an exogenous manpower constraint is exemplarily depicted in Figure 4. Here it can be seen that the terrorist

organization may not make full use of its manpower if it tries to maximize the revenues from kidnapping activities.

Governments only choose to actively fight terrorism within certain parameter ranges. For very high *s*, the costs of counter-terrorism measures are higher than its benefits, so no counter-terrorism spending takes place.

This illustrates propositions 1 and 3. Due to the inter-country effects described in the last section, there are several "spikes" of counter-terrorism spending and terrorist activity over the range of *s* in Figure 5, showing a particular susceptibility of labour to terror at these points.

Also, as laid out in proposition 1, FDI losses as calculated by the ratio between the levels of FDI in the absence of terrorism and the levels in the kidnapping scenario, decrease in *s* (see Table 3). It is to be noted here that any level of terrorism of course adversely affects output. It would therefore be economically efficient to buy off terrorists as long as they are fighting for economic gains instead of spending money on counter-terrorism measures and suffering attacks. This is exactly what happened in Nigeria where the government has pardoned terrorists in the Niger delta and is funding job-creating, infrastructure and education projects in the area.

## Terrorism against capital and labour

Finally, I consider the case where the terrorist organization is out to cause as much economic havoc as possible. In this case, the terrorists' available funds are exogenously given. The simulation results for varying share parameters of capital and labour are depicted in Figures 6, 7 and 8. As put forward in proposition 4, the more important production factor is expected to be the focus of both government and terrorists. If $\alpha$ is low, governments protect and terrorists attack mainly labour. The opposite pattern emerges if $\alpha$ is high. For intermediate $\alpha$, labour and capital are about equally under attack. The FDI and output effects can be seen in Table 4. Figures 6 to 8 also illustrate the shift of terrorism towards the less defended production factor[22]. As put forward in proposition 2, a sector with high $\alpha$ and high *s* suffers the highest reduction in FDI, output and therefore tax revenues.

One can see from Table 4 that output and FDI effects differ strongly. If, for example, *s* is high and $\alpha$ is low, just considering FDI as a measure of the impact of terrorism understates its

[22] This has the real world equivalent of a change in terrorist tactics as a reaction to their adversaries' strategies, something that has happened several times in Iraq and Afghanistan.

economic impact. If capital is the more important production factor, however, the change in FDI throughout overstates terrorism's economic effect.

## 4. Conclusion

This paper has developed a microeconomic framework with rational actors to model the impact of terrorism on FDI/output and the interactions between firms, governments and terrorist organizations.

A result of the model is that an all-out counter-terrorism campaign to fully suppress terrorist activity might not be in the economic interest of a government if terrorism mainly engages in kidnapping or if terrorism levels are very high. But if the aim of the terrorists is to topple the government, terrorism will of course also be fought for non-economic reasons not captured in this model. Furthermore, if terrorists are interested in reducing economic activity and the government starts protecting one factor of production, they will change their tactics, i.e. attack the less well-defended input.

It has been shown 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 FDI and output, regardless of the size of their diseconomies of scale. A sector that displays such characteristics is the resource extraction industry[23]. While copious amounts of capital are needed to buy the required mining or drilling equipment it is also possible to substitute capital to a certain degree, especially in developing countries. There, safety measures and working conditions are worse and thus tie up less capital than in developed countries, and many menial tasks are not mechanized[24]. Also, electronic surveillance equipment is replaced by manual inspections, an economically sound substitution if labour is relatively cheap.

As pointed out in the introduction, 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 proves to be most effective in developing countries which can afford setbacks to economic activity the least. This result of the model is

[23] In Germany, mining is the 4th most capital intensive industry sector, while the processing of mineral oil ranks 3rd (Löbbe 2009). The resource extraction industry, and especially oil extraction, commonly shows a high elasticity of substitution in empirical research (Arrow et al. 1961, Balistreri et al. 2002 and Salem 2004). Salem (2004) estimates the Tunisian $s$ to be 2.575 for the oil and gas and 0.906 for the ores and minerals sectors. Arrow et al. (1961) also find the highest capital intensity in the resource extraction business.

[24] 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).

in line with the findings of Abadie and Gardeazabal (2008) and 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.

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# Appendix

| | | |
|---|---|---|
| Very Low *s* (VL*s*): | *s=0.1* | *B*=20 |
| Low *s* (L*s*): | *s=0.5* | *h*=0.5 |
| Medium *s* (M*s*): | *s*=0.99 | $\varphi_1$=1 |
| High *s* (H*s*): | *s*=2 | $\varphi_2$=2 |
| Low α (Lα): | α=0.1 | $i_1$=$i_2$=0.1 |
| Medium α (Mα): | α=0.5 | $w_1$=0.5 |
| High α (Hα): | α=0.9 | $w_2$=0.1 |
| | | $C_K$=$C_L$=1 |

**Table 1: Simulation parameter settings**

| | VLs | | | | Ls | | | | Ms | | | | Hs | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $K_2$ | $L_2$ | $Y_2$ | $t_2/R_2$ | $K_2$ | $L_2$ | $Y_2$ | $t_2/R_2$ | $K_2$ | $L_2$ | $Y_2$ | $t_2/R_2$ | $K_2$ | $L_2$ | $Y_2$ | $t_2/R_2$ |
| **Lα** | 48.76 | 60.74 | 15.17 | 0.69/10.47 | 28.60 | 85.81 | 16.91 | 0.70/11.84 | 12.00 | 105.66 | 18.42 | 0.71/13.08 | 1.46 | 118.38 | 19.83 | 0.72/14.27 |
| **Mα** | 54.52 | 54.52 | 14.77 | 0.68/10.04 | 51.75 | 51.75 | 14.39 | 0.68/9.78 | 49.42 | 49.42 | 14.06 | 0.67/9.42 | 44.95 | 44.95 | 13.41 | 0.65/8.82 |
| **Hα** | 58.33 | 46.82 | 14.87 | 0.68/10.11 | 68.46 | 22.82 | 15.11 | 0.65/9.82 | 72.79 | 8.27 | 15.29 | 0.62/9.48 | 72.78 | 0.90 | 15.55 | 0.62/9.64 |

**Table 2: FDI, labour, output and tax rate/revenues without terrorism**

| | | VLs | | | Ls | | | Ms | | | Hs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *No Terror* | *Terror* | *Loss in %* | *No Terror* | *Terror* | *Loss in %* | *No Terror* | *Terror* | *Loss in %* | *No Terror* | *Terror* | *Loss in %* |
| $K_2$ | **Lα** | 48.75 | 17.45 | 0.64 | 28.60 | 12.90 | 0.55 | 12.00 | 8.68 | 0.28 | 1.46 | 3.32 | -1.27 |
| | **Mα** | 54.51 | 14.39 | 0.74 | 51.74 | 23.37 | 0.55 | 49.42 | 40.27 | 0.19 | 44.95 | 54.18 | -0.21 |
| | **Hα** | 58.32 | 17.12 | 0.71 | 68.46 | 43.34 | 0.37 | 72.78 | 68.53 | 0.06 | 72.78 | 72.78 | 0.00 |
| $Y_2$ | **Lα** | 15.17 | 7.99 | 0.47 | 16.91 | 8.84 | 0.48 | 18.42 | 8.97 | 0.51 | 19.82 | 9.88 | 0.50 |
| | **Mα** | 14.77 | 7.19 | 0.51 | 14.39 | 7.60 | 0.47 | 14.06 | 9.23 | 0.34 | 13.41 | 11.04 | 0.18 |
| | **Hα** | 14.87 | 7.67 | 0.48 | 15.10 | 10.43 | 0.31 | 15.29 | 14.13 | 0.08 | 15.55 | 15.54 | 0.00 |

**Table 3: FDI and output losses from terrorism against labour**

| | VLs | | | Ls | | | Ms | | | Hs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $K_2$, *loss in %* | $L_2$, *loss in %* | $Y_2$, *loss in %* | $K_2$, *loss in %* | $L_2$, *loss in %* | $Y_2$, *loss in %* | $K_2$, *loss in %* | $L_2$, *loss in %* | $Y_2$, *loss in %* | $K_2$, *loss in %* | $L_2$, *loss in %* | $Y_2$, *loss in %* |
| **Lα** | 0.96 | 0.97 | 0.82 | 0.93 | 0.98 | 0.84 | 0.83 | 0.98 | 0.84 | 0.45 | 0.98 | 0.85 |
| **Mα** | 0.97 | 0.97 | 0.83 | 0.97 | 0.97 | 0.83 | 0.97 | 0.97 | 0.84 | 0.98 | 0.98 | 0.85 |
| **Hα** | 0.97 | 0.97 | 0.83 | 0.99 | 0.96 | 0.87 | 0.99 | 0.92 | 0.90 | 0.99 | 0.38 | 0.91 |

**Table 4: FDI, labour and output losses from terrorism against capital and labour for *M*=2**

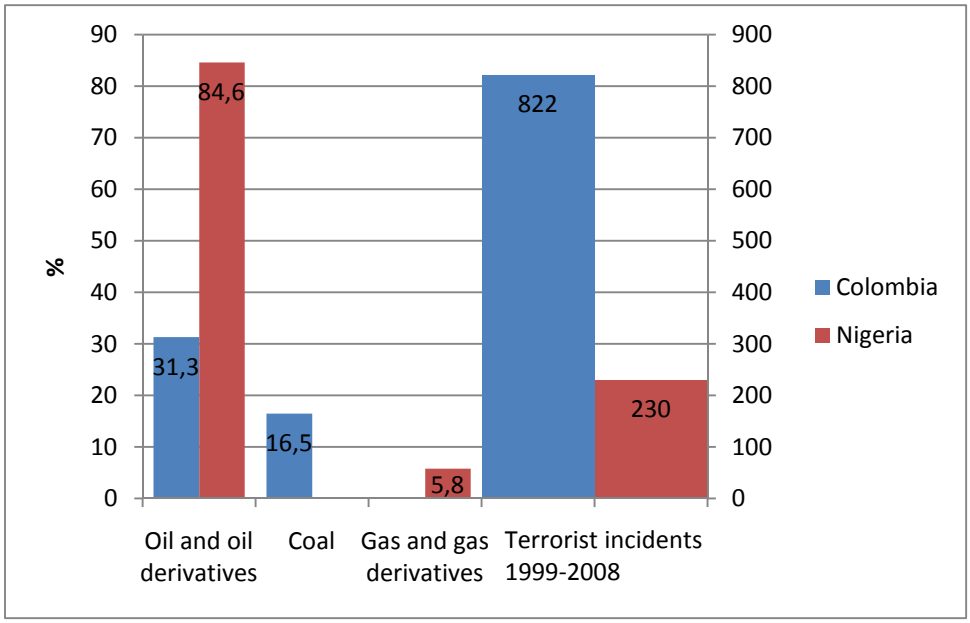


**Figure 1: Resource exports in % of total exports and terrorist incidents 1999-2008 in Colombia and Nigeria. (Terrorist incidents on right axis). Source: Global Terrorism Database (2011) and Germany Trade and Invest (2010)**

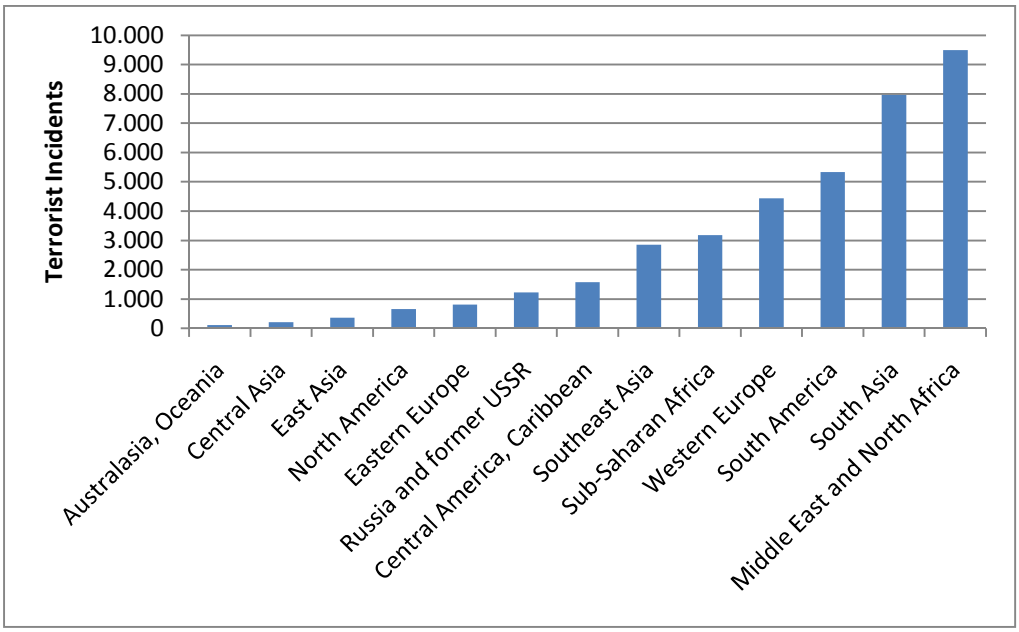


**Figure 2: Terrorist incidents per region, 1991-2008. Source: Global Terrorism Database (2011)**

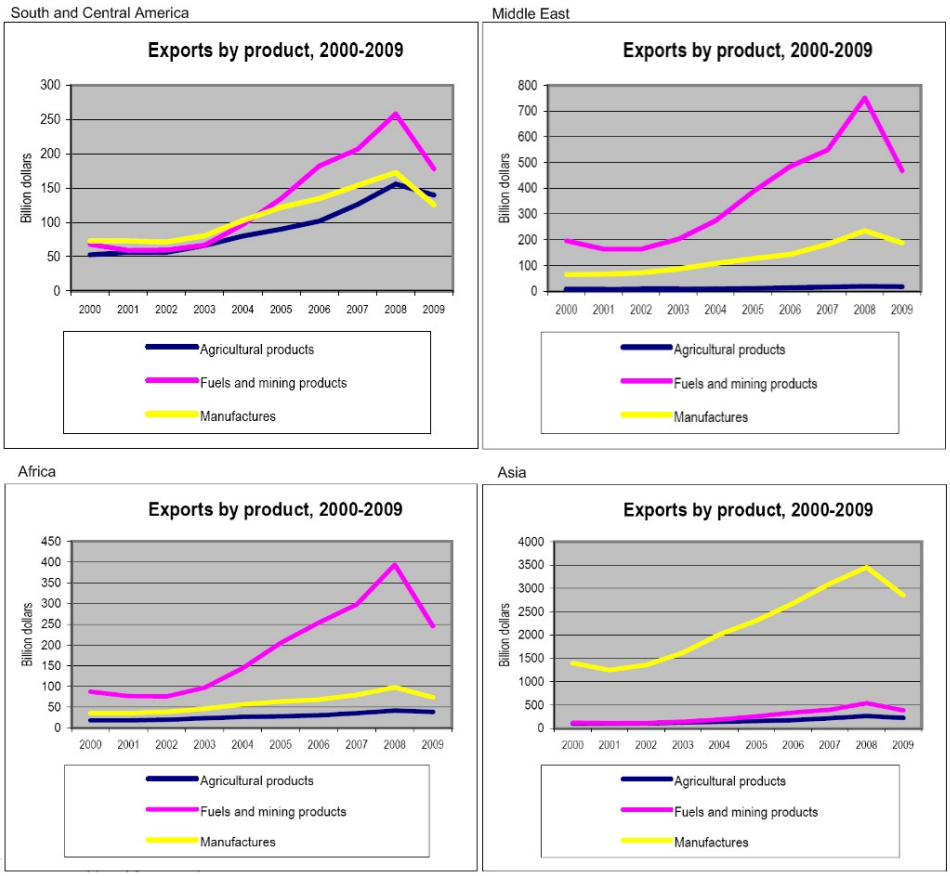


**Figure 3: Main exports per region[25]. Source: WTO (2010)**

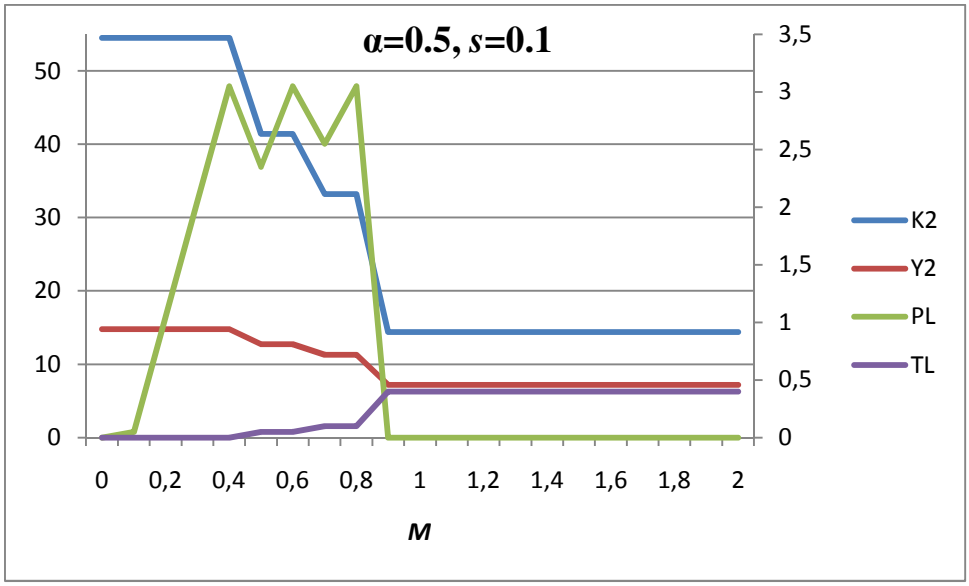


**Figure 4: Simulation results with terror against labour for exogenous *M*. (K2 and Y2 on the left axis)**

[25] As Asia includes manufacturing countries such as India, Japan and China, resource extraction is little in comparison.

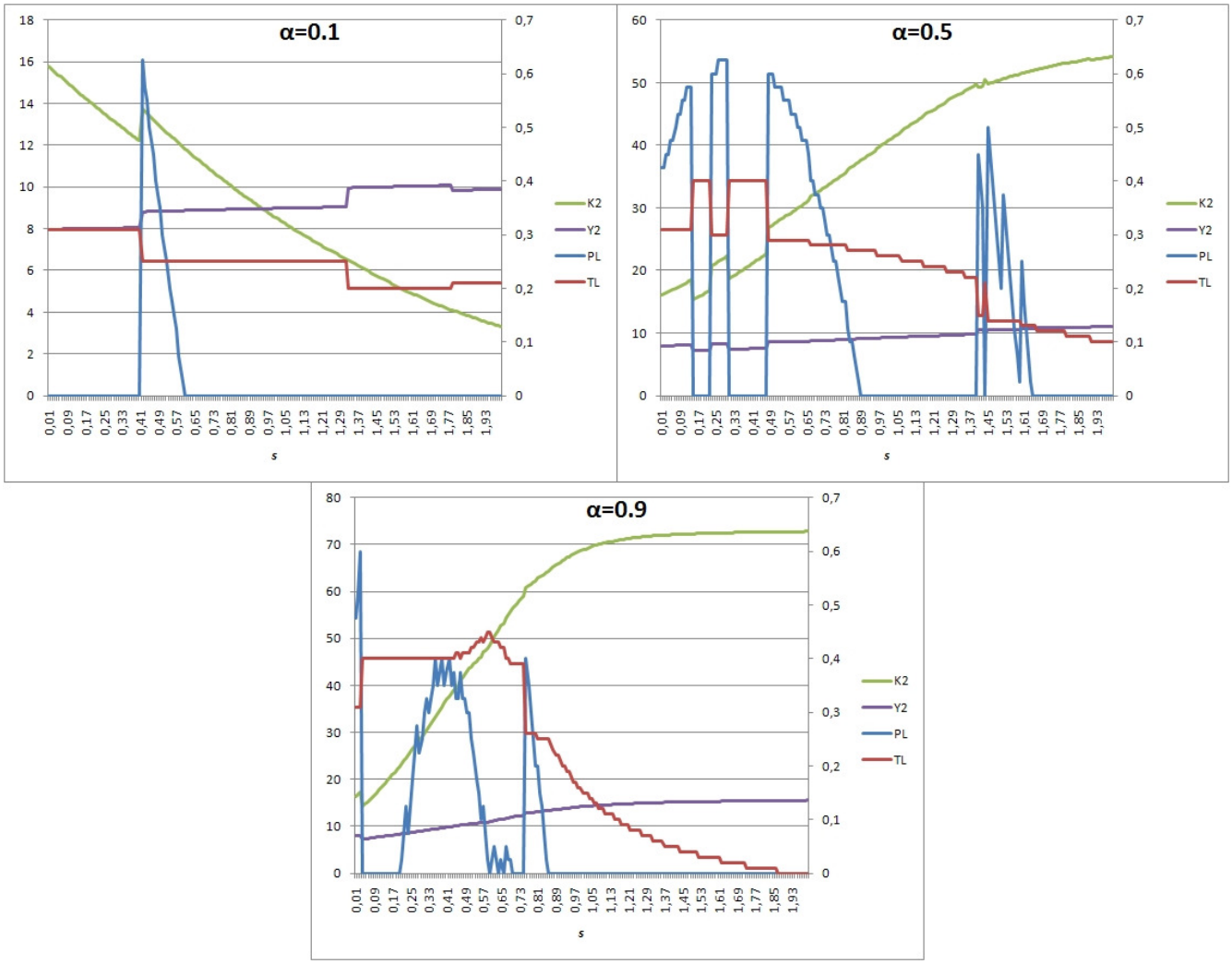


**Figure 5: Simulation results with terror against labour for endogenous *M*. (K2 and Y2 on the left axis)**

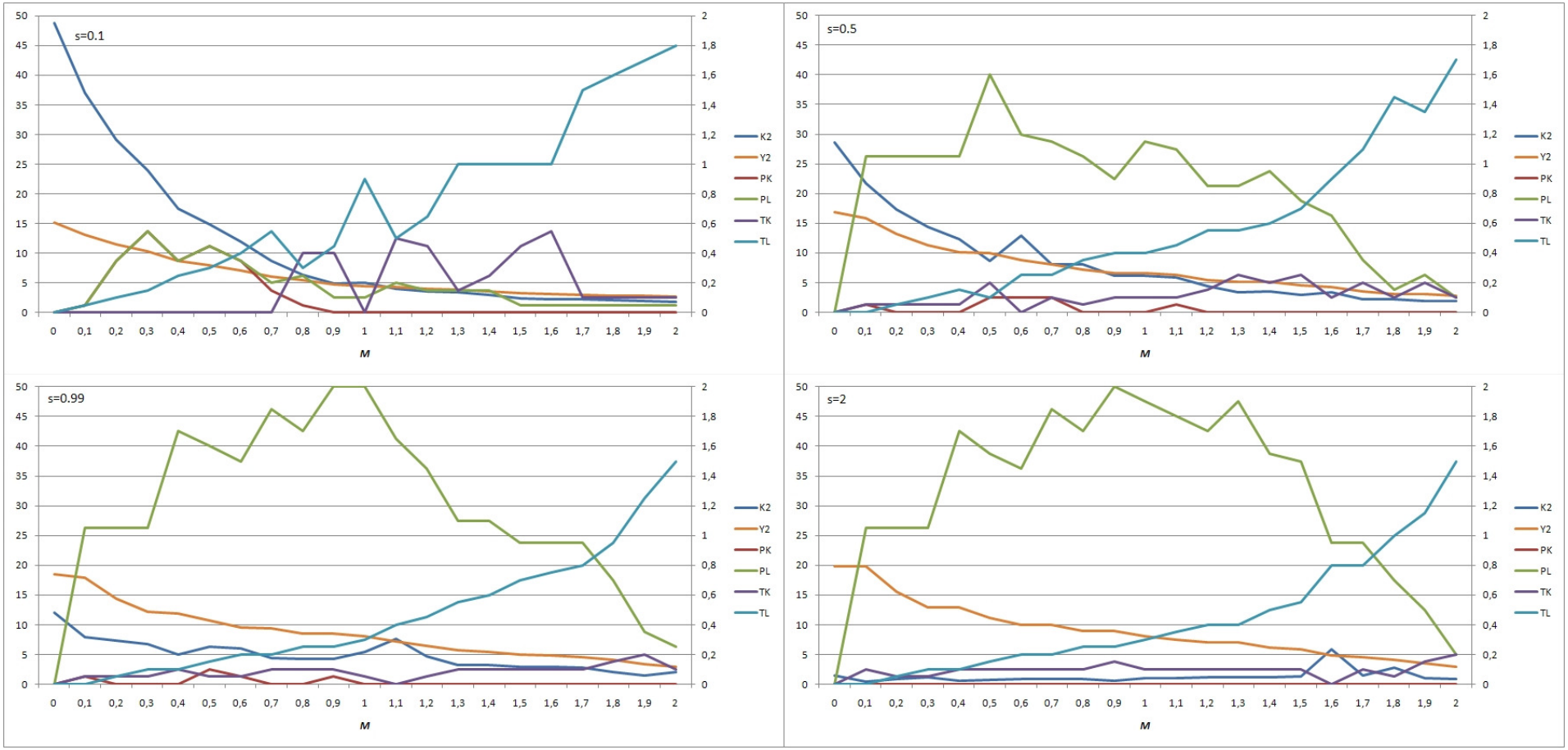


**Figure 6: Simulation results for α=0.1 with terror against capital and labour for varying *M*. (K2 and Y2 on the left axis)**

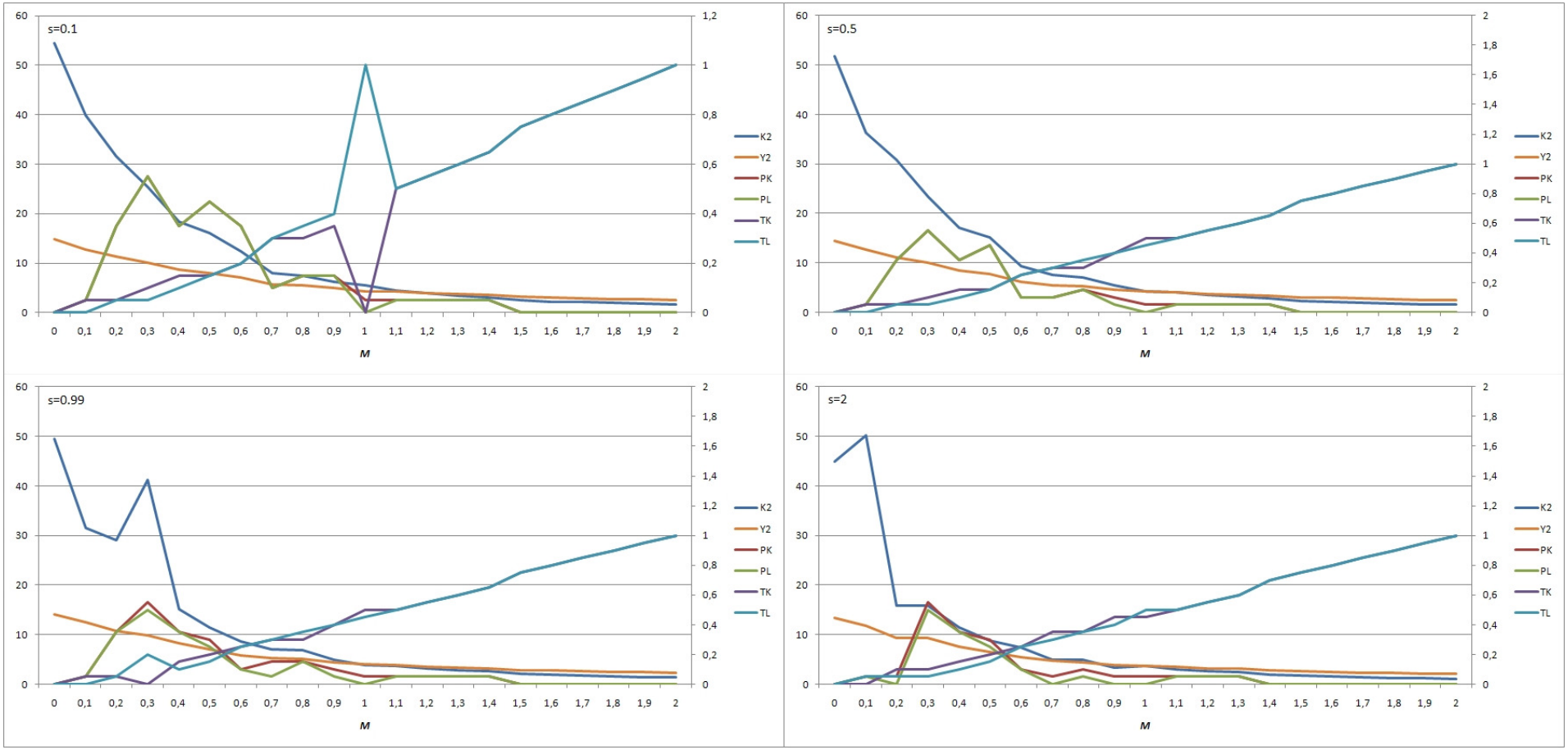


**Figure 7: Simulation results for α=0.5 with terror against capital and labour for varying *M*. (K2 and Y2 on the left axis)**

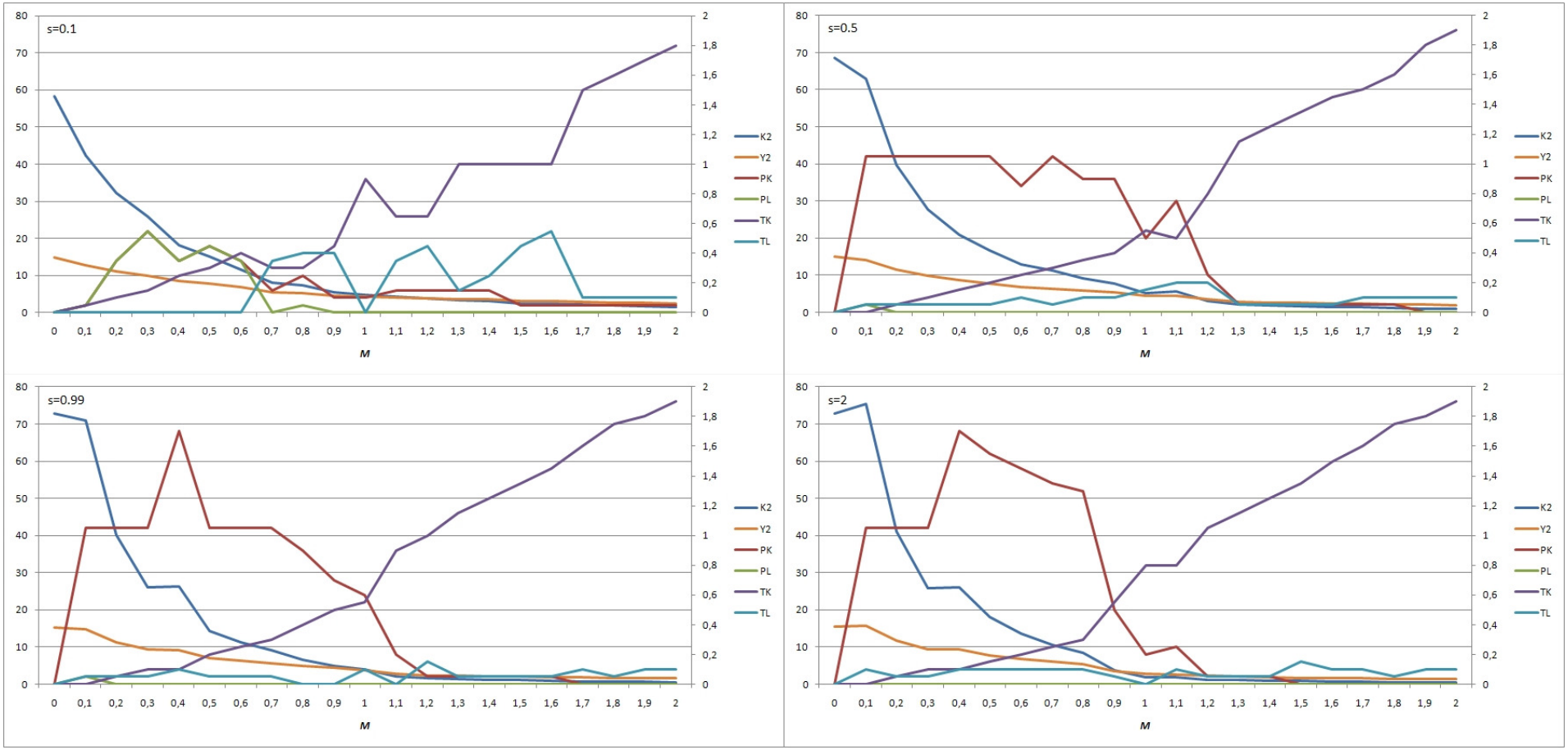


**Figure 8: Simulation results for α=0.9 with terror against capital and labour for varying *M*. (K2 and Y2 on the left axis)**