# OPTION VALUE, POLICY UNCERTAINTY, AND THE FOREIGN DIRECT INVESTMENT DECISION

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## Abstract

In this paper we analyse the impact of policy uncertainty on foreign direct investment strategies. The paper follows the real options approach, which allows to investigate the value to a firm of waiting to invest and/or disinvest, when payoffs are stochastic due to political uncertainty and investments are partially reversible. Across the board we find that political uncertainty can be very detrimental to FDI decisions.

## 1. Introduction

The foreign direct investment (FDI) literature is extensive and consists of three mainstream models. The so-called OLI model is a model that tries to identify the attractiveness of a country for foreign investors on the basis of ownership, location and internationalisation factors [Dunning (1993)]. The gravity model tries to predict FDI flows on the basis of macroeconomic variables like the level of GDP, GDP growth and the population size [Brenton and Gros (1997), Brenton and Di Mauro (1998), Brock (1998)]. The transaction costs models try to determine which mode of investment is most suited for a business based on its cost structure [Buckley and Casson (1981)]. This stream of research examines firm choices among alternative market-servicing modes, such as exporting, licensing, or joint ventures in addition to full ownership.

Contrary to this literature, the recent literature on investment interprets a firm as consisting of a portfolio of options, and uses options-based pricing techniques to study the investment decision. The general idea behind the idea that investment opportunities are option-rights is that each investment project can be assimilated, in its nature, to the purchase of a financial call option, where the investor pays a premium price in order to get the right to buy an asset for some time at a predetermined price (exercise price), and eventually different from the spot market price of the asset (strike price). Analogously, the firm, in its investment decision, pays a price (the cost of setting up the project) which gives her the right to use the capital (exercise price), now or in the future, in return for an asset worth a strike price. Taking into account this options-based approach, the calculus of profitability cannot be done simply applying the net present value rule to the expected future cash flows of the operation, but has rather to consider the following three characteristics of the investment decision:

1. there is uncertainty about future payoffs from the investment;

2. the investment does not entail a now-or-never decision and

3. the investment is at least partially irreversible.

The three characteristics imply that the opportunity cost of investment includes the value of the option to wait that is extinguished when an investment decision is taken. Therefore, the investment decision is affected by the determinants of the value of this option and consequently, an appropriate

identification of the optimal exercise strategies for real options plays a crucial role in the maximisation of a firm´s value.

The real options studied in the literature include, other things equal, operating options [McDonald and Siegel (1985)], the option to wait and undertake an investment later [McDonald and Siegel (1986)] and uncertainty from future interest rates [Ingersoll and Ross (1992)]. More recent contributions to the literature include Abel and Eberly (1994, 1997) and Abel et al. (1996).[1] Almost uniformly, this literature focuses on the effect of demand, price and/or exchange rate uncertainty upon investment decisions of firms. The scope of this paper is to apply the real option theory to the case of foreign direct investment under political instability, i.e. we aim to explain FDI decisions with a specific focus on the political environment. The sources of political risk include, inter alia, an unreliable legal system, potential capital expropriation, major government crisis, separatist movements, nationalization policies, the imposition of foreign exchange and capital controls, and the institution of tariffs and barriers.[2]

From the policy viewpoint, an extremely important form of uncertainty faced by investors is the imperfect credibility of policy reforms. Investment-friendly reforms typically raise expected returns, but may also increase uncertainty if investors believe that the reform measures could be reversed. In such context, investors' perceptions about the probability of policy reversal become a key determinant of the investment response. These issues are explored by Rodrick (1991) using a model in which investment involves sunk costs of entry and exit. He shows that a reform favourable to capital, but regarded as less than fully credible, will fail to trigger off an investment response unless the return on capital becomes high enough to compensate investors for the losses they would incur should the

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[1] The literature is too vast to survey here. Excellent surveys of the real options literature are provided by Amran and Kulatilaka (1999), Copeland and Antikarov (2001), Coy (1999), Dixit and Pindyck (1994) and Lander and Pinches (1998). Graham and Harvey (2001) survey a large representative set of US firms and find that a quarter of them incorporates the real options of a project when evaluating it.

[2] Most of the FDI literature [including the papers reviewed by Markusen and Maskus (2001)] relies on non-stochastic models. One exeption is Goldberg and Kolstad (1995) who study the effects of exchange rate uncertainty on FDI. Culem (1988) and Garibaldi et al. (2002) confirm the general finding that the quality of institutions and governance and macroeconomic stability are important factors in determining the level and regional allocation of FDI flows. A comparison of the results of different surveys on FDI in the Central and Eastern European countries is provided in European Bank for Reconstruction and Development (1994), p. 130.

reversal take place. Similar qualitative conclusions are reached by van Wijnbergen (1985) who considers the case of a trade reform suspected to be only temporary.[3]

The hypothesis that an unstable political environment can become a powerful aggregate investment deterrent seems to be supported by mounting empirical evidence. Barro (1991) and Alesina and Perotti (1996) find that measures of government instability, unrest and political violence are significantly related to cross-country differences in investment and growth. Keefer and Knack (1995) show that indicators of uncertainties in property rights enforcement (perceived risk of expropriation and repudiation of contracts) derived from expert surveys are negatively associated with private investment performance across countries. Pindyck and Solimano (1993) and Mauro (1995) find that political uncertainty and an aggregate institutional indicator (a bribery and corruption indicator) is negatively associated with aggregate investment spending. Finally, Brunetti and Weder (1998) have found that high corruption, a lack of rule of law, and volatility in real exchange rate distortions are most detrimental to aggregate investment spending. The literature concerning the empirical investigation of the main macroeconomic determinants of FDI flows, also connotes the importance of political and economic instability.

The remainder of this paper is constructed as follows. The next section of the paper describes the model and assumptions, drawing inspiration from the real options literature. In section 3, we derive the analytical solution and section 4 contains a numerical analysis. Finally, section 5 provides a summary and some general comments pertaining to policy implications and future research.


## 2. The Basic Model of Investment with Adjustment Costs

Consider the problem of a firm whose production is located exclusively at home but is contemplating expanding its production capabilities abroad. The firm will engage in FDI only if such a move is deemed to be beneficial in the medium and long run. In order to focus on the impact of uncertainty, we

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[3] It should be pointed out, however, that a higher level of investment may encourage the host government to change policies in the future, so that a firm anticipating this kind of time inconsistency will tend to be self-protective, assuming that the jump parameter is positively correlated with the stock of invested capital and therefore an endogenous variable. See Cherian and Perotti (2001) for a discussion of the effects of strategic interactions drawing inspirations from the time-inconsistency literature. In the context of transition economies, a

assume zero transportation costs. Hence, proximity to the consumer does not play a role in determining production patterns. Formally, we assume an economy where the individual firm maximises the intertemporal objective function

(1)     $V = \int_0^\infty \left( \pi(K_t) - C(I_t) \right) e^{-rt} dt$

where $\pi(\cdot)$ is the twice differentiable maximised value of the firm's instantaneous profits with $\pi_K > 0$ and $\pi_{KK} < 0$, $r$ is the discount rate, and $C(\cdot)$ are the total investment expenditures.[4] The firm is risk-neutral, but the owners may be risk averse.[5] These standard assumptions guarantee that the firm's problem is well-behaved. The total costs of investment are determined by

(2)     $C(I) = \begin{cases} a_K + p_K^+ I + c(I) & \text{for} \quad I > 0 \\ 0 & \text{for} \quad I = 0 \\ a_K + p_K^- I + c(I) & \text{for} \quad I < 0 \end{cases}$

Fixed costs $a_K$ are non-negative costs of investment that are independent of the level of investment. However, a firm can avoid these fixed costs by setting investment to zero. Purchase (sale) costs are the costs of buying (selling) capital. Let $p_K^+$ ($p_K^-$) be the price per unit of investment good at which the firm can buy (sell) any amount of capital. We assume that $p_K^+ \geq p_K^- \geq 0$.[6] Adjustment costs $c(\cdot)$ are continuous and strictly convex in $I$ satisfying $c(0) = 0$, $c_I > 0$ and $c_{II} > 0$. Considering the depreciation of capital, the adjustment of capital over time is denoted by

(3)     $\dfrac{dK}{dt} = I - \delta K$ ,

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where $\delta$ represents the depreciation rate. To solve the model, we consider the Bellman equation

$$(4) \qquad rV = \pi(K) - C(I) + \frac{E[dV]}{dt} = \pi(K) - C(I) + q(I - \delta K).$$

The first condition characterising the optimum is the derivative of the Bellman equation with respect to the control variable (*I*) is zero, i.e.

$$(5) \qquad p_K^{+/-} + c_I = q,$$

where $q \equiv V_K$ denotes Tobin´s marginal *q*. Note that since $C_I$ is increasing in *I*, equation (5) implies that investment is increasing in *q*, i.e.

$$(6) \qquad I_t = f(q_t) \qquad\qquad \text{with } f(p_K^{+/-} = 1) = 0 \text{ and } f' > 0.$$

The above model of investment has at least one failure as a description of actual behaviour. Our analysis so far assumes that firms are certain about future revenues. In practice, however, they face uncertainty. Thus we need to modify the model if we are to obtain a reasonable picture of actual foreign direct investment decision. To evaluate such impacts, it is necessary to recognise that investment and production are inherently dynamic and uncertain processes. Acknowledging the high degree of irreversibility associated with FDI ventures, let's assume that FDI decisions may be represented by a set of real options to acquire productive assets abroad. Consequently, an appropriate identification of the optimal exercise strategies for real options plays a crucial role in the maximisation of the firm's value. So far, the real options literature provides relatively little insight into the impact of institutional and policy uncertainty on the investment decision of a firm although many people would agree with the view that policy uncertainty and instability can be serious obstacles to fixed investment decisions. The existing papers mainly consider continuous changes in the value of relevant variables. This, most of the time, results in the assumption that the entire uncertainty in the economy can be

described by a geometric Brownian motion.[7] It is, however, more realistic to model institutional and policy uncertainty as a process that makes infrequent but discrete jumps. In such cases, use can be made of the Poisson jump process.[8]

On the supply side of the economy, we assume that the present value of operating profits is given by

(7) $\qquad \pi(K_t) = gK^a$

where the productivity parameter $g$ is intended to proxy for all aspects of the environment of the host country impinging on the incentive to invest, such as demand and exchange rate fluctuations, capital control regulations, weak and poorly enforced property rights, government instability, unstable incentive frameworks, discontinuous changes in the tax environment, social unrest, etc. In other words, $g$ measures the host country's potential in generating profits. In this paper, we propose a simple unifying framework where the parameter $g$ is allowed to jump or drop, combined with continuous-time stochastic process. Consequently, our objective is to model explicitly the dynamics of policy uncertainty and its effect on foreign direct investment when the firm has incomplete information about the moment of the change. This feature of the policy process is particularly relevant in developing countries and transition countries where investors may be particularly wary of the potential for radical and unexpected swings in economic policy. It is assumed that $g$ follows the combined geometric Brownian motion and jump process

(8) $\qquad dg = \eta g dt + \sigma g d\varpi + d\tau_1 + d\tau_2,$

where $\varpi$ is a Wiener process; $d\varpi = \varepsilon\sqrt{dt}$ (since $\varepsilon$ is a normally distributed random variable with mean zero and a standard deviation of unity), $\eta$ is the drift parameter, $\sigma$ the variance parameter, $d\tau_1$

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[7] The use of option-pricing models that capture the role of uncertainty in international economics is well-established since the mid 1980s. Some of the most influential contributions focused on providing a theoretical argument to explain the hysteretic effect that the large exchange rate swings of the 1980s had on trade prices and quantities. Foreign firms that entered the U.S. market during the first half of the 1980s, when the real U.S. Dollar exchange rate was appreciating, could not exit when the U.S. Dollar returned to its original level due to the sunk costs incurred. The exchange rate would have had to decline strictly below the level that triggered entry in order to induce firms to exit [see, for example, Baldwin (1988) and Baldwin and Krugman (1989)].

and $d\tau_2$ are the increments of Poisson processes (with mean arrival rates $\lambda_1$ and $\lambda_2$). With this process,

$\eta$ is the expected growth rate of profitability, i.e. $E[(g_\tau/g_t)|g_t] = \exp[\eta(\tau-t)]$ for $\tau \geq t$.[9] It is assumed that

if an "event 1" ("event 2") occurs, $g$ increases (falls) by $\phi_1$ ($\phi_2$) percent with probability 1. Over each

time interval $dt$ there is a probability $\lambda_1 dt$ (or $\lambda_2 dt$) that it will rise (drop) by $\phi_1 g$ ($\phi_2 g$) and $Z$ fluctuates

until next event occurs. Additionally, we assume that $(dq_1, dq_2)$ and $d\varpi$ are independent to each

other, i.e. $E(d\varpi d\tau_1) = 0$, $E(d\varpi d\tau_2) = 0$, and $E(d\tau_1 d\tau_2) = 0$. Equation (8) indicates that there are two

sources of uncertainty. Type I uncertainty represented by the geometric Brownian motion captures

exchange rate and/or demand uncertainty. Instability of this type may be helpful in predicting the

variability in investment returns, but it is not the type of risk that is most important to FDI decisions.

To understand FDI behaviour, we should focus on the large downside risks that we expect to be

resolved and where new information is arriving. We have therefore additionally assumed type II

uncertainty (represented by the independent jump processes). This newly added uncertainty represents

political and/or institutional uncertainty.[10] In our work, the timing of the potential policy shifts is

exogenous.[11]

To complete the economic model, we are assuming quadratic costs of adjustment in order to replicate

the empirical fact that the capital stock displays considerable smoothness and inertia

(9)     $c(I) = \dfrac{\gamma}{2} I^2$.

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[8] An interesting recent application is provided by Hassett and Metcalf (1999) who analyse changes in the investment tax credit in a setting where a Poisson process describes discrete changes in the tax regime.

[9] The drift parameter may represent productivity improvements during the catching-up process of transition economies.

[10] We generalise the model by also introducing generic demand and/or exchange rate risk, orthogonal to political risk, in order to produce a general real options model. There are a few papers that have performed related work but none has emphasized the interaction between type I and type II sources of uncertainty that surround FDI decisions. On a methodological level, the closest work to hours is that of Dixit and Pindyck (1994), pp. 303-309. The OLI theory of FDI includes among the location advantages of a host country a variable „political stability". However, the OLI framework fails to formalise this issue in a coherent economic model.

[11] An important assumption of the model is that investment does not resolve political uncertainty, it is time that resolves uncertainty. Clearly, this assumption will not be valid for other types of uncertainty in which the firm gains the critical information *because* it has invested. For example, R&D investments will give the firm information about the likelihood of a product´s success. In practical terms, we are not exploring endogenous uncertainty but exogenous uncertainty that may (or may not) be resolved with time but cannot be resolved by action on part of the firm.

In the scenario hypothesised below, it is assumed that the firm assigns constant probabilities of the government changing policy, i.e. it is time itself and not the state of the economy that governs the change. The next section solves the real options setup under political uncertainty.

### 3. Solution to the Optimal Stopping Problem

The decision whether or not to engage in FDI constitutes an optimal stopping problem, for which the relevant Bellman equation is

$$(10) \quad \begin{aligned} rV = gK^a &- \left[ a_K + p_K^{+/-} I + \frac{\gamma I^2}{2} \right] + V_K (I - \delta K) + \eta g V_g + \frac{1}{2} \sigma^2 g^2 V_{gg} \\ &+ \lambda_1 [V(g(1 + \phi_1)) - V] - \lambda_2 [V - V(g(1 - \phi_2))] \end{aligned}$$

and the optimal condition for $I$ is denoted by

$$(11) \quad p_K^{+/-} + \gamma I = q \Rightarrow I = \frac{q - p_K^{+/-}}{\gamma}.$$

In this framework, the optimal investment strategy is a two-trigger policy that can be expressed in terms of Tobin´s $q$. If $q$ exceeds the upper threshold $q_K^+$ gross investment occurs. In turn, if $q$ falls below a lower threshold $q_K^-$, negative investment takes place – the firm sells part of its capital stock. In the region of inaction $p_K^- \leq q \leq p_K^+$, investment equals zero. Table 1 gives the intuition behind this result.

**Table 1: The Optimality Conditions**

|  | Marginal Benefit (MB) | Marginal Cost (MC) | MB=MC and $I = 0$ |
|---|---|---|---|
| $I > 0$ | Firm's value raised by $q$ | Buying additional $K$ for price $p_K^+$ and paying for marginal adjustment cost for $K$: $\gamma I$ | $q_+ = p_K^+ + \gamma I$ $\Rightarrow q_+ = p_K^+$ |
| $I < 0$ | Selling the redundant $K$ for $p_K^-$ | Firm's value reduced by $q$ and paying for marginal adjustment cost for $K$: $-\gamma I$ since $I$ is negative | $q_- - \gamma I = p_K^-$ $\Rightarrow q_- = p_K^-$ |

Given (11), the firm´s solution to the optimal stopping time requires

$$(12) \quad -a_K - p_K^{+/-}I - \frac{\gamma}{2}I^2 + V_K(I - \delta K) = -a_K - p_K^{+/-}I - \frac{\gamma}{2}I^2 + \left(p_K^{+/-} + \gamma I\right)(I - \delta K)$$

or, equivalently

$$(13) \quad \frac{\gamma I^2}{2} - a_K - \delta\left(p_K^{+/-} + \gamma I\right)K = \frac{\left(q - p_K^{+/-}\right)^2}{2\gamma} - a_K - \delta q K.$$

Substituting into the Bellman equation (10) we have

$$(14) \quad rV = gK^a + \frac{\left(q - p_K^{+/-}\right)^2}{2\gamma} - a_K - \delta q K + \eta g V_g + \frac{\sigma^2}{2} g^2 V_{gg}$$
$$+ \lambda_1\left[V\left(g(1 + \phi_1)\right) - V\right] - \lambda_2\left[V - V\left(g(1 - \phi_2)\right)\right]$$

Using the definitions $q = V_K$, $q_g = V_{Kg}$, $q_K = V_{KK}$ and $q_{gg} = V_{Kgg}$ and differentiating both sides with respect to $K$, we are able to rewrite (14) in the following form:

$$(15) \quad (r + \delta)q = agK^{a-1} + \frac{\left(q - p_K^{+/-}\right)q_K}{\gamma} - \delta q_K K + \eta g q_g + \frac{\sigma^2}{2} g^2 q_{gg}$$
$$+ \lambda_1\left[q\left(g(1 + \phi_1)\right) - q\right] - \lambda_2\left[q - q\left(g(1 - \phi_2)\right)\right]$$

The optimal stopping problem is simplified by observing that we have $q = p_K^+$ and $q = p_K^-$ within the no-action region. In this case, equation (15) therefore takes the following simpler form

$$(16) \quad (r + \delta)q = agK^{a-1} - \delta q_K K + \eta g q_g + \frac{\sigma^2}{2} g^2 q_{gg}$$
$$+ \lambda_1\left[q\left(g(1 + \phi_1)\right) - q\right] - \lambda_2\left[q - q\left(g(1 - \phi_2)\right)\right]$$

The solutions for (16) consist of the particular and general solutions, i.e. $q = q^P + q^G = p_K^{+/-}$. Given the above model, we can show that the following holds:[12]

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[12] See Appendix *A* and *B* for formal proofs. Outside and inside the no-action-area, the problem in its general form has no closed form solution because the term $\dfrac{\left(q - p_K^{+/-}\right)q_K}{\gamma}$ does not disappear.

(17) $\quad q^P = \dfrac{agK^{a-1}}{r + a\delta - \eta - \lambda_1\phi_1 + \lambda_2\phi_2}$

(18) $\quad q^G = -A_1\left(gK^{a-1}\right)^{\beta_1} + A_2\left(gK^{a-1}\right)^{\beta_2}$

(19) $\quad \dfrac{1}{2}\sigma^2\beta(\beta-1) - \delta\beta(a-1) + \eta\beta + \lambda_1\left[(1+\phi_1)^\beta - 1\right] - \lambda_2\left[1 - (1-\phi_2)^\beta\right] - (r+\delta) = 0$

where $A_1$ and $A_1$ are unknown parameters and $\beta_1$ and $\beta_2$ are the positive and negative roots of the

characteristic equation (19), respectively. The set of boundary conditions that applies to this optimal

stopping problem is composed by the value-matching and smooth-pasting conditions

(20) $\quad \dfrac{ag_+K^{a-1}}{r + a\delta - \eta - \lambda_1\phi_1 + \lambda_2\phi_2} - A_1\left(g_+K^{a-1}\right)^{\beta_1} + A_2\left(g_+K^{a-1}\right)^{\beta_2} = p_K^+$

(21) $\quad \dfrac{ag_-K^{a-1}}{r + a\delta - \eta - \lambda_1\phi_1 + \lambda_2\phi_2} - A_1\left(g_-K^{a-1}\right)^{\beta_1} + A_2\left(g_-K^{a-1}\right)^{\beta_2} = p_K^-$

(22) $\quad \dfrac{aK^{a-1}}{r + a\delta - \eta - \lambda_1\phi_1 + \lambda_2\phi_2} - A_1\beta_1 g_+^{\beta_1-1}K^{(a-1)\beta_1} + A_2\beta_2 g_+^{\beta_2-1}K^{(a-1)\beta_2} = 0$

(23) $\quad \dfrac{aK^{a-1}}{r + a\delta - \eta - \lambda_1\phi_1 + \lambda_2\phi_2} - A_1\beta_1 g_-^{\beta_1-1}K^{(a-1)\beta_1} + A_2\beta_2 g_-^{\beta_2-1}K^{(a-1)\beta_2} = 0$.

The value matching conditions require the equality between the net present value of the project and the

value of the option. The smooth pasting conditions require the equality between the slopes of the net

present value of the investment project and the value of the option. Equations (19) – (23) determine

the two thresholds ($g_+$ and $g_-$) that bisect the firm´s decision-making space into a zone where it is

optimal to exercise the option and a no action zone where the firm maximises its value by leaving the

option unexercised. In other words, in the no action range between $g_+$ and $g_-$ the firm´s optimal policy

is to continue with the status quo, i.e. the firm will neither invest nor disinvest.

The next section makes use of numerical techniques to generate simulations of the demand of fixed

assets exposed to political risk.

## 4. Numerical Simulations

To have a feel on the quantitative importance of the various parameters discussed above, we present some numerical examples. All simulations are performed with regard to a benchmark case (see Appendix C for a description of the benchmark parameters).[13] In order to check the sensitivity of the thresholds to these benchmark parameters, optimal decision rules are then computed for alternative parameter combinations.[14]

Figure 1 provides a sensitivity analysis of the thresholds with respect to $\lambda_1$ and $\lambda_2$, i.e. we illustrate the impact of alternative arrival rates upon the optimal investment and dis-investment thresholds. The 3-D graphs clearly indicate the entire no-action areas. If $\lambda_2$ increases, then the $g_+$ investment threshold will rise – firms will be more reluctant to invest to avoid getting caught with too much capital, should the future turn out worse than expected. By contrast, if the future turns out better than expected, the firm can just add more capital as needed. The implication is that the textbook net present value rule is blantly inappropriate in any context other than the unrealistic setting where sunk costs are negligible and there is certainty regarding the determinants of the profitability of the project to be undertaken. On the contrary, if $\lambda_1$ increases, then the $g_+$ threshold declines. The less accentuated curvature of the $g_+$ threshold with respect to $\lambda_1$ results because there are two offsetting effects. First, an increase in $\lambda_1$ increases the option value of waiting and therefore delays investment decisions. On the other hand, a higher $\lambda_1$ parameter raises expected profitability and, *ceteris paribus*, the desired capital stock.[15] This effect goes in opposite direction to the threshold effect above, and the net result is in general indeterminate. This qualitative result is consistent with Bernanke´s (1983) bad news principle: under investment irreversibility, bad events affect the firm´s propensity to invest.[16]

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[13] The numerical boundary value problem is solved with the method of Newton-Raphson for nonlinear systems. A description of the numerical programming technique is provided in Press et al. (2002).

[14] Note, however, that the goal of this paper is not to derive precise quantitative estimates of the impact of political uncertainty, but rather to illustrate the qualitative predictions of the model and to identify key features of the framework.

[15] Or said another way, in some cases the $g_+$ threshold *falls* as uncertainty *increases*; the threshold elasticity of investment is negative. One may describe this behaviour as *inferior*.

[16] As stated by Bernanke (1983, pp. 92-93), „The investor who declines to invest in project *i* today (...) gives up short-run returns. In exchange for the sacrifice, he enters period *t+1* with an „option" (...). In deciding whether to „buy" this option (...), the investor therefore considers only „bad news" states in *t+1* (...)".

**Figure 1: The Threshold Values as Functions of $\lambda_1$ and $\lambda_2$**
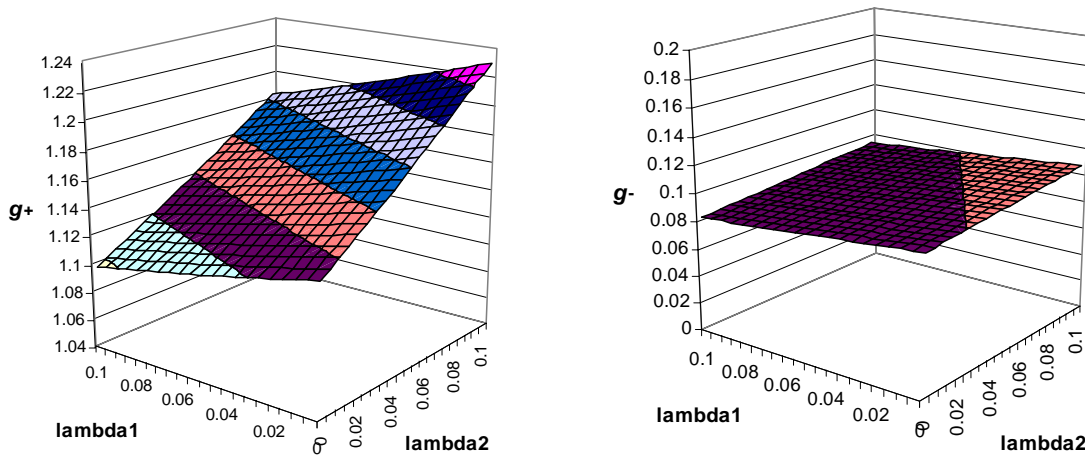
**(The values of the other parameters are those presented in Appendix C)**
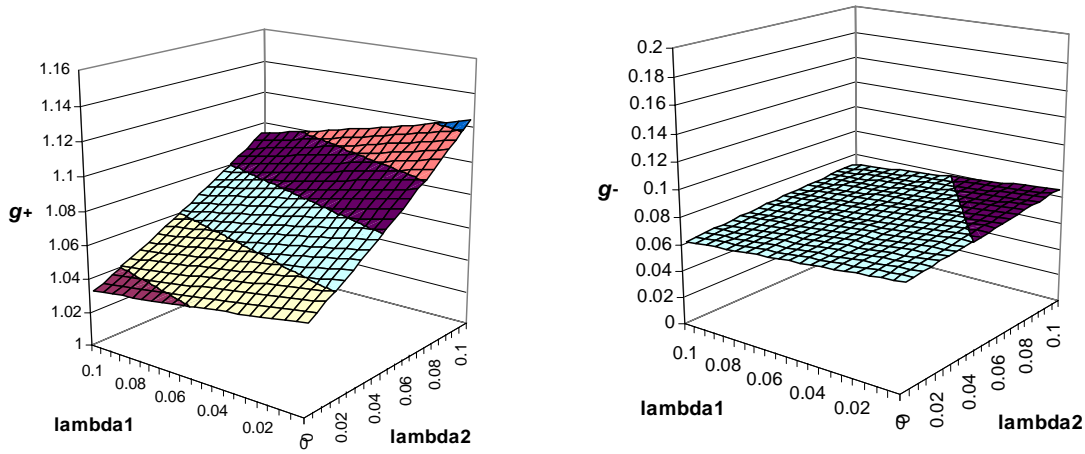


Let us next examine how the drift term affects the firm´s decision. Figure 2 shows the thresholds for $\eta$ = 0.00. This makes no meaningful difference to the profit maximising tactic except that political instability poses an even more formidable obstacle to FDI decisions.[17]

**Figure 2: The Threshold Values as Functions of $\lambda_1$ and $\lambda_2$ for $\eta = 0.00$**

**(The values of the other parameters are those presented in Appendix C)**



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[17] These large premia are consistent with the high hurdle rates applied in practice by firm managers when assessing investment projects.

**Figure 3: The Threshold Values as Functions of $\phi_1$ and $\phi_2$**

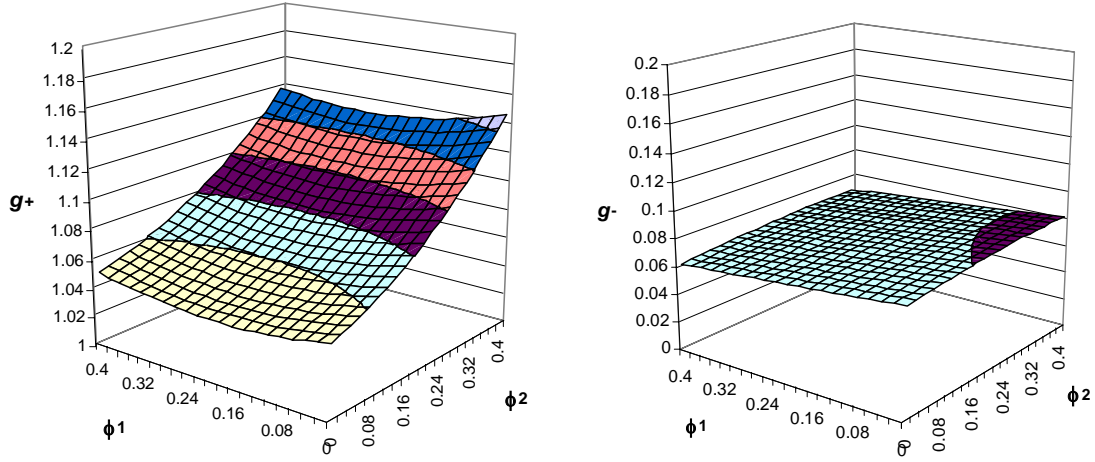**(The values of the other parameters are those presented in Appendix C)**



Figure 3 shows how the magnitude of the jumps (respresented by $\phi_1$ and $\phi_2$) affects investment. Two main messages emerge from Figure 3. The first concerns the investment threshold: The simulations suggest that perceived downside risks act as an important deterrent to FDI. Pari passu, an unreliable political environment system translates into a higher no action area and hence lowers FDI and the efficiency in the host country´s economy.[18] This implies that a nation that takes steps to increase the degree of political stability could expect significant increases in the level of FDI into their country. This increased investment translates into more resources, which in turn increases social welfare and economic efficiency. The impact of $\phi_1$ on the optimal investment rule is non-monotonic. This is due to the fact that there are two terms that depend upon $\phi_1$. The first of these is the option value of waiting which is increasing in $\phi_1$ while the second is expected profitability. As a result, at first glance the relation between $\phi_1$ and $g_+$ is ambiguous. The second argument concerns the dis-investment threshold. Again the result is that the threshold for dis-investment is rather flat.

Let us now consider changes in $\sigma$. In other words, we analyse the sensitivity of the optimal thresholds with respect to changes in the volatility of the geometric Brownian motion representing demand and/or exchange rate uncertainty for given values of political uncertainty. As in the existing literature, we

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[18] This calibration result is consistent with the empirical fact that the Czech Republic, Hungary and Poland accounted for the majority of FDI inflows in the Central Eastern European region in the 1990s. These countries

find that the threshold value at which investment takes place is increasing in the "noisiness" level even though the firm is risk neutral. In volatile environments, the best tactic is to keep options open and await new information rather than commit an investment today.[19]

**Figure 4: The Threshold Values as Function of $\sigma$**

**(The values of the other parameters are those presented in Appendix C)**
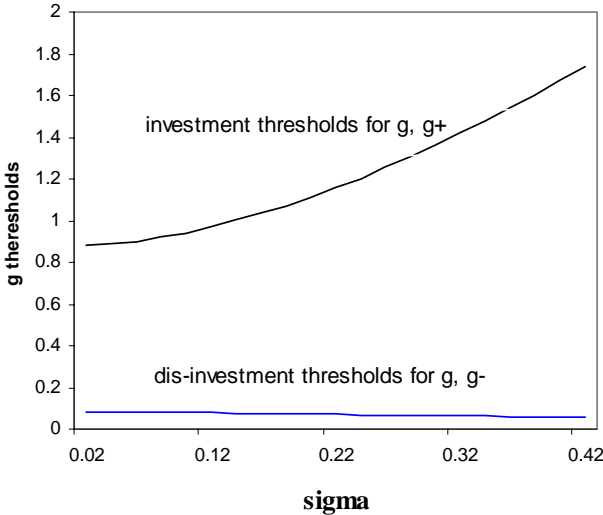


We end the section considering $p_K^-$ changes. Intuition tells us that increasing irreversibility (lower $p_K^-$) should lower the "exit incentive". Indeed this is the case, as depicted in Figure 5. We find that the threshold at which dis-investment takes place is decreasing in $p_K^-$ (the degree of reversibility). For $p_K^-$ close to zero, capital is almost completely irreversible. The numerical results indicate that this effect alone tends to increase the no action zone substantially.

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have been widely recognised as the leaders of the liberalising reforms in Central Europe having implemented policies creating a balanced and rather solid macroeconomic and political environment.

[19] Figure 4 reveals that the $g^+$ surface is much more sensitive to changes in $\sigma$ than the $g^-$ surface.

**Figure 5: The Threshold Values as Function of $p^-$**

**(The values of the other parameters are those presented in Appendix C)**
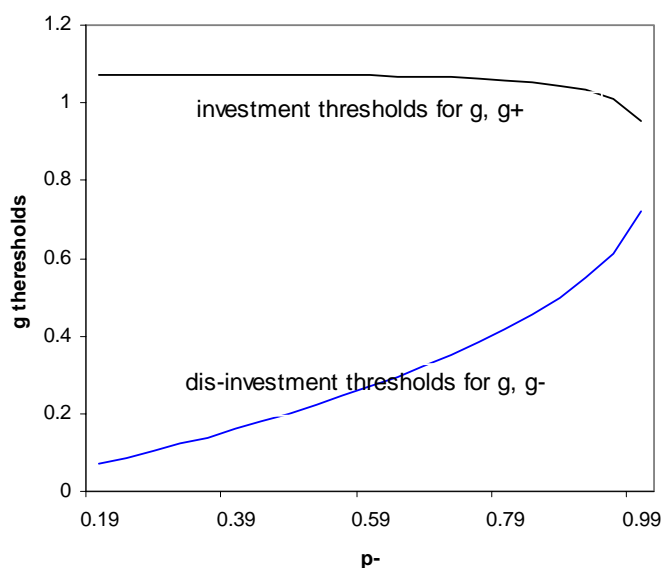


## 5. Summary Remarks and Conclusions

In this paper, we have looked in detail at the link between political uncertainty and foreign direct investment spending by employing ideas and analytical techniques developed in the real options literature. Of course, the model developed in this paper is stylized and may not capture all of the details. However, our model clarifies thinking on the inter-linkages between policy uncertainty, option value and the timing of FDI at the firm level. The main result is that an uncertain political environment exerts a non-trivial influence upon FDI decisions. This appealing insight can enrich theory by clarifying issues concerning the "if" and "when" of FDI.[20]

An important feature of our model is that the opportunity to invest or disinvest is assigned to one firm only, i.e. the analysis was decidedly partial equilibrium. Yet it is obvious that one cannot just translate mechanically the above microeconomic results to aggregate investment. One implication is that waiting may no longer be feasible when FDI is available to any of several firms. There can be strategic situations with more firms, where moving first may be profitable. In practice, these considerations

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[20] Empirical estimation of the suggested model is, however, far from straightforward, even after abstracting from data limitations (which can be acute because the model is micro-based). First, one would need information about the manner in which firms form expectations of future political events, as opposed to the changes per se. Second,

may call for early investment at the same time that political uncertainty suggests waiting. The optimal choice would then have to balance the two. To assess the role of political uncertainty in aggregate investment it is also essential to take explicitly into consideration the heterogeneity of individual firms´ investment decisions. Bertola and Caballero (1994) have explored the implications of irreversibility for aggregate investment in a model in which individual firms´ investment proceeds in discontinuous bursts. Individual investments are not synchronized, and firms are subject to idiosyncratic uncertainty in addition to aggregate uncertainty. As a result, aggregate uncertainty shows smoothness and a shock may take a long time to develop its full impact. Finally, the discussion ignored the ability of, and incentives for, firms to diversify their capital stock internationally in times of political uncertainty. This diversification may partially offset the forces highlighted here.

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in reality there are a number of alternative modes to service a foreign market, and failure to consider the entire range of feasible options might lead to a misspecification of the reduced-form empirical equations.

## Appendix A: The Derivation of Equation (17)

Equation (16) is a differential equation of a familiar form. Our experience suggests that the solution takes the form

(A1) $\quad q = BgK^{1-a}$.

Then, we have $q_g = BK^{1-a}$, $q_{gg} = 0$, $q_K = (a-1)BgK^{-a}$, $q(g(1-\phi_2)) = Bg(1-\phi_2)K^{1-a}$, and $q(g(1+\phi_1)) = Bg(1+\phi_1)K^{1-a}$. Substituting into equation (16) yields

(A2) $\quad (r+\delta)B = a - \delta(a-1)B + \eta B + \lambda_1[B(1+\phi_1) - B] - \lambda_2[B - B(1-\phi_2)]$.

Rearranging and collecting terms yields

$$B = \frac{a}{r + \delta a - \eta - \lambda_1\phi_1 + \lambda_2\phi_2}.$$

It is then straightforward to obtain equation (17).

## Appendix B: The Derivation of Equations (18) and (19)

The homogeneous part of the Bellman's equation is denoted by:

(B1) $\quad (r+\delta)q = -\delta q_K K + \eta g q_g + \dfrac{\sigma^2}{2} g^2 q_{gg} + \lambda_1[q(g(1+\phi_1)) - q] - \lambda_2[q - q(g(1-\phi_2))]$

The homogeneous solutions should have the same components as in particular solutions. Assume the homogeneous solutions have the functional form

(B2) $\quad q = A\left(gK^{1-a}\right)^{\beta}$.

Then we have

(B3) $\quad -\delta q_K K = -\delta\beta(1-a)A\left(gK^{1-a}\right)^{\beta}$,

(B4) $\quad \eta g q_g = \eta\beta A\left(gK^{1-a}\right)^{\beta}$,

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(B5) $\quad \dfrac{1}{2}\sigma^2 gg q_{gg} = \dfrac{1}{2}\sigma^2 \beta(\beta-1)A\left(gK^{1-a}\right)^{\beta},$

(B6) $\quad q\left(g(1+\phi_1)\right) = (1+\phi_1)^{\beta} A\left(gK^{1-a}\right)^{\beta},$

(B7) $\quad q\left(g(1-\phi_2)\right) = (1-\phi_2)^{\beta} A\left(gK^{1-a}\right)^{\beta}.$

Now substitute into equation (B1). It is straightforward to obtain the following characteristic equation:

(B8) $\quad \dfrac{1}{2}\sigma^2 \beta(\beta-1) - \delta\beta(a-1) + \eta\beta + \lambda_1\left[(1+\phi_1)^{\beta}-1\right] - \lambda_2\left[1-(1-\phi_2)^{\beta}\right] - (r+\delta) = 0$

Equation (19) is thus proven.

## Appendix C: The Benchmark Parameters

We set the central benchmark parameters as follows: $\sigma = 0.18$, $\eta = 0.03$, $r = 0.03$, $\delta = 0.08$, $\lambda_1 = 0.05$, $\lambda_2 = 0.05$, $\phi_1 = 0.2$, $\phi_2 = 0.2$, $p_K^+ = 1.0$, $p_K^- = 0.2$, $a = 0.65$, and the initial value for capital ($K$) = 100. All these parameters seem reasonable on an annual basis. To motivate the analysis of policy uncertainty, special attention has to be paid to the calibration of the Poisson processes. The Poisson process implies that the likelihood of a policy change is determined by the arrival rate $\lambda$. This means that the time $t$ one has to wait for the switch event to occur is a random variable whose distribution is exponential with parameter $\lambda$:

(C1) $\quad F(t) \equiv prob\{event\ occurs\ before\ t\} = 1 - e^{-\lambda t}$

The corresponding probability density is

(C2) $\quad f(t) \equiv F'(t) = \lambda e^{-\lambda t}$

In other words, the probability that the event will occur sometime within the short interval between $t_0$ and $t_0+dt$ is approximately $\lambda e^{-\lambda t}dt$. In particular, the probability that it will occur within $dt$ from now (when $t = 0$) is approximately $\lambda dt$. In this sense $\lambda$ is the probability per unit of time. Moreover, the

number of policy changes ($x$) that will take place over any interval of length $\Delta$ is distributed according to the Poisson distribution

(C3)     $g(x) \equiv prob\{x \ \ event \ \ occur\} = \dfrac{(\lambda \Delta)^x e^{-\lambda \Delta}}{x!}$

whose expected value is the arrival rate times the length of the interval $\lambda \Delta$. We can back out from equation (C3) the agent´s beliefs about policy changes. As a guide to calibration, the Table below provides the probabilities that either one ($x = 1$) or three ($x = 3$) jumps will occur within 5 years ($\Delta = 5$) or 10 years ($\Delta = 10$) for the three arrival rates $\lambda = 0.01$, $\lambda = 0.05$ and $\lambda = 0.10$, respectively. For example, for $\lambda = 0.05$ the probability that one jump will occur within 5 years is 19.5 percent.

**Table: Jump Probabilities for the Poisson Process**

|  | $\lambda = 0.01$ | $\lambda = 0.05$ | $\lambda = 0.10$ |
|---|---|---|---|
| prob{1 event in 5 years} | 0.048 | 0.195 | 0.303 |
| prob{3 events in 5 years} | 0.000002 | 0.002 | 0.013 |
| prob{1 event in 10 years} | 0.090 | 0.303 | 0.368 |
| prob{3 events in 10 years} | 0.0001 | 0.012 | 0.061 |

The results indicate that for $\lambda = 0.10$ the firm faces a very substantial exposure to political risk. The variability embodied with $\lambda_{1,2} = 0.05$ therefore seems to be a plausible and realistic parameterization of the model for developing countries and and transition economies.

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