

## Mathematical Modelling of the Dependence of Foreign Direct Investments on the Protection Level of Property Rights

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**Abstract** - The importance of protected property rights to assets for economic growth causes no doubts. However, the issue of the role of property rights protection in raising Foreign Direct Investments (FDI) has stuck in the debates and still has no clear answer. Therefore it requires additional analysis. In this paper we outline the dependence of the FDI amount on the level of protection of property rights. The problem of attracting FDI depends on the property rights protection and is subject to broad-ranging discussion, but so far it has no definite solution. We develop a mathematical model to address this issue, which confirms the existence of a positive impact of the property rights protection on the efficient implementation of investment projects.

**Keywords**- *property rights protection; foreign direct investments; investment project; net present value; transaction costs.*

### I. INTRODUCTION AND LITERATURE REVIEW

The issue of foreign investments is increasingly emerging both in influential international companies and in whole states due to their growing importance for all participants. FDI play a very important role in the development and strategic planning of the leading international companies and in the economic development of the state in general.

Earning profit or achieving a social effect is actually the main goal of the investment activity. However, each company sets its own goals, the so-called motives for investing. Each investment is implemented in various forms, which an investor also selects according to their own priorities.

There are many different factors that influence the decisions of foreign investors to invest capital in a particular industry or in a particular country [1, 2]. Some factors encourage and attract investors to a particular industry or country, while others, on the contrary, are a barrier to investing. The property rights protection is one of these factors.

It is emphasized in the economic literature that the property rights protection is an extremely important component of the institutional environment and, therefore, is important for domestic and foreign investments [3, 4].

This is primarily due to the fact that unprotected or poorly regulated property rights increase the risk of expropriation, which reduces incentives for investments and production.

The theoretical propositions that efficient property rights protection contributes to foreign and domestic investments have been empirically tested in many interstate studies. Despite the increasing general agreement that improving the

institutional environment can significantly increase FDI inflows [4, 5], the same cannot be said about its specific components.

For example, while some empirical studies indicate that improving the efficiency of protecting property rights has a positive effect on both domestic [6, 7] and foreign direct [8, 9] investments, the authors do not find any reliable evidence in support of this hypothesis in other studies [10, 11].

The latest solid study, which indicates a positive relationship between the quality of property rights protection and the inflow of FDI in particular, is the development of the International Property Rights Index (IPRI) under the auspices of the well-known American organization Alliance for Property Rights. The reports have been published annually since 2007 to assess the consequences of improving property rights protection at the macro level.

The IPRI consists of 3 main components and 10 variables (subcomponents) used to calculate it, see Table I.

TABLE I. STRUCTURE OF THE INTERNATIONAL PROPERTY RIGHTS INDEX [11]

Components	Variables
Legal and political environment (LP)	Judiciary independence
	Law supremacy
	Political stability
	Fighting corruption
Physical property rights (PPR)	Protection of physical property rights
	Property registration
	Access to loans
Intellectual property rights (IPR)	Protection of intellectual property rights
	Patent protection
	Copyright infringement

Annual reports indicate a positive relationship between the IPRI value and the inflow of FDI. Countries with more

efficient property rights protection attract more FDI. In addition, a positive relationship with the inflow of FDI can be numerically traced for each of the components in the index [12, 13].

*The Purpose of the Study:* Based on these findings, there is a clear need to confirm by analytical derivation the above relationship through the development of a mathematical model to describe the impact of the property rights protection level on the performance of the investment project.

## II. MODEL OF THE FDI DEPENDENCE ON THE PROPERTY RIGHTS PROTECTION LEVEL

Let us consider a multistage investment project implemented within one economy, but at two different levels of the property rights protection: the one existing in countries with transitional economies and the one functioning in countries with developed economies.

Net present value (NPV) is one of the most frequently used indicators for measuring the efficiency of investment projects in international practice, and the investor solves the following maximization problem when making investment decisions:

$$NPV = \max \left\{ NPV_1 = \sum_{j=1}^n R_j v^{j+m} - \sum_{i=1}^m K_i v^i \right\} \quad (1)$$

where  $m$  is duration of the investment period (investment phase),  
 $n$  is duration of the income receipt period (operational phase),  
 $K_i$  is investment costs at stage  $i, i \in \hat{N}, i \in [1, m]$ ,  
 $R_j$  is net income at stage  $j, j \in \hat{N}, j \in [1, n]$ , and  
 $v$  is discount factor at rate  $E$  (reduction rate, adopted rate of return).

However, it is advisable to use this indicator in such a form only in developed countries with efficient property rights protection.

Countries with transitional economies should consider the impact of the property rights protection inefficiency, which manifests itself through:

1) additional bureaucratic barriers under the current legislation and weak property rights protection by the state, which is manifested in the variables "Property registration" and "Protection of physical property rights" of the "Physical property rights" component of the IPRI.

2) the existence of administrative corruption, which depends on the quality of the legal and political environment – one of the IPRI components.

The World Bank's annual Doing Business studies reveal that bureaucratic barriers to legal registration, licensing and certification procedures increase the investment period and total investment costs.

To take this into account, a parameter  $p \in (0, 1]$  is introduced in NPV, which reflects the efficiency of property rights protection and specification, and which is approximately proportional to the number of the investment period stages. The investment period has the least number of stages for  $p = 1$ , i.e. when property rights are protected and specified by the state in the most efficient manner.

The imperfect property rights protection by the state also generates additional costs  $\gamma_t \geq 0$  and  $\gamma_j \geq 0$  associated with the need for individual protection (protection costs, hiring lawyers, etc.) [14] at each stage of the investment and operational phases of the project, respectively. It is clear that for  $p = 1$  these costs are zero, since there is no need for such additional private protection.

At each stage of the investment period, it is also necessary to account for transaction costs  $\delta_t \geq 0$  caused by the existence of corruption during the passage of administrative procedures (bribes, kickbacks, etc.).

Thus, an investor solves the following maximization problem in countries with transitional economies:

$$NPV = \max \left\{ NPV_2 = \sum_{j=1}^n (R_j - \gamma_j) v^{j+k} - \sum_{t=1}^k (K_t + \gamma_t + \delta_t) v^t \right\} \quad (2)$$

where  $k$  is duration of the investment period (investment phase),

$n$  is duration of the income receipt period (operational phase),

$K_t$  is investment costs at stages  $t, t \in \hat{N}, t \in [1; k], k \approx m/p$ ,

$\delta_t$  is transaction costs from administrative corruption at stage  $t$ ,

$\gamma_t$  is transaction costs associated with individual protection at stage  $t$ ,

$R_j$  is net income at stage  $j, j \in \hat{N}, j \in [1, n]$ ,

$\gamma_j$  is transaction costs associated with individual protection at stage  $j$ , and

$v$  is discount factor at rate  $E$  (reduction rate, adopted rate of return).

It must be noted that the expected revenues in the operational phase and its duration do not change, since there is the same investment project in the same economy, but with two different modes of property rights protection.

For simplicity, it is assumed that the discount rate does not change and the time periods between the stages are equal. Besides, it is assumed that the investor has fulfilled the minimization task for variables  $\gamma_j, \gamma_t, \delta_t$  and the optimal distribution of the investment phase of the project when calculating  $NPV$ , with due consideration for the specified property rights protection level, which is necessary for reducing transaction costs and shortening the investment period. Therefore,  $NPV_1$  and  $NPV_2$  values will be used further, considering the maximization already performed.

As such, economic losses due to the inefficiency of property rights protection can be measured as follows:

$$\begin{aligned} \Delta &= NPV_1 - NPV_2 = \sum_{j=1}^n (R_j (v^{m-k} - 1) + \gamma_j) v^{j+k} + \\ &+ \sum_{t=1}^k (K_t + \gamma_t + \delta_t) v^t - \sum_{i=1}^m K_i v^i \approx \\ &\approx \sum_{j=1}^n \left( R_j \left( v^{m \left( \frac{k-1}{p} \right)} - 1 \right) + \gamma_j \right) v^{j+\frac{m}{p}} + \\ &+ \sum_{t=1}^{\frac{m}{p}} (K_t + \gamma_t + \delta_t) v^t - \sum_{i=1}^m K_i v^i. \end{aligned} \quad (3)$$

Since these losses have two components, economic losses from inefficient property rights protection and specification, as well as losses from the poor quality of the political and legal environment can be estimated separately, using formulas (4) and (5), respectively:

$$\begin{aligned} \Delta_b &\approx \sum_{j=1}^n \left( R_j \left( v^{m \left( \frac{k-1}{p} \right)} - 1 \right) + \gamma_j \right) v^{j+\frac{m}{p}} + \\ &+ \sum_{t=1}^{\frac{m}{p}} (K_t + \gamma_t) v^t - \sum_{i=1}^m K_i v^i \end{aligned} \quad (4)$$

$$\Delta_c \approx \sum_{t=1}^m \delta_t v^t \quad (5)$$

Since  $NPV_1 > 0$ ,  $NPV_2 > 0$ ,  $k > m$ ,  $\gamma_j \geq 0$ ,  $\gamma_t \geq 0$ ,  $\delta_t \geq 0$ , it is obvious that economic losses are always positive, i.e.  $\Delta > 0$ . This indicates inefficiency of the economic system in the context when the mode of property rights protection encourages an increase in the number of stages of an investment project and incurs additional transaction costs.

This fact corresponds to the well-known approach of R. Coase, according to which "the failures of the state" in providing protection and specification of property rights are the main problem for the economy.

As a result, it can be asserted that an investor will choose the most efficient modes of protecting property rights when financing investment projects, whenever possible, which incur the least transaction costs and do not extend the investment period.

At the same time, it is clear from formula (3) that with a decrease in the number of stages (duration) of the investment project, the magnitude of losses decreases.

As such, the following statement is true: an investor will choose investment projects with the least number of stages in the context of the inefficient regime of the property rights protection.

### III. CONCLUSION

Objective economic laws and processes of international capital migration indicate that Russia cannot stand apart from intensive attraction and use of foreign investments. Most importantly, FDI can be a source of not just capital but also new technologies, management skills, and a marketing system. These resources, in turn, encourage competition, innovation, capital accumulation, and, as a result, create jobs and encourage economic growth.

As such, it can be concluded that attracting FDI to the Russian economy has significant advantages. However, this process requires the development of a regulatory mechanism to make foreign investments mutually beneficial and prevent negative aspects.

Based on the above, it can be stated that an investor will give preference to efficient modes of protecting property rights when choosing investment projects, and therefore, more investments are attracted in countries with more advanced property rights.

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