An Econometric Framework for Testing the Eclectic Paradigm of International Firm Activities

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Abstract: In empirical research on direct investments, Dunning's eclectic paradigm is widely accepted. While this paradigm serves as a theoretical basis for selecting possible explanatory variables, econometric specification usually is ad hoc. This paper shows the implications of the eclectic paradigm for the econometric estimation of investment determinants using firm-level data. The assumptions of the eclectic paradigm lead to a multiplicative model, which calls for a particular estimation strategy. In this way, the empirical analysis is coherently linked to the theoretical base. Furthermore, it becomes possible to systematically test the assumptions of the eclectic paradigm. JEL no. F21, F23
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1 Introduction

While there is no generally accepted theory of foreign direct investment, various theoretical approaches are available. The eclectic paradigm – also called Ownership-Location-Internalization approach (OLI approach) – stems from Dunning (1981b) and has found wide use for the explanation of direct investments. According to this approach, a firm only makes direct investments when three conditions are simultaneously fulfilled. First, the firm must have a competitive advantage over foreign competitors in the form, for example, of a patent or a brand name (ownership advantages). Second, location advantages exist in the host country which make local production attractive (location advantages). Third, exploiting the competitive advantage within the firm itself must be superior

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to marketing through licensing agreements (internalization advantages due to transaction cost).

Existing empirical work on direct investment activity often uses the eclectic paradigm as a theoretical background. However, use of the theory is mostly limited to the selection of possible explanatory variables (cf. the overview in UNCTC 1992). Beyond this, econometric specification usually is rather ad hoc. There is a danger that the OLI approach is reduced to a "shopping list of variables" (Dunning 1991), from which one can choose variables at will for explaining direct investment. As this paper will show, the customary specification is not in accordance with the eclectic paradigm. Indeed, the choice of proper estimation strategy becomes a major issue, to be addressed in this study.

The goal of this paper is to clarify the implications of the eclectic paradigm. For this purpose, an empirical model is developed which shows important characteristics of the eclectic paradigm. The first step is to examine the international involvement of firms. Direct investments, exporting or licensing are possible internationalization strategies. The choice between these three strategies depends on ownership, location, and internalization advantages. These three advantages are the cornerstone of the OLI approach and form the basis of the empirical model.

Moreover, the eclectic paradigm can be used to guide the choice of functional form in econometric estimation and not only selection of explanatory variables. The procedure suggested in this study estimates the investment determinants in agreement with the OLI approach, thus closing the gap between theory and empirical analysis.

This paper is structured as follows: The second part summarizes the core arguments of the eclectic paradigm. Next, the widely used procedure for estimating the investment determinants with the help of the OLI approach is described. The fourth part presents the econometric estimation strategy designed to be in accordance with the OLI approach. These general results are completed by the examination of a special case of the model in the fifth part. Using Swiss firm-level data, the proposed econometric approach is implemented empirically in the sixth section. In the last part, the estimation strategy for identifying the determinants of direct investment is summarized, and possible future uses of the model are discussed.

2 Ownership-Location-Internalization Approach

The eclectic or OLI approach stems from Dunning (1981b, 1988, 1991, 1993). According to this theory, three conditions have to be fulfilled for a firm to engage in direct investment: (1) the firm has ownership-specific advantages (O advantages), (2) there are internalization advantages (I advantages) involved, and (3) the foreign country has location advantages (L advantages). In the following, we shall examine these three conditions more closely.

(1) The necessity for O advantages rests on the consideration that foreign firms are originally at a competitive disadvantage compared to local competitors. This results from its poorer knowledge of local conditions and from the costs arising from activity at a distance. Only when ownership-specific advantages compensate these primary disadvantages is an involvement abroad considered at all. Patented technologies, established brand names, and the human capital of employees may be sources of O advantages.

(2) However, an O advantage need not be exploited internally but may also be used externally, e.g. through licensing arrangements or the sale of a patent. From this follows the second necessary condition for direct investment. The exploitation of the O advantage within the organization itself must be superior to its marketing, e.g. in the form of licensing. These so-called internalization (I) advantages occur when licensing is connected with high transaction costs because of insufficient protection of intellectual property.

(3) Finally, location (L) advantages in the potential host country of direct investment are also necessary, otherwise the transfer of a value-adding activity is not worthwhile. The income from O advantages can also be realized through inland production followed by export. Consequently, a firm without L advantages will serve the foreign market through exports and not by means of local production.

Table 1 summarizes the OLI approach. Only when all three conditions are simultaneously fulfilled is direct investment superior to the alternatives of exporting or licensing to a foreign firm. If, apart from O advantages, only I advantages exist, serving the foreign market by means of exports suggests itself. In contrast, when a firm has only O advantages at its disposal, it will choose licensing as the internationalization strategy. According to Dunning's concept, every successful operation in a foreign market requires O advantages.

Table 1: *OLI Approach*

Ownership advantages	Location advantages	Internalization advantages	Route of serving market
yes	yes	yes	⇒ Foreign direct investment
yes	no	yes	⇒ Exports
yes	no	no	⇒ Contractual resource transfers

Source: Dunning (1981a: 32).

Within the framework of the OLI approach, the above-mentioned advantages are, according to Stehn (1992), necessary and sufficient for explaining all three internationalization strategies, i.e. exporting, licensing, and direct investment. Dunning (1981b) states that the importance and configuration of the three advantages differ according to the country, industry and firm involved. For the empirical examination of foreign activities, therefore, the following conclusion suggests itself: the probability of a direct investment is higher, the more ownership advantages a firm possesses, the stronger the incentives are to exploit these internally as opposed to externally, and the more it is in its interest to make use of the O advantages from a foreign location.

In the OLI approach, direct investment, exporting and licensing are alternatives for serving a foreign market. However, the L and I advantages lead to an "either/or" decision between the three internationalization strategies. According to the eclectic paradigm, a firm producing one single type of one good has no reason to be active in a market with more than one strategy. Thus, this approach cannot explain why such a firm would use several internationalization strategies in one foreign market. However, if a firm produces different goods, the constellation of the O, L and I advantages may vary and different internationalization strategies may be optimal for different goods.

This important characteristic is included in our model and has implications for the empirical analysis. According to the model, a firm is active in a certain market with no more than one strategy. In a realistic setting, however, there may well be firms using more than one internationalization strategy. In order to make the data compatible with the OLI model, the most important strategy could be chosen for these firms.

3 The Simple Logit and Probit Models as a Misspecification

A logit or probit model in a way represents a natural starting point for estimating the determinants of investment using firm-level data.[1] However, this procedure is not in accord with the OLI approach. Let the binary dependent variable y_j indicate whether firm j is involved in direct investment or not. Various indicators of the O, L and I advantages serve as explanatory variables, resulting in the following equation:

$$y_j^* = \beta_0 + x_{1j}\beta_1 + x_{2j}\beta_2 + ...+x_{kj}\beta_k + \varepsilon_j\,, \qquad (1)$$

$$\text{with } y_j = 1 \text{ if } y_j^* > 0\,.$$

Firm j is a direct investor if y_j^* is larger than zero. However, y_j^* is not directly observable; it can be interpreted as the expected profit from direct investment activity. If expected profit from foreign direct investment is positive and larger than from exporting or licensing, then the firm makes the investment and the binary variable y_j takes on the value 1. Variables x_1–x_k symbolize the explanatory variables for the presence of O, L and I advantages in the firm j.

The unsatisfactory aspect of (1) is that the three necessary conditions of the eclectic paradigm are additive. For example, missing I advantages can be compensated by pronounced O advantages, so that y_j^* is nevertheless larger than zero, causing the firm to make direct investments. According to the OLI approach, however, the three advantages must be simultaneously present for direct investment. Using a logit or probit model for estimating foreign direct investment is not suitable when the eclectic paradigm provides the theoretical basis. Therefore, another specification needs to be developed.

4 A Multiplicative Model for the OLI Approach

Let v_{Oj} stand for the ownership-specific advantages of firm j, v_{Ij} for its internalization advantages, and v_{Lj} for its location advantages. These advantages apply to activity in a certain country or region. Location advantages in particular depend on the country selected. In order not to complicate the notation unnecessarily, the index for the potential target country has been omitted.

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[1] Wagner and Schnabel (1994) for example chose this procedure.

Finally, advantages $v_{\cdot j}$ represent conditions in the target country as they affect firm j. For example, the low labor costs in Eastern Europe provide an incentive for the transfer of production to that region. In principle, any foreign investor can make use of the low wage costs; however, for firms with labor-intensive production, this location advantage of Eastern Europe takes on greater importance than for capital-intensive firms.

The individual factors $v_{\cdot j}$ can take on any value, but they are not directly observable. If v_{Oj} is larger than zero, the firm has ownership-specific advantages. With a negative v_{Oj}, the firm has not been successful in distancing itself from competitors through an O advantage. A positive v_{Ij} points to internalization advantages. With a negative value, the marketing of the O advantage by means of licensing abroad is superior to internal exploitation. The variable v_{Lj} is defined analogously. If location advantages exist for a firm in the potential target country, then v_{Lj} is positive.

With negative values for v_{Ij} and v_{Lj}, one can speak of I or L disadvantages. In contrast, a negative v_{Oj} is not to be taken as a competitive disadvantage, since such a firm would disappear from the market. In his model, Stehn (1992) starts from the assumption that the variable for the O advantages is limited to positive values. This restriction is neglected in the following in order to be able to assume the normal distribution for the error term. A strongly negative value for v_{Oj} is to be interpreted to the effect that the firm is far from achieving an ownership-specific advantage.

Let us now assume that the three factors v_{Oj}, v_{Ij} and v_{Lj} can be described as linear functions:

$$v_{Oj} = x_{Oj}\beta_O + \varepsilon_{Oj}, \tag{2}$$

$$v_{Ij} = x_{Ij}\beta_I + \varepsilon_{Ij}, \tag{3}$$

$$v_{Lj} = x_{Lj}\beta_L + \varepsilon_{Lj}. \tag{4}$$

The vector x_{Oj} contains the variables that have an influence on the presence of ownership-specific advantages. Furthermore, β_O represents the vector of parameters and ε_{Oj} the error term. The formulation of (2), (3) and (4) mirrors the assumption that the presence of individual advantages can be explained by various independent variables. For example, a firm with high research and development expenditure or numerous

patents (x_{oj} large) is ceteris paribus more likely to have ownership-specific advantages.

In order to record the international activity of a firm j, the following variables are defined:

$$y_{Dj} = \begin{cases} 1 & \text{if the firm } j \text{ is active internationally by way of direct investment} \\ 0 & \text{otherwise} \end{cases}$$

$$y_{Ej} = \begin{cases} 1 & \text{if the firm } j \text{ is active internationally by way of exporting} \\ 0 & \text{otherwise} \end{cases}$$

$$y_{Zj} = \begin{cases} 1 & \text{if the firm } j \text{ is active internationally by way of licensing} \\ 0 & \text{otherwise} \end{cases}$$

$$y_{Kj} = \begin{cases} 1 & \text{if the firm } j \text{ is not internationally active at all} \\ 0 & \text{otherwise.} \end{cases}$$

The internationalization strategies refer to a certain country or region. We assume here that a firm produces only one good. In this case, as argued in Section 2, the OLI approach predicts that only one internationalization strategy is efficient for a firm. Therefore, precisely one of the four variables should equal one for firm j. Indeed, the OLI approach imposes the following restrictions, which derive directly from Table 1:[2]

$$\begin{aligned} y_{Dj} = 1 \quad &\text{if} \quad v_{Oj} > 0 \quad \text{and} \quad v_{Ij} > 0 \quad \text{and} \quad v_{Lj} > 0; \\ y_{Ej} = 1 \quad &\text{if} \quad v_{Oj} > 0 \quad \text{and} \quad v_{Ij} > 0 \quad \text{and} \quad v_{Lj} \leqslant 0; \\ y_{Zj} = 1 \quad &\text{if} \quad v_{Oj} > 0 \quad \text{and} \quad v_{Ij} \leqslant 0 \quad \text{and} \quad v_{Lj} \leqslant 0; \\ y_{Kj} = 1 \quad &\text{if} \quad v_{Oj} \leqslant 0. \end{aligned}$$

[2] If there are O and L advantages, but no I advantages ($v_{Oj} > 0$ and $v_{Ij} \leq 0$ and $v_{Lj} > 0$), the OLI approach says nothing about the optimal internationalization strategy. This case is therefore not defined in the model. By slight modification of the model this can be rectified, whereby then the local factors only influence the choice between export activities and direct investment. If O advantages but no I advantages are present, the foreign market will be worked by licensing in every case. As the model should show the OLI approach in its original form, we have omitted this assumption.

Regarding the error terms ε_{Oj}, ε_{Ij} and ε_{Lj}, a trivariate normal distribution is assumed:

$$\begin{pmatrix} \varepsilon_{Oj} \\ \varepsilon_{Ij} \\ \varepsilon_{Lj} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho_{OI} & \rho_{OL} \\ \rho_{OI} & 1 & \rho_{IL} \\ \rho_{OL} & \rho_{IL} & 1 \end{pmatrix} \right).$$

Let $F(.)$ be the distribution function of this normal distribution and $\Phi(.)$ the distribution function of the one-dimensional standard normal distribution. Then, the probabilities of firm j being direct investor, exporter, licenser or a firm without international activity are, respectively,

$$\begin{aligned}
\Pr(y_{Dj} = 1) &= \Pr(v_{Oj} > 0 \text{ and } v_{Ij} > 0 \text{ and } v_{Lj} > 0) \\
&= F(x_{Oj}\beta_O, x_{Ij}\beta_I, x_{Lj}\beta_L; \rho_{OI}, \rho_{OL}, \rho_{IL}); \\
\Pr(y_{Ej} = 1) &= \Pr(v_{Oj} > 0 \text{ and } v_{Ij} > 0 \text{ and } v_{Lj} \leqslant 0) \\
&= F(x_{Oj}\beta_O, x_{Ij}\beta_I, -x_{Lj}\beta_L; \rho_{OI}, -\rho_{OL}, -\rho_{IL}); \\
\Pr(y_{Zj} = 1) &= \Pr(v_{Oj} > 0 \text{ and } v_{Ij} \leqslant 0 \text{ and } v_{Lj} \leqslant 0) \\
&= F(x_{Oj}\beta_O, -x_{Ij}\beta_I, -x_{Lj}\beta_L; -\rho_{OI}, -\rho_{OL}, \rho_{IL}); \\
\Pr(y_{Kj} = 1) &= \Pr(v_{Oj} \leqslant 0) = \Phi(-x_{Oj}\beta_O).
\end{aligned}$$

The expression $y_{Kj} = 1$ follows from the fact that a sub-vector of a normally distributed vector is normally distributed as well. Then, the log-likelihood function for n firms is given by

$$\begin{aligned}
&L(\beta_O, \beta_I, \beta_L, \rho_{OI}, \rho_{OL}, \rho_{IL}) \\
&= \sum_{j=1}^{n} \Big(y_{Dj} \ln\left[F(x_{Oj}\beta_O, x_{Ij}\beta_I, x_{Lj}\beta_L; \rho_{OI}, \rho_{OL}, \rho_{IL})\right] \\
&\quad + y_{Ej} \ln\left[F(x_{Oj}\beta_O, x_{Ij}\beta_I, -x_{Lj}\beta_L; \rho_{OI}, -\rho_{OL}, -\rho_{IL})\right] \\
&\quad + y_{Zj} \ln\left[F(x_{Oj}\beta_O, -x_{Ij}\beta_I, -x_{Lj}\beta_L; -\rho_{OI}, -\rho_{OL}, \rho_{IL})\right] \\
&\quad + y_{Kj} \ln\left[\Phi(-x_{Oj}\beta_O)\right] \Big).
\end{aligned} \tag{5}$$

The log-likelihood function (5) represents the starting point for estimation. Maximization of this function allows the parameters of interest $\beta_O, \beta_I, \beta_L, \rho_{OI}, \rho_{OL}$ and ρ_{IL} to be estimated. The formulation of (5) takes

into consideration the assumption that for direct investment to occur, both O and L and I advantages must exist.

Interdependence of O, L and I Types of Advantage

There is mutual interdependence between the three types of advantages. The locational conditions in a country can, for example, influence not only the ownership-specific advantages of a firm but also its ability to internalize its competitive advantage. It is sometimes claimed that the OLI approach creates the wrong impression in viewing the three advantages as independent of each other (Dunning 1991). In the following, two kinds of interdependence between O, L and I advantages are admitted. First, all three advantages may depend on the same factors, since the vectors x_{Oj}, x_{Ij} and x_{Lj} overlap to some extent. The same variable, then, explains the O as well as the I and L advantages.

Second, the three necessary conditions for direct investment may be interdependent through the correlation of the error terms. A positive correlation between the error terms ε_{Oj} and ε_{Ij} means, for example, that firms which have an ownership-specific advantage by chance are also more likely to exploit this internally, than would be predicted based on systematic factors.

From the theoretical viewpoint, neither the sign nor the size of these correlation coefficients can be predicted with great confidence. However, the following argument speaks in favor of a positive correlation between ε_{Oj} and ε_{Ij}. For technical reasons, the O equation above includes all explanatory variables that are easily observed and measured. For example, some empirical papers use the number of patents registered or the introduction of new products. Patents enjoy a relatively good deal of protection, making their exploitation by licensing possible. In contrast, the efficient organizational structure of a firm (e.g. non-codifiable knowledge that can also lead to O advantages) usually is not measured, causing it to be reflected in the error term. However, these O advantages can only be exploited internally as a rule. Firms with these O advantages, therefore, also have a positive error term in the I equation, resulting in a positive correlation between the O and I error terms.

In view of limited theoretical knowledge, the interdependence between error terms becomes an empirical issue. The assumption of independent error terms simplifies the model. For each of the three variables ε_{Oj}, ε_{Ij} and ε_{Lj}, a one-dimensional standard normal distribution applies

in this case. The log-likelihood function then becomes

$$\begin{aligned} L(\beta_O, \beta_I, \beta_L) = \sum_{j=1}^{n} \Big(& y_{Dj} \ln\left[\Phi\left(x_{Oj}\beta_O\right)\right] + y_{Dj} \ln\left[\Phi\left(x_{Ij}\beta_I\right)\right] \\ & + y_{Dj} \ln\left[\Phi\left(x_{Lj}\beta_L\right)\right] + y_{Ej} \ln\left[\Phi\left(x_{Oj}\beta_O\right)\right] \\ & + y_{Ej} \ln\left[\Phi\left(x_{Ij}\beta_I\right)\right] + y_{Ej} \ln\left[\Phi\left(-x_{Lj}\beta_L\right)\right] \\ & + y_{Zj} \ln\left[\Phi\left(x_{Oj}\beta_O\right)\right] + y_{Zj} \ln\left[\Phi\left(-x_{Ij}\beta_I\right)\right] \\ & + y_{Zj} \ln\left[\Phi\left(-x_{Lj}\beta_L\right)\right] + y_{Kj} \ln\left[\Phi\left(-x_{Oj}\beta_O\right)\right] \Big). \end{aligned} \tag{6}$$

Rearranging terms, one gets the following log-likelihood function:

$$\begin{aligned} & L(\beta_O, \beta_I, \beta_L) \\ & = \sum_{j=1}^{n} \Big(\left(y_{Dj} + y_{Ej} + y_{Zj}\right) \ln\left[\Phi\left(x_{Oj}\beta_O\right)\right] + y_{Kj} \ln\left[\Phi\left(-x_{Oj}\beta_O\right)\right] \\ & \quad + \left(y_{Dj} + y_{Ej}\right) \ln\left[\Phi\left(x_{Ij}\beta_I\right)\right] + y_{Zj} \ln\left[\Phi\left(-x_{Ij}\beta_I\right)\right] \\ & \quad + y_{Dj} \ln\left[\Phi\left(x_{Lj}\beta_L\right)\right] + \left(y_{Ej} + y_{Zj}\right) \ln\left[\Phi\left(-x_{Lj}\beta_L\right)\right] \Big). \end{aligned} \tag{7}$$

In each of the three lines of (7) only one vector of parameters appears. A separate maximization of the three lines leads to the maximization of (7). The first line yields an estimate for β_O, the second for β_I, and the third for β_L, derived from a binary probit model. The first probit estimation determines the parameters of the O advantages, in which firms with international activity of any kind are coded with one and all others with zero.[3] The two other probit estimations only take into consideration firms with international activity. For the estimation of I advantages, firms which serve the foreign market with direct investments or exports make up one category of the dependent variable, while licensers belong to the other category. In the determination of L advantages, finally, direct investors serve as the benchmark for exporters and licensers.

5 Multiplicative Model with Partial Observability

In line with (5) and (7), the estimation of determinants of direct investment requires – apart from details of the direct investments of a firm –

[3] Meyer (1998) chose this procedure for estimation of the O advantages.

information on exports and licensing as well. Often this additional information is not available, as the data come from surveys that concentrate exclusively on direct investment activities. It is merely known whether a respondent made direct investments or not. The logit or probit estimation described in the second section is also based on information about direct investment activities only.

This section investigates the consequences of this limited data availability. Among the four variables y_{Dj}, y_{Ej}, y_{Zj} and y_{Kj} of the preceding section only y_{Dj} is observed. If a firm is a direct investor, according to the OLI paradigm it has the three types of advantage. If it does not report direct investments, at least one of the three types must be lacking. With this information the following distribution for y_{Dj} can be derived:

$$\begin{aligned}\Pr(y_{Dj} = 1) &= (v_{Oj} > 0 \text{ and } v_{Ij} > 0 \text{ and } v_{Lj} > 0)\\ &= F(x_{Oj}\beta_O, x_{Ij}\beta_I, x_{Lj}\beta_L; \rho_{OI}, \rho_{OL}, \rho_{IL});\\ \Pr(y_{Dj} = 0) &= (v_{Oj} \leqslant 0 \text{ or } v_{Ij} \leqslant 0 \text{ or } v_{Lj} \leqslant 0)\\ &= 1 - F(x_{Oj}\beta_O, x_{Ij}\beta_I, x_{Lj}\beta_L; \rho_{OI}, \rho_{OL}, \rho_{IL}).\end{aligned}$$

On the basis of the distribution of y_{Dj}, the log-likelihood function is

$$\begin{aligned}&L(\beta_O, \beta_I, \beta_L, \rho_{OI}, \rho_{OL}, \rho_{IL})\\ &= \sum_{j=1}^{n} \left(y_{Dj} \ln\left[F\left(x_{Oj}\beta_O, x_{Ij}\beta_I, x_{Lj}\beta_L; \rho_{OI}, \rho_{OL}, \rho_{IL}\right)\right]\right.\\ &\quad \left. + \left(1 - y_{Dj}\right) \ln\left[1 - F\left(x_{Oj}\beta_O, x_{Ij}\beta_I, x_{Lj}\beta_L; \rho_{OI}, \rho_{OL}, \rho_{IL}\right)\right]\right).\end{aligned} \tag{8}$$

If the three error terms are independent of each other, then the log-likelihood function becomes

$$\begin{aligned}L(\beta_O, \beta_I, \beta_L) = \sum_{j=1}^{n} &\left(y_{Dj} \ln\left[\Phi\left(x_{Oj}\beta_O\right)\Phi\left(x_{Ij}\beta_I\right)\Phi\left(x_{Lj}\beta_L\right)\right]\right.\\ &\left. + \left(1 - y_{Dj}\right) \ln\left[1 - \Phi\left(x_{Oj}\beta_O\right)\Phi\left(x_{Ij}\beta_I\right)\Phi\left(x_{Lj}\beta_L\right)\right]\right).\end{aligned} \tag{9}$$

Maximization of (8) or (9) results in estimates for the three parameter vectors. Despite partial observability, it is thus theoretically possible to estimate the determinants of direct investment. When comparing (8) and (9) with the probit model in the second section, differences appear. The OLI approach imposes restrictions in the functional form, disallowing substitution between the three advantages.

This formulation derives from the bivariate probit model with partial observability, which is a combination of two probit models. The two binary dependent variables describe four possible events, of which only one is observed (Poirier 1980; Meng and Schmidt 1985).[4] It is not possible to differentiate between the remaining three events. The OLI model of (8) and (9) represents an extension of the bivariate probit model with partial observability to accommodate three decision variables. There are three probit models with eight possible events of which seven cannot be differentiated. Correspondingly, one can speak of a trivariate probit model with partial observability.

The estimation of a bivariate probit model with partial observability is inefficient in comparison to the results obtained with complete information, that is, when all four possible conditions of the two dependent variables are identifiable (Poirier 1980). This lack of efficiency in estimation represents the cost of partial observability. According to Meng and Schmidt (1985), this cost is high. The estimation of investment determinants on the basis of information about direct investment, exporting, and licensing is, therefore, more efficient than the maximization of (8). Furthermore, in the trivariate model, the efficiency loss could be even larger than in the bivariate probit model. Thus, the procedure suggested in the fourth section is preferable to the one described here.

6 Empirical Findings

In this section, we implement the proposed econometric approach empirically. We use the data from a representative survey of the Swiss Institute for Business Cycle Research on the activities of Swiss firms in Eastern Europe.[5] This survey was carried out in 1997. The data set comprises 297 firms from the secondary sector. The firms had to assess the importance of Eastern Europe as an export market, as a licensee and as a location for direct investments. We therefore have details of all three internationalization strategies available.

According to Dunning's OLI approach, each firm pursues at most one internationalization strategy for one single type of good. This character-

[4] As each variable takes the value 0 or 1, the following four events are possible: (0,0), (0,1), (1,0) and (1,1). Normally, the three events (0,0), (0,1) and (1,0) cannot be differentiated.

[5] For information on the survey, cf. Hollenstein and Lenz (1998).

istic is built into in the empirical model. Some of the firms questioned in the survey, however, utilized several forms to supply the Eastern European market. For the implementation of the econometric approach, only one strategy can be optimal for each firm. The firms assess the importance of the individual strategies using a five-step scale. For the estimation of the investment determinants, we assume that the strategy with the greatest importance for the firm is the optimal one.

On the basis of the available data, a clear classification is possible for 288 firms. Of these 288 companies, 180 (62.5 percent) put no importance on any of the three activities. For 22 (7 percent) licensing is to the fore. About a quarter put export into the highest category (73 firms), and 4.5 percent gave direct investment activities (13 firms) the most importance.

6.1 Explanatory Variables

Various variables are used to explain the three advantages. These variables are represented by x_{Oj}, x_{Ij} and x_{Lj}. First we deal with the factor of influence for ownership-specific competitive advantages, then the internalization advantages and finally the location advantages. Table A.1 in the Annex contains an exact definition of the variables used as well as the mean and standard deviation.

Ownership advantages: O advantages can be based on technological superiority. The attainment and securing of technological superiority is usually connected with corresponding expenses for research and development. The companies questioned assessed the expenses paid for research and development on a five-step scale from "none" to "very high". Based on theoretical considerations, the hypothesis is that firms with high research and development expenditure are more likely to have O advantages at their disposal.

The data set shows whether the firm has introduced products which are new worldwide in their sector during the past three years. According to the theoretical expectations, the capacity to introduce new products is positively linked with the presence of O advantages.

In the estimation of ownership-specific advantages, a dummy variable is adopted which shows the status of the company. Legally independent subsidiaries are given the value one. Firms without a legal

connection with other companies and parent companies take the value zero. Subsidiaries can profit from the ownership-specific advantages of the parent company without having these themselves.

Large enterprises have ownership-specific advantages at their disposal due to the fixed-cost character of many activities which are connected with international involvement. To measure the size of an enterprise, we use the number of employees. In order to show a non-linear relationship, the number of employees is also squared in the estimation. In general, the relationship between the number of employees and ownership-specific advantages is assumed to follow an inverted "u" course. This leads us to expect a positive sign for the linear term and a negative sign for the squared term.

Internalization advantages: While there are a number of indicators which suggest themselves from the theoretical viewpoint for ownership-specific advantages, for the internalization advantages it is far more difficult to find the corresponding explanatory variables. In this connection John H. Dunning writes: "It is when one comes to pinpointing operationally testable proxies for internalisation advantages one runs into difficulties. This is [...] because the various forms of market failure and/or administrative fiat are extremely difficult to quantify [...]" (Dunning 1981a: 50). The indicators used here to explain the internalization advantages attempt to measure the transaction costs of external exploitation of O advantages.

Internalization advantages are present when an enterprise has ownership-specific advantages at its disposal, but cannot secure them by appropriate patent rights. The introduction of products which are new worldwide is a possible cause of ownership-specific advantages. The innovation behind such new products may, under certain circumstances, be protected by a patent. In this case, nothing stands in the way of exploiting the O advantages through the market. If the innovation does not enjoy patent protection, problems concerning asymmetric information and the unauthorized transmission of knowledge may arise. Internal exploitation is therefore superior to the external one. On the basis of the information about patent applications and the introduction of new products, an indicator for the presence of internalization advantages can be determined. If the company has introduced new products but not applied for patent, problems with the external exploitation of the O advantages will result due to inadequate protection. Internalization

advantages exist. The variable "new products without patent" then takes the value *one*.

The firms questioned had to assess various mechanisms as to their effectivity for securing innovation-specific competitive advantages. The assessment followed a five-step scale from "not effective" to "very effective." The mechanisms to be assessed were, among other things, patent rights as well as secrecy. The transaction costs of external exploitation of O advantages depend on the effectivity of the various mechanisms for securing innovation-specific competitive advantages. The corresponding information forms a direct indicator for the possibilities and problems relating to the sale of O advantages. Where patent rights effectively secure the innovation-specific competitive advantages, they can be exploited by means of license agreements and there are no internalization advantages. On the other hand, where secrecy forms the effective mechanism for protecting know-how, there is a tendency for internalization advantages to exist, as by marketing the O advantages secrecy can hardly be guaranteed – even with corresponding agreements.

As a further factor of influence for internalization advantages, we use the degree of diversification of the firm. Diversified firms have detailed knowledge about the market of a certain country in which they produce and sell a wide range of products. The wider knowledge of diversified firms permits a simpler solution to the problems connected with foreign investment. A company which is already used to running various product lines will probably find it easier to organize production and marketing in a foreign country. Correspondingly they may prefer internal exploitation of the competitive advantages.

Location advantages: As the firms form the unit of analysis, the location advantages should be examined with regard to the consequences for the individual firm. A certain location factor can be of varying importance to different firms. The central question here concerns the characteristics of firms which find location advantages in Eastern Europe.

Eastern Europe is characterized by low labor costs. For labor-intensive firms, the low labor costs represent an important location factor. The labor intensity is measured by the number of employees per SFr 100,000 turnover. A high value for this variable reflects high labor intensity. The hypothesis is that labor-intensive firms are more likely to have location advantages in Eastern Europe.

The importance of low labor costs for a firm also depends on the qualification structure of the employees, whereby the possibility of a transfer to Eastern Europe exists mostly for activities requiring semi-skilled and unskilled workers. Firms with a high portion of semi-skilled and unskilled workers use relatively simple production technologies which make a transfer easy. Eastern Europe with its low labor costs offers these firms attractive location conditions. As no other information is available, we shall use the mean for the industry. This variable reflects the average percentage of semi-skilled and unskilled workers in the total work force of the industry.

As a further explanatory factor for the estimation of L advantages, we shall use the portion of academics in the work force. Switzerland, as a highly developed industrial country, is relatively well endowed with well-trained employees. Companies which employ a great number of academics have comparative advantages in the location of Switzerland. This argumentation appears to favor a negative relationship between the percentage of academics and the location advantages in Eastern Europe. Again, there is no firm-specific information regarding the percentage of academics in the total work force, only the mean for the industry is available.

For firms with technology-intensive production there is a tendency towards location advantages in Switzerland, as Switzerland is relatively well endowed with resources for research and development. Furthermore, there is less necessity for these firms to search for location advantages to reduce costs. Technology-intensive firms are less dependent on the exploitation of the lower labor costs in Eastern Europe. As an indicator of technology-intensive production, we shall use the variable patent, which takes the value *one* if the firm applied for a patent in the past three years. The size of the firm is adopted as a control variable in the estimation of L advantages.

6.2 Econometric Method

The log-likelihood function (5) is the most general formulation of the proposed econometric framework and is therefore the starting point for the estimation. However, the normal distribution of the error terms in the three equations is three-dimensional. As the maximization of a likelihood function with three-dimensional normal distribution is very complex and cannot, for example, be carried out by the usual computer pro-

grammes like LIMDEP, we slightly modify the method. The estimation is made by three bivariate probit models, whereby two of the three advantages are to be found in each model. With each bivariate probit model, therefore, the correlation between two error terms can be estimated.

In the first bivariate probit model, the equations for ownership-specific advantages and internalization advantages are dealt with simultaneously. Internalization advantages are only present if ownership-specific advantages are available to the firm. Thus, here we are dealing with a bivariate probit model with sample selection (see Greene 1998: 492; 2000: 857). In this model the data of one dependent variable are only observable when the other dependent variable takes the value *one*. The simultaneous estimation of ownership-specific advantages and location advantages is also performed within the framework of a bivariate probit model with sample selection, as the information regarding L advantages is only available for firms which have an ownership-specific advantage and are therefore internationally active. The third bivariate probit model includes the internalization and location comparison. Contrary to the two previous models, there is no selection here.[6]

6.3 Results

Table 2 summarizes the results of the three estimations. First of all, we shall look at the estimated correlation coefficient between the error terms, which are printed in the third from last line of Table 2. None of the three estimated correlations is significant. We can, therefore, not reject the hypothesis that the three error terms are independent. However, when generalizing the results obtained here, it must be taken into consideration that the estimated standard errors are relatively large due to the limited size of the sample. A larger number of observations

[6] On the basis of the OLI approach (see Table 1) the following coding for the dependent variables results for the three bivariate probit models. For the O advantages, firms which are active internationally, whether through direct investment, export or licensing, form one category of dependent variables, and firms without international involvement the other. Internalization advantages exist for firms which assess exports or direct investment as the most important strategy. These two forms of international involvement form one category of dependent variables. The other category consists of companies which deal with the Eastern European market by means of licensing. For the location advantages, firms which regard direct investment as the most important strategy are compared with the group of exporters and licensees.

Table 2: *Estimation of the Bivariate Probit Model*

Variable	Model 1		Model 2		Model 3	
	B	SE	B	SE	B	SE
O Equation						
R&D expenditure (+)	0.219 **	0.093	0.167 *	0.090		
New products (+)	0.397 *	0.205	0.379 *	0.198		
Subsidiary (+)	0.501 ***	0.192	0.319 *	0.192		
Employees (+)	0.115 **	0.047	0.171 **	0.081		
Employees, squared (−)	−0.185 **	0.080	−0.401	0.776		
Constant	−1.274 ***	0.239	−1.179 ***	0.225		
I Equation						
New products w/o pat. (+)	0.748	0.462			0.563	0.424
Effectivity						
−Patent rights (−)	0.508 **	0.227			0.423 *	0.238
−Secrecy (+)	−0.593 ***	0.222			−0.590 **	0.231
Diversification (+)	1.003 *	0.571			1.079 *	0.621
Constant	0.438	0.979			0.587	0.862
L Equation						
Labor intensity (+)			−3.185 *	1.928	−3.310	2.026
Semi- and unskilled (+)			−0.027 *	0.022	−0.025	0.023
Academics (−)			−0.179	0.148	−0.188	0.157
Patent (−)			−1.131 *	0.601	−1.277 **	0.618
Employees (?)			0.131	0.089	0.108	0.085
Constant			1.257	2.203	1.719	1.732
Correlation of error terms	0.123	0.539	0.401	0.973	0.707	0.940
Observations	246		262		90	
Log-likelihood function	−178.80		−176.91		−56.82	

Note: For the definition of the variables, see Table A.1. The expected sign is in parentheses.
B = Estimated coefficient. SE = Standard error. * $p \leqslant 0.1$, ** $p \leqslant 0.05$, *** $p \leqslant 0.01$.

could lead to a reduction in the estimated standard error and, in certain circumstances, to different conclusions.

Let us now turn to the influence of the various explanatory variables on the three advantages. The procedure chosen with three bivariate probit models means that for each equation two estimations exist. However, the differences between the two estimations are small, so the results obtained can, therefore, be regarded as relatively stable. With regard to O advantages, the results are very encouraging. The estimated coefficients are largely significant and show the expected sign. The results can be interpreted as confirmation of this part of the OLI approach.

On the other hand, the results regarding the I and L equations are unsatisfactory. Some of the variables show a sign which is contrary to

theoretical expectations. Various alternative specifications of the estimation equation for I advantages do not lead to other results. The positive influence of the effectivity of patent rights and the negative effect of secrecy are stable. The inconsistency with the theoretical expectations remains. As the two variables directly measure the transaction costs of external exploitation of O advantages, from a theoretical viewpoint they appear to be a convincing construct for capturing the idea of internalization.

With the results of the L equation, one must consider that the variables used have certain shortcomings. For labor intensity only turnover data are available and not value-added data, and with the qualification structure of the work force, we have to fall back on the mean for the industry. The unsatisfactory results could, however, also be due to a faulty theoretical basis. The assumption of the OLI approach that the location advantages delimit direct investment from the other forms of international activity, is therefore to be questioned.

6.4 Interpretation

In summary, the following conclusions can be drawn from this first implementation of the proposed econometric framework for the eclectic paradigm. In the most general formulation of the model, we assumed a three-dimensional normal distribution for the three error terms. However, from the theoretical viewpoint, there are no conclusive arguments for a link between the error terms. The empirical results are in harmony with this assumption. No significant value can be proved for any of the three correlation coefficients. The more special formulation of the model in equation (7), which begins with the assumption that error terms are independent, can therefore serve as a starting point. The empirical implementation of this approach is considerably simpler, as the explanatory variables of O, L and I advantages can be determined independently from each other. The estimation with this approach (results not presented) leads to only slightly different results for the data used here.

The O advantages are explained by variables which are in accordance with the theoretical considerations. Therefore, the empirical results support this part of the OLI approach. Common O advantages influence all three forms of international activity. The conclusions from the estimation of internalization and location advantages are less clear. In the interpretation, one must take into consideration that this is the first

attempt to bring together various new variables to explain the internalization advantages. Further research based on a more extensive data set will bring more clarity. Even taking the insufficient data into consideration, the estimation of location advantages tends to speak against the OLI approach. According to our results, location factors scarcely influence the decision between export and direct investment.

7 Concluding Remarks

This study develops an empirical model for the international activity of a firm on the basis of the eclectic paradigm developed by Dunning to explain direct investment. For this to occur, the firm must simultaneously have ownership (O), location (L), and internalization (I) advantages. The OLI approach suggests the following strategy for the econometric estimation of direct investment determinants using firm-level data: The log-likelihood function (5) is the most general formulation of the model, representing the starting point for estimation. Maximization of this function determines the set of explanatory variables of the three types of advantage. Any variable which favors the presence of one of the three conditions increases the probability of a direct investment.

The general model also suggests correlations between the error terms of the three equations. Should the three error terms be uncorrelated, the simplified estimation according to (7) is more efficient. The determinants of international activity can, then, be estimated by means of three binary probit models.

As the eclectic paradigm also specifies conditions for export activity and licensing, an efficient estimation of the three types of advantage requires details of the corresponding activity. Failing this information, the suggestion is to use a trivariate probit model with partial observability.

The proposed model specification can be usefully employed in four areas. First, the model allows estimation of investment determinants in agreement with the eclectic paradigm. Thus, the theoretical approach serves not only in the choice of explanatory variables, but also guides econometric specification. The theoretical and the empirical analysis are linked together in this way.

Second, in contrast to the additive model where a explanatory variable cannot be assigned to one of the three types of advantage, the multiplicative model required by the OLI approach allows these variables to be grouped into the three categories. Making the direct investment decision

dependent on three conditions which must be fulfilled simultaneously is therefore not only a theoretical construct but obtains empirical content in this way.

The third area of application results from the estimation of the correlation between the error terms. With regard to the interdependence between the O, L and I advantages, there is a need for explanation both on the theoretical and the empirical level. The results of the estimation can contribute to a better understanding of the eclectic paradigm. In a first implementation of the econometric framework with data on the activities of Swiss industrial firms in Eastern Europe, the correlations between the error terms are not significantly different from zero. These empirical results lead to the conclusion that the error terms of the three advantages are independent of each other.

Fourth, consistent modelling of the OLI paradigm makes empirical testing possible. Despite widespread use of the OLI approach, there have been no tests to this date that go beyond scanning the list of regressors in the light of the OLI approach (Dunning 1993). Using the model developed here, the assumptions of the OLI approach can be systematically tested. The estimations presented in this paper show encouraging results and provide interesting indications for further research – both on the theoretical and empirical level. Within the framework of the OLI approach, the O advantages are responsible for whether a firm is internationally active at all or not. It was possible to estimate this first decision very well. The variables which explain the O advantages are in agreement with the theoretical expectations. Indirectly this can be interpreted as confirmation of this part of the OLI approach.

According to the OLI approach, the L and I advantages are responsible in the second phase for the choice between the different internationalization strategies. The estimation of this second phase produced unsatisfactory results in the empirical implementation. There are two possible explanations for this finding. First, the cause could lie in the shortcomings of the explanatory variables used. With better data sets, a satisfactory estimation on the second phase should be successful. Second, there is also a possibility that this deficiency is due to false assumptions in the theoretical approach which we took as a basis. Other data sets would then not lead to satisfactory estimations either. This could be an indication of the fact that this second phase of the OLI approach cannot be confirmed empirically and should be modified accordingly. Further empirical analyses with different data sets and based

on the proposed econometric framework would contribute to further clarification.

Appendix

Table A.1: *Description of the Independent Variables*

Variable	Definition	Mean[a]	Std dev.
R&D expenditure	Expenditure for research and development for the innovations, five-step scale from "none" (1) to "very high" (5)	2.336	1.092
New products	Products introduced which for the sector are new worldwide (yes = 1, no = 0)	0.282	0.451
Subsidiary	Legally independent subsidiary (1), otherwise (0)	0.301	0.459
Employees	Number of employees divided by 100	2.276	5.866
Employees, squared	Divided by 1,000,000	0.395	3.063
New products without patent	−1: new product with patent 0: no new product introduced 1: new product without patent	0.156[b] 0.718[b] 0.126[b]	
Effectivity			
– Patent rights	Assessment of the effectivity of patent rights to secure innovation-specific competitive advantages, five-step scale from "not effective" (1) to "very effective" (5)	2.276	1.142
– Secrecy	Assessment of the effectivity of secrecy to secure innovation-specific competitive advantages, five-step scale from "not effective" (1) to "very effective" (5)	2.625	1.168
Diversification	Number of product areas in which the firm is active	1.095	0.550
Labor intensity	Number of employees per SFr 100,000 turnover	0.567	0.347
Semi- and unskilled	Percentage of semi- and unskilled in the total work force (in percent), sector mean	39.258	15.329
Academics	Percentage of academics in the total work force (in percent), sector mean	3.018	3.889
Patent	Patent applications (yes = 1, no = 0)	0.296	0.457

[a] The sample contains 297 firms. According to the variable, the calculation of the mean and of the standard deviation is based on a slightly smaller number due to missing values. – [b] Percentage of firms in this category.

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